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QUALITY EVALUATION OF GRAPEFRUIT USING NEURAL NETWORK

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ABSTRACT

Grapefruit is classified based on its size in Egypt. It is very important to classify fruits according to its quality. Grapefruit is classified as medium size, short height, and glossy surface. Experimental results are to evaluate grapefruit using image processing and neural networks. Neural network is a massively interconnected system which has the ability to learn and adapt a given environment by self adjustment of its internal condition. Images of 50 grapefruits were used by colour TV camera. Features expressed fruit colour, shape and roughness of fruit surface were extracted from the images. It was considered that fruit colour and shape were relatively easy to be expressed by ratio of grey level values in red and green component images and Feret's diameter ratio. However, it was difficult to extract appropriate features for roughness of fruit surface from binary image. Therefore, textural features were used. in this experiment. Features and weight of fruits were inputted to neural network and sugar content of each fruit was investigated. It was observed that the relation between measured values and calculated one have high correlation efficiency.

INTRODUCTION

Fruit classification is an essential operation after harvesting in Egypt. Many varieties of fruits are usually classified based on only their size or shape, whoever their inside qualities are different. The inside quality such as sugar content, acid etc. are evaluated non-destructively. The sugar content can be measured by using reflected light in infra-red region from inside the fruit through thin skin as in peach. In case of grapefruit it is impossible to measure the sugar content by using the same method because its skin is thick and the light cannot go through the skin but reflected on the fruit surface. The farmers always say the fruit whose height is smaller is sweeter **(Kondo, N. 1991)**. A number of researchers have used computer vision systems to evaluate grain quality factors. **Ounasekaran and Paulsen (1986)** evaluated several non-destructive testing techniques and concluded that computer vision is the most suitable form of automatic quality evaluations. Seed quality evaluations **(Ounaasekaran, et al., 1988)** and seed contamination evaluations seem particularly well suited to analysis by machine vision. **Neuman, et al. (1989)** used colour image processing method to classify different wheat varieties with considerable success. **Zayas et al. (1990)** used a colour feature based pattern recognition technique to analyse corn defects. This technique was reported to be successful for detecting defects such as damaged corn and blue-eye mould. **Shearer and Holmes (1990)** used co-occurrence matrices from image matrices which included intensity, saturation, and hue, 33 colour

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texture features in total to identify plants with satisfactory accuracy.The neural network is a new information processing technique that offer solutions to problems that have not been explicitly formulated. **Bleyberg et al. (1991)** used 24 distinguishing colour features and a backpropagation network system for grain classification. They reported that neural networks outperform traditional statistical methods when probability distribution functions are unknown. **Liao (1992)** developed a knowledge-based machine vision system for discrimination of corn kernels and used a Learning Vector Quantization algorithm to classify colour properties of white and/or yellow corn kernels. **Burks et al. (1994)** also used a trained neural network classifier to differentiate between as many as seven cultivars of containerized nursery stock using up to 33 texture features. Results showed that computationally efficient neural network classifiers are capable of accuracy in the range of 77% to 97%. **Xu et al. (1995)** developed a neural network based machine vision system to classify barley and malts grades using shape and colour features with a successful classification rate of 90.1 %.

In this study there is possibility of grapefruit quality evaluation using image processing technology and neural networks to automate fruit classification operation.

MATERIALS AND METHODS

There are many varieties of citrus fruits in Egypt. Grapefruit, orange and mandarin have much correlation between their appearance and taste. The analysis of this experiment was analysed at the department of agricultural engineering laboratory, Okayama University, Okayama, Japan. The sugar content was measured after image input. The degree of roughness was assigned to every fruit using number 1 (glossy) to number 5 (rough) by human eyes.

Image Processing: Fig. 1, shows a block-diagram of experimental device and the image imputing method. Image of grapefruit was inputted to computer by TV camera and image input board under the condition of 500 lx using lamps whose colour temperature are 5500 K. The imputed image consisted of 256 x 256 pixels that have 256 grey level values. The object colour was decoded into red, green and blue colour components.

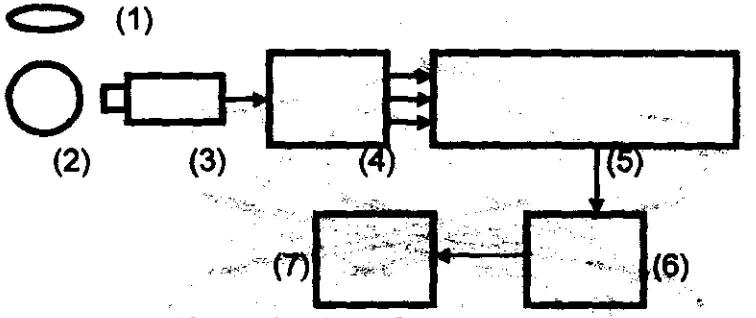


Figure 1. Block-diagram of experimental device.

(1) 5500K lamp, (2) Fruit, (3) TV camera, (4) Decoder, (5) Image processing device(R, G and B), (6) Computer, (7) Display.

So it was easy to know the difference of fruit colour using the ratio of colour components such as combination of red and green. The binary image can be made by using the one colour image RGB (red, green or blue). In this study, red image was used. The size and height of the fruits were extracted from the binary image as Feret's diameters. Fruit's shape can be expressed by Feret's diameters ratio (R) as shown in equation 1.

$$R= Dv / Dh \quad (1)$$, Where:

Dv= vertical Feret's diameter.

Dh= horizontal Feret's diameters.

Texture of fruit surface was investigated based on the 16 grey tone image through co-occurrence matrix. Angular second moment, inverse difference moment and contrast **(Haralick, et al.,1973)** were used as textural features in this study. The features were expressed by the following equations 2, 3 and 4.:

$$ASM = \Sigma\Sigma\{p(I,j)\}^2 \quad (2)$$

$$IDM = \Sigma\Sigma \{1/(1+(i-j)^2)*p(i,j)\} \quad (3)$$

$$Con = \Sigma\Sigma (i-j)^2* p(i,j) \quad (4)$$

Where:

ASM= Angular Second Moment.

IDM= Inverse Difference Moment.

Con= Contrast.

P = (i,j)th entry in a normalized grey level spatial-dependence matrix.

ASM and IDM mean homogeneity and local homogeneity on the fruit surface in the grey level image. The values of textural features depend on the distance and the angle between pixels which were necessary to construct the co-occurrence matrix. This experiment was conducted under the condition that the distance was changed from 1 to 16 and the angle was zero.

Neural Network (NN): Neural network is a massively interconnected system which has the ability to learn and adapt a given environment by self adjustment of its internal condition. It consists of non-linear elements which are called neurons and has connecting these neurons with synoptic weights process information.

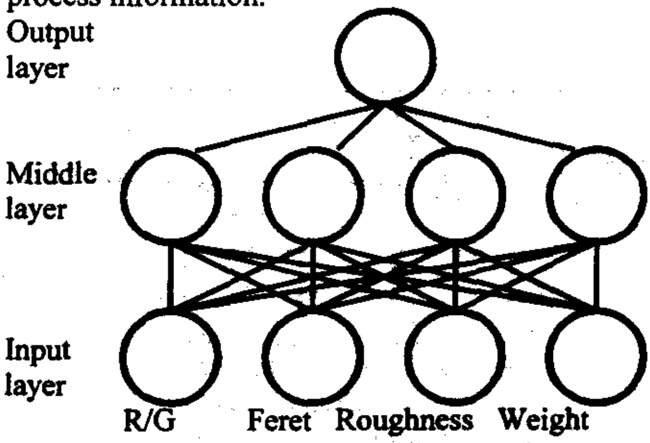


Figure 2. Neural networks.

of middle layer were changed from 4 to 8 and one unit was given to output layer corresponding to sugar content. The features were extracted from image of 30 fruits and they Feed forward NN have excellent ability to approximate non-linear functions and model non-linear systems without any need to specify how outputs depend on inputs mathematically. Fig. 2 shows a neural network used in this study. Colour component ratio, Feret's diameter ratio, degree of roughness and weight were inputted to the input layer. When they were inputted, the values were changed into 5 digit codes (0,0,0,0,1) to (1,0,0,0,0). Unit number were used as teaching data while the iteration was 2000. The evaluation result was outputted from output layer as value between 0 and one.

RESULTS AND DISCUSSIONS

Grey Level Image: A previous research **(Elbatawi and Barrett, 2002)** shows the examples of grey level on horizontal line of inputted images on different conditions of light and fruit surface. From the figure of that previous research, it was observed that fluctuation of the grey level was different from on light part and on dark part, even when the roughness of fruit surface was the same. Therefore, it was considered that the features extracted from the grey level image have different values corresponding to the light condition.

Sugar Content and Features: Figure 3 shows the relation between sugar content measured by Brix meter and colour component ratio (R/G). It was observed that sugar content tended to increase when R/G ratio increased. However, correlation coefficient was not so high because shape and roughness of the fruits were different.

Fig. 4 shows the relation between sugar content and Feret's diameter ratio. In this figure we can understand the meaning of the words that say the fruit whose height is smaller is sweeter. Fig. 5 shows the relation between sugar content and degree of roughness and Fig. 6 shows the relation between sugar content and weight. From these figures, it was observed that glossy fruit was sweeter but that correlation with weight was low.

Textural Features: Figure 7 shows relation between textural features and roughness on light part of fruit surface. It was observed that ASM and IDM tended to increase and contrast decreased when fruit surface become rough, since glossy surface have less homogeneity than rough surface **(Elbatawi and Barrett, 2002)**. On the contrary, the features had converse tendency on dark part of fruit surface as shown in fig. 8 because fluctuation of grey level on rough surface was bigger than that on glossy surface on dark part. From these figures, it was found that textural features were effective for expressing the roughness of fruit surface. However, their values depended on brightness of fruit surface. It was found that the features extracted from image had some correlation to the fruit quality. However, some of them had non-linear relation since the features influenced on the quality complicatedly. It was considered that the inside quality of fruit could be guessed by neural network because neural network could express the non-linear relationship.

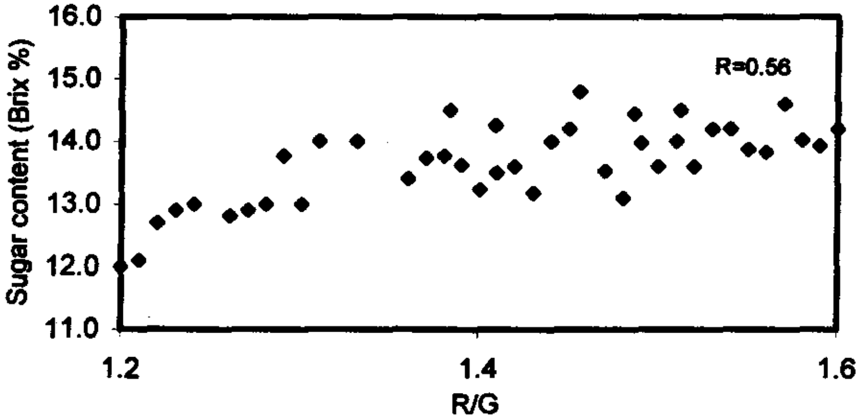


Figure 3. Relation between sugar content and colour component ratio.

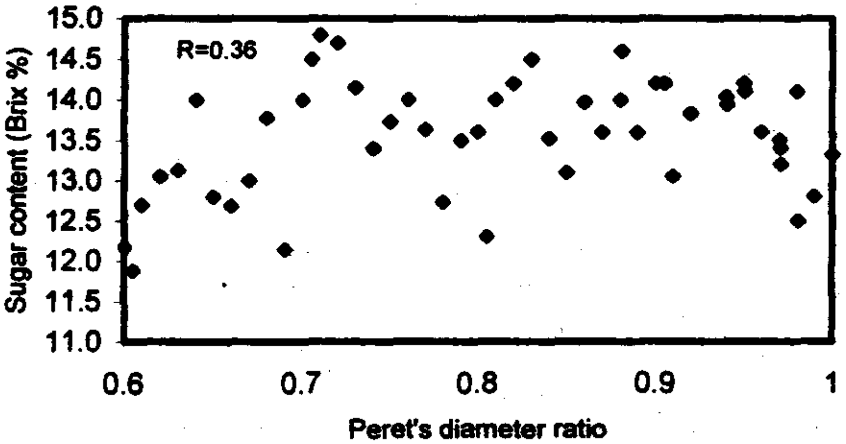


Figure 4. Relation between sugar content and Feret's diameter ratio.

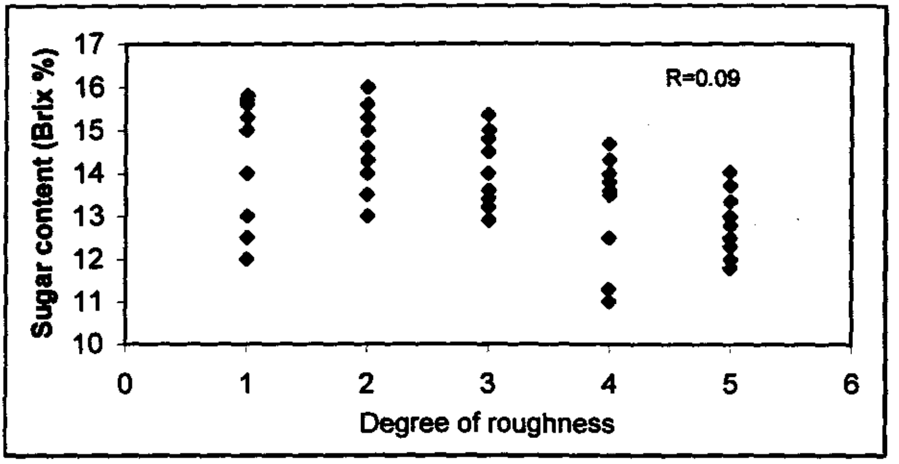


Figure 5. Relation between sugar content and roughness.

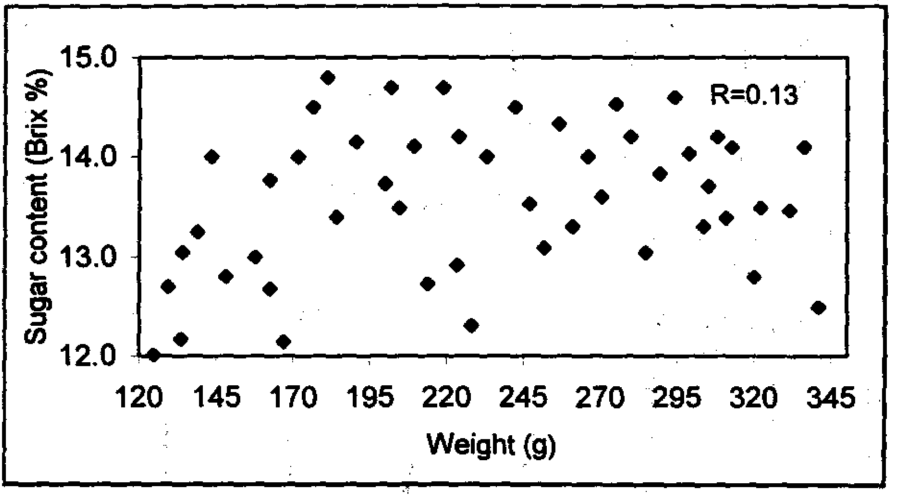
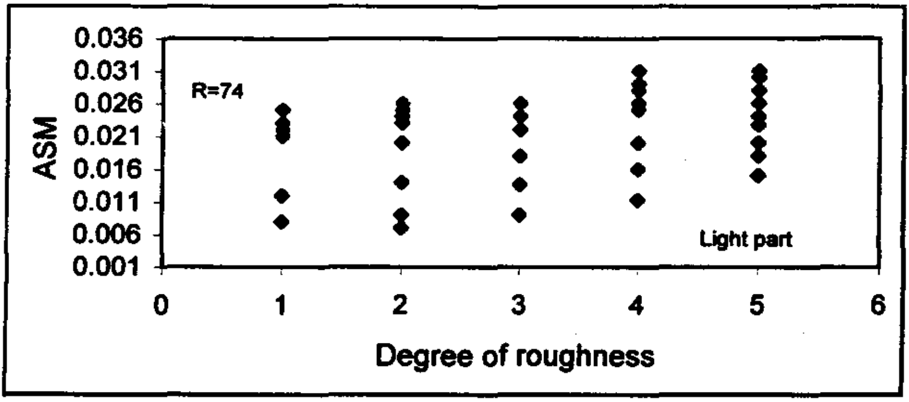
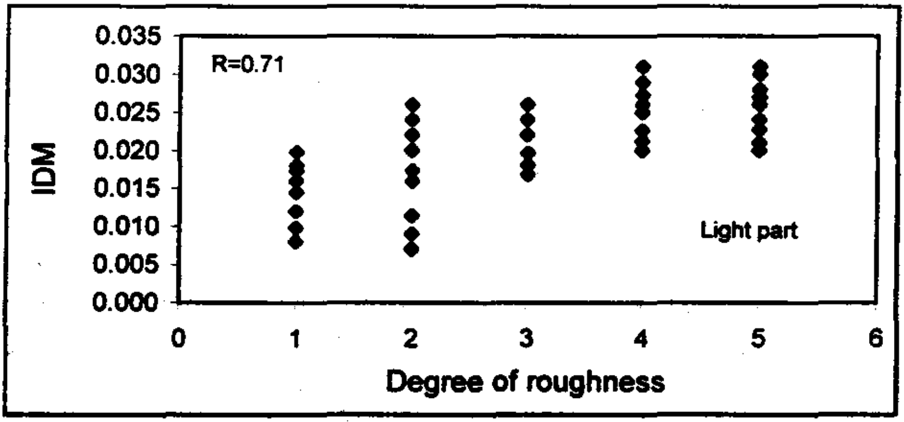


Figure 6. Relation between sugar content and weight (g).





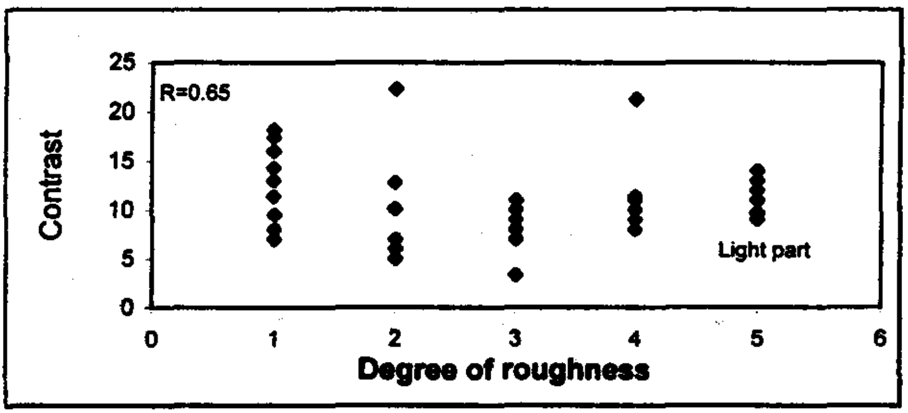


Figure 7. Textural feature on light part.

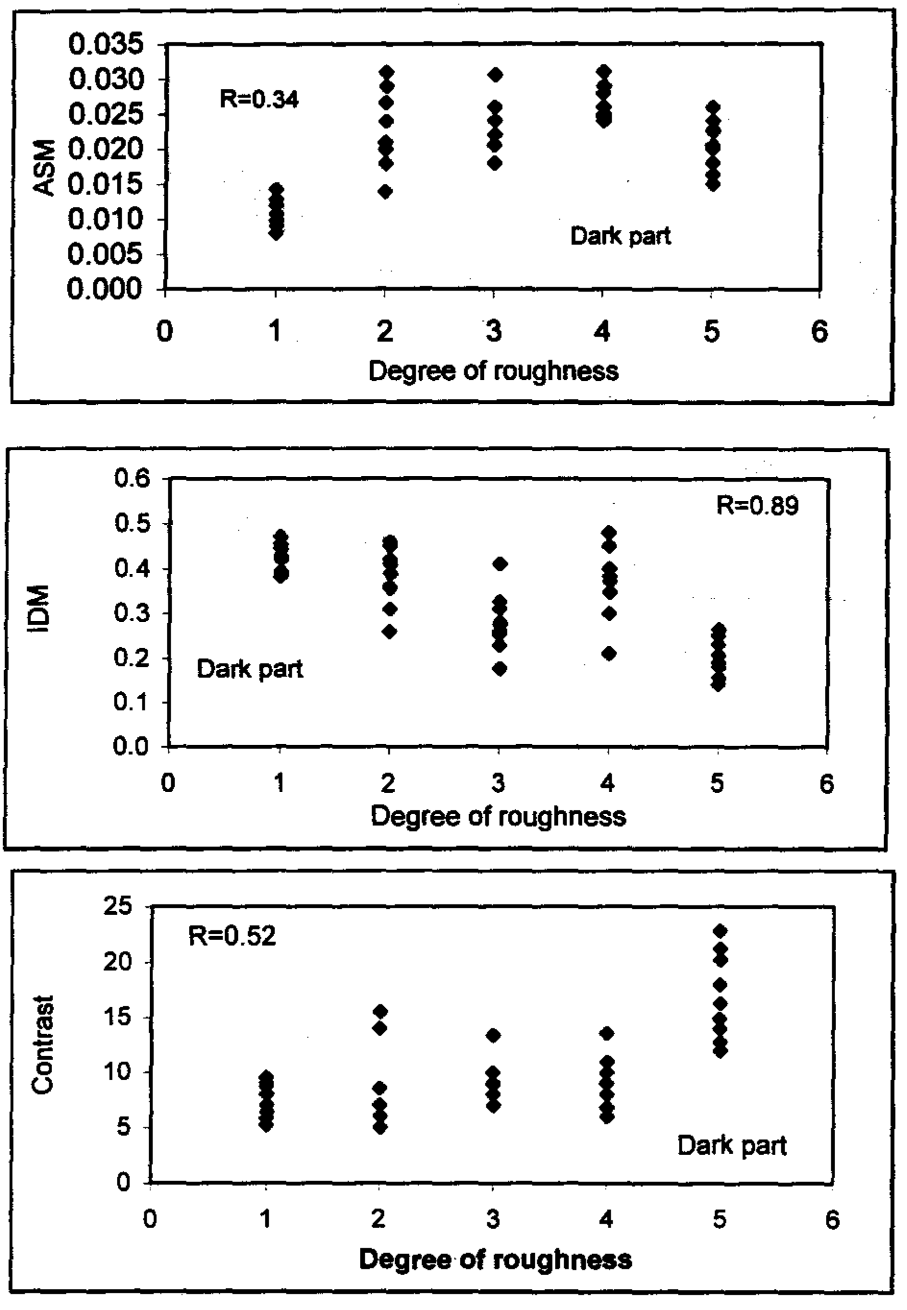


Figure 8. Textural feature on dark part.

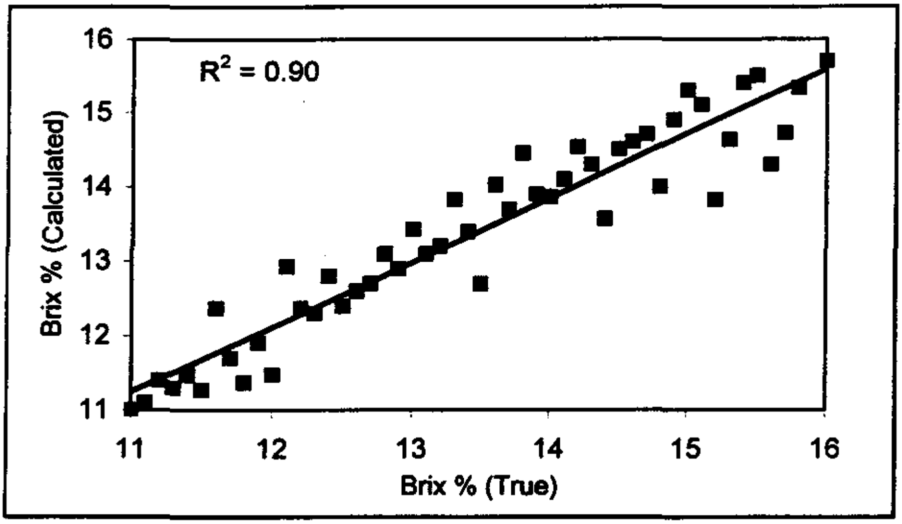


Figure 9. Results from neural network (NN).

Neural Network: Figure 9 shows relationship between measured sugar content and calculated one obtained from neural networks. The correlation efficiency was 0.87 and it was considered that the possibility to evaluates grapefruit (non-destructively) by combination of use image processing and neural networks. However, each feature extracted from the image had not process so much correlation.

CONCLUSION

It was confirmed that common saying red, low height and glossy grapefruit is sweet by using the features extracted from the image processing. However all features have no linear relationship with the inside quality and some features have not so much correlation. It was considered that investigation of not only the features used in this study but also other features and synthetically evaluation method such as neural network were necessary to construct a non-destructive quality evaluation system for grapefruit.
Furthermore, acid content also should be measured as well as sugar content.

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الملخص العربي

تقييم جودة الجريب فروت باستخدام الشبكة العصبية

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الجريب فروت مصنف في مصر بحجمه فقط . لذلك من المهم جدا تصنيف هذا النوع من الفاكهة علي أساس الجودة . والجريب فروت مصنف علي أساس حجم متوسط – ارتفاع قصير – وسطح أملس لامع (glossy)) تم تحليل حوالي 50 ثمرة من الجريب فروت بواسطة كاميرا تليفزيونية . ومن الخصائص التي تم استبعادها في الجريب فروت هي لون الثمرة – شكل سطح الثمرة . تم الأخذ في الاعتبار ان اللون والشكل من السهل ان يقيما علي أساس نسبة مستوي الـ grey في مكونات الألوان الأحمر والأخضر والازرق (RGB) وكذلك نسبة قطر Feret .

ولذلك كان من الصعب استبعاد بعض الخواص مثل خشونة سطح الثمرة من التحليل الضوئي لذلك تم استخدام خواص القشرة في هذا البحث . كذلك تم إدخال خاصية الوزن في الشبكة العصبية وكذلك نسبة السكر في الثمرة في كل ثمرة ثم فحصها .

ومن النتائج وجدنا ان هناك علاقة بين القيم المقاسه وكذلك المحسوبة مع وجود علاقة ارتباط قوية .فعلي سبيل المثال عندما كانت القيمة الحقيقية 11.8 كانت القيمة المجسوبة 11.37 و عندما كانت القيمة الحقيقية 15.3 كانت القيمة المجسوبة 14.63

كما انه باستخدام الشبكة العصبية يلاحظ ان هناك بعض الصفات ليس لها علاقة ارتباط مع بعضها البعض . فعلي سبيل المثال وجد انة ليس هناك علاقة ارتباط بين المحتوي السكري ودرجة صلابة قشرة الثمرة وكذلك ليس هناك علاقة بين المحتوي السكري ووزن الثمرة.

كما وجد ان هناك ارتباط قوي بين القيم المقاسة الحقيقية بواسطة شبكة النيورال والقيم المحسوبة بنسبة اكثر من 90 % . كما لابد من الأخذ في الاعتبار في دراسات قادمة المحتوي الحامضي كما تم الأخذ في الاعتبار المحتوي السكري .