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Study on the Fault Diagnosis Technique of Aerial Camera Exposure Board Based on Petri Net

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Abstract

Because of the mechanical situation, aerial carrier condition, environment condition and usage maintenance of the aerial camera, faults always occur. So it is necessary to check and maintain the aerial camera on the ground, and the interior structure of the aerial camera is very complex, and the aerial camera is composed by many circuit boards, and the checking must be performed from the whole camera to each component. Aiming at the demands of aerial camera fault diagnosis, the board level fault diagnosis system of aerial camera was developed in the article. The failure mode of the exposure board in the aerial camera electric control system was completely analyzed, and the exposure board fault board model based on Petri net was established, and the dynamical transition of the system status was solved by the relational matrix method, and the TPS program of the exposure board was compiled, and the fault diagnosis of the exposure board was primarily actualized in the article.

Keywords: Fault diagnosis, Petri net, Dynamical transition

1. Introduction

Aerial camera is the platform of aerial reconnaissance. The accurate imaging components are installed in the camera and the ground imaging workstation and the intelligence picking personnel all depend on the images shot by the aerial camera to pick up intelligences. The work of aerial camera directly influences the generation quality and generation cycle of intelligences.

The interior structure of aerial camera is very complex, and the electric control system is composed by multiple circuit boards. The fault diagnosis must be performed from the whole camera to each component. To test and diagnose the electric control system of aerial camera, the aerial camera fault model based on Petri net was established in the article, and aiming at the checking demands of the army, the board level fault diagnosis system of aerial camera was developed, which is the ground guarantee equipment of the panoramic aerial camera and is used to check the work of the camera, test and diagnose the various functional circuit boards of the fault camera, and orientate the fault in the minimum replaceable unit.

2. Total scheme design of the aerial camera board level fault diagnosis system

According to the work environment and setup function, the board level fault diagnosis system adopts the ATE design principle and many functional modules such as PC104 embedded industrial control computer structure, additive signal simulation function module, communication data bus interface module, checking signal acquirement conditioning function module and other suited function modules to complete main functions of the system (Tian, 2008). For the hardware design, various additive encouragement signal sources, nonstandard signal conditioning and testing control function module, and the data interfaces of various checking sub-channels correspond with the diagnosed circuit board interfaces to actualize the fault diagnosis of various function circuit boards. The total design structure of the system is seen in Figure 1.

3. Principle of Petri net

3.1 Brief introduction of Petri net

Petri Net is a sort of mathematical model proposed by German Scientist Petri, and it is also a sort of figure method whish is used to denote and analyze the dynamical behaviors of the system, and it adopts some basic figure symbols to describe the relation between conditions and events (Yuan, 2005). The dynamical transition process of the system status can be studied through the shifts of data, resources and conditional decisions. The place node and the transition node can be used to implement static structured analysis to the system, and the token on the node can be used to implement the dynamical behavior analysis.

3.2 Petri net and the description of event logic relationship

Petri net is a sort of directional figure composed by position, transition, directional arc and token, and it includes following definitions (Jiang, 2003).

Definition 1. Tetrad PN= (P, T, A, M) is the Petri net, and it fulfils $P\cup T\neq\Phi$, $P\cap T=\Phi$ and $A\subseteq(P\times T)\cup(T\times P)$.

Pi= {Pi | Pi is the place, $1\le i\le I$ (I is a integer)}

T= {Ti | Ti is the transition, $1\le i\le I$}

A= {Ai |Ai is the directional arc from the place to the transition or from the transition to the place}

M= {Mi |Mi is the amount of certain place with sign which denotes a sort of status whether the condition or event of the place is tenable}

Definition 2. The transition in the Petri net is enabled, i.e. if the each input place of certain transition in Petri net contains a sign at least, the transition in Petri net is enabled.

Definition 3. Transition fire: if the transition is enabled, and remove one sign in all input places of the transition and add one sign in all output places of the transition, so the transition is fired.

Based on above definitions, the logic relation described by the Petri net can be obtained as seen in Figure 2.

4. Establishment of the exposure board fault model based on Petri net

The camera electric control system is composed by multiple circuit boards including the exposure board. Through analyzing the fault events of the exposure board, the Petri net fault model (seen in Figure 3) can be obtained. In Figure 3, P1 denotes component SN54HC04J is in failure, P2 denotes component SN74HC02 is in failure, P3 denotes component S26LS32M is in failure, P4 denotes component ADC0808 is in failure, P5 denotes component DAC1230LCJ is in failure, P6 denotes component ADOP071 is in failure, P7 denotes component TIL117 is in failure, P8 denotes component LF156J is in failure, P9 denotes component SG1524BJJ is in failure, P10 denotes component ADC0808 is in failure, P11 denotes component ADOP072 is in failure, P12 denotes the communication between the main control board and the exposure board is abnormal, P13 denotes the exposure board is not reactive to the scale change of the exposure, P14 denotes the light-stick motor control circuit is abnormal, P15 denotes the step motor drive circuit is abnormal and P16 denotes the exposure board is in failure.

From Figure 3, the events when the exposure board works abnormally includes the communication between the main control board and the exposure board is abnormal, the exposure board is not reactive to the scale change of the exposure, the light-stick motor control circuit is abnormal and the step motor drive circuit is abnormal.

5. Solving the dynamical transition of the system status by the relational matrix method

The solutions of the status transition of the diagnosis model system based on Petri net mainly include the relational matrix method and the ladder diagram solution, and the relational matrix method (Hu, 2001) is adopted to solve the dynamical transition of the system.

The column vector M is used to denote the sign of the Petri net diagnosis model, and the sign amount of the place Pi is denoted by the elements in i'th row, and the status transition of the system denotes the dynamical evolvement process of the sign. The next status of the system is decided by the present status and the logic structure of the system. To compute the status transition of the system, following definitions should be made.

(1) M_K denotes the k'th evolvement status of the system, and M_0 is the initial status of the system.

(2) A^T is the relational matrix of the system, the rows of the matrix denote places which represents transition, and when the i'th place is the output place of the j'th transition, the element $(A^T)_{ij}$ in the i'th row and the j'th column of A^T is 1, and when the i'th place is the input place of the j'th transition, $(A^T)_{ij}$ is -1, and when there is not the direct

relation, $(A^T)_{ij}$ is 0.

(3) S^k are column vectors, and when the element in the j'th row is 1, the transition T^j is fired.

Based on above definitions, the status transition expression of the system is

$$M_{k+1}=M_k+A^T S_k \tag{1}$$

From the recursion relation of the formula (1), the following formula can be obtained.

$$M_n=M_0+A^T\sum_{k=0}^{n-1} S_k \tag{2}$$

From the formula (2), the final status of the system is accumulated from the initial status to each transition. According to the formula (1), the k+1'th status of the system M_{k+1} is decided by the k'th status M_K, and the logic structure of the system decides A^T, and the trial and error method (Xu, 2005) is adopted to confirm the system status S_k.

The concrete approaches of the trial and error method include that supposing n_T denotes the transition amount in the exposure board fault diagnosis model, $S_k^{\ i}$ (i=1, 2…, n_T) denote the status of the i'th transition in the k+1'th evolvement, and if $S_k^{\ i}$=1, the transition is fired, and if $S_k^{\ i}$=0, the transition is not fired. First, order $S_k^{\ i}$=0 (i=1, 2…, n_T), and order $S_k^{\ i}$=1 in turn, and compute $A_T S_k$, and if all elements exceed 0, so the i'th transition in the k+1'th evolvement fulfills the fire condition, $S_k^{\ i}$=1 comes into existence, or else, the fire condition of the i'th transition in the k+1'th evolvement is not fulfilled, order $S_k^{\ i}$=0 again. When $S_k^{\ i}$=0(i=1, 2…, n_T) all are confirmed, S_k is confirmed, and formula (1) can be used to solve S_{k+1}. Supposed that the initial sign of the exposure board Petri net diagnosis model $M_0=(1000010000000000)^T$, and according to the definition, the relational matrix of the exposure board fault model can be confirmed first.

A^T =

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15
P1	–1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P2	0	–1	0	0	0	0	0	0	0	0	0	0	0	0	0
P3	0	0	–1	0	0	0	0	0	0	0	0	0	0	0	0
P4	0	0	0	–1	0	0	0	0	0	0	0	0	0	0	0
P5	0	0	0	0	–1	0	0	0	0	0	0	0	0	0	0
P6	0	0	0	0	0	–1	0	0	0	0	0	0	0	0	0
P7	0	0	0	0	0	0	–1	0	0	0	0	0	0	0	0
P8	0	0	0	0	0	0	0	–1	0	0	0	0	0	0	0
P9	0	0	0	0	0	0	0	0	–1	0	0	0	0	0	0
P10	0	0	0	0	0	0	0	0	0	–1	0	0	0	0	0
P11	0	0	0	0	0	0	0	0	0	0	–1	0	0	0	0
P12	1	1	1	0	0	0	0	0	0	0	0	–1	0	0	0
P13	0	0	0	1	1	1	0	0	0	0	0	0	–1	0	0
P14	0	0	0	0	0	0	1	1	1	0	0	0	0	–1	0
P15	0	0	0	0	0	0	0	0	0	1	1	0	0	0	–1
P16	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1

By the trail and error method, S_0=(1000010000000000)^T and S_1=(0000000000001100)^T, so $M_2=M_0+A^T\sum_{i=0}^{1}S_i=(0000000000000002)^T$, i.e. the peak place P16 is signed, so the following diagnosis conclusions can be obtained. The events of "component SN54HC04J is in failure" and "component ADOP071 is in failure" represented by the bottom places P1 and P6 induce the occurrence of peak event, i.e. induce the fault of the exposure board of the aerial camera.

6. Conclusions

Aiming at the ground checking demands of the aerial camera of the army, the fault diagnosis system of aerial camera is studied in the article, and the fault diagnosis method based on Petri net is adopted to diagnosis the faults of the exposure board of the aerial camera, and the systematic fault model is established. The method is simple and convenient for modeling, and it can conveniently perform knowledge denotation, diagnosis reasoning and logic relation expression, and it is very effective to systematically analyze the complex net topological structure, and it is a fault diagnosis method based on model with very wide applied foreground (Chen, 2000). At present, the panoramic aerial camera has been equipped in the scout plane, and the aerial camera fault diagnosis system has been approved. The fault diagnosis system is stable in reliability and servicing, and its fault diagnosis cover rate of the camera electric control system can achieve 100%. The system can provide powerful guarantee for the development and usage of the panoramic aerial camera and the accomplishment of the scout tasks.

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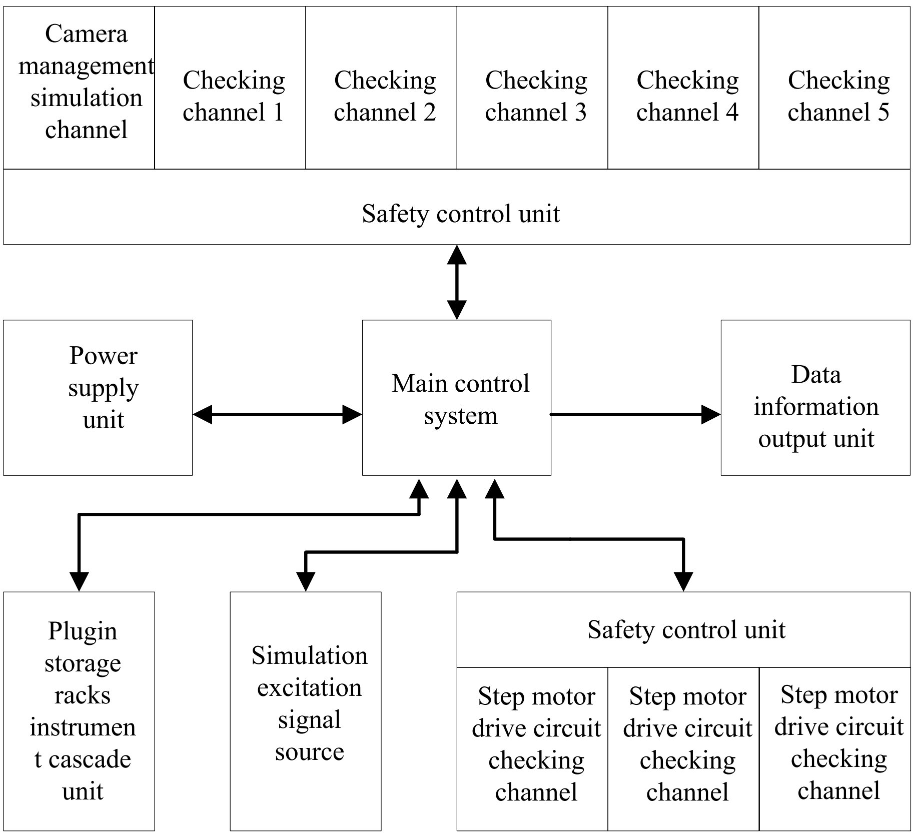

Figure 1. Total Structure of the Fault Diagnosis System

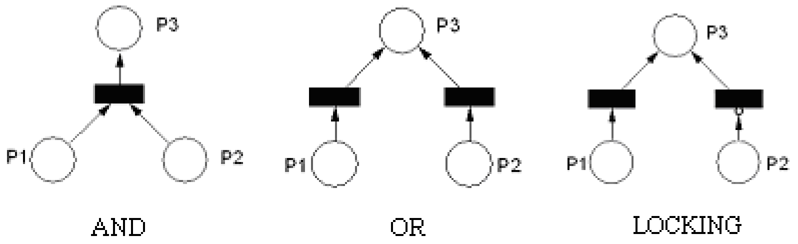

Figure 2. Petri Net Model of Logic Operation

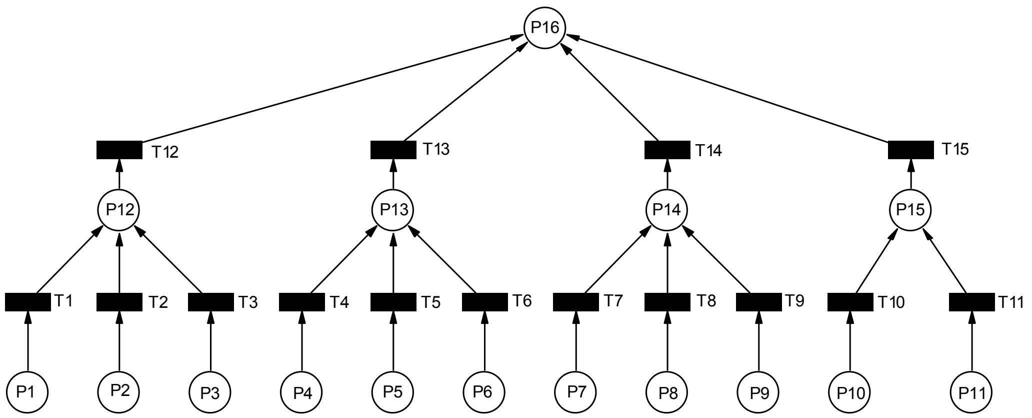

Figure 3. Exposure Board Petri Net Fault Model