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A Framework for Selection of Information Systems Development Methodologies

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Abstract

Information systems are increasingly becoming regarded as crucial to an organisation's success. A development methodology for an information system is a framework to organize, program and supervise the process of developing an information system. There many are different methodologies for information systems development. Obviously, no methodology can claim that it can be applied to any organisation. Therefore, organisations should have an evaluation framework for selecting an appropriate and efficient methodology. In this paper, we propose an evaluation framework for selecting information systems development methodology in order to facilitate the development process of information systems in organisations.

In this work, we will describe and compare different hard and soft systems approaches at first, then in the following sections, one kind of methodology's classifications is pointed and one methodology from each class is introduced. Finally, a comparison framework is proposed and methodologies are compared by this framework. The value of this framework is that, with use of it, organisations can evaluate their development methodology with respect to the key features of it before implementing any methodology as well as expending extra costs. This framework is theoretical in nature, and is build based on a review of related literature.

Keywords: Systems methodologies, Information systems, Methodology selection, Methodology comparison framework

1. Introduction

Methodology is defined by Britain computer society (BCS): (Avison, 2006)

"Systems development methodology is a set of recommended means for information systems development or part of it which is based on logics and specific philosophy. The recommended means often contain of definition of phases, procedures, activities, rules, techniques, documentations, tools and guidance. It may also include suggestions which notice on management and organisation, approach and determining and training participations."

In last decades, it is clear for anyone that information systems and their development are important. Information systems development is a complicated and long process in which different elements collaborate from beginning to end. It is evident that programming and managing these projects are very hard and even impossible without utilizing a methodology (Inman, 2006). Many researchers and companies have designed and introduced methodologies in academic and commercial levels. Each of these methodologies uses a set of tools, models, and specific concepts; therefore they are successful and applicable in some specific backgrounds. Whereas these methodologies are very

numerous, selecting appropriate methodology for applying in a specific system is a very important and difficult process. Two different approaches can generally be adopted in the process of this methodology selection: (Niaki, 2001)

Select a known methodology and accomplish its steps carefully;

Combine two or many comparatively suitable methodology and adjust them according to specific situation of project.

Methodology comparison is done with the following purposes: (Avison, 2006)

Academic purpose: for better understanding the nature of methodologies (goals, philosophy, characteristics and so on.) in order to do some classifications and improving coming information systems development

Practical purpose: to select one or more methodologies for specific applications or the whole organisation.

In this paper, at first, hard and soft systems approaches are considered and compared, then one kind of methodology's classifications is pointed and one methodology from each class is introduced. At the end, comparison frameworks were proposed and methodologies are compared by this framework.

2. Hard and Soft Systems Approaches

Hard systems thinkers observe the world systematically. They believe that systems have a specific and defined goal and determined boundary. In other words, there is no search about system's goal and boundary. Hard systems analysis in mechanical cases or simple biophysical problems would be useful. Hard systems thinkers observe social phenomena as stable, predictable, and repeatable problems.

On the other hand, soft systems thinkers believe that problems are happening when hard systems thinking is applied in problem situations which in behavior, action, and human aspects are effective factors. They know phenomena as dynamic, unpredictable, full of chaos, and immethodical. They do not always observe the world systematically but sometimes observing the world systematically is known useful. (Checkland, 1981)

In order to distinguishing that the information systems development problem is hard or soft, a framework which is represented by Harry is used (Harry. 1997):

Definition: Is there any knowing and agreeing about what the problem is?

Boundary: Does the definition of problem enable the clarification of what the problem is, and what it is not?

Separation: Can issues be dismissed as being not part of the problem as a result of drawing the boundary?

Responsibility: Does the definition and separation of the problem make it clear who should be involved in its solution and who not?

Information: If there is clarity on what the problem is and whose responsibility it is, do we know what information is required for its solution?

Description: Is it known what a solution would, and would not, look like if all the previous criteria have been satisfied?

If the answer to these questions based on all the above criteria is "yes", then the problem can be classified as a hard problem. If at least one of these answers is "no", we are facing a soft or hard uncertainty problem.

According to Checkland, the most important difference between the two concepts is the fact that in hard systems thinking, the end result would be to implement the designed system, while in soft systems thinking, one would implement the agreed changes. (Watkins, 2003)

3. Hard Systems Methodologies in Information Systems Development

Different classifications are represented for hard methodologies. In this paper, we gain this taxonomy by combining some of them: (Harry, 1997; Scott, 2005; Course of information systems development, 2005)

Structured methodologies

Data-oriented methodologies

Process-oriented methodologies

Blended methodologies

Object-oriented methodologies

In the next chapter, each of these classifications is introduced as well as a methodology of each classification.

3.1 Data-Oriented Methodologies

In this group of methodologies, the focus is on the data aspect of system to information systems development and data flows are very important. Information engineering methodology (IEM) is an example of this group.

The basic framework of information engineering methodology is developed by Clive Finkelestien and James Martin. Its

source is the methods which Finklestien suggested for data modeling in the end of 1970s in Australia. In 1981, they published a book with a title, information engineering, which described principles and its application of methodology. On the other hand, in the end of 1970s, another group in England innovated a new methodology, system development in a shared data environment (D2S2). It is effective on IE methodology development. For the moment, different narratives of these methodologies are represented by numerous companies and organisations which insert on general IE framework but each of them are different to each other according to circumstances or focuses on parts of methodology. Martin said regarding this subject: "It should not consider that IE is a completely specific methodology. Identical software engineering, IE is an echelon of methodologies." (Avison, 2006)

Different steps of IE are as follows: (Course of information systems development, 2005)

1) Information strategic planning which is contained existing situation analysis, needs analysis, architecture definition and information strategic plan collect.

2) Domain analysis which is earning attributes analysis, interaction analysis, existing systems analysis, designing confirmation and planning.

3) Design and programming system:

Logical designing

Technical designing

4) Build and implementation:

Build: producing and evaluating system

Implementation

Protecting

3.2 Process-Oriented Methodologies

This group, unlike data-oriented methodologies, focuses on existing processes in information system and tries to apply these processes into information systems development. Yourdon systems method (YSM) is one of these methodologies.

This method is one of the most comprehensive systems development methodologies whose last version is represented in 1993. Yourdon innovated this method in order to eliminate inexpressiveness's which these methods have indicated in practice. This method has three phases which each of them have some steps. Its steps and phases are as follows: (Yourdon Inc., 1993)

Phase 1: Feasibility

Interviewing with users

Building DFD

Building ERD

Phase 2: Main model building

Building Enterprise Essential Model (EEM)

Building System Essential Model (SEM)

Phase 3: Performance model building

Building Enterprise Performance Model

Building System Performance Model

3.3 Blended Methodologies

In this group, the attention in information systems development process is on both data and process aspect of the system. The most important methodology in this group is Structured Systems Analysis and Design Methodology (SSADM).

At first, SSADM was represented to standardize development methods and built systems in governmental centers by CCTA in 1981. By now, it has changed very much. On of the results would be technology's changes and methodology week points. Its third edition introduced new techniques to contact users with system in 1986. In version 4.0, prototyping technique was mooted at first time. Its last version, 4.3, was represented in 1996. (Avison, 2006)

This methodology steps are expressed in five phases and seven steps which are as follows: (Poon, 2005)

Phase 1: feasibility study

Stage 0: feasibility

Phase 2: requirement analysis

Stage 1: investigation of current environment

Stage 2: business system options (BSO)

Phase 3: requirement specification

Stage 3: definition of requirement

Phase 4: logical system specification

Stage 4: technical system options

Stage 5: logical design

Phase 5: physical design

Stage 6: physical design

3.4 Object-Oriented Methodologies

By encapsulating processes and data together, defining objects, and capturing the essential building blocks of the system, Object-Oriented methodologies modularize the system, allowing objects to be defined based on boundaries existing in the real world system. Such methodologies encourage the analyst to look at the 'what' of a system rather than the 'how', holding off the design phase until all objects within the system have been analyzed to their fullest. This category encompasses such methodologies as: Rational Unified Process (RUP). (Kruchten, 2003)

The roots of rational processes go back to the original spiral model of Barry Boehm. The Rational Approach was developed at Rational Software in the 1980s and 1990s. The Rational Unified Process (RUP) is based on the integrated work of three primary methodologists, Ivar Jacobson, Grady Booch and, James Rumbaugh. The Unified Process is consists of cycles that may repeat over the long-term life of a system. A cycle is consists of four phases: Inception, Elaboration, Construction, and Transition. Each cycle is concluded with a release, there are also releases within a cycle. RUP is based on a set of building blocks, or content elements, describing what is to be produced, the necessary skills required and the step-by-step explanation describing how specific development goals are achieved. (Formal RUP, 2008)

The main building blocks, or content elements, are as follows:

Roles (who) – A Role defines a set of related skills, competences, and responsibilities.

Work Products (what) – A Work Product represents something resulting from a task, including all the documents and models produced while working through the process.

Tasks (how) – A Task describes a unit of work assigned to a Role that provides a meaningful result.

The process can be described in two dimensions, or along two axes: (Scott, 2005)

The horizontal axis represents time and shows the dynamic aspect of the process as it is enacted, and it is expressed in terms of cycles, phases, iterations, and milestones.

The vertical axis represents the static aspect of the process: how it is described in terms of activities, artifacts, workers and workflows.

4. Soft Systems Methodologies in Information Systems Development

These methodologies are focused on soft (human) aspect of systems and supposed that people in organisation are influenced in systems development process. We classify soft methodologies into two groups: ETHICS methodology and SSM.

4.1 ETHICS Methodologies

ETHICS is a shortened form of Effective Technical and Human Implementation of Computer- based Systems. The name of this method means methodology establishment which is designed by Enid Mumford. In order to make system effective, technology should have many adoptions with social and organisational factors. Therefore, the main goal of methodology from system design process is high quality of work life and extensive user job satisfaction. (Avison, 2006)

The steps of this methodology are as bellow: (Course of information systems development, 2005)

1) Why change? 2) System boundaries, 3) Description of existing system, 4, 5, and 6) Definition of key objectives and tasks, 7) Diagnosis of efficiency needs, 8) Diagnosis off job satisfaction needs, 9) Future analysis, 10) Specifying and weighing efficiency and job satisfaction needs, 11) The organisational design of the new system, 12) Technical options, 13) The preparation of a detailed work design, 14) Implementation, and 15) Evaluation.

4.2 SSM Methodologies

Checkland try to apply systems theory to an applicable methodology. He demonstrated that system analyzers apply their skills in problems which are not well-defined. These soft, fuzzy, or ill-structured problem situations which are

complicated are ordinary in organisations. Checkland's methodology was developed in Lancaster University. He represented soft systems methodology description in 1981. SSM has seven stages which are shown in figure2.

Those stages which above dash line (1, 2, 5, 6 and 7 stages) are real world activities that contain people in problem situation. Those stages which below dash line (3 and 4 stages) are activities that think about problem situations. (Checkland & Scholes, 1990)

5. Existing Frameworks Deliberation for Hard and Soft Systems Methodologies Comparison

There are different approaches for information systems development methodologies which we consider some of them:

5.1 Andersen Framework

Andersen identifies a checklist which includes criteria relating to values and society. This checklist is consists of the following questions:

1) What research paradigms/perspectives form the foundation for the methodology?

2) What are the underlying value systems?

3) What is the context where a methodology is useful?

4) To what extend is modification enhanced or even possible?

5) Does communication and documentation operate in the users' dialect, either expert or not?

6) Does transferability exist?

7) Is the societal environment dealt with, including the possible conflicts?

8) Is users participation really encouraged or supported?

This checklist is useful because focuses on those wider issues that are ignored. Furthermore, it's a subjective list and makes some assumptions. (Avison, 2006)

5.2 NIMSAD Approach

NIMSAD is the abbreviated of "Normative Information Model- based Systems Analysis and Design" and based on the models and epistemology of systems thinking and to a large degree evaluation and measures a methodology against these criteria. Three elements of this evaluation are:

The problem situation (the methodology context)

The intended problem solver (the methodology user)

The problem-solving process (the methodology)

The evaluation of elements has a wide-ranging and expressed in terms of the kinds of question that require answers. An example of questions which are related to the first elements is:

The clients and their understanding, experiences and problems.

A sample of questions concerning the second element is:

The methodology users' philosophical views, for example, science or systems-based.

A sample question concerning the third element asks about the way in which the methodology provides specific assistance for:

Understanding the situation of concern and setting of boundaries.

One feature of this framework is that it recommends that the evaluation be conducted at three stages. First, before intervention, second, during intervention, and finally, after intervention. These stages are important features of the framework and introduce the important element of organisational learning. (Avison, 2006)

5.3 Avison and Taylor Approach

Avison and Taylor identify five different classes of situation and appropriate approaches as follows: (Avison, 2006)

1) Well-structured problem situations with a well-defined problem and clear requirements. A traditional SDLC approach might be regarded as appropriate in this class of situation.

2) As above but with unclear requirements. A data, process modeling, or a prototyping approach is suggested as appropriate here.

3) Unstructured problem situation with unclear objectives. A soft systems approach would be appropriate in this situation.

4) High user-interaction systems. A people-focused approach, like ETHICS, would be appropriated here.

5) Very unclear situations, where a contingency approach, such as multiview, is suggested.

5.4 Presenting a Framework for Hard and Soft System's Methodologies Comparison

As explained before, comparing methodologies is a very difficult task. There are different views as many as methodology writers. It is not necessary that analysts' views adopt on users views and in some cases are discordant. In this framework, we have six basic elements and some of them broken into some sub elements. The headings are not mutually exclusive and there are interrelationships between them. For example, aspects of philosophy are reflected in some senses. In the following section, we explain each of these elements:

5.4.1 Philosophy

We know the philosophy as a principle or set of principles that are background of methodology. The question of philosophy is an important aspect of methodology because choosing areas covering by methodology, orienting to people, data or systems, the bias or otherwise toward an IT solutions and other aspects are made on the base of methodology philosophy. Therefore it has influence on all other aspects. It may be explicit but in most methodologies, is implicit because methodology authors rarely stress on their philosophy. Philosophy consists of paradigm, objectives, domains, and applications.

5.4.2 Model

The second element of the framework concerns of analysis of the model that the methodology adhere to. The model is based on the view of methodology of the world. It is an abstraction and representation of important factors of the information systems or the organisation. Model is a means of communication. It is also a representation that provides insight into the problem or area of concern.

Models have four different types:

1) Verbal;

2) Analytic or mathematical;

3) Iconic, pictorial or schematic;

4) Simulations.

Models which concern with information systems methodologies are often of the third type.

5.4.3 Tools

A key element of the framework is the identification of tools used in a methodology.

5.4.4 Scope

Scope is an indication of the stages of the life cycle of systems development that methodology covers. Some methodologies do not follow a life cycle. They may adopt with an iterative, evolutionary or spiral model. Nevertheless, we suppose that an examination of methodology's scope in relation to the life cycle is useful.

5.4.5 Background

With this element, we can identify each methodology in which environment (academic or commercial) created.

5.4.6 Participations

It contains of users and analysts. Participations determine that can it be undertaken by users or must involved by professional analysts and what skills levels are required.

Table 1 compares introduced methodologies. In this table and in scope column, there signs are used:

☑: Methodology covers this stage with its details.

☒: Methodology shows this area but with less details and practice.

☐: It is introduced in methodology but no procedure, technique, or rule is provided.

6. Conclusion

The Proposed comparison framework is represented with attention to the key features of each methodology. These features play an important role in successful performing the methodologies. This represented framework can help organisations to select their suitable methodology based on methodology's features, to apply it in organisation, and to ensure that methodology will be performed successfully.

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Table 1. Methodology comparison and selection framework

	Approach	Philosophy: Paradigm	Philosophy: Objectives	Philosophy: Domain	Philosophy: Application	Major Model	Tools	Scope: Strategy	Scope: Feasibility	Scope: Analysis	Scope: Logical design	Scope: Physical design	Scope: Planning	Scope: Examination	Scope: Implementation	Scope: Evaluation	Scope: Maintenance	Background	Participations
SSM	Soft	Systemic	For complex situations analysis	information and organisational systems planning Not well-defined or unstructured	Situations include human activities	Rich picture	-	☑	☒	☑	-	-	-	-	-	-	-	Academic	System users and experts
ETHICS	Soft	Systemic	Improve work life quality and increase user job satisfaction	Determined problem solving methodology	Any system with any size	Social-technical model	-	-	☒	☑	☑	☒	-	-	-	-	-	Academic	Systems users (experts as counselor)
YSM	Hard	Scientific	Computerized information systems development	Determined problem solving methodology	Big System	DFD	Advice to use	□	☑	☑	☑	☑	-	-	-	-	-	Commercial	Professional IS developers
IE	Hard	Scientific	Computerized information systems development	Strategic information and organisational systems planning	Big System	ERD	use because of complexity and time	☑	☒	☑	☑	☑	☒	☑	☒	☒	□	Commercial	Professional IS developers
SSADM	Hard	Scientific	Computerized information systems development	Determined problem solving methodology	Big System	DFD	Advice to use	☒	☑	☑	☑	☑	-	-	-	-	-	Commercial	Professional IS developers
RUP	Hard	Scientific	Computerized information systems development	Determined problem solving methodology	Big System	Object Model	use because of complexity and time	□	☒	☑	☑	☑	☒	☑	☑	☒	-	Academic	Professional IS developers

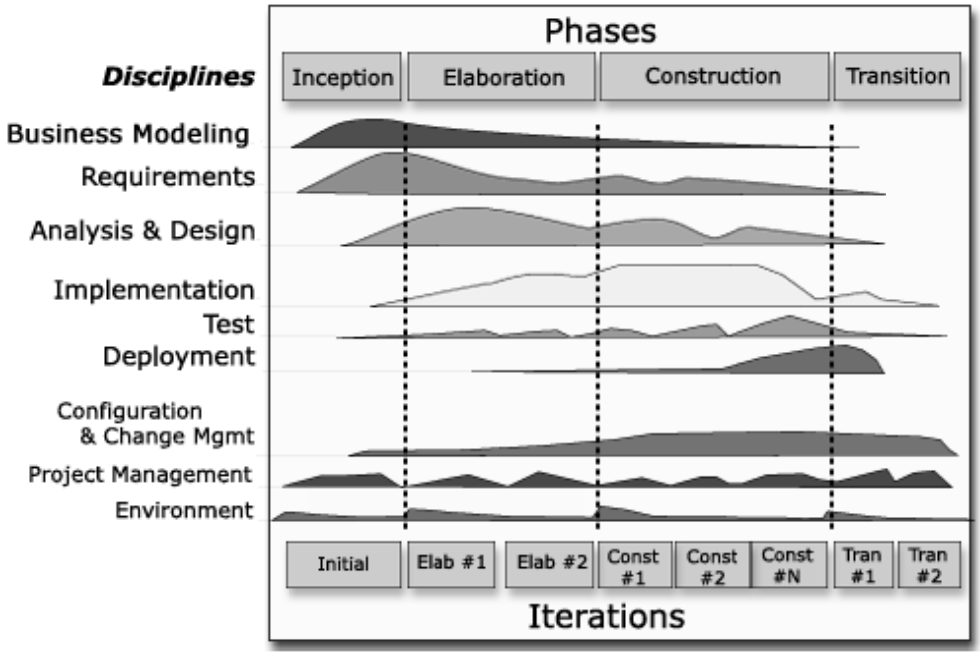

Figure 1. RUP General Structure (Scott, 2005)

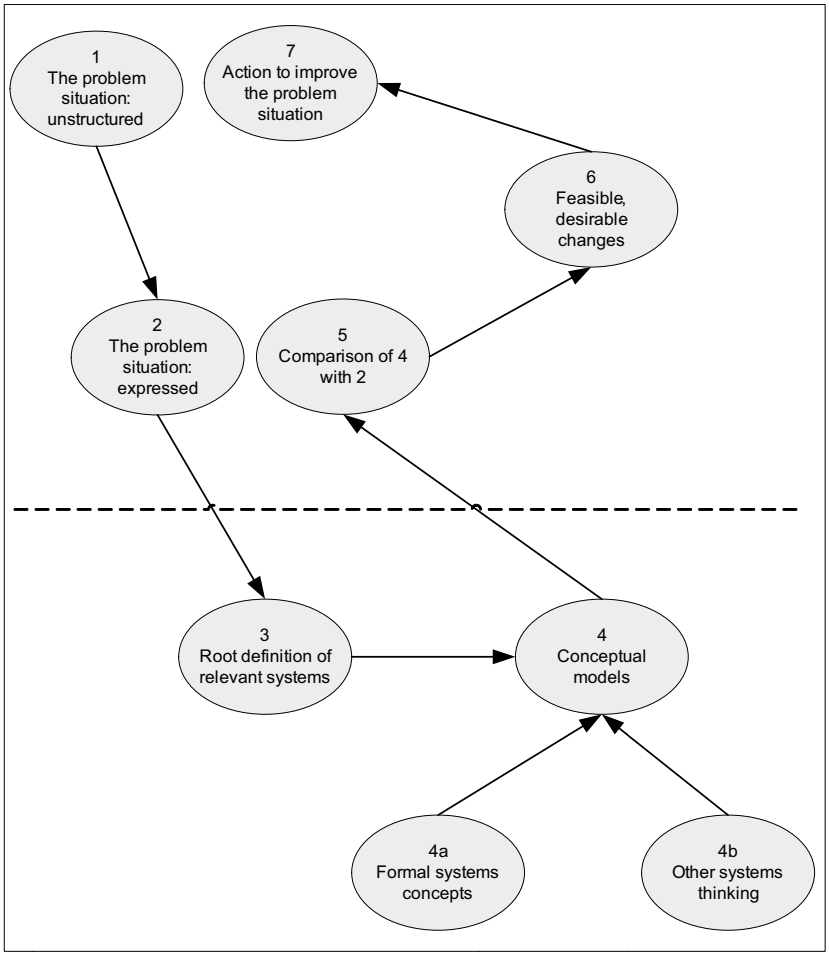

Figure 2. Soft Systems Methodology Stages (Checkland, 1981)

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Model Checking the Inconsistency and Circularity in Rule-Based Expert Systems

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Abstract

In the past several years, various techniques were proposed to analyze various types of structural errors, such as inconsistency (conflict rules), and circularity (circular depending rules), of rule-based systems. Model checking is a technique for the verification of temporal logic specifications in state transition systems. In this paper, we model the rule-based systems as finite state transition systems and express consistency and acyclic as Linear Temporal Logic (LTL) logic formula and then use the technique of model checking to detect inconsistency and circularity in Rule-Based Systems with the model checker NuSMV.

Keywords: Model checking, Inconsistency, Circularity, Rule

1. Introduction

Expert systems have been widely used in many real world applications. The central part of an expert system is a rule base that codifies the knowledge from domain experts in the form of inference rules. Often these inference rules are built into a rule base incrementally over years and subject to frequent refinements. Due in part to the above construction process of a rule base and in part to the different and even conflict views provided by domain experts, a rule base can contain many structural errors. According to (D.L. Nazareth. 1989), the typical types of structural errors include

inconsistency (conflict rules), incompleteness (missing rules), redundancy (redundant rules), and circularity (circular depending rules).But we just focus on the inconsistency and circularity in this paper.

Many different techniques have been proposed to detect the above structural errors in rule-based systems (a quite comprehensive list of references can be found in (M. Ramaswamy, et al., 1997)). Earlier work mainly focused on detecting structural errors by checking rules pair-wisely. Recent work aimed at detecting structural errors caused from applying multiple rules in longer inference chains. The majority of the recent verification techniques involve using some graphical notation such as Petri nets and graphs. Several of the above approaches cannot detect structural errors accurately and report spurious errors when compound antecedent clauses overlap. The approach in (D. Zhang and D. Nguyen,1994) could only detect structural errors matching a set of pre-defined syntactic patterns. The approaches in (G. Valiente,1993) and(S. J.H. Yang, et al.1998)did not address inconsistency errors. In (M. Ramaswamy, S. Sarkar, and Y.S. Chen, 1997), an adjacency matrix technique was used, which has a higher computational cost both in terms of space (the sparseness of typical adjacency matrices) and time (the number of addition and multiplication involved in matrix operations).

Model checking (William Chan,1998) is a technique for the verification of temporal logic specifications in state transition systems. In this paper, we present a model to model the rule set of rule-based systems as state-transition systems and express consistency and acyclic as LTL logic (A.Pnueli . 1981) formula and then use the technique of model checking to detect inconsistency and circularity in Rule-Based Systems with the model checker NuSMV. This technique is simple, efficient, and automated. We highlight the unique features of this new approach and demonstrate its application through an example by the model checker NuSMV.

2. Model checking

Model checking (William Chan,1998) is an automatic approach to formal verification based on state exploration. This verification is performed by software tools, which given a state transition system and a property, model checking algorithms exhaustively explore the state space to determine whether the system satisfies the property. Fig. 1 is a schematic of the process of model checking, a model of the specification and a property are fed to a model checker. The result is either a claim that the property is true or else a counterexample (a sequence of states from some initial state) falsifying the property. In practice, counterexamples often provide valuable debugging information, and can be used by the user to modify the model, or the property checked. This iterative process is inherent in our work. In this context the model is a state transition system and the specification is formalized with temporal logic which pinpoints desired behavior over paths and states in the model.

In the rest of Section 2, we give an overview of the basics of LTL model checking and NuSMV, the model checker that we used.

2.1 The LTL Model Checking Problem

In temporal-logic model checking, we are given a state transition system, which models a software or hardware system, and a property specified as a formula in a certain temporal logic, and determine whether the system satisfies the formula. A common logic for model checking is the Linear Temporal Logic (LTL), which extends propositional logic with certain temporal operators. Typical formulas include the following(The symbol "**p**" is an atomic proposition,):

F p : p holds eventually or sometime in the ***future***.

G p : p holds ***globally*** or always in the future.

Formally, a state transition system $<P, R, I>$, consists of a set of states P, a state *transition relation* $R \subseteq P \times P$, and a set of initial states $I \subseteq P$. A *path* is an infinite sequence of states such that each consecutive pair of states is in R. The set of states P is often encoded by a set of *state variables*, such that each state corresponds to some valuation for the variables and no distinct states correspond to the same valuation (that is, the mapping of P to the variable valuations is one-to-one).

For simplicity we discuss just a subset of LTL, namely the subset with only the temporal operators F and G, which are sufficient to understand our examples. We can recursively define this restricted class of LTL formulas as follows: We say that a *proposition* is any Boolean combination of predicates on the state variables. A *formula* is either a proposition, a Boolean combination of formulas, or of the form *F f*, *G f,* where *f* is a formula. And we use the symbolic "! ", "| ", "&" to denote the logic NOT, OR, AND , respectively. Each formula is evaluated at some state q. A proposition holds at q if q satisfies the proposition.

The system satisfies a formula if the formula holds at all initial states. If not, a model checker typically attempts to find a counterexample. For example, if the formula !(F P5=1 & F P5=0) is false, a counterexample is a finite path starting at some initial state sometime satisfies the proposition *P5*=1 and sometime *P5*=0.

Readers familiar with temporal-logic model checking may notice that, although a LTL formula is usually interpreted over a *Kripke* structure which is a model for the representation of a finite-state concurrent system. The model consists of

the set of states, transition relation and labeling (which gives semantics to the structure). In our definition, a state is not explicitly labeled, but can be thought as being labeled implicitly by its corresponding state-variable valuations. This more restricted formulation is sufficient for our presentation.

2.2 NuSMV

Verification of the inconsistency and circularity problem in Rule-Based Systems has been carried out by the symbolic model checker NuSMV(R. Cavada, et al.2005) that originated from reengineering, reimplementation and extension of CMU SMV, the original BDD-based model checker developed at CMU. NuSMV allows for the representation of specifications expressed in CTL and Linear Temporal logic(LTL) using BDD-based and SAT-based model checking techniques. The primary purpose of the NuSMV input language is to describe the transition relation of a finite *Kripke* structure. The input file describes both the model and the specification (with possible fairness constraints). The states are defined by a collection of state variables, which may be of Boolean or scalar type. The transition relation of the *Kripke* structure is determined by a collection of parallel assignments, which are introduced by a keyword ASSIGN. The semantics of assignment in NuSMV is similar to that of a single assignment data flow languages. A program can be viewed as a system of simultaneous equations, whose solutions determine the next state. When a set is assigned to a variable, the result is a nondeterministic choice among elements of the set. The case statements of NuSMV are evaluated from the top down: if several expressions to the left of a ":" are true, then the command corresponding to the first, top-most true expression will be executed.

3. Inconsistency and circularity problem in Rule-Based Systems and our method

3.1 Model the Rule Base

An inference rule (clause) has the following general form (William Chan, et al. 1998): $P \rightarrow Q$, or IF P THEN Q, where P and Q are called premise and conclusion respectively. P *(or Q)* can be an atomic propositional logic formula (a proposition or its negation) or a compound propositional logic formula containing multiple propositions and logical connectives: $\wedge$, $\vee$). In the following discussion, we use lower case letters to denote atomic formulas and capital letters to denote compound formulas. We assume that all the inference rules in a rule base are syntactically valid propositional logic formulas (syntax errors are easily detected by a parser). Furthermore, we assume that P and Q are in conjunctive normal form $P1 \wedge \ldots \wedge Pm$ and $Q1 \wedge \ldots \wedge Qn$ respectively, in which each Pi ($1 \le i \le m$) (or Qj ($1 \le j \le n$)) is a disjunction of propositional symbols and their negations, i.e. $p1 \vee \ldots \vee pk$.. The above assumption does not limit the error detecting capability of our approach since any propositional logic formula can be easily and mechanically transformed into a semantically equivalent conjunctive or disjunctive normal form. The following example is modified from an example in [11]. A rule base R is defined as follows:.

R={ r1: p1$\rightarrow$ p2 $\wedge$ p5

r2: p2$\rightarrow$ $\neg$ p5

r3: p3$\rightarrow$ p1 $\wedge$ p2

r4: p1 $\vee$ p4 $\rightarrow$ p5

r5: p5$\rightarrow$ p4 }

Formally, we model the rule-based system we describe as above as a finite-state transition system $<P, R, I>$ consists of a set of states P, a state *transition relation* $R \subseteq P \times P$, and a set of initial states $I \subseteq P$, where P is a set of state variables *{p1,p2,...pn}*(n is the number of atomic propositions) which correspond to the atomic propositions appear in the rule base, and all of these variables of enumeration type *{1, 0, neither}*.When variables *pi*=1, it means pi is true, and when *pi*=0,it means *pi* is true, if *pi=neither*, it means neither pi nor *pi* is true. In our definition, a state *transition relation* is not explicit presentation. The initial states I is also not explicit presentation. We use the variable *InitTrue* of enumeration type *{r1, r2,...rm, neither}*(m is the number of rules in the rule base) to denote the initial state implicitly, when *InitTrue = ri*, it indicates that the premise of rule *ri* is true. Initially, the initial value of state variables *pi* is *neither*, and the initial value of *InitTrue* is a nondeterministic choice among elements of the set *{r1,r2……rm }*. If *InitTrue = ri*, it indicates that rule *ri* is enable (Doing this is similar to the procedure we input some facts enable rule *ri*), and then we start the reasoning to change the values of state variables according to the rules in the rule base. If the value of state variable pi is non-neither and there no other rules assign 1 or 0 to it, then we reset *pi* to *neither*. And we also set the subsequent value of *InitTrue* to be *neither*. This is the state *transition relation* of this model. For the rule base R in Fig.1, suppose the initial value of *InitTrue* is *r3*, then the state transition is illustrated in Fig.4.This is the way how we model the rule-based system as a finite-state transition system.

3.2 Inconsistency

Inconsistency results in conflict facts and must be resolved for correct functioning of an expert system. There are two cases of contradiction.

Case 1: When we start reasoning from a rule, sometime pi is true and some time ¬*pi* is true, then the contradiction occurs. So, if there exists both *pi* and ¬*pi* in the rule base, we should check whether the LTL formula !(F pi =1 & F pi=0) be satisfied or not in the model. For the instance we presented in Fig.1 , initially, we enable rule *r1*,then *p5* and *p2* is valued to 1. and then rule *r2* is fired by *p2*, as the result, *p5* is evaluated to 0.This results a contradiction.

Case 2 : If there are some rules make *pi* true and some make ¬*pi* true, then the premises make *pi* true and *pi* true respectively should not be true at the same time. So we use LTL formula !F((p4=1| p1=1) & (p2=1)) to check the example we given whether satisfies this property.

3.3 Circularity

Circularity occurs when several inference rules have circular dependency. Circularity can cause infinite reasoning and must be broken. An example of circularly dependent rules is as follows:

r1: p . q

r2: q . p

If a rule is a part of a circle, then the state variables such as pi form the rule will be assigned to 1 or 0 infinite often. So, if there no circularity in the rule set, then all of state variables *pi* should always equal to neither in the future. We use the LTL formula F G(p1=neither & p2=neither & ……& pn=neither) to express this property. If this formula can't be satisfied, we conclude there must be some circularity occurs.

4. The experiment about the example presented in 3.1

We use the NuSMV to check the example presented in 3.1,the source code we used as below:

```
MODULE main
    VAR
    p1:{0,1, neither};
    ……
    p5:{0,1, neither };
    InitTrue:{r1,r2,r3,r4,r5, neither };
    ASSIGN
    init(p1) := neither;
    ……
    init(p5) := neither;
    init(InitTrue):={r1,r2,r3,r4,r5};

    next(InitTrue):= neither;
    next(p1):= case
    InitTrue=r1 | InitTrue=r4 | p3=1 : 1 ;
    p1 !=   neither : neither;
    1     :   p1;
    esac;

    next(p2):= case
    InitTrue=r2 | p1=1 | p3=1: 1 ;
    p2 !=   neither : neither;
    1:   p2;
    esac;

    next(p3):= case
    InitTrue=r3 : 1 ;
    p3 !=   neither : neither;
```

```
    1:    p3;
    esac;
    next(p4):= case
    InitTrue=r4 | p5=1 : 1 ;
    p4 !=    neither : neither;
    1:    p4;
esac;

    next(p5):= case
    InitTrue=r5 | p4=1 | p1=1 : 1 ;
    p2=1    : 0;
    p5 !=    neither : neither;
    1:    p5;
    esac;
    LTLSPEC !(F p5=1 & F p5=0);
    LTLSPEC !F((p4=1| p1=1) & (p2=1));
    LTLSPEC F G(p1=neither & p2=neither & p3=neither &        p4=neither & p5=neither);
```

The NuSMV shows that all the three LTL formulas are false, and produce the counterexamples as Fig.2 indicates rule *r2* is inconsistent with rules r1 and rules *{r3,r4}*, rules *r4* and *r5* are in self-loop.

5. Conclusion and future work

In this paper we have proposed a finite-state transition system model which can be used for describing the behaviors of the rule-based system. We have focused on the inconsistency and circularity problem of a given rule base, and identified two sorts of inconsistency problems and circularity problem. We also present two kinds of LTL formulas and a kind of LTL formula for checking the consistency and circularity of the rule base respectively, and carry a experiment to explain our method. Our technique has the following advantages:

(1) It is general and is capable to detect all potential inconsistency and circularity errors without imposing any restrictions on the form of rules;

(2) It can produce the results automated, The result is easy to understand and we can locate the errors easily with the help of the counterexamples;

(3) It is easily extensible to predicate forms such that each *pi* is a predicate instead of simple proposition. Although describing of *transition relation* between states becomes more complicated and requires more careful.

But since the conversion from rules to the model we input into the model checker is manual work, we will develop a software tool to implement the method we proposed automatic in the future. And from theoretical point of view, to check the Inconsistency and circularity in rule base, we have to check the validity of each possible state space. The possible state spaces in our method is 3^n (n is the number of state variables), which is exponential. So, unfortunately, the size of the state space is exponential in the size of the rule base, resulting in the *state explosion problem*. But since many methods were proposed to deal with this problem, we still can do some research when the rule base is too huge to apply the method proposed in this paper directly.

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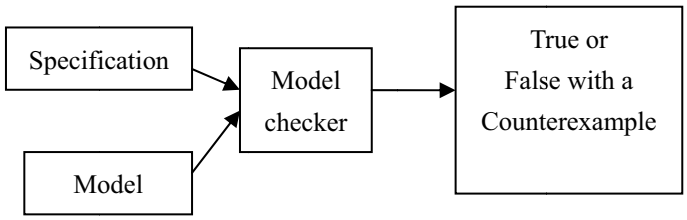

Figure 1. Model checking at a glance.

Loop	Step	InitTrue	p1	p2	p3	p4	p5
	0	r3	neither	neither	neither	neither	neither
	1	neither	neither	neither	1	neither	neither
	2	neither	1	1	neither	neither	neither
	3	neither	neither	1	neither	neither	1
	4	neither	neither	neither	neither	1	0
	5	neither	neither	neither	neither	neither	1
	6	neither	neither	neither	neither	1	neither
	7	neither	neither	neither	neither	neither	1

Figure 2. One of the counterexamples produced by NuSMV.

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End-User Computing Satisfaction (EUCS) in Computerised Accounting System (CAS): Which the Critical Factors? A Case in Malaysia

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Abstract

This paper is to examine critical factors; content, accuracy, format, ease of use, timeliness, satisfaction with system speed and system reliability in End-User Computing Satisfaction (EUCS) that influence most end-users' satisfaction. The research was conducted using a set of questionnaire consist of seven factors; content, accuracy, format, ease of use, timeliness, satisfaction with system speed and system reliability to measure end-users' satisfaction. In addition, this study covered 90 end-users of Computerised Accounting System (CAS) in finance department from 62 Responsibility Centres. This study is analyzed with reliability analysis, descriptive analysis and multiple regressions. Overall, this study indicates that most of end-users are almost satisfied with Computerised Accounting System (CAS). The results show that ease of use, content, and accuracy has a significant effect on end-users' satisfaction. Therefore, the empirical results of this study can provide support for the Doll and Torkzadeh model (1988), which related to the factors contributing end-users' satisfaction toward accounting system.

Keywords: End-User Computing Satisfaction, Computerised Accounting System, Multiple Regressions

1. Introduction

1.1 Introduction

Since the beginning of 1980s, many researches had conducted survey in information system field highlighting the tremendous development in end-user computing world. In fact, the growth of end-user computing is one of the significant phenomena of the 1980s in the information management world (David, 1983). A study by the International Data Corporation predicted that four out of five administrative and professional workers would be using personal computing to support their work and personal activities by 1990.

In general practices, there are different between the practices in the public or government sectors and the business/private companies. Hence, the applications of the Computerised Accounting System (CAS) in these organisations also differ from one to another. For instance, the private organisation utilizes the general ledger system and the accounting principles based on accrual basis. However, the public organisations employ vote accounting system, which is based on cash basis. The financial management of the organisation is also related to budgeting using a code and warrant system (Statutory Bodies Act 1980 (Account and Annual Report) (Act 240)). Thus, it seems to be interesting to investigate the level of satisfaction among end-user computing in government sector, since it is different compared to the company or business organisation.

Most of the end-user claimed that they are not satisfied with the Computerised Accounting System (CAS) which it was using in the government sector office. The previous study showed that the main factor contributing to dissatisfaction

because of the limitation of stand-alone system among the various accountant general departments. Furthermore, it seems clear that a study on End-User Computing Satisfaction (EUCS) in Malaysia is best described as limited especially in government sectors. Therefore, the scarcity of empirical research in the area of end user satisfaction among Computerised Accounting System (CAS); especially in the Malaysian context is significant to this research.

Perhaps, having a good financial or computerised accounting information system will increase the performance of an organisation. Eventually, this enables the organisation to increase revenue in order to follow the recommendation of self-financing by the ministry. Therefore, the objective of the study is merely to examine the most critical factor that influences End-User Computing Satisfaction (EUCS) towards Computerised Accounting System (CAS).

The remainder of this paper is organized as follows. A review of related literature on end-users computing satisfaction and hypotheses is discussed. Next, the methodology employed in this study, research instruments used and data analysis method involved are described. Finally, the empirical results and discussion of the study are drawn.

1.2 Research Objective

1) To examine critical factors of content in End-User Computing Satisfaction (EUCS) that influence most end-users' satisfaction.

2) To examine critical factors of accuracy in End-User Computing Satisfaction (EUCS) that influence most end-users' satisfaction.

3) To examine critical factors of format in End-User Computing Satisfaction (EUCS) that influence most end-users' satisfaction.

4) To examine critical factors of ease of use in End-User Computing Satisfaction (EUCS) that influence most end-users' satisfaction.

5) To examine critical factors of timeliness in End-User Computing Satisfaction (EUCS) that influence most end-users' satisfaction.

6) To examine critical factors of system speed in End-User Computing Satisfaction (EUCS) that influence most end-users' satisfaction.

7) To examine critical factors of system reliability in End-User Computing Satisfaction (EUCS) that influence most end-users' satisfaction.

2. Literature review

2.1 Literature review

Unlike the other researchers, Pather et al. (2003) argued that the advent of e-Commerce has shifted the location of the traditional user of Information Systems out of the physical domain of the organisation or business. E-commerce businesses now have to deal with a new type of user viz. the e-Customer. Thus, they disputed that established instruments that measure user satisfaction of IS in traditional (brick and mortar) businesses are not completely appropriate. The authors, building on a comprehensive literature study, derived an appropriate model for exploring the measurement of e-customer satisfaction in the South African context.

Markovic & Wood (2004) addressed the issue of user satisfaction with a computer lab in a university. Both formal and informal data gathering techniques were used to provide comprehensive data for this research. Data was gathered from both users and managers in order to provide a complete picture of the current situation. This data led to a research study of user satisfaction among students and support staff. The research revealed that satisfaction with hours and software and hardware performance had the greatest impact on user satisfaction followed closely by quality of support staff.

Bengts (2004) studies usability as a constituent of end- user computing satisfaction. Different measurement instruments and rating scales for user satisfaction have been created; however, the relationship between satisfaction and usability remains unclear. A web-based system with three different user interface alternatives was implemented and the system was used by information technology students to practice SQL-queries in a university course. 43 students reported their preference and the underlying reasons by answering both structured and open-ended questions in a web-based questionnaire. The results also indicated that availability of desired features, simple interaction and user-control are as constituents of satisfaction more important than simple screen design and error- free usage.

Huang et al. (2004) argued that while end-user computing satisfaction has been studied extensively, new aspects such as purchasing convenience, product prices in the system and product delivery have to be included. In their study, they developed an instrument for reliably and accurately measuring business-to-employee success. Test–retest reliability and construct validity were examined. Finally, they concluded that convenience, delivery, interface, accuracy, price and security influence employee assessments of satisfaction. Managers can use the instrument developed in their study to assess the success of their business-to-employee systems.

This study is continuing from Azleen et al. (2007) that measured the level of satisfaction among the end users of CAS in Labuan F.T government sectors and also determine the relationship of seven factors (content, accuracy, format, ease of use, timeliness, satisfaction with system speed, system reliability) that influence satisfactory level among the end users toward the CAS. Furthermore, Azleen et al. (2007) also measured the level of EUCS among CAS end users in private companies. They evaluated the significant relationship between EUCS factors and the overall EUCS in Malaysian context and examined the differences of perception on overall EUCS among the demographic variables. This study found that EUCS factors more reliable as compared to previous studies and the correlation between satisfaction and EUCS factors are fairly strong. However, the study failed to detect significant differences of perception on overall EUCS on gender, level of education and position.

The scope of the discussion is related to EUCS; the previous factors that contribute to EUCS, Doll and Torkzadeh Model (1988); i.e., content, accuracy, format, ease of use, and timeliness and the modification made by Chin and Lee (2000), i.e. satisfaction with system speed, and system reliability (self developed). The model will become the fundamental guidelines to examine factors contributing to EUCS among Accountant General Department.

2.2 Research Hypotheses

The hypothesis of overall End-User Computing Satisfaction (EUCS) is constructed based on seven factors: (1) content (2) accuracy (3) format (4) ease of use (5) timeliness (6) satisfaction with system speed and (7) system reliability. These seven factors measure is formulated to test the relationship with the overall End-User Computing Satisfaction (EUCS) that more focused questions, aimed specifically on CAS. Thus, the hypotheses for this study are summarized as follows:

H1: There is significant effect between content and end-users' satisfaction towards Computerised Accounting System (CAS)

H2: There is significant effect between accuracy and end-users' satisfaction towards Computerised Accounting System (CAS).

H3: There is significant effect between format and end-users' satisfaction towards Computerised Accounting System (CAS).

H4: There is significant effect between ease of use and end-users' satisfaction towards Computerised Accounting System (CAS).

H5: There is significant effect between timeliness and end-users' satisfaction towards Computerised Accounting System (CAS).

H6: There is significant effect between system speed and end-users' satisfaction towards Computerised Accounting System (CAS).

H7: There is significant effect between system reliability and end-users' satisfaction towards Computerised Accounting System (CAS).

3. Research Methodology

3.1 Sampling and Instrumentation

This study relies on survey design as it deemed more appropriate compared with other designs of research in order to achieve the objective of the study. The population of this study covered the end users of Computerised Accounting System (CAS) in each Responsibility Centres in East Malaysia. Responsibility Centres known as government agencies that responsible to manage and control financial management in order to collect and report revenue and cost information by areas of responsibility. However, only 62 Responsibility Centres were chosen due to time and cost limitation. We have distributed two questionnaires for each department and the total population are 124 respondents. Sekaran, U. (2003) has stated that the sample should be taken for this population are 97 respondents. Nevertheless, only 90 respondents have completed and submitted these questionnaires.

Basically, the instrument of this study is based on the instruments, which was developed by Chin and Lee (2000). It presents a new set instrument while focusing on the same five construct domains. They are: content, accuracy, format, ease of use, and timeliness (Doll & Torkzadeh, 1988); and satisfaction with system speed (Chin & Lee, 2000). According to their findings, the relationship between the overall measures of satisfaction than the baseline model is expected to be relatively strong.

3.2 Data Analysis Method

To analyse the data, this study conducts descriptive analysis and multiple regression analysis using the SPSS 13.0 (statistical package for social science) software for windows. The study also tested reliability of the instrument so that it enables to produce a robust and valid result.

4. Data Analysis and Results

4.1 Reliability Analysis

Table 1 summarizes the reliability analysis for each items and satisfaction. Each items show above 0.7. It seems that this study provides more reliable instruments because most of the score is higher than Doll and Torkzadeh (1988). The content score in Doll and Torkzadeh (1988)'s study is 0.89 as compared to 0.918 in this study; accuracy=0.91 (0.875); format=0.78 (0.927); ease of use=0.85 (0.927); timeliness = 0.82 (0.751). The coefficient alpha for system speed is higher (0.800) than Chin and Lee study (0.72) and system reliability is a new factor provides 0.759 and presents a reliable dimension for EUCS measurement. The reliability of the instruments of the study can be compared with Amdan et al (2006). From the table, only system reliability and ease of use show better than Amdan et al (2006).

4.2 Descriptive Statistics

The results of the descriptive analysis are shown in Table 2. From the result, the highest mean is satisfaction with the format (3.69) and the lowest mean is timeliness (3.34). It seems like most of the staff satisfied with format factor and less satisfied with timeliness factor. The highest standard deviation is ease of use (0.69) and the lowest is system reliability (0.56). The ease of use is deviate too far from the mean and system reliability is too close to the mean.

4.3 Multiple Regressions

Multiple regression analysis was performed in analysing the data. Properties of casual paths, including standardised coefficients beta, t values and significant results, for each equation in the hypothesized model, are presented in Table 5. Table 3 presents the result of model summary that system reliability, timeliness, format, accuracy, content, ease of use and system speed predict the end-users satisfaction towards computerized accounting system (CAS) usage. From this model, R represents the simple correlation .922 and R Square is .850, which shows that 85% changes in satisfaction can be explained by system reliability, timeliness, format, accuracy, content, ease of use and system speed. However, 15% changes can also be explained by other variables that influence the level of satisfaction. The result of the Adjusted R Square tested shows that system reliability, timeliness, format, accuracy, content, ease of use and system speed contribute significantly ($F = 66.564$; $P < .001$) as shown in Table 4 and predict 83.8% of variation in end-users' satisfaction.

4.4 Discussion

The results show that Hypothesis 1, Hypothesis 2 and Hypothesis 4 has significant effect with end-users' satisfaction. The significant relationship was found between ease of use and end-users' satisfaction towards computerized accounting system (CAS), (ß=.280, t=3.501, p=.001). This factor will be the most critical factor that contribute in end-users' satisfaction and it seems that users need to have accounting system that easy to be understood and handled according to the structured module. This result has support to accept Hypothesis 1. Next, null hypothesis for Hypothesis 2 is rejected because second most critical factor is between content of accounting system and satisfaction based on the findings (ß=.216, t=2.702, p=.0080) is revealed. This is because most of the end-users satisfied with the content of accounting system. The last factor that contribute to the satisfaction is accuracy of accounting system (ß=.183, t=2.088, p=.040) and Hypothesis 4 is substantiated. Most likely this circumstance is contributed by the high quality of accounting information.

Furthermore, Hypothesis 3, Hypothesis 5, Hypothesis 6 and Hypothesis 7 are also constructed to examine the significant effect with end-users' satisfaction. Hypothesis 3 avers that format of the accounting system has significant effect on end-users' satisfaction. Table 3 illustrates that the effect of format of the system on end-users' satisfaction was not substantiated (ß=.087, t=1.120, p=.266). Next, Hypothesis 5 asserts that timeliness has significant effect on end-users' satisfaction. However, table 3 shows that the timeliness has insignificant effect with end-users' satisfaction and null hypothesis is accepted (ß=.105, t=1.740, p=.086). Further, null hypothesis for Hypothesis 6 is accepted according to the result in table 3 (ß=.125, t=1.538, p=.128). The factor of system speed also do not effect significantly to end-users' satisfaction. It seems not important to influence the usability and emotional responses among users. Finally, the hypothesis regarding reliability of accounting system has significant effect on end-users' satisfaction (Hypothesis 7) was not confirmed (ß=.087, t=1.120, p=.266). Undoubtedly, some of end-users are not aware with accounting system security or privacy. This is because most of accounting system in government sector is supervised by information technology unit or department. Thus, most of end users only intend to use and utilize this system regardless the reliability of its security system.

5. Conclusion

This research attempted to measure the end-users satisfaction of CAS using multiple regression by determine the significant effect of seven factors that influence end users' satisfaction. Overall, this study indicates that most of end users are almost satisfied with the CAS. It can be explained by descriptive statistics result which indicates high satisfaction for each of EUCS factors. In addition, this study has enabled to identify the most critical factor that

influences end-user computing satisfaction towards CAS. The results show that ease of use, content, and accuracy has a significant effect on end-users satisfaction. In other words, the usability of CAS is enormously important in producing accurate output or content of CAS.

6. Implications and future research

The study demonstrated the EUCS factors in the government sectors with the CAS. The study also suggests that content, accuracy, format, ease of use, timeliness, satisfaction with system speed and system reliability must be emphasized to the standardized CAS. However, software developers must emphasize the user friendly and usability of the system which might generate better output especially in terms of accuracy of the content.

The finding of this study is preliminary and shall not be generalized to the other government sectors. This is due to the different in the adoption of the information technology and CAS especially in information system usage. Besides, the number of the sample is relatively small. The small sample size is limited only 90 end-users of CAS. This small sample size may be jeopardizing the population of the end user among the government sectors. The aspect of time also affected the data collection method; i.e., by using questionnaire. A respondent who is not particularly interested in answering the questionnaire is more likely interspersed to answer the question. This is because some of them are very busy with their tasks and duties. As a result, they did not answer the questionnaire genuinely.

The future study can propose the other data collection method such as in depth interview with the end user computing. In this study, questionnaire has been used to collect the data through owing to the fact that financial and time are of the essence. The sample size should also be increased. A larger sample size would be required to ensure that the generalisation ability of research. The future research should also consider the type of software, whether the department purchases or develops the system. It is essential to measure the different perception on the overall EUCS among these two types of the system since the end users are expected to have a different level of satisfaction.

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Notes

Table 1. Reliability Analysis

Variable	Alpha (Coefficient)	Alpha (Coefficient)	Alpha (Coefficient)	Alpha (Coefficient)
	Current study	Doll and Torkzadeh (1988)	Chin and Lee (2000)	Amdan et al. (2006)
Satisfaction (DV)	0.771	-	-	0.8550
Content	0.918	0.89	-	0.9243
Accuracy	0.875	0.91	-	0.8834
Format	0.927	0.78	-	0.9256
Ease of Use	0.927	0.85	-	0.8912
Timeliness	0.751	0.82	-	0.8711
System Speed	0.800	-	0.72	0.9126
System Reliability	0.759	-	-	0.7204

Table 2. Descriptive Analysis

N	Minimum	Maximum		Mean	Std. Deviation
Content	90	2.33	5.00	3.76	.58
Accuracy	90	2.43	5.00	3.55	.59
Format	90	2.43	5.00	3.69	.68
Ease of Use	90	2.14	5.00	3.60	.69
Timeliness	90	2.50	5.00	3.34	.59
System Speed	90	2.33	4.83	3.48	.56
System Reliability	90	2.29	4.71	3.49	.57
Satisfaction (Dependent Variable)	90	2.14	5.00	3.61	.63
Valid N (listwise)			90		

Table 3. Model Summary

Model	R	R Square	Adjusted R Square
1	.922	.850	.838

a. Predictors: (Constant), System reliability, Timeliness, Format, Accuracy, Content, Ease of Use and System Speed

b. Dependent Variable: Satisfaction

Table 4. ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	30.274	7	4.325	66.564	.000
	Residual	5.328	82	.065		
	Total	35.602	89			

a. Predictors: (Constant), System reliability, Timeliness, Format, Accuracy, Content, Ease of Use and System Speed

b. Dependent Variable: Satisfaction

Table 5. Coefficients between EUCS factors and end-users' satisfaction towards Computerised Accounting System (CAS)

Model		Standardized Coefficients Beta	t	Sig.
1	(Constant)		-1.991	.050
	EASE	.280**	3.501	.001
	CONTENT	.216**	2.702	.008
	ACCURACY	.183**	2.088	.040
	TIME	.105	1.740	.086
	SPEED	.125	1.538	.128
	RELIABLE	.095	1.392	.168
	FORMAT	.087	1.120	.266

a. Dependent Variable: Satisfaction

** Significant at the 0.05 level (2-tailed).

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Layer Model and Algorithm of Organization Authorization Based on Position Network

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Abstract

After the RBAC model formalized in 1992 by David Ferraiolo and Rick Kuhn, the models of organization authorization have been developing fast. Among these models, the one based on position network will be used widely and has a prospective future. Algorithms for single-layer model and multi-layer model based on position network were cited in this article. Meanwhile an algorithm example was given at the end of this article.

Keywords: Position, Network, Organization, Authorization, Layer, Model, Algorithm

1. Preface

In modern complex government systems, there are too many roles to be setup and provided to the users. If the duties or privileges of users are changed, or the objects in system are changed, it will take lots of time to adjust the relationship of User-Role and Role-Object. The integration of different government application systems has been affected by this bottleneck. For improving the efficiency and security and reducing the workload of system maintenances, “Position” was added between the “User” and “Role”. This makes it more close to the reality of Chinese government.

After turning this into reality, we found that a straight and effective algorithm was needed to evaluate the rationality of the authorization process, make sure the strictness, and find out the problems. So the single-layer model algorithm and multi-layer model algorithm for organization were put forward.

2. Algorithm for Organization Authorization System

We can easily connect the users, positions, roles and objects in different systems with network model. Show as figure 1.

How to look at the connection clearly and check out whether it is right? We need to setup a kind of model system to evaluate the feasibility of the connection.

According to the relationship of the "user" ontology, the "users" in the e-government systems have the character of social network. Meanwhile the "position" ontology also has the same character. For making the description and expression of the character clearly, we describe the algorithm as follows.

2.1 Single-layer Model Algorithm for organization authorization system

Because of the complexity of the government, the mapping of user ontology and position ontology is not one-to-one. It is multi-mapping. Show as figure 2.

Define a set of user ontology:

$\{user_1, user_2, ..., user_m\}$, recorded as vector $U = [user_1, user_2, ..., user_m]^T$;

Define a set of position ontology:

$\{pos_1, pos_2, ..., pos_n\}$, record as vector $P = [pos_1, pos_2, ..., pos_n]^T$;

We record the relationship $user_m \to pos_n$ of $user_m$ and pos_n as u_{mn}, and describe it with the form $U \cdot P^T$:

$$U \cdot P^T = \begin{bmatrix} user_1 \\ user_2 \\ ..... \\ user_m \end{bmatrix} \cdot [pos_1, pos_2, ..., pos_n]$$

$$= \begin{bmatrix} user_1 pos_1 & user_1 pos_2 & ..... & user_1 pos_n \\ user_2 pos_1 & user_2 pos_2 & ..... & user_2 pos_n \\ ..... & ..... & ..... & ..... \\ user_m pos_1 & user_m pos_2 & ..... & user_m pos_n \end{bmatrix} = \begin{bmatrix} u_{11} & u_{12} & ..... & u_{1n} \\ u_{21} & u_{22} & ..... & u_{2n} \\ ..... & ..... & ..... & ..... \\ u_{m1} & u_{m2} & ..... & u_{mn} \end{bmatrix}$$

Shorten the $U \cdot P^T$ as U_P, then we get: $U_P = [u_{mn}]_{m \times n}$.s

Especially, under this structure, if the only aim is to show the connection of $user_m$ and pos_n, we can use 0 and 1 to realize it.

If $user_m$ has no right to access pos_n, $user_m \to pos_n = 0$, record as $u_{mn} = 0$;

If $user_m$ has the right to access pos_n, $user_m \to pos_n = 1$, record as $u_{mn} = 1$.

If so, we can get a matrix like $\begin{bmatrix} 1 & 0 & ..... & 1 \\ 1 & 1 & ..... & 0 \\ ..... & ..... & ..... & ..... \\ 0 & 0 & ..... & 1 \end{bmatrix}$, which is formed only with 0 and1.

For keeping consistence with traditional $RBAC$ model, the roles in the organization authorization system still have the definitions and attributes as in $RBAC$ model. And also the roles can be formed as layer structure. It is multi-mapping between the positions and roles. Show as figure 3.

Define a set of role ontology:

$\{rol_1, rol_2, ..., rol_i\}$, record as vector $R = [rol_1, rol_2, ..., rol_i]^T$;

We record the mapping $pos_n \to rol_i$ between pos_n and rol_i as p_{ni}. We describe the mapping with the form of $P \cdot R^T$:

$$P \cdot R^T = \begin{bmatrix} pos_1 \\ pos_2 \\ ..... \\ pos_n \end{bmatrix} \cdot [rol_1, rol_2, ..., rol_i]$$

$$= \begin{bmatrix} pos_1 rol_1 & pos_1 rol_2 & ..... & pos_1 rol_i \\ pos_2 rol_1 & pos_2 rol_2 & ..... & pos_2 rol_i \\ ..... & ..... & ..... & ..... \\ pos_n rol_1 & pos_n rol_2 & ..... & pos_n rol_i \end{bmatrix} = \begin{bmatrix} p_{11} & p_{12} & ..... & p_{1i} \\ p_{21} & p_{22} & ..... & p_{2i} \\ ..... & ..... & ..... & ..... \\ p_{n1} & p_{n2} & ..... & p_{ni} \end{bmatrix}$$

Shorten $P \cdot R^T$ for P_R, then: $P_R = [p_{ni}]_{n \times i}$.

We still use the descriptions for roles and operations in $RBAC$ model, and setup multi-mapping for them. By allowing this, the workload for distributing the system function is reduced a lot. Show as figure 4.

We define a set of operation:

$\{oper_1, oper_2, ..., oper_j\}$, record as vector $O = [oper_1, oper_2, ..., oper_j]^T$;

We record the mapping $rol_i \to oper_j$ of rol_i and $oper_j$ as r_{ij}, and record it as the form of $R \cdot O^T$:

$$R \cdot O^T = \begin{bmatrix} rol_1 \\ rol_2 \\ ..... \\ rol_i \end{bmatrix} \cdot [oper_1, oper_2, ..., oper_j]$$

$$= \begin{bmatrix} rol_1 oper_1 & rol_1 oper_2 & ..... & rol_1 oper_j \\ rol_2 oper_1 & rol_2 oper_2 & ..... & rol_2 oper_j \\ ..... & ..... & ..... & ..... \\ rol_i oper_1 & rol_i oper_2 & ..... & rol_i oper_j \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & ..... & r_{1j} \\ r_{21} & r_{22} & ..... & r_{2j} \\ ..... & ..... & ..... & ..... \\ r_{i1} & r_{i2} & ..... & r_{ij} \end{bmatrix}$$

Shorten $R \cdot O^T$ for R_O, then: $R_O = [r_{ij}]_{i \times j}$.

By the matrix of the mapping of "User-Position", "Position-Role" and "Role-Operation", we can get the $m \times j$ matrix T for single layer organization authorization. With T, the relationship of different parts in the system can be found out easily.

$$T = U_P \cdot P_R \cdot R_O$$

$$= [u_{mn}]_{m \times n} \cdot [p_{ni}]_{n \times i} \cdot [r_{ij}]_{i \times j}$$

$$= \begin{bmatrix} u_{11} & u_{12} & ..... & u_{1n} \\ u_{21} & u_{22} & ..... & u_{2n} \\ ..... & ..... & ..... & ..... \\ u_{m1} & u_{m2} & ..... & u_{mn} \end{bmatrix} \cdot \begin{bmatrix} p_{11} & p_{12} & ..... & p_{1i} \\ p_{21} & p_{22} & ..... & p_{2i} \\ ..... & ..... & ..... & ..... \\ p_{n1} & p_{n2} & ..... & p_{ni} \end{bmatrix} \cdot \begin{bmatrix} r_{11} & r_{12} & ..... & r_{1j} \\ r_{21} & r_{22} & ..... & r_{2j} \\ ..... & ..... & ..... & ..... \\ r_{i1} & r_{i2} & ..... & r_{ij} \end{bmatrix}$$

We record t_{mj} as the elements in T, and t_{mj} is the mapping of users and operations. So we get *Single-layer Model Algorithm for Organization Authorization System*:

$$T = [u_{mn}]_{m \times n} \cdot [p_{ni}]_{n \times i} \cdot [r_{ij}]_{i \times j} = [t_{mj}]_{m \times j}$$

If $t_{mj} \neq 0$, it shows that the user m has the right to get the operation j; if $t_{mj} = 0$, it shows that the user m has no right to get the operation j. From this matrix T, all the operations that each user can get are shown clearly. This can help the system administrator check the rationality of each user, and enhance the reliability of the whole system.

From the above process, $\begin{bmatrix} u_{11} & u_{12} & ..... & u_{1n} \\ u_{21} & u_{22} & ..... & u_{2n} \\ ..... & ..... & ..... & ..... \\ u_{m1} & u_{m2} & ..... & u_{mn} \end{bmatrix} \cdot \begin{bmatrix} p_{11} & p_{12} & ..... & p_{1i} \\ p_{21} & p_{22} & ..... & p_{2i} \\ ..... & ..... & ..... & ..... \\ p_{n1} & p_{n2} & ..... & p_{ni} \end{bmatrix}$ shows the relationship between users and positions, recorded as: $U_R = [u_{mn}]_{m \times n} \cdot [p_{ni}]_{n \times i}$;

And $\begin{bmatrix} p_{11} & p_{12} & ..... & p_{1i} \\ p_{21} & p_{22} & ..... & p_{2i} \\ ..... & ..... & ..... & ..... \\ p_{n1} & p_{n2} & ..... & p_{ni} \end{bmatrix} . \begin{bmatrix} r_{11} & r_{12} & ..... & r_{1j} \\ r_{21} & r_{22} & ..... & r_{2j} \\ ..... & ..... & ..... & ..... \\ r_{i1} & r_{i2} & ..... & r_{ij} \end{bmatrix}$ shows the relationship between positions and roles, recorded as: $P_O = [p_{ni}]_{n\times i} \cdot [r_{ij}]_{i\times j}$.

U_R and P_O are very helpful in the application of checking the middle layer mapping in organization authorization system.

2.2 Multi-layer Model Algorithm for organization authorization system

In the practice of government, a structure like pyramid has been formed between different layers and sections. And this caused that the same structure has been used in the former constructed systems. And also there are lots of "pyramid" structures in positions.

Meanwhile for the easy configuration of organization authorization system, the "pyramid" structures were formed between roles in many systems based on $RBAC$.

Because of the multi-layer structures, we need to expand the single-layer model for further detection to verify the authorization process.

For the multi-layer, we add a column vector between each two layers. Each column vector consists of the mapping of the elements of the two layers.

As to the multi-layer structure of positions, if the number of positions is n, and they have been divided into t layers, we describe each position as pos, and show the abstract description as figure 5.

We describe the whole position set as $\begin{bmatrix} pos_1\ pos_1\ .....\ pos_1 \\ pos_2\ pos_2\ .....\ pos_2 \\ .....\ .....\ .....\ ..... \\ pos_n\ pos_n\ .....\ pos_n \end{bmatrix}_{n\times t}$, and describe the layer l as $p_l = \begin{bmatrix} pos_1 \\ pos_2 \\ ..... \\ pos_n \end{bmatrix}, l \in [1,t]$; if there are t layers, we can get t vectors.

We get the relationship of layer l and layer $l+1$ with the multiplication of column vector l and the transpose of column vector $l+1$, and record it as $\hat{p}_{l(l+1)}$:

$$\hat{p}_{l,l+1} = \begin{bmatrix} pos_1 \\ pos_2 \\ ..... \\ pos_n \end{bmatrix} \cdot [pos_1, pos_2, ..., pos_n] = \begin{bmatrix} pos_1pos_1 & pos_1pos_2 & ..... & pos_1pos_n \\ pos_2pos_1 & pos_2pos_2 & ..... & pos_2pos_n \\ ..... & ..... & ..... & ..... \\ pos_npos_1 & pos_npos_2 & ..... & pos_npos_n \end{bmatrix}_{n\times n}$$

When pos_i has some kind of relationship with pos_k, we record the value of $pos_ipos_k, i,k \in [1,n]$ as 1. If there is no relationship, we record it as 0. So we can get a $n\times n$ matrix which only consists of 0 and 1. Suppose there are t layers in position structure, we can get $t-1$ $n\times n$ matrices in total. Record them as $\hat{p}_{12}, \hat{p}_{23}, ..., \hat{p}_{(t-1)t}$. Multiply these $t-1$ $n\times n$ matrices one by one, we can get the whole position structure matrix $\hat{P}$:

$$\hat{P} = \prod_{l=1}^{t-1} \hat{p}_{l(l+1)}, (l, n \in N, t: \textit{total}\ \text{layers of positions})$$

For the roles with abstract layer structure, figure 6 gives an example.

We use $\hat{r}_{k(k+1)}$ to describe the mapping matrix between the two nearby role layers, then we can get the whole role

structure matrix $\hat{R}$:

$$\hat{R} = \prod_{k=1}^{h-1} \hat{r}_{k(k+1)}, (k, h \in N, h : total \text{ layers of roles})$$

The organization authorization system structure with multi-layer positions and roles shows in figure 7.

When getting the position structure matrix and role structure matrix, we can get the *Multi-layer Model Algorithm for Organization Authorization System*:

$$T = U_P \cdot \hat{P} \cdot P_R \cdot \hat{R} \cdot R_O = [u_{mn}]_{m \times n} \cdot \prod_{l=1}^{t-1} \hat{p}_{l(l+1)} \cdot [p_{ni}]_{n \times i} \cdot \prod_{k=1}^{h-1} \hat{r}_{k(k+1)} \cdot [r_{ij}]_{i \times j}$$

$(l, t, h \in N, t : total \text{ layers of positions}, h : total \text{ layers of roles})$

3. Example for Single-layer Model Algorithm

For a given existing organization authorization system, we analyze its internal relationship between users, positions, roles and operations.

Figure 8 shows the mapping between users and positions.

We get:

$$U_P = [u_{mn}]_{m \times n} = \begin{bmatrix} u_{11} & u_{12} & u_{13} & u_{14} & u_{15} \\ u_{21} & u_{22} & u_{23} & u_{24} & u_{25} \\ u_{31} & u_{32} & u_{33} & u_{34} & u_{35} \\ u_{41} & u_{42} & u_{43} & u_{44} & u_{45} \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix};$$

Figure 9 shows the mapping between positions and roles:

We get:

$$P_R = [p_{ni}]_{n \times i} = \begin{bmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \\ p_{41} & p_{42} & p_{43} \\ p_{51} & p_{52} & p_{53} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix};$$

Figure 10 shows the mapping between roles and operations:

We get:

$$R_O = [r_{ij}]_{i \times j} = \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} & r_{15} \\ r_{21} & r_{22} & r_{23} & r_{24} & r_{25} \\ r_{31} & r_{32} & r_{33} & r_{34} & r_{35} \end{bmatrix} = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 \end{bmatrix};$$

The whole system mapping is shown in figure 11.

From $U_R = [u_{mn}]_{m \times n} \cdot [p_{ni}]_{n \times i}$ we get:

$$U_R = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 3 & 2 & 1 \\ 2 & 3 & 2 \\ 1 & 2 & 3 \\ 0 & 0 & 1 \end{bmatrix};$$

From $P_O = [p_{ni}]_{n \times i} \cdot [r_{ij}]_{i \times j}$ we get:

$$P_O = \begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 0 & 0 & 0 \\ 1 & 2 & 1 & 0 & 0 \\ 1 & 2 & 2 & 1 & 1 \\ 0 & 1 & 2 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 \end{bmatrix};$$

From $T = [u_{mn}]_{m \times n} \cdot [p_{ni}]_{n \times i} \cdot [r_{ij}]_{i \times j}$ we get:

$$T = \begin{bmatrix} 1 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 \end{bmatrix} = \begin{bmatrix} 3 & 5 & 3 & 1 & 1 \\ 2 & 5 & 5 & 2 & 2 \\ 1 & 3 & 5 & 3 & 3 \\ 0 & 0 & 1 & 1 & 1 \end{bmatrix};$$

Now we can get the conclusion from the above calculation results:

From the mapping U_R, the relationship of users and roles, we can see that there are 3 paths for “user 1” to access “role 1”, 3 paths for “user 2” to access “role 2”, 3 paths for “user 3” to access “role 3”, and only 1 path for “user 4” to access “role 4”. Among these users, user 1, 2, 3 get full the rights to access all the roles, but user 4 does not.

From the mapping P_O, we can see that “position 1” can only access two operations, but “position 3” can get the right to access all the operations in the system.

From the mapping T, there are 5 paths for user 1, user 2 and user 3 to get operation 2 and operation 3. Obviously the authorization process was duplicated, and threatened to the safety of the system. If some user has more than 1 path to get an operation, when someday the system administrator changes the configuration of the system and bans one path of the user, the user can still access the operation through other paths. This can cause some uncertainty of the system.

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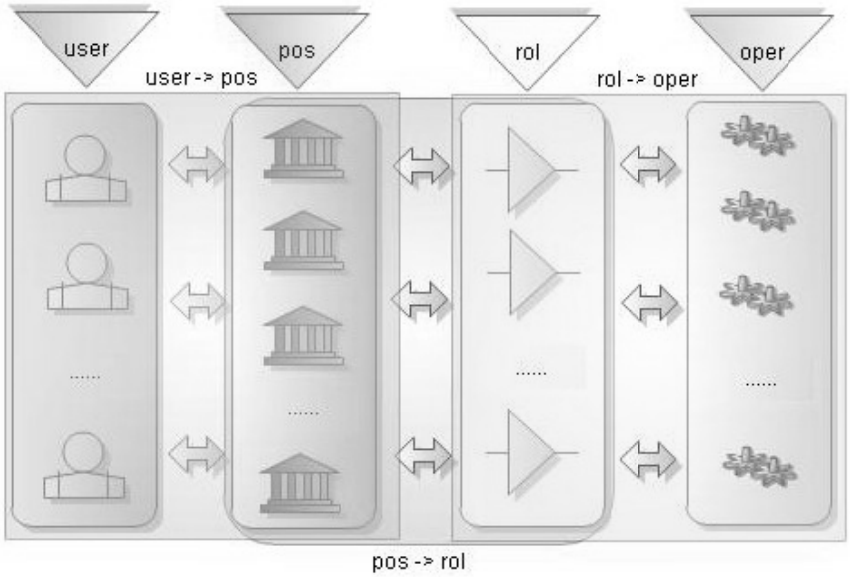

Figure 1. User-Position-Role-Operation Model

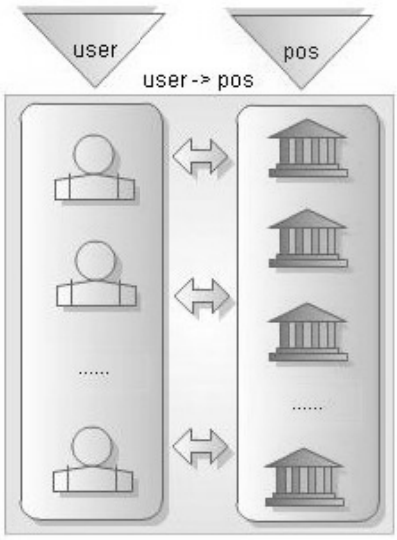

Figure 2. User-Position Mapping

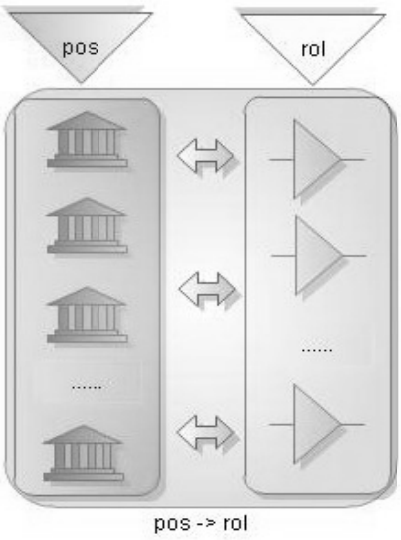

Figure 3. Position-Role Mapping

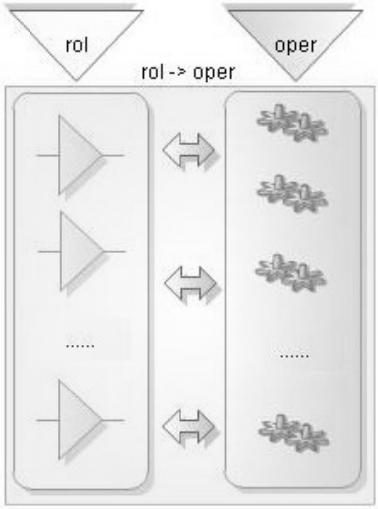

Figure 4. Role-Operation Mapping

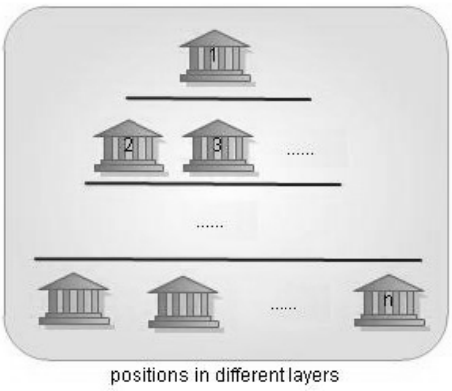

Figure 5. Positions Layers

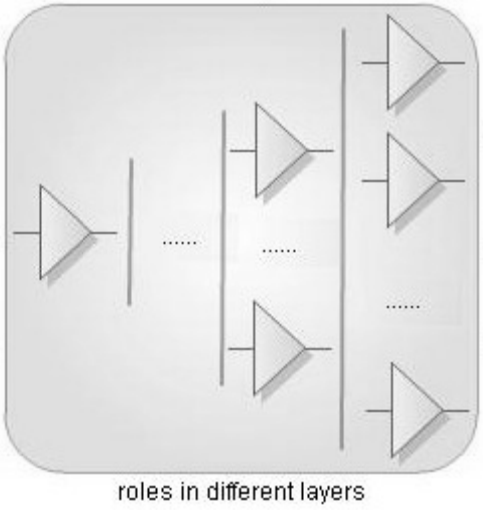

Figure 6. Roles Layers

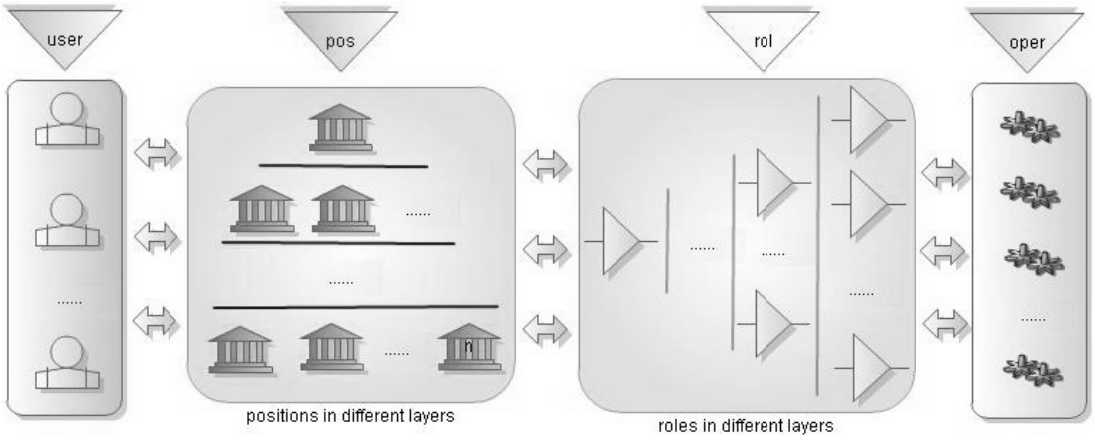

Figure 7. Complex Organization Authorization System Model Based on Positions and Roles

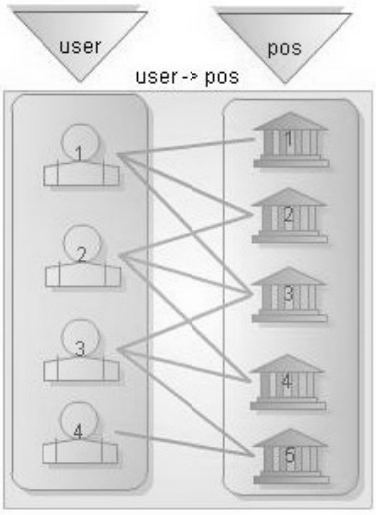

Figure 8. User-Position Mapping

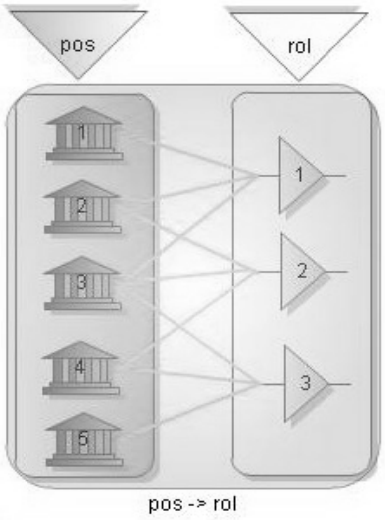

Figure 9. Position-Role Mapping

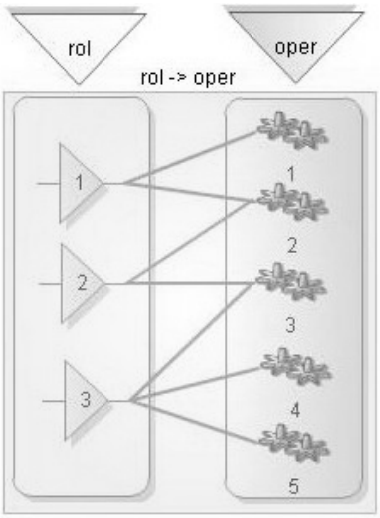

Figure 10. Role-Operation Mapping

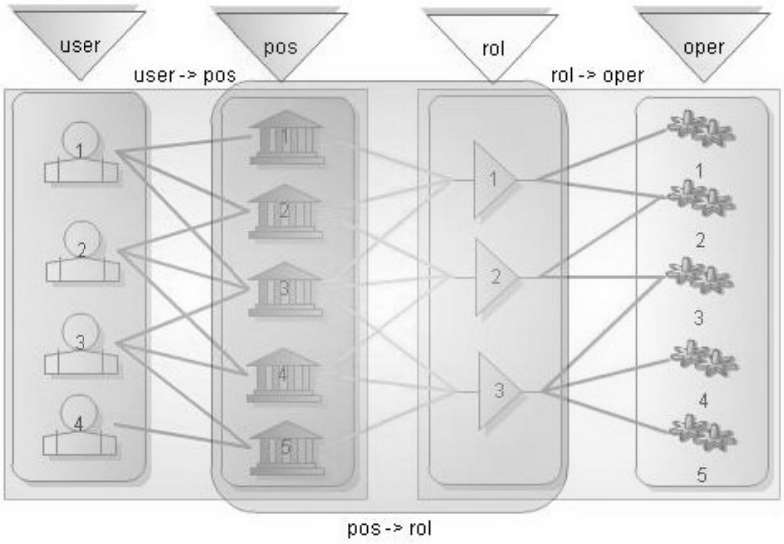

Figure 11. Relationship in Organization Authorization Process

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Chi-Square Test for Anomaly Detection in XML Documents Using Negative Association Rules

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Abstract

Anomaly detection is the double purpose of discovering interesting exceptions and identifying incorrect data in huge amounts of data. Since anomalies are rare events, which violate the frequent relationships among data. Normally anomaly detection builds models of normal behavior and automatically detects significant deviations from it. The proposed system detects the anomalies in nested XML documents by independency between data. The negative association rules and the chi-square test for independency are applied on the data and a model of abnormal behavior is built as a signature profile. This signature profile can be used to identify the anomalies in the system. The proposed system limits the unnecessary rules for detecting anomalies.

Keywords: Anomaly detection, Chi-square test, Negative association rule, XML

1. Introduction

XML is a simplified subset of the Standard Generalized Markup Language (SGML). It provides a file format for representing data, a schema for describing data structure, and a mechanism for extending and annotating Hyper-Text Markup Language (HTML) with semantic information. The XML data model carries both data and schema information, being naturally suitable to represent semi-structured data. It is a standard for representing and exchanging information on the Internet.

XML is a markup language for structured documentation. Structured documents are documents that contain both content and some indication of what role that content plays. Almost all documents have some structure. A markup language is a mechanism to identify structures in a document. The XML specification defines a standard way of adding markup to documents. Information marked up as XML data is becoming increasingly persistent that allow data to be imported, accessed and exported in the XML format. XML database may prove more efficient and easier to store the data in XML format. As XML document storage formats become popular, the task of detecting anomalies within XML document collections becomes more important.

Deviation from the normal or common order or form or rule or deviation from the normal standard, especially as a result of congenital defects is called anomaly or outlier. Otherwise (Jiawei Han, Micheline Kamber. 2004.) very often, there exist data objects that do not comply with the general behavior or model of the data. Such data objects, which are grossly different from or inconsistent with the remaining set of data, are called outliers or anomaly. Due to anomalies, data may be inconsistent. Since anomalies are rare event which violate the frequent relationships among data. Anomaly Detection may refer to an unsupervised data mining technique that produces a data mining model for identifying cases (records) that deviate from the norm in a dataset. The general step for anomaly detection schemes is

Build a profile of the abnormal behavior. Profile can be patterns or summary statistics for the overall population (Dataset)

Use the abnormal profile to detect anomalies. Anomalies are observations whose characteristics agree significantly with the abnormal profile

2. XML Documents

Extensible Markup Language (XML) is a simple, very flexible text format derived from SGML. Originally designed to meet the challenges of large-scale electronic publishing, XML is also playing an increasingly important role in the exchange of a wide variety of data on the Web and elsewhere. In the real world, computer systems and databases contain data in incompatible formats. XML data is stored in plain text format. This provides a software- and hardware-independent way of storing data. This makes it much easier to create data that different applications can share. With XML, data can easily be exchanged between incompatible systems. One of the most time-consuming challenges for developers is to exchange data between incompatible systems over the Internet. Exchanging data as XML greatly reduces this complexity, since the data can be read by different incompatible applications.

XML documents must contain a root element. This element is the parent of all other elements. The elements in an XML document form a document tree. The tree starts at the root and branches to the lowest level of the tree. All elements can have sub elements (child elements):

<root>

<child>

<subchild>.....</subchild>

</child>

</root>

The terms parent, child, and sibling are used to describe the relationships between elements. Parent elements have children. Children on the same level are called siblings (brothers or sisters). All elements can have text content and attributes. Fig 1 shows the sample XML document.

The root element in the example is <bookstore>. All <book> elements in the document are contained within <bookstore>. The <book> element has 4 children: <title>,< author>, <year>, <price>.

3. Association Rule Mining

The definition by Agrawal et al (R. Agrawal, T. Imielinski & A. Swami. *1993.*) the problem of association rule mining is defined as: Let $I = \{i_1, i_2, \ldots, i_n\}$ be a set of *n* binary attributes called *items*. Let $D = \{t_1, t_2, \ldots, t_m\}$ be a set of transactions called the *database*. Each transaction in *D* has a unique transaction ID and contains a subset of the items in *I*. A *rule* is defined as an implication of the form $X \Rightarrow Y$ where $X, Y \subseteq I$ and $X \cap Y = \emptyset$. The sets of items *X* and *Y* are called *antecedent* (left-hand-side) and *consequent* (right-hand-side) of the rule.

To select interesting rules from the set of all possible rules, constraints on various measures of significance and interest can be used. The best-known constraints are minimum thresholds on support and confidence. The *support* supp(*X*) of an itemset *X* is defined as the proportion of transactions in the data set which contain the itemset. The *confidence* of a rule is defined

$$\text{conf}(X \Rightarrow Y) = \text{supp}(X \cup Y)/\text{supp}(X).$$

Confidence can be interpreted as an estimate of the probability $P(Y \mid X)$, the probability of finding the RHS of the rule in transactions under the condition that these transactions also contain the LHS

The interestingness of an association rule can be defined in terms of the measure associated with it, as well as in the form an association can be found. The most common framework in the association rules generation is the "support-confidence" one. Although these two parameters allow the pruning of many associations that are discovered in data, there are cases when many uninteresting rules may be produced. The measure interest is used to discover interesting rules.

$$\text{Interest}(X, Y) = \text{Support}(X \cup Y) - \text{Support}(X).\text{Support}(Y)$$

4. Chi-Square Test

Generally speaking, the chi-square test is a statistical test (Glenn A. Walker.) used to examine differences with categorical variables. There are a number of features of the social world we characterize through categorical variables - religion, political preference, etc. To examine hypotheses using such variables, use the chi-square test.

The chi-square test is used in two similar but distinct circumstances:

For estimating how closely an observed distribution matches an expected distribution - we'll refer to this as the goodness-of-fit test

For estimating whether two random variables are independent.

4.1 Goodness-of -fit test

The chi-square test is a "goodness of fit" test: it answers the question of how well do experimental data fit expectations. The chi-square test of independence can be used for any variable; the group (independent) and the test variable (dependent) can be nominal, ordinal, or grouped interval.

The following algorithm illustrates calculating a goodness-of-fit test with chi-square:

1) Establish hypotheses.

2) Calculate chi-square statistic. Doing so requires knowing:

The number of observations

Expected values

Observed values

3) Assess significance level. Doing so requires knowing the number of degrees of freedom.

4) Finally, decide whether to accept or reject the null hypothesis.

4.2 Testing Independence

The other primary use of the chi-square test is to examine whether two variables are independent or not. What does it mean to be independent, in this sense? It means that the two factors are not related. Typically in social science research, we're interested in finding factors that are related - education and income, occupation and prestige, age and voting behavior. In this case, the chi- square can be used to assess whether two variables are independent or not. More generally, we say that variable Y is "not correlated with" or "independent of" the variable X if more of one is not associated with more of another. If two categorical variables are correlated their values tend to move together, either in the same direction or in the opposite.

5. Anomaly detection in XML documents

The system is based on rules that define signatures and it detects anomalies that fall in abnormal signature profile. Fig 1 shows the anomaly detection in XML documents.

5.1 Two-dimensional (2-D) representation of XML documents

An XML document is defined (Jong P. Yoon, Vijay Raghavan, Venu Chakilam. 2001.) as a sequence of elementary paths with associated element contents. An elementary path is a sequence of nested elements where the most nested element is simple content element. In a two-dimensional representation of XML documents a row represents an XML document and column represents an elementary paths. Fig 2 and 3 show the sample mushroom XML document and 2-D representation of XML document

In the above example the elementary paths are

ep1 = <Mushroom><Cap><Shape>

ep2 = <Mushroom><Cap><Surface>

ep3 = <Mushroom><Cap><Color>

ep3 = <Mushroom><Brusises>

ep4 = <Mushroom><Odor>

ep5 = <Mushroom><Gill><Attachment> etc.,

5.2 Mining Negative Association rules

There are rules that imply negative relationships such rules are called Negative Association Rules. A negative association rule (Xindong wu, Shichao zhang. 2004.) also describes relationships between item sets and implies the occurrence of some item sets characterized by the absence of others. To eliminate unwanted rules and focus on potential interesting ones, the system predict possible interesting negative association rules by incorporating domain knowledge of the data sets. The negative association rule can be written in the form X→¬Y, ¬X→Y, , where X and Y are itemsets.

Measures for X→¬Y

$$\text{Support}(X \rightarrow \text{not } Y) = \text{support}(X) - \text{support}(X \rightarrow Y)$$

$$\text{Confidence}(X \rightarrow \text{not } Y) = 1 - \text{conf}(X \rightarrow Y)$$

$$\text{Interest}(X, \text{not } Y) = \text{Support}(X \cup \text{not } Y) - \text{Support}(X).\text{Support}(\text{not } Y)$$

$$\text{CPIR}(\text{not } Y/X) = \frac{\text{Support}(X \cup not Y) - \text{Support}(X).\text{Support}(\text{not } Y)}{\text{Support}(X)(1 - \text{Support}(\text{not } Y))}$$

Measures for ¬X →Y

$$\text{Support}(\text{not } X \rightarrow Y) = \text{support}(Y) - \text{support}(Y \rightarrow X)$$

$$\text{Confidence}(\text{not } X \rightarrow Y) = 1 - \text{conf}(Y \rightarrow X)$$

$$\text{Interest}(\text{not } X, Y) = \text{Support}(\text{not } X \cup Y) - \text{Support}(\text{not } X).\text{Support}(Y)$$

Interesting Negative Rule $\text{CPIR}(Y/_{\text{not } X}) = \dfrac{\text{Support}(\text{not } X \cup Y) - \text{Support}(\text{not } X).\text{Support}(Y)}{\text{Support}(\text{not } X)(1 - \text{Support}(Y))}$

if $\text{Support}(X \cup \text{not } Y) \geq \text{ms}$ and $\text{Support}(X) \geq \text{ms}$ and $\text{Support}(Y) \geq \text{ms}$ and

$\text{Interest}(X, \text{not } Y) \geq \text{mi}$ and $\text{CPIR}(\textit{not } Y/_{X}) \geq \text{mc}$

then $X \rightarrow \text{not } Y$

Interesting Negative Rules for ¬X →Y

if $\text{Support}(X \cup \text{not } Y) \geq \text{ms}$ and $\text{Support}(Y) \geq \text{ms}$ and support(x) ≥ m

$\text{Interest}(\text{not } X, Y) \geq \text{mi}$ and $\text{CPIR}(Y/_{\textit{not} X}) \geq \text{mc}$

then $\text{not } X \rightarrow Y$

ms – minimum support threshold and mc – minimum confidence threshold

From the above measures interesting negative association rules are identified and these antecedents and consequents are applied for chi-square test to identify the independency.

5.3 Chi-Square test

Chi-square test is a statistical test to verify the independence between two variables. Using Chi-square test, independency between the two variables are identified by finding contingency tables and expected frequencies

The following is a contingency table, a tabular representation of a rule.

R1 and R2 represent the Boolean states of an antecedent for the conclusions C1 and C2. The X11, X12, X21, X22 represent the frequencies of each antecedent-consequent pair. The R1T, R2T, CT1, CT2 are the marginal sums of the rows and columns, respectively.

5.3.1 Calculating Chi-square:

1) Calculate and fix the sizes of the marginal sums,

2) Calculate the total frequency, T, using the marginal sums.

3) Calculate the expected frequencies for each cell

Formula:

$$eij = \sum \frac{(R_{ij} - C_{Tj})^2}{T}$$

Where C_{Tj} and R_{ij} are the row total for i[th] row and the column total for j[th] column.

4) Select the test to be used to calculate χ^2 based on the highest expected frequency, m.

5) Calculate χ^2 using the chosen test.

6) Calculate the degrees of freedom. df=(r-1)(c-1)

A critical factor in using the chi-square test is the "degrees of freedom", which is essentially the number of independent random variables involved.

7) Use a chi-square table with χ^2 and df to determine if the conclusions are independent from the antecedent at the selected level of significance

8) For the selected level of significance α

if $\chi^2 > \chi^2_\alpha$

Reject the null hypothesis of independence

else

Accept the null hypothesis of independence

5.4 Signature generation

From the chi-square test the strongly independent attributes are identified and are stored in the form of XML file as a signature profile. For example

<cap_shape:b>→ ⌉<cap_surface:r>

(support=20% CPIR=70% interest=50%>

For the above negative association rule the abnormal profile in XML format is shown in fig 4

Using XQUERY the test data is checked with abnormal signature profile for detecting anomalies.

Fig 5 shows the proposed system model.

6. Discussion and Experiment Results

Giulia et al (Giulia Bruno, Paolo Garza, Elisa Quintarelli, Rosalba Rossato. 2007.) identifies the anomalies in simple nested XML documents using quasi-functional dependencies and association rule The system query the original datasets to extract the instances that violate the dependences and for each quasi-functional dependency relating the sets X and Y query all the stored association rules that involve X c and Y, with a low confidence (i.e., with a confidence lower than a fixed threshold).

Proposed system identifies anomalies using negative association rules and enhanced with chi-square test. The anomalies are identified whose confidence value is grater than minimum confidence threshold in negative association rule which is improved with chi-square test.

The proposed system uses XML Mushroom data set includes 8124 hypothetical samples corresponding to 23 species of gilled mushrooms. Table 2,3 & 4 show the number of rules generated by the proposed system. The number of rules generated by the system is low because the uninteresting rules are filtered by interesting measure and chi-square independence test. The anomalies are identified between two attribute levels.

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Xindong wu, Shichao zhang. (2004). 'Efficient Mining of Both Positive and Negative Association Rules', ACM Transactions on Information Systems, Vol. 22, No. 3.

Table 1. Contingency Tables

	C1	C2	Marginal Sums
R1	X11	X12	R1T=X11+X12
R2	X21	X22	R2T=X21+X22
Marginal Sums	CT1=X11+X21	CT2=X12+X22	T=X11+X12+ X21+X22

Table 2. Number of rules generated at minimum support =0.2

Minimum Confidence	**Positive Association rule (Confidence < mc)**	**Interesting Negative Association rule (Confidence > mc)**
0.6	333	66
0.7	409	50
0.8	460	43
0.9	513	32

Table 3. Number of rules generated at minimum support =0.3

Minimum Confidence	**Positive Association rule (Confidence < mc)**	**Interesting Negative Association rule (Confidence > mc)**
0.6	92	47
0.7	137	34
0.8	162	29
0.9	191	24

Table 4. Number of rules generated at minimum support Level=0.4

Minimum Confidence	**Positive Association rule (Confidence < mc)**	**Interesting Negative Association rule (Confidence > mc)**
0.6	48	0
0.7	70	25
0.8	82	24
0.9	100	21

```
<bookstore>
<book>
<category="COOKING">
<title lang="en">Everyday Italian</title>
<author>Giada De Laurentiis</author>
<year>2005</year>
<price>30.00</price>
</book>
<book>
<category="CHILDREN">
<title lang="en">Harry Potter</title>
<author>J K. Rowling</author>
<year>2005</year>
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</book>
<book>
<category="WEB">
<title lang="en">Learning XML</title>
<author>Erik T. Ray</author>
<year>2003</year>
<price>39.95</price>
</book>
                </bookstore>
```

Figure 1. Sample XML document

```
<Mushroom>
        <Cap>
                <Shape>convex</Shape>
                <Surface>smooth</Surface>
                <Color>brown</Color>
        </Cap>
        <Bruises>bruises</Bruises>
        <Odor>pungent</Odor>
        <Gill>
                <Attachment>free</Attachment>
                <Spacing>close</Spacing>
                <Size>narrow</Size>
                <Color>black</Color>
        </Gill>
        :
        :
</Mushroom>
```

Figure 2. Sample mushroom document

	ep1	ep2	ep3	ep4	ep5	ep6															ep23
D1	c	s	b	b	p	f															

Figure 3. 2-D representation of Mushroom document

<Nrule support = 20% CPIR = 70% interest=50%>
<antecedent>

<cap_shape>b</cap_shape>
</antecedent>
<consequent>

<cap_surface>r</cap_surface>
</consequent>
</Nrule>

Figure 4. Format of abnormal signature profile

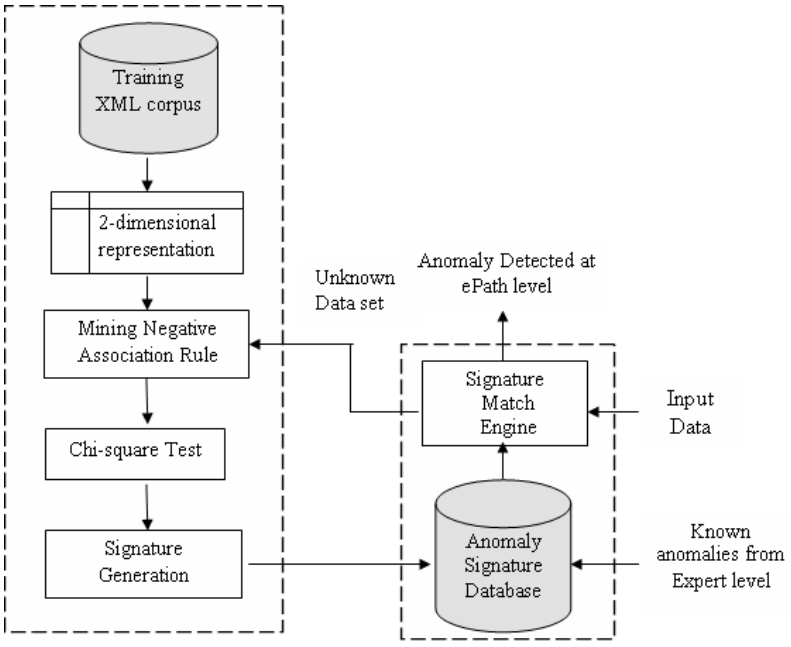

Figure 5. Anomaly detection in XML documents

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Research of Sales Contract Management System Based on WEB

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Abstract

On the basis of study on information stream of management of contract, a frame of an information system of management of contract with holistic information is designed. Sale and production forecast is put forward in terms of data mining technique and customer management concept and relevant system is developed. System information includes customer management system, elaborate content of contract, finance management in the execution of contract, record of change of contract, control of dispatch process, shares information with packaging system, and also shares information with warehouse management system to realize the control of dispatch process. Data of customers and sale of products information is obtained through data mining of customers and contract information. Good forecast for market can be made by the data which also places perfect basis for the decision of production planning.

Keywords: Sell contract, Management system, WEB, Object-Oriented, Whole lifecycle

1. Introduction

The sales contract is the important production information of manufacturing firm, it includes the attribute of the user request, specification and delivery time and the information which enterprise formulation and in the execution productive plan process involves. The Manufacturing firm and user's link are connected by it. In the Manufacturing firm, the contract schedule must be formulated between Master Production Schedule and Production Schedule. Contract schedule must guarantee that all duties in the Master Production Schedule are completed and that production schedule arranges well production as schedule in each contract. Contract schedule is the refinement of the Master Production Schedule. To make the enterprise interior operation be Consistent, its function is not only Communication between inside and outside, but also reducing the contradiction and the error between the Sale branch and Production department.

Manufacturing industry enterprise's contract management includes management completed in ERP system and independent management system. The two kinds of systems have some Weaknesses such as incomplete information record, not thorough integrations with other systems and weak analysis ability. It is disadvantageous to enterprise's informationization construction and influences seriously on enterprise market reaction rate and market competition ability, which is more obvious to the large-scale manufacturing companies that have complex products than others.

On the foundation of contract management information flow is studied, contract management information system's

frame having complete information is designed, and sales and the production forecast method according to the data mining technology and client management's theory is proposed. The corresponding system has been developed. The system core goal is that a transformation to production schedule and job instruction is made, and that market demand is mapped in the manufacturing promptly and accurately to enhances the enterprise' reaction capacity to the market and enterprise's competitive ability.

2. System function and Structure

With analysis of operating methods of contract management, the management processes and management content is concluded based on whole lifecycle sales contract management. The structural feature of process is as shown in Figure 1. The functional modules are as follows:

(1) Contract input

Contract information, including customer information, the framework of the contract, a variety of equipment specifications, model, quantity, and special note, and other information involved by contract is input by staffs of sale department.

(2) Customer Management

Users can look for, modify the information of existing customers and add new customer information into system.

(3) System Maintenance

Including import and export data, backup and recovery, as well as the management of users (user addition, delete, and the rights granted), operated by the system administrator.

(4) Search

The sales can inquiries contract information signed by the sale department, as well as execute-status of contract. The top leaders can inquire information and execute-status of contract of all sale departments

(5) Contract Modify

Sales can modify the mistake contents of contract, such as payment, product name and specification caused by carelessness. But other some contents can not be modified such as contract ID and contract type.

(6) Financial Check

Accountants check the payment details of contract content in the System on basis of original contract. The contract will not continue the execute process without Accountant's agree, and should be modified by the sales of departments. Only if the contract contents match the rules of company, Accountant will verify the contract.

(7) Generation of production plans report

The Staff of central sale department make an production application based on the actual situation of stock. Technology department make the BOM on the basis of production of application. Manufacture department staffs make the production plan and order play according to the contents of ERP system, and the Manufacture report will be given to factories.

(8) Financial check for delivering product

Accountants will check the delivering devices on the basis of arrived payment of customer.

(9) Generation of the bill of lading

The bill of lading will be generated according to the financial check and actual stock situation.

The system uses technology structure based on Web, and use the MS SQL Server as database. The development language of system is JAVA, and ECLIPSE is as development environment.

Using the Web Service technology will make the System get further more development and third-party application integration. Figure 2 showed as structure of the system. Web Service uses the standard output interface WSDL (Web Service Description Language) serving for the client of internet/ intranet. It will not emphasis on using what technology to get web solutions.

Web Service changes the programming-Oriented conception of WEB application into a service-oriented conception. The most valuable technology is to integrated different model components and different model components. This contract management system using Web Service technology provided technical support for the system integration in the future of the inevitable internal and inter-enterprise.

3. Management of the Change of Contract Process

Customers often require that the contract be changed during the execution of the contract, and the change of contract mainly covers the following range:

Elimination of contract

Increase and decrease of number

Change of equipment type

Change of equipment parameter

Change of transportation means and so on

The different extent of the change would affect the capital of contract as well as the execution of production plan. Effective management of the data from the change provides data source to guarantee the implementation of data mining. Meanwhile, the system attains the change of production cycle according to the change, and the change provides production planning with basis.

Design of Database

A table recording change of contract is designed in database, and following is its structure:

No. of contract; date of change; content of change; reason of change,..

Content of change directly relate to contract in terms of code. After opening the database, relevant content would be modified and be recorded. Reason of change is character field, which elaborately record the reason that customers put forward and provide data processing with data source.

Other Change Management Results from Change of Contract

Change in many other aspects resulting from change of contract mainly affects production plan. System communicates with PDM system, applies for change of design and exports changed data of BOM according to changed data. Generally, there is no change of production planning process. Therefore, it is required that change of production planning as well as changed data of purchasing planning be obtained by change module in production system according to production capacity.

Management module in change of contract process will record data which is created in the process of change of contract in database. Data becomes affluent with the increasing use of system.

4. The application of Data Mining Technology

(1) Data Mining System

Data Mining System is an independent three-tier structure. The bottom layer is data, and read data sources from the SQL Server. The middle is mining, and has multi-dimensional database and excavation engine. Top-layer can switch data with user interface.

(2) The realization of Data Mining

(3) Association Rules Mining

Data Mining (Data Mining), refers to mine hidden, useful and not yet found the information and knowledge from a large number of the raw data, is considered an effective method to resolve the current "data rich and information poor". Association Rules Mining is one of important areas of Data Mining (Liu, xin, etc. 2007).

According to different situations association rules can be classified as follows:

a) According to dealing with the types of variables of rules, the association rules can be divided into Boolean and Value type.

b) According to data abstract level of rules, the association rules can be divided into single and multi-association rules.

c) According to relating to the dimensions of the data of rules, the association rules can be divided into one-dimensional and multi-dimensional.

(4) Association Rules Mining Algorithm

From the large-scale database mining association rules require two steps:

a) Finding all the frequent set.

b) Producing strong association rules by the frequent set.

The study of Association Rules Mining focuses on the first step (Li, Shujuan, etc. 2004). The discovery ways of association rules, the most influential algorithm is the Apriori algorithm, which uses a gradual approach called iterative search. The basic algorithm is as follows: firstly, traversing one time to goal database, recording appearance times of each item and attribute. that is, calculating the degree of support for each project to collect project constitutes frequent table-L1which all the support degree is not less than the minimum support degree of user, and then link all the elements right of L1, form candidate-C2, once again traversing the services database, calculated support degree for each set of

options of C2, to collect project constitutes frequent table-L2 which all the support degree is not less than the minimum support degree of user, and then link all the elements right of L2, form candidate-C3, traversing the services database to get L3, repeatedly implementing the course until the options stopping.

(5) Multi-association Rules Mining device

Apriori algorithm is more complicated, using an improved algorithm of the SDA in the paper, and using this improved algorithm to develop a multi-level association rule mining device, two interrelated can be found in relational association: property correlation and cross-attributes link. The former is a link among different properties; the latter is an inner association of one property or attributes collection, at the same time that the association integrates with another set of attributes or properties (Yang, guang & Wang, rui. 2007.).

Through the analysis of the data mining system gets the trend of product sales, as well as products associated with the user, the factor weight to the contract changes, the integration of contract change and association of products and users etc..

5. Integrated with packaging system

Delivering product is an important part of contract management, the completion of shipments of equipment marks contract completed. Generally, customers will clearly stipulated batches delivering product in a different time in the contract, because of the size of the goods being different, a device may be divided into a number of packing cases, or many devices may be put a pacing case due to the smaller size of the goods.

Delivering product list must be marked information of packing cases, including the number of cases, identification number etc., the information is not included in the contract information and need integrated with packaging system to get product packing information of a contract.

In the database system level system integrates with packaging system, in the packaging systems database has packing case and contract data table, this table will relate with equipment constitute table in contract management, and generate detail data including delivering product list of packing case.

6. Integrated with financial system and inventory system

Shipments must meet the requirements of the stock and financial conditions, and to financial the user must pay the money of contract demand before delivering product, to inventory, products must check to inventory before delivering product. The information of inventory and financial needs integrate with inventory system and financial system.

System integrates with financial system and inventory system in the database level, the database in the financial system has detail information of the process of payment of user, and the database in the inventory management system has detail information of products, this table will relate with delivering product control management table in contract management, and strictly control delivering product behavior of products.

7. Conclusion

1) Contract management system has closer ties with customer management systems, packaging system, financial system, and inventory management system etc., and easy to integrate with these systems, owing to the system architecture applying B / S system based on WEB.

2) Contract management system using data mining techniques provided the basis for forecasting, and data sources for data mining based on complete record to contract changes.

3) Information of system integrated with financial system and inventory information system reaches purpose of controlling delivering product, and put an end to human error.

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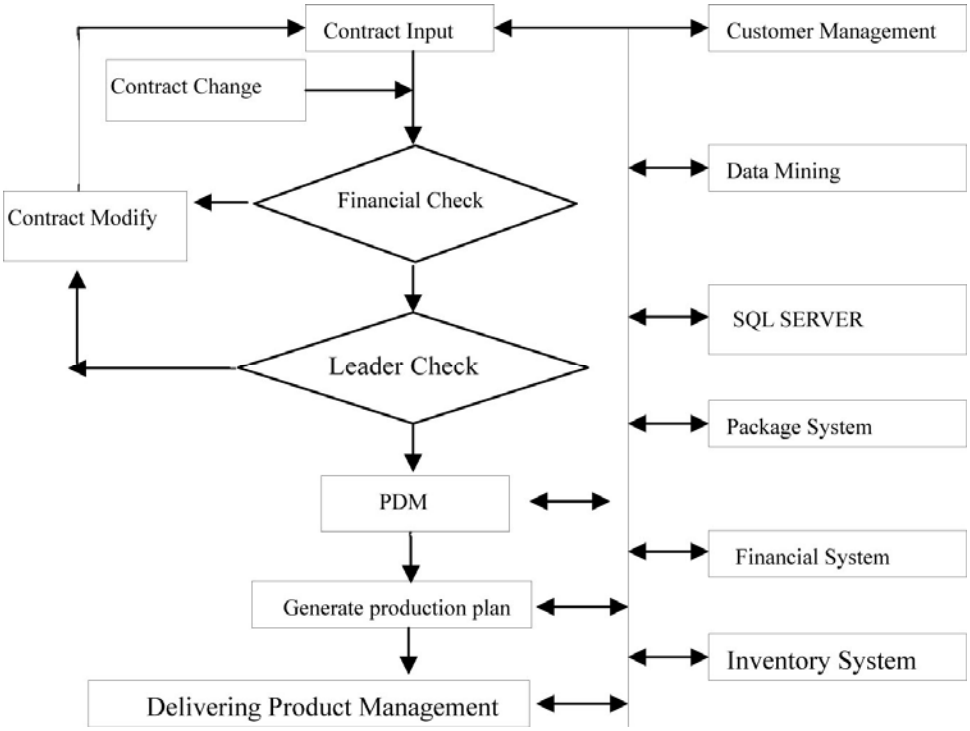

Figure 1. function Structure

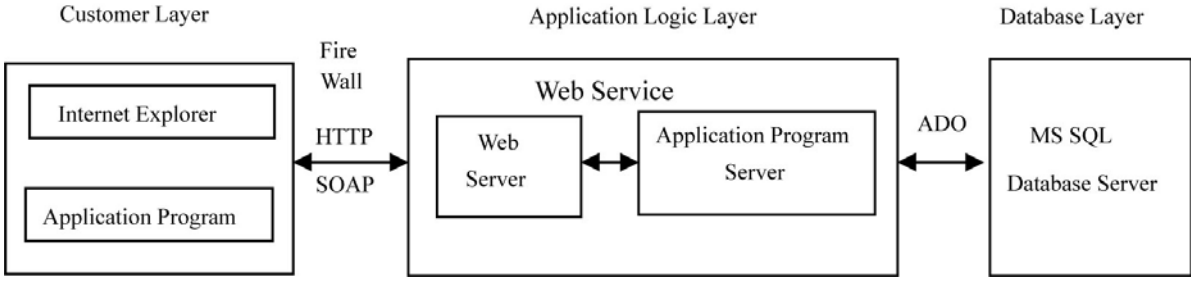

Figure 2. System Structure

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Complexity Analysis in Heterogeneous System

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Abstract

Complexity analysis in heterogeneous system is one of the more complicated topics in the subject mathematics for computing. It involves an unusual concept and some tricky algebra. This paper shows how various algorithms take part in heterogeneous system and how they affect the overall system complexity? All analysis and methods are situation specific. Here we show a comparative study of various method and techniques of algorithm analysis giving their specific advantages and disadvantages. We will specify general guidelines for calculating the complexity of heterogeneous system which still gives sleepless nights to the researchers.

Keywords: Heterogeneous system, Complexity analysis, Time complexity, Space complexity

1. Introduction

In recent years heterogeneous system has begun to play a vital role in computing. The potential use of heterogeneous system in safety-critical applications increases the importance of their reliability. The system includes telecommunications, consumer products, robotics, and an automotive control system is called heterogeneous system. Heterogeneous system contains many different kinds of hardware and software working together in cooperative fashion to solve problems. There may be many different representations of data in the system. This might include different representations for integers, byte streams, floating point numbers, and character sets. Most of the data can be marshaled from one system to another without losing significance. Attempts to provide a universal canonical form of information is lagging. There may be many different instructions sets. An application compiled for one instruction set cannot be easily run on a computer with another instruction set unless an instruction set interpreter is provided. Heterogeneous system may be based on software as well as hardware, e.g. we have a system

in which our data is on site A and on site B, Site A having the SQL Server and Site B having DB2. In this scenario we may have same hardware but platforms are different. In another case we may have SQL server or DB2 on both site but hardware may be different.

An *algorithm* is a well-defined sequence of steps to solve a problem of interest. The complexity of an algorithm means a function representing the number of steps (times) required to solve a problem under the worst-case behavior. The worst-case behavior of an algorithm, means the maximum number of steps executed (or time taken) to solve a problem. Hence, for any algorithm, even before implementing it, its complexity function should be analyzed. Such analysis will help us predict the maximum magnitude of time required to solve a problem using the algorithm. There is one more type of complexity function, namely *volume complexity function*, which represents the maximum primary memory requirement while executing the algorithm (Design And Analysis of Algorithms).

Time complexity function of an algorithm gives the worst-case estimate in terms of the number of steps to be executed for the algorithm. The order of the algorithm is defined like (n^2), $O(n!)$, $O(2^n)$, etc. The big *O* means the maximum order of the algorithm. $O(n^2)$ means that order of the algorithm is n^2, which indicates the maximum number of steps required to solve any problem by that algorithm is n^2 where n is the problem size. The time complexity function may be either polynomial or exponential.

Volume complexity: The Volume complexity function of an algorithm represents the amount of prime memory space required while executing the algorithm. Again this may be either polynomial or exponential. In the case of the branch and bound technique, if Breath First Search (BFS) is used, the function representing the memory space required to store the sub-problems will be in exponential from; if Depth First Search (DFS) is used, the function representing the memory space required to store the sub-problems will be in polynomial form. The type of the algorithm as well as data structure affects the volume complexity. This analysis will be helpful in deciding the types of computer to be used for implementing the algorithm.

2. Methods for Analysis

Apriori means designing then making. The principle of apriori Analysis was introduced by *Donald Knuth*. In apriori Analysis first we analyze the system or problem then we design or write the code for the problem.

Posterior Analysis refers to the technique of coding a given solution and then measuring its efficiency. Posterior Analysis provides the actual time taken by the program. This is useful in practice. The drawback of posterior analysis is that it depends upon the programming language, the processor and quite a lot of other external parameters.

Micro analysis refers to perform the instruction count for all operations. It counts each and every operation of the program. Micro analysis takes more time because it is complex and tedious (Average lines of codes are in the range of 3 to 5 million lines).Those operations which are not dependent upon the size or number of the input will take constant time and will not participate in the growth of the time or space function, So they need not be part of our analysis.

Macro Analysis Perform the instruction count only for dominant operations or selective instructions which are costliest. The following are a few examples of dominant (or basic) operations e.g. Comparisons and Swapping are basic operations in sorting algorithms. B**est**, **worst** and **average cases** of a given algorithm express what the resource usage is *at least*, *at most* and *on average*, respectively.

Amortized analysis refers to finding the average running time per operation over a worst-case sequence of operations. In this kind of analysis we do not include probability we always use actual data so it guarantees the time per operation over worst-case performance, hence it is different from average case.

E.g. In the implementation of the dynamic array, we double the size of the array each time it fills up. Because of this, array reallocation may be required, and in the worst case an insertion may require $O(n)$. However, a sequence of n insertions can always be done in $O(n)$ time, so the *amortized* time per operation is $O(n) / n = O(1)$.(Allan Bording and Ran El-Yaniv. 1998.) *Aggregate analysis* determines the upper bound $T(n)$ on the total cost of a sequence of n operations, and then calculates the average cost to be $T(n) / n$.

Accounting method determines the individual cost of each operation, combining its immediate execution time and its influence on the running time of future

operations. Usually, many short-running operations accumulate a "debt" of unfavorable state in small increments, while rare long-running operations decrease it drastically (Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein.).

Potential method is like the accounting method, but overcharges operations early to compensate for undercharges later.

3. Complexity of various algorithms in the system

The example given in figure 1 there are number of algorithm like authentication, encryption, fault tolerant, routing algorithms, ACID (atomicity, consistency, isolation, durability) properties for transaction and, communication protocol etc. In figure 1.terminals at a branch connected to a set of clustered web servers for authentication. The web servers are in turn connected to a set of application servers for implementing banking rules and policies. The application server's access mirrored and/or replicated data storage. Redundancy is present in the network also. Telephone banking using an Interactive Voice Response System is used as a backup if the branch terminals break down. The design of the authentication hardware and software requires fault tolerance – the users should not have to Re-login if one or more servers fail – some state should be stored in the form of cookies in non-volatile storage somewhere. The banking calculations require very high accuracy (30+ digit accuracy). Various kinds of fault tolerance schemes are used for storage. For example, two mirrored disks always keep identical data. A write to one disk is not considered complete till the other is written also. The servers have to respond within seconds to each user level request (deposit, withdrawal, etc) – the real time response of the system has to be evaluated using queuing theory and similar techniques. For TTS, the response output speech samples have to be guaranteed to be delivered at periodic time intervals, say every 125*ms* (micro-seconds). We have to calculate the complexity of overall system.

In a communication network routing is one of the latency sources. Routing algorithm has task to determine the suitable port for delivering message address to one network node. Correct delivery of message from source node to destination node is considered as optimal routing. The aim is to have the fastest and optimal routing available in the network.

The principle of routing with routing tables is straightforward. Ever node keeps a table with entries for each node. Using these entries, it could be determined via which outgoing port a message had to be sent. Interval routing is a space efficient routing strategy used in computer networks. The basis of interval routing idea is to label all of the nodes with integer from one set (for example $\{1, 2, 3...n\}$) and labeling of all arcs with interval (in range of number of nodes). These intervals means that a message addressed to a node labeled with u, via a port labeled with interval which includes a node u is forwarded.

The mechanism used for detecting and correcting faults is called fault tolerance. It can be further classified based on place of deployment, fault coverage, fault or error latency, cost of recovery .In real time systems fault tolerance can be achieved by online fault (K. Chandy, J. Browne, C. Dissly and W. Uhrig. 1975.) detection followed by a hardware-based checkpoint and rollback recovery mechanism. Cost is measured in terms of hardware and or time overheads (F.P. Preparata, G. Metze, and R.T. Chien. 1967.). The complexity for k faults $O(n^2RL)$, where n is the number of periodic tasks in a task set, R is the ratio of largest task period to smallest task period, and L is the number of frequency levels supported by the processor (K. Shin and Y. Lee).

4. Measure complexity in Heterogeneous System

In table 3 we have five heterogeneous systems and each system has five different modules, in the table their module wise complexity is given in the table. Now we will calculate the overall complexity of the system (T_C).

Scenario1. In H_system 1 we have a very simple system and no module is running in parallel, all the modules are running in sequence, simply by adding the complexity of each module will give the overall complexity of the system *(i.e.* $T_c = n^2 + n \log n + 2^n + \log n + n$*).* $T_C = 2^n$ .It is an easy example and these types of systems are rare in use.

Now we have more dynamic system with inter connections and multiple dependencies with distributed, parallel or other techniques of advance computing.

Scenario2. In H_system2 some of the modules are running parallel, so approach to measure the complexity will be different. If module 3 and module 5 are running in parallel fashion, so the highest complexity from both the module will be taken in to the account (the complexity of module 3 and module 5 is n^3 and n respectively so will take n^3 highest one), so the total complexity (T_c) of the system H_system 2 will be $T_c = \log n + n! + n^3 + n \log n$, $T_C = n^3$. These types of systems are most common one. Some time all the modules are running in parallel manner then the highest complexity will be the Total complexity *(*T_c*)* of the system. In actual it may not be that simple and many more parameters may affect overall complexity.

Scenario3. Heterogeneous system may include one or more critical module like security where it cannot be compromised in context to complexity, so in this type of cases one module can affect the overall system's complexity. Like in banking system or online payment system security, atomicity, accuracy, consistency, isolation and durability are modules those cannot be compromised we have to take care these modules, they can increase the total complexity of the system.

Scenario4. In this scenario we may have some dependencies. One module may dependent on another one so the complexity will increase. Like in H_system 3 we can't start the second module until first module is not finished if the complexity of module one is high then automatically the overall system's complexity will get effected and output of Module 3 is dependent module 2 if output varies then it may has effect on T_C.

Scenario5. Now we have system in which two modules (module 1and module 2) are running in parallel and have one complex module 3 the output of module 5 is dependent on module 4. If we do some computations on client side rather than to do all computations on server side, we do so the complexity of module 3 is decreased n^4 to n. the overall system complexity will automatically decreased.

There are various other factors that will play significant roles in the overall complexity. Communication is one of them. Depending upon the distance of locations where servers may be placed due to security or feasibility of the application. Backup is another issue where system needs some time to reconsolidate with the back end links or system. Depending upon the types of backup (hot or cold backup) different timings may be taken up by the system. In case of database application there may be delays due to commit and other updates on various types of storage media, which needs to be taken into account. These, will be looked into in our future study of this area.

Conclusion

This paper gives relative comparison of various techniques to analyze the complexity like Apriori Analysis, Posterior Analysis ,Micro Analysis ,Macro Analysis, Amortized Analysis ,Big *O* Notation ,Theta Notation, Potential Method ,Accounting Method and also lists there advantages and disadvantages, But still people face problem determining the complexity of complex systems. Many points has come up relating to various specific problems formulation and various design technique elements giving an insight into the area of complexity analysis of algorithms.

In this type of system, there are many algorithms that are running simultaneously as we discussed earlier like fault tolerance, authentication, encryption, routing tables, communication protocols and for error recovery. Every algorithm contributes in the system, so every algorithm have time and space complexity, if the algorithms are running parallel then the complexity will be highest out of them. E.g. we have complexities n, n+1, n2 then the complexity will be n^2. If we have N algorithms and they are running sequentially then the complexity will be sum of all these.eg. We have N algorithms running simultaneously then the total complexity will be $Tc = 1+2+\ldots\ldots+N$.

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Table 1. Comparison of all Methods

Apriori Analysis	Require less effort because we don't actually implement it. Less risky,Simple and Easy
Posterior Analysis	Whole effort may go waste if analysis gives negative data. Actually resources or infrastructure is required. Not applicable in many instances.
Micro Analysis	Checks all instruction. It takes more time,Not useful for large code.
Macro Analysis	Check only dominant operation It takes less time comparative to Micro Analysis As useful as micro analysis
Big*O* Notation	Represent worst case growth of an algorithm in time and space when they are dependent on *n.* Big *O* represents an upper bound. Easy to calculate and widely acceptable.
Theta Notation	It represents tight bound. Useful for many problems.
Omega Notation	It represents a lower bound. Not used very often.
Amortized Analysis	Probability is not involved. Guarantees the time per operation over worst-case performance
Accounting Method	It determines the individual cost of each operation. Balancing can be done between heavy and light operations.
Potential Method	Use in Online Algorithms [1]. Good to calculate the overall cost of a data structure.

Table 2. Complexity of latency of message passing in wide area networks.

	Routing Tables	*Interval routing*
Space complexity	*O(n log Δ)*	*O(k Δ log n)*
Time complexity	*O(1)*	*O(log(k Δ))*

Note: - Δ is maximum degree of the graph, n is number of nodes in the graph, k is interval.

Table 3. Heterogeneous Systems and module wise complexity.

	Module 1	*Module 2*	*Module 3*	*Module 4*	*Module 5*
H_system 1	n^2	*n log n*	2^n	*log n*	*N*
H_system 2	*log n*	*n!*	n^3	*n log n*	*n*
H_system 3	n^3	*N*	*log n*	*O(1)*	*n log n*
H_system 4	n^2	*(log n) / 2*	n^4	*N*	*O(1)*
H_system 5	n^2	*n log n*	$n^2 \log n$	$(\log n)^2$	*n log n*

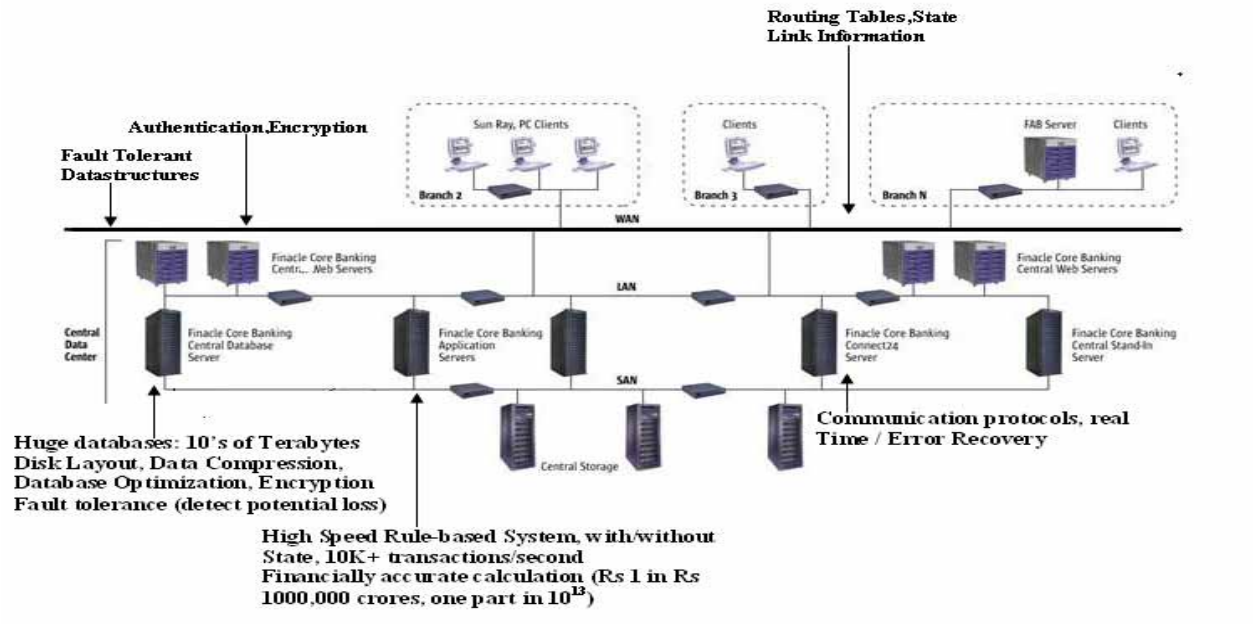

Figure 1. An Hetrogeneous system

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Pixel Based Temporal Analysis Using Chromatic Property for Removing Rain from Videos

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Abstract

The raindrops degrade the performance of outdoor vision system, and it brings difficulties for objects detection and analysis in image sequence. In this paper, we propose an algorithm detect moving objects using chromatic based properties in rain-affected videos captured by outdoor vision systems. Thus the raindrop removal algorithm includes two parts that is removal raindrops in background and removal raindrops in moving objects. Since the degradation made by raindrops is complex and appears as various changes. The raindrops detection function considering the chromatic properties of image sequence is induced, which does not need the velocity and time information of raindrops. Therefore, it is suitable for all the blur effects caused by raindrops. The removal raindrops are able to distinguish accurately the raindrops-affected pixels from the immovable or movable objects. Although the objects are moving in the rain, the algorithm is also effectual. The experiment results show that the proposal algorithm is able to remove the raindrops and improve the quality of image sequence remarkable.

Keywords: Imaging model, Complex scenes, Video processing, Outdoor vision and weather

1. Introduction

The rain-affected image sequences annoy human viewers and degrade image quality. The degraded images also decrease performance of computer vision algorithm in areas such as object detection, tracking, segmentation, video surveillance.

Now many algorithms are proposed to remove obvious rain streaks. But there are still two difficult points needing further research.1. To remove light rain. Rain streaks are too small to be detected in single frame when the background is complex, but viewer can feel rain streaks in videos. 2. To get accurate intensity value. Due to the imaging precision and video compression algorithms, it's difficult to get the true intensity value of a rain-affected pixel. The existing algorithms just have good effectiveness for detecting and removing obvious and clear rain streaks. So to resolve the two difficult points described above, in this paper, we propose a general pixel based algorithm using chromatic property for removing rain from an ordinary video.

1.1 Previous work

The methods of removing rain streaks can be classified into two types: pixel-based method and frequency-based method. The first pixels-based method used a temporal median filter in (Starik, 2003). This works during moderate rain in which the scenario is not seriously corrupted. But moving objects will cause blur effects.

For removing rain streaks during video acquisition, Garg and Nayar (2007, pp.3-27) proposed modifying the camera parameters by increasing exposure time or reducing the depth of field. But for some types of cameras their parameters are not adjustable. For removing rain streaks in video, Garg and Nayar (2004) supposed that there are few raindrops will cover three consecutive frames. So if a pixel is covered by one raindrop, the intensity change of this pixel between this frame and its previous frames is equal to the intensity change between this frame and its latter frame. Then they used a linearity constraint to reject improperly detected pixels. Finally they calculated the binary rain field to segment rain area. This method has two limits: 1. In heavy rain, raindrops could frequently affect the same position in three consecutive frames. 2. Due to noise or video compress algorithm, the linearity constraint is not always valid.

Zhang at al (2006, pp.461-464) proposed another pixel-based algorithm using the chromatic constraint. They found If a pixel is covered by raindrops, the varieties of the intensities of R , G , and B , are approximately the same. This property is used to segment moving objects and rain area. But in some videos, the intensity changes of R , G , and B in area where comprise object motion are far less than in rain-affected area. It is difficult to find an appropriate threshold that is suitable for both stationary and dynamic objects.

Barnum at al (2007) used frequency information to detect and remove rain streaks. They used a blurred Gaussian to approximate the blurred effect caused by a moving raindrop. It works when the streaks are clear. But for light rain or heavy rain, the model of a blurred Gaussian is not always effective.

1.2 Our work

This paper focuses on rain removal in video. If a video is captured by a moving camera, the frames can be stabilized in advance. So to make the problem simpler, we mainly focus on scenario comprising a stationary background and some moving objects captured by a stationary camera.

First, we make a further study of the raindrop's model, and give a general detecting method using chromatic property which is able to avoid noise effect. Then we estimate the distribution of the detected variable to reject improperly detected pixels. In the removal step, we use the imaging model to restore the background information. In this paper, we don't use the information of raindrops' velocities or shapes. Therefore our method is suitable for various types of raindrops. The result shows that our method is effective and has a better performance.

2. Chromatic properties of rain streaks

Garg and Nayar (2007, pp.3-27) got a conclusion that when a raindrop is passing through a pixel, the intensity of its image is brighter than the background. This imaging process is illustrated by the formula:

$$I_r(x,y) = \int_0^{\tau} E_r(x,y)dt + \int_{\tau}^{T} E_b(x,y)dt \tag{1}$$

Where I_r is the intensity of this pixel affected by the raindrop. τ is the time during which the raindrop projects onto the pixel. E_r is the irradiance caused by the raindrop during the time τ , E_b is the average irradiance of the background. T is the exposure time of the camera.

If the background is stationary, or the motion of it is slow, we can use the average irradiance value E_b to calculate the background intensity of the pixel I_b over the time duration T .

$$I_b(x,y) = T \cdot E_b(x,y) \tag{2}$$

Also we use the time-averaged irradiance $\bar{E}_r(x,y) = \frac{1}{\tau}\int_0^{\tau} E_r(x,y)dt$ to compute the intensity of raindrops.

$$I_r(x,y) = \tau \bar{E}_r(x,y) + \frac{T-\tau}{T} I_b(x,y) \tag{3}$$

Use $\Delta I(x,y) = I_r(x,y) - I_b(x,y)$ to denote the change in intensity at a pixel due to a raindrop, we obtain

$$\Delta I(x,y) = I_r(x,y) - I_b(x,y) = \tau \bar{E}_r(x,y) - \frac{\tau}{T} I_b(x,y) \tag{4}$$

Let $I_E(x,y) = T\bar{E}_r(x,y)$, $\alpha = \frac{\tau}{T}$, rewrite Eq.(3) and Eq.(4)

$$I_r(x,y) = \alpha I_E(x,y) + (1-\alpha) I_b(x,y) \tag{5}$$

$$\Delta I(x,y) = \alpha I_E(x,y) - \alpha I_b(x,y) \tag{6}$$

Here $I_E(x,y)$ means the equivalent ideal intensity caused by raindrops during the exposure time T. $\alpha = \tau / T$ means the ratio of rain-affected time to the exposure time.

From Eq.(6) we know that the intensity change of pixels along a rain streak is proportional to its background values. But usually the intensity values of pixels along a rain streak are similar.

$$\alpha = \frac{\Delta I_1(x,y) - \Delta I_2(x,y)}{I_{b2}(x,y) - I_{b1}(x,y)} \tag{7}$$

proximate to the intensity of a little white sphere. Therefore the equivalent ideal intensity $I_E(x,y)$ and the ratio α are uniform respectively in R, G, B channels. That is, although a falling raindrop appears as complicate shape and intensity change along the falling direction, the values of $I_E(x,y)$ and α at each pixel are equal respectively in three channels. But the Eq.(6) shows the relation of rain-affected pixel and its background. When rain is heavy, raindrops usually cover the same position in consecutive frames**.** It's hard to get the accurate value of background. In the next part, we will derive the formula of the relation between rain-affected pixels in consecutive frames.

2.1 Relation of Background pixel and rain pixel

Consider pixels at the same position in two consecutive frames, one is background pixel, and the other is rain-affected pixel. The brighter one is rain-affected pixel. $\Delta \vec{I}(x,y)$ denotes the vector of intensity change between frames in R, G, B channels. $\vec{I}_b(x,y)$ is the vector of background intensity in three channels. We rewrite the Eq.(6)

$$\Delta \vec{I}(x,y) = \alpha \vec{I}_E(x,y) - \alpha \vec{I}_b(x,y) \tag{8}$$

Where $\vec{I}_E(x,y) = [I_{ER}(x,y), I_{EG}(x,y), I_{EB}(x,y)]^T$.

From the discussion above, we get $I_{ER}(x,y) = I_{EG}(x,y) = I_{EB}(x,y)$. We still use $I_E(x,y)$ to denote this value.

2.2 Relation of Two Rain Affected Pixels

When rain is heavy, or the frames extracted from videos are not consecutive frames. Sometimes the pixels at position (x,y) in both frames are covered by raindrops. We use $\vec{I}_r(x,y) = [I_{rR}(x,y), I_{rG}(x,y), I_{rB}(x,y)]^T$ denotes the intensity vector of the brighter one, use $\vec{I}'_r(x,y) = [I'_{rR}(x,y), I'_{rG}(x,y), I'_{rB}(x,y)]^T$ denotes the other one. $\vec{I}_b(x,y) = [I_{bR}(x,y), I_{bG}(x,y), I_{bB}(x,y)]^T$ is its background intensity vector. $\vec{I}_E(x,y) = [I_{ER}(x,y), I_{EG}(x,y), I_{EB}(x,y)]^T$ and α is the parameters according to the brighter pixel. $\vec{I}'_E(x,y) = [I'_{ER}(x,y), I'_{EG}(x,y), I'_{EB}(x,y)]^T$ and α' is the parameters of the other one. We get

$$\vec{I}_r(x,y) = \alpha \vec{I}_E(x,y) - (1-\alpha)\vec{I}_b(x,y) \tag{9}$$

$$\vec{I}'_r(x,y) = \alpha' \vec{I}'_E(x,y) - (1-\alpha')\vec{I}_b(x,y) \tag{10}$$

From Eq.(10), we get $\vec{I}_b(x,y) = -\frac{\vec{I}'_r(x,y) - \alpha' \vec{I}'_E(x,y)}{1-\alpha'}$, substitute it into Eq.(9), we get

$$\vec{I}_r(x,y) - \vec{I}'_r(x,y) = \alpha \vec{I}_E(x,y) - \frac{1-\alpha}{1-\alpha'} \alpha' \vec{I}'_E(x,y) - \frac{\alpha - \alpha'}{1-\alpha'} \vec{I}'_r(x,y) \tag{11}$$

Comparing Eq.(11) with Eq.(8), it shows that Eq.(8) is the special form of Eq.(11) when $\vec{I}'_r = \vec{I}_b$. In this condition the pixel with less intensity value is background pixel. And the rain-affected time is zero, so $\alpha' = 0$.

Since the terms of $\alpha\vec{I}_E(x,y) - \frac{1-\alpha}{1-\alpha'}\alpha'\vec{I}'_E(x,y)$, and $\frac{\alpha-\alpha'}{1-\alpha'}$ in Eq.(11) are equal respectively in three channels, let $\vec{A} = \alpha\vec{I}_E(x,y) - \frac{1-\alpha}{1-\alpha'}\alpha'\vec{I}'_E(x,y)$, $K = \frac{\alpha-\alpha'}{1-\alpha'}$, we can rewrite Eq.(11)

$$\Delta\vec{I}(x,y) = \vec{A} - K\cdot\vec{I}'_r(x,y) \tag{12}$$

Eq.(12) is the pixel-based imaging formula using chromatic properties.

3. Existence of solution and noise effect

Eq.(12) is the imaging model of rain-affected pixels which is used as a detecting function. But when $\vec{I}'_r(x,y)$ is affected by noise, it is difficult to get an accurate value so that K is inaccurate. Let $\vec{\xi} = [\xi_{R,}\xi_{G,}\xi_{B,}]^T$ denote the noise in three channels, from Eq.(12), we get

$$\Delta\vec{I}(x,y) = \vec{A} - K\cdot\vec{I}'_b(x,y) + \vec{\xi} \tag{13}$$

Using two channel to calculate the value of K, for example using R, G channels:

$$K = -\frac{\Delta I_R(x,y) - \Delta I_G(x,y)}{I'_{bR} - I'_{bG}} + \frac{\xi_R - \xi_G}{I'_{bR} - I'_{bG}} \tag{14}$$

Calculation of K is of two types.

(1) $I'_{bR} - I'_{bG}$ does not approach to zero

When $I'_{bR} - I'_{bG}$ does not approach to zero, suppose $I'_{bR} - I'_{bG} \geq C$, and $C > 0$. The term of noises is negligible. Using Eq.(12), we will get three K values respectively in R, G channels. So according to the imaging model of pixels covered by raindrops, if the three K values are similar, this pixel is a rain-affected pixel. Otherwise it belongs to a moving object.

(2) $I'_{bR} - I'_{bG}$ approaches to zero

When $I'_{bR} - I'_{bG}$ approaches to zero, the term of noises is not negligible. Although a pixel is rain-affected pixel, the three K values calculating by three channels may be not equal to each other. In this condition, $(I'_{bR} - I'_{bG}) \to 0$, $K = (\alpha - \alpha')/(1-\alpha')$, where $\alpha = \tau/T$, due to the fast movement of raindrops, $0 < \tau \ll T$, therefore $|K| < 1$, we get $K(I'_{bR} - I'_{bG}) \to 0$. From Eq.(13), when a pixel is affected by a raindrop, $(\Delta I_R(x,y) - \Delta I_G(x,y)) \to (\xi_R - \xi_G)$. Since the noise is caused by illumination or imaging process, it's far less than the intensity change caused by a mobbing object. We get $\xi_R - \xi_G \to 0$. So if we use k and k' to denote different channels, when $\Delta I_k(x,y) - \Delta I_{k'}(x,y)$ approaches to zero, the pixel at (x,y) is affected by raindrops, otherwise it's of a moving object.

4. Segmentation of moving object

From the discussion above we know if a pixel is covered by a raindrop, either $\Delta I_R(x,y) - \Delta I_G(x,y) \to 0$, or $I'_{bR}(x,y) - I'_{bG}(x,y)$ does not approach to zero. So the equation $K = -(\Delta I_R(x,y) - \Delta I_G(x,y))/(I'_{bR}(x,y) - I'_{bG}(x,y))$ has a solution. We use a general formula to calculate the variable k.

$$K = J(\Delta I_R(x,y) - \Delta I_G(x,y)) - (1-J)\frac{\Delta I_R(x,y) - \Delta I_G(x,y)}{I'_{bR}(x,y) - I'_{bG}(x,y)} \tag{15}$$

Where $\begin{cases} J = 1, \text{ when } I'_{bR}(x,y) - I'_{bG}(x,y) \leq C \\ J = 0, \text{ when } I'_{bR}(x,y) - I'_{bG}(x,y) > C \end{cases}$, C is a threshold to judge if $I'_{bR}(x,y) - I'_{bG}(x,y)$ approaches to zero. For three channels we will get three k values by using Eq.(15). That is

$$\begin{cases} K_1 = J_1(\Delta I_R(x,y) - \Delta I_G(x,y)) - (1-J_1)\dfrac{\Delta I_R(x,y) - \Delta I_G(x,y)}{I'_{bR}(x,y) - I'_{bG}(x,y)} \\ K_2 = J_2(\Delta I_R(x,y) - \Delta I_B(x,y)) - (1-J_2)\dfrac{\Delta I_R(x,y) - \Delta I_B(x,y)}{I'_{bR}(x,y) - I'_{bB}(x,y)} \\ K_3 = J_3(\Delta I_B(x,y) - \Delta I_G(x,y)) - (1-J_3)\dfrac{\Delta I_B(x,y) - \Delta I_G(x,y)}{I'_{bB}(x,y) - I'_{bG}(x,y)} \end{cases} \quad (16)$$

The final value of k is $\max(k_1, k_2, k_3)$ .To determine whether a pixel is covered by a raindrop by values of k is very tedious. Here we use another method to segment moving object from rain field.

From Eq.(11) and Eq.(12), we know $K = (\alpha - \alpha')/(1-\alpha')$. Consider $K - \alpha$, because $K - \alpha = \alpha' \cdot (\alpha - 1)/(1-\alpha')$, and $0 < \alpha$ 1 we get $K - \alpha < 0$, that is $K \le \alpha$. So

$$K^n \cdot \Delta I(x,y) \le \alpha^n \cdot \Delta I(x,y) < \alpha^{n+1} \cdot I_E(x,y) \quad (17)$$

Where $\alpha = \tau / T$, and τ T . So when the pixel at (x,y) is covered by a raindrop, we have $\lim_{n\to\infty} \alpha^{n+1} \cdot I_E(x,y) \to 0$.

However when the pixel belongs to a moving object, the term of $K^n \cdot \Delta I(x,y)$ does not converge to zero. The detecting function is

$$F(x,y) = K^n \cdot \Delta I(x,y) \quad (18)$$

If $F(x,y)$ dose not converge to zero, the pixel is of a moving object. We obtain the edges of moving object by using this detecting function.

5. Detection and removal of rain

As mentioned in section 1.2, we suppose those frames abstracted from video are aligned in advance. Using the detecting function, a frame is divided into two parts: static background and foreground. So the removal algorithm is twofold:

(a) To remove raindrops in background.

(b) To remove raindrops in foreground.

Many methods are suitable for removing raindrops in static background. We use Kalman Filter to suppress intensity increase caused by raindrops. To remove raindrops in foreground, we align the foregrounds respectively, and then use the method of removing raindrops in background like the first step.

6. Results and Analyses

Our experiments use a threshold of 3 gray levels to detect the intensity change of pixels. Use a threshold of 5 gray to judge if the subtraction between channels such as $I'_{bR}(x,y) - I'_{bG}(x,y)$ approaches to zero. In calculating of detecting function, the order of K is 1, the threshold of the detecting function is 5.

Fig.2 (a) is an image of static scene from the video captured by Zhang and Li (2006, pp.461-464). (b) is removal result using Garg and Nayar's method (2007, pp.3-27). The result shows that the method of Garg and Nayar is not effective when rain is heavy because their removal algorithm only calculates two consecutive frames. Image using method of Zhang and Li (2006, pp.461-464) has better quality. But their method uses K-means clustering to calculate the background color which is effective in static scene. But this method will damage the image quality in some areas of dynamic scene by improperly regarded some moving object pixels as rain-affected pixels.

Fig. 3 shows results in dynamic scenes. Fig. 3 (b) and (c) are result of Zhang's method. The improperly detected pixels obviously damage the visual quality of derained image. (d) is our result. (e) and (f) are local areas of (d). Compared with (c), our results accurately detected rain-affected area. (g) is another frame in this video. (j) is derained frame. (h) and (i) are local areas of (g). (k) and (l) are local areas of (j). Our results show a better performance in this conditon.

7. CONCLUSIONS

By further studying the model of raindrops, we obtain a detecting function using chromatic property which is suitable for a general rain condition. It can segment rain-affected pixels from moving objects between two frames. Then removing approach is classified into two steps: to remove raindrops in background and to remove raindrops covered moving objects. The removal method makes the pixels at the same position of backgrounds in each frame similar and shows a better visual quality. Another advantage is that our method does not use any information about the shape, the velocity of raindrops, neither uses the value of camera's exposure time. Therefore it is effective in various conditions, such as heavy rain, light rain, rain in focus, rain out of focus and so on. When the objects are moving in the rain, this is

also effective. Moreover the method of Garg (2007, pp.3-27) and Zhang (2006, pp.461-464) need many consecutive frames to calculate the information of rain-affected area. However our algorithm is able to segment rain field from moving object in two arbitrary frames. The results show that our method has better visual quality.

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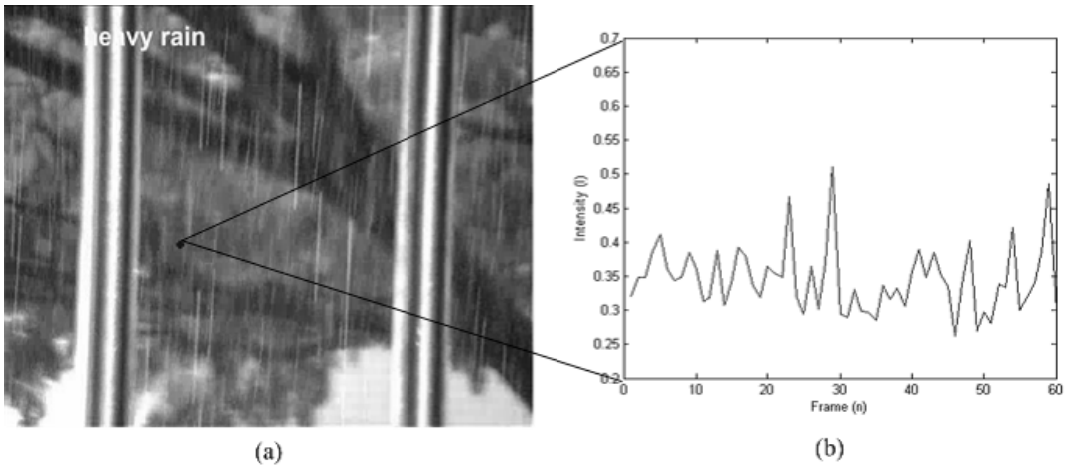

Figure 1. Rain affected frame and the intensities change at one fixed position in this video.

(a) is a rain-affected frame with stationary background in heavy rain.

(b) shows the intensities change of the position in (a)

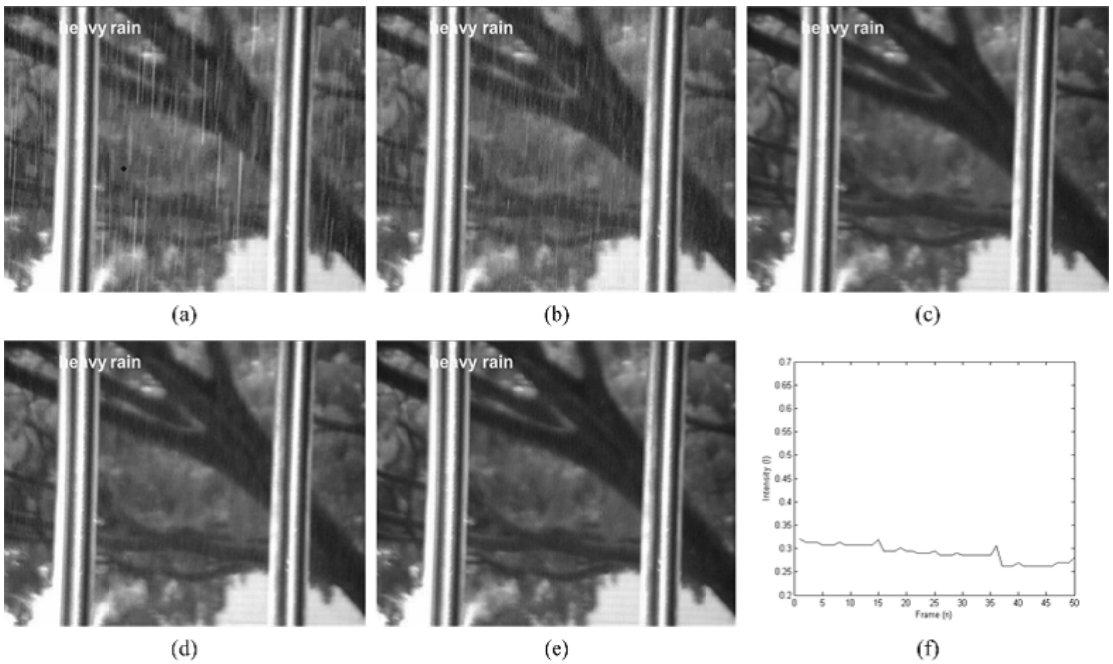

Figure 2. One frame in static scene from the video captured by Zhang and Li.

(a) is the original frame. (b) is the result using Garg's method. The removal algorithm uses three frames. (c) is the result using Zhang's method. The removal algorithm uses 200 frames. (d) is the result using our method. The removal algorithm uses 10 frames. (e) is the result of our method using 50 frames. (f) is the intensities change of the de-rained frames on the position in (a), the removal algorithm uses 10 frames

Figure 3. Some experiment results in dynamic scenes.

The video is a chip from the movie ”Magnolia”. It has been used by Garg and Zhang. (a) is the original frame. (b) is the result of Zhang’s method. (c) is a local area of (b). (d) is our result calculating 10 frames. (e) and (f) are local areas of (d). (g) is another frame of this video. (h) and (i) are local areas of (g). (j) is our result calculating 10 frames. (l) and (k) are local areas of (j)

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Fault Recovery Mechanisms in Utility Accrual Real Time Scheduling Algorithm

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Abstract

In this paper, we proposed two recovery solutions over the existing error-free utility accrual scheduling algorithm known as General Utility Accrual Scheduling algorithm (or GUS) (Peng Li, 2004). A robust fault recovery algorithm called Backward Recovery GUS (or BRGUS) works by adapting the time redundancy model i.e., by re-executing the affected task after its transient error period is over. The BRGUS is compared with a less complicated recovery algorithm named as Abortion Recovery GUS (or ARGUS) that simply aborts all faulty tasks. Our main objectives are (1) to maximize the total accrued utility and (2) to ensure correctness of the executed tasks on best effort basis and achieve the fault free tasks as much as possible. Our simulation results reveal that BRGUS outperforms the ARGUS algorithm with higher accrued utility and less abortion ratio, making it more suitable and efficient in adaptive real time system.

Keywords: Adaptive Real-Time System, Utility Accrual Scheduling, Fault Recovery, Time Redundancy, Discrete Event Simulation

1. Introduction

A real time system is a system where the time at which events occur is important. In adaptive real time system, the deadline misses and delays during overloads are tolerable and do not have great consequences. The definition of deadline constraints in existing deadline based scheduling algorithms such as Earliest Deadline First (or EDF) is limited in expressiveness by its singular metrics. A clear distinction has been made between the urgency and the important of a task by Jensen and it is known as time/utility functions (or TUFs) (Jensen, 1985; Locke, 1986). As illustrated in Figure 1, the urgency is measured as a deadline on X-axis and importance is captured by utility in Y-axis. A task's time constraint expresses the utility for completing a task as a function of when the task is completed. As shown in Figure.1, completion of a task within its initial time and termination time will accrued some utility or zero utility otherwise. We specify the deadline constraint of a task a binary value, downward step shaped TUF as shown in Figure 1.

The scheduling optimality criteria are based on maximizing accrued utility from those tasks. These criteria are named as Utility Accrual (or UA) (Wu, 2004). A closer look at the UA algorithms in (Ravindran, 2005; Edward, 2007) indicates that only the Aborted-Assured Utility Accrual (or AUA) and Handler-Assured Utility Accrual (or HUA) algorithms consider fault in its scheduling decision. These algorithms consider the abortion and released handler for all task failures. To the best of our knowledge, none of the prior works in UA scheduling domains consider time redundancy in their fault recovery design model. In this paper, we apply the time redundancy model for fault recovery in UA scheduling domain.

2. Literature Review

2.1 Fault

The term error and fault are often used as synonym. However, the definition in (Sasikumar, 1997) is appropriate in the context of problems analyzed in this study. A fault is a defect in component or design of a system. Fault can be categorized as permanent and transient. Permanent faults include hardware breakdowns, connection disruption as well

as design errors. A transient fault category is when an error disappear shortly after it appearance. These types of faults are caused by software design error or environmental variations. We focused on transient faults since previous studies in (Sasikumar, 1997; George, 2003) have indicated that majority of faults observed during the lifetime of a system are caused by transient faults.

2.2 Fault Recovery

Almost every fault recovery mechanism relies on some form of redundancy. Space redundancy is employed by extra hardware and software component that is introduced in the system only for fault recovery purposes (Mejia, 1994). A less expensive approach is via the use of time redundancy, which is based on repeating the computation and typically does not require a large amount of extra resources (Sasikumar, 1997). This paper focused on time redundancy paradigm, since it is suitable for non-distributed and uniprocessor environment.

Two main approaches for fault recovery are backward and forward recovery technique. In forward recovery technique, the system does not roll back to its previous safe state and it allows for another available resource to perform recovery. This technique works well in distributed system environment whereas extra resources are widely available. In contrast, the backward technique attempts to take the system back to its previous safe state and then proceeds to re-execute the affected task (Sasikumar, 1997).

3. The Proposed Algorithms

3.1 Task Model

During the lifetime of a task, it may request one or more resources. As shown in Figure 2, a task specifies duration to hold the requested resource in *holdtime*. We apply the Jensen's TUFs (Jensen, 1985; Locke, 1986) to define the time constraints of a task. Each task has an initial time and a termination time. If the termination time of a task is reached and the task has not completed its execution, it will then be aborted. Aborting a task will change the task state from Normal to Abort mode. Completion of task before the deadline in Normal mode accrues some uniform utility and accrues zero utility otherwise. Following (Peng Li, 2004), our proposed algorithm measures the metric called Potential Utility Density (or PUD) that was originally developed in (Jensen, 1985). The PUD of a task measures the amount of utility that can be gained per unit time by executing the task. Thus, executing task in Abort mode will accrues zero PUD and accrued zero utility to the system.

3.2 Fault Definition

In our fault model we assumed that the system have error containment capabilities to prevent the propagation of a specific error to other tasks. The transient faults in a request can be effectively overcome by re-execution of the request in the affected task. A request is suspended temporarily to model the transient error defects. Figure 3 shows the procedures to detect and simulate the transient error in the system. The fault occurrences and its duration follow the exponential distribution as detailed in Table 1. We further assumed that no error occurred during the fault recovery process.

3.3 The Fault Recovery Algorithms

Figure 4 shows a description of Backward Recovery GUS (or BRGUS) and Abortion Recovery GUS (or ARGUS) for error recovery. The recovery process follows three stages and is described as follows:

1) The transient erroneous period of the erroneous task, *Trec* is over.

After the transient error is over, the task needs to release the resource before executing the recovery algorithm in stage 2.

2) Executes the fault recovery algorithm, either ARGUS or BRGUS

In BRGUS, after the erroneous period of a request is over, the time taken to re-execute the request (i.e., *holdtime)* is measured. The system is rolled back to its previous safe state (i.e., before error occurred) and then proceeds to re-execute the affected task (Sasikumar, 1997). A request is eligible for re-execution if the *holdtime* of the request does not exceed the remaining execution time of a task. Otherwise, the task will be aborted since re-executing the task will finally result in abortion later during termination time. The *AbortTime* is the time taken for the task to abort the resource. Our proposed recovery algorithm works in a best-effort basis, in the sense that a task is simply aborted if it does not have enough time to be re-executed or continue re-execution otherwise. In ARGUS, all faulty tasks are simply aborted and no error recovery performed (Edward, 2007).

3) Check the availability of the requested resource.

If the related resource is available, the requesting task continues its re-execution or abortion procedure directly. On the other hand, if the resource is busy and currently being used by other task, the requesting task has to wait for the resource in the unordered task list (or *utlist*).

4. Experimental Model

4.1 Simulation Model

We developed a discrete event simulator to verify the performance of our proposed algorithm. We used experiment settings that are similar to those in (Peng Li, 2004) for comparison purpose. Figure 5 shows the entities involved in the simulation model. It consists of a stream of 1000 tasks that are exponentially generated, an unordered task list (or *utlist)* and a set of active resources. The requests from tasks are queued in the unordered task list before it can use the resources. The scheduling algorithm decides which request to be executed by calculating the PUD of the request. The tasks are assumed to be independent of each other. The events defined in the simulation model are the arrival of a task, the completion of a task, a resource request, a resource release, the arrival of termination time of a task, the arrival of fault in a request and the arrival of a fault recovery in a request. Table 1 summarized the details task settings used in our model.

4.2 Performance Metric

The Accrued Utility Ratio (or AUR) metric defined in (Jensen, 1985) has been used in many algorithms stated in (Locke, 1986; Wu, 2004; Peng Li, 2004; Ravindran, 2005; Edward, 2007) and can be considered as standard metric in UA scheduling domain. AUR is defined as the ratio of accrued aggregate utility to the maximum possibly attained utility. The Abortion Ratio (or AR) is the ratio of aborted task to the total of task in the system. The Average Response Time (or ART) measures the time taken for a task to complete its execution.

5. Results and Analysis

Figure 6 shows the AUR results under an increasing load. The error-free in GUS is the upper limit of our proposed recovery algorithms. We observed that BRGUS algorithm accrued higher utility compared to ARGUS for the entire load range. Clearly, the attempt to re-execute the faulty tasks significantly improved the accrued utility in BRGUS. Since aborted tasks produced zero utility, this caused ARGUS to accrue lower utility. Figure 7 plots the success ratio of BRGUS and ARGUS under an increasing error rate. We observed that the number of successfully executed tasks decreases as the error rate and load is higher. Figure 8 verifies our speculation, proving that the abortion ratio in BRGUS is lower than in ARGUS, which ultimately leads to higher utility accrued.

Figure 9 shows the ART effects of the proposed algorithms. Although BRGUS accumulates higher ART compared to ARGUS, it is always lower than its execution time (i.e., 0.5seconds). This is identified as BRGUS tradeoff, whereby the extra time taken is the time overhead incurred for re-execution of the faulty tasks during recovery process. The more tasks get re-executed, the higher utility that BRGUS is able to accrue back to the system

6. Conclusion

This paper presents quantitative results of a best effort UA real time scheduling algorithm called BRGUS that applied time redundancy paradigm for fault recovery. Simulation studies shows that the BRGUS achieved higher accrued utility with smaller abortion ratio, conforming to our design objectives. Future work includes implementing in real time operating system (RTOS) to observe the actual behavior of BRGUS algorithm.

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Table 1. Simulation Parameters

Parameters	Value	Descriptions
load	0.2 to 1.5	Range of load
C_AVG	0.5 seconds	Task Average Execution Time
iat	Exponential(C_AVG/load)	Task Inter-Arrival Time
holdtime	Normal (0.25,0.25)	Time duration for holding a resource
max_au	Normal (10,10)	Task's Maximum Utility
mean_tasks	Exponential (0.1)	Inter- arrival of error in the system
MEAN_DURATION	Exponential (0.1)	Duration of error (transient)
MAX_RESOURCES	5	Number of available resources

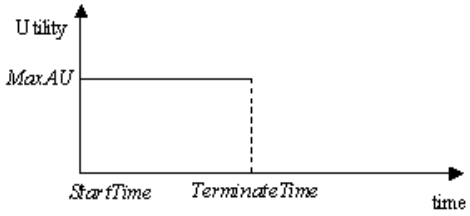

Figure 1. The Step TUF [1], [4]

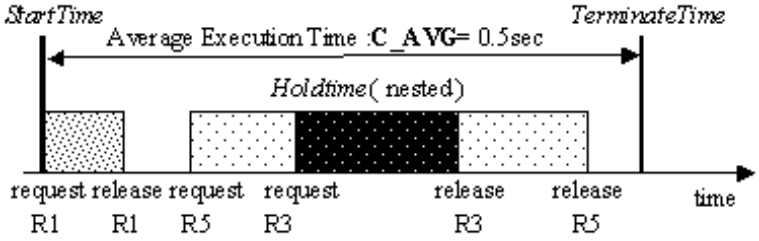

Figure 2. Task Model

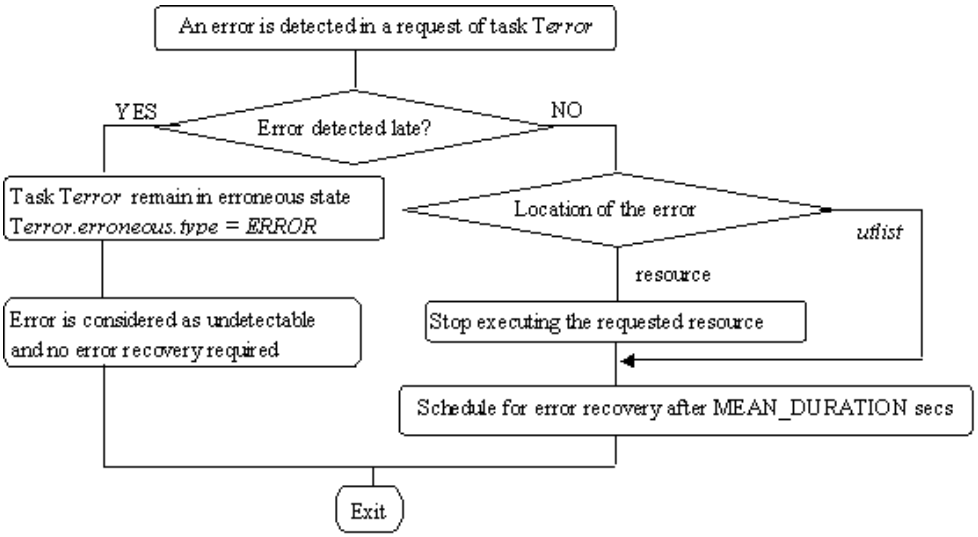

Figure 3. Fault Assignment

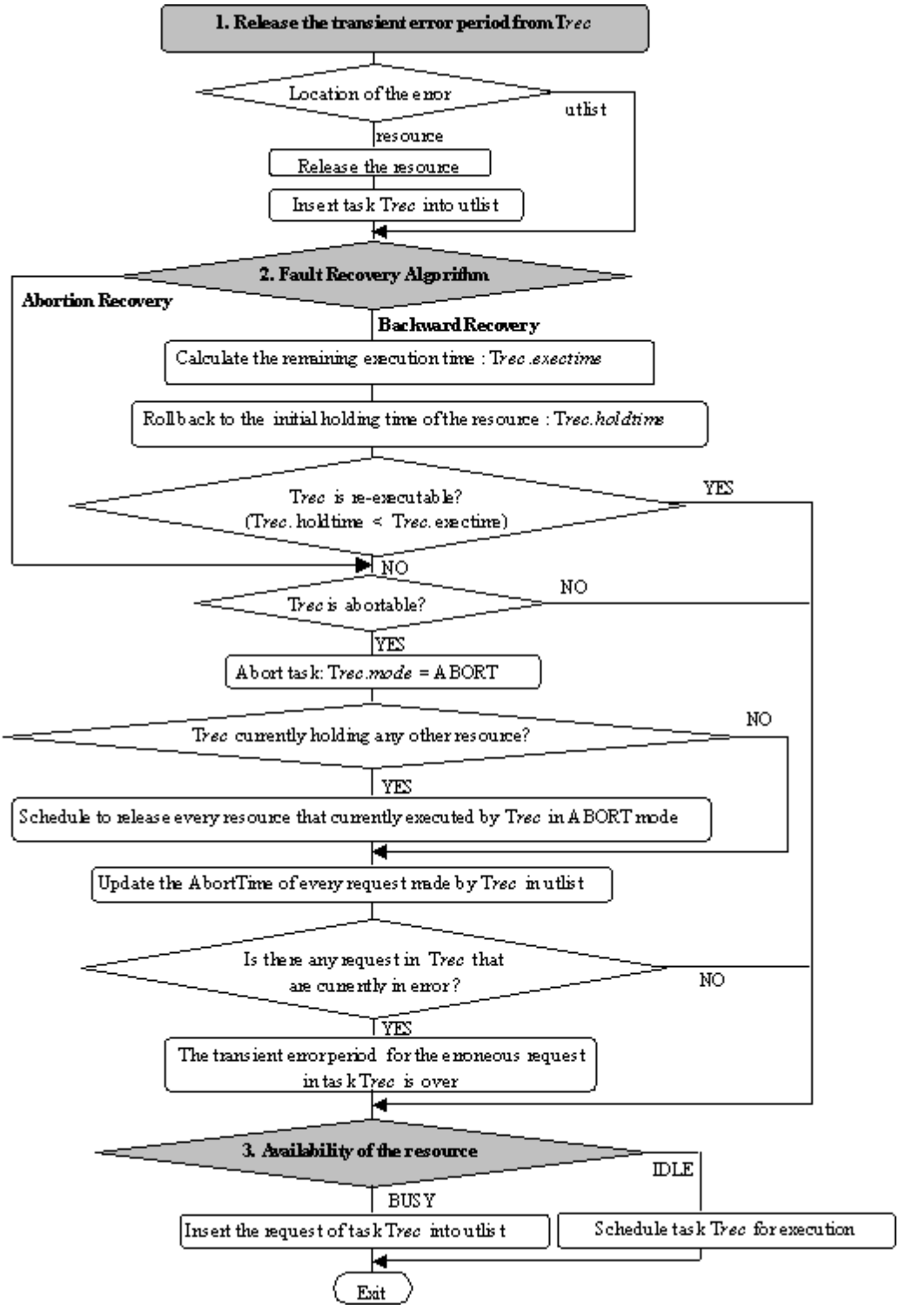

Figure 4. Fault Recovery Algorithms

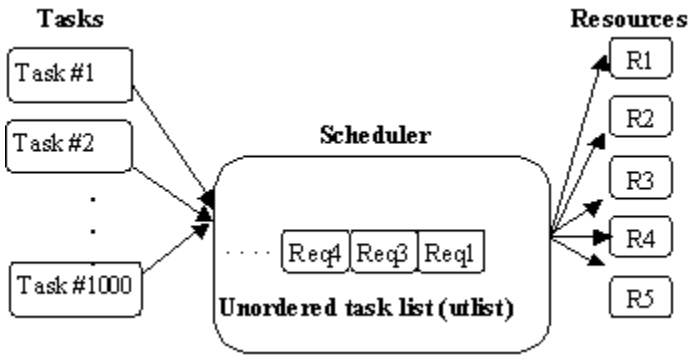

Figure 5. Simulation Model

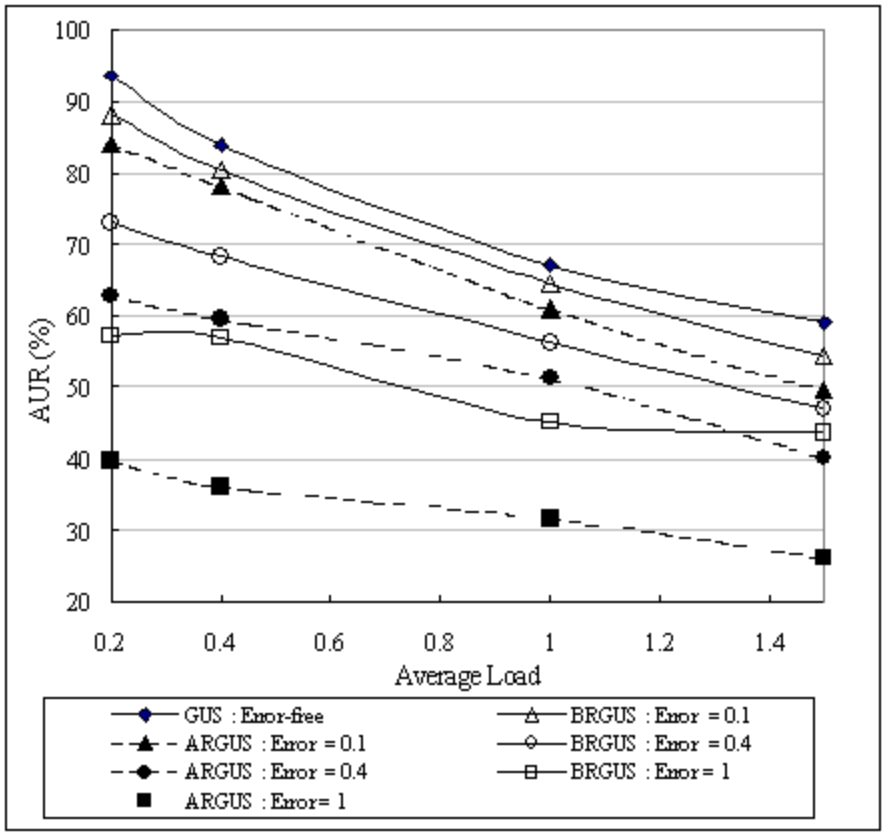

Figure 6. Accrued Utility Ratio (AUR) vs. Average Load

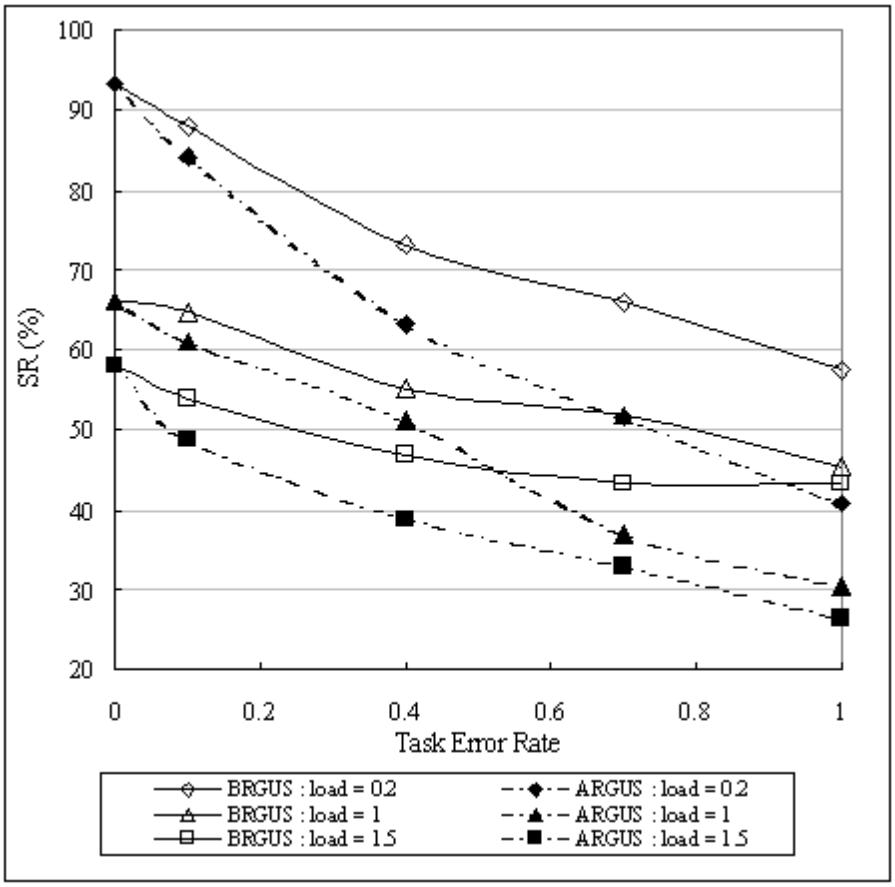

Figure 7. Success Ratio (or SR) vs. Task Error Rate

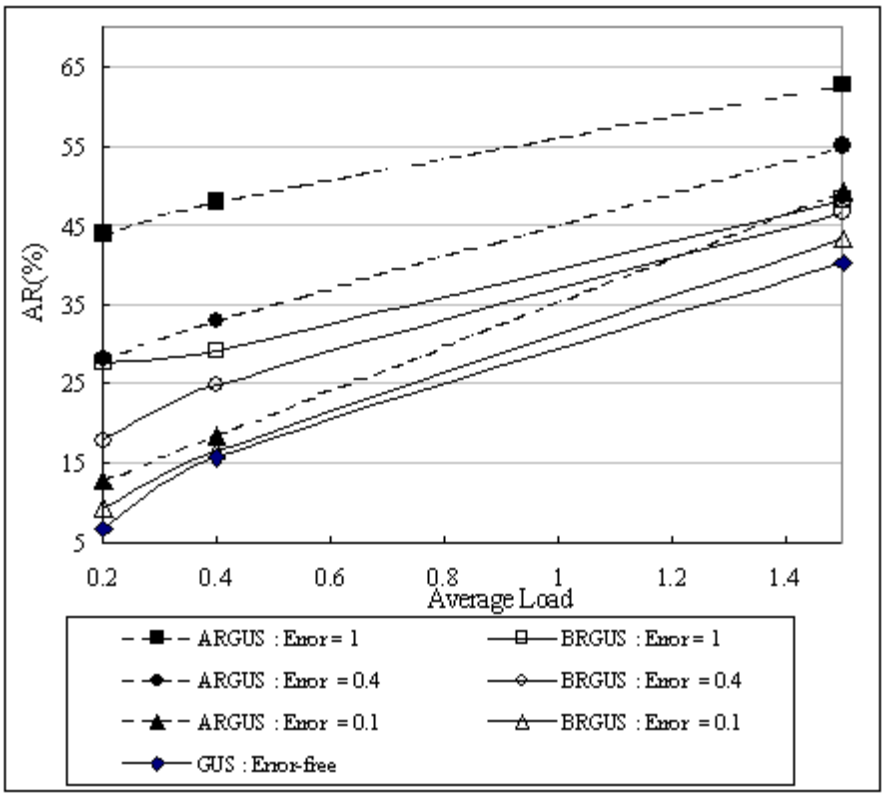

Figure 8. Abortion Ratio (or AR) vs. Average Load

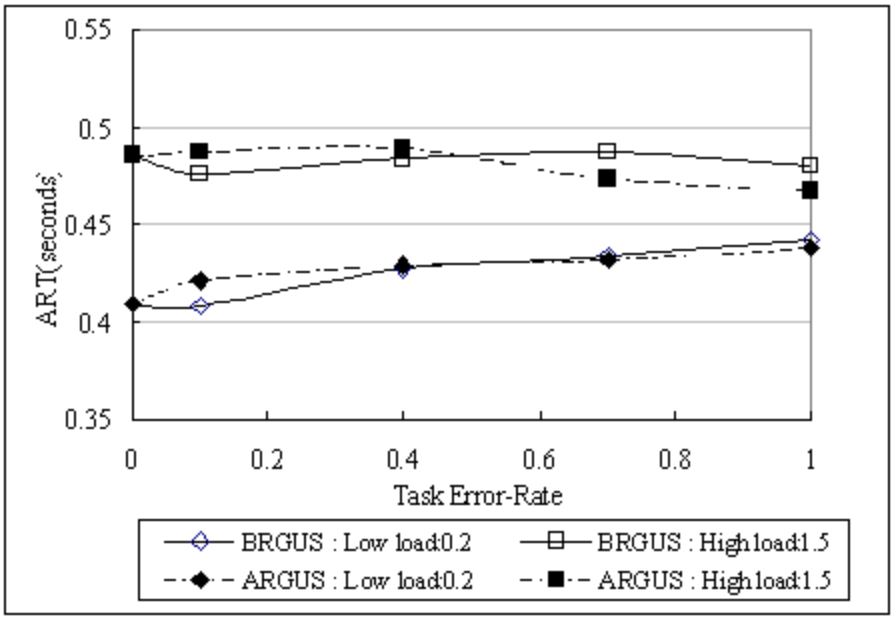

Figure 9. Average Response Time (or ART) vs. Task Error Rate

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The Fusion of Remote Sensing Images Based on Lifting Wavelet Transformation

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Abstract

The fusion of remote sensing images has become one of the new hotspots in recent years. It can not only improve spatial resolution effectively, but can keep the integrity of the multi-spectral image. In this paper, we take the Hangzhou area as an example and put forward a new image fusion based on lifting wavelet transformation, and carry out the qualitative and quantitative comparison to the spatial characteristics and spectral characteristics with traditional fusion methods, such as IHS transform, PCA transform and Brovey transform. The results show that by lifting scheme wavelet transformation the characteristics and information of the fusion image have been preserved greatly, and the spatial quality of the original image has been better improved. Furthermore, this method is much simpler and easier.

Keywords: Remote sensing, Image fusion, Lifting wavelet transformation, IHS transform, PCA transform, Brovey transform

1. Introduction

The remarkable characteristic of modern remote sensing is to use multiple sensors, multiple resolutions, multi-spectral and multi-temporal technology together to obtain the remote sensing image with different spatial resolution, temporal resolution and spectral resolution(Zhu S L, Zhang Z M. 2000.). Spatial resolution and spectral resolution are the two highly related factors for optical sensors. Usually, the sensor with higher spectral resolusion has lower spatial resolution, though it can capture more radiation information from different object styles in various electromagnetic spectrums, and it can not obtain optimum resolution(María González-Audícana. 2004.).

Image fusion is an important image enhancement technology, which can fuse high spatial resolution and multi-spectrum image. So far, we have developed various remote sensing image fusion technologies, such as Brovey transform(Vrabel, Jim. 1996.), Principle Component Analysis (PCA)(Haydn R. 1982.), IHS transform(Chavez S, Sides C, Anderson A. 1991.), high-pass filtering(Chang S G, Yu B. 2000.), multi-resolution analysis (Aiazzi B, Alparone L, Baronti S, et.al. 2002.) and wavelet transformation(Chipman J, Orr M, Lewis N. 1995.)(Li H, Manjunath B S, and Mitra S K. 1995.)(Kingsbury G. 2000.). Brovey transform, IHS transform, PCA transform are most widely used in many remote sensing commercial softwares. But they have two defects. Firstly, it requires three low-resolution images in Brovey transform and IHS transform, or even more for PCA transform. Secondly, compared to low-resolution image, there will be a general spectral distortion in fused images. During the fusion of remote sensing image, the spectral and detailed information should be both taken into consideration. Wavelet transformation is a famous algorithm in recent years, which can retain effective original spectral information while enhancing spatial resolution. First, original image is

decomposed into approximate and detailed image by wavelet transformation, and then fuse the image on each characteristic fields by high frequency substitution. Though wavelet transformation has multi-resolution and more advantages in the image fusion with different image resolution, it has larger computational complexity.

In this paper lifting scheme (Calderbank R, Daubechies I, Sweldens W. 1998.) and a new wavelet transformation based on lifting scheme is introduced. To prove its effectiveness, the experiment with ETM+ multi-spectral image and panchromatic imagery based on the Hangzhou area is conducted, and the spectral quality and spatial quality are also analyzed and compared with the traditional fusion such as IHS transform, PCA transform and Brovey transform.

2. Common image fusion algorithms

2.1 IHS transform

IHS transform refers to a transformation between RGB space and IHS space, it can transform the color space from red (*R*), green (*G*), blue (*B*) to hue (*H*), saturation (*S*) and intensity (*I*). The former describe the color from physics while the latter from human subjective vision. Firstly, the spatial characteristic (*I*) and spectral characteristics (*H*, *S*) is separated. Secondly, the high-resolution image is stretched according to *I* component, and then *I* was substituted by the high-resolution image. At last, IHS inverse transform is carried out to improve resolution and enhance spectral characteristics. IHS forward and reverse transformation formulas are as follows (Zhang W, Ding X W, Chen H L. 2007.).

2.2 PCA transform

Principle Component Analysis(PCA)is a multi-dimensional orthogonal linear transformation based on computing the statistical character of the imagery, which is called K-L transform in mathematics(Zhang W, Mao Q M, Zhang X C, et.al. 2005.). It aims to compress and integrate the multi-band imaginary information into one image, using main components information to substitute the information of multi-band image, so that the information of different bands could be furthest displayed in new and irrelevant images. PCA transform first requires PCA forward transformation to obtain n (n≥3) components and stretches high resolution panchromatic band and other data to obtain the same mean and variance with the first principal component, and substitutes the first principal component with stretched high resolution image and fuse the image by PCA reverse transformation.

2.3 Brovey transform

Brovey transform is a simpler but widely-used RGB color fusion. The algorithm decomposes the phase space of the multi-spectral image into color and intensity, which essentially substitute the *I* component of multi-spectral image with high resolution image. It simplifies the image transformation coefficience to furthest reserve the multi-band image information, and all the intensity information is transformed into high resolution panchromatic image. The formulas of Brovey transform are as follows:

$$\begin{cases} \mathrm{Re}\, d = Pan \cdot R/(R+G+B) \\ Green = Pan \cdot G/(R+G+B) \\ Blue = Pan \cdot B/(R+G+B) \end{cases} \tag{1}$$

In this formula, *R* stands for the red band of multi-band image, *G* stands for the green band of multi-band image, *B* stands for the blue band of multi-band image, and *PAN* stands for the intensity of high spatial resolution image.

In addition, Brovey transform need better pretreatments and noise filtering in order to reduce redundant data and non-spectral information.

3. Image fusion based on lifting wavelet transformation

3.1 Lifting wavelet scheme

Lifting wavelet transformation is a new wavelet construction proposed by Sweldens based on lifting scheme. Lifting scheme consists of split, predict and update. This reversible wavelet transformation is applied widely in the image process and becomes the core part of JPEG2000. Besides, lifting method avoids FFT operation of a convolution and requires only shift, addition and subtraction operations, which makes the hardware implementation easier.

The frame of lifting format is as follows:

①split: suppose there is a source data set s_0, and split the data set s_0 into two subsets s_1 and d_1. The simplest way is to split s_0 into even sequence d_1 and odd sequence s_1, namely

$$\text{split}\ (s_0) = (s_1, d_1) \tag{2}$$

②predict: according to correlation between image data, a prediction operator p which is irrelevant to data structure is adopted. First act p filter on even signal to obtain the prediction value $p(s_1)$ of odd signal. In practical application, the prediction value $p(s_1)$ is quite close to d_1, which can be substituted by the difference between d_1 and $p(s_1)$:

$$d_1 = d_1\text{-}p(s_1) \tag{3}$$

This difference has less information than d_1.

③update: some characteristics of the coefficient subset s_1 (such as mean) and s_0 are different, so the update operator u is introduced to update s_1 and preserve the integrity of signal s_0:

$$s_1 = s_1 + u(d_1) \tag{4}$$

So far the subset s_1 and d_1 substitute the original dataset s_0. When the recursion of the previous process repeats, s_1 will be divided into subsets s_2 and d_2. d_2 is substituted by difference between d_2 and $p(s_0)$, and s_2 is substituted by the sum of s_2 and $u(d_2)$. When the recursion goes on the original dataset s_0 is substituted by a more compact expression $\{s_n, d_n, \cdots, s_1, d_1\}$.

The decomposition and reconstruction of lifting scheme wavelet show as Fig.1(Sweldens W. 1998.)

This paper uses (4,2) lifting scheme to decompose and reconstruct image data:

$$\begin{cases} d_1(n) = s_0(2n+1) - \dfrac{9[s_0(2n) + s_0(2n+2)] - [s_0(2n-2) + s_0(2n+4)]}{16} \\ s_1(n) = s_0(2n) + \dfrac{d_1(n-1) + d_1(n)}{4} \end{cases} \tag{5}$$

$$\begin{cases} s_0(2n) = s_1(n) - \dfrac{d_1(n-1) + d_1(n)}{4} \\ s_0(2n+1) = d_1(n) + \dfrac{9[s_0(2n) + s_0(2n+2)] - [s_0(2n-2) + s_0(2n+4)]}{16} \end{cases} \tag{6}$$

Formula (5) is the forward wavelet transformation based on lifting scheme, Formula (6) is the reverse wavelet transformation based on lifting scheme.

3.2 Wavelet transform based on lifting scheme

Lifting wavelet transformation is a new wavelet construction based on more efficient and simpler-to-inverter lifting scheme, which needs less operation storage space and has better expansibility. Lifting wavelet transformation fuses the multi-spectral and panchromatic bands of ETM+ images. The concrete process shows in Fig2.

In this paper, we first match PAN image (high resolution image) and MS image (multi-spectral image), and resample MS image to get the same pixel as PAN images, and then stretch PAN image according to mean and variance in the single band image.

Lifting wavelet transformation of PAN image can be conducted to obtain four components by formula (5), which are *HH ´* , *LH ´* , *HL ´* and *LL ´* . And among them, *HH ´* , *LH ´* and *HL ´* represent spatial detailed information of high resolution image of "*P*" resolution, *LL ´* represents approximate image of "P/2" resolution. Lifting wavelet transformation of MS single-band image can be similarly conducted to obtain *Mi-HH ´* , Mi-*LH ´* , Mi-*HL ´* and Mi-*LL ´* .

Substitute *LL ´* with Mi-*LL ´* and reverse transformation by formula (6) to obtain Mi ´ . Till then, the fusion of PAN images and MS single-band images has been completed.

This process is repeated until the images of other bands are fused and the spatial detail information of high resolution images are conducted to various bands of multi-spectral images, so that the original images have kept both spectral information and spatial detail information.

4. Experimental Results

In order to prove the effect of lifting wavelet transform, the Landsat-7 ETM+ multi-spectral image with the resolution of 30m and panchromatic image with the resolution of 15m are fused. First, the 7, 4 and 3 bands of ETM+ image are resampled to obtain the same pixel as panchromatic image. The size of the 7, 4 and 3 bands and panchromatic band of ETM+ image is 512×512.

From Fig.3 we can see that all the spatial information of fused image is better than the original image by visual interpretation. And among them, Brovey transform leads to larger spectral distortion. But it is difficult to identify which method can keep better spatial detail information or less spectral distortion. Therefore, the quantitative evaluation of the fused images is separately carried out from the spatial quality and the spectrum quality.

4.1 Evaluation of spatial quality

In this paper, the entropy and average gradient as the two indicators to evaluate the enhancement effect of the fused images. Among them, entropy represents the abundance of image information, the higher the entropy is, the more

information the image has. Average gradient shows the fine contrast, texture characteristic and clarity. Higher average gradient has more image levels and the image is clearer. The formula of the entropy and average gradient is as follows:

$$H = -\sum_{i=0}^{L-1} P_i \times \ln P_i \tag{7}$$

H is entropy, P_i is the grey value which is equals to the probability of i and L are total grey level.

$$\nabla \overline{G} = \frac{1}{(M-1)(N-1)} \sum_{i=1}^{M-1} \sum_{j=1}^{N-1} \sqrt{\frac{\nabla_i^2 f(i,j) + \nabla_j^2 f(i,j)}{2}} \tag{8}$$

Among them, $\nabla \overline{G}$ is average gradient, $\nabla_i f(i,j)$ and $\nabla_j f(i,j)$ are the gradient on row-column direction, M and N represent the row number and column number of image f.

According to formula (7) and formula (8), the entropy and average gradient of original ETM+ and fused images are shown as tab2. We can see that compared to Brovey transform, IHS transform and PCA transform, the entropy and average gradient of the image fused by lifting wavelet transformation are larger, which means this method can hence the spatial detail information much better. Analyzed from algorithm principle, this method preserves the high frequency information by low frequency substitution in wavelet domain, which corresponds to the detail information of the multi-spectral image, so the entropy and average gradient of the fused image are larger.

4.2 Evaluation of spectral quality

In order to evaluate the spectral information, the correlation efficient and deviation index are adopted to measure the fusion quality. The correlation efficient shows the similar degree of the two images and the alternation of spectral information, while the deviation index shows the offset degree of the two images. The formula is as follows:

$$R(f_1, f_2) = \frac{\sum_{i,j}\left[\left(f_1(i,j) - \mu_{f_1}\right) \times \left(f_2(i,j) - \mu_{f_2}\right)\right]}{\sqrt{\sum_{i,j}\left[\left(f_1(i,j) - \mu_{f_1}\right)^2\right] \times \sum_{i,j}\left[\left(f_2(i,j) - \mu_{f_2}\right)^2\right]}} \tag{9}$$

Among them, $R(f_1, f_2)$ is the correlation efficient of f_1 and f_2, and $f_1(i, j)$ and $f_2(i, j)$ are the grey values of f_1 and f_2 on the point (i, j). u_1 and u_2 are the average grey values of the two images.

$$D = \frac{1}{MN} \sum_{i,j} \frac{\left| \hat{f}(i,j) - f(i,j) \right|}{f(i,j)} \tag{10}$$

Among them, D is the deviation index of $\hat{f}$ compared to f, M and N are the row number and column number of f, and $\hat{f}(i,j)$ and $f(i, j)$ are the grey values on the point (i, j) of the fused image and original image.

We can see that compared to Brovey transform, IHS transform and PCA transform, the image fused by lifting scheme wavelet transformation has the highest correlation coefficient and the lowest deviation index, which means that this method keeps more spectral information of the low resolution images. Analyzed from algorithm principle, Brovey transform fuses high resolution panchromatic images and multi-spectral images directly by multiplication, while IHS transform substitutes I component with panchromatic image and results in spectral distortion. PCA transform substitutes PC1 component with panchromatic image, which results in the loss of spectral information. The method proposed in this paper makes full use of the thoughts of wavelet transformation and fuses the images on the sub-band to preserve spectral information.

5. Conclusions

In this paper, we introduce the lifting wavelet transformation fusion of low resolution multi-spectral image and high resolution image. This method decomposes the panchromatic image with high resolution and the multi-spectral image with low resolution by lifting wavelet transformation. It fuses the low-frequency component of the high resolution image into the low-frequency component of the multi-spectral images, which further reserves spectral information of original image and enhances spatial resolution of fused image. The results show that compared to Brovey transform, IHS transform and PCA transform, the lifting wavelet transformation fusion is a better fusion method.

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Table 1. IHS Forward and Reverse Transformation Formulas

Condition	Forward Transformation Formula	Reverse Transformation
$R>B \leq G$ or $0 \leq H<1$	$I = (R + G + B) / 3$ $H = (G - B) / [3 (I - B)]$ $S = 1 - B / I$	$R = I (1 + 2S - 3SH)$ $G = I (1 - S + 3SH)$ $B = I (1 - S)$
$G>R \leq B$ or $1 \leq H<2$	$I = (R + G + B) / 3$ $H = (B - R) / [3 (I - R)] + 1$ $S = 1 - R / I$	$R = I (1 - S)$ $G = I (1 + 5S - 3SH)$ $B = I (1 - 4S + 3SH)$
$B>G \leq R$ or $2 \leq H<3$	$I = (R + G + B) / 3$ $H = (R - G) / [3 (I - G)] + 2$ $S = 1 - G / I$	$R = I (1 - 7S + 3SH)$ $G = I (1 - S)$ $B = I (1 + 8S - 3SH)$

Table 2. Statistic parameters of spatial performance between original *ETM+* images and fusion images

Statistics \ Methods		original image	Brovey transform	IHS transform	PCA transform	lifting wavelet transformation
Entropy	Band7	3.8945	4.4069	5.2968	5.2255	5.4947
	Band4	3.9982	4.6351	5.1402	5.1850	5.5129
	Band3	3.6828	4.4202	5.2752	5.3013	5.4828
Average gradient	Band7	16.1102	23.4662	20.6459	24.0035	24.1366
	Band4	13.2060	17.6053	19.3091	20.9073	21.1347
	Band3	13.6423	19.8649	17.5965	15.4116	23.4283

Table 3. Statistic parameters of spectral performance between original ETM+ images and fused images

Statistics \ Methods		original image	Brovey transform	IHS transform	PCA transform	lifting wavelet transformation
correlation coefficient	Band7	1.0000	0.9060	0.9321	0.9197	0.9741
	Band4	1.0000	0.9410	0.9445	0.9336	0.9802
	Band3	1.0000	0.9117	0.9411	0.9797	0.9812
deviation index	Band7	0.0000	0.5535	0.5040	0.4971	0.3731
	Band4	0.0000	0.4651	0.3854	0.3804	0.3166
	Band3	0.0000	0.4963	0.3707	0.2895	0.2381

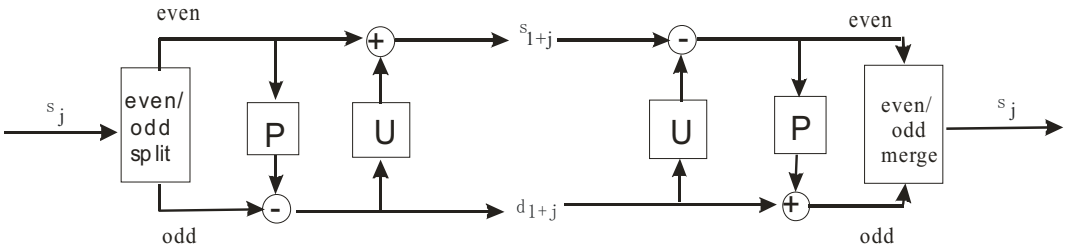

Figure 1. Decomposition and reconstruction of lifting scheme wavelet

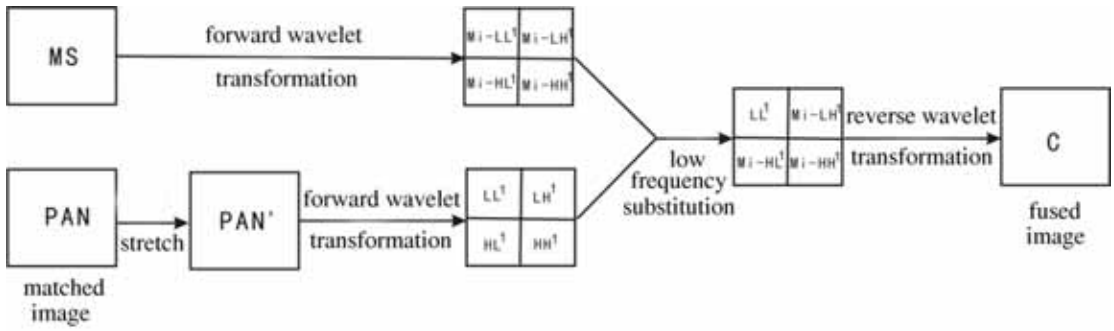

Figure 2. Remote sensing image fusion based on lifting scheme wavelet transformation

(a) Original ETM+743 bands image

(b) Original ETM+ PAN image

(c) Fusion image using Brovey transform

(d) Fusion image using IHS transform

(e) Fusion image using PCA transform

(f) Fusion image using the proposed method

Figure 3. Experimental results by different fusion methods

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Individual Differences, Perceived Ease of Use, and Perceived Usefulness in the E-Library Usage

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Abstract

This study examines the usage of e-library among students in a public university in Malaysia using the Technology Acceptance Model. Data from a questionnaire survey of 201 students were analyzed using linear regression. The results show that individual differences (computer self-efficacy and knowledge of search domain) had a significant positive relationship with perceived ease of use. Perceived ease of use showed significant relationship with perceived usefulness but non significant with the actual usage of the e-library. For perceived usefulness, it showed a significant relationship with the actual usage of the e-library. Lessons and discussions for individual differences, perceived ease of use, perceived usefulness, and actual usage are presented.

Keywords: Computer self-efficacy, Knowledge of search domain, Perceived ease of use, Perceived usefulness, Actual usage, E-library, Malaysia

1. Introduction

The term “e-library” has been associated with many connotations such as digital library, hybrid library, or virtual library. There are different definitions in the literature as to what constitutes an e-library. Akla (2002) as cited in Ramayah, Aafaqi, and Ignatius (2004), for example, defined e-library as the digital library that requires technology to link the resources of many libraries and information services. Deb, Kar, and Kumar (2003) defined e-library as a system that is accessible from anywhere via the Internet, to deliver knowledge directly to their users, without being confined to the contents neither of a physical library nor by being caught in a web of unorganized, unmanaged information. The emergence of e-library provides more opportunities for users to access a variety of information resources.

There a lots of reasons why e-library is important especially for the students in doing their course work assignments, so that they can do their work more efficiently and faster. Chen (2000) pointed out that e-library use the internet to create and store massive amounts of digital media information. To satisfy the demands of library users, e-library provides highly efficient and consistent methods for the search and retrieval information. Furthermore, e-library is the integration of materials, collection, information, services and operation (Chen, 1999). Ke (2000) shows that e-library are composed of three important factors; electronic collection, electronic operation, and electronic service. Besides that, the goal of e-library is to perform online all the functions of the traditional library, plus many more available in today's digital world (Deb et al., 2003).

Millions of dollars have been invested into the development of e-library. However, research on the e-library is still in its infancy (Xie, 2006) particularly the applicability of the Theory of Acceptance Model (TAM) on user acceptance of e-library. Therefore, there is a need for research to identify the factors that determines users' adoption of e-library. Using the TAM as theoretical framework, this study investigates the effect of the set of individual differences to the usage of e-library.

2. Review of literature and hypotheses development

2.1 Technology Acceptance Model (TAM)

Davis (1986) developed the Technology Acceptance Model (TAM) in studying the determinants of IT usage. The goal of TAM was "to provide an explanation of the determination of computer acceptance that is generally capable of explaining user behaviour across a broad range of end-user computing technologies and user populations, while at the same time being both parsimonious and theoretically justified" (Davis, 1989). TAM can be seen as an adaptation of the generic Fishbein and Ajzen's Theory of Reasoned Action (TRA) and was developed to explain individual system use in the workplace (Davis, 1989). TAM posits that perceived ease of use (PEOU) and perceived usefulness (PU) are important factors that determine the user's attitude toward his or her intention to use and actual usage of information systems (IS). According to TAM, usage behavior is a direct function of behavioral intention which in turn a function of attitude toward usage reflect feelings of favorableness or unfavorableness toward using the technology and PU which reflect the belief that using the technology will enhance performance. Attitude is determined jointly by PU and PEOU (Davis, 1989). Furthermore, a key purpose of TAM is to provide a basis for discovering the impact of external variables on internal beliefs, attitudes, intentions, and usage. The TAM developed by Davis (1986) is shown in Figure 1.

2.1.1 Individual Differences

According to Hong, Thong, Wong, and Tam (2002), individual differences are believed to be most relevant to both IS success (Harrison & Rainer, 1992; Zmud, 1979) and human computer interaction research (Dillon & Watson, 1996). Individual differences play a major role in determining user performance on information retrieval systems (Chen, Czerwinski, & Macredie, 2000). Previous studies have examined various individual differences such as computer self-efficacy (Chau, 2001; Hong et al., 2002; Ramayah & Aafaqi, 2004; Thong, Hong, & Tam, 2004; Ramayah, 2006; Amin, 2007; Hasan, 2006), knowledge of search domain (Hong et al., 2002; Thong et al., 2004; Ramayah, 2006), computer experience (Thong et al., 2004; Ramayah, 2006), and demographic variables (Lu, Yu, Liu, & Yao, 2003) on technology acceptance. Following research by Hong et al. (2002), this study will examine computer self-efficacy and knowledge of search domain as individual differences in the context of e-library usage. In the following section, these individual differences will be explored that may influence user acceptance of e-library.

2.1.2 Computer Self-Efficacy

In the context of using IS, computer self-efficacy represents "an individual's perceptions of his or her ability to use computers in the accomplishment of task, rather than reflecting simple component skills' (Compeau & Higgins, 1995, p. 191). Prior IS research has found that computer self-efficacy has a positive impact on perceived ease of use (Agarwal, Sambamurthy, & Stair, 2000; Venkatesh, 2000; Hong et al., 2002; Thong et al., 2004; Hasan, 2006; Amin, 2007). The proposed relationship between computer self-efficacy and PEOU is based on the theoretical argument by Davis (1989) and Mathieson (1991). Library and information science researchers have also recognized the possible impact of computer literacy on increasing usage of information retrieval systems (Jacobson & Fusani, 1992; Davies, 1997). Thus,

H_1: Computer self-efficacy is positively related to perceived ease of use of the e-library.

2.1.3 Knowledge of Search Domain

Knowledge of search domain is another individual difference that may positively affect PEOU of e-library. According to Thong et al. (2004), in a study of information seeking behaviour in a hypertext environment, domain experts were found to conduct faster and more focused searches than did the novices (Marchionini, Lin, & Dwiggins, 1990). Prior studies (Hong et al., 2002; Thong et al, 2004; Ramayah, 2006) have shown that knowledge of search domain does have a significant and positive relationship with PEOU. The associated hypothesis for testing in this study is as follows:

H_2: Knowledge of search domain is positively related to perceived ease of use of the e-library.

2.1.4 Perceived Ease of Use

PEOU has been extensively studies in the IS literature. PEOU is the "degree to which a person believes that using a particular system would be free of effort" (Davis, 1989; Dholakia & Dholakia, 2004). The easier it is for a user to interact with a system, the more likely he or she will find it useful (Thong et al., 2004). There is substantial empirical support for this view (Chau, 2001; Hong et al., 2002; Thong et al., 2004; Ramayah & Aafaqi, 2004; Ramayah et al., 2004; Lallmahamood, 2007; Shim & Viswanathan, 2007; Amin, 2007). In the digital libraries setting, Hong et al. (2002) submitted that digital libraries need to be both easy to learn and easy to use. Based on the evidence that link perceived ease of use with perceived usefulness in the context of e-library, it is hypothesized that:

H_3: Perceived ease of use is positively related to perceived usefulness of the e-library.

When the application of the e-library is perceived to be easier to use, it is more likely to be accepted by the users. Although most researches have found perceived usefulness to be directly related to usage, there are some findings that show no significant effect on usage such as Ndubisi, Jantan, and Richardson (2001). There are also many researches that have found ease of use to be influential in system usage (Adams, Nelson & Todd, 1992; Davis, 1989; Ramayah, Siron, Dahlan, & Mohammad, 2002; Ramayah & Jantan, 2004; Ramayah & Aafaqi, 2004). Hence, the hypothesis posited in this study is as follows

H_4: Perceived ease of use is positively related to actual usage of e-library.

2.1.5 Perceived Usefulness

PU is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989). Within the organizational context, a system that is high in perceived usefulness is one that the user believes will have a positive use-performance relationship. In fact, IS adoption research suggests that "a system that does not help people perform their jobs is not likely to be received favourably" (Nysveen, Pedersen, & Thornbjomsen, 2005, p. 537). The ultimate reason that users exploit digital libraries is that they find the systems useful to their information needs or search tasks (Hong et al., 2002). Past researches (Ramayah et al., 2004; Ramayah & Aafaqi, 2004; Davis, 1989; Mathieson, 1991; Adams et al., 1992; Segars & Grover, 1993, Igbaria, Iivari, & Maragahh, 1995; Igbaria, Zinatelli, Cragg, & Cavaye, 1997; Ndubisi et al., 2001; Ramayah, Ignatius, & Aafaqi, 2002, Ramayah, Sarkawi, & Lam, 2003) has shown that PU influences computer usage directly. Hence, it is hypothesize that:

H_5: Perceived usefulness is positively related to actual usage of e-library.

3. Research model

Based on the above discussion, an augmented TAM was proposed (Figure 2). The model was adapted from the previous study by Hong et al. (2002), Thong et al. (2004), and Ramayah et al. (2004).

4. Methodology

4.1 Research design and sampling

The population for this study was students from one of the Malaysian public university. A convenience sample was drawn from this population (n=201). Convenience sampling refers to the collection of information from members of the population who are conveniently available to provide it (Sekaran, 2003). A survey-questionnaire approach was used to gather data in this study. A questionnaire was personally administered to the student in the university. This method is chosen because the designed questionnaire could be collected within a short period of time and any doubts that the respondents might have on any question could be clarified on the spot (Sekaran, 2003).

The average age of the students was 23 years, and the majority (96%) were single. More than half of the students were female (58.7%), while 82.6 per cent were Malay, 11.9 per cent were Sarawak Bumiputera, and 5 per cent Sabah Bumiputera. In terms of status of candidacy, most students reported they are full-time students (77.6%), the remainder part-time students. In respect of faculty, almost half of the students came from Faculty of Administrative Science and Policy Studies (43.3%), Faculty of Information Technology and Quantitative Sciences (21.4%), Faculty of Architecture, Planning and Surveying (2.5%), Faculty of Mechanical Engineering (1.5%), Faculty of Applied Sciences (3.5%), Faculty of Hotel and Tourism Management (6.5%), Faculty of Business Management (15.4%), Faculty of Civil Engineering (0.5%), Faculty of Art and Design (1%), and Faculty of Accountancy (4.5%).

4.2 Measurements

Computer self-efficacy was measured with the ten-item measure developed by Compeau and Higgins (1995). Knowledge of search domain was tapped by Davies's (1997) two-item scale. PEOU and PU were measured by four items each, taken from Hong et al. (2002). These items in the questionnaire were rated on five-point Likert scales raging from 1 = strongly disagree o 5 = strongly agree, except computer self-efficacy, which was rated from 1 = not at all confident to 5 = totally confident. Actual usage was assessed with the frequency of usage and daily usage measure developed and validated by Igbaria et al. (1995) and Thompson, Higgins, & Howell (1991). Frequency of e-library

usage is measured on a five-point scale ranging from 1 = never/almost never to 5 = several times a day, whilst daily e-library usage is measured by the amount of time spent daily on the databases. A five-point scale ranging from 1 = never/almost never to 5 = more than three hours per day is used to measure daily e-library usage.

5. Findings

5.1 Means, standard deviations, reliability, and correlations between all study variables

A summary of the means, standard deviations, reliability, and correlations is provided in Table 1.

It can be seen that the mean value for each of the study's variables ranges from 2.856 to 3.479, with a standard deviation of .461 to 1.123. It revealed that all variables charted higher than the midpoints of their respective scales except for actual usage. To assess reliability among the study's variables, Cronbach's alpha values were generated. Alpha values of .765 (computer self-efficacy), .776 (knowledge of search domain), .846 (PEOU), .855 (PU), and .820 (actual usage) suggested more than adequate reliability within the respective factors (Nunnally & Bernstein, 1994).

According to correlations between variables, PEOU and PU have a strong and positive relation (r=.558, p<.01). Computer self-efficacy (r=.243, p<.01) and knowledge of search domain (r=.434, p<.01) affects PEOU in a positive manner, as well. However, this effect is not as strong as PU. PEOU (r=.183, p<.01) and PU (r=.224, p<.01) also positively affect actual usage. The zero order correlation between computer self-efficacy and PU and computer self-efficacy and actual usage were non-significant.

5.2 Direct effects of computer self-efficacy and knowledge of search domain and perceived ease of use variables

The results of the tests of effects of computer self-efficacy and knowledge of search domain and PEOU are presented in Table 2. It can be seen that R^2 value of .258 suggests that 25.8 per cent of the variance in the PEOU is explained by computer self-efficacy and knowledge of search domain. In addition R^2 change (0.258) is significant. This implies that the additional 25.8 per cent of the variation in the PEOU is explained by knowledge of search domain and computer self-efficacy. The Durbin-Watson index (1.963) shows that auto-correlation was not the problem. Knowledge of search domain (β = .459, p < .01) and computer self-efficacy (β = .159, p < .05) had significant and positive effects on PEOU. Thus, H_1 and H_2 were supported.

5.3 Direct effects of perceived ease of use and perceived usefulness variables

As depicted in Table 2, the coefficient determination (R^2) was found to be .325 indicating that 32.5 per cent of PU is explained by PEOU. The R^2 change (.325) is significant. This implies that the additional 32.5 per cent of the variation in PU is explained by PEOU. The value of Durbin Watson index is 1.883. PEOU (β = .570, p < .01) had significant and positive effects on PU. Based on this result, it provided support for H_3.

5.4 Direct effects perceived ease of use and perceived usefulness and actual usage variables

An examination of Table 2 revealed that only PU (β = .177, p < .05) had significant and positive effect on actual usage. Contrary to expectation, there was no significant relationship between PEOU and actual usage. Based on these results, H_5 and H_4 are rejected. R^2 is 5.5 percent. The R^2 change is 5.5 per cent and was found to be significant (p<.01). This findings show that an additional 5.5 percent of the variations in the actual usage is explained by PEOU and PU. The Durbin-Watson index is at 2.111, which is within the acceptable range 1.5 to 2.5 (Coakes & Steed, 2003). It shows no auto-correlation problems detected in the model.

6. Discussion and conclusions

This study tested the relation between individual differences (computer self-efficacy and knowledge of search domain) and PEOU on the one hand and PEOU and PU towards the actual usage of e-library on the other. In addition, PEOU is examined in relation to PU. In general, four hypotheses were confirmed, but one was rejected.

6.1 Computer self-efficacy

As predicted, there was a positive relationship between computer self-efficacy and PEOU of the e-library. Thus, it received support for research hypothesis. This finding is consistent with previous research that has found positive relationship between computer self-efficacy and PEOU of use in IS research (e.g., Hong et al., 2002; Thong et al., 2004; Ramayah & Aafaqi, 2004; Hasan, 2006; Amin, 2007). This finding implies that the high level of computer self-efficacy indicated that the students will be have high levels of confidence in using e-library in general especially in doing their assignment and more likely to find the e-library is easy to use. Hence, high level of computer self-efficacy indicates that the students will be often using e-library in their study. Besides, students can also improve their performance in their study once they are confident in using e-library.

6.2 Knowledge of search domain

As shown in the regression result of this study, knowledge of search domain was found to be contributing to PEOU of e-library. This result support prior research of Hong et al. (2002), Thong et al. (2004), and Ramayah (2006) on user

acceptance of digital libraries or e-library. Domain experts could conduct faster and more focused searches than novices as they are able to separate relevant information from irrelevant responses and increase effective searches (Ramayah, 2006). This finding supports the recommendation of library science researchers to provide customized interfaces to different individuals (Archer, Head, & Yuan, 1996; Meadow, Wang, & Yuan, 1995). When the students are familiar and knowledgeable with e-library it will encourage the students using e-library frequently in their study.

6.3 Perceived ease of use

The result from this study also suggested the significant and positive relationship between PEOU and PU. This result is in line with previous studies on this link (Chau, 2001; Hong et al., 2002; Lallmahamood, 2007; Shim & Viswanathan, 2007; Ramayah & Aafaqi, 2004; Ramayah et al. 2004; Thong et al., 2004; Amin, 2007). This indicates that if students find that the e-library is easy to use, they will be more willing to use it for information retrieval in order to improve the quality of their assignments.

The finding of an insignificant relationship between PEOU and actual usage did concur with Ramayah and Aafaqi's (2004) and Igbaria and Iivari's (1995) insignificant finding. More work needs to be done in this area.

6.4 Perceived usefulness

PU was also found to be positively related to actual usage of the e-library. It implies that if students feel that a system is useful, their usage level will be higher. This finding support prior research that has found a direct positive relationship between PU and actual usage (Ramayah et al., 2004; Ramayah & Aafaqi, 2004; Davis, 1989; Mathieson, 1991; Adams et al., 1992; Segars & Grover, 1993, Igbaria et al., 1995, 1997; Ndubisi et al., 2001; Ramayah, Ignatius, & Aafaqi, 2004; Ramayah, Jantan, & Aafaqi, 2003).

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Table 1. Descriptive statistics, reliability, and correlations

		Cronbach's Alpha	Mean	S.D.	1	2	3	4
1.	Computer Self-Efficacy	.765	3.461	.461				
2.	Knowledge of Search Domain	.776	3.231	.654	.146*			
3.	PEOU	.846	3.394	.606	.243**	.434**		
4.	PU	.855	3.479	.614	.122	.283**	.558**	
5	Actual Usage	.810	2.856	1.123	-.094	.236**	.183**	.224**

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 2. Results of regression

Variables	Perceived Ease of Use (Std Beta)	Perceived Usefulness (Std Beta)	Actual Usage (Std Beta)
Computer Self-Efficacy	.159**		
Knowledge of Search Domain	.459***		
PEOU		.570***	.085
PU			.177**
R^2	.258	.325	.055
R^2 Change	.258	.325	.055
Sig. F Change	.000	.000	.004
Durbin Watson Index	1.963	1.883	1.997

Note: **p<.05, ***p<.01

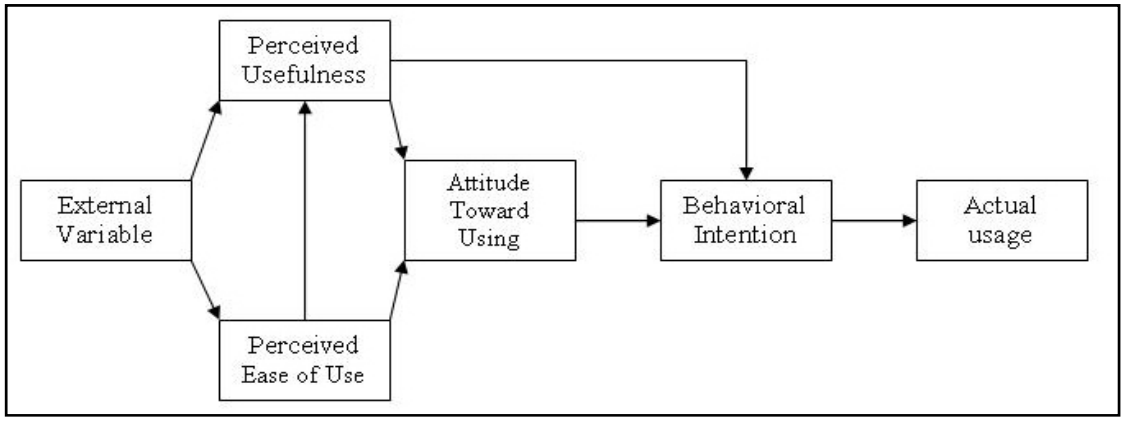

Figure 1. Technology Acceptance Model (TAM)

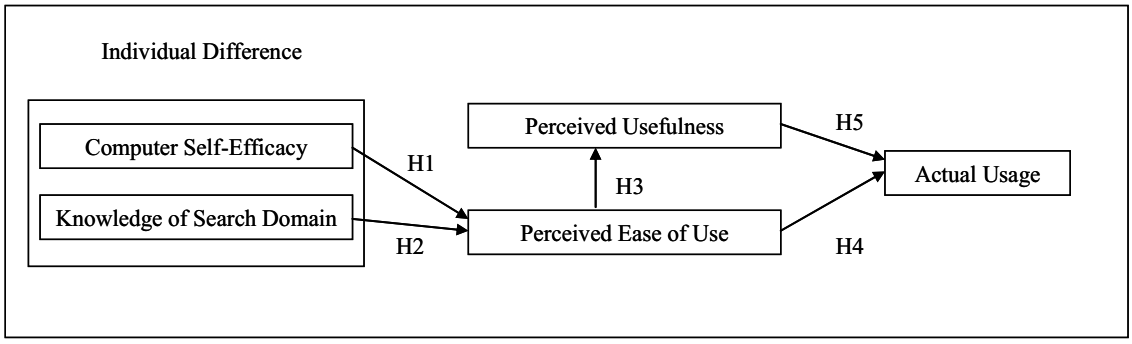

Figure 2. Research framework for e-library usage

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Research and Application of the 3D Virtual Community Based on WEBVR and RIA

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Abstract

Starting from the development of VR and WEB technologies, in this article, we analyze the characters and the development foregrounds of the 3D virtual community based on the WEBVR (Web Virtual Reality) technology, and introduce the characters of the RIA (Rich Internet Application) technology system. And we put forward the technical frame of the 3D virtual community based on WEBVR and RIA, and introduce the information organization, storage, interaction and other key technologies of the 3D virtual community based on WEBVR and RIA. Finally, taking the "Real-time Interactive 3D Simulation Web Community Platform" as the example, we prove the extensive application foreground of WEBVR and RIA in future web interaction.

Keywords: WEBVR, RIA, 3D virtual community, Value of new media

Virtual Reality (VR) is a sort of computer system which can create and experience the virtual world. The virtual world is created by the computer, and it is the reappearance of the real world, and it can also be the world in the mind, and users can naturally interact with the virtual world by virtue of many sensor channels such as vision, hearing and feeling. It can create a 3D virtual world which can real-time reflect the changes of entity objects and interactions for users by the mode of simulation, and offer users a 3D interface where users can interact with the virtual world and make users directly participate in and explore in the function and changes of simulation objects in the environment and produce immersion feelings by helmet-mounted display (HMD), data gloves and other assistant sensors.

With the development of VR and relative domains, only the analog and simulation to real scenes have not completely fulfill users' high-layer demands, and real-time and dynamic scene digital information acquisition based on web and effective management, transmission and analysis computation are inspired as a sort of new demand. Under this background, the combination of WEB3D and VR is the necessary tendency for the technical development.

WEBVR is the web virtual reality technology based on Internet which is realized depending on the software technology. In 1994, Mark Pesce and Tony Parisi created the browser which was called as Labyrinth, and it was the initial shape of 3D browser on WWW. The game of Second Life developed by US Linden Lab perfectly combined VR and WEB3D, i.e. in a 3D space, establishing virtual online world can copying various scenes, details and experiences of human living to the Internet. After Google Company pushed the 3D map orientation technology based on satellite image diagrm, Google Earth, it also pushed the online war game GEWar taking Google Earth as the platform. The new edition map service issued by US Microsoft could simulate "Virtual Earth 3D", offer the vivid simulation of real world, establish real and sensitive construction model through pictures and make users "fly" and enjoy the diorama in the browser. The implementation of web virtual reality based on WEBVR is the result to effectively integrate "social media" and "user-generated content".

1. Characters and development foreground of the virtual community technology based on WEBVR

In existing WEBVR virtual community, users browse through user website and log in the system user main interface through web browser, browse through the classification content according to the main control menu, interact with community activity according to system information, and produce interactions with other virtual people in the activity.

The webpage issuance mainly depends on WEB3D technology and WEBGIS technology, and the integration part adopts the system frame idea of the design mode and implements data transmission by virtue of XML document, and uses XHTML and CSS standardization representation, and uses DOM to realize dynamic display and interaction, and uses XML and XSTL to implement data exchange and data processing. The system structure of data exchange is seen in Figure 1.

With the quick change of Internet, Internet continually goes deep into human livings and WEB3.0 will largely change the Internet form of human living. As same as WEB2.0, WEB3.0 is not the technical innovation, but the idea innovation, and guides the development and application of the technology. WEB3.0 will create new virtual community which will be divided not by the terrain and border, but by the interests, language, topic, occupation and specialty. Everyone could create a new Internet kingdom and be the king, and be the president through democratic election in the Internet kingdom, and at that time, you will possess web citizens from all over the world.

As the substitute of WEB2.0, WEB3.0 is still based on WEB2.0, and is the Internet mode which realizes more intelligent communication among humans and between human and machine. Based on the grasp to WEB3.0 concept, in this article, we think that future web community should be new digital technology based on web virtual reality technology and intelligent information customization, and develop to the directions of subsection, specialty and compatibility.

(1) The information in the website could directly interact with information in other websites, and could be integrated and used in multiple websites through the third party information platform.

(2) Users possess their own data in the Internet and the data can not use it in other websites.

(3) WEB3.0 is completely based on WEB, and can implement the function that complex system program can only possess by browser.

2. Structure and characters of RIA system

RIA is the next generation web application which combines interactive user experience of desk application with the deployment flexibility and cost analysis of traditional web application. The rich client technology in RIA connects with existing back-end application server through offering the running environment which can load compiled client port application (transferring by HTTP and the form of file) and using asynchronous client/server frame by client application, and it is a sort of safe and updating and service-oriented model with good adaptability, and it simplifies and improves the user interaction of WEB application, and the developed application can offer more abundant user experiences with more interaction and response. At the same time, it can realize more visible and effective application service of user experience with more responses, and it can develop the application combining the strong interaction and the abundant content of desk software with the extent of web together.

The concept of “rich” includes two aspects, i.e. the “rich” of data model and the “rich” of user interface. The “rich” in data means that the user interface could display and operate more complex data model embedding into the client port, and could operate the computation of the client port and asynchronously send and receive data. Relative to traditional HTML page, the advantage of this mode is that the program runs at the client port and the program can interact with the server few when it interacts with users more. The complex data model balancing client port and server port can give you larger space to establish more effective and interactive web application. The “rich” can also describe the completely improved user interface, and HTML only offers users very limited interface control elements, and the user interface of RIA offers flexible interface control elements which can better combine with data model. Traditional Internet model uses the linear design and offers users some choices, and then users send choice results to the server, and this single mode doesn’t accord with the flexible and interactive requirement of application and users’ wills. Frequent server requests and page fresh have many deficiencies such as slow page opening speed and reduced network bandwidth. If the rich client interface is adopted, the part of application only receiving the requests could make corresponding change, but the former server response would influence the whole interface. That means the interface will be decomposed into many independent models which will make responding reactions to received information, and some of them will interact with the server port, and some of them are communications among these models.

The applied character of RIA includes following aspects.

(1) Strong interaction. RIA offers abundant UI components, strengthens localization and uses distribution to manage the components. Label guide, collapse column and tree catalog have approached to the development modes of AWT and SWING.

(2) Direct management. Using RIA, user and interface interaction only need the part needing to be disposed. The request/return model is not necessary for all user interface actions, and the computation of the client port can directly realize the responses of users’ requests.

(3) Multiple-approach processing. RIA allows development personnel to put all contents in one interface and add

conversion and effects, and makes users more easily know the context and work flow of the application. It can mainly deal with certain approach and easily be moved among approaches in the application.

(4) Client caching. Under the environment of RIA, data can be cached in the client port, and the user interface with quick response speed and small times that data come and go the server can be realized, and the EMS memory consumption of the server can be reduced, and the resource allocation will be more reasonable.

(5) Text independence. RIA text uses a sort of opening vector graph description language based on XML, so the text can be searched by the web search engine or be inquired and compiled by the user browser.

(6) Platform independence. The language style is consistent for all client ports, so the code should not be rewrote for different applications.

3. The virtual community frame based on WEBVR and RIA

RIA offers a strong technical platform which makes the computation ability of the client port can very approach to the desk software system or the ability of the client computer in traditional C/S system, and it is fit for the traditional N-layer development process. And it can also be integrated with residual environment to develop existing application but not implement large numbers of modification. The virtual community frame based on WEBVR and RIA put forward in the article is seen in Figure 2.

Under the system structure of WEBVR, the former so-called concept of single data center has not existed, and the model and geography information may be distributed in any nodes of the web, so it is urgent to make users find and use needed data in tremendous amount of Information Ocean. In addition, 3D web virtual community possesses large numbers of data with different formats, and it is a very important problem to effectively manage these data and realize information sharing. Facing this actuality, the space data storage, transmission and representation under the environment of RIA can obtain satisfactory results. Because RIA server text uses a sort of opening vector graph description language based on XML, so it can not only be used in the exact expression of data, but offer effective method of data communication among asynchronous information systems. And most present browsers all support FlashPlayer, so the client port needs not download any data processing components. For numerous non-professional users, they can conveniently organize and issue their own space information resource through various universal RIA visualization creation and editing tools and make WEBVR resources and other web resources can be shared conveniently by the whole society and fully exert their own values. On the other hand, WEBVR based on RIA can make the map in front of the client port possess more abundant interface expressive force and support complex image interaction, and make WERVR become into real interactive system.

Furthermore, the technical characters of RIA also decide that it is fit for the large scale data-oriented application. WEBVR is developed in the process converting from system-orientation to data-orientation, so whether for practical meaning or for theoretical meaning, RIA has very important meaning for WEBVR.

4. The key technology of virtual community based on WEBVR and RIA

The 3D virtual community platform based on WEBVR and RIA adopts the bottom integration frame including WEBVR, RIA and WEBGIS, and integrates web foregrounding platform module, background 3D scene map module, virtual community construction module and compressive system integration module. Its total frame uses the idea of design mode for reference, harmonizes the complexity of time and space, and enhances the natures of re-plantation and extension. For the concrete implementation of the technology, the platform uses the technology of automatic modeling which can automatically identify and acquire data and enhance the production efficiency. The platform also could establish the multidimensional data pyramid model, classify and compress the multidimensional data of various kinds of scene into corresponding data layers. For the data transmission between the client port and the server data, the platform can optimize the transmission through the transfer algorithm and implement parallel transmission of multithreading. And the platform could realize seamless integration and display multidimensional data by using the 3D panorama imaging technology and the 3D model imaging engine technology through the expressive mode of 3D reality simulation.

4.1 Seamless combination and low delay load based on browser non-insert multidimensional data

For the vector data, the platform establishes a set of vector data real-time reading, converting and rendering system from the bottom layer, and it can translate the vector data into the data format supported by the browser for transmission, i.e. the server port directly reads the vector data, and plots them to supportable format and sends them to the client port. And then the platform connects the data produced from the foreground vector data resource with 3D data resource. The platform uses exact mathematical algorithm and VR theory, considers the link compactness and the strain of the effect representation, and finally achieve the effect of seamless link through multiple times operation, which can not only inosculate with the reality but represent the art property.

After opening the browser, the system adopts pre-load technology with classified batch and parallel reading to the

multidimensional data. In the 3D space data transmission process, the single task program execution efficiency is low, and if blocks happen when program receives data input, the program can keep on running after the program obtains data. In the web environment, because the system usually receives and accepts data, if the blocks happen in the process of receiving data, the program will be in the waiting state and can not implement any operation, and this web application can not let users implement normal web interaction operations. The 3D virtual community platform based on WEBVR and RIA can overcome these problems, and it can execute multiple relatively independent threads simultaneously, establish the thread which could be used in 3D space data input, the thread which could be used in data output and the thread which could be used for data processing at the background. If the input data thread is blocked when receiving data, the output data thread and the data processing thread can still run. The design of multithreading 3D space data web transmission would largely enhance the acquisition execution efficiency and the parallel processing ability of 3D space data linking multidimensional data server through the web, and it is specially fit for the web environment and multi-computer environment.

4.2 Real-time interaction between server and client 3D information

Utilize asynchronous document transmission technology to implement interaction between the operation layer and the data layer, encapsulate the 3D information and the geographical data coding and transfer to the data layer, and through the query computation of the data layer, and the final result will be feed back to the operation layer and implement reverse coding. Implement web transmission taking XML document as the carrier to response users' operations real time.

4.3 The combination of Web community and 3D VR technology

Use Web3D to realize the VR display on the web, establish a 3D scene, and users can run in the scene from the first visual angle. The interaction created between the scene and the controllers and the HD pictures will make users be personally on the scene. In the 3D web virtual community, everyone will integrate his ID and behaviors in different web activity spaces, and map a complete self in the virtual space, and everyone will have a his own multidimensional image, and users can change his dress and body at will. Based on that, for the design of the client port, adopt RIA technology, possibly offer IM, Blog, page customization, information customization and usual software interface, and make users' usage more convenient and fulfill individual demands.

4.4 The automatic 3D modeling technology through identifying and simulating acquired data

Based on the theory of pattern recognition, automatically classify the acquired data, and divide them into segment grain data and overall arrangement image data, utilize multi-angle and multi-orientation acquired overall arrangement image data to establish the outline models of various architectures in the scene and put up the position relation of the model group. Correspond the segment grain data with the architecture surface at the corresponding position, and implement pastes after optimized processing. This new technology could make the 3D model be quickly and automatically simulated and established.

5. Implementation and expectation

In this article, we select the "real-time interactive 3D simulation web community platform" as the applied case. And the platform possesses following five characters for the interactive experience.

(1) Possessing abundant interface expressive force and quick interactive speed.

(2) Offering multiple information representation and 3D scene visualization function.

(3) The information loading speed is quick and users' waiting time is short.

(4) Click the measurement point on the WEB-3D Map, the detail geographical information can be displayed. And in the information display column, HD pictures, 360° panorama graph and VR scene are especially fit for issuing to the public.

(5) Realizing the connection with other governmental information databases, and users can directly interact with charts and acquire deeper information.

The development tendencies such as specialty, segment and compatibility of the future web virtual community decide the distributed Internet. The occurrence of RIA offers a sort of effective mechanism about information display, organization, sharing and utilization for WEBVR. As a new tool, RIA has many parts lacking in clear definitions and perfections to be developed further. We will continue to deeply study the technology of RIA. We hope the research of RIA can guide the development and practice of WEBVR community, and further enhance the computation ability of the client port, and fulfill human more and more intensive individuality demand. Otherwise, the enhancement of function also induces many hidden safe troubles which should be improved in our future researches.

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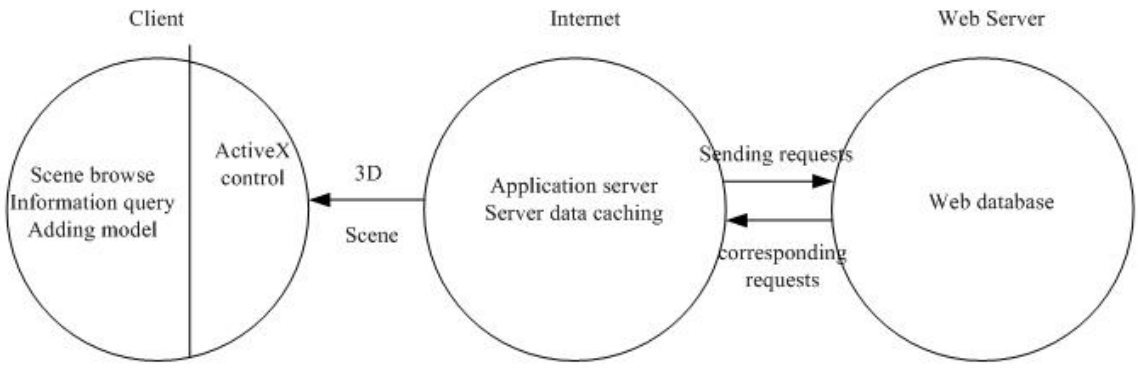

Figure 1. The System Structure of the Network VR Based on Web-3D

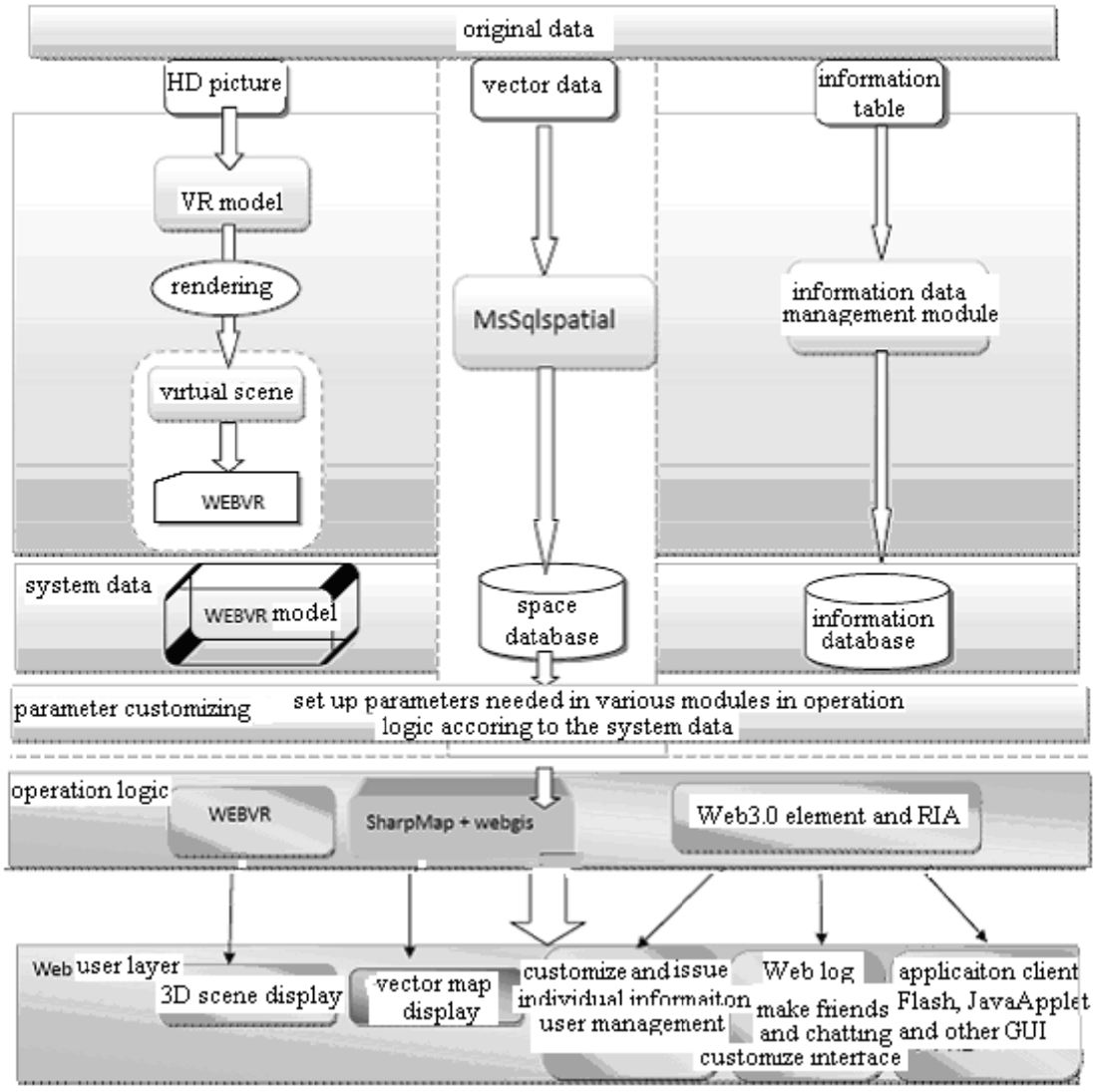

Figure 2. The Virtual Community Frame Based on WEBVR and RIA

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Framework for Conference Management System

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Abstract

This paper presents a Web-based Conference Management System framework that is intended to support multiple conferences and facilitate the conference management starting from the conference preparation until the attendance tracking process during conference day. The framework derived from the analysis of several web-based related applications. The framework is presents and the results are discussed.

Keywords: Conference Management, Web Application, System Framework

1. Introduction

Conference is a meeting for researchers to present, discuss, identify important problems and formulate future research direction on specific themes. It provides a true learning environment. However, organizing a conference entails plenty of time-consuming work. For instance, collecting paper submission from authors, assigning paper submitted to the reviewers, notifying authors about whether the paper submitted is rejected or accepted. These processes will surely consume a lot of precious time and complicated works if a conference is conducted manually. Unfortunately, there are no reports from literatures that are seriously looking in how to produce an efficient system in managing the entire process of conferences.

Lately, the need of systems for collaboration support has expanded, leading to their growing application in organizational, communication, and cooperation processes. Hence, various applications have been developed for conference organization to support or manage the workloads. The emergence of information communication technology has changed the way the conferences suppose to organize. Thus this paper analyzes several online conferences and proposes a framework for conference management system.

This paper presents a web-based Conference Management System framework that is intended to support multiple conferences and facilitate the conference management starting from the conference preparation until the attendance tracking process during conference day.

The rest of paper is organized as follows. In section 2 the analysis of features of current system and the solution are discussed. An overview of a proposed solution is discussed in section 3. Section 4 includes the result and discussion. Section 5 includes the conclusion and future suggestion.

2. Analysis of Existing Conference System

A Conference Management System shall include functions such as the online participant registration, paper submission, paper reviewing, and notification process and so on. Through the study of the Conference Management System available in the market, we study four most popular solutions for conference system which is ConfMan, CyberChair, Confious and Chairman. The study revealed some differences between the systems. Details of the analysis are listed in the table below:

The result from the Table 1 shows that each product has own advantages and disadvantages. Most of them are still lacking throughout the entire conference management process.

As far as we are concerned, there is no research to produce a common framework for any Conference Management System. Each system only developed when the conference is going to organize. The system developed not only includes the main function of a conference but also to propose a common framework that allows the conference organizer to

create and customize the conference website. Hence, the main objective of the system is to reduce the effort and in the meantime increase the efficiency and productivity in managing a conference.

3. Proposed Framework.

The old fashioned ways in organizing a conference will costs and consume a lot of precious time and effort. For this reason, technical support tools and components are integrated to cope with the problems.

Basically, the system developed consists of three layers, Conference Management Dashboard, Conference Management Platform (operation), and the database layer. There are five stakeholders for the system, namely the system administrator, conference administrator, participant, presenter and reviewer. The Conference Management Dashboard is managed by System Administrator to monitor the performance/status of all registered conference in the portal. The operation of the Conference Management System consists of several modules which are the participant registration, paper management, paper review manager, messaging module.

3.1 Paper Submission Process

For the paper submission process, "apache common fileupload" component is used to ease the process. This uploading tool allows the presenters to submit their papers electronically with just a few mouse clicks. Apart from that, the papers uploaded by presenter will be kept in a file directory that facilitate the paper management and reduce the possibility of paper lost. A search engine is built-in in order to reduce the time taken in the searching paper or document process.

3.2 Notification Process

Conference Administrator uses the messaging module to notify the presenters about the paper's acceptance decision. Other than that, the messaging module will be integrated with SMS to provide e-mail to short messaging. This SMS function is to ensure that the participants and reviewers are always updated with the conference information.

3.3 Paper Assignment Process

Paper assignment is proposed to assign the papers submitted to reviewers.

3.4 Paper Reviewing Process

The system developed allows reviewers to download and grade the papers assigned to them. Besides that, multiple files download function also included to assist Conference Administrator in downloading all the papers submitted.

3.5 Conference Customization

Content Management System (CMS) is integrated in order to assist the conference organizer to customize the conference website. This CMS allow the conference organizer to manage the creation, modification, and removal of content from a Web site without needing the expertise of a Webmaster.

4. Result and Discussion

From the stimulation, paper submission, and paper assigning process can be done within 5 seconds. Other than that, papers or documents are well-managed and errors caused by human are reduced.

5. Conclusion and Future Suggestion

The system developed is expected to reduce the cost, effort and time in managing a conference. It also promotes paperless and environment friendly by reducing the paperwork involved in a conference. Our future effort is to propose autonomous Conference Management System with the aims further reducing resources in managing conferences.

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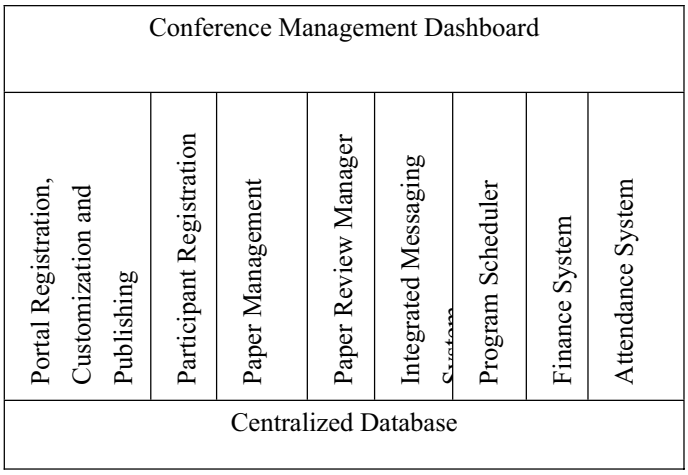
Table 1. Comparison of existing Conference Management System

Function	**ConfMan [3]**	**CyberChair [5]**	**Confious [1]**	**Chairman [4]**
Participant Registration	Y			Y
Paper Submission	Y	Y	Y	Y
Paper Assignment		Y	Y	Y
Bidding Process			Y	
Paper Downloading	Y	Y		
Paper Reviewing	Y	Y	Y	Y
Notification Process	Y		Y	Y
Online PC meeting	Y			
Setup Phase			Y	Y

Table 2. System Framework



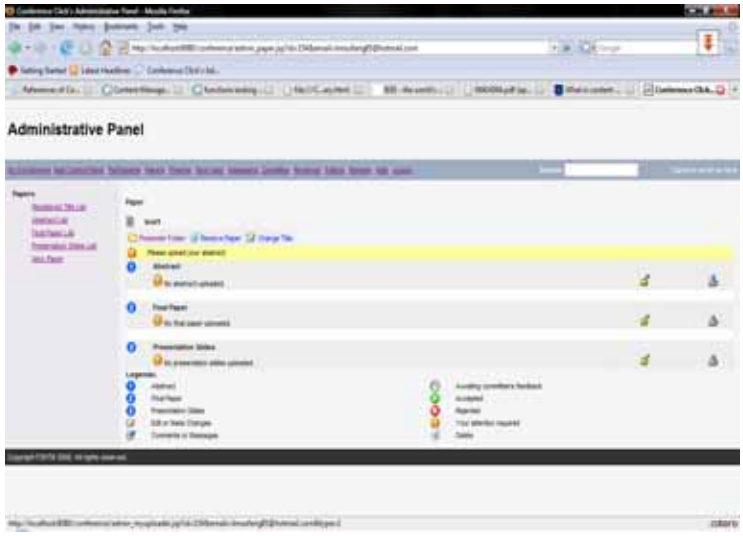


Figure 1. Screen Snapshot of Paper Submission Process

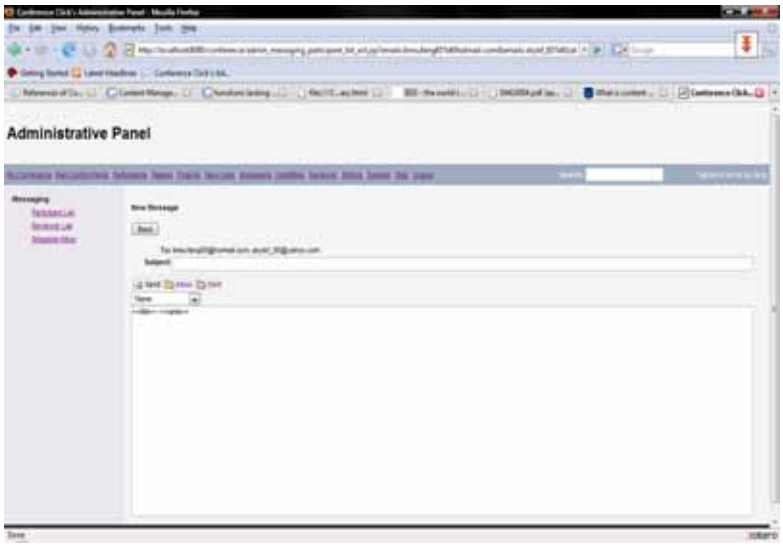


Figure 2. Screen Snapshot Notification Process

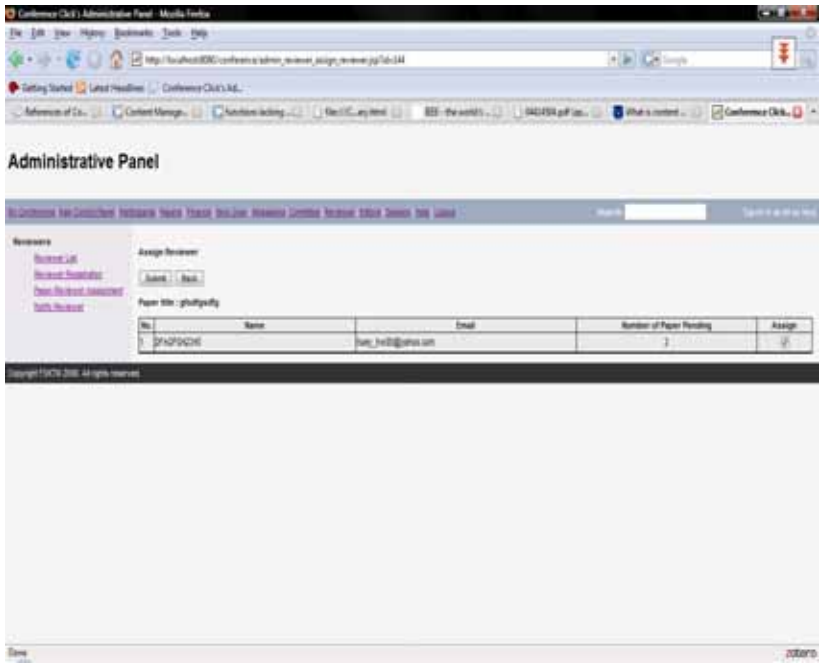


Figure 3. Screen Snapshot Paper Assigning Process

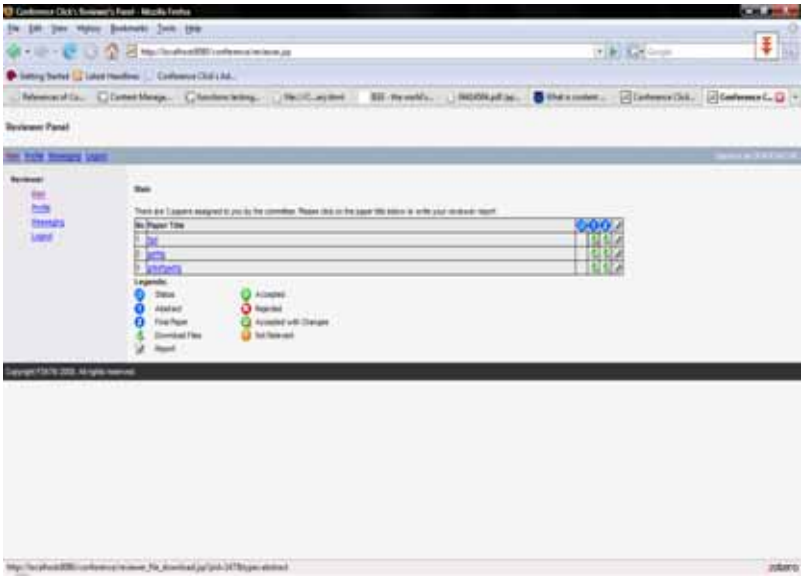


Figure 4. Screen Snapshot of Paper Reviewing Process

Figure 5. Screen Snapshot Customization Process

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Design of the Closed Loop Speed Control System for DC Motor

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Abstract

This article introduces the speed control principle of DC motor, expatiates on the speed control system taking PIC16F877 SCM as the main control component, utilizes the characters of catching module, comparing module and analog-to-digital conversion module in PIC16F877 SCM to be the trigger circuit, and gives the program flow chart. The system has many advantages including simple structure, synchronization with the main circuit, stable shifting phase and enough shifting phase range, the control angle of 10000 steps, stepless smooth control of motor, steep pulse front edge, enough amplitude value, setting pulse width, good stability and anti-jamming, and cheap cost, and this speed control system with good practical values can be realized easily.

Keywords: PIC16F877, DC motor speed control, Control circuit, PI control algorithm

1. Introduction

The quick development of electric technology makes the speed control of DC motor gradually translate from analog to digital, and at present, the KZ-D towage system which extensively adopts the thyristor equipment (i.e. silicon controlled thyristor, SCR) in the electrical towage control systems to supply power to electromotor has replaced cumbersome F-D system of generator-electromotor, and especially the application of SCM technology makes the speed control technology of DC motor enter into a new phase. In the DC governor system, there are many sorts of control circuit. SCM has many advantages such as high performance, quick speed, small volume, cheap price and reliable stability, extensive application and strong currency, and it can increase the ability of control and fulfill the requirement of real-time control (quick reaction). The control circuit adopting analogy or digital circuit can be implemented by SCM. In this article, we will introduce a sort of DC motor speed control system based on SCM PIC16F877.

2. Speed regulation principle of DC motor

In Figure 1, the armature voltage is U_a, the armature current is I_a, the total resistance of armature loop is R_a, the motor constant is C_a, and the excitation flux is Φ. According to KVL equation, the rotate speed of the motor is

$$n = \frac{U_a - I_a R_a}{C_a \Phi}$$

pN

$$C_a = \frac{pN}{60a}$$

$$U_a - I_a R_a \approx U_a$$

$$T_d(k) = T_d(k-1) + a_0 e(k) - a_1 e(k-1) = T_d(k-1) + 0.84e(k) - 0.63e(k-1)$$

$$a_0 = Kp\left(1 + \frac{T_I}{T_i}\right)$$

$$a_1 = Kp$$

$$Tf = T + Td$$

Where, p is the pole-pairs, N is the number of turns. For the motor that the armature spur track number is *a*, the motor constant $C_a = \frac{pN}{60a}$, that means when the motor is confirmed, the value is fixed. But in $U_a - I_a R_a$, because R_a is only the winding resistance, so $I_a R_a$ is very small, and $U_a - I_a R_a \approx U_a$. So it is obvious that when we change the armature voltage, the rotate speed n changes with that.

3. System composition and work principle

3.1 Module frame of system hardware structure

The module block diagram of system hardware is seen in Figure 2.

3.2 Work principle of the system

The system is mainly composed by master switch, motor exciting circuit, thyristor speed control circuit (including tachometer circuit), rectifying filter circuit, flat wave reactor and discharge circuit, energy consumption braking circuit, and the system adopts the closed loop PI regulator to implement control. When the master switch closes, the single-phase AC obtains continual current with small pulse through the control of thyristor speed control circuit, and bridge rectifier, filtering and flat wave reactor for the motor, and at the same time, through the rectifying of exciting circuit, AC makes the motor obtain excitation to begin to work. The speed in the regulation trigger circuit sets the potentiometer RP1 to make the control angle output by PIC16F877 decrease when AN1 input voltage decreases, and the flow angle of thyristor increases with that, and the output voltage of main circuit increase, and the motor speed increases, and the output voltage of tachometer circuit increases, and the motor stably runs in the setting speed range through the function of PI regulator.

4. Circuit designs of various parts in the system

4.1 Design of main circuit

The parameters of various components in the circuit are seen in Figure 3.

Press the start-up button SW, electrify the contactor KM loop, and KM normally open contact closes, and the normally closed contact opens, and start the button self-lock, the main circuit connects, and the thyristor speed control circuit controls the AC output through changing the control angle of bidirectional thyristor, and obtains the DC through bridge rectifying and filtering, and at the same time, the motor obtains the excitation through rectifying of exciting circuit to begin to work.

To limit the pulsation of DC, connect the flat wave reactor in the circuit, and the resistance R3 offers discharge loop for the flat wave reactor when the master circuit suddenly breaks off.

To quicken braking and stopping, the energy consumption braking is adopted in the equipment, and the braking part is composed by the resistance R4 and master circuit contactor normally closed contact.

The motor excitation is powered by the single rectifying circuit, and to prevent the uncontrollable high speed accident induced by the excitation loss of motor, in the exciting circuit, serially connect the under-current relay KA, and the action current can be regulated through the potentiometer RP.

4.2 Design of thyristor trigger circuit

The voltages at the point A and the point B in the main circuit change to 20V through the transformer, and after bridge rectifying, the half signals about 100H occur at these two points, and the signals meet with NPN audion through voltage-division R6 and R7 to amplify, produce zero passage pulse at the collector of the audion, and catch the zero passage pulse ascending edge by CCP1 module and note the time of occurrence first, and catch the zero passage pulse descending edge, and the time difference between both is the zero passage pulse width, and the half of the value is the midpoint of pulse, and by this catching mode, we can exactly obtain the actual zero passage point of AC, and at the

same time, we can utilize ADC analog/digital conversion module to translate the simulation voltage of PIC16F877 pin RA1/AN1 as the setting value of thyristor control angle (setting value of motor speed), change the setting value of potentiometer RP1 and correspondingly change the setting value of thyristor control angle, and the output value of tachometer circuit is input by the pin RA1/AN1 of PIC16F877, and the value is taken as the speed feedback value through A/D conversion. The oscillation frequency of SCM in the system adopts 4MHz, and according to the character of PIC16F877 order period, the resolution of thyristor control angle is the reciprocal of one fourth of SCM oscillation frequency, i.e. 1μs, for the half wave time of 10ms of the power, the control angle can achieve 10000 steps, which can completely realize the stepless smooth control of motor.

4.3 Design of tachometer circuit

The tachometer circuit is composed by the optical coded disc accreting with motor rotor and the electric pulse amplifying and shaping circuit. The frequency of electric pulse has fixed proportion with the rotate speed of motor, and through amplifying and shaping, the electric pulse output by the optical coded disc is input from the pins RC0/T1CK1 of PIC16F877 as the standard TTL level, count by the TMR1 counter to compute the rotate speed, and compare this rotate speed with the presetting rotate speed and obtain the difference value, and PIC16F877 implements PI operation to this difference value to obtain the control increase, and send the thyristor control angle in CCP2 to change the effective voltage of two ports of the motor, and finally control the rotate speed.

5. Software design

To obtain small super modulation of thyristor control angle, we design the speed closed control as the typical I system, i.e. PI regulator, which is used to regulate the thyristor control angle time T_d, and its control algorithm is

$$T_d(k) = T_d(k-1) + a_0 e(k) - a_1 e(k-1) = T_d(k-1) + 0.84e(k) - 0.63e(k-1)$$

$$a_0 = Kp\left(1 + \frac{T_I}{T_i}\right)$$

Where, $a_1 = Kp$, Kp is the proportion coefficient of controller, T_I is the integral time constant, and T_i is the sampling cycle.

Considering that the motor time constant of electromotor in the system is 0.12s, the warps couldn't be eliminated in several sampling cycles, so we select 2ms as the tachometer sampling cycle in the system.

The software design module in the system mainly includes CCP1 ascending catching module, CCP1 descending catching module, control angle setting value A/D conversion module, tachometer circuit pulse timing counting module, PI regulator module and CCP2 comparison output module, and the program flow charts are seen in Figure 5 and Figure 6.

Suppose we obtain the zero-pass time T, and the thyristor control angle time is T_d, so the comparison value which is sent into CCP2 register CCPR2H:L is $Tf = T + Td$, and when the comparison is consistent, output high level in the pin of CCP2 to make the thyristor connect, and modify the value of CCPR2H:L again according to the required trigger pulse width value to sustain the output high level trigger pulse for certain time and return to low level again, so a bidirectional thyristor trigger pulse output is completed.

6. Conclusions

The speed control system taking PIC16F877 SCM as the bidirectional thyristor trigger circuit designed in the article possesses many characters such as simple structure, reliable running, wide regulation range, good current continuity and quick response in the middle and small sized DC motor speed control system, and the rotate speed loop adopts PI control algorithm, which can effectively restrain the super modulation of rotate speed, so it is a feasible design to adopt the speed control system of SCM, and the running curve is seen in Figure 7.

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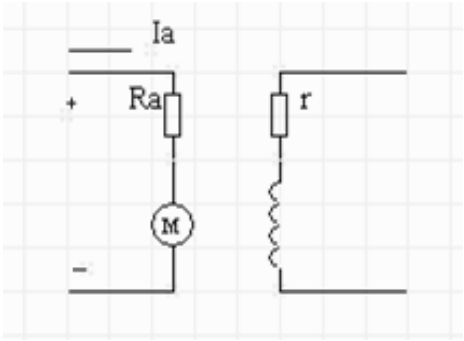

Figure 1. Principle Diagram of DC Motor

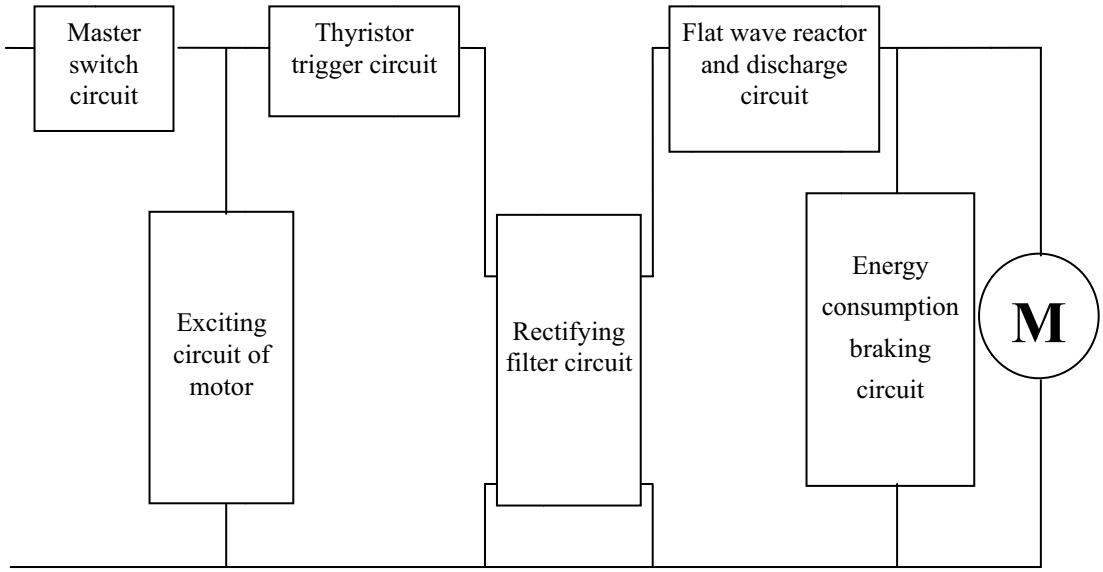

Figure 2. Block Diagram of Hardware Structure Module

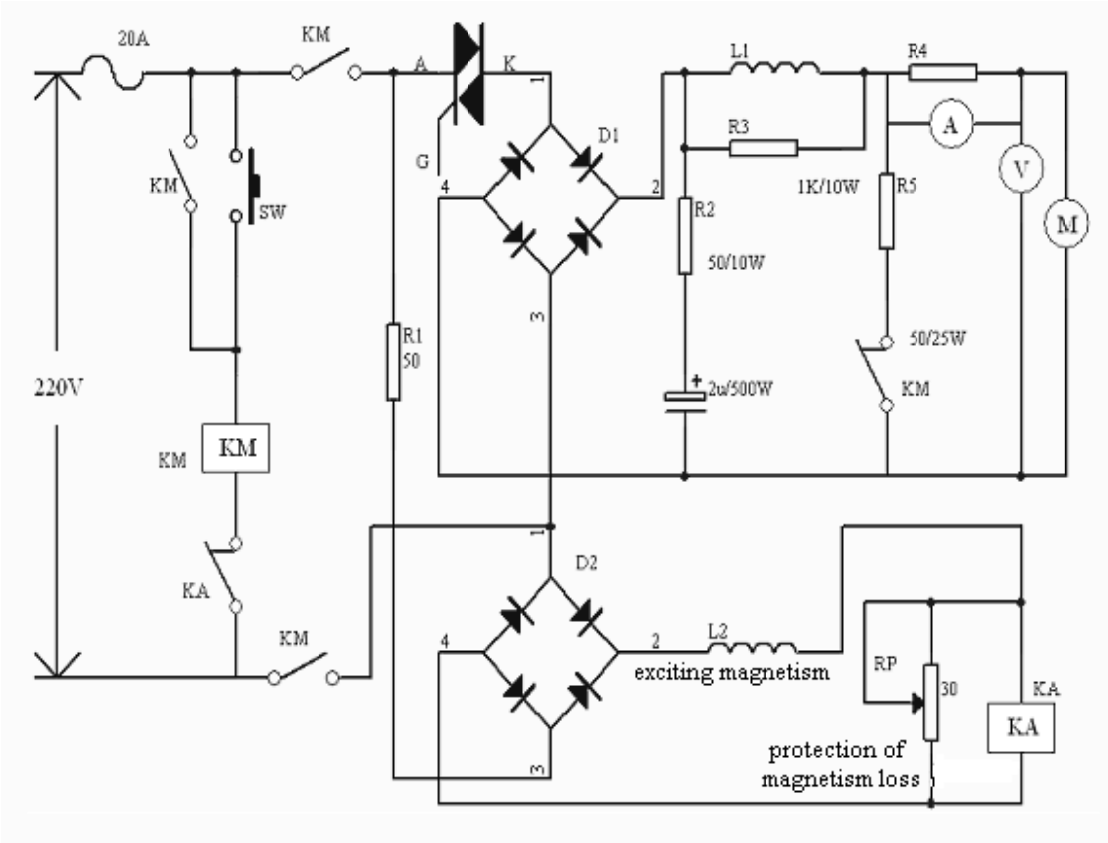

Figure 3. Diagram of Main Circuit

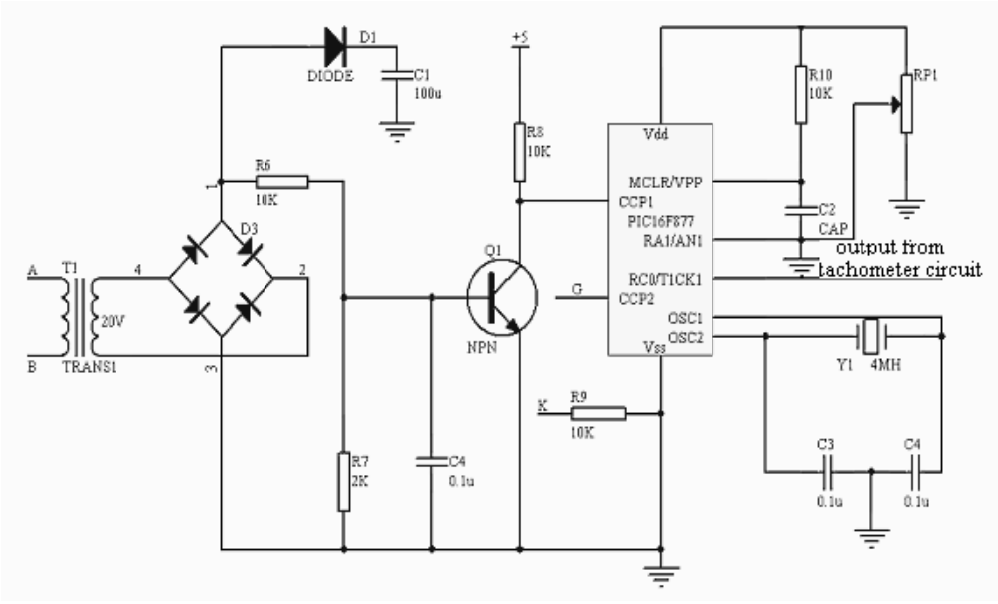

Figure 4. Thyristor Trigger Circuit

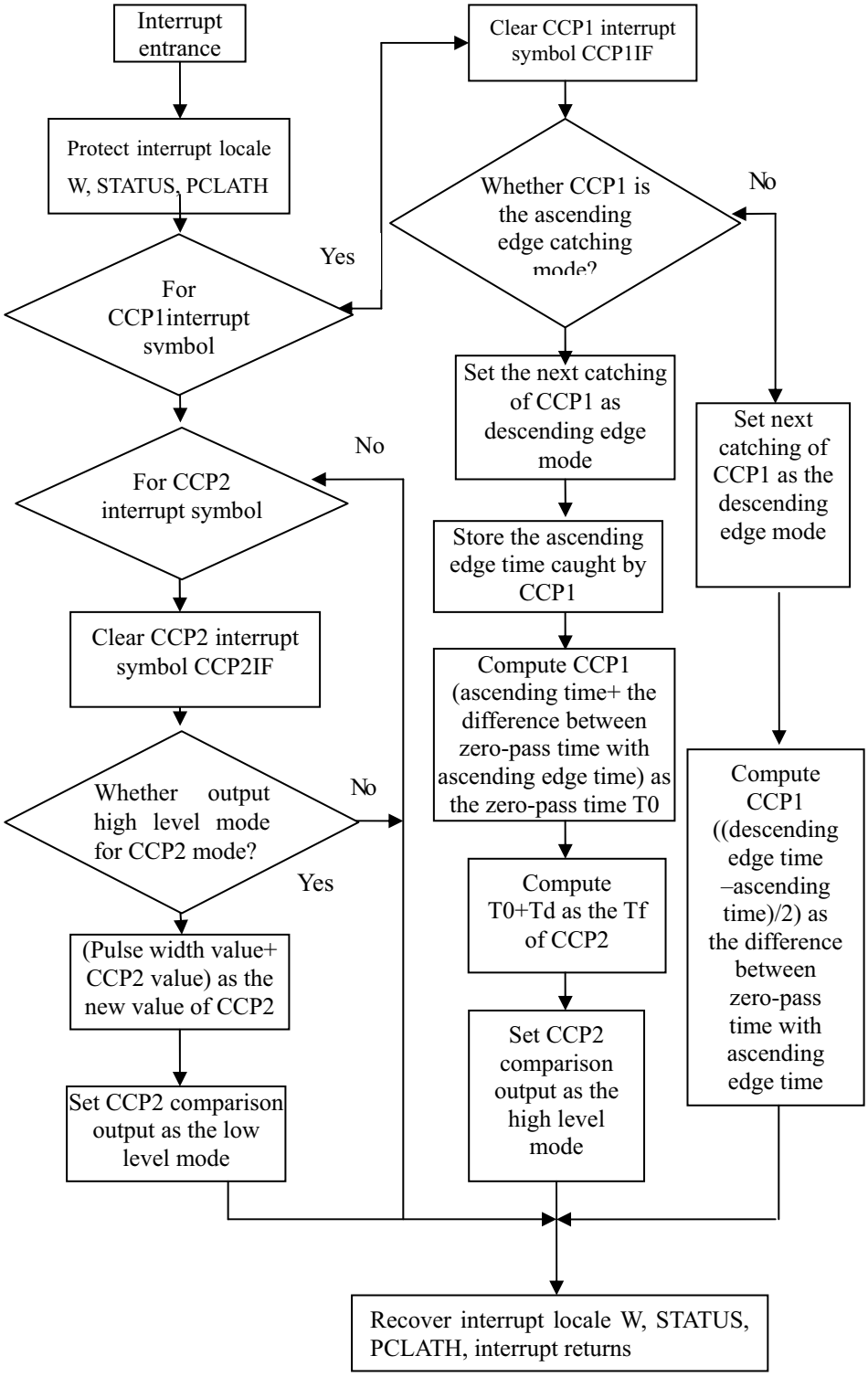

Figure 5. Interrupt Program Flow Chart of CPP1 Module and CPP2 Module

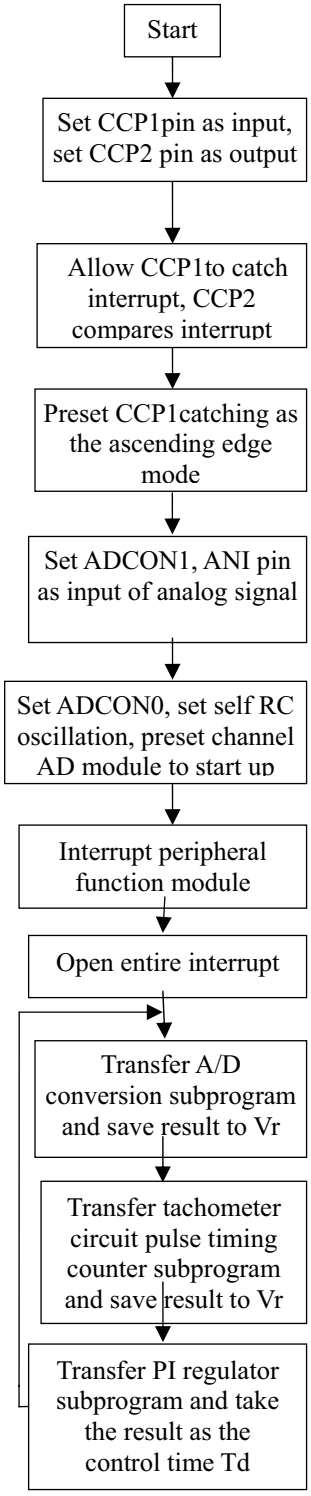

Figure 6. Flow Chart of Main Program

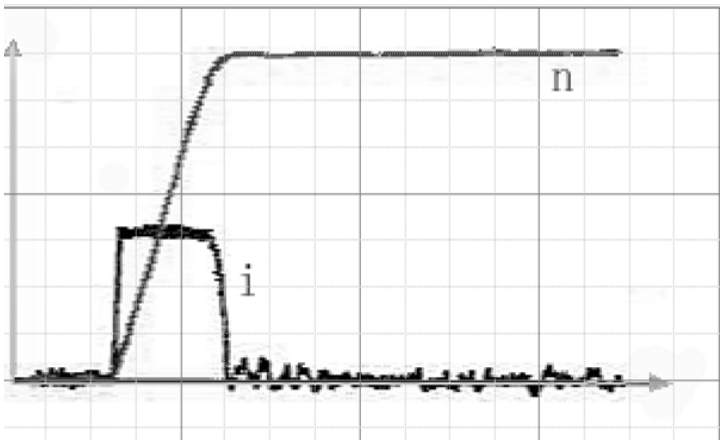

Figure 7. Running Curve