DEVELOPMENT OF AN NIR SORTING MACHINE FOR DETECTING INTERNAL DISORDER AND QUALITY OF APPLE FRUIT

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This project report is dedicated to my beloved mother and family including my wife and children including my son Saud and my daughters Sama and Aseel

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ABSTRACT

The quality level for fresh fruits is very important for the fruit industries. In presents study an automatic online sorting system according to the internal disorder for fresh apple fruit has developed by using near infrared (NIR) spectroscopic technology. The automatic conveyer belts system along with sorting mechanism was constructed. To check the internal quality of the apple fruit, apple was exposed to the NIR radiations in the range 650-1300nm and the data were collected in form of absorption spectra. The collected data were compared to the reference (data of known sample) analyzed and an electronic signal was pass to the sorting system. The sorting system was separate the apple fruit samples according to electronic signal passed to the system. It is found that absorption of NIR radiation in the range 930-950nm was higher in the internally defected samples as compared to healthy samples. On the base of this high absorption of NIR radiation in 930-950nm region the online sorting system was constructed

ABSTRAK

Tingkat kualiti daripada kesegaran buah adalah sangat penting untuk industri buah. Dalam kajian ini, sistem pengasingan automatik menuruti talian gangguan dalaman pada epal segar telah dibangunkan dengan penggunaan teknologi spektroskopi near infrared (NIR). Sistem Sabuk konveyor automatik vbersamaan dengan mekanisme pengasingan telah dibina. Untuk menyemak kualitas dalaman daripada buah epal, epal tersebut dipapar dengan radiasi pada kisaran 650-1300nm dan data telah dikumpul dalam bentuk serapan spektrum. Data yang telah diperoleh selanjutnya dibandingkan dengan analisa rujukan (data sampel yang diketahui) dan satu isyarat elektronik diloloskan ke sistem pengasingan. Sistem pengasingan itu memisahkan sampel buah epal sesuai dengan isyarat elektronik yang dihantarkan kepada sistem. Kajian ini telah mendapati bahawa penyerapan sinaran NIR pada kisaran 930-950nm adalah lebih tinggi untuk sampel yang buruk berbanding dengan sampel yang sihat. Sistem pengasingan ini telah dibina terhadap dasar penyerapan radiai yang tinggi daripada NIR di kawasan 930-950nm.

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CHAPTER 1

INTRODUCTION

1.1. Background of Study

The quality of the fruits and vegetables is very important for the consumer. In addition, the fruit and the vegetable markets require from suppliers to supply fruit goods with high standards of quality. In market, the quality of the fruit is also very important because the physiological disorder, damage (caused by insects and diseases inside the fruit) hinder the growing export market. Generally, quality of the food product includes outer parameters (size, color intensity, color homogeneity, bruises, shape, stem identification surface appearance and mass), inner parameters (sugar contents, acid contents or inner diseases) and firmness. The most important factors, which influence the shopping behavior, are taste/flavor, freshness/ripeness, visual appeal and cleanliness. In order to meet these criteria a fruit sorting and grading systems are required for fruit processing industries. The fruit sorting system based on weight, color or size are available but the system to fulfill the criteria such as internal defects, ripeness and firmness are needed. Computer machine vision and image processing techniques are found useful in the fruit industry, especially for applications in quality inspection and shape sorting. Traditionally the firmness of the fruits have been measured by the technique penetrometer, consists of a cylindrical rod which is pushed into the fruit and the force required is measured [2].

From last few years, different methods have been developed to sort out and evaluate the quality of agricultural products. In these methods, different physical properties of food products are detected and then correlate with certain quality factors. The different physical properties such as density, X-ray and γ-ray transmission, vibrational characteristics, optical transmission and reflectance, electrical properties, and nuclear magnetic resonance (NMR) are studied to check the quality of the food product [3].

Different automated grading and sorting techniques are used to supply high quality food products. For example, a vision based online fruit grading systems are common in European countries and USA. Light transmittance configuration is used to determine the internal defects in vegetables and fruits, six color cameras and NIR spectrum system with more than 100 facilities is used in Japan [4]. The vision-based systems (either 2D or 3D) consist of CCD or CMOS sensors are used to estimate the size, shape and to classify according to surface color and external defects [5].

Non-destructive measurement MIR and continuous NIRS spectroscopes are used to estimate the several quality parameters in fruits and vegetables. The NIR radiations penetrate into product, its spectral characteristics changes due to scattering and absorption depends upon chemical composition of the products. These spectral changes give the information about microstructures of product as stiffness and internal damage [6]. The spectroscopy in VIS/NIR regions are applied to determine the internal quality and online sorting of fruits and vegetables. A reflectance spectrum of radiations from this VIS/NIR region provides information not only about the physical appearance such as shape, size, external defects, surface color and gloss also provide information related to the internal quality [7].

Non-destructive methods to evaluate the firmness of fruits are grouped under five categories: (a) Impact Sensors, (b) Velocity Measurements or Dampening of a Vibration, (iii) Resonant Vibration Frequency Measurements (iv) Radiation Absorption Measurements and (v) Scattered Radiations Measurements through the fruit [8].

Laser induced light backscatter imaging is also used to analyzing fruit quality such as SSC and flesh firmness. When, the light beam exposes fruit sample, a small portion of incident light reflects from the sample surface and the rest of radiations penetrates into fruit tissues. The radiations reflect back from the sample surface, as specular reflectance is about 4% of the total incident radiations. The radiation inside the sample are absorbed or scattered in different direction and some transmitted through the tissues. Absorption of the light through fruit is due to chemical constituents, such as color pigments, sugar contents and water, etc. The phenomenon scattering of light depends on size of the cell and intercellular and extracellular characteristics of tissue matrices. The detection of scattered light by imaging is useful for prediction of textural characteristics of fruit such as flesh firmness. In addition, the spectral information available, are helpful to determine soluble solid contents and firmness of fruit simultaneously [9].

1.2. Problem Statement

Fruits and vegetables are most important sources of energy and nutrients for human body. Apples are one of the most important fruits across the world. It contains low calories, no cholesterol and reduces the risk of colon, prostate and lung cancer. With a raised consumption, the quality of apples is becoming highly important for the food processing industries. The defect inspection is an important procedure to sort out and for grading the fruit. The internal defects or disorders are also important quality issues in competitive markets, in addition to appearance, flavor, and nutritional value. The traditional procedure to sort out the apple is by visual inspection apple-by-apple. This procedure is labor intensive and prone to human errors and variability. Hence, an automatic online machine vision system is required for inspection and to speed up the inspection procedure. Some of the available sorting systems are near this objective, but prices of these systems are major reason for small companies to maintain standard and competitive levels. Mostly the available systems are based on special architectures, processors boards and hardware implantation etc. Thus, there is a need to design a

cheap and efficient automatic system, which can sort out the apples using a non-destructive technique according to internal order and disorder.

1.3. Objectives

The main objective of this project work to design and construct system able to control conveyer belt to sort out the apples (fruit) according internal defects. The purpose will be achieved by

1. Use of Near Infrared (NIR) sensor to detect the internal disorder of the apples
2. Use of online sorting system for apples

1.4. Scope of Study

In this project, an automatic system will be constructed to sort out the apples according to internal disorder. The task will be achieved by Near Infrared (NIR) spectroscopic technique, which will be coupled to the online sorting system. The spectrasuit software will be used to operate the sorting system according to input signal and separate the internally defected apples. Conveyer belt moving with specific velocity controlled by motor system will be used to pass the apple through NIR sensing system in periodic manner.

1.5. Contribution of Study

NIR spectroscopy is one of the non-destructive techniques to measure the quality parameter of fruits as SSC, pH, sugar contents, firmness, texture parameters, internal defects etc. This project will be helpful for the small food processing industries to sort out and grading the fruits to maintain quality level in market.

1.6. Thesis Outline

This dissertation with title “Development of an NIR Sorting Machine for Detecting Internal Disorder and Quality of Apple Fruit” includes the six chapters. The details for each chapter are given below:

The first chapter includes a brief introduction about project, problem statement, objectives and the scope of study.

The second chapter is about the literature review of the use of NIR technology in food industry.

In third chapter the theoretical background of the study, i.e. NIR radiations, NIR sensor, different configurations for NIR spectroscopy, use of NIR technique in food industry and advantages & disadvantages of NIR spectroscopy have been discussed.

The fourth chapter contains details for the experimental setup, the specifications of the equipments used in experiment and the procedure to perform experiment.

The fifth chapter has the NIR results and the interpretation of the results.

The last sixth chapter includes the conclusion

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