

Prototype for Automatic Fruit Sorting Using Artificial Intelligent (Part 1)

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ABSTRACT

This study aimed to manufacture a prototype for automatically sorting fruits using artificial intelligence technology, to be a time-saving, low energy consumption, cost reduction, accuracy in the sorting process, sorting more than one product on the same model, saving labor, and not wasting the product for sorting fruit. The food industry relies on rapid and accurate sorting and grading of fruits immediately after harvest, before spoilage. The first fruit sorting model was built using an open-source Arduino Nano board, a color sensor, and two Servo motors to recognize fruit colors. The Arduino IDE was used to code the Arduino C language. The results of the model are as follows:

1. In the beginning we put the colored circles that we want to sort by color inside a tube at the top so that the end of the tube is on the piece of wood connected to the upper servo motor.
2. Then the servo motor rotates and brings one colored circle to the bottom of the color sensor, which detects the color of this circle below it.
3. After that, the lower servo motor rotates to the specified position according to the color of the circle that was recognized in the code, and moves the lower piece of the device (the guide rail) that lowers the colored circles into the sorting container.
4. Then the upper servo motor rotates again until the colored circles fall into the guide rail and then fall into the bowl of the color circle.

Accordingly, the prototype can easily sort the fruit into three categories of ripe, immature and spoiled fruit.

1. INTRODUCTION

Human power is commonly utilized in Egypt's agriculture industry. If the sorting and grading is done by hand, the procedure will be overly sluggish and prone to error. Human power is more important and prevalent in today's world, particularly in agriculture. There is frequently a lot of human error when sorting fruit. As a result, this strategy aims to minimize or remove inefficiencies. During the fruit sorting process, there is usually a lot of human error. As a result, this approach is intended to reduce or eliminate inefficiencies. People can usually work for 7-8 h/day. Working for longer periods of time causes people to lose attention, making it difficult for them to concentrate on their jobs. Today's automation solutions are attempting to solve this issue. Science and technology progress is founded on a more sophisticated human mindset and its drive to find things that are simpler, more practical and less expensive. Sensor and microcontroller technology is one of the most extensively used technologies nowadays. Microcontrollers are employed as a tool to assist humans in their work. So that human job can be done without human intervention. Similarly, as people's incomes improve and their awareness of nutrition and health grows, so does demand for fruit. Fruit demand is also increasing rapidly, thus sorting fruit takes a long time for farmers and traders. Fruit selection in Egypt is still largely manual, relying on human strength. Whereas in industrialized countries, automatic sorters are currently in use, the cost of such a sorter is relatively high. As a result, a study including the development of an orange fruit sorter is required in order to boost the effectiveness and efficiency of fruit sorting. Fruit and vegetables of various kinds, such as citrus, onions, pears, peppers, potatoes, tomatoes, and so on, must be sorted, packaged, and transported after harvest. Over the years, a variety of systems for sorting by color,

density, diameter, shape, and weight have been created or refined (**Manoj and Satish, 2013**). Because computers or machines are capable of executing repeated tasks swiftly and effectively, industrial automation is becoming increasingly crucial in the sorting process. As a result, machines are also capable of accurately sorting fruit into grades. This automation system, which would have a mechanical framework as well as an electrical element, is intended for use in small agricultural businesses. There are a number of advantages to using this machine as a solution. For accurate tomato categorization and sorting, color is the most significant attribute. Because of the increased need for high-quality food items in a short amount of time, many farmer organizations are prioritizing automated grading of agricultural products. Increased customer knowledge of their better health well-being and a response by manufacturers to the requirement to supply quality guaranteed products with consistency are the driving forces behind these trends. In this regard, the field of automatic inspection and machine vision plays an essential role in agricultural product quality control (**Tabatabaefar and Rajapour, 2005**).

In the food sector, color, shape and other quality-based sorting is a chronic challenge (**Aleixos et al., 2002; Blasco et al., 2003**). Such technology is required to sort fruit and vegetables such as olives (**Diaz et al., 2000**), dates, tomatoes, peppers (**Gergely and Beke, 2013**), canned peaches, grains, crops, or manufactured-processed food products (**Mohd and Mohd, 2017**) with the goal of saving time and ensuring efficient sorting according to various parameters. In reality, in certain nations, sorting vegetables or seeds is still immature and done by hand (**Blasco et al., 2003**). Manual sorting wastes a lot of time and energy in developing sectors, and it affects efficiency and precision. In this discipline, color detection is a big problem. The grading and sorting of organic products are an

important activity for producers, since it affects the quality assessment of natural products and the export market (**Sergio et al., 2011**). Although human grading and sorting can and has always been done, it is slow, tedious, and error-prone, necessitating the development of a smart fruit grading and sorting machine system. Researchers at various levels devised various designs and algorithms for fruit grading based on textural and morphological aspects to distinguish healthy from defective fruit (**Bruce and Whelan, 2002**). As a result, optical sorting, also known as automated solid product sorting, is the automated process of sorting solid objects utilizing sensors. By sensing the color of fruit, form, and other auxiliary qualities, such sensors make use of product-driven knowledge of the picture-making system (**Sahu et al., 2007**). The sensor (sorter) compares fruit based on the client's characterized acknowledgment to distinguish, sort, and expel defective fruit and other foreign material from the production line, or to isolate the results of multiple evaluations. An image handling (color) algorithm, i.e. the use of vision-based systems, was used in this design. This device's operation (automation) is based on an Arduino microcontroller prototype board. It is the system's control unit, as it contains all of the research's software design. Servo motors, high torque low rpm 12V DC motors, a TCS 2300 color sensor, HD 44780U LCD, HC-05 module, and an Android-based remote controller are among the other significant components. The goal is to design and build a fruit sorting machine prototype that can sort fruit more quickly and efficiently (**Adamu et al., 2019**).

A computer, another Arduino, or other microcontrollers can all be communicated with using the Arduino Nano. On digital pins 0 (RX) and 1 (TX), the AT mega 328 provides UART TTL (5V) serial connection (TX). The serial communication is channel led through USB by an FTDI FT232RL on the board, and the FTDI drivers (included with the Arduino

software) offer a virtual com port to applications on the computer. A serial monitor is included in the Arduino software, allowing simple textual data to be transferred to and from the Arduino board. When data is transmitted via the FTDI chip and USB connection to the computer, the RX and TX LEDs on the board will flash (but not for serial communication on pins 0 and 1). Serial communication can be done on any of the Nano's digital pins using a Software Serial library (**Sai Rakesh et al., 2019**). A microcontroller is a type of microprocessor used for instrumentation and control. A microcontroller is a digital electrical device with input and output, as well as control over programmer that may be created and deleted in a certain manner. Depending on the design, each microcontroller has a unique architecture. Even so, the principle and operation of each microcontroller design are essentially the same (**Setiawan, 2006**). Between 1930 and 1950, food evaluation using various sensors began to emerge; since then, the food sector has improved its automated procedures and is still refining previously developed methodology (**Abu Shawish et al., 2013**). With state-of-the-art hardware and software setups, refinement can point to better quality elements, and improvement can also indicate to cheaper and more cost-efficient solutions. In the food business, color sensors and sensor-based setups have lately been used in a variety of applications (**Kanade and Shaligram, 2018; Rahman et al., 2018; Henry et al., 2017**). With the help of RGB to CIE Lab conversion (**León et al., 2006**), computer vision and a simple sensor kit were employed for Salmon Fillet certification (**Quevedo et al., 2010**). **Afshari-Jouybari and Farahnaky (2011)** employed a software-enabled method to investigate camera-based colorimetry approaches. **Bordbar et al. (2018)** employed sensor-based colorimetry to analyze

hazardous compounds in fruit samples (**Bordbar et al., 2018**). According to recent literature, there is still a need for more research towards low-cost and cost-effective alternatives. Because servo motors give high angular precision, they can spin as desired by the user and then stop and wait for the next signal to take action. As a result, it is frequently employed. A servo motor varies from a typical electrical motor in that it turns on as soon as power is applied and continues to rotate even when the power is turned off. Only the rotational speed of an electrical motor can be changed, and it can be turned ON and OFF, but the rotational progress cannot. The aim of the study to manufacture a prototype for automatically sorting fruit for commercial applications, using an embedded system to serve as a time saving, low energy consuming and cost-effective alternative, accuracy in the sorting process, sorting more than one product on the same model, saving labor, and not wasting the product for sorting fruit. Servo motors are a versatile and unique type of motor that operates automatically up to a specific point for a given command, and then uses error sensing feedback to adjust the performance. As a result, servo motors are employed in situations where motor movement is required for only a specific angle. They have a particular configuration that allows them to rotate at a specific angle for a given electrical input. The servomechanism is used to control the servo motor. A servo motor can be either a DC or an AC motor. A DC servo motor is one in which the motor is a DC motor that is controlled by a servomechanism. An AC servo motor, on the other hand, is one in which the regulated motor is driven by the AC (**Moyeed Abrar, 2019**).

This study aims to manufacture a prototype for automatically sorting fruits using artificial intelligence technology.

2. METHODOLOGY

The design of the embedded system with machine vision has been divided into three primary sections: mechanical system design and components, implementation of microcontrollers and other electrical hardware, and command flow to achieve machine automation. The system's design criteria and considerations are based on two control loops: the define-measure-analyze-control loop and the sensor system, which is combined with downstream analysis software (Arduino).

3. PROTOTYPE DESIGN PARAMETERS

3.1 Microcontroller

The Arduino Nano (AT mega 168) microcontroller is utilized in this project for motion control and object detection. The microcontroller follows a series of preprogrammed instructions that are stored in memory. It then takes the instructions from its programmer and follows them one by one, carrying out the appropriate operations. The Arduino Nano is a surface mount breadboard embedded version of the Arduino with built-in USB. It's the tiniest, most complete, and most breadboard-friendly. It has the same (electrically) features as Decimal, but with more analogue input pins and an inbuilt + 5V AREF jumper, as shown in Fig. 1.

3.2 Color sensor

The color sensor utilized is the TCS 3200 Color Sensor, which is a full color detector that includes a TAOS TCS 3200 RGB sensor chip as well as four white LEDs. The TCS 3200 is capable of detecting and measuring a nearly infinite number of visible colors. The TCS 3200 has a number of photo detectors, each of which has a red, green, or blue filter or none at all (clear). The device contains an oscillator that generates a square-wave output whose frequency is proportional to the intensity of the selected color, as shown in Fig. 2.

3.3 Servo motor

A servo motor typically consists of a simple DC motor and a gear wheel system. A sensor system for detecting gear wheel rotation is also included in the servo motor. As a result, we may rotate it to the necessary angle. The servo motor can usually rotate from zero to 180 degrees. If you like, you may also purchase 360 degree servo motors on the market. The majority of these servo motors are employed in robotic arms. Servo motors of various sizes are available on the market. It is dependent on the project that we are working on. The PWM signal on the Arduino board can rotate these servo motors. PWM pins on the Arduino board can be used for this. Three wires make up the servo motor. The wire is orange, red, and brown in hue. The servo motor is powered by the red and brown wires. The servo motor is rotated to the desired number of degrees using the orange wire. For this, a PWM signal can be used. All servo motors share these characteristics. The servo motor operated in a voltage range of 4.5 to 6V, with 5V being the most common value. From zero to 180 degrees, it rotated in the shape of a semi-circle. The power, ground, and control cables were all attached to the servo motor. The speed and degree of rotation of a servo motor can be controlled using server-side programming. The servo motor does not require a shield. A servo motor is unique in that it does not allow the output shaft to rotate continuously (like conventional DC motors do) - instead, it allows the output shaft to move very quickly to highly accurate output angles (usually somewhere between zero and 180degrees). To accomplish so, it requires a properly pulsed input signal, as shown in Fig.3.

Fig. 1: Microcontroller Arduino Nano

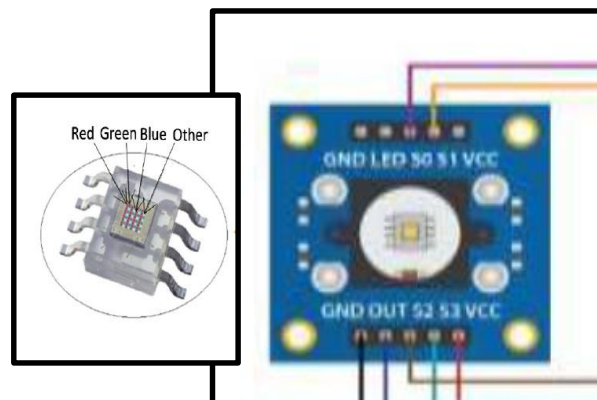


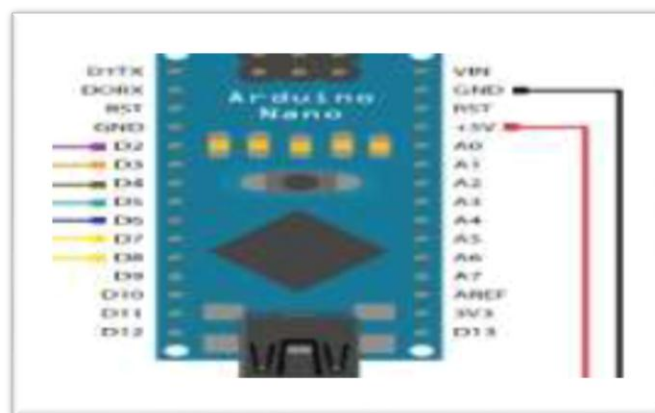
Fig. 2: TCS 3200 color sensor



Fig. 3: The servo motor

4. RESULTS AND DISCUSSION

4.1 Hardware of the prototype



The hardware connections were established in accordance with the circuit diagram. The necessary hardware was obtained in the form of an Arduino Nano microcontroller board and a servo motor. The servo motor is controlled by three wires: the ground wire, the power wire, and the signal or control wire. The ground wire is normally black in color; however brown colored wire is occasionally used as well. The power line is normally red, while the signal or control wire is typically orange, yellow, or white. The servo motor's red and brown wires were linked to the Arduino board's +5V and ground power pins. Arduino parts (Arduino board - color sensor - servo motors) were installed and assembled on the prototype chassis. Also, connect each part by wires to connect it to the Arduino board according to the electrical circuit.

The color sensor frameworks are increasingly being used in computerized applications to detect computerization errors and screen quality at the pace of the manufacturing line. They are used to distinguish and organize things by color as part of sequential construction methods. Their intended uses include determining the type of an object, encouraging sorting and bundling, inspecting the regularity of goods thrown away, and screening waste materials.

As a result, there are a plethora of color sensors to choose from, and the decision is typically based on the application. For less demanding applications where cost and power consumption are the most important factors, simple color sensors and less effort are preferred over complicated solutions. Color names can be used to elicit sensible, predictable responses. White, dim, dark, red, yellow, green, blue, orange, purple, pink, and cocoa are some of the eleven basic color designations that have been recognized. In terms of color variations and mixtures, most or all colors can be shown. Because three separate types of cone cells in the retina

contribute to human color vision to some extent, it follows that those three attributes are necessary and sufficient to characterize any color.

The color sensor, which is connected to the servo motor, serves as the foundation for the entire electrical circuit. The color sensor and servo are connected to an Arduino single board microcontroller (basic card computer based on a microcontroller), which is the system's central logic, as shown in Fig. 4. The orange wire was linked to the Arduino board's digital pin 3 (pulse width modulation). Instead of using an external power supply, the machine received its power through a USB cable.

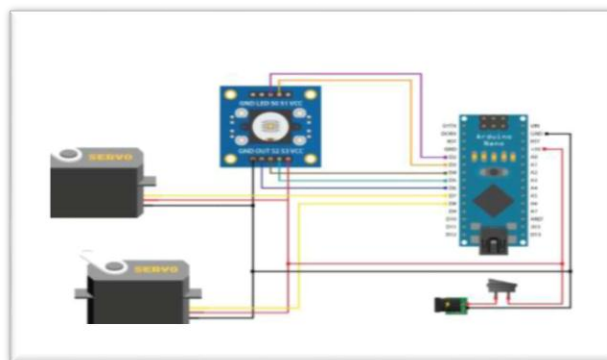


Fig. 4: The color sensor and servo with an Arduino single board microcontroller

4.2 Software of the prototype

The Arduino IDE (Integrated development environment) software was utilized to implement the software. The Arduino IDE software, which is open source, was first installed on the laptop desktop. The code is uploaded directly to the part to be programmed without the need for another program to upload the code. Double-clicking on the Arduino IDE software on the laptop desktop launched it.

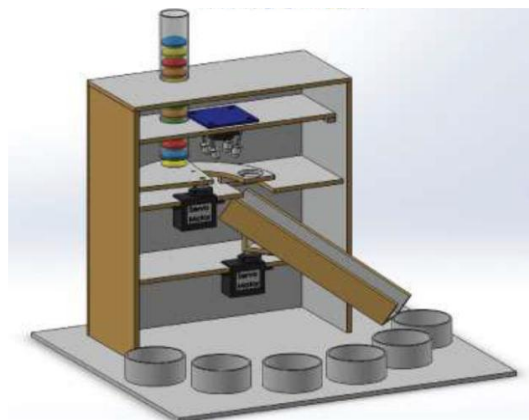
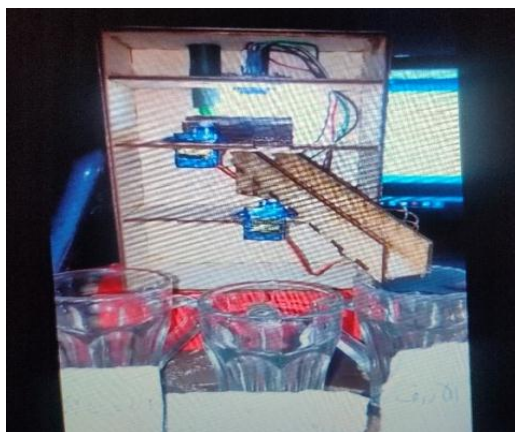


Fig. 5: The prototype of color fruit sorting equipped with a color technique, designed for this study

The prototype tests are being conducted to see if the TCS 3200 color sensor fruit can function properly and display RGB data on the LCD and Serial Monitor. The test is carried out by connecting the color sensor output pin to the analogue pin on the Arduino (A0, A1, A2, A3 and A4). This is done with colored balls during the testing phase. The colored balls are placed just above the color sensor, and the RGB (Red, Green, and Blue) data values on the LCD and Serial Monitor are read by them. The tests are carried out to see if the servo motor-colored balls can run smoothly and receive commands from the Arduino to move the colored balls to the right and left according to the container. According to this study, fruit sorting equipment that is manufactured has multiple sensors that can identify yellow, orange, green, and red. First, the colored balls that will be sorted are placed in one container, and then the circle's container is slid through a hole into which the TCS 3200 color sensor has been inserted. The colored balls will be separated by the sensors based on their color, and then the colored balls will be separated by the actuator, which is operated by the servo motor. The colored balls will land in the appropriate spot based on their color.

Based on the findings of the aforementioned analysis, design, and implementation of an automatic fruit sorting prototype using an

Arduino Nano microcontroller board, the following conclusions can be drawn:

The TCS 3200 RGB color sensor is exceptionally good at detecting the color of the fruit. Because the color sensor has such a strong influence on the ambient light in this study, three phases of automatic calibration are required during the color reading stage. Fruit can be easily classified as ripe, unripe, or spoiled using the prototype.

The results of the automatic sorting of fruit using the prototype demonstrate a number of benefits, including no color recognition flaws, reduced manual labor, fruit sorting according to the specified range, and reduced time spent detecting color.

Finally, this prototype technique can be employed in a variety of large-scale agricultural companies that produce packed fruit juices. Fruit may be simply sorted here without the need for human participation; we know that human eyes can make errors in fruit color recognition, but color detection is 100% here.

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نموذج أولي لفرز الثمار تلقائياً باستخدام الذكاء الاصطناعي (الجزء الأول)

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الملخص

تهدف هذه الدراسة إلى تصنيع نموذج أولي لفرز ثمار الفاكهة تلقائياً باستخدام تقنية الذكاء الاصطناعي، ليكون بمثابة توفير للوقت، واستهلاك منخفض للطاقة وتقليل التكلفة، ودقة في عملية الفرز، وفرز أكثر من منتج على نفس النموذج، توفير العمالة، وعدم إهدار المنتج لفرز الفاكهة.

تعتمد صناعة المواد الغذائية على فرز وتصنيف الفاكهة بشكل سريع ودقيق بعد الحصاد مباشرة وقبل التلف. تم تصنيع النموذج الأولي لفرز ثمار الفاكهة باستخدام لوحة Arduino Nano مفتوحة المصدر ومستشعر الألوان Color Sensor وعدد اثنين محرك سيرفو Servo motor للتعرف على ألوان الفاكهة. تم استخدام برنامج Arduino IDE في كتابة الأكواد البرمجية بلغة Arduino C. أظهرت نتائج النموذج كالتالي:

١- في البداية نضع الدوائر الملونة التي نريد فرزها حسب اللون داخل أنبوب في الأعلى بحيث تكون نهاية الأنبوب على قطعة الخشب المتصلة بمحرك السيرفو العلوى.

٢- ثم يدور محرك السيرفو ويجلب دائرة ملونة واحدة إلى أسفل جهاز استشعار الألوان الذى يكشف لون هذه الدائرة التى أسفل منه.

٣- بعد ذلك يدور محرك السرفو السفلى إلى الموضع المحدد حسب لون الدائرة الذى تم التعرف عليه فى الكود البرمجى، ويحرك القطعة السفلى من الجهاز (سكة التوجيه) التى تنزل الدوائر الملونة الى الوعاء الذى يتم الفرز فيه.

٤- ومن ثم يدور محرك السيرفو العلوى مرة أخرى حتى يسقط الدوائر الملونة فى سكة التوجيه ومن ثم تسقط فى الوعاء الخاص بلون الدائرة. وفقاً لذلك، يمكن للنموذج الأولي فرز ثمار الفاكهة بسهولة إلى ثلاث فئات من الفاكهة الناضجة وغير الناضجة والفاضة.



مجلة العلوم الزراعية والبيئية المستدامة