Microcontrollers and Sensors in Post-Harvest Application of Agricultural Commodity: Sorting/Grading and Storage

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Now days, there is general trend of industrial automation which is nothing but the process of handling different industrial processes automatically with the help of various machines such as computers and robots i.e. with the help of microcontrollers and sensors. This approach increases efficiency, productivity and decreases the human efforts and labour cost. Food industry is also incorporating this same approach of industrial automation in processing techniques to reduce production time and labour cost for enhancing quality of the produce and profit. There are many processing techniques such as sorting, grading, screening, dehulling and storage which required to be done in food industry for obtaining uniformity in products for further processing. Automatic sorting mechanism is a basic need in agricultural fields or in food industries. Sorting of any raw material can be depend on color, size, shape and weight of the commodity. In case of storage of the commodity, it is very difficult to monitor and control the storage parameters by manually, so with the interventions of sensors, actuators and microcontrollers one can easily control the real time storage conditions automatically with better precision and accuracy.

Automatic Sorter Based on color

Automatic color sorters are used in food industry for basic classification. Color sorter is a machine that separate objects in different sets depending on its color. In agricultural industries, there are many categories of color sorters used like rice sorter, beans sorter, peanut sorter, fruit sorter, seeds sorter, etc. Also, in other industries there are several sorters like gear sorter, plastic granule sorter, etc. Poojary et al. (2017) designed an automated fruit and vegetable sorter based on colour detection. The proposed method uses Open CV library for Colour detection. Entire algorithm is programmed using Python 2.7 IDE. Sheela et al. (2016) studied automatic sorting of objects using raspberry pi 3. Authors proposed a highly automated system which uses Raspberry pi 3 for detecting the presence of objects and their color and allows only those objects which are of desired color to pass through conveyor belt and rejecting those colored objects which are undesirable away from the belt. A linear actuator is activated by passing a high signal when the color is undesirable which pushes away the objects using PYTHON code with Raspberry pi 3 support. Gaikar et al. (2016) sorted objects using color sensor, arduino (controller) and shading sensor. Shading sensor distinguishes shading and gives serial yield of RBG. The distinguished shading is recognized as measure of three essential shading values to be specific Red, Green and Blue with 8 bit exactness for every essential shading. Shading can be isolated or consolidated into three essential hues red, green and blue utilizing the RBG values. Shen et al. (2015) designed a color sorting robot with Arduino Uno microcontroller, TCS3200D Color Sensor, SG90 Tower Pro Servo Motor and other electronic components. The system has the ability to sort the object according to their color into respective color station in minimum time.

The following components are required for development of color sorter model

1. Ardiuno board
2. Servo motors
3. Color sensor
4. Jumper wires
5. Color balls/ Cadbury gems

Arduino Mega 2560 is used as microcontroller unit. The Arduino Mega 2560 is an open source hardware, based on ATmega 2560. It has 54 digital input/output pins, 16 analog inputs, a 16 MHz crystal oscillator, a USB

Fig. 1. Arduino Mega Board

connection, a power jack and a reset button. It is used for building digital devices and interactive objects that can sense and control objects in the physical and digital world. (https://www.arduino.cc/)

Servo motor: The servo motor is controlled with an electric signal which determines the amount of movement of the shaft. Servo motor has some special arrangement which makes the motor to rotate a certain angle for a given electrical input (signal). Servo motors are controlled by sending an electrical pulse of variable width, or pulse width modulation (PWM), through the control wire.

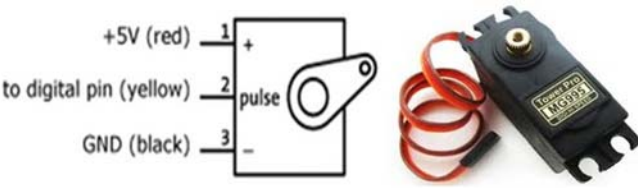

Fig. 2. Servo motor

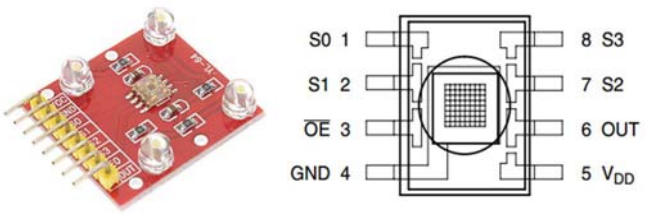

Fig. 3. TCS3200 Color Sensor Module

As shown in figure, sensor has 8 x 8 array of photodiodes. Sixteen photodiodes have blue filters, 16 photodiodes have green filters, 16 photodiodes have red filters, and 16 photodiodes are clear with no filters. Each 16 photodiodes are connected in parallel, so using the two control pins S2 and S3 we can select which of them will be used for reading specific color.

Table: Photodiode colors of TCS3200

S2	S3	Photodiode type
0	0	Red
0	1	Blue
1	0	No Color
1	1	Green

Color sensor: TCS3200 color sensor module (shown in figure) is used for color sensing. The TCS3200 color sensor is a module that includes RGB sensor chip and 4 white LEDs. It senses color with the help of photodiode array and then using a current-to-frequency converter, the readings from the photodiodes are converted into a square wave with a frequency directly proportional to the light intensity.

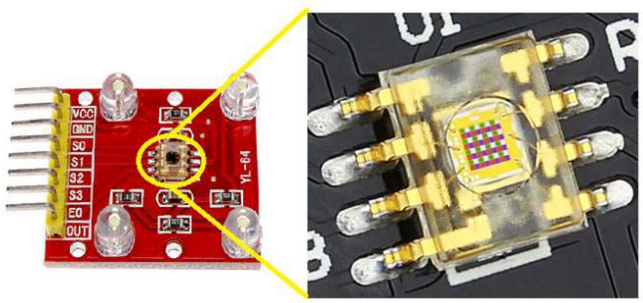

Fig. 4. Photodiode array

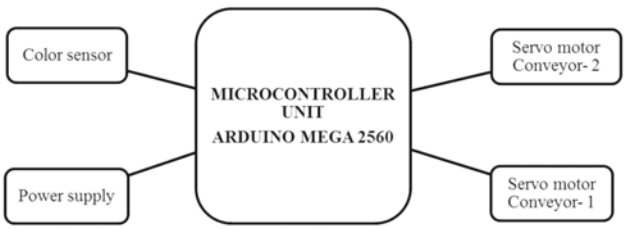

Fig. 5. Block Diagram of System

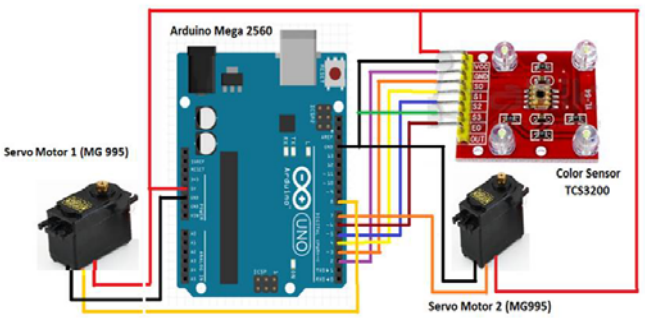

Fig. 6. Connection set up for the Color Sorter

Process flow description:

1. Microcontroller unit is programmed using Arduino Integrated Development Environment (IDE) such that, first it initializes all peripherals i.e., both servo motors and color sensor. Initialization of color sensor includes selection of pins of microcontroller as output pins for selecting lines of color sensor (S0, S1, S2, and S3) and as input pin for output of color sensor (OUT). Also, microcontroller selects output frequency scaling using S0 and S1 control pins in initialization routine.

2. Program is written in a loop so that top servo motor continuously rotates the conveyor plate having circular hole for ball i.e. from position at bottom of the hopper to position at below the color sensor and from position at below the color sensor to the hole from which the conveyor tube starts.
3. When top servo brings the conveyor plate below the color sensor and waits for fraction of time then color sensor measures the color frequencies in R, G and B channel.
4. The color sensor reads the colors in red, green and in blue channels and sends it to the microcontroller unit, then on the basis of color value, microcontroller sends the signal to the bottom servo motor to rotate the conveyor tube in specified degree as per values of colors.
5. This process will continue in loop till objects to be sorted are finished.

Model of color sorter worked well for sorting of color balls with diameter 7 cm. Six different type of color balls sorted through sorter using color properties. This model has a limitations that it requires a uniform color of the object, it will be a good solution for food industry which is producing a products like Cadbury Gems or toffies with uniform color. Model have a bright future perspective and it will give a way to small scale fruit and vegetable sorting automated machines with some advanced sensors like camera and actuators.

Automatic Sorter Based on Weight

In India, highest post-harvest loss was recorded for tomato (12.44%), highest loss of tomato (18.34%) was observed in western plateaus and hills region, Maharashtra (Jha et al., 2015). The severe post-harvest loss occurs during handling and transportation and ultimately, gives adverse result during marketing. In order to address these challenges and for well managed handling, transportation and marketing, grading and sorting of fruits and vegetables is necessary.

Generally, sorting of fruits and vegetables is done according to their geometry and shape either by visual inspection or using image processing technology. Since size of fruits depends on cell division and cell expansion while weight of fruit depends on total solid (water soluble and insoluble) content present in it. So, there is lack of precision in sorting of fruits and vegetables on weight basis by considering only their geometry and shape.

Shendage and Narawade (2015) developed automated weight based fruits sorting system as an economical sorting solution. Rautu et al., (2017) conducted study on sorting of objects based on color, weight and type on a conveyor line using programmable logic controller to sort objects depending upon the color and to analyse the quality of the object. Vashistha et al., (2017) conducted study on design and implementation of weight based object sorting system to eliminate monotonous work done by human and to achieve accuracy and speed of work. Bhausaheb et al., (2017) developed automation (load cell) technique using programmable logic controller to sort object on weight basis.

Materials used: The following components are required for development of weight sorter model

1. Ardiuno board
2. Servo motors
3. Weight sensor amplifier
4. Weight sensor/load cell
5. Jumper wires

HX711 weight sensor amplifier

As load cell output value ranges in mV that doesn't give significant change in displayed output while changing load. So, there is need to amplify output data obtained from load cell. HX711 weight sensor amplifier was used to amplify data obtained from load cell.

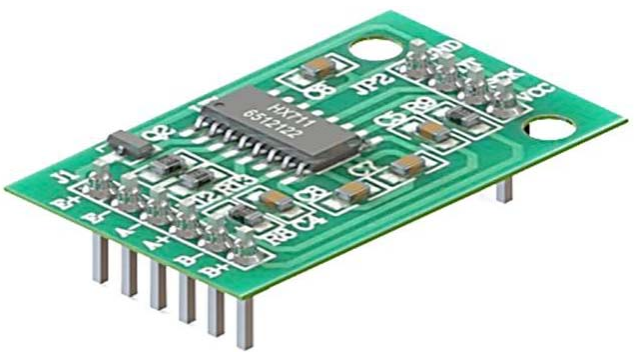

Fig. 7. HX711 weight sensor amplifier

Load cell

Load cell is a weight sensing device. A 5 kg strain-gauge type load cell was used. It works on the principle that when a one end mounted thin elastic wire is subjected to load at its other end then either it gets stretched or compressed and this change in length or diameter causes change in resistance of wire and ultimately change in potential difference along the wire. One end of load cell is mounted and the other end at which load is sensed is kept free.

Fig. 8. Load cell

Working principle of the system

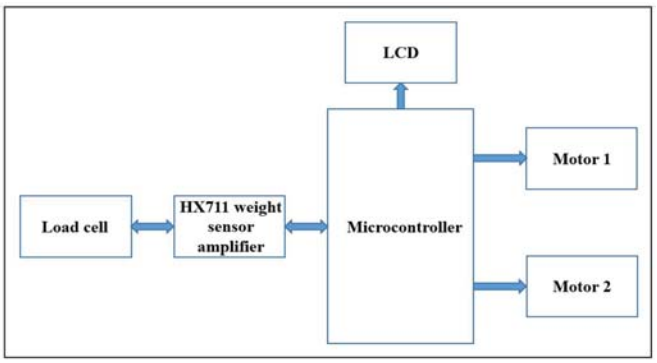

Fig. 9. Block diagram of whole system

"When any sensor senses, it can transfer what it sensed and can be able to operate other actuator". The model for automatic sorter on weight basis for tomato mainly consists of three section viz., electronic control section, weighing section and conveying mechanism. The electronic control section consists of arduino UNO and HX711 weight sensor amplifier, weighing section consists of load cell and conveying mechanism is combination of product dropping and collection mechanism.

At first Arduino software and HX711 library was installed to control whole electronic control segment. Microcontroller, HX711 weight sensor amplifier, load cell and servo motor were used as electronic control segment. Tomatoes of different weight were sorted in five grade. By using statistical analysis (K-means clustering) range of weight for grading was determined for different grades, like more than 150g (1st grade), 110-150g (2nd grade), 80-110g (3rd grade), 50-80g (4th grade) and less than 50g (5th grade). With the help of two servo motor, tomatoes were dropped in their respective compartment according to their weight.

The model gives precision in sorting on weight basis that can't be obtained only by considering shape and geometry of fruits and vegetable but by considering the actual weight of the produce. Error of about ±3g also appears but it doesn't take significant role because range of weight is considered while sorting. It also speeds up time of sorting and thereby processing. In addition to design, a conveyor can also be joined as extended part which will convey material to weighing part and stop till weight will sensed and dropping of material in their respective compartment will take place. This will result in drudgery reduction and also speed up time of processing. With inclusion of advance sensors and microcontroller this model will be good asset for large capacity automatic sorting operation.

Development of low cost real time automatic data-logger for measuring temperature and humidity

Pertinent information about the temperature and humidity during a certain time period is very important in the scientific, medical and industrial fields. For retrieval of this information, various methods can be used. Either it can be done manually, or devices such as chart recorders or data loggers can be used. Data logger can be considered as a self-sufficient tool to collect data, having the ability to clearly present real-time data with sensors and probes able to respond to parameters that are beyond the normal range available from the most traditional equipment. A data logger or a data recorder is an electronic measuring device, logs the data over a period of time with a sensor, built in instrument or via external instruments. The data logger measurements may include: temperature and humidity of air, alternating and direct current and voltage, air pressure, room occupancy, intensity of light, temperature of water, level of water, water content in soil, dissolved oxygen, measurement of rain, motion of wind and its path, pulse signals, leaf wetness etc. These are widely used inside the building, outside the building and in submarine circumstances where the data is required. The purpose of having data loggers is its capacity to spontaneously collecting data for 24 hours

cycle continuously without a break. After activating, the data loggers are left not attending to measure and log data for the particular date and time. This permits exact and complete image of the atmospheric conditions which are being observed such as temperature of air, moisture content in the air, and many more parameters.

We have tried to build a low cost, automatic, real time embedded arduino based data-logger to meet the purpose (i.e. read temperature and humidity with respect to time). The arduino microcontroller board is used which has an inbuilt ADC and other peripheral circuit components (i.e. DHT 22, 16*2 LCD I2C Display, SD card and RTC module) necessary for its working. The physical parameters are sensed by the sensor and then are converted to analog signal. This analog signal is then fed into the arduino board ADC pins which is then converted to an equivalent digital quantity. The processed signal from the microcontroller can then directly be displayed on the serial monitor or recorded on the LCD screen or it can be saved to the SD card for further research. Lakooju et al. (2011) stated that ATmega 2560 contributes incredibly in electronics control applications such as data logging, data acquisition system and many more as it is well known for its economical and greatly flexible chip amongst electrical circuit designer. Apart from that, the chip is always referred as a high-performance microcontroller and it was totally supported by many other researchers to have a great performance microcontroller in their researches.

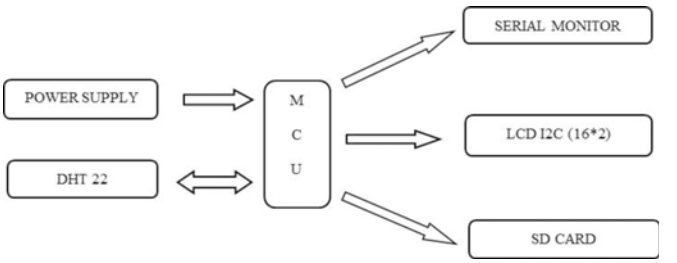

Fig. 10. Block Diagram of Data-Logger

The block diagram is shown below:

SYSTEM COMPONENTS:

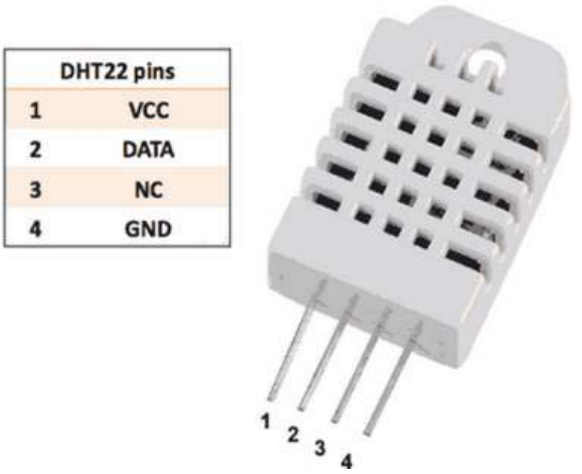

Fig. 11. DHT 22 Sensor

Data logger consists of the following components:

1. Sensors (DHT 22)
2. Arduino Mega 2560
3. LCD Display (16*2)
4. SD Card with module
5. Real time clock module
6. Jumper wires

The DHT 22 sensor is used in this project can be described as follows:

AM2302 capacitive humidity sensing digital temperature and humidity module is one that contains the compound which has been calibrated to digital signal output of the temperature and humidity.

For Relative Humidity:

Parameter	Specification	Unit
Resolution	0.1	%RH
Range	0-99.9	%RH
Accuracy	±2	%RH
Response	<5	S

For Temperature:

Parameter	Specification	Unit
Resolution	0.1	
Range	-40-80	
Accuracy	±1	
Response	<10	S

After setting up the connection and performing experiment, the results were summarised as:

Fig. 12. Overall setup of the designed data- logger

OUTPUT OBTAINED:

The signal out of the microcontroller as the required output can simultaneously be displayed and recorded in the following:

1. LCD Display
2. Serial monitor
3. SD Card/Memory card

Developed data logger is calibrated by comparing it with standard measuring instruments. The variation of measured parameters is studied. We can change the time interval between two readings as per user requirement. Also we can add more sensors in data logger so that one can take reading of different parameters from different locations within permissible range. These measured parameters are displayed in real time on the LCD of the data logger and as well as logged on the serial monitor and saved to the memory card for further analysis.

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