ELECTRONIC VISION AND USES IN AUTOMATIC HANDLING OF AGRICULTURAL MATERIALS

By

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B.Sc. Agric. Sc. (Mechanization), Ain Shams University, 2006

M. Sc. Agric. Sc. (Mechanization), Ain Shams University, 2014

A Thesis Submitted in Partial Fulfillment

Of

The Requirements for the Degree of

DOCTOR OF PHILOSOPHY

in

Agricultural Sciences

(Farm Machinery and Power Engineering)

Department of Agricultural Engineering

Faculty of Agriculture

Ain Shams University

2019

Approval Sheet

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ABSTRACT

Alshaymaa Mohammed Ramzy Abdel-Zaher : Electronic Vision and Uses for Automatic Handling of Agricultural Materials. Unpublished Ph.D. Thesis, Department of Agricultural Engineering, Faculty of Agriculture, Ain Shams University, 2019.

Sorting machines of fruits are mostly used in the industries. The process of sorting started by detecting the color of the fruits to indicate its classification based on the color of the fruit. In this dissertation, a fruit sorting machine has been designed and built for small scale industries needing low cost compared to those now being used, which are expensive. This quest focuses on sorting the different types of fruits such as apples, tomatoes, and navel orange which are green and red.

Study also includes using computer program to draw the relationship between productivity of sorting and system speed. "Matlab software – version 8.5", and cycle time of processes of sorting system are supplemented for the completion of outcomes.

The main results and conclusions can be summarized as follows:

- The productivity is arranged from low to high as follows: tomatoes (27.3 : 61.2 kg/h), apples (34.1 : 76.5 kg/h), and navel oranges (68.1 : 153 kg/h).
- The efficiency of sorting was as follows: tomatoes efficiency was 96 % at the lowest belt speed and increased to 100 % at the mean belt speed then decreased to 94 % at the highest speed, apples efficiency was 95 % at the lowest belt speed and increased to 100 % at the mean belt speed then decreased to 91.25 % at the highest speed, and navel oranges efficiency was 95 % at the lowest belt speed and increased to 100 % at the mean belt speed then decreased to 80 % at the highest speed.
- The simulation of equations in MATLAB program gave close results to the experiments with drawing of the relationship between belt speed and productivity.

- The most suitable belt speed was 0.8 km/h with delay time 1.3 second of servo motor which gave the highest efficiency of sorting within free flowing conditions.
- The sorting process cost by using the developed machine was as follows: it was more expensive sorting tomatoes by the developed machine compared with manual sorting by 25 %, reduced the cost of fruits sorting by 4% for apples and by 52% in navel oranges.

Keywords: Optical Inspection, ARDUINO, Navel oranges, Apples, Tomatoes, Matlab software, Small entrepreneurs, Sorting conveyor, Color sensor, Quantitative sorting, Time study.

ACKNOWLEDGEMENT

First of all, thanks to **ALLAH** for his blessings.

The author wishes to express her deep appreciation and gratitude to **Prof. Dr. Mohammed Nabil El Awady,** Prof. Emeritus of Agric. Engineering, Fac. of Agric., Ain Shams University, for suggesting the problem of study and for his kind supervision throughout this work. The author is grateful for his valuable discussions, suggestions and helpful criticism, which helped him to finalize this work.

The author wishes to express her sincere gratitude and appreciation to **Prof. Dr. Essam A. El-Sahhar,** Prof. of Agricultural Engineering, Dept. of Agric. Engineering, Faculty of Agriculture, Ain Shams University, for his kind supervision, problem suggestion, continuous encouragement and valuable advices throughout this work.

The author wishes to express her sincere gratitude to **Eng. Abdallah M. Hendy,** Eng. of Aviation Engineering, R and D manager at Arab Tech. Company, for his help with his team to fulfil the prototype of this study.

Special thanks to all staff members of Agricultural Engineering Department, for their valuable help during carrying out the experiments of this work.

Finally, deepest appreciations go to my family for their understanding, patience and loving encouragement.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Agriculture is one of the most important fields to develop the economy of Egypt. As fruits play an important role in today's life, Fruit is one of the most important horticultural crops, which is characterized by great benefits and high nutritional value to humans. The post-harvest handling of fruits is one of the most important operations aimed to preserving the fruit quality and nutritional value. Sorting of fruits is necessary in evaluating agriculture produce, quality standards and increasing market value.

If sorting and grading are done manually, the process will be very slow and sometimes invalid. After harvesting, fruits and vegetables such as apples, citrus, onions, peppers, potatoes, tomatoes, etc. have to be sorted, packaged and transported.

A wide range of technologies has been developed for sorting according to color, density, diameter, shape and weight. Automation is getting important in the sorting process, because computers or machines work quickly and effectively. Thus machines also sort fruits according to grades without mistakes.

This automation system, which consists of mechanical structure with electronics, is designed to be used in small agricultural industries. Usually, a lot of human errors occur during the process of fruit sorting.

Usually operators can work 7-8 hours per day. Working more hours can make workers lose their focus. Automation systems are designed to solve this problem and produce efficient and high productivities.

The main objective of this study is to integrate an "Arduino technique" as a main control system with color sensor. This research is divided into two major parts. The first part is mechanical and the second is electronic. The mechanical part includes conveyor belt, while the

electronic part constitutes an RGB (Red, Green, and Blue) color sensing with "Arduino Uno board".

The Arduino technology is quite recent and realizes a few advantages:

1- Simple technique and equipment.

2- Saves labor requirement and skills.

3- Economical.

4- Might realize better sorting quality.

5- May lead to further robotic technology.

REVIEW OF LITERATURE

2-1- Fruits:

2-1-1 Tomatoes:

Tomatoes are the most important vegetable crop in Egypt with the first rank of Arab countries in production. Tomatoes area is 196,770 ha and productivity is 39.27 Mg/ha. It showed that the value of tomato exports were estimated at 91470 ton with 73.81 million US $ per year. **AASY (2015)**.

UNECE standard (2017) classified tomatoes in three classes: Extra class, Class I and Class II. In all classes, the fruits must be in the same color with tolerance of 0.5%, 5% and 10% of color uniformity in Extra class, Class I and Class II, respectively.

2-1-2 Apples:

Apples are one of the most important fruit crops in Egypt. Apples area is 71544 fed and productivity is 10.42 Mg/fed. The value of apple exports was less than imports which was estimated at 425.52 Gg with 454.76 billion US $ per year. **EAS (2019)**.

2-1-3 Oranges:

Oranges is the first important fruit crop in Egypt with the first rank of Arab countries in production. Oranges area is 477510 fed and productivity is 9.32 Mg/fed. The value of orange exports was estimated at 1.28 Tg with 511.65 million US $ per year. **EAS (2019)**.

2-2- Fruit size:

Depending on the fruit variety the classification according to size is specifically defined. Size is determined by cross diameter, circumference and weight. Size can be determined using the projected area method. In this method, three characteristic dimensions are defined:

1. Major diameter, which is the greatest dimension of the maximum projected area;

2. Intermediate diameter, which is the minimum diameter of the maximum projected area or the maximum diameter of the minimum projected area; and

3. Minor diameter, which is the smallest dimension of the minimum projected area.

Length, width, and thickness terms, commonly correspond to major, intermediate, and minor diameters, respectively **Sahin and Sumnu (2006).**

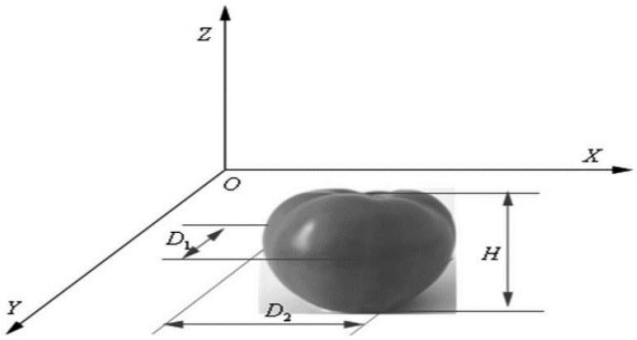

Fig. (1): Orientation of fruit to take dimensions. **Sahin and Sumnu (2006)**

2-3- Description of the sorting processes:

Fruits are transported from field to packing houses by specially prepared trailers or lorries in order to reduce mechanical damage. These means are prepared to be suitable to keep fruits fresh for the longest time. Postharvest important processes are: **Kitinoja and Kader (2003)**

- Loading fruits on trailers.
- Transporting fruits to packing houses.
- Dumping fruits into lines.
- Washing fruits by water (if applicable).
- Drying fruits (if applicable).
- Wax polishing application (if applicable).

- Sorting fruits by color (manually or by automatic systems as in our case).
- Grading fruits to classes by size (if applicable).
- Storing, packing, or shipping to final consumers, as shown in **Fig. (2)**.

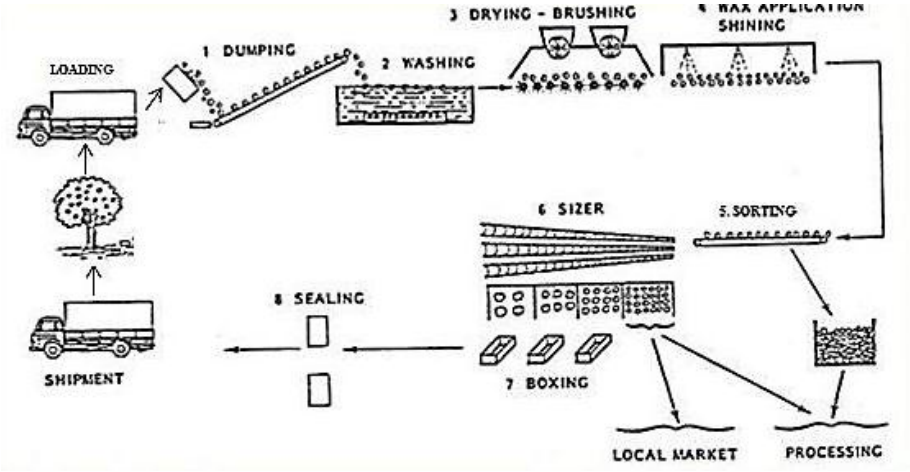

Fig. (2): Cycle sequence for packing processes. **Kitinoja and Kader (2003)**

Shen and Hassan (2015) pointed out that in order to create a smart robot that can recognize color ball and place them at the correct location, research in wave length is needed. The real contribution of this system is that it is able to save time to sort the color hence making this Arduino-powered color recognizing and sorting robot more efficient than the existing system. Upon finishing of this project, a robot that has capability to recognize color of the ball and sorts them according to their color is successfully created.

Abd-El Rahman (2006) said that during short distance (from 50 to 100 km) transportation of three ripening stages of tomatoes, slight increases in the mechanical damage were found between the three tomatoes ripening stages and three packaging materials. Meanwhile, a higher increase in the mechanical damage percentage was found when transportation distance increased over 100 km of three ripening stages of tomatoes.