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Categorizing Of Allium Sativum Based On The Philippines National Standard And Asian Standard Using Pixel Per Metric Ratio And Blob Detection Methods

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ABSTRACT

The researchers used the Blob detection and Pixel per metric ratio methods to determine the texture and size of the garlic based on the Philippine National Standard (PNS/BAFPS No. 51 :2007) and Asian Standard (ASEAN Stan 13:2009). The formulated Blob percentage value in quality grading for Extra Class is less than 20%, Class I is 20% - 40%, Class II is greater than 40% -60%, and Reject is greater than 60%. The size of the garlic was categorized by Class A, Class B, Class C, Class D, and Class E. The functionality and reliability of the conveyor system were also examined in this study.

1. Introduction

Philippines is one of the producers of the garlic in Asia. In 2017, based on the Philippine News Agency (PNA), Ilocos Norte reported that can have shared 6,284 metric tons of garlic bulbs to the 9.133 metric tons' production output in the country. Occidental Mindoro ranks second with a production of 2,012 metric tons, followed by Nueva Ecija, Quezon

Province with 324, 268 metric tons and Ilocos Sur with 245 metric tons. In 2018, the garlic production in country was reported 7.6 thousand metric tons approximately. Sorting of garlic is necessary to check the good and reject before the delivery in the market. Usually, the texture of the garlic can be identify using manual method.

The researchers of this study used blob detection algorithm to detect the quality grading of the garlic. The blob detection method is aimed to detect region of interest points like the dots, spots, particles, and other desirable features [1]. There are most three common algorithms in Blob detection such as 1) Laplacian of Gaussian (LoG), 2) Difference of Gaussian (DoG), and 3) Determinant of Hessian (DoH). The LoG is a point detection method [2]. This method is a most accurate but slowest approach. The DoG is faster method of LoG approach. The DoH is the fastest method among the algorithms. The blobs are determined by finding maximas in the matrix of the Determinant of Hessian of the image.

$$LoG = \square^2(Gxx(x,y,\square) + Gyy(x,y,\square)) \quad (1)$$

$$DoG = G(x,y,k\square) - G(x,y,\square) \quad (2)$$

$$DoH = t^2(GxxGyy - G^2xy) \quad (3)$$

The equation 1 is the Laplacian method formula. The x and y are the pixel coordinates. The equation 2 is the DoG which can be computed as the difference between two images smoothed with Gaussian kernels of different scales. The DoH formula is using the equation 3.

The Pixel metric ratio method is used to determine the size of the object. The dimensions of the object (width or height) should have a reference object for calibration. The pixel is a picture element. Every element of the array or square in the grid is a pixel. The formula of Pixel Per Metric is the ratio of the image width and the field of view:

ppm = Image Width (in pixels) / Field of view (in meters) (4)

This study will be helpful to the agricultural sectors and future researchers. The garlic will be delivered in the market with high-quality value. The main objective of this study is to develop a system that will classify the size and quality grading of the garlic based on the Philippine National Standard and Asian Standard. This study can be achieved with the following specific objectives; 1) to develop a system that can detect the texture and size; 2) to formulate blob percentage values that can categorize the garlic based on the local standard and Asian standard; and 3) to test the functionality and reliability of the developed conveyor system.

The Philippine National Standard (PNS) category for garlic is based on the PNS/BAFPS No. 51 :2007 as shown in Table I. The diameter size has four categories such as small, medium, and large.

Table I. *Classification of garlic size based on pns*

Size	Diameter (cm)
Large	>4.0
Medium	3.0 – 3.9
Small	2.0-2.9

There are five (5) size categories of the garlic in Asian Standard (AS) based on the ASEAN Stan 13:2009 as shown in Table II.

Table 2. *Classification Of Garlic Size Based On Asian Standard*

Size Code	Diameter (mm)
1	>35
2	30-<35
3	25-<30
4	15-<25
5	<15

The quality grading of garlic is classified such as; a) Extra Class (superior quality), b) Class I (good quality), c) Class II (satisfy the minimum requirements).

2. Related works

The research about classification of pineapples' size and weight based on Thai Agricultural Food Standard using image processing and fuzzy logic [3]. The study from China about garlic classification based on linear regression [4]. Another research is the garlic mapping using random forest classifier in Jinxiang County, Shandong Province, China [5]. The research about fuzzy logic method that can recognize the maturity of the hybrid tomatoes based on the United States Standards [6]. Classification of maturity and size of mango fruits using Raspberry Pi and open-CV [7]. The research about the real-time smart fruits quality grading by color image processing techniques and with Artificial Neural Network (ANN) model [8]. Guava fruits classification using machine vision with ANN application based on the CIE1931 chromaticity coordinates [9]. Fruits ripeness classification using using K-means clustering and artificial neural network [10]. A research from India: Apple, orange, pear , and lemon grading classification using deep convolution neural network[11]. Fruit maturity and quality monitoring with an application of electronic–nose (E-nose).

The mentioned studies used image processing algorithms to detect the quality grading and size of agricultural production. However, they are

not focused on the garlic classification based on Philippine National Standard and Asian Standard.

3. Methodology

The developed conveyor system can categorized the garlic based on the Philippine National Standard (PNS) and Asian Standard (AS) as shown in the Fig. 1.

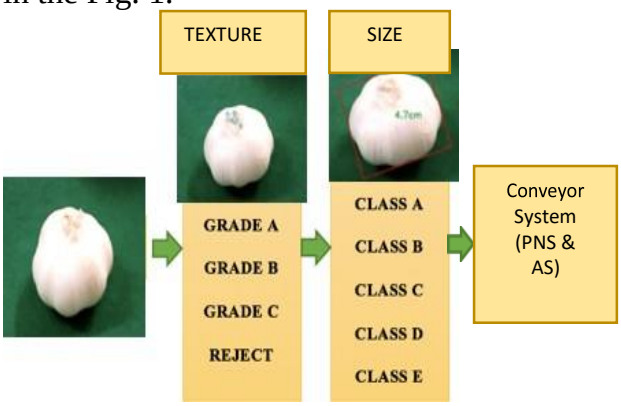


***Fig. 1**. Block Diagram of the System*

The quality grading is identified using Blob Detection algorithm while the size of the garlic is using Pixel per Metric Ratio. The researchers graded the Extra Class as Grade A, Class I as Grade B, Class II as Grade C, and Reject. The size detection has five categories such as the Class A, Class B, Class C, Class D, and Class E. The researcher used openCV to develop a system, a python based library for computer vision.

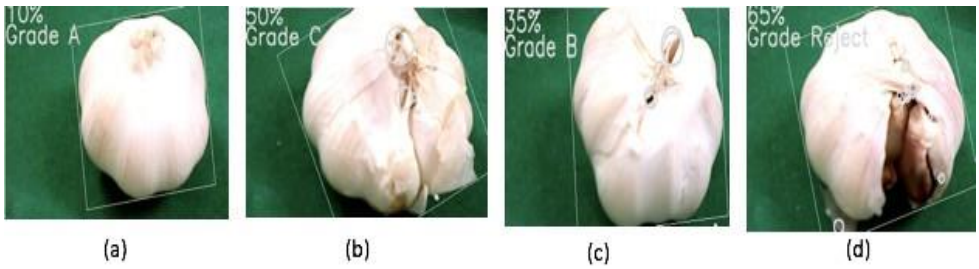


***Fig. 2.** Quality Grading Disposition*

The results of the disposition are displayed to the GUI as shown in Fig. 2. The formulated percentage values of the Blob are for texture analysis. The Blob percentage value with less than 20% is Grade A (Extra Class), the percentage from 20% - 40% is Grade B (Class I), the percentage with greater than 40% -60% is Grad C (Class II), and the percentage value with greater than 60% is a Reject category.

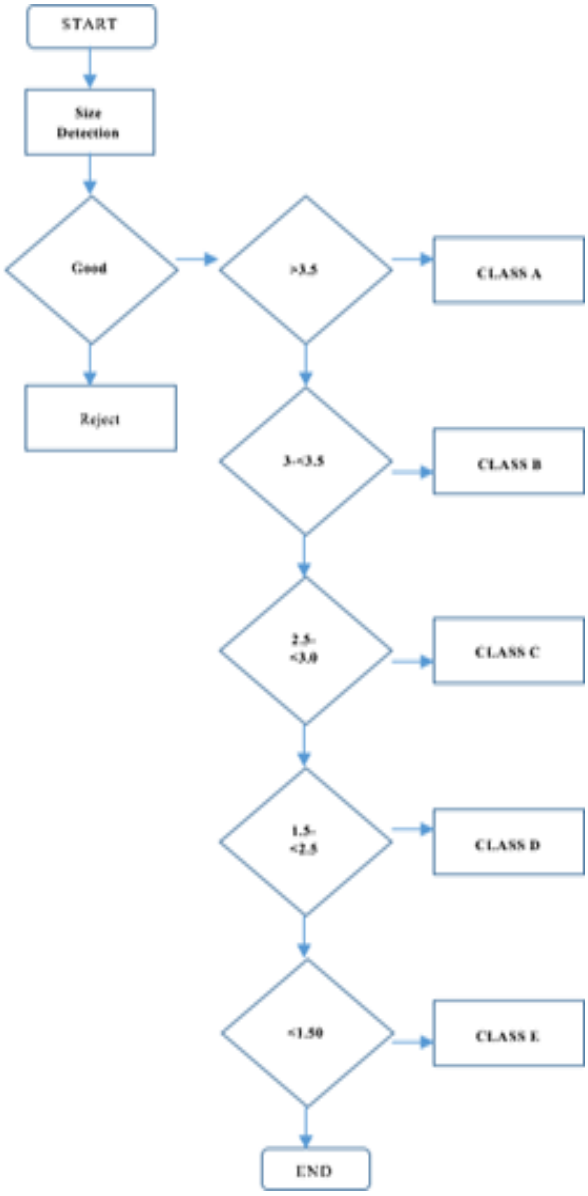


Fig. 3. *Size Detection Process based on AS*

Fig. 3 shows the size detection process based on the AS of the garlic which has six dispositions: the Class A (greater than 3.5cm), Class B (3.0cm to 3.5cm), Class C (2.5 cm to 3.0cm), Class D (1.5cm to 2.5cm), and Class E (less than 1.5 cm) . Once the garlic is classified as Good, the system checked the size category disposition into Class A, Class B, Class C, Class D, and Class E otherwise the garlic is automatically rejected.

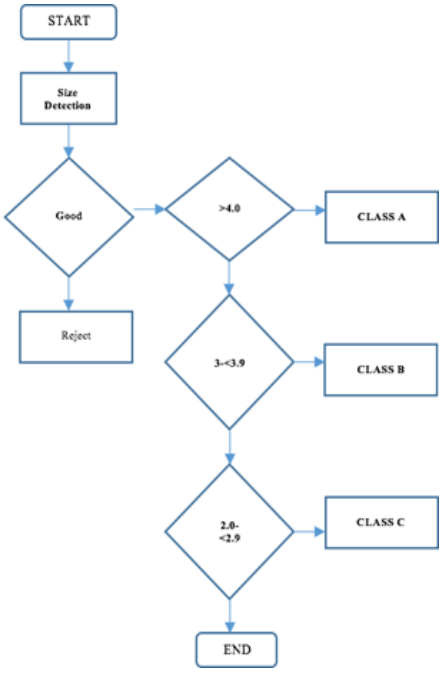


Fig. 4*. Size Detection Process based on PNS*

Fig. 4 shows the size detection process based on the PNS: the Class A (Large) is greater than 4.0 cm, Class B (Medium) is from 3.0cm to 3.9 cm, and Class C (Small) is 2.0 to 2.9 cm.

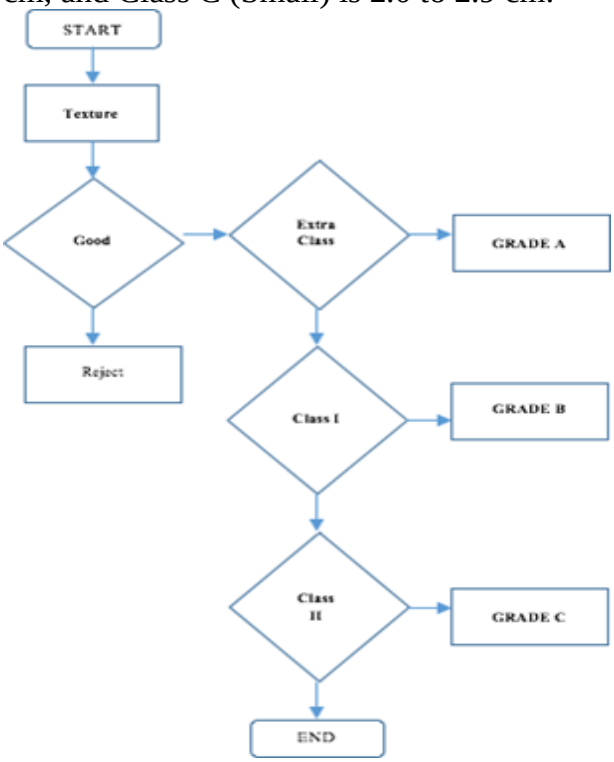


Fig. 5. *Texture Detection Process based on AS and PNS*

Fig. 5 shows the texture detection process for quality grading based on the AS and PNS: Grade A (Extra Class), Grade B (Class I), and Grade C (Class II).

4. Results and discussion

A. Texture Detection for Quality Grading

The blob detection method was used to determine the quality grading of the garlic. The system can display the Grade category with the percentage value of blobs.

***Fig. 6**. Grade A Category*

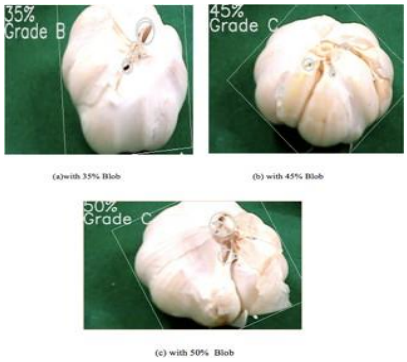


***Fig. 7.** Grade B and C Category*

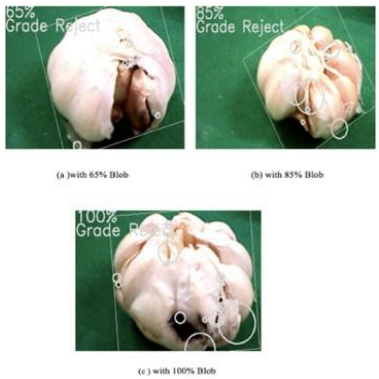


***Fig. 8**. Reject Category*

The developed system can detect the texture of the garlic according to its category based on the PNS and AS such as Grade A, Grade B, Grade C, and Reject as shown as in Fig. 6, Fig. 7, and Fig. 8. Clean, dry, no sprouts, and no roots bulbs of garlic were used during the tests.

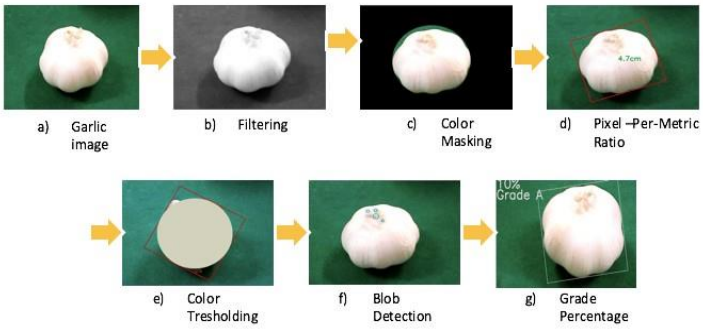


Fig. 9. *Process of Feature Extractions to determine the Grading and Size of the Garlic*

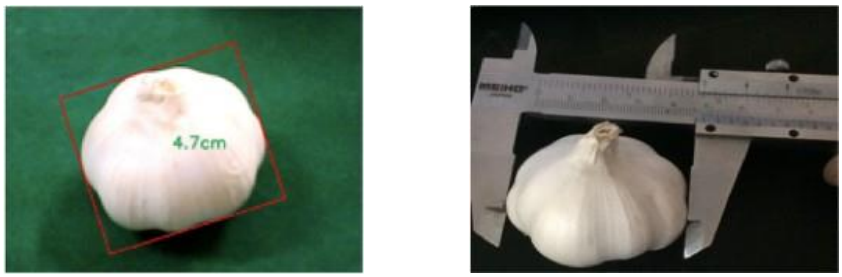
Fig. 9 shows the feature extraction process to detect the grading and size of the garlic. After the filtering method using Gaussian Blur, color masking was next method before the pixel-per metric ratio to determine the size of the garlic. Next is color thresholding before blob detection method to get the grade percentage of the garlic such as Grade A, Grade B, Grade C, and Reject.

The actual percentage value of samples was checked if matched with the formulated percentage values (Target Blob) as tabulated in Table III.

Table iii. *Classification of garlic based on blob percentage*

Sample No.	Actual % Blob	Target Blob	Grade	Remarks
1	10	<=20%	A	MATCHED
2	10	<=20%	A	MATCHED
3	10	<=20%	A	MATCHED
4	0	<=20%	A	MATCHED
5	5	<=20%	A	MATCHED
6	60	>40%-60%	C	MATCHED
7	20	<=20%	A	MATCHED
8	0	<=20%	A	MATCHED
9	40	>20%-40%	B	MATCHED
10	100	>60%	REJECT	MATCHED
11	45	>40%-60%	C	MATCHED
12	50	>40%-60%	C	MATCHED
13	35	>20%-40%	B	MATCHED
14	25	>20%-40%	B	MATCHED
15	70	>60%	REJECT	MATCHED
16	90	>60%	REJECT	MATCHED
17	25	>20%-40%	B	MATCHED
18	5	<=20%	A	MATCHED
19	30	>20%-40%	B	MATCHED
20	85	>60%	REJECT	MATCHED

B. Size Detection based on the PNS and AS



b) Pixel per Metric Ratio a) Measurement using Caliper

Fig. 10. *Size Detection using Pixel per Metric Ratio and Caliper*

Fig. 10 shows the size detection method using pixel per metric ratio and using caliper. The reseachers compared the developed system actual results and the manual method. To test the program, the actual size was measured using caliper and compare the results to the developed system. Series of experimental tests are conducted to compare the two treatments, the Manual and Automated in classifying the size of the garlic based on the AS and PNS.

The statistical method used for this study is T-test to evaluate the hypothesis: "*There is no significant difference between the manual quality grading and the automated quality grading".* The results of the conducted tests are shown in Table IV and Table V. The t-values for AS is 0.0308, and for PNS is 0.1475 which are less than to the critical value of 2.01. It means that the null hypothesis is accepted. Therefore, the manual quality grading is the same with the automated quality grading.

Table iv. *T-test results of garlic asian standard*

ASIAN STANDARD (AS)		
	Manual	***Automated***
Mean	4.918	4.9048
Variance	2.2158	2.3663
Standard Dev.	1.4886	1.5383
n	25	25
t	0.0308	

Table v. T-test results of philippine standard

PHILIPPINE NATIONAL STANDARD (PNS)		
	Manual	***Automated***
Mean	5.0625	5.0204
Variance	1.0195	1.0061
Standard Dev.	1.0097	1.003
n	25	25
t	0.1475	

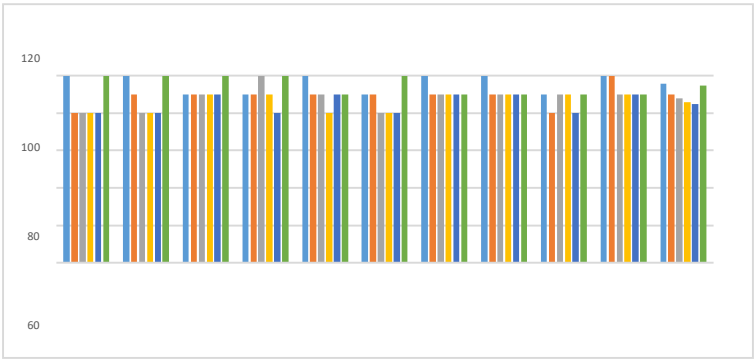


Fig. 11. *Size Repeatability Test*

The repeatability test for size detection was examined. The highest and lowest percentage value are the Class A is 96%, and Class E is 85% as shown in Figure 11.

C. Conveyor System of the Garlic

The conveyor belt has a width of 5 inches and total length of 134 inches, which is made up of synthetic leather. The conveyor has 6 bins designed for the Class A, Class B, Class C, Class D, Class E, and Reject. Each bin has IR sensor to detect if there is a garlic pass through the bins. Once the sensor detects the garlic, the conveyor stopped, and load another garlic. The 12 V motors activate the stoppers to stop and move the garlic from the conveyor to the designated bin. The installation of the limit switch is to determine if the stopper is moved at the initial position. Once the stopper touches the limit switch, the Arduino microcontroller will give the signal to the Raspberry Pi to load and scan the next garlic.

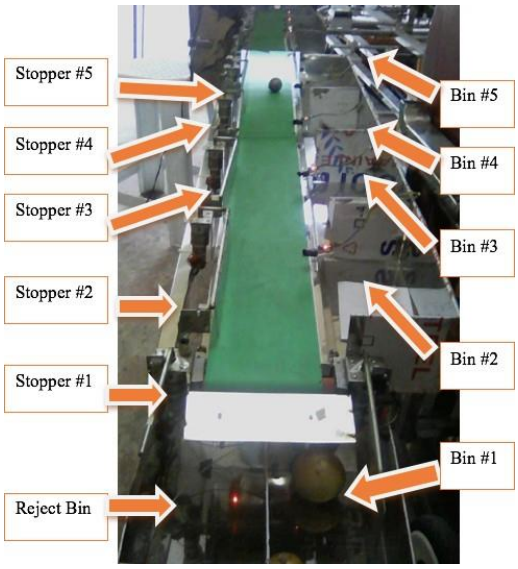


Fig. 12*. Garlic Conveyor Ssytem*

The width and length of the conveyor as shown in Fig.12 is 45 inches and 60 inches respectively. Its height is from the floor is 27.5 inches. The lighting box where the image processing is occurred has a size of 12inx13inx12in. Each bin has a size of 5inx12inx12in. The funnel of the conveyor is a cone shape that measured by 8inx13inx13in.

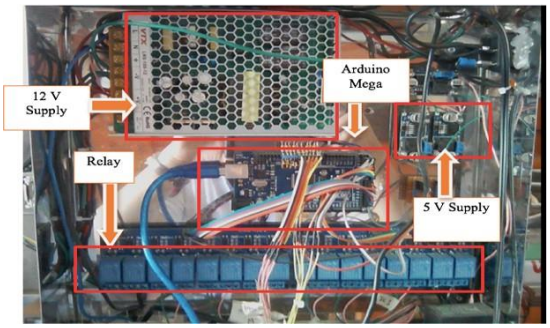


Fig. 13. *Control Panel Board*

The control panel board of the conveyor as shown in Fig.
13 has 5V power supply for Arduino and Raspberry Pi boards,12V regulated power supply for the DC motors, and relays. Each bin has two relays designated. The camera is connected to the Raspberry Pi for the image processing while the Arduino is for the sensors and actuators. Once the image is captured, the Raspberry PI sent signal to Arduino for the disposition of the garlic based on the PNS and AS.

Table vi. *Procees time for each bin*

Class	Ave. Time (sec) Per Garlic	Ave. Time (min) For 10 Bulbs of Garlic
Class A	20 sec	3.33 min
Class B	17 sec	2.83 min
Class C	14 sec	2.33 min
Class D	11 sec	1.83 min
Class E	8 sec	1.33 min
Reject	20 sec	3.33 min

The highest average time travel of the garlic conveyor from the conveyor funnel to the bin is the Class A and Reject bins as tabulated in Table VI. For 10 bulbs of garlic, it takes time up to
3.33 min to reach the Class A bin. The Class E bin is the nearest bin. The width and length of the conveyor 45 inches and 60 inches respectively.

D. Software Development

The researchers install the openCV, numpi, imutils, and Anaconda to program the image processing in Raspberry Pi board. For the SSH connection, the researchers used Xming and Putty. In programming, it is important to establish the same baud rate, 115200 for the serial communications of the Arduino board and Raspberry Pi. All DC motors, IR sensors, and relays are functioning based on the program installed in Arduino board.

```
void segregate()
{
  if (rec == "one")
  {
    //move blocker
    digitalWrite(MOTOR1_C, LOW);
    delay(670);
    digitalWrite(MOTOR1_C, HIGH);

    //wait til it detects the object
    while (digitalRead(SENSOR1) == HIGH)
    {
      digitalWrite(MOTOR7_F, LOW);
    }
    //delay to drop the objec to the bin
    delay(2000);
    digitalWrite(MOTOR7_F, HIGH);
    //close blocker
    while (digitalRead(LIMIT1) == HIGH)
    {
      digitalWrite(MOTOR1_O, LOW);
    }
    digitalWrite(MOTOR1_O, HIGH);
    //reset rec and item flag
    newItem = false;
    rec = "";
  }
```

Fig. 14. *Arduino Program for Segregation*

The program as shown in Fig. 14. is a sample function of Arduino code for segregation of the garlic. If the Raspberry Pi send a string “one” to the Arduino board, the motor from the bin becomes activated, and the the stopper moved left to pass the garlic into the bin based on its category.

The size of the garlic can be detected using this formula:

Diameter of garlic = Image width in pixel /Pixel-per-metric

Sample Program Pixel-Per-Metric System for Size:

pixelsPerMetric = 31

diameter = dPixel / pixelsPerMetric #requirement A diameter = round(diameter,2)

font = cv2.FONT_HERSHEY_SIMPLEX

cv2.putText(im,"{:.1f}cm".format(length),(int(m[0]),int(m[1])), font, 1,(75, 150, 10),2,cv2.LINE_AA)

Sample Blob Detection System Program:

roi_ctr = 0

roi_ctr = roi_ctr + 1

roi_circ = cv2.minAreaRect(ci) roi_l = roi_circ[1]

roi_m = roi_circ[0]

roi_a = roi_l[1] #smaller region for getting average color roi_r = int(roi_l[0])/2 #bigger region to get the size cv2.circle(img,(x+int(roi_m[0]),y+int(roi_m[1])),

roi_r, (255,100,0),2)
print roi_ctr #blob counted
The blob color 0 is to select darker blobs, and 255 value for lighter blobs. The region of interest for blob detection is important in the program to identify the smaller and bigger regions. The quality grading is based on the percentage value of the blob.
The program for segregation based on the percentage blob is written below:
#Quality Grading if roi1_ctr < 20:
grade = "A"
elif roi1_ctr > 20 and roi1_ctr < 40: grade = "B"
elif roi1_ctr > 40 and roi1_ctr < 60: grade = "C"
elif roi1_ctr > 60:
grade = "Reject"
If the percentage blob value is less than 20, the disposition is Grade A. If the blob value is greater than 20 but not more than 40, it is Grade B. If the blob value is greater than 40 but not more than 60, it is Grade C. If the percentage blob value is greater than 60, the garlic is automatically rejected.
This is the program for size segregation based on its category:
#Size Category if diameter < 1.5:
class5 = class5 + 1 varClassIV.set(class5)
port.write("one")
elif diameter < 1.5 and diameter > 2.5: class4 = class4 + 1 varClassIV.set(class4) port.write("two")
elif diameter < 2.5 and diameter > 3: class3 = class3 + 1 varClassIII.set(class3) port.write("three")
elif diameter > 3.1 and diameter < 3.5: class2 = class2 + 1 varClassII.set(class2) port.write("four")
elif diameter > 3.5: class1 = class1 + 1 varClassI.set(class1) port.write("five")
else:
rej = rej + 1 varReject.set(rej) port.write("six")
The disposition of the garlic is based on the AS and PNS. If the system detects the garlic size with greater than 3.5cm, the Raspberry Pi send string “five” to the Arduino Uno to activate the motor from the bin number 5 which is Class A. This process is the same with other categories such as Class B (3.0cm to 3.5cm), Class C (2.5 cm to 3.0cm), Class D (1.5cm to 2.5cm), and Class E (less than 1.5 cm). The last condition is reject disposition which is the bin 6. The garlic is automatically rejected if its color and texture are not good based on the standards, AS and PNS.

5. Conclusion

The conveyor system can classify the good garlic as Grade A as Extra Class, Grade B as Class I, and Grade C as Class II based on the Philippine National Standard (PNS/BAFPS No. 51
:2007) and the Asian Standard (ASEAN Stan 13:2009). It can also identify the reject. The formulated Blob percentage value for categories such as Extra class, Class I, Class II, and Reject were successfully examined. If the percentage value is less than 20%, the garlic disposition is Grade A (Extra Class). The percentage from 20% - 40% is Grade B (Class I), the percentage with greater than 40% -60% is Grad C (Class II), and the greater than 60% is a Reject category. Based on the tests conducted, the formulated blob percentage were matched with the Grade classification.

The size detection between manual and automated was also examine using T-Test statistical method analysis. The T-test value of the garlic based on the PNS was 0.1475 while the garlic AS was 0.0308. It was proven that null hypothesis should accept because the T-test values were less than the critical value of 2.01

Over all, the texture bulbs of garlic can be identified using Blob percentage values ranged as formulated in this study. The functionality and reliability of the conveyor system were also checked from actual value to formulated values. Therefore, the objectives of this study were met successfully.

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