INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 4, No. 1, p. 220-224, 2014

RESEARCH PAPER OPEN ACCESS

Detecting bruises on apples using ultraviolet (UV) imaging for grading purposes

Amin Lotfalian Dehkordi[1*], Sadegh Seiiedlou[1], Saeed Golmohammadi[2]

[1]*Department of Agricultural Machinery Engineering, University of Tabriz, Tabriz, Iran*

[2]*Department of Emerging Technologies, University of Tabriz, Tabriz, Iran*

Key words: UV Imaging, UV camera, apple bruises, image processing, grading.

doi: http://dx.doi.org/10.12692/ijb/4.1.220-224 Article published on January 05, 2014

Abstract

Machine vision and image processing systems are novel methods with various applications in the agricultural sector. Machine vision systems are used for grading different products. This study investigates the feasibility of detecting bruises on apple fruits using the Ultraviolet (UV) imaging and image processing methods for grading purposes. Therefore, a complete machine vision system was prepared including a lighting package at 365 nm wavelength (UV-A), a Ultraviolet (UV) imaging camera, and a computer. Then 25 apples (Red Delicious) with different damage levels were selected, and each was imaged under UV lighting. The images were then processed using MATLAB. Once the images were binarized and the pixels from the bruise areas were counted, the samples were graded into 5 groups (Cull, Utility, Fancy, Extra Fancy, and Intact). Results showed that the UV imaging technique can grade apples with a 92% accuracy.

* **Corresponding Author:** Amin Lotfalian Dehkordi ✉ Lotfalian@tabrizu.ac.ir

Introduction

Apples are among the first fruits known to and grown by humans from the prehistoric era. Each year, a large portion of horticulture products, including apples, become useless and are not supplied to markets due to mechanical impacts. Moreover, failing to meet a target market's standard and requirements decrease their exports. During their production cycle, apples undergo harvesting, packaging, grading, storage and transportation practices. In these stages, numerous static and dynamic loads are imposed to each of the products, inflicting damages and bruises. In this regard, dynamic forces create more bruises, and impact is a dynamic load which occurs when an apple falls on different surfaces or hits another apple (Pourdarbani *et al*., 2009). Bruises are inflicted to the tissue and alter its physical and physiological structure. They finally cause discoloration and usually inflict no rupture on the skin. A large body of research has been performed on impact-induced bruises during the past four decades, which is because of its relatively complex mechanism (shekarbeigi *et al*.,2011). Bruising damages not only impair the quality and marketability of unprocessed products, but also affect the quality of processed products like compotes. Moreover, due to a lack of qualitative grading systems in compote plants, these damages are often observed in their final products (nikbakht *et al*., 2008). Against this background, this issue was the main focus of this study, and, in doing so, a review of national and international literature revealed that using cameras with regular charge couple device (CCD), which did not have the required sensitivity at the illuminated wavelengths, the captured images had poor quality and accuracy, reducing the accuracy of the grading system (Balasundaram *et al*., 2009). There are cases where the grading device was developed using a visible light source. The visible spectrum is not capable of penetrating into damaged areas, and therefore these devices failed to remove products with damages under their skins. This ultimately increased the damage level of graded products (Bennedsen & Peterson., 2005). Several studies have shown that, in fruits with red colors or close to this spectrum, using infrared (IR) spectrum for grading increases errors (Gowen *et al*., 2009). Moreover, since this wavelength can be easily absorbed by moist tissues, its penetration and reflection are both reduced significantly. This, in fact, indicates that IR-based devices have low accuracy. Generally, the literature review revealed that there is a primary stress on increasing the speed and accuracy of devices and also using light sources with wavelengths capable of penetrating into and reflecting from the product tissues. Due to the drawbacks caused by visible and IR wavelengths in detecting damages under product skins (*e.g*. bruises), and also the damages of short-length waves (*e.g*. x-ray) to operators and products (Huang & Lu., 2010. Hsieh & Lee., 2009. ElMasry., 2008. Kader., 2002), this study used the UV wavelengths which are to some extent capable of penetrating into the lower layers and reflecting from (Slaughter *et al*., 2008). Research shows that UV waves better penetrate into bruised tissues and, on the other hand, they are not harmful. Here, the detection of bruises on apples using the UV imaging technique was studied. Using CCD cameras sensitive to the UV wavelength relatively improved the accuracy and resolution of images compared to the cases from the literature. It is also predicted that it would have proper speed and accuracy for grading purposes.

Materials and methods

In doing so, a total of 25 apples (Red Delicious) with bruises were placed inside a trapezoid lighting chamber at a 45° angle under a UV lamp with 365nm wavelength (ElMasry *et al*., 2009). An Ultrak UV camera was used to capture images with 480x640 resolution and transfer them to a PC for storage. The captured images were black and white and monochrome, and the bruises were apparently brighter than the rest. Therefore, the pilot experiments were adopted as a basis for image processing and calculating bruised areas in order to classify the apple samples into 5 grades (Utility, Cull, Fancy, Extra Fancy, and Intact) (Mohsenin., 1986). According to the study procedure, the images were

imported to MATLAB for processing and binarizing. Then, using a proper algorithm and image processing codes, the images were binarized. This way the apple contour was separated from the background. The bruised area was also clearly shown in white (the bruise area pixels were in white color) (Figure 1) (Gonzalez., 2008).

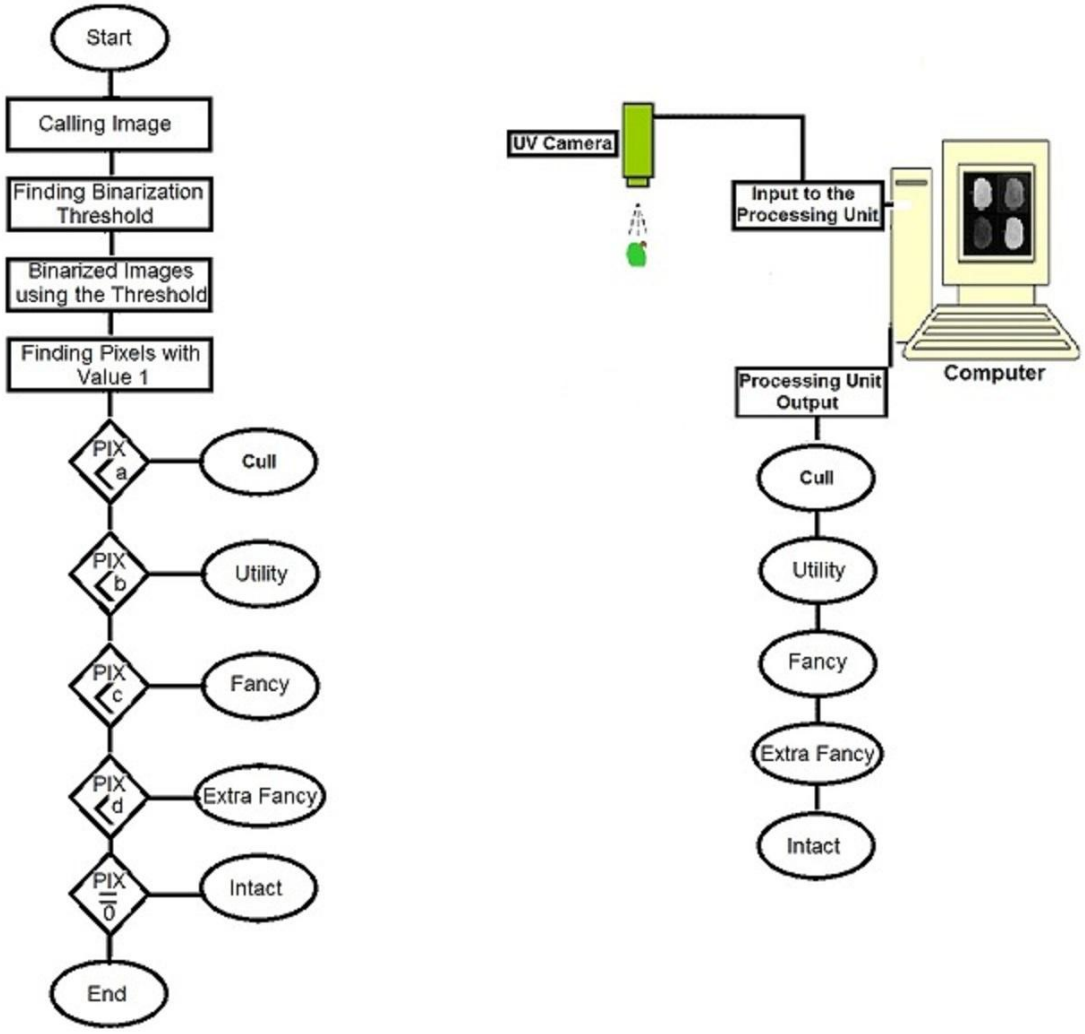

Fig. 1. schematic view of the grading process (left) and the imaging and image processing (right).

For the final separation of the bruised area, the whole image was binarized using the image processing codes, and all points except the bruising area were turned into black. Then using the pixel counting codes, the application counted the number white pixels (Figure 2).

Afterwards, using the pixel to area conversion scale, the number of pixels was converted to area (mm^2). For the scaling procedure, a transparent panel marked with 1-mm^2 meshes was used to measure a 1-mm^2 area. Then the number of pixels from the measured area was counted to determine how many pixels were in 1 mm^2. This procedure was used for converting pixels to area (mm^2). Similarly, it could be used for comparing the area from the image processing system and the actual area of the bruised area. to manually measure the bruised area, the area's skin was cut with a sharp blade, and then the meshed panel was used for area measurements. These readings were recorded and were compared to those from the UV-image processing. This comparison was used as a basis for the system performance evaluation

(Pourdarbani., 2009). The results of processing images in MATLAB are presented in Table (1).

Discussion and conclusion

The study indicated that the combination of UV imaging (365 nm) and UV cameras with CCD sensitive to UV rays is a reliable method for detecting bruises on red apples. Therefore, this study can be a basis for design and development of an apparatus capable of rapidly and accurately separating bruised apples from intact ones by image processing and with regard to their damage level. Furthermore, according to Table (1), the system's capability to detect damages and grade apples in five classifications (Intact, Cull, Utility, Fancy, and Extra Fancy) was measured and evaluated. To do so, an apple was selected from each grade. The results showed that the accuracy decreases with smaller bruised areas, especially in Fancy and Extra Fancy grades where 80% accuracy was recorded for both. However, for intact apples and samples with wider bruised areas (especially Cull and Utility), the system worked perfectly (100%) in grading. Generally, the overall accuracy of the system was about 92% which is good in comparison with other available bruise detection and grading systems for apples.

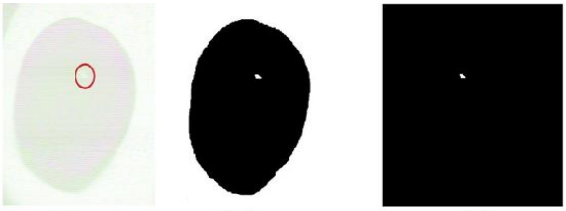

Fig. 2. from left to right: a) UV image from the camera; b) image binarization and separation of the apple sample; and c) binarization and separation of the bruised area.

Table 1. System evaluation and grading results.

Apple Grade	Apple per Grade	Accurately Graded Apples	Grading Accuracy %
Cull	5	5	100
Utility	5	5	100
Fancy	5	4	80
Extra Fancy	5	4	80
Intact	5	5	100

mean grading accuracy: 92 percent.

References

Balasundaram D, Burks TF, Bulanon DM, Schubert T, Lee WS. 2009. Spectral reflectance characteristics of citrus canker and other peel conditions of grapefruit. Postharvest Biology and Technology **51(2),** 220–226. http://dx.doi.org/10.1016/j.postharvbio.2008.07.014

Bennedsen BS, Peterson DL. 2005. Performance of a System for Apple Surface Defect Identification in Near-infrared Images. Biosystems Engineering **90(4),** 419–431. http://dx.doi.org/10.1016/j.biosystemseng.2004.12.005

ElMasry G, Wang N, Vigneault C, Qiao J, ElSayed A. 2008. Early detection of apple bruises on different background colors using hyperspectral imaging. LWT - Food Science and Technology **41(2),** 337–345. http://dx.doi.org/10.1016/j.lwt.2007.02.022

ElMasry G, Wang N, Vigneault C. 2009. Detecting chilling injury in Red Delicious apple using hyperspectral imaging and neural networks. Postharvest Biology and Technology **52(1),** 1–8. http://dx.doi.org/10.1016/j.postharvbio.2008.11.008

Gonzalez RC, Woods RE. 2008. Digital image processing (3rd ed). Prentice Hall.

Gowen AA, Taghizadeh M, O'Donnell CP. 2009. Identification of mushrooms subjected to freeze damage using hyperspectral imaging. Journal of Food Engineering **93(1),** 7–12. http://dx.doi.org/10.1016/j.jfoodeng.2008.12.021

Hsieh C-L, Lee M-H. 2009. Applied Hyperspectral Image on Detecting the Maturity, Weight, and Sugar Content of Tai-Farm No.2 Papaya. ASABE Annual International Meeting Sponsored by ASABE Grand Sierra Resort and Casino Reno, Nevada.

Huang M, Lu R. 2010. Apple mealiness detection using hyperspectral scattering technique. Postharvest Biology and Technology **58(3),** 168–175. http://dx.doi.org/10.1016/j.postharvbio.2010.08.002

Kader AA. 2002. Post harvest Technology of Horticultural Crops. UCANR Publications.

Mohsenin, NN. 1986. Physical Properties of Plant and Animal Materials. Gordon and Breach science Publishers, 2nd edition.

Nikbakht AM. 2008. Non-Destructive Evaluation of Quality in Agricultural Produce: a review of novel optical techniques. Agricultural and Environmental Resources Engineering Quarterly **6(22),** 26-33.

Pordarbani R, Gasemzadeh HR, Golzadeh AA, Behfar H. 2009. Feasibility Study of Apple Quality Grading Using Image Processing**.** Journal of Food Research **19(1),**75-85.

Shekarbeigi S, Afkari-Sayyah AH, Shayeghi-Moghanloo H, Shokuhian AA. 2011. Effect of temperature and padding surface on apple bruise volume due to impact and its prediction by artificial neural network. food science and technology quarterly **8(31),** 85-94.

Slaughter DC, Obenland DM, Thompson JF, Arpaia ML, Margosan DA. 2008. Non-destructive freeze damage detection in oranges using machine vision and ultraviolet fluorescence. Postharvest Biology and Technology **48(3),** 341–346. http://dx.doi.org/10.1016/j.postharvbio.2007.09.012