Comparison of the Effect Using Color Sensor and Pixy2 Camera on the Classification of Pepper Crop

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ABSTRACT: Image processing applications are currently spreading rapidly in industrial agriculture. The process of sorting agricultural fruits according to their color comes first among many studies conducted in industrial agriculture. Therefore, it is necessary to conduct a study by developing an agricultural crop separator with a low economic cost, however automatically works to increase the effectiveness and efficiency in sorting agricultural crops. In this study, colored pepper fruits were sorted using a Pixy2 camera on the basis of algorithm image analysis, and by using a TCS3200 color sensor on the basis of analyzing the outer surface of the pepper fruits, thus this separation process is done by specifying the pepper according to the color of its outer surface, afterward selecting the fruit is achieved, then the crop is sorted by color. An electromechanical system was developed for this process with three different belt conveyor speeds (0.8, 2 and 3 m/s). The image processing algorithms and external surface color analysis that were developed within the scope of the study were tested on this system in real practical time. Moreover, choosing the appropriate speed for the conveyor belt, depending on the time sufficient to process the images or analyze the colors of the outer surface of the pepper fruits. The highest success average of 93.33% was recorded along with the lowest error average of 6.66%, at the first speed using the Pixy2 camera, whereas the sorting process using the TCS3200 color sensor recorded the highest success average of 83.33% along with the lowest error average of 16.66%, at the first speed. It is evident from the above-mentioned values, that the method of sorting the pepper with the Pixy2 camera is more successful than the second method of using the TCS3200 color sensor, nevertheless, the second method can also be used in the process of sorting the pepper fruits.

KEYWORDS: Pixy2 Camera, TCS3200 Color Sensor, Peppers, Image Processing, Belt Conveyor.

INTRODUCTION

The increasing in the world's population makes the classification and packaging of the agricultural products that are presented to the market an important process. After the agricultural crops are transported from the field, to the storehouse warehouse for packing, the products should be classified according to their special characteristics. In these warehouses, various operations are performed such as "sorting, classification, washing, packing and storing". Classifying the product and its packaging according to its characteristics such as length, diameter, shape and color, lead to increasing the marketing value of the product, along with reducing the losses of the product. Thus the price increases moreover the sales of the standard product are clearly distinct [1]. The technical processes that emerged with the development of modern technology contribute to achieving a sustainable and productive economic management, that it is considered a goal for the Agricultural production. Artificial intelligence techniques have become an important tool in facilitating agricultural operations and aids in finding alternative solutions to problems.

The researchers conducted many studies, based on the algorithms and software that are developed during the agricultural production on various topics, the most important of which are: planning crop production, classifying plants, estimating productivity, determining plant diseases, identifying pests and weeds, determining pathways in agricultural robots, determining appropriate environmental conditions in greenhouses, Irrigation systems management, choosing the most appropriate types of fertilizers and spreaders, detecting animal diseases,
determining the appropriate amount of feed and determining animal behavior [2]. The development of science and technology depends on the human mind and its desire to find easier, practical and economical methods. One of the technologies in widespread use today, is the use of remote sensing and microcontroller technology. A microcontroller is used as an aid in human work, so that human laboring can be done automatically, alternatively the demand for fruit increases with an improved income along with awareness of nutrition and health. Obviously the demand for agricultural crops increases sharply, so farmers and traders often need a long time to sort these crops.

The process of grading / classifying agricultural crops by hand is still largely manually done, in other words, using manpower. While in advanced countries, automatic sorting devices are used, the price of this sorting method is relatively high. Knowledge of the physical properties of agricultural products such as color, length, thickness, width and surface area is very important in engineering specialties. These features are required in designing new machines, or in developing machines [3]. However, since these products do not resemble known geometric shapes, they are difficult to measure with traditional methods. Therefore, modern methods such as image processing technology (image algorithms) are used during the experiments. In image processing technology, it is possible to analyze the images that are transferred from high-resolution cameras to the computer using some programs. This technique is used in many fields for many purposes such as analyzing color in fruits, classification, spoilage/damage and leaf area measurement [4,5].

Kabas ve Ozmerzi used image processing technology in determining some of the physical properties of sweet pepper, hence comparing them with the values found by manual measurement [3]. Image processing technology was also used to determine the shape traits of 15 varieties of wheat that are being grown in India. During the experiment, they put wheat grains on the paper, then the grains were scanned, and the images were transferred to the computer. Thus, they determined the length, width, thickness, projection area, circumference and some shape parameters of wheat- grains with the aid of image processing software [6]. A digital camera was used to monitor the leaves of some fruits using an image analysis program in three periods in order to study the effect of gelling agents on color characteristics of fruit jams [7]. Artificial intelligence algorithms were also used to build smart classifiers that have the ability to separate and classify three types of seeds of one wheat plant type from the other depending on the engineering properties of those seeds [8].

A group researchers have sorted strawberries automatically using image processing technology [9]. In this study, three basic characteristics of strawberries have been used: shape, size and color. While used image processing technology to determine the size of the kiwi [10]. The specified size by the image processing technology was compared to the size specified by the transfer method. A group researcher transferred the images of wheat - grains to the computer, later analyzed it using image processing technology, the determination of the percentage of damaged seeds in wheat was conducted using image processing technology [11]. A group researchers developed tools for sorting citrus fruits using RGB color method [12]. (Red, Green, Blue, RGB) using TCS3200 color sensor and Arduino Uno Microcontroller to recognize RGB colors of orange. The fruit was separated by sensing sensors based on the color of the citrus fruit.

Therefore, it is necessary to conduct a study by developing an agricultural crop separator with low economic cost, however automatically works to increase the effectiveness and efficiency in sorting agricultural crops. The current work aims to develop an electromechanical system for sorting the colored pepper fruits, on the basis of the image processing using a Pixy2 camera and a TCS3200 color sensor, according to the color of the outer surface, furthermore conducting a comparison between the two previous mentioned methods efficiency of sorting. Moreover, choosing the appropriate speed for the conveyor belt, depending on the time sufficient to process the images or analyze the colors of the outer surface of the pepper fruits.

MATERIALS AND METHOD

Two computer systems were used to determine the color of fruits, the first depend on image processing with a Pixy2 camera, and the other depend on the TCS3200 color sensor. The computer vision system comprised of two units, which are the image processing unit, the color analysis unit and the recognition unit of the different patterns.
A computer vision system captures an image of the basic fruit and transmits it to an image processor. Afterwards the peppers fruit are classified into groups according to the color of the outer surface. After processing the image, the processor links the image algorithms with the Arduino Uno Microcontroller, similarly, the colors of the outer surface of the pepper fruits are analyzed depending on the color sensor TCS3200 in order to direct the pepper fruits to its own estimated box. In this experiment, an industrial color Pixy2 camera was used to take pictures of pepper fruits (Figure 1). Due to its low cost and ease of use, it is commonly used in small projects related to robotics and artificial intelligence. The camera contains Omnivision OV9715 sensor, 1/4", 1280 x 800. It can receive 50 frames per second (20 milliseconds for the image) and can also be connected to a computer via USB. In addition, it has a very light weight of 27 grams with a low power consumption reaches 140 mA [13].

The PixyMon program was used (Figure 2) for processing the images that were captured by the Pixy2 camera, processing such as dividing these images into groups according to the color of the outer surface of the pepper fruits by using the software’s settings. In analyzing the images obtained from the camera, it was noted that there were differences with the actual shapes of the pepper fruits. In order to prevent this negative situation, an attempt has been made to reduce the shadow before capturing the image using the camera settings. When the system is in operation, it takes approximately 20 milliseconds to analyze an image of each fruit.

The tests was carried out by making use of the images captured with the Pixy2 camera module which already contained a fixed software that could detect colors, through a graphic user interface (GUI). The Pixy2 camera was calibrated by inserting the different colors of pepper fruits. Pictures taken with the Pixy2 camera module can be seen in Figure 3.

After processing the different colored peppers, the next step is to adjust the test environment. The thing to note is the light intensity level inside the test room. The light intensity inside the room should be bright enough so that the image can be clearly seen inside the test field. The sunlight must be prevented from entering the room so that
the intensity of the light from outside the test room does not interfere within the room, during the testing process. This is because light from outside the room will continue to change during the testing process. The outside light changes the intensity of the light in the room which results in a change in the calibration process that will be performed, also the image captured by the camera will be different from the natural appearance of the fruit [14,15]. For this reason, a box was added to the system with a homogeneous lighting mechanism through the lamps of the Pixy2 camera, in order to make the picture that is captured, is clear and the shading is less. In the experimental design, there is a conveyor belt made of a rubber material. its speed is controlled by a DC motor to provide an adequate speed of three different speeds (8, 2 and 3 m/s), in addition to a box mounted on the belt, providing isolation from ambient lighting conditions. The belt conveyor will carry the pepper fruits as they pass through the partially closed box, in order to take pictures of the pepper fruits via the Pixy2 camera, that which afterward, send them to the computer (Figure 4).

![Figure 4. A locally made pepper fruit sorter](image)

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (cm)</td>
<td>150</td>
</tr>
<tr>
<td>Width (cm)</td>
<td>60</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>35</td>
</tr>
<tr>
<td>Dark Chamber Dimensions (L/W/H cm)</td>
<td>30 / 45 / 20</td>
</tr>
<tr>
<td>Number of servo motors</td>
<td>2</td>
</tr>
<tr>
<td>Number of separator plates</td>
<td>2</td>
</tr>
<tr>
<td>Number of plastic crates</td>
<td>3</td>
</tr>
<tr>
<td>Plastic crate dimensions (L/W/H cm)</td>
<td>30 / 15 / 18</td>
</tr>
</tbody>
</table>

In the second method, a TCS3200 color sensor (Figure 5) was used to analyze the color of the outer surface of the pepper fruits. This sensor detects RGB colors (red, green, blue, RGB). Accordingly, Peppers will be separated by this sensor on the basis of the outer surface color of the pepper fruits.

![Figure 5. The TCS3200 color sensor](image)

Two small motors (Figure 6) were used, to direct the pepper fruits in the sorting machine that works with an image processing program of a real-time color analysis sensor. Thus, the pepper is directed to its crate’s boxes with the help of a movable arm.
In both of the two mentioned methods, the Pixy2 camera and the TCS3200 color sensor are linked to the Arduino Uno Microcontroller, in order to send the appropriate instructions to the (Servo Motor). Whereby two small Motors were used, one of which works to direct the pepper to the right direction and the other to the left, depending on the color of the outer surface of the pepper fruits. The Arduino IDE program, which is an opened source, was used for writing the code. The image processing system and color analysis system program was written by the C++ programming language (Figure 7).

RESULTS AND DISCUSSION

In this study, the colored pepper fruits were sorted using a Pixy2 camera and a TCS3200 color sensor. These methods of hardware were used to distinguish fruits according to their color, using software according to an algorithm image analysis method as well as color analysis of the outer surface of fruits. For this purpose, a sample consisting of 100 fruits of pepper was chosen, that is divided into three different categories according to the color, such as yellow, red and green. Figures 8 and 9 show the success rates according to these classes at the different speeds of the chain conveyor.

![Figure 8. Sorting success rates with Pixy2 camera](image-url)
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Figure 8 shows the success rates of sorting with the Pixy2 camera. The success rate of the sorting process reaches 100% in sorting the green pepper fruits at the first speed, and gradually decreases with the increase in the belt conveyor speed whereas the third speed recorded the lowest sorting percentage for sorting the red pepper fruits.

![Figure 8. Sorting success rates with the Pixy2 camera.](image1)

Figure 9 shows the success rates of the sorting process, using the TCS3200 color sensor, which recorded the highest percentage of the sorting process up to 90% of the red pepper fruits at the first speed of the belt conveyor, whereas this percentage decreases with the increase in the belt conveyor speed reached 30% with the yellow pepper fruits and The third speed. Kunhimo, carried out a process of separating some different colored objects using a color sensor TCS230 at the speed of a conveyor belt 3.5 per minute and the efficiency of the color detection and classification process was 100% [16]. Figure 10 shows the success and error averages of the sorting process obtained by different machine learning algorithms using the same data according to the colors of the pepper fruits.

![Figure 9. Sorting success rates using the TCS3200 color sensor.](image2)

The best success average in classifying sorting the pepper fruits according to their outer surface color, was obtained by using the Pixy2 camera with the first speed of the belt conveyor. These averages decreased with the increasing in the speed of the belt conveyor. A success average of 93.33%, 90% and 71.66%, with the speeds
respectively, was recorded in the classification sorting of pepper fruits. Whereas the error averages of 6.66%, 10% and 28.33%, were recorded with the speeds respectively, whereby the third speed recorded the highest error average recorded. The success average of the sorting process using the TCS3200 color sensor was 83.33%, 68.33% and 65%, with the speeds respectively, whereas the first speed gave the highest average in the sorting process, while it did record an error averages of 16.66%, 31.66% and 65% with the speeds respectively, whereby the third speed recorded the highest error average. It is evident from the above values that the success averages of the sorting process decrease, and the error averages increase with the increase of the belt conveyor speed. The reason for this is the shortage of time required to perform the algorithm image analysis or the color analysis of the outer surface of the pepper fruits. Erdoğan use the precision camera to identify different objects [17]. It was found that increasing the speed of the conveyor reduces the degree of recognition and classification of object. The Pixy2 camera can receive pictures per second (20ms per photo) [13]. Therefore, when the belt conveyor speed is increased, the fruit will pass in a time of less than 20 milliseconds through the camera, which is insufficient time to perform the algorithmic image analysis process, thus the error averages will increase.

CONCLUSION

In this study, colored pepper fruits were sorted using a Pixy2 camera on the basis of algorithm image analysis, and by using a TCS3200 color sensor on the basis of analyzing the outer surface of the pepper fruits, thus This separation process is done by specifying the pepper according to the color of its outer surface, afterwards selecting the fruit is achieved, then the crop is sorted by color. An electromechanical system was developed for this process with three different belt conveyor speeds (0.8, 2 and 3 m/s). The image processing algorithms and external surface color analysis that were developed within the scope of the study were tested on this system in the real practical time. The highest success average of 93.33% was recorded along with the lowest error average of 6.66%, at the first speed using the Pixy2 camera, whereas the sorting process using the TCS3200 color sensor recorded the highest success average of 83.33% along with the lowest error average of 16.66%, at the first speed. The Pixy2 camera sorting method appears to be more successful than the second method of using the TCS3200 color sensor. Taking into account the standard error and success averages of sorting the pepper crop, it will be evident the success of using the Pixy2 camera's sorting method. Alternatively Sorting with the TCS3200 color sensor appears to be successful as well, although the recorded success average is low in comparison with the first method, eventually it has been observed that this method can also be used in the process of sorting pepper fruits.

REFERENCES


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