Automatic Classification of Weevil-Infested Harum Manis Mangoes Using Artificial Immune Systems Approach

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Abstract - ***Nondestructive detection method is vital in quality, safety and integrity assurance during fruits and vegetables post harvest. X-ray imaging technology has been proven to be one of the successful nondestructive methods ever to be applied in detecting diseases and defects in agricultural products. In this research, infested Harum Manis mango fruits detection and quality classification will be done by integrating X-ray imaging techniques and Artificial Immune Systems (AIS). The classification is made by applying the AIS self and nonself recognition process unto the Harum Manis mango X-ray images. The output of this study is the proposed automatic nondestructive classification system of Harum Manis mango.***

Keywords: Artificial Immune Systems, Nondestructive Detection Method, Self and Nonself Recognition

I. INTRODUCTION

The Harum Manis mango weevil's distribution has becoming a threat to Malaysia's fruits production. No known insecticide has been able to kill the weevil. Currently, in Malaysia, the fruit inspection or the existing quality control system is done manually. This paper describes the initial stage in developing an automated nondestructive detection system for post harvest quality inspection. Nondestructive detection is very important for maintaining fruits quality and increasing the production volume and the selling price and thus can help to boost the economy. There are several imaging methods implemented in nondestructive detection such as X-ray imaging, magnetic resonance imaging and Near Infrared Imaging (NIR). Among these methods, X-ray imaging technology has been proven to be one of the successful nondestructive methods ever to be applied in detecting diseases and defects in agricultural products. X-ray imaging requires interactions of X-ray photons with object, in this case, the Harum Manis mangoes, that work in a specific energy band [1]. In this research, infested Harum Manis mango fruits detection and quality classification will be done by integrating X-ray imaging techniques and Artificial Immune Systems (AIS). In the next section, the concept of AIS will be further explored along with its basic immune models. This paper will then focus on the Negative Selection Algorithm (NSA) as a tool to perform analysis on image recognition. Procedures on performing the image classification will then be developed. The result is presented in the form of proposed methodology that can perform an automatic classification of infested Harum Manis mangoes. Finally, this paper is concluded by indicating the areas for additional research in the future.

II. ARTIFICIAL IMMUNE SYSTEMS

AIS can be defined as metaphorical computational systems developed using ideas, theories, and components, extracted from the immune system [2]. It is a relatively new field that tries to exploit the mechanisms present in the biological immune system (BIS) in order to solve computational and engineering problems such as anomaly detection, data mining, computer security and image recognition [3]. The AIS theory for image recognition is basically inspired from the concept of self and non-self recognition inside the human immune system. The immune cells, known as B-cells and T-cells in the human immune system are responsible to distinguish between the self and nonself elements inside the human body. This paper will delve into this concept by applying the self and non-self recognition process in the Harum Manis mango X-ray image classification technique. In real application, the self and nonself elements are represented as strings of data and the matching of these two strings is determined by a function that produces a binary output (match or not-match) [3]. Most of the AIS models have adopted this recognition processes in many ways such as the negative selection, clonal selection, and the immune network theory. Negative selection method has been chosen as the algorithm to be used in evaluating the image recognition in this paper. It is chosen due to its simplicity and suitability to model image recognition problem as compared to the other two methods. A brief description on the NSA is provided in the following section.

Negative Selection Algorithm

The NSA was proposed by Forrest and his group [4] and this algorithm is inspired by the mechanism used by the immune system to train the T-cells to recognize antigens (nonself) and to prevent them from recognizing the body's own cells (self). The NSA contains three phases: defining self, generating detectors and monitoring the occurrence of anomalies. The concept is to generate a set of binary detectors by first randomly making candidates and then removing those that recognize or match the training self data [5]. These binary detectors can later be used to detect anomaly [5]. These phases can be simplified as shown in Figure 1[2]. The NSA method described relies basically on determining the match between strings. There are several expressions that can be employed in the determination of the degree of match or affinity between the self string and the detectors. One of the methods is to calculate the Hamming distance (D_H) between these two elements [2]. The Hamming distance is calculated using Equation (1) [6].

$$D_H = \sum_{i=1}^{L} \delta_i \text{ , where } \delta = \begin{cases} 1 & if \;\; p_i \neq m_i \\ 0 & otherwise \end{cases} \tag{1}$$

p = antigens
m = detectors
L = length

III. PROCEDURES

An experiment was conducted using an X-ray scanning device at Kepala Batas, Kedah Airport, in order to scan the harvested Harum Manis mango fruits for mango pulp weevil (MPW) infestation. The images taken from the X-ray scanning device will then be processed, analyzed and classified using AIS method. In order to apply the AIS algorithm, the images taken will be used as foreign elements to be tested against a protected element (self). The foreign elements or images taken will be represented in binary strings. The sets of binary strings will be tested and compared against the protected string. The method describes rely basically on determining the match between strings. Sets of detectors for infested mangoes images will be developed based on the matching level between the tested strings and the protected string. These detectors will then be used in performing the automatic classification of the Harum Manis mango fruits.

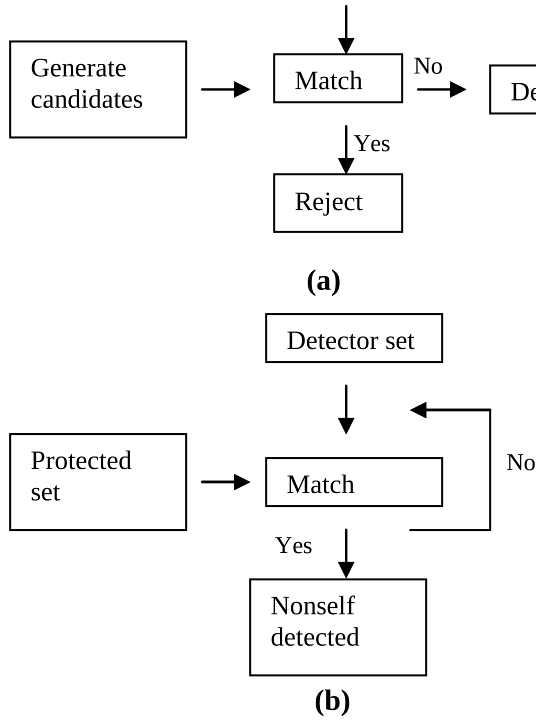

Figure 1 - Pattern recognition via the negative selection algorithm. (a) Generating the set of detectors. (b) Monitoring the presence of undesired (nonself) patterns.

A. Acquisition Process

The acquisition system used in this study to retrieve the Harum Manis mangoes images, as mentioned, was the X-ray imaging technique. The X-ray machine captured the images while the Harum Manis mangoes passing through a conveyor belt. During the image acquisition process, the orientation of the mangoes were neither controlled nor fixed. Based on these images, the damages caused by the MPW infestation were visible and could be detected from the real-time TV monitor images. The MPW-infested mangoes showed light-colored fragments outside the image of the seeds as a result of the weevil existence. These fragments correspond to the tunnels and holes made by the insects in the fruit pulp. Uninfested mangoes showed clear and uniform light grey images of the seeds and the pulps. The sample images of uninfested and infested Harum Manis mangoes generated by the X-ray imaging technique are shown in Figure 2 and 3.

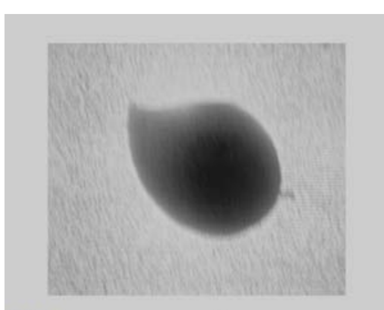

Figure 2 – Image of uninfested mango.

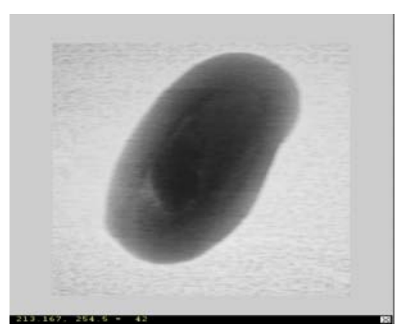

Figure 3 – Image of suspected infestation mango.

B. Initial Processing

The original image of the infested mango, 640x480 in dimension with three-color channels (RGB), is further analyzed by dividing it into smaller pixels and converting it from RGB into grayscale. The grayscale image is then converted into binary. The binary image of infested mango is shown in Figure 4. The binary representation of this image is collected as data sets to be tested using AIS algorithm.

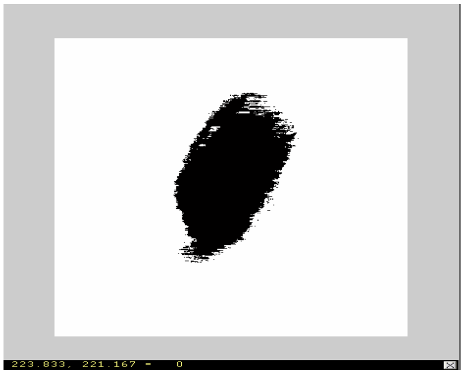

Figure 4 – The mango image turned binary.

C. AIS model

The main purpose of NSA is to generate a system that capable of identifying a protected element and distinguishing between the protected elements (self) and the foreign elements (nonself). In order to apply the proposed algorithm, the large collection of binary data sets acquired from B will be tested and compared against a predefined protected binary string. The protected string is actually a sample image of uninfested mango. A set of detectors, which consist of sets of binary strings, are then generated based on the affinity level between the test strings and the protected string. If the affinity level is high, the test string will be accepted as detector, and if the test string has low affinity level, the string will be rejected. The affinity level is calculated using Equation (1), and it is also dependent on a threshold value that has been set. High threshold value will produce high selectivity rate, thus reducing the number of detectors generated, and if the threshold value is reduced, more detectors can be generated. These generated detectors will then be used to detect anomalies that exist on images of Harum Manis mangoes. In this stage, if a detector pattern matches any newly test string pattern, it is then considered that new anomaly must have occurred in the monitored system. The final stage is to perform the classification based on the anomalies that exist in the images. The classification process will separate between the infested and uninfested Harum Manis mangoes.

IV. RESULT

The output of this study is the proposed methodology that can perform an automatic classification of infested Harum Manis mangoes as shown in Figure 5.

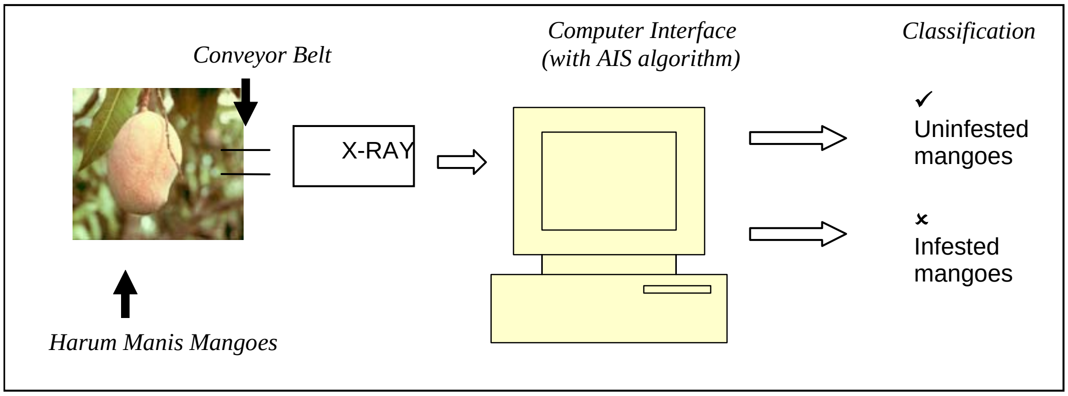

Figure 5 – Harum Manis mango fruits nondestructive detection system.

V. CONCLUSION

The AIS method is foreseen as cost effective, speedy and can be implemented in real time environment. An automatic detection system has been proposed to solve current manual fruits inspection system. However, this study serves as an introductory level analysis, future work is needed in:

1. Generating better and more images from the X-ray scanning device.
2. More detailed feature extraction of the images using much more accurate method is needed.
3. Other selection algorithms (clonal selection and immune network theory) have to be taken into consideration to provide better comparison in the analysis.

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