VOL. 14, NO. 23, DECEMBER 2019 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

DEVELOPMENT OF A MACHINE VISION SYSTEM FOR QUALITY CONTROL OF FRUITS

Aaron Don M. Africa, Emmanuel C. Del Rosario, Joshua Vincent G. Legal and Raine Mattheus C. Manuel
Department of Electronics and Communications Engineering, Gokongwei College of Engineering,
De La Salle University Manila, Philippines
E-Mail: emmanuel_delrosario@dlsu.edu.ph

ABSTRACT

The study aims to produce a theoretical design of a Machine Vision system. The system will be capable of looking for and identifying fruits, especially oranges, that are about to spoil. The system will make use of image processing to identify oranges and determine whether they are about to go bad. The system will serve as quality control that can be utilized by manufacturers and suppliers. The system is designed to be accurate, reliable and consistent as opposed to the human eye which is more susceptible to errors. The process of the system is as follows: the input of the images of fruits to the system, the identification of the orange using edge detection, the identification of dark spots, molds or skin peeling off the orange, and the identification that the orange is no longer qualified produce. The process that the system follows ensures the capability of the system to check for oranges that are about to go bad.

Keywords: machine vision, image processing, quality control, fruit grading, edge detection.

1. INTRODUCTION

In today's modern world, automation has been a vital part of industrial tasks. Manually doing tasks with a lot of labor just does not meet industry standards today mainly because of inconsistency based on the person's state. Therefore, automated machines were made, to be able to do tasks that keep up with the industry.

These automated machines are of course not enough, they have to be smart enough to do tasks that would require them to adapt and for them to adapt, they have to learn. Of course, learning is not enough, they should have some way to be able to perform certain tasks, complex industrial tasks to be exact. This is where machine vision comes in. Machine vision uses the combination of hardware and software that provides guidance to the machines through capture and processing of images. With the images captured, the machine processes this through a computer made to do the process, and after the process, the machine works based on the information provided to it by the computer.

Machine vision systems rely on digital sensors. These sensors are part of industrial cameras that acquires images that are sent to the computer hardware for processing and analysis of information. Automated Imaging Association (AIA) claims that machine vision is the peak in industrial and non-industrial applications where hardware and software work together to operate guidance to machines [1].

An example of a machine vision application is using a machine to test the qualities of products manufactured. The computer is programmed to analyze captured images of the products produced; it will access its data based on information about the required qualities of each product where it serves as the basis for product inspection [2]. After analyzation and processing of information, the machine connected to the computer will then either accept or reject the product. This application of machine vision helps in quality control of products.

2. BACKGROUND OF THE STUDY

Machine Vision is the study and development of systems capable of artificial vision. It carries out tasks that can be done by human vision. It can be made to identify and process anything the human eye can see. Image processing is the direct application of machine vision [3]. Machine vision is comprised of a hardware and software component. The hardware component obtains the imagery and works as the artificial eyes of the system, while the software part is capable of identifying and processing the imagery the system is feeding to it [4].

Machine Vision is an essential field in engineering. There is a lot of research needed to further develop image processing. Image processing has a lot of application in the daily life of people [5]. One of the major users of image processing is the manufacturing and production field. Error detection can be made easier with the further development of machine vision [6].

The Philippines is one of the top exporters of fruits. Tons and tons of fruits are being exported from the country every year. Image processing can be utilized to maintain the quality of these exported goods. Machine Vision can be used to look for and identify fruits that are about to go bad [7]. Instead of doing the manual labor of checking this absurd amount of fruits which can be more inefficient due to human error, image processing can be used [8].

Dark spots, mold and peeling skin can indicate that fruits are going bad. Image processing can be used to look for these indicators and can alert the system that the fruit is not good quality anymore [9]. By doing this, the system can be more efficient and there is a smaller chance of exporting fruits that are about to rot. Quality control of export products will surely be improved if the concept of machine vision is implemented.

3. STATEMENT OF THE PROBLEM

When it comes to industrial production of things, ideally, top quality is always a must for every individual product. While this is possible, when seeing things practically, there will always be errors big and small. Another problem here is that in the stage of production, quality inspection is difficult to do manually with labor and machines that are tasked to produce and assemble things are not smart enough to do the job. So basically, without the means to inspect the quality of all productions, there is always a product with a defect or failed quality that would get into the market. Of course, this is minimized by industrial manufacturers by reducing the margin of error in production but again, without the means to inspect, there is always a chance for the defective or bad quality product to get into the hands of consumers in the market.

In response to this problem, this study aims to be able to help solve the said problem of the industry with the use of machine vision application. The machine vision system will be responsible for inspecting certain products through the use of captured images, images in the database for quality basis, and a program that analyzes the product's quality that then tells the machine whether to discard the product or not.

4. SIGNIFICANCE OF THE STUDY

The aim of the study is to reduce the number of defective products, or products that did not pass the quality requirements. With a machine vision application in industrial manufacturing, the machine will be able to distinguish produced products that have passed the quality check in order to prevent products that are factory rejects to go out into the market.

With the data that will be gathered in the research, it will help improve machines that will be used in industrial manufacturing in quality checking the products individually. The data will not only contribute to simple inspections by the machine but will also help in the in-depth checking of the product based on images from the database that the researchers used. The system will help advance the technology used in industrial manufacturing that will be able to not only prevent recalling of products but also help in bringing out the best quality products. The machine will also help set the standards in manufacturing products because it will serve as the guide to the produced items. With this, the margin of error can be reduced in manufacturing and thus not only helping in distinguishing bad productions from the good ones but also help reduce producing a big number of defective products. This also serves as prevention for wasting resources in the industry.

5. LITERATURE REVIEW

Agriculture has been an essential part of harvesting in any culture. That early human civilization has dependent on increasing the food source by using agriculture [10]. The demand for a growing global population has never decreased which calls for an increase in its production however to do this effective growth would need proper monitoring [11]. Safe storage of the fruits is proportional to our daily life and health it is crucial because there are different factors that will affect the produces growth, therefore, a need for a real-time monitoring system that would analyze the plants growth as changes in the environment develop with the use of various interface and sensors as opposed to human monitoring that is expensive and ineffective [12]. Automation increases the productivity, quality and economic growth of the agricultural industry [13]. However, diseases in fruits result in heavy economic loss and production worldwide which can be hard for a small scale farming plant to have to lose their capital [14]. Therefore, usage of automatic methods is to be used also as a detector early on would be a game-changer because it would also protect the other crops of the production and remove potential crops that may be infected [15]. These automatic methods are namely using image processing to let the computer detect signs of diseases by having the fruit classified from its color, texture, and morphology with the use of artificial neural network which employs effective algorithms that would read the extent of spread of disease a fruit has suffered [16]. Moreover, we could also use image processing could also be used to estimate the volume of fruit it would be categorized into simpler shapes like ellipsoid, spherical, and paraboloid this also helps production to cut off outlier sizes of the products which would maintain the quality of the production [17]. Additionally, when applying artificial neural network there must be the usage of K-means clustering to be able to detect the spots of the infected produce that would be categorized based on the classifications said above [18]. Machine vision has become a key technology in the are of quality control. The vision system is focused on computer vision in becoming an inspection tool of the product such as pharmaceuticals, and food [19]. This is also supported by Feng *et al* as they stated that machine vision system can be used for automatic high-speed fruit sorting with the use of segmentation techniques such as the Ohta-color-space thresholding algorithm, blob algorithm is used to improve the image by removing noises, while the spline-interpolation algorithm was adopted to detect the contour of the fruit, and the fruit sorter was a Bayes classifier which achieved a 90% of accuracy [20, 21]. This has been a common occurrence with the usage of machine vision system even when with different classifier they still maintain a 90% accuracy rate with their classification which we could say that the usage of machine vision hand in hand with artificial neural networks and Digital Image processing is successful in determining the disease of a fruit. In a machine vision system, it is essential to take into consideration the different theories that will improve the efficiency of the system. For example, spatial imaging is crucial in image processing in the sense that, the number of pixels is utilized in the analysis of the image. Spatial imaging is important in the recognition of the image and in the analysis of whether the system deems the product as good quality or bad quality product. Electronic sensors, another theory is also essential in a machine vision system. Some form of the sensor is responsible for feeding the

program the information it needs which, in the case of the system, is the image of the product it will identify.

6. THEORETICAL CONSIDERATION

6.1 Spatial imaging

Spatial Imaging is the process of processing an image digitally with a certain number of pixels utilized in the construction of the image [22]. The higher the spatial resolution means that the number of pixels is larger. The higher the resolution, the more detailed the image is. For this research, spatial imaging is a crucial part of detecting even the tiniest details in inspecting the quality of the product [23].

6.2 Rough set theory

The rough set theory is a mathematical approach to understand and manipulate a problem given the lack of knowledge [24]. This theory is supported by other mathematical theories. Rough set theory tackles the problem by using different theories on set theories and approximations [25]. In approaching a problem using the theory, the vagueness of the problem is expressed by a boundary region of a set [26, 27]. For this research, rough set theory can be used for approximations of data because processing and analyzing of images is not always perfect compared to the database in the system that will be used for comparison in order to determine the quality [28, 29].

6.3 Electronic sensors

Usually, when an electronic system needs to gather information from outside its system, sensors are used. Using the sensors, the system can do certain tasks depending on how the system is made or programmed [30]. These sensors can be classified into analog and digital sensors. Example of electronic sensors is IR sensors that could detect certain characteristics of its surroundings, ultrasonic sensors that could detect physical objects and their distance, temperature sensors, and many more. Electronic sensors are a critical part of this research because they will serve as the once used for gathering information on the object being analyzed [31].

6.4 Logic scoring of preference

Logic scoring of preference is a multicriteria decision-making method that would work with some fuzzy reasoning with some analysis and some computing [32]. This research, this decision-making method can be used together with information gathered from processed image and analyzation to decide whether the product has good quality or not. This method requires multiple input criteria [33].

6.5 Artificial neural network

An artificial neural network is a tool used for machine learning [34, 35]. This type of system enables a machine to adapt and learn from gathered information, similar to how humans learn. The neural network has an input and output and has a hidden layer that has units that could transform the input into something that the output can use in later occasions [36]. The artificial neural network can be used for finding patterns that are difficult to do manually without programming [37]. In this research, this is especially useful for quality checking while not only relying on current information but with new once gained from the capture and processing of images [38].

6.6 Database monitoring

Database monitoring is used to help the system know of what information is used, new information gathered, and how it will help the process improve. In this research, database monitoring is used for accessing the database of perfect quality fruits for analyzing newly captured images of fruits. The database can also be updated through machine learning whenever it learns of a pattern, making the process better and more efficient [39].

6.7 Data/Information transfer

Data is a critical part of this research. The system must first have an initial database that contains information that tells the system the type of fruit quality it is supposed to follow when doing the process [40]. This data contains information and transferring this to the system at work enables the machine to work its function. Basically, the data is the source of information, which is updated, and the transfer of the information from it is a vital part in doing the process of checking the quality of the fruits being captured and processed in machine vision [41].

7. DESIGN CONSIDERATION

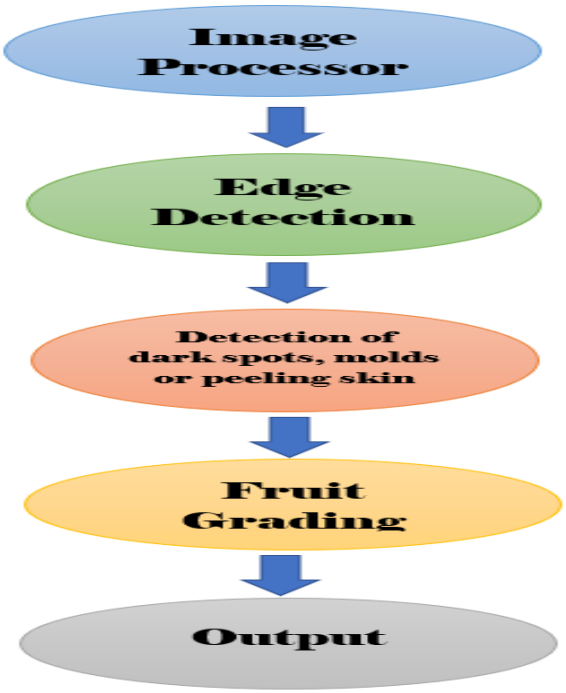


Figure-1. Flowchart of the system process.

The system will follow the process presented in the flowchart to function. It will first process the image that is being fed into the program. It will then determine the object, which in the case of the study, an orange. The system will use edge detection to determine each individual orange being identified by the system. The system will then check for indicators that the orange is no longer quality produce by checking for dark spots, molds or peeling skin. Based on these criteria, the system will determine if the orange is about to or already spoiled or not. The system will now be able to determine all the oranges that are likely close to spoiling or already spoiled.

8. METHODOLOGY

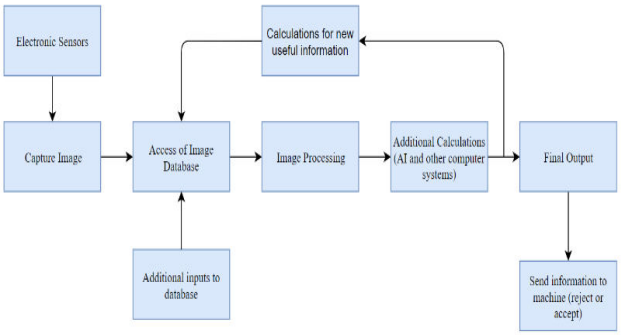


Figure-2. Flowchart of the theoretical system design of a Quality control system using image processing.

The system's main objective is to inspect a fruit using machine vision that would determine whether it has an acceptable quality or not. This can be done possible using the concept of machine vision together with some mathematical theories such as rough set theory, logic scoring, and many more. These theoretical concepts will help build the system's overall AI or program that calculates information based on multiple inputs gained from image processing. The calculations are based on theories such as the logic scoring of preference and rough set theory. The system is also supported by an artificial neural network, which is where the system learns more information whenever it captures and processes images. Information learned here are beyond from what the initial database is [42].

The overall summarized process is, the machine captures an image, the image is processed and the database will be used for reference, the calculations will be made, feedback from calculations will go to the database for any updates through machine learning, and finally, the output, which will determine whether to reject or accept the fruit [43].

9. DATA AND RESULTS

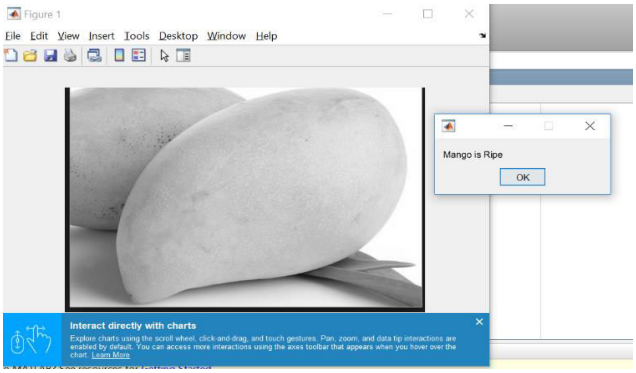


Figure-3. Good quality mango as identified by the system.

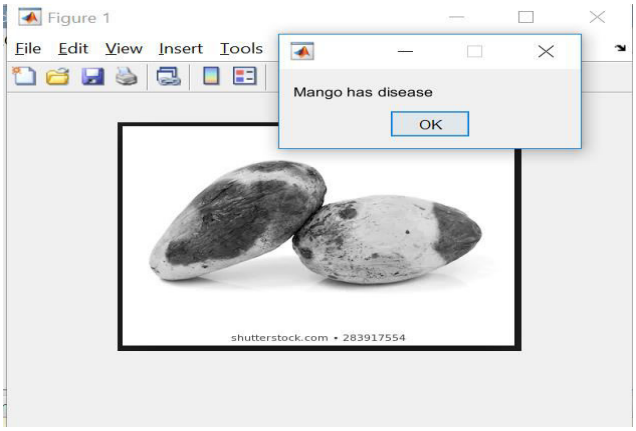
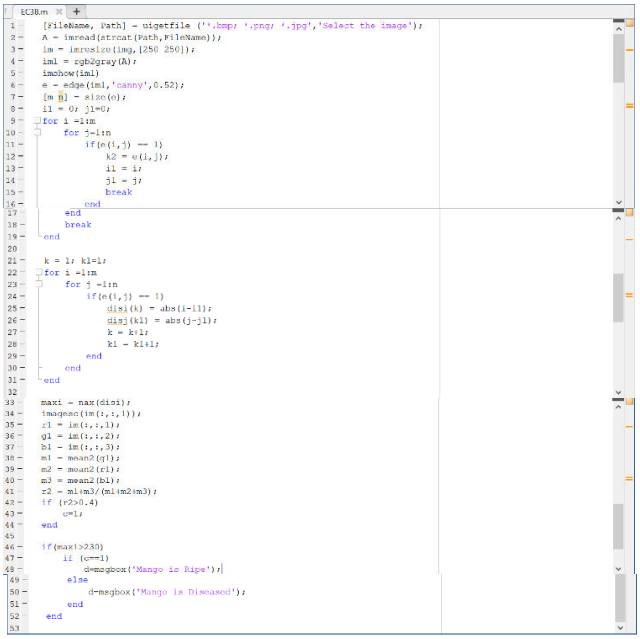


Figure-4. Bad quality mango as identified by the System.

CODES:



```
[FileName, Path] = uigetfile ('*.bmp; *.png; *.jpg','Select the image');
A = imread(strcat(Path,FileName));
im = imresize(img,[250 250]);
iml = rgb2gray(A);
imshow(iml)
e = edge(iml,'canny',0.52);
[m n] = size(e);
i1 = 0; j1=0;
for i =1:m
    for j=1:n
        if(e(i,j) == 1)
            k2 = e(i,j);
            i1 = i;
            j1 = j;
            break
        end
    end
    break
end

 k = 1; k1=1;
for i =1:m
    for j =1:n
        if(e(i,j) == 1)
            disi(k) = abs(i-i1);
            disj(k1) = abs(j-j1);
            k = k+1;
            k1 = k1+1;
        end
    end
end

maxi = max(disi);
imagesc(im(:,:,1));
r1 = im(:,:,1);
g1 = im(:,:,2);
b1 = im(:,:,3);
m1 = mean2(g1);
m2 = mean2(r1);
m3 = mean2(b1);
r2 = m1+m3/(m1+m2+m3);
if (r2>0.4)
    c=1;
end

if(maxi>230)
    if (c==1)
        d=msgbox('Mango is Ripe');
    else
        d=msgbox('Mango is Diseased');
    end
end
```

Figure-5. Sample program code for the System.

10. ANALYSIS OF DATA

The researchers have been able to implement software for checking the quality of mangoes by having its image sent to a computer wherein they would process for

black spots and mark them as diseased produce. With the usage of Digital Processing Image Toolbox, we're to use K-means to be able to check whether the mango has a consistent yellow color or has a big spot of black. The group has chosen to have this method because it is computationally less intensive while providing high accuracy in determining the status of the mango. Additionally, there are parts of the code like how 'image' and 'show' are two different codes that should be used separately because if we use the code 'image' for showing the grayscale picture of the figure the picture would be disoriented with what the system finds as the most dominant color. Moreover, we are other than spotting black marks in the figure we also measured the color of the mangoes it's yellow intensity to be able to determine if the produce is mature or not. If it is below the threshold intensity it would also tell the user that is not ripe. Furthermore, the system can also read the size of produce by checking the edges of the mango which would tell the user if the mango is large or small. All in all, with the system we are able to segment the size, color, and determine if the mango is not edible by having this parameter the user can segregate the production into his liking for him to continue the quality of the produce.

11. CONCLUSIONS

The research done was a machine vision system. Image processing was used to determine and identify the fruit and check whether it is rotten or about to rot. The program implemented is a system that will contribute to the quality control of the manufacturing and production industry.

The process of the system works by first recognizing the image. The system will use edge detection to identify the fruit. In the case of the research, a mango was used. The system will then detect for either black spots, molds, or peeling of the skin. These are indicators that will determine if the mango is spoiled or about to spoil. The system will then process the image to give its verdict.

The study was conducted with the basis of six theories namely: Spatial imaging, rough set theory, electronic sensors, logic scoring of preference, artificial neural network, database monitoring, and data and information tracker. Spatial imaging was crucial for identifying the smallest detail of the image in order to determine the fruit. Rough set theory was used to make approximations for the data gathered in the research. Since the focus of this topic is machine vision, electronic sensors are one of the key factors in the study. Since the program relies on the image being processed, machine vision systems should have a form of electronic sensor to feed the program the image it will process. For logic scoring of preference, the decision-making methods were used to further make the verdict of the system as accurate as possible. Since quality control is a repeated process of checking the produce, the artificial neural network helps the system become more accurate when exposed to more and more inputs. This helps make the decision making faster and more efficient. Database monitoring is closely linked to an artificial neural network. Since quality control is a repeated process, the system can use what it already knows and update its database to make it run more efficiently. Data and information tracker is used to feed the system the needed input.

12. RECOMMENDATION

For future studies, the researchers recommend sampling of different types of fruits instead of just mangoes. The system should be able to identify each type of fruit from a large sample of fruits. The system should also be able to check if each fruit going spoiled or about to spoil. The theoretical system should also have more parameters to check if the fruit is to spoil or about to spoil. The program should not be limited to checking for dark spots, molds, and peeling of the skin. These parameters may include the size and color of the fruit. Size and color may indicate if the product is good or not. Future studies may consider these parameters to check if the fruit is going bad. The researches did a theoretical design of the system without actual hardware or software implementation. The research would be more precise given actual software and hardware implementation of the system. More efficient image processing could also be implemented given the topic; future researches can have better-performing machine vision systems for image processing. Also, the fruit detection method used was edge detection. Other researchers can develop or use other ways of identifying different types of fruits.

Future researches could also benefit from the study presented. Quality control is not limited to fresh produce like fruits. Quality control should be implemented by every manufacturer and producers. The study can help shed light in different ways machine vision can be used to help implement quality control. Machine vision is not limited to quality control. The medical field can also benefit from image processing. Machine vision systems can also be used in the diagnosis of different diseases. Since the artificial neural network is under machine vision, it can be used to predict if a person may have an injury or a disease like tumors, fractures and the like.

REFERENCES

[1] Jadhav R. S. and Patil S. S. 2013. A Fruit Quality Management System Based on Image Processing. OSR Journal of Electronics and Communication Engineering. 8(6): 1-5.

[2] Li B. 2018. Application of machine vision technology in geometric dimension measurement of small parts. EURASIP Journal on Image and Video Processing. 127.

[3] Chen S., Xiong J., Guo W., Bu R., Zheng Z., Chen Y., Yang Z. and Lin R. 2019. Colored rice quality inspection system using machine vision. Journal of Cereal Science. 87-95.

[4] Morgunov V. 2019. Applying Machine Vision in Quality Control. International Student Scientific Herald. 2.

[5] N. j. N. and B.k. A. 2015. Role of Computer Vision in Automatic Inspection Systems. International Journal of Computer Applications. 123(13): 28-31.

[6] Onita D., Vartan N., Kadar M. and Birlutiu A. 2018. Quality control in porcelain industry based on computer vision techniques. 2018 International Young Engineers Forum (YEF-ECE). 79-84.

[7] Prasad P. Machine Vision Systems and Image Processing with Applications. Journal of Innovation in Computer Science and Engineering. 2(2).

[8] Pavan Kumar G. and Bhanu Prasad P. 2014. Article: Machine Vision based Quality Control: Importance in Pharmaceutical Industry. IJCA Proceedings on International Conference on Information and Communication Technologies ICICT. 8: 30-35.

[9] Awate A., Deshmankar D., Amrutkar G., Bagul U. and Sonavane S. 2015. Fruit disease detection using color, texture analysis and ANN. 2015 International Conference on Green Computing and Internet of Things (ICGCIoT). 970-975.

[10] Devi M. R. and Kavitha V. 2015. Comparison of Citrus fruit diseases revealing with Data Mining and Image Processing Techniques based on assorted parameters. 2015 International Conference on Computer Communication and Informatics (ICCCI). 1-4.

[11] Dubey S. R. and Jalal A. S. 2012. Detection and Classification of Apple Fruit Diseases Using Complete Local Binary Patterns. 2012 Third International Conference on Computer and Communication Technology. 346-351.

[12] Kaur K. and Marwaha C. 2017. Analysis of diseases in fruits using image processing techniques. 2017 International Conference on Trends in Electronics and Informatics (ICEI). 183-189.

[13] Ilic M., Spalevic P., Veinovic M. and Ennaas A. A. M. 2015. Data mining model for early fruit diseases detection. 2015 23rd Telecommunications Forum Telfor (TELFOR).

[14] Iqbal S. M., Gopal A., Sankaranarayanan P. and Nair A. B. 2015. Classification of Selected Citrus Fruits Based on Color Using Machine Vision System. International Journal of Food Properties. 19(2): 272-288.

[15] Jhuria M., Kumar A. and Borse R. 2013. Image processing for smart farming: Detection of disease and fruit grading. 2013 IEEE Second International Conference on Image Information Processing. 521-526.

[16] Feng G. and Qixin C. 2004. Study on color image processing based intelligent fruit sorting system. Fifth World Congress on Intelligent Control and Automation. 6: 4802-4805.

[17] Kumar S. and Gill G. S. 2015. Automatic Fruit Grading and Classification System Using Computer Vision: A Review. 2015 Second International Conference on Advances in Computing and Communication Engineering. 598-603.

[18] Anabtawi N. and Ferzli R. 2015. An auto focus framework for computer vision systems. Proc. SPIE 9405, Image Processing: Machine Vision Applications VIII. 9405.

[19] Basavaprasad B. and Ravi M. 2014. A Study on the Importance of Image Processing and Its Applications. International Journal of Research in Engineering and Technology. 3(15): 155-160.

[20] Eisert P., Pollefeys M. and Tubaro S. 2009. Three-Dimensional Image and Video Processing. EURASIP Journal on Image and Video Processing. 1-2.

[21] Kavita, Saroha R., Bala R. and Siwach S. 2013. Review paper on Overview of Image Processing and Image Segmentation. International Journal of Research in Computer Applications and Robotics. 1(7): 1-13.

[22] Loresco P. and Africa A. 2018. ECG Print-out Features Extraction Using Spatial-Oriented Image Processing Techniques. Journal of Telecommunication, Electronic and Computer Engineering. 10(1-5): 15-20.

[23] Isgro F., Trucco E., Kauff P. and Schreer O. 2004. Three-dimensional image processing in the future of immersive media. IEEE Transactions on Circuits and Systems for Video Technology. 14(3): 288-303.

[24] Africa A. and Cabatuan M. 2015. A Rough Set Based Data Model for Breast Cancer Mammographic Mass

Diagnostics. International Journal of Biomedical Engineering and Technology. 18(4): 359-369.

[25] Africa A. 2017. A Rough Set Based Solar Powered Flood Water Purification System with a Fuzzy Logic Model. ARPN Journal of Engineering and Applied Sciences. 12(3):638-647.

[26] Africa A. 2017. A Mathematical Fuzzy Logic Control Systems Model Using Rough Set Theory for Robot Applications. Journal of Telecommunication, Electronic and Computer Engineering. 9(2-8): 7-11.

[27] Africa A. 2017. A Rough Set-Based Expert System for diagnosing information system communication networks. International Journal of Information and Communication Technology. 11(4): 496-512.

[28] Africa A. 2016. A Rough Set Data Model for Heart Disease diagnostics. ARPN Journal of Engineering and Applied Sciences. 11(15): 9350-9357.

[29] Hutagalung A. and Nugroho H., Suheryadi A. and Yunanto P. E. 2017. Detection and Counting of Mango Fruits in Occluded Condition Using Image Analysis. 5th International Conference on Instrumentation, Communications, Information Technology, and Biomedical Engineering. 190-195.

[30] Africa A., Aguilar J., Lim Jr C., Pacheco P. and Rodrin S. 2017. Automated Aquaculture System that Regulates Ph, Temperature and Ammonia.9th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM).

[31] Montgomery B., Dragićević S., Dujmović J. and Schmidt M. 2016. A GIS-based Logic Scoring of Preference method for evaluation of land capability and suitability for agriculture. Computers and Electronics in Agriculture. 124: 340-353.

[32] Africa A. 2018. A Logic Scoring of Preference Algorithm using ISO/IEC 25010:2011 for Open Source Web Applications Moodle and Wordpress. ARPN Journal of Engineering and Applied Sciences. 13(15): 4567-4571.

[33] Salunkhe R. P. and Patil A. A. 2015. Image processing for mango ripening stage detection: RGB and HSV method. Third International Conference on Image Information Processing. 362-365.

[34] Africa A. and Velasco J. 2017. Development of a Urine Strip Analyzer using Artificial Neural Network using an Android Phone. ARPN Journal of Engineering and Applied Sciences. 12(6): 1706-1712.

[35] Brucal S., Africa A. and Dadios E. 2018. Female Voice Recognition using Artificial Neural Networks and MATLAB Voice box Toolbox. Journal of Telecommunication, Electronic and Computer Engineering. 10(1-4): 133-138.

[36] Li L., Gao Z. and Yuan Z. 2019. On the sensitivity and uncertainty of wave energy conversion with an artificial neural-network-based controller. Ocean Engineering. 183: 282-293.

[37] Africa A., Bautista S., Lardizabal F., Patron J. and Santos A. 2017. Minimizing Passenger Congestion in Train Stations through Radio Frequency Identification (RFID) coupled with Database Monitoring System. ARPN Journal of Engineering and Applied Sciences. 12(9):2863-2869.

[38] Nanaa K., Rizon M., Rahman M. N. A., Ibrahim Y. and Aziz A. Z. A. 2014. Detecting Mango Fruits by Using Randomized Hough Transform and Backpropagation Neural Network. 18th International Conference on Information Visualisation. 388-391.

[39] Merchant M., Paradkar V., Khanna M. and Gokhale S. 2018. Mango Leaf Deficiency Detection Using Digital Image Processing and Machine Learning. 3rd International Conference for Convergence in Technology. 1-3.

[40] Africa A., Mesina A., Izon J. and Quitevis B. 2017. Development of a Novel Android Controlled USB File Transfer Hub. Journal of Telecommunication, Electronic and Computer Engineering. 9(2-8): 1-5.

[41] Ali M. A. H. and Thai K. W. 2017. Automated fruit grading system. IEEE 3rd International Symposium in Robotics and Manufacturing Automation. 1-6.

[42] Sako H. 2007. Recognition Strategies in Machine Vision Applications. International Machine Vision and Image Processing Conference. 3-3.

[43] Sarma G. 2011. Image Processing - A Gizmo for Video Content Extraction. ARPN Journal of Systems and Software. 1(8): 251-257.