Modern Applied Science; Vol. 11, No. 3; 2017
ISSN 1913-1844 E-ISSN 1913-1852
Published by Canadian Center of Science and Education

Automation of a Cans Waste Sorting System Using the Ejector System

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Received: May 27, 2016 Accepted: June 8, 2016 Online Published: December 12, 2016

doi:10.5539/mas.v11n3p48 URL: http://dx.doi.org/10.5539/mas.v11n3p48

The research is financed by (Sponsoring information).

Abstract

This research aims to integrate a mechanical system of cans waste sorting with the identification system in real-time which the mechanical system is designed using an ejector system. This system is made based on a five-bar mechanism of aluminum plate where the last bar that serve as end effector is connected a servo motor as a driving force. The controller of servo motor uses microcontroller arduino uno. The cans waste are sorted based on three types of cans waste. They are pure aluminum cans (type 1), aluminum cans mixture of metal (type 2) and aluminum cans mixture of hazardous substances (type 3). The testing result of automation of a cans waste sorting system is got the success rate of 92.53%.

Keywords: arduino uno, cans waste, ejector system, servo motor, sorting system

1. Introduction

Today, automation of a system has been utilized by many industries for various purposes such as material handling, packaging, distributing, and sorting system. In the plantation industry, the automation of system is used to detect the level of maturity or the quality of the fruit. The level of ripeness of the fruits at the time of packaging will determine the time of delivery to an area. Therefore, the probability of fruit damaged by improper levels of maturity can be minimized. In the modern industry of solid waste processing, the automation of a system is applied in a sorting system to separate the waste based on weight, size or type.

Automation of a cans waste sorting system can be designed with various hardware components, which are controlled by a computer system. Automation of the sorting system is constructed by integrating the mechanical sorting system with a system of identification of an object in real-time. Wahab et al. (2006), Khojastehnazhand et al. (2010), Yani et al. (2013), Golmohammadi et al. (2013) and Poudarbani et al. (2015) used a pneumatic system as the end effector in building automation sorting system. However, according to Scavino et al. (2009) who built the automation of a plastic bottles sorting system, the pneumatic system is only capable of sorting 1 bottle per 600 milliseconds, while the identification speed ranging from data acquisition to classification which requires time does not exceed 150 milliseconds.

Automation of a system that integrates a mechanical system with an identification system is a very complex process and it is generally designed to exploit the capabilities of the system optimally. Mechanical systems are designed to automate sorting system and will determine the performance of the device (i.e. The efficiency of sensor time and the optimization of sensor speed). According to Chikte & Ughade (2015), for automating a system, in addition to the pneumatic system which uses fluid as a driving force, can also be used ejector system that uses the motor as a driving force. In this study, the automation of cans waste sorting system is constructed using an ejector system, in which the system is designed based on a five-bar mechanism and using the aluminum plate which is connected to the servo motor as a driver, and a microcontroller Arduino Uno as a servo motor controller.

2. Method

In this experiment, the mechanical systems is built using ejector system that designed using a five-bar mechanism, in which the end effector serves as a sorter for three types of cans waste: 1)Pure aluminum cans (type 1), 2) Mixture 1 of aluminum cans (type 2) and 3) Mixture 2 of aluminum cans (type 3). The end effector is made of aluminum plate with a length of 40 cm associated with a TowerPro MG 996R servo motor 0.4025 Nm torque. To control the movement of servo motors, we used microcontroller arduino uno.

The ejector system is designed by considering the force of trajectories of its end effector. The force analysis of ejector system performed to determine the ability of an aluminum plate measuring 40 cm, which is driven using a TowerPro MG 996R servo motor 0.4025 Nm torque in push each type of aluminum cans waste to each of a bin. The force of end effector must be greater than the mass of aluminum cans waste, which are objects to be sorted. Trajectories's end effector are calculated to obtain the position and the orientation so that it moves in the right direction. The calculation trajectories of ejector system aims to get the position and orientation of the end effector by entering multiple values for each corner of the aluminum bar. To obtain the kinematics equations directly from the bars we used the method of Denavit-Hartenberg (D-H) (missing of reference).

The next step is the integration of the identification system of cans waste to the mechanical system in order to drive the end effector. When the cans waste were identified as one of three types of cans waste, the end effector will automatically move and put the cans into each bins in accordance with its type. The flow chart of the integration system is represented in Figure 1.

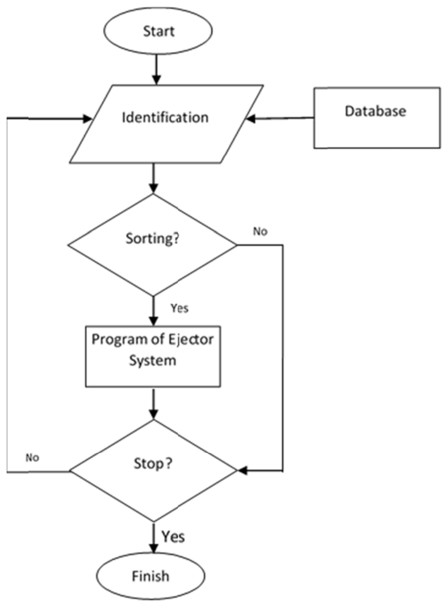

Figure 1. Flow chart of integration system

3. Results and Discussion

3.1 Forces Analysis of Ejector System

The design and the kinematic model of the ejector system for the cans waste sorting using five-bar mechanism are represented in Figure 2 (a) and (b) respectively, where the bar 4 serves as an end effector to separate the types of cans waste.

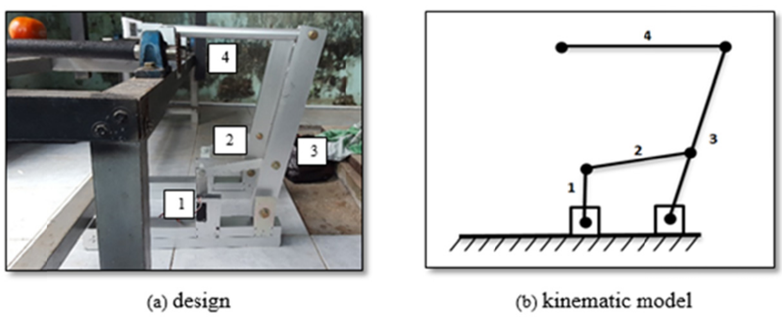

Figure 2. The ejector system

The force generated from the kinematic model of ejector system, as shown in Figure 2 (b), can be described as the force that occurs at each bar. The force on the bar 1 to 4 from the ejector system is represented in Figure 3.

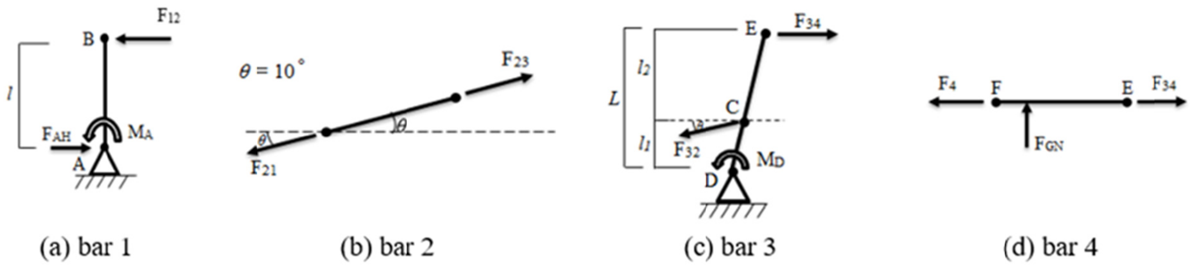

Figure 3. Forces on each bar of ejector system

By using the obtained equilibrium forces that occur in each bar, are F12 = 15.41 N, F21 = F23 = 15.67N, and F34 = 4.24 N = 432.36 gram, This F34 is that affects force at bar 4 to push the aluminium waste into an exile using a TowerPro MG 996R servo motor.

Table 1. Table title (this is an example of table 1)

Type of aluminum cans waste	**Mass (gr)**	**Force of end effector (gr)**
1	13 – 30	
2	17 – 285	432.36
3	13 – 156	

From Table 1 it is known that the force of end effector (F) produced greater than the mass of each type of aluminum cans waste. Therefore, this designed ejector system can sort or push any kind of the cans waste to the related bin.

3.2 Motion Trajectory of End Effectors on the Ejector System

The calculation of trajectories bar 4, as the end effector on the ejector system, aims to get the position and the orientation of the end effector by entering multiple angle values for each bar of ejector system. After obtaining the trajectories of end effector, we will get the angle of servo motor.

The analysis of the relationship of rotational motion and the translational motion between bars connected in an ejector system expressed as a forward kinematics equations of the ejector system is obtained by using the method Denavit-Hartenberg (D-H). Figure 4 illustrates trajectories of ejector system, where Z1 is the base frame of the ejector system, while the centre of the frame ejector system Z0 is located in the ground of the overall system.

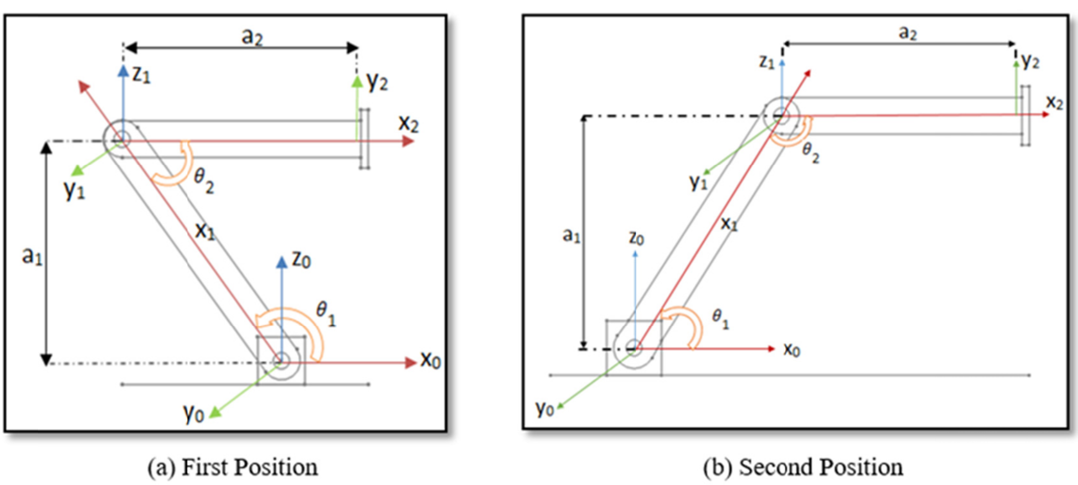

Figure 4. Trajectories motion of ejector system on the first and second positions

Forward kinematic calculation using the D-H was conducted to determine the coordinates (x, y, z) on the ejector system, in which the z coordinate is fixed at zero. The four initial parameters of the DH method represent the design parameters obtained by measuring the height and width of the belt conveyor and estimate the slope of the rod 3. These four parameters are a, A, D and θ. The height and the wide of belt conveyor respectively are denoted as a1 (ay) and a2 (ax), the change in the angle of the end effector (bar 4) is denoted as A, the magnitude of the translational motion at z0 is denoted as D, the angle between the the center of frame with bar 3 is denoted as θ1, and the angle between bar 3 with bar 4 is denoted as θ2. The parameters of the ejector system for n-DOF mechanism are represented in Table 2.

Table 2. Table title (this is an example of table 1)

Coordinate (I)	a (mm)	$A(^o)$	D (mm)	θ_1 (^{o})
y	340	0	0	80
x	400	0	0	100

By using the transformation matrix between Z1 as a base frame by frame Z0 the center of of the ejector system, the transformation matrix T values is obtained for first position, ${}^{0}_{1}T$,

$${}^{0}_{1}T = \begin{bmatrix} 0.984 & -0.173 & 0 & 393.92 \\ 0.173 & 0.984 & 0 & 69.45 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

From the initial position of matrix T can be obtained matrix T for second position, ${}^{1}_{2}T$

$${}^{1}_{2}T = \begin{bmatrix} 0.173 & -0.984 & 0 & 59.04 \\ 0.984 & 0.173 & 0 & 334.83 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

From the kinematic calculation using the D-H method is obtained the first position of the ejector system, Px = 394.089 mm, Py = 409.136 mm.

The movement of ejector system is located in the x, y, z, but for straight forward movement of bar 4 as the end effector only works in the field of x. The position x is determined by calculating the value oblique angle θ. By the same method used to calculate the initial position of the end effector, the second position (position furthest end effector) is calculated.

Table 3. Parameters D-H for End Effector in Second Position

Coordinate (I)	a (mm)	A (^{o})	D(mm)	$\theta(^o)$
y	380	0	0	70
x	340	0	0	110

The kinematic motion of the bar 4 in the second position is Px = -202 808 mm and Py = 375 157 mm.

3.3 Performance and Success Rate of Automation of the Sorting Systems

We have developed an automation of a cans waste sorting system by integrated a mechanical system with the identification system which the mechanical system is designed using an ejector. Performance the automation of the sorting system running in real time is obtained by testing on 100 cans waste were selected randomly. The testing is done by sorting each of the cans waste repeated 10 times with different positions. The test results showed that the average time required by the cans waste that are placed on a belt conveyor to be in front of the end effector since the belt conveyor runs was 12.06 seconds; while the average time required by the data processing program from begin the web camera capturing the cans waste image until successfully identify the cans waste was 11.47 seconds, and the time required by the end effector to push the cans waste into an exile was 0.257 seconds. This means that the time required by the system from data acquisition until successfully sorting the cans waste is 11.727 seconds, which is closed to the average time of cans waste reached the end effector, 12.061 seconds. Therefore, it can be concluded that the automated sorting system can work in real time. The test of success rate of the sorting is done by sorting each cans waste repeatedly at any position. The results show the percentage of success reached 92.53%.

4. Conclution

This paper proposed an ejector system as the mechanical system in building an automation of cans waste sorting system, where the system is designed using a five-bar mechanism of aluminum plates. The last bar in kinematic model of the mechanism serves as an end effector to separate the cans waste based on the types: pure aluminum cans (type 1), aluminum cans mixture 1 (a mixture of metal) and aluminum cans mixture 2 (a mixture of hazardous substances). The end effector is connected to a servo motor that using microcontroller arduino uno as controller. The test result shows that the automation of the developed sorting system iscapable of running in real time with sorting success percentage reached 92.53%.

References

Chikte, V. G., & Ughade, P. D. (2015). Industrial Automation of Object Sorting System Using Programmable Logic Controller. *International Journal for Engineering Applications and Technology, 9*(1), Robonance-15. Retrieved from http://www.ijfeat.org

Golmohammadi, A., Bejaei, F., & Behfar, H. (2013). Design, Development and Evaluation of an Online Potato Sorting System Using Machine Vision. *International Journal of Agriculture and Crop Sciences.* Retrieved from www.ijagcs.com/IJACS/2013/6-7/396-402

Khojastehnazhand, M., Omid, M., & Tabatabaeefar, A. (2010). Development of a Lemon Sorting System Based on Color and Size. *African Journal of Plant Science, 4*(4), 122-127. Retrieved from http://www.academicjournals.org/ajps

Poudarbani R., Ghassemzadeh, H. R., Seyedarabi, H., Nahandi, F. Z., & Vahed, M. M. (2015). Study on an Automatic Sorting System for Date Fruits. *Journal of the Saudi Society of Agricultural Sciences, 14*, 83-90.

Scavino E., Wahab, D. A., Hussain, A., Basri, H., & Mustafa, M. M. (2009). Application of Automated Image Analysis to The Identification and Extraction of Recyclable Plastic Bottles. *Journal of Zhejiang University Science, A*, 794-799. Retrieved from http://www.zju.edu.cn/jzus; http://www.springerlink.com

Wahab, D., Hussain, A., Scavino, E., Mustafa, M. M., & Basri, H. (2006). Development of a Prototype Automated Sorting System for Plastic Recycling. *American Journal of Applied Sciences, 3*(7), 1924-1928).

Yani, I., Scavino, E., Hannan, M. A., Wahab, D. A., & Basri, H. (2013). An Automatic Sorting System for Recycling Beverage Cans using the Eigenface Algorithm, Proceedings of the Third International Conference on Soft Computing Technology in Civil. *Structural & Environmental Engineering,* 1-11.

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