Implementation of Fruit Grading & Sorting Station Using Digital Image Processing Techniques

*Engr. Ghulam e Mustafa Abro, and **Engr. Kundan Kumar

***Abstract*- No doubt that today's technology has approximately solved many common as well as complex issues. Engineers and researchers are always in the quest for the best, brief and efficient methods to cope up the real world problems, hence fruit grading and sorting are one of the problems in export/import industry. In this regard industry requires a station that can check the skin of fruit, i.e. an apple whether it has rotten spots on it or not beside this whole procedure this specific station will also check the radius of an apple for sorting it further for packaging process. This whole procedure will be followed by a running conveyor belt, 2 AC plungers and a wooden box in between them, which will have 5 Mega pixel camera mounted on it. The camera will be triggered by a brief algorithm of digital image processing designed on the platform of MATLAB R2015a version and conclude whether the fruit, i.e. an apple is healthy or having some rotten spots on its skin. Once results are shown, then the algorithm will activate the respective plunger for grading and sorting of apples.**

***Index Terms*- Segmentation, Gradient Filter, RGB, Grayscale, Binary and Threshold**

I. INTRODUCTION

As it is obvious, an excellent vision of a human being may also ignore minor errors and commit lapses, initially this lapses do not produce any harm to the system, but as these all once gathered at some place it may bring imbroglio to the system hence paper suggests the computer vision based systems. It has been seen mostly that the conveyance of fruits to different countries take place by the manual inspection (naked eye). This may ignore the majority of fruits having scratches and rotten spots whereas the export/import of fruits is two to three day transportation based processes and a normal vision cannot say with hundred percent assurances that the packets of fruits may maintain their taste and quality after travelling to other countries. Keeping the very same problem, this paper suggests the computer vision based fruit grading and sorting station. This Station will not only translate the image of specific fruit, i.e. an apple into machine understandable form, but will detect the spots/scratches and can sort out one healthy fruit from unhealthy ones. Here the area of computer vision named as Digital Image Processing DIP has been picked up for executing the above procedure.

This paper suggests an algorithm that will be applied to a runtime image captured by the camera, hence here it is mandatory to brief image. An image is basically defined as two dimensional signal or a function F(x, y) where x and y are the two coordinates horizontally and vertically.

The below image is an example of digital image which shows two dimensional array with different intensity level.

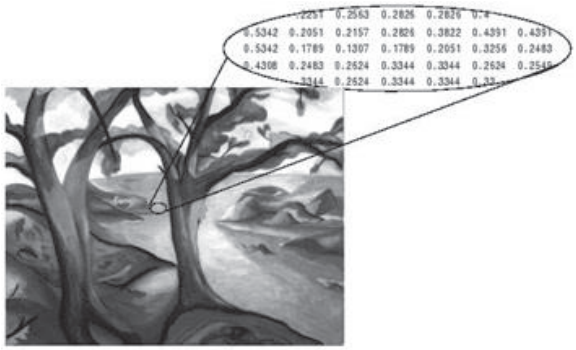

Fig.1. Image with specific intensity levels varying from 0 to 255.

Whereas the image has been classified into 3 types RGB, Gray Scale and Binary Images hence discuss RGB, it stands for Red, Green and Blue color intensity levels whenever any image may consist of these three color intensity levels or the combinational intensity of these colors, whereas gray scale image means restricting the intensity levels in between 0-255 levels, such an image is known as Gray Scale Image. When the intensity levels are restricted or converted in between 0-1 intensity level showing either dark black or white color intensity levels, such an image is known as Binary and this rendered image can be used for machine perception. Here the below image shows you the 3 types of digital image:

*Department of Electronics Engineering FEST Hamdard University, Karachi Mustafa.abro@hamdard.edu.pk
**Department of Electronics Engineering FEST Hamdard University, Karachi Kundan.kumar@hamdard.edu.pk

Fig.2. RGB, Binary and Gray Scale Images respectively

Algorithm suggested in this paper has been designed on the platform of MATLAB R2015a version, hence it is very much necessary to discuss the image extensions and data types treated by the software so that the image processing can be done easily. If there is an image it must have a name along with extensions that can be shown as name, extension i.e. fest.jpg. Here are some of the formats, along with extensions mentioned below:

#	Format	Full Form	Extension
01	XWD	X Window Dump	.xwd
02	TIF	Tagged Image File Format	.tif
03	RAS	Sun Raster	.ras
04	PNM	Portable Any Map	.pnm
05	BMP	Windows Bitmap	.bmp
06	CUR	Windows Cursor resources	.cur
07	FTS	Flexible Image Transport	.fts
08	GIF	System	.gif
09	ICO	Graphics Interchange Format	.ico
10	JPG	Icon resources	.jpg
11	PBM	Joint Photographic Experts	.pbm
12	PGM	Group	.pgm
13	PBM	Portable Bitmap	.pbm

Table I. shows formats of an image along with extensions.

As mentioned earlier about an image, it is a function F (x, y) where x and y show different intensity levels, which are treated as data type/classes in the environment of MATLAB. Here is the table that shows data types treated in the suggested software:

#	Data Type Classes	Description
01	Single	Single precision floating numbers ranges - 1038 to +1038 (4 bytes/element)
02	Double	Double precision floating numbers ranges - 1038 to +1038 (8 bytes/element)
03	uint8	Unsigned integer 8- bit ranges in between [0 to 255] levels
04	uint16	Unsigned integer 16- bit ranges in between [0 to 65535] levels
05	uint32	Unsigned integer 32- bit ranges in between [0 to 4294967295] levels
06	int8	Signed integer 8-bit ranges in between [-128 to 127] levels
07	int16	Signed integer 16- bit ranges in between [-32768 to 32767] levels
08	int32	Signed integer bit ranges in between [-2147483648 to 2147483647] levels
09	Char	Character 2 bytes per element Binary values 0 or 1 (1 byte per element)
10	Logical	Description

Table II: Data types/classes of an image

Moreover an image processing is an area used to amend the nature of one image. As an image is a function or a signal and it is obvious that signals are on analogue and digital nature, hence this subject is also classified as analogue and digital image processing whereas the paper suggests digital image processing for two major reasons as mentioned here:

1. For the improvement of pictorial information and
2. For rendering an image more suitable for autonomous machine perception

Hence this paper is concerned about the second objective of the subject. This can be better understood by below mentioned figure:

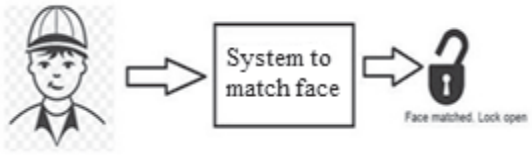

Fig.3. Image rendering based system locking and unlocking

In our society, there are several security systems in which facial, eyes and veins detection based security systems are available. The above figure illustrates the same phenomenon in which the image of ones face has been captured and rendered to lock/unlock the system. Keeping the same object here the image of an apple will be rendered and brief algorithm based on segmentation and thresholding will be operated that will soon afterwards sort and grade our entered amount of fruits (apples).

II. LITERATURE REVIEW

The quality of fruit first of all should be defined on the bases of some parameters or features, i.e. color, shape and surf features of fruit, so in this regard, there had been

several recognition methods and this paper provides a brief review of them [1]. There is KNN algorithm used for the recognition of specific fruit in the fruit salad on behalf of color and shapes [2]. As for the proper shape of an apple or a fruit from an image is concerned, there are several algorithms related to extraction of boundary background, i.e. shape signature, chain code, Fourier descriptors and Wavelet decomposition methods [3]. These all methods are basically a contour based detection method in which we detect the medial axis of an image and then extract the background.

During the study, some papers also presented the shape detection like shape indices and multivariate detection Analysis which can provide up to 90% efficient results whereas some provided solutions based on segmentation technique [4].

Mostly the procedure is divided into two stages, namely traditional region segmentation followed by Deformity Detection algorithm working on the probability and statistics of image intensities and histogram [5]. The area of concern is to detect the intensity levels along with shape of fruit by any method that provides maximum efficiency hence in this regard review concludes Neural Networks, Image Extraction, Clustering and Feature Extraction Methods in [6]. which focuses on the color intensities and will not only detect the external skin but can help us to detect the shape of fruit by computing radius of fruit i.e. mango [7]. Many technical contributions emphasize the size of fruit and it is indeed an important element because with this any fruit or food processing industry may come up with the scarcity of economical budgets i.e. Packaging, Placement, Marketing and transportation [8]. K means algorithm discussed in [8] and conveys the method of dividing an image into segments and identifying the skin of fruit, whereas one can also do the similar job using the concept of entropy calculation and at last it provides a brief advantages and disadvantages of all techniques mentioned below [9,10]:

Technique	Advantages	Disadvantages
K, C Means Method [1]	Provide the optimal results	Includes salt and pepper noise in the results
Wavelet Decomposition method [2]	Provides 94 percent efficient results	Very expensive and needs memory for computation work
Ratio and Space indices method [3]	Detects fruit shape	Having greater chances of error
Outline based Method [4]	It is used for the detection of curveandprovides93. 2% efficient results	Only used for outline detection
Chain Code Method [5]	Need no memory for computational work and easy to implement	It never removes the noise from image
Gray Level co-occurrence [6]	Used of the motion detection of an object and provide high accuracy as well	Very difficult to implement
Organization Feature Parameter OFP [7]	Provide fine texture extraction of object	But it detects Gaussian noise
Optimal Edged Based Shaped method [11]	This basically used to localize the object and shape	Difficult to detect the aerial object
Gabor Filters [12]	This method provide the background extraction of any circle shape	Implement on any one band of colors

Table III. Shows image processing techniques along advantages and disadvantages

III. METHODOLOGY

The techniques studied and discussed in literature review had some Merits and demerits as well, hence the aim of this paper is to suggest the solution having less disadvantages, maximum efficiency and an algorithm which can be understood easily. In this regard the paper conveys the solution which is the combination of Gray Level Co-occurrence using threshold and segmentation technique. In the implementation of above mentioned scenario, this situation requires following equipment mentioned in the bullets below:

- MATLAB Software
- Arduino UNO Board
- Conveyor Belt
- Box Embedded with LEDs and Webcam of 5 MP
- AC plunger
- IR Sensor

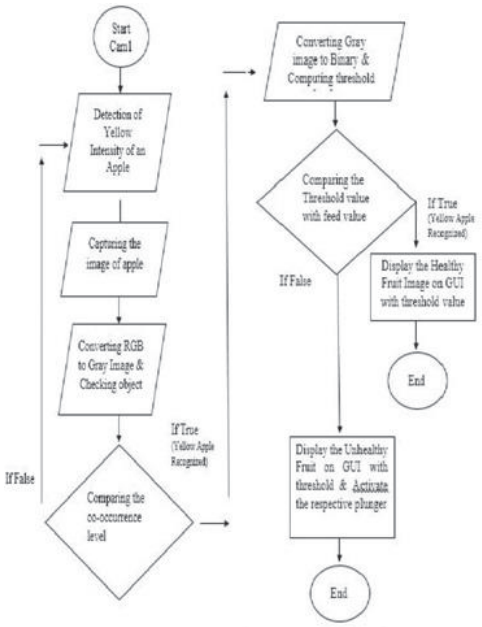

Fig.4. Flow chart of fruit grading/sorting system

Whereas the above figure shows the complete flow chart of the station. The procedure begins with a click of start button present at Graphical User Interface GUI designed on the platform of MATLAB R2009a version. Once the button clicked by the user the conveyor belt will start running via 12 Volt DC Motor controlled by a relay circuit. Moreover an apple placed on a conveyor, it will travel through and comes nearer to the box; here this particular apple will cut the IR Sensor which ultimately will actuate the webcam embedded with box, The Box has been designed very carefully. It has some pair of led strips which will assure the quality picture of an apple. Once webcam has been actuated it will detect the yellow intensity of an apple and soon afterward will capture its image. This very image further more will be converted into Gray scale image followed by the brief algorithm of gray level co-occurrence. If the co-occurrence level is equal to the level of yellow intensity based apple (once converted into gray scale) than its threshold will be measured whereas in failure case it will start detecting the apple again. Now the threshold value has a significant role because once this value has been computed it will be compared with the field value which can be set as per the department of quality assurance. If the value comes in between the quality band then the user will be shown the result as a healthy apple with its particular threshold value and if it is not so, then it will be discarded by the AC plunger (striker) from the conveyor belt. This AC Plunger operates on 220 AC Volts and controlled by a relay logic. In this whole procedure the paper suggests simple controller of Arduino UNO which can be easily interfaced by MATLAB R2009a version by adding some libraries from the MATH WORK site.

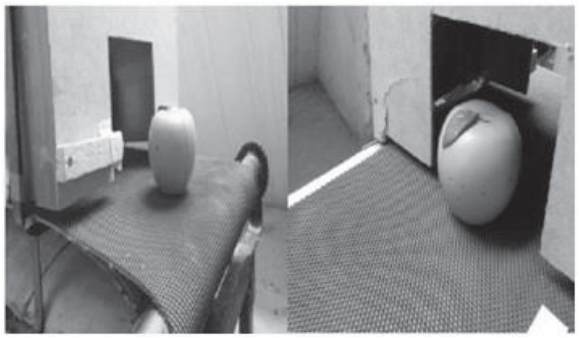

Fig.5. shows the arrival and departure of an apple

IV. RESULTS

The results have been achieved by placing different quality apples both healthy and unhealthy and followed by the whole procedure shown in flow chart. As the technique of gray level co-occurrence was very difficult to implement as discussed in the literature review, but yet this paper provides proper establishment of the technique which is quite easy once combined with segmentation technique. The results have been concluded on a specific GUI in a manner that when the fruit is healthy it displays green fruit symbol, but if it is unhealthy then a red fruit symbol will be displayed to user to conclude the result.

In the above picture the leave of an apple has been captured and it displays it as a spot on apple hence it is very much necessary that whenever fruit is placed on conveyor it must be gone through the process of light wash and cleaning of leaves. This paper also provides the result computed other than the GUI as shown below:

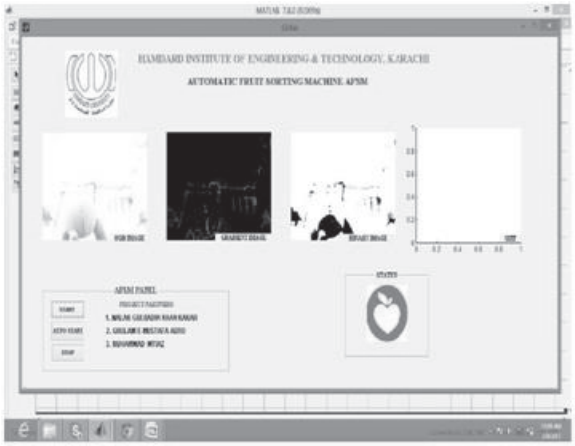

Fig.6. Shows Healthy Status of an apple on GUI

Fig.7. Shows Unhealthy Status of an apple on GUI

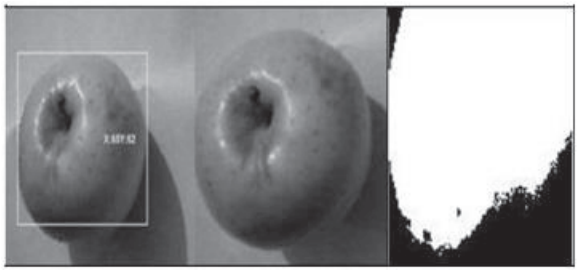

Fig.8. Shows Detection of a Healthy Fruit

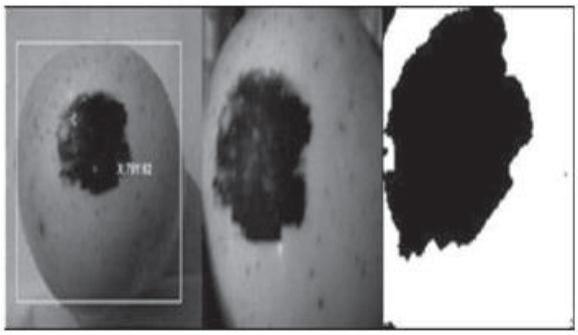

Fig.9. Shows Detection of an Unhealthy Fruit

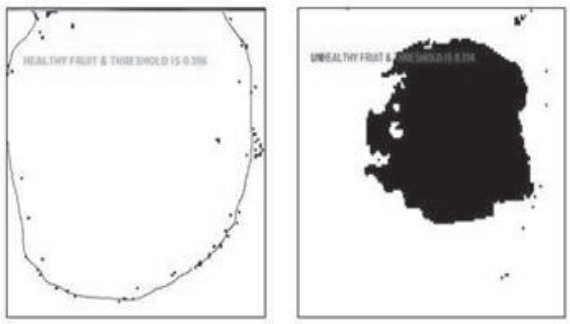

Fig.10. Shows Healthy an Unhealthy status other than GUI

V. CONCLUSION

This work reviewed the advancement of digital Image processing technology in the field of food or fruit processing and the export import business. This technical paper gives a brief review of different image processing approaches along with a new approach. The new approach specifically targets the grading of an apple and it is based on a combination of gray level co-occurrence and segmentation technique. In this research piece the skin of a yellow apple has been detected and graded healthy or unhealthy and sorted out accordingly with the help of an AC Plunger (striker). Here only 2D image has been focused and in future the whole procedure may carry out on a 3D image of an apple or on more than 2 sides of an apple may be examined. The suggested technique was difficult, but by the combination of threshold and segmentation technique, it becomes easy to implement and provides the best results as well. The other future work includes the implementation of such systems in real life which detect apple of any color and try to provide the best solution for size measurement for packaging.

VI. ACKNOWLEDGMENT

While bringing out this work in its final form, there had been a number of people who come across and helped in the completion of this piece of research. It is an immense pleasure to acknowledge here Mr. M. Ovais Khan, Assistant Professor at Hamdard Institute of Engineering and Technology HIET, Karachi his invaluable encouragement and support. Whereas I would like to express my deep sense of indebtedness to my guide Ms. Dur e Gabon for her suggestions from an early stage of this research and providing extraordinary guidance throughout the work. Their involvement with pure originality has nourished my intellectual maturity. I am highly grateful to my co-guide and author Mr. Kundan Kumar for his kind support for bringing dissertation to its final stage.

REFERENCES

[1] Sharma, M., Jaiswal, V. P., & Goyal, A. (2013). Fruit Recognition with Multiple Features using Fuzzy Logic. IJCSC, 4(2), 99-115.

[2] Seng, W. C., & Mirisaee, S. H. (2009, August). A new method for fruits recognition system. In Electrical Engineering and Informatics, 2009. ICEEI'09. International Conference on (Vol. 1, pp. 130-134). IEEE.

[3] Meruliya, T., Dhameliya, P., Patel, J., Panchal, D., Kadam, P., & Naik, S. (2015). Image Processing for Fruit Shape and Texture Feature Extraction-Review. International Journal of Computer Applications, 129(8), 30-33.

[4] Costa, C., Antonucci, F., Pallottino, F., Aguzzi, J., Sun, D. W., & Menesatti, P. (2011). Shape analysis of agricultural products: a review of recent research advances and potential application to computer vision. Food and Bioprocess Technology, 4(5), 673-692.

[5] Rege, S., Memane, R., Phatak, M., & Agarwal, P. (2013). 2D geometric shape and color recognition using digital image processing. International journal of advanced research in electrical, electronics and instrumentation engineering, 2(6), 2479-2487.

[6] Sardar, H. (2014). Fruit quality estimation by color for grading. International Journal of Modeling and Optimization, 4(1), 38.

[7] Mansoory, M. S., Fardad, H., Enteshari, R., & Mansouri, Y. S. (2010). Isolating healthy bananas from unhealthy ones based on feature extraction and clustering method using neural network. Modern Applied Science, 4(11), 51.

[8] Sardar, H. (2013). Quality Analysis in grayscale color using visual appearance of a guava fruit. International Journal of Engineering Sciences, 46-56.

[9] Sardar, H. (2014). Fruit quality estimation by color for grading. International Journal of Modeling and Optimization, 4(1), 38.

[10] Ramprabhu, J., & Nandhini, S. (2014). Enhanced Technique For Sorting And Grading The Fruit Quality Using Msp430 Controller. International Journal of Advances in Engineering & Technology, 7(5), 1483.

[11] Duygulu, P., Barnard, K., de Freitas, J. F., & Forsyth, D. A. (2002, May). Object recognition as machine translation: Learning a lexicon for a fixed image vocabulary. In European conference on computer vision (pp. 97-112). Springer, Berlin, Heidelberg.

[12] Grigorescu, S. E., Petkov, N., & Kruizinga, P. (2002). Comparison of texture features based on Gabor filters. *IEEE Transactions on Image processing*, *11*(10), 1160-1167.