ON-LINE SORTING MATURITY OF CHERRY TOMATO BY MACHINE VISION

Yinglong Zhang[1], Xiaoping Yin[2], Xiaobo Zou[2,*], Jiewen Zhao[2]

[1] *Industry Center, Jiangsu University, Zhenjiang, Jiangsu 212013, China*

[2] *Agricultural Product Processing and Storage Lab, Jiangsu University, Zhenjiang, Jiangsu 212013, China*

[*] *Corresponding author, Address: Agricultural Product Processing and Storage Lab, Jiangsu University, Zhenjiang, Jiangsu 212013, China, Tel:+86-0511-88780201, Fax:+86-0511-88780201, Email: Zou_xiaobo@ujs.edu.cn*

Abstract: The cherry tomatoes online sorting according to their maturity is an important procedure after harvest. This research proposed an automated cherry tomato grading system base on machine vision. Three images of different angles are obtained from each cherry tomato, allowing the inspection of approximately 90% of the fruit surface. 9 features were extracted from the one cherry tomato images. In order to distinguish into three grades (immature, half ripe and ripe), Principal component analysis (PCA) and linear discrimination analysis (LDA) were used to analyze the features. The PCA results show that ripe cherry tomatoes are distinguished from immature and half ripe ones. 414 cherry tomatoes were tested by the online sorting system. The overall accuracy was up to 94.9%. Furthermore, the grading speed of the sorting line reaches 7 cherry tomatoes per second which meet the actual demand of many farms.

Keywords: Cherry tomato; Machine Vision; On-line Sorting; maturaty

1. INTRODUCTION

A cherry tomato is a smaller garden variety of tomato. With its highly nutritional value and good appearance, cherry tomato had become one of the most popular fruit in the world.

Nowadays cherry tomatos are sorted by hand in many farms. However, the manual inspection process is not only labor-intensive and tedious, but

Please use the following format when citing this chapter:

Zhang, Y., Yin, X., Zou, X. and Zhao, J., 2009, in IFIP International Federation for Information Processing, Volume 295, *Computer and Computing Technologies in Agriculture II, Volume 3*, eds. D. Li, Z. Chunjiang, (Boston: Springer), pp. 2223–2229.

also subject to human error which results in poor quality. Farmers want an automated grading device to facilite this work. Considerable effort has been made in the field of machine-vision-based sorting and grading of fruit. Miller took into account the mean fruit colour and a measureof the dispersion (normalised mean squared differences)of the colour, plus a shape parameter to grade citrus fruits according to their external quality. The author compared three different classifiers and had the best results with Bayesian – Gaussian techniques, with between 69 and 86% of the fruit correctly graded into two classes (accepted or rejected) (Miller W M ,1995). Otherwise, V. Leemans proposed a method for apple external quality grading showed correct classification rates of 78 and 72%, for Golden Delicious and Jonagold apples, respectively, according to European standards(V. Leemans etal. ,2002). However, much of the works have not been used in commercial sorting systems because of the constraints in speed, accuracy and flexibility.

Colour grading based on United States Department of Agriculture (USDA) standard colour charts is according to six different maturity stages(United States Department of Agriculture, 1991). Surface colour is considered as a good maturity index.

In this research, a machine-vision system was developed for on-line high-speed cherry tomato maturity sorting according to the surface colour, grading of cherry tomatos into three classes from immature to ripe.

2. MATERIALS AND METHODS

cherry tomato “little angel” was selected for the experiment. The samples were hand harvested on 23th November 2007 from the experimental orchard in “jin rui” Institute of Agricultural, zhenjiang.

Cherry tomatoes were selected completely randomized in the same plant with each fruit as an experimental unit. All fruits of each sample were individually numbered. Without any procedure, five assessors with previous experience in tomato assessment were invited to classified cherry tomatoes into three different maturity states (immature , half-ripe, and full-ripe), each with 30 samples. A total of 90 machine vision measurements were performed.

For validation, the same variety, cherry tomato ‘little angel ’, was selected for the experiment. A total of 414 cherry tomatoes were ispectioned for validation.

2.1 Hardware

The machine vision system was composed of a three charge coupled device (CCD) colour camera (SenTec STC-1000) and a frame grabber

(GRABLINK Value), connected to a compatible personal computer [Pentium 2.8GHz, 512Mb random access memory (RAM)]. The system provides images of 768 per 576 pixels. The frame grabber digitised and decoded the composite video signal from the camera into three user-defined buffers in red, green and blue colour coordinates (RGB). Lighting system is the most important part of the machine vision system(Sunil Kumar Kopparapu,2006). In this project lighting system was composed of two ring-shaped LEDs inside of a chamber, with a hole in the top to place the camera.

The vision system was part of the robotic system for automatic inspection and sorting. Before entering the inspection chamber the fruit was individualised ,then made the fruit to be presented to the camera in three different, nonoverlapped positions, in order to inspect as much of the fruit surface as possible. Entire system is made of 4 part as follows: ①mechanical conveyer; ②CCD combine with PC; ③ executive mechanism ; ④electronic device(Fig 1).

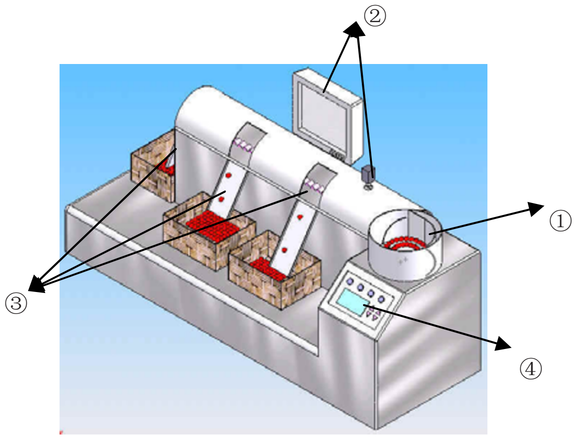


Fig.1: Cherry tomato online sorting device entire map

2.2 Image analysis

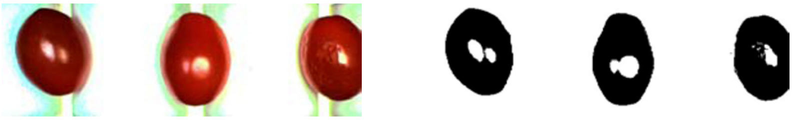
Fig.2: On-line grading software flow chart

On-line operation started with the acquisition of the first image. Three images of different angles are obtained from each cherry tomato, allowing the inspection of approximately 90% of the fruit surface fig3(a).

The second step consisted of image segment use fixed threshold (Rafael C.Gonzelez Richard et al., 2003)as :

$$f_t(x,y)=\begin{cases}0, f(x,y)<T\\255, f(x,y)\geq T\end{cases} \tag{1}$$

Cherry tmatoes was separated from background as shown in fig3(b).



(a)Raw image of cherry tomato (b) Result of image segment

Fig.3: Result of image processing

The third step is feature extracting. Color is one of the most significant inspection criteria related to fruit quality, in that surface color of a fruit indicates maturity. Color representation in RGB (red, green and blue) provides an efficient scheme for statistical color discrimination. Therefore, color evaluation of apples was achieved by analyzing the RGB value of each cherry tomato. A total of 9 feature were extracted from the one cherry tomato, because 3 images are obtained from each cherry tomato.

2.3 Principal component analysis and linear discriminant analysis

Principal component analysis (PCA) is a linear, unsupervised and pattern recognition technique used for analyzing, classifying and reducing the dimensionality of numerical datasets in a multivariate problem. This method permits extraction of useful information from the data, and exploration of the data structure, the relationship between objects, the relationship between objects and variables, and the global correlation of the variables. The main features of PCA are the coordinates of the data in the new base (scores plot) and the contribution to each component of the 9 features(loads plot). The score plot is usually used for studying the classification of the data clusters, while the loads plot can provide information on the relative importance of the feature array to each principal component and their mutual correlation.

The linear discriminant analysis (LDA) calculates the discriminant functions and similar to the PCA—a two- or threedimensional display of the training set data. The difference between PCA and LDA is that PCA does not consider the relation of a data point to the specified classes, while the LDA calculation uses the class information that was given during training. The LDA utilizes information about the distribution within classes and the distances between them. Therefore, the LDA is able to collect information from all sensors in order to improve the resolution of classes (Cheong Hee Park,etal.,2008; Yang, J., Yang, J.-Y,2003)

2.4 Cherry tomato samples

The cherry tomato samples were of the same variety, from the experimental orchard in "jin rui" Institute of Agricultural, zhenjiang. The maturity of cherry tomato is normally sorting into 3 classes which are ripe, half-ripe and immature.

3. RESULTS AND DISCUSSION

To investigate whether the machine vision system was able to distinguish between different ripe state, PCA and LDA analysis were applied to 90 samples. PCA and LDA analysis results are shown in Fig.4 and Fig.5. These figures show the analysis results on a two-dimensional plane, principal component 1 (PC1) and principal component 2 (PC2) in Fig. 4and first and second linear discriminant LD1 and LD2 in Fig.5.

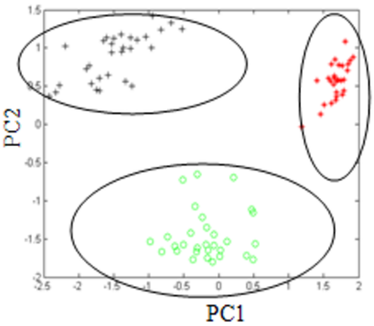


Fig.4: PCA analysis for tomato ripeness

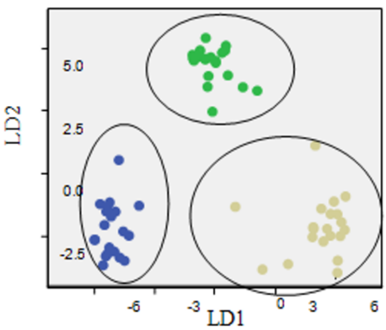


Fig.5: LDA analysis for tomato ripeness.

PCA is a linear combinatorial method, which reduces the complexity of the dataset. The inherent structure of the dataset is preserved while its resulting variance is maximized. Fig.4 shows a clearer discrimination among the various clusters representing the cherry tomato ripe state. Each group was clearly distinguishable from the other groups by using PCA analysis.The processed data show a shift of the different maturity state coinciding with the classification by the trained profile panel. The first principal component, PC1, explains 60.10% of the total variation, while 36.03% of the total variance is explained by PC2 as shown in fig.4. The system has enough resolution to explain the tomato ripe state. PCA analysis showed the variation of each group along the abscissa (PC1) with a trend. The ripe and immature groups show a clear upward and downward displacement in negative and positive direction on the ordinate axis (PC2), respectively, moving these groups away from the other two groups.

The LDA analysis was applied to the same dataset, and it showed a very clear discrimination among the various clusters representing different cherry tomato ripeness state, all cherry tomatoes were perfectly classified (Fig.5). In this plot, about93.3% of the total variance of the data is displayed. LDA function 1 (LD1) and function 2 (LD2) accounted for 84.6% and 8.7% of the variance, respectively as shown in fig.5.

Using PCA and LDA analysis, it is possible to classify the fruit into Three maturity states. When the machine vision system was performed with LDA, better classification rates were observed.

Validation analysis was performed using 414 samples.Tomatoes were of the same variety, from the experimental orchard in “jin rui” Institute of Agricultural, zhenjiang.The Result is as table1. The main error is caused by the half-ripe.

*Table.1:*The detection accuracy rate of cherry tomato

	ripe	Half-ripe	immature
total	211	120	83
correct	205	121	88
error	5	11	5
Repeatability		94.9%	

4. CONCLUSION

This paper has presented a method of cherry tomatos maturaty detecion by machine vision. The main conclusions of this study are as follows:

1.Three images of a cherry tomato by the CCD camera during the motion of the fruit on the grading line. Three images of a cherry tomato could enough cover the 90% of the fruit surface.

2.The cherry tomato is segmented from the background by fixed threshold method, allowed fruits to be precisely distinguished from the background. 9 features (red, green and blue value) were extracted from three image of one cherry tomato.

3.Principal componentanalysis (PCA) and linear discriminant analysis (LDA) were used to investigate whether the 9 features was able to distinguishing among different ripe states. Results indicated that using LDA analysis is possible to differentiate and to classify the different cherry tomato maturity states, and this method was able to classify 94.9% of the total samples in each respective group.

Furthermore, the grading speed of the sorting line reaches 7 cherry tomatoes per second.The sorting line can be used in most of cherry tomato farms, and with a slight change of software it also can be used to sort the other miniature fruit

ACKNOWLEDGEMENTS

This work is supported by “Natural Science Foundation of China” and “863 high-tech fund of China” Fund. We also wish to thank many of our colleagues for many stimulating discussions in this field.

REFERENCES

Cheong Hee Park, Moonhwi Lee. On applying linear discriminant analysis for multi-labeled problems .Pattern Recognition Letters, 2008,29(7): 878-887

Miller W M. Optical defect analysis of Florida citrus. Applied Engineering in Agriculture, ASAE, 1995,11(6):855-860

Rafael C.Gonzelez Richard, Digital Image Processing [M].Beinjing :Publishing house of electronics industry,2003

Sunil Kumar Kopparapu. Lighting design for machine vision application. Image and Vision Computing , 2006,24:720-726

United States Department of Agriculture.United States Standards for Grades of Fresh Tomatoes.1991:4~4

V. Leemansa, H. Mageinb, M.-F. Destain. On-line Fruit Grading according to their External Quality using Machine Vision. Biosystems Engineering,2002, 83 (4): 397-404

Yang, J., Yang, J.-Y. Why can LDA be performed in PCA transformed space?. Pattern Recognition, 2003,36: 563 – 566.