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RESEARCH ARTICLE

AUTOMATIC BRUISE DETECTION SYSTEM USING THERMAL IMAGES

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ABSTRACT

Developed algorithm sorts bruise apple fruits automatically and uses image processing and machine vision technology to detect bruises. Machine vision includes the capturing of images, processing and analyzing images and therefore the assessment of visual quality characteristics of fruits by non-destructive method is made feasible (5). A Thermal camera is used to capture the image of the fruit and project not only aims to detect a bruise in fruit but also to estimate the size of that bruised part. As well as it gives the count of number of fruits bruised over the unbruised fruits. This will reduce the wastage of the fruits during storage time and also prevents fruit borne illness.

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INTRODUCTION

Bruises are the most common forms of damage on the surface of fruits during transportation and handling. Bruise is defined as damage of fruit tissue as a result of external forces which cause physical changes of texture or chemical changes of colour, smell and taste. Ensuring quality means minimizing manual handling and labour intensive processing. Fruit handlers may contaminate the fruit product with microorganisms present in the human body. Quality evaluation performed manually by trained inspectors, is expensive, tedious, laborious and inherently unreliable due to its subjective nature. Visual inspection is an interaction process involves the products, eyes and brain, which can now be implemented for fruit quality control using thermal imaging cameras, image processing techniques and classification algorithms implemented as computer software. Image processing as well as analysis is recognized as being the core of computer vision. Tedious human inspection task is reduced by series of image processing operations. Computer vision is successful for the qualitative assessment of fruits with various applications ranging complex vision guided robotic control to routine inspection. The development of computer vision systems for grading, sorting and quality inspection of diverse raw and processed food is due to the advancements in hardware and software for image processing [Yang, 1995]. Thermal imaging (TI) is an emerging, non-contact technique suitable for the fruit and food industry and commonly used for fruit safety and quality assessment such as bruise and foreign body detection, temperature validation and grain quality evaluation, in research. The basic principle of thermal imaging is fact that all materials emit infrared radiation and the amount of radiation emitted by an object is dependent on temperature and emissivity (ε). Thermal imaging utilizes the radiation emitted from surface to produce a pseudo image of the thermal distribution. The thermal information obtained in the passive mode describes surface thermal properties. Non-contact temperature measurement of foods during processing requires thermal information. Capture image of fruit using a camera and convert the input image to a gray scale image. Linear contrast stretching method is used to adjust the gray scale image intensity values and contrast of the gray scale image is enhanced using histogram equalization to get enhanced image. Brighten most of details of image except the infected region by adding linear contrast stretched image and histogram equalized image to get image M1. Highlight all the objects and its borders in the image using subtraction of linear contrast stretched image and histogram equalized image to get new image M2. Remove almost all the other components and retains the infected region with minimum affect of distortion using addition of M1 and M2. Calculate a global threshold value using Otsu's method for converting image into binary.

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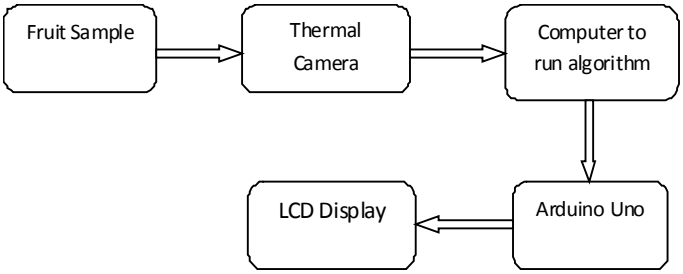


Automatic detection system

The term automatic detection refers to the process of applying technologies and methods to provide automatic inspection, process and control by imaging.

Automatic detection using software is a novel technology for capturing, processing and analyzing images to facilitate the objective and non-destructive assessment of bruises in fruits. Automatic detection system consists of Hardware and Application Frameworkas shown below.

Fig.1.Components of Automatic Detection System

A. Hardware

1. Thermal Camera:

The TI used in this experiment is FLIR C2.The FLIR C2 is the world's first full-featured, pocket-sized thermal camera and C2's must-have features include MSX® real time image enhancement, high sensitivity, a wide field of view and fully radiometric imagery to clearly show where problems are and verify the completion of repairs.

2. Arduino UNO Board:

The Arduino Uno is a AVR microcontroller board based on the ATmega328. It has 14 digital input/output pins out of which 6 are used as PWM outputs, 6 analog inputs, a power jack, a 16 MHz ceramic resonator, an ICSP header, a USB connection and a reset button. It contains on chip programmer and memory everything needed to support the microcontroller; simply we can power it with a AC-to-DC adapter or connect it to a computer with a USB cable (Panth Shah and Tithi Vyas, 2014).

3. LCD Display:

LCD modules are most widely used for low power applications, like watches, calculators, instrument panels etc. In this project selection of LCD module is done purposefully, as

- Consumes less power.
- Easy to display Numeric-Alphanumeric character.
- Compact size and number of characters are, in limited size.
- Light bulb in background mode makes LCD module readable in night also.

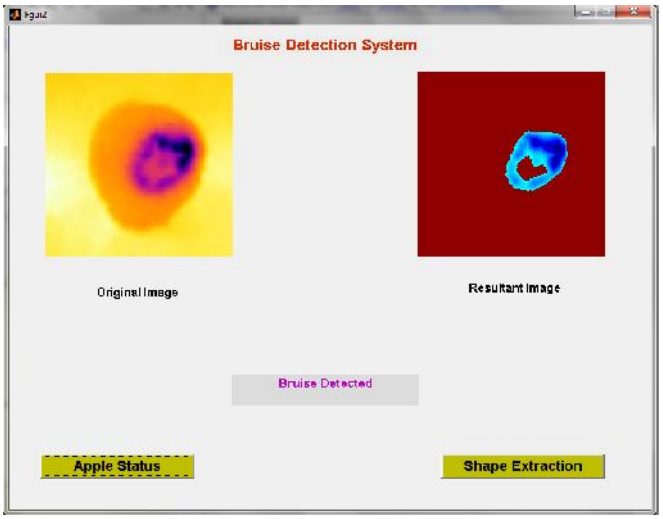
LCD is not only used to display status of apple whether it is bruise or not but also display count of bruise and non bruise apple (Adil Naseem *et al*., 2015).

4. Serial communication:

Serial communication port is used to send character from MATLAB GUI to arduino microcontroller. If apple is bruised MATLAB GUI sends 'A' to arduino microcontroller otherwise it sends 'B'. For serial communication we used COM6 (Panth Shah and Tithi Vyas, 2014).

B. Application Framework (4):

Developed application must be very interactive and easy to use so that person who has very little knowledge of computer can handle developed computer application system. MATLAB software is used to develop this application and to make it user friendly Graphical User Interface (GUI) is developed. Image processing algorithm is developed at the back end of GUI. Buttons are created in GUI for capturing as well as processing image to separate bruise portion of fruits by controlling Buttons will run algorithm developed at back end to get result (http://web.csulb.edu/~hill/ee444/Research%20Library/2_XBee.pdf). Developed GUI is shown in figure:



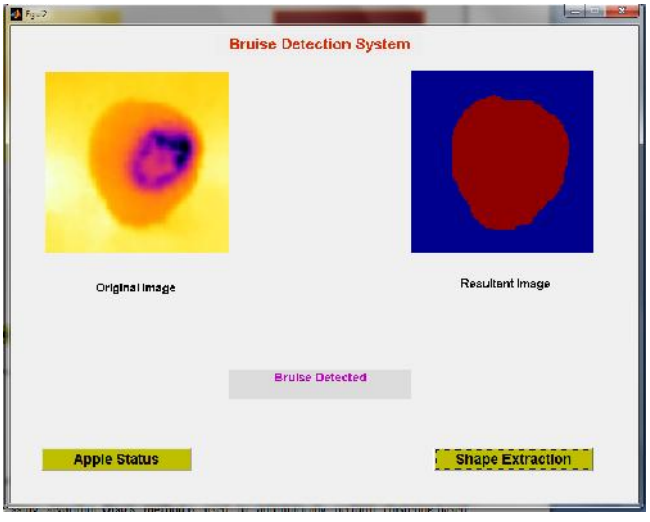


Figure: Graphical User Interface First GUI shows Bruise region second shows Apple Shape area

Developed algorithm for GUI shows total apple area and bruise apple area, Total Apple area is 16402 and bruise area is 3041.

Proposed Algorithm

In image processing algorithm, Otsu's method is used to automatically perform clustering-based image thresholding i.e. process of converting a grayscale input image to a bi-level image by using an optimal threshold. Pixels represent a range of intensities but Information is in binary. Thus binarization aims to mark pixels that belong to true foreground regions with a single intensity and background regions with different intensities. Here, algorithm assumes that the image consists of two classes of pixels following bi-modal histogram first foreground pixels and second background pixels. The main advantage of using Otsu is the simplicity of calculation of the threshold.

Algorithm:

1. Capture image using thermal camera.
2. Convert the input image, A, to a gray scale image B.
3. Adjust the gray scale image intensity values with contrast stretching to get image L.
4. Enhance the contrast of B the gray scale image, using histogram equalization to get image H.
5. Obtain the image R1=L+H to Brighten most of the details in the image except the infected region
6. Obtain the image R2=L-H to Highlight all the objects and its borders in the image
7. Obtain the image R3=R1+R2 to Remove almost all the other components while retaining the infected region with minimum affect of distortion.
8. Implement minimums filter of 3-by-3 on the image R3.
9. Calculate a global threshold value using Otsu's method.

RESULTS AND CONCLUSION

Image processing algorithm is proposed and evaluated in this paper for classification and grading of bruise apple fruit images. We made database of different bruise and normal apple fruit image. Morphological operation and Otsu's method is used to sort bruise apple fruits. Proposed algorithm sorts 27 bruise apple fruits from dataset of 30 images as well as it successfully sorted 28 normal images from dataset of 30 images. Our experimental result shows that the proposed algorithm can automatically sort bruise apple fruits. To improve and enhance the system functionality and flexibility system more future work should be implemented.

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