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Edible Bird Nest Processing using Machine Vision and Robotic Arm

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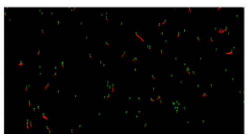
Graphical abstract



Abstract

Edible bird nest food product is one of the demanding food product in food production industry. Government looking into ways to improve this industry to boost the economy. Many large scale production are being operated around Malaysia. One of the major difficulties faced in processing the bird nest is to remove its impurities or more formerly known as dirt. Current conventional cleaning method which is manual cleaning is not cost effective and time consuming. Furthermore, it also requires large number of workforce to be used for processing small quantities of bird nest. This paper presents an automated system which utilizes machine vision system and an industrial robot to accomplish a better processing system for edible bird nest. This system offers great advantage compared to conventional process by reducing the time consumed for processing and increase the efficiency.

Keywords: Edible; bird nest; automation; vision; robotic

1.0 INTRODUCTION

Edible bird nest are one of the food product which is consumed by human since 400 years ago [1]. It is produced by Swiflet birds called Aerodramus Fuciphagus [2]. The nutrient contents of the bird nest makes it one of the best food product to be consumed by human for greater health. It is proven that it has the ability to improve human immune system and provides Anti-aging effect [3]. Since then bird nest production has been one of the major industry in Southeast Asia. The demand grown to a state where the industry unable to cope.

This is mainly due to conventional process of processing the bird nest. The current processing method utilizes human force. Human force equipped with a tweezers styled tool with sharp end used to clean the tiny dirt's on the bird nest [4]. Thus large workforce is needed in order to complete a large quantity of bird nest. It has been calculated that cleaning 10 nest takes 8 hours per person [5]. Each nests weight from 35grams to 45 grams. Usage of human force requires large workspace and cost. Furthermore there is a limit for human workforce work period. Thus this effecting continuous production rate. This indulges extra cost on the bird nest end product production.

Another method has been introduced in the market where the bird nest is turned into powder form or called bird nest extract [6]. This method proven to be effective and easy for purification. It can retain most of the contents of the bird nest and reduces the wastage of the bird nest. However the major market for bird nest requires the bird nest shape or bird nest strands to be retained. These type of powder form used in medical and cosmetic products.

Thus a better and efficient automated system is required in order to reduce the cost of production at the same time increase the production rate to cope the demands. A system with continuous operation with less human interference and high efficiency rate is required in order for continuous production for bird nest industry.

2.0 SYSTEM DESCRIPTION

2.1 Design

Figure 1 shows the prototype system for processing bird nest. The system equipped with an industrial robot arm, machine vision camera, lighting and a structure with platform [7-9].

The system uses machine vision system which is the main part of the automation process [8]. Machine vision system used to capture the image of bird nest. The image then processed using image processing algorithm to identify the dirt's on the bird nest. The identified dirt position is extracted and stored for every dirt in the captured image. This data then used in the mechanical action of the system. Figure 2 shows the process involved in the system.

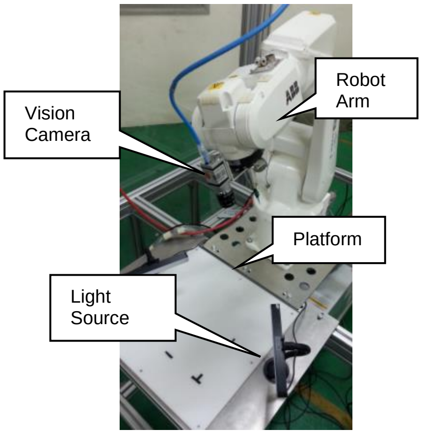


Figure 1 System setup

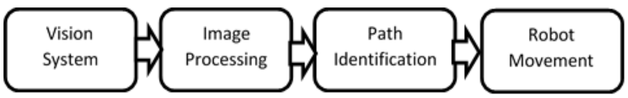


Figure 2 Process from vision to implementation

The data from the image processing contains location of each dirt which has been identified. This data is then converted to robot coordinate system which in this case uses RAPID programming language by ABB. The position data need to be converted in terms of axis rotation positions, speed and end point curves..

2.2 System Overview

The system consists of three main parts. They are image capture and input device, data processing and actuation. Figure 3 shows the overview of the system setup.

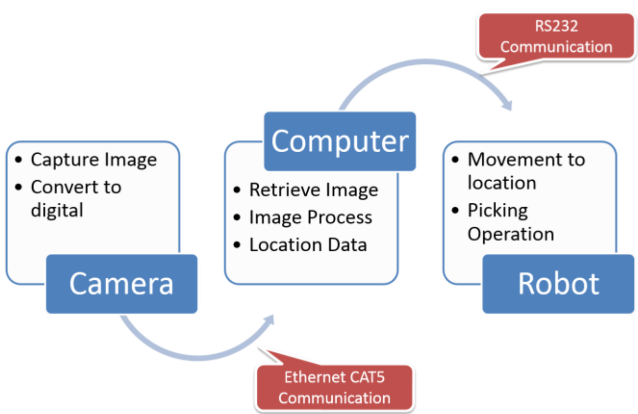


Figure 3 System overview

The camera used is an industrial based Gige network camera. It has 50 frames per second specification with adjustable lens. This camera mounted at the end effector section of robot arm. Thus the system has a better control of the areas which this image capture covers. The image are captured in segments of the specimen. The captured image transferred to a processing computer through Ethernet communication. The processing computer uses National Instruments Labview software equipped with Vision Development Module. NI IMAQ DX device drivers used to retrieve the image and processed through the algorithm written in graphical programming language. Then the processed data locations send to ABB robot IRC5 controller through RS232 serial port communication. A sequence of RAPID programming algorithm written in the robot controller which operates in UNIX system with custom ABB Robot ware [10]. The algorithm written in ABB controller then translated into actions of robotic arm. The robotic arm is equipped with a custom designed end effector for effectively remove the impurities on bird nest.

■3.0 METHODOLOGY

3.1 Machine Vision

The original bird nest captured using vision camera is fed to an image buffer to store in memory is shown in Figure 5. Then the image is extracted from its RGB colour plane to obtain monochrome image. This process is applied since the particle which will be extracted from the bird nest are in dark colour. While the camera used to capture the bird nest is a colour camera. The Red plane from the image is extracted since it has higher intensity level. Then the extracted image fed through some filters to optimize the image before implementing threshold process. Then threshold process applied to differentiate levels of dark particles from its background shown in Figure 6(b). This process will identify the unwanted particles on the bird nest.

Then it is followed by advances morphology process. This is used to filter the image by removing smaller particles and noises. This process also used to filter only sizes of particles which is required to be removed by the system in later stages. After that, the image will go through dilation process to fill gaps and holes in the particles detected shown by Figure 6(a). Once the processing of particles has been completed, particles analysis method is implemented. This process utilized to identify the location of particles detected. This system uses Labview vision blocks algorithm to process the image which is a faster platform to develop. Figure 4 shows the vision system sequence used in the algorithm.

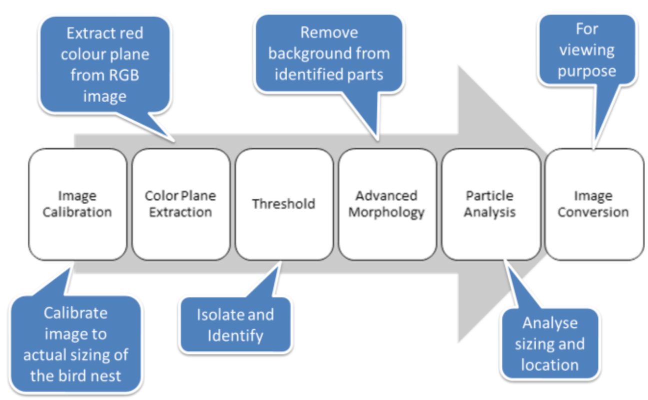


Figure 4 Vision algorithm sequence

Figure 5 Captured bird nest

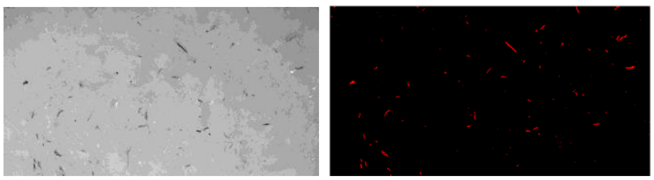


Figure 6 (a) Gray Morphology, (b) Threshold

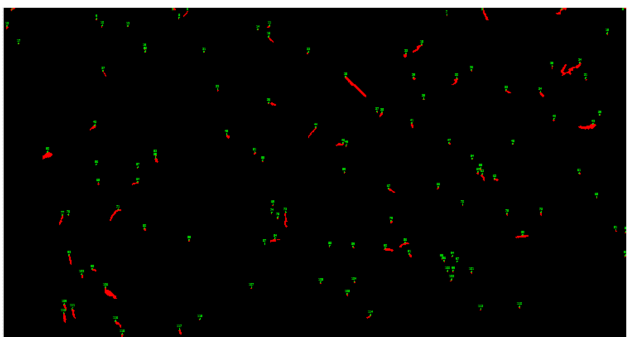


Figure 7 Particles analysis

From the particle analysis on Figure 7, a total of 139 dirt's has been identified. The identified particles sized from 0.04 mm^2 to 0.60 mm^2. This position data obtained with real size measurement through calibrated axis configuration. Figure 8 shows the interface design with particle location logging.

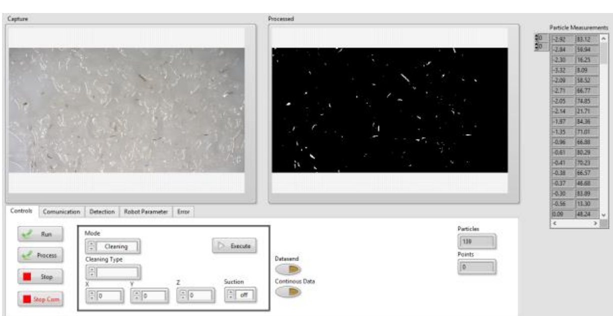
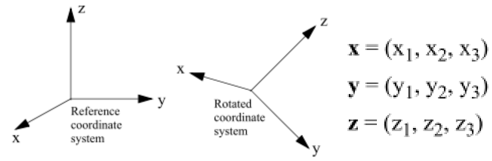


Figure 8 Vision system interface

3.2 Robot Implementation

In order to implement cleaning process on bird nest an industrial robot arm is been used. This robot equipped with six rotational axis. This robot has the accuracy of 0.01mm at the end effector. An algorithm written in RAPID robotic language used to run the robot. The algorithm perform continuous movement of up and down with increasing and decreasing height of 0.01mm. At the same moment a suction force being applied through the end effector to remove the located particle.



$$q1 = \frac{\sqrt{x_1 + y_2 + z_3 + 1}}{2}$$

$$q2 = \frac{\sqrt{x_1 - y_2 - z_3 + 1}}{2} \qquad \text{sign } q2 = \text{sign } (y_3 - z_2)$$

$$q3 = \frac{\sqrt{y_2 - x_1 - z_3 + 1}}{2} \qquad \text{sign } q3 = \text{sign } (z_1 - x_3)$$

$$q4 = \frac{\sqrt{z_3 - x_1 - y_2 + 1}}{2} \qquad \text{sign } q4 = \text{sign } (x_2 - y_1)$$

Figure 9 Robot end effector position data calculation

This robot uses position data which contains coordinate position (x,y,z) , rotation quaternion and robot configuration. Each data from the particle analysis location translated into robot position data which described in Figure 9. This is used to perform the cleaning operation. Figure 10 shows the six axis robot configuration used in this system.

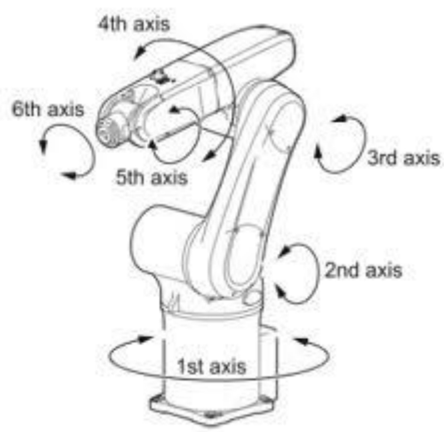


Figure 10 Six axis robot arm

3.3 End Effector Design

End effector is used to remove the particles identified through the image processing. This end effector is attached to the sixth axis of industrial robot arm. The end effector for this operation is intended to remove tiny particles sized up to 0.04mm^2. The conventional method of dirt removal is using tweezers which has two end with sharp tips. The application of this method is not effective when used with robot arm. An effective and efficient method is need to be used in this process. Figure 11 shows a tweezers based effector design.

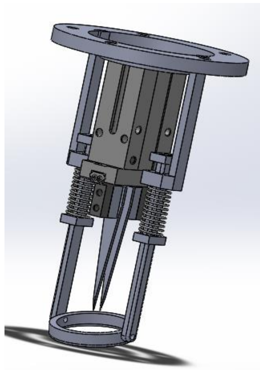


Figure 11 Tweezers based end effector

■4.0 EXPERIMENT AND RESULTS

A suction based operation is selected in order to have a better controllable dirt removal technique. A sharp nozzle is used to target the large suction circumference at the vacuum generator. The sharp end of the end effector has a diameter of 1mm. The sharp end of the nozzle is directed towards the position of the dirt to be removed with a distance of 0.5mm. The bird nest is soaked for a duration of 12 hour using distilled water which suited for food product. This is in order to soften the bird nest strands and loosen the interwoven structure. A bird nest spread with a size of 100mm by 100mm is placed on the special specimen base with a thickness of 2mm.

The image of bird nest captured using the camera attached to the robot end effector. The computer used to process and send the data to the robot. Each of the dirt identified is removed using suction end effector. A controlled amount of water is added during the suction process in order to cover the nozzle area of the suction head. This increases the suction flow, at the same time improves the efficiency of the suction.

Three different bird nest is used to perform the cleaning process. Each of the specimen run through cleaning process for three run. Averagely this system able to clean 80% of the total dirt on the bird nest identified. This rate able to be achieved with a total of three cleaning run using the system with a single bird nest specimen. Table 1 shows the results from the cleaning process.

Table 1 Dirt detection and removal data

Specimen	Detected Dirts	Removed Dirts	Yield(%)
1	86	73	84.88
2	54	37	68.18
3	58	7	87.93

■5.0 CONCLUSIONS

This system presented in this paper is developed in order to remove dirt from the target bird nest. However there are some limitation of current developed system. The designed machine vision system only able to capture and process two dimensional image data. Thus the specimen need to be flat as possible with thickness of less than 2mm. Even though bird nest product requires original shape of the bird nest to be retained, most of the end product using bird nest does not require shape to be retained such as bird nest drinks. The suction system is targeted to remove tiny particle up to 2mm in diameter only. A further design and update will be done in order to cater multiple sizing of the dirt and also image processing system to cater three dimensional position data of the dirt.

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