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Automated Object Sorting with QR Scanning and Image Processing

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Abstract*— There is a wide use of many products in our daily life, and these products are manufactured in many large and small scale industries. Sorting is one of the difficulties that is faced after production. Sorting is a process during which two or more objects which are similar, yet different characteristics are arranged in a systematic order. The sorting of objects on a conveyer belt is usually administered manually or by using sensors and actuators. In this project we have proposed a low-cost automated system which uses Raspberry Pi 3B+ and a USB camera for detecting the type, color and size of the objects. Objects which are not of desired type, color or size are discarded by pushing them out of the conveyor belt. A linear actuator is used to push the objects into specific boxes. Type of the object is determined using QR Codes while we use OpenCV for detecting the color and size of the objects. Data is displayed locally and recorded locally on mounted storage as well as remotely on server made specifically for this project.

Keywords*— Raspberry Pi 3B+, conveyor belt, linear actuator, camera, OpenCV, Low-Cost Automation, Manufacturing, Sorting, Internet of Things (IoT)

I. INTRODUCTION

In today's world of technology, the production rate has increased tremendously due to speed running industries. Generally, manufacturing with little variation in height, color, weight, shape of same models is done in industries. And here sorting plays an important role. Industries can't bare human errors for sorting these products in such cases. Hence for sorting these products in accurate manner, it becomes necessary to develop Low-Cost Automation (LCA) . Developing automations having low cost, low maintenance, long durability and to make systems user friendly as possible is mainly focused in industrial automation. Extensive use of sorting of objects is done in many industries like food processing industries, toy industries, etc. This also ensures that the quality of the product is up to the mark. Automation is used to simplify this process.

Automation can be defined as the use of various control systems like computers or robots for managing different process and machineries to replace a human being and to provide mechanical assistance. Generally use of more complex algorithms is done by automated systems which increases the cost of the design and also power consumption increases. Automation not only reduces manual efforts, time consumed but also gives more time for marketing and prevents danger which might occur when working in a hazardous environment. Productivity along with scalability is highly improved by automation. OpenCV is a computer vision library that is used extensively in the industry. We use OpenCV along with Python programming language as it is easy to use and provides sufficient speed for our task. Raspberry Pi 3B+ is a low-cost single board computer which is powerful enough to do computer vision at real time. A USB camera is used to capture the real time video of the objects. The frames of the video are analyzed in real time for type, color and size estimation. Data is displayed locally and recorded locally on mounted storage as well as remotely on server made specifically for this project.

II. LITERATURE SURVEY

The maturity levels of the mangoes were predicted by using the video signals of the CCD (Charge Coupled device) camera which was placed on top of the conveyer belt. The use of CCD cameras in the above method consumed lot of power, dissipated more heat and required additional ICs for operation. This also had a drawback that the maturity levels of mangoes with

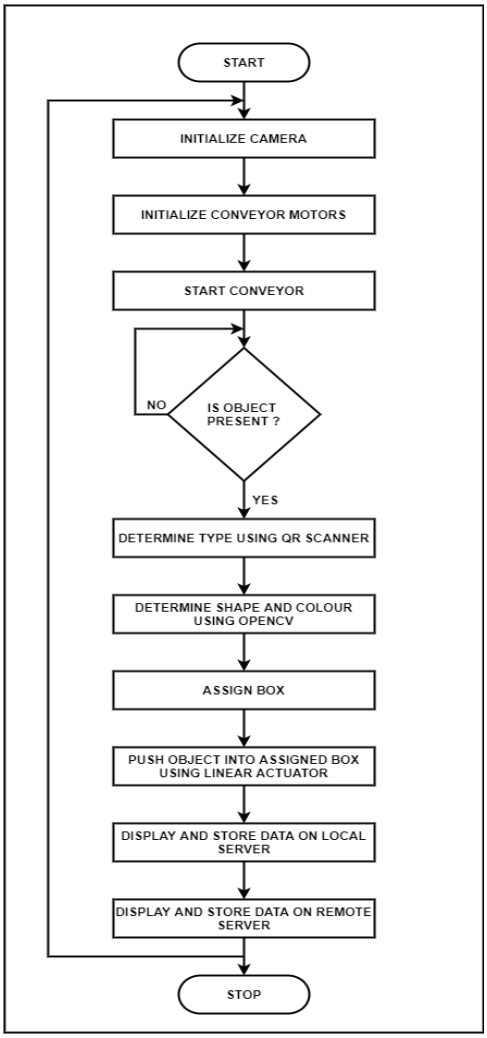
scratches and black spots on their skin could not be detected with the signals obtained from the CCD camera [1]. Robots were developed to sort the objects in bulk which required more mathematics and kinematics for their operation and made the system complex and also less economical. Robotic arms should be designed as to match to the size of the objects to be sorted which made it object specific design and hence less flexible [2]. Most of the Robots use Mat lab software for Image Processing that has less processing speed and they are controlled by Microcontrollers which is application specific [3]. Hence, we tried to establish a system that overcomes some of the above mentioned drawbacks by using Raspberry Pi 3B+.

III. PROBLEM STATEMENT

To design and develop an Automatic Sorting Conveyor System which has following features:

1. Sorts objects based on type, color and shape.
2. Type of object is identified using the QR Code attached to it.
3. Color and Shape is recognized using OpenCV.
4. Provides local data storage and display.
5. Provides remote data storage and display.

IV. FLOWCHART



V. HARDWARE COMPONENTS

1. Raspberry Pi 3B+

The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of

doing everything you'd expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games.

Features:

- CPU: Quad-core 64-bit ARM Cortex A53 clocked at 1.2 GHz
- GPU: 400MHz Video Core IV multimedia
- Memory: 1GB LPDDR2-900 SDRAM (i.e., 900MHz)
- USB ports: 4
- Video outputs: HDMI, composite video (PAL and NTSC) via 3.5 mm jack.
- Network: 10/100Mbps Ethernet and 802.11n Wireless LAN
- Peripherals: 17 GPIO plus specific functions, and HAT ID bus
- Bluetooth: 4.1
- Power source: 5 V via MicroUSB or GPIO header.
- Size: 85.60mm × 56.5mm
- Weight: 45g (1.6 oz)

2. Memory Card

It is used as a ROM for Raspberry Pi and contains the OS files for Raspberry Pi. Also, codes for the project are saved into the memory card.

3.USB Camera

A webcam is a video camera that feeds or streams its image in real time to or through a computer to a computer network. When "captured" by the computer, the video stream may be saved, viewed or sent on to other networks travelling through systems such as the internet, and e-mailed as an attachment. When sent to a remote location, the video stream may be saved, viewed or on sent there. Unlike an IP camera(which connects using Ethernet or Wi-Fi), a webcam is generally connected by a USB cable, or similar cable, or built into computer hardware, such as laptop. The term "webcam" (a clipped compound) may also be used in its original sense of a video camera connected to the Web continuously for an indefinite time, rather than for a particular session, generally supplying a view for anyone who visits its web page over the Internet. Some of them, for example, those used as online traffic cameras, are expensive, rugged professional video cameras. Here it is used for QR Code scanning as well as detecting shape and color of the product.

4. IR Sensor

Infrared radiation (IR), sometimes called infrared light, is electromagnetic radiation (EMR) with wavelengths longer than those of visible light. It is therefore generally invisible to the human eye, although IR at wavelengths up to 1050 nanometers (nm)s from specially pulsed lasers can be seen by humans under certain conditions. IR wavelengths extend from the nominal red edge of the visible spectrum at 700 nanometers (frequency 430 THz), to 1 millimeter (300 GHz). Most of the thermal radiation emitted by objects near room temperature is infrared. As with all EMR, IR carries radiant energy and behaves both like a wave and like its quantum particle, the photon.

5. MG995 Servo Motor

MG995 Metal Gear Servo Motor is a high-speed standard servo can rotate approximately 180 degrees (60 in each direction) used for airplane, helicopter, RC-cars and many RC model. Provides 10kg/cm at 4.8V, and 12kgcm at 6V. It is a Digital Servo Motor which receives and processes PWM signal faster and better. It equips sophisticated internal circuitry that provides good torque, holding power, and faster updates in response to external forces. Features and Electrical Characteristics:

- Metal geared servo for more life
- Stable and shock proof double ball bearing design
- High speed rotation for quick response
- Fast control response
- Constant torque throughout the servo travel range
- Excellent holding power
- Weight: 55 g
- Dimension: 40.7×19.7×42.9mm
- Operating voltage range: 4.8 V to 7.2 V
- Stall torque: 9.4kg/cm (4.8v); 11kg/cm (6v)
- Operating speed: 0.2 s/60º (4.8 V), 0.16 s/60º (6 V)
- Rotational degree: 180º
- Dead band width: 5 µs
- Operating temperature range: 0ºC to +55ºC
- Current draw at idle: 10mA
- No load operating current draw: 170mA
- Current at maximum load: 1200mA

7. L293D Motor Driver

L293D is a basic motor driver integrated chip (IC) that enables us to drive a DC motor in either direction and also control the speed of the motor. The L293D is a 16 pin IC, with 8 pins on each side, allowing us to control the motor. It means that we can use a single L293D to run up to two DC motors. L293D consist of two H-bridge circuit. H-bridge is the simplest circuit for changing polarity across the load connected to it.

8. LED

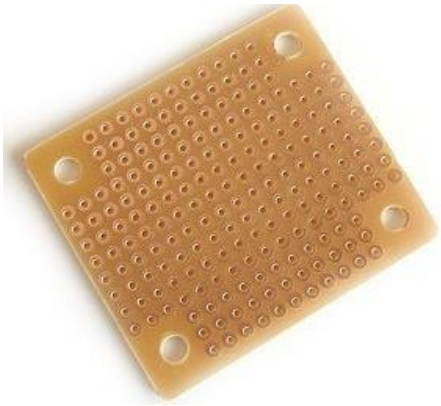
A light-emitting diode (LED) is a semiconductor device that produces light from electricity. LEDs last a long time and do not break easily (compared to incandescent lightbulbs). They can produce many different colors. They are efficient - most of the energy turns into light, not heat. An LED is a type of diode that makes one color of light when electricity is sent through it in the expected direction (electrically biased in the forward direction). This effect is a kind of electroluminescence. The color of the light depends on the chemical composition of the semiconducting material used, and can be near ultraviolet, visible or infrared. The color affects how much electricity is used by the LED. A white LED has either two or three LEDs inside, of different colors. Some white LEDs have one single-color LED inside (usually blue), combined with a phosphor that converts that single color to white. LEDs are used in many places. They are the colored indicator lights on many electronic devices, they can be used to make bright advertising signs, brake lights on some newer cars, in TVs, and more recently, light bulbs for the home. White LEDs bright enough to illuminate rooms are usually more expensive than regular lightbulbs but they last longer and burn less electricity. LEDs, which make their own light, should not be confused with LCDs, which block light. Some displays, however, mix the two technologies, using LEDs to backlight the LCD.

9. Buzzer

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm

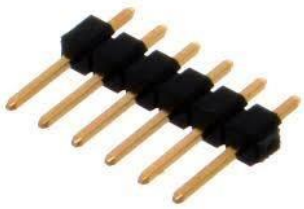
devices, timers, and confirmation of user input such as a mouse click or keystroke.

10. Perf Board



Perf Board is a material for prototyping electronic circuits (also called DOT PCB). It is a thin, rigid sheet with holes pre-drilled at standard intervals across a grid, usually a square grid of 0.1 inches (2.54 mm) spacing. These holes are ringed by round or square copper pads, though bare boards are also available. Inexpensive zero PCB may have pads on only one side of the board, while better quality zero PCB can have pads on both sides (plate-through holes). Since each pad is electrically isolated, the builder makes all connections with either wire wrap or miniature point to point wiring techniques. Discrete components are soldered to the prototype board such as resistors, capacitors, and integrated circuits. The substrate is typically made of paper laminated with phenolic resin (such as FR-2) or a fiberglass-reinforced epoxy laminate (FR-4).

11. Male Header



Male pin headers are often associated with ribbon cable connectors. When used alone, they can be recipients of jumpers, which have spacings of 2.54 mm (0.1 in) and 2.00 mm (0.079 in). The spacing distance between pins (measured from center to center) is often known as pitch.

12. Female Header

Female pin headers are used when you have a board and you'll either want to plug another board into it, or use jumper wires to connect to another board. Plugging one board into the female pin headers of another board. DIY boards with female pin headers for connecting things together.

13. Jumper Wires Male to Female

Jumper wires typically come in three versions: male-to-male, male-to-female and female-to-female. The difference between each is in the end point of the wire. Male ends have a pin protruding and can plug into things, while female ends do not and are used to plug things into.

14. Jumper Wires Female to Female

Jumper wires typically come in three versions: male-to-male, male-to-female and female-to-female. The difference between each is in the end point of the wire. Male ends have a pin protruding and can plug into things, while female ends do not and are used to plug things into.

15. Jumper Wires Male to Male

Jumper wires typically come in three versions: male-to-male, male-to-female and female-to-female. The difference between each is in the end point of the wire. Male ends have a pin protruding and can plug into things, while female ends do not and are used to plug things into.

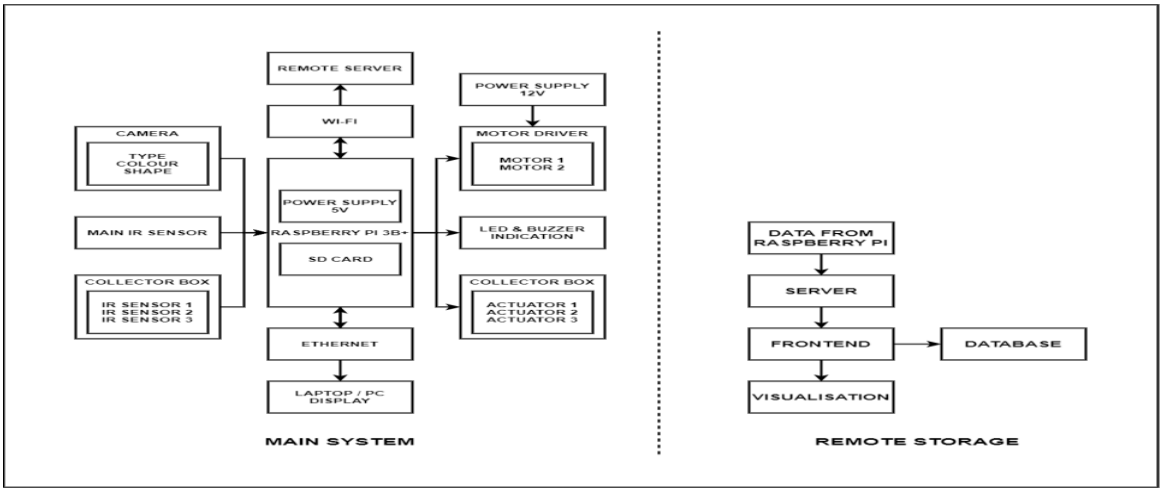
16. Single Stranded Wire

Since stranded wire is more flexible than solid core wire of equal size, it can be used when the wire needs to move around frequently.

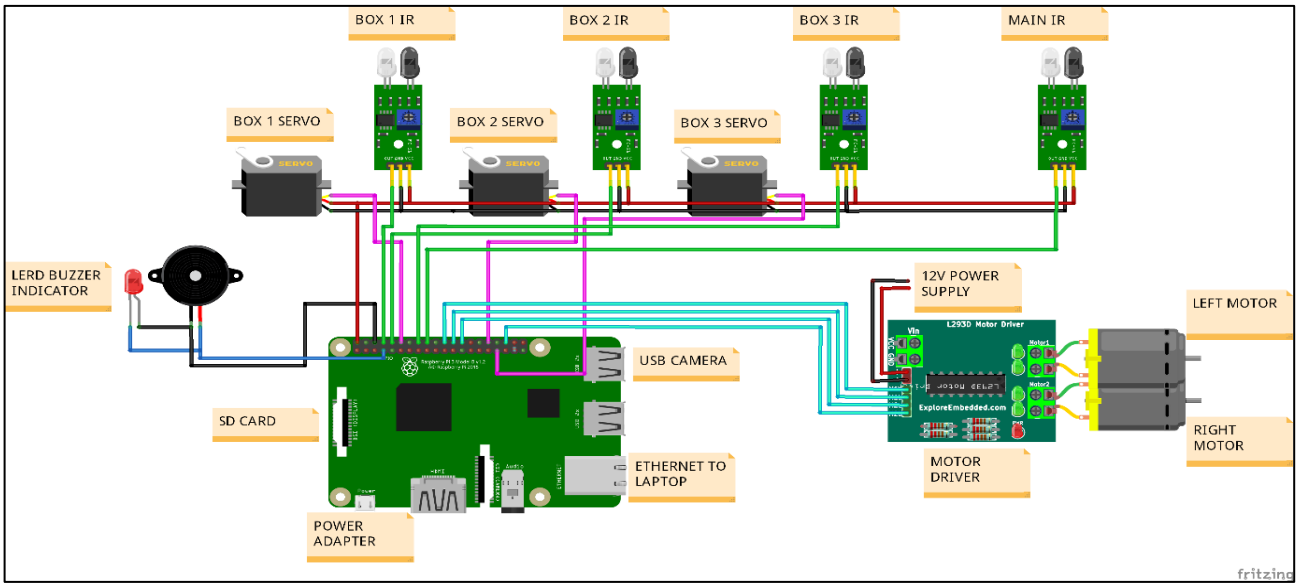
15. Power Adapter

A power supply is an electrical device that supplies electric power to an electrical load. A 5V and 12V supply is used for supplying power to Arduino UNO and CNC Shield respectively.

VI. SYSEM ARCHITECTURE



VII. CIRCUIT DIAGRAM



VIII. WORKING

1. The system uses Raspberry Pi 3B+ as the microcontroller. It has a MicroSD card that stores OS and other required files. It is also used as a local storage.
2. The conveyor belt is made to rotate over two dc motors using a L293D Motor Driver Board.
3. Object when placed in front of camera is identified by main IR Sensor and is scanned for QR Data which helps identify type of object. Along with this the object shape and color are recognized using OpenCV.
4. Based on the data obtained the object is assigned a box into which it needs to be pushed.
5. The object is conveyed from one place to another using belt and when it reaches the desired position it is recognized by IR Sensors connected for individual box.
6. It is then pushed into the box using a linear actuator which is 3D Printed Linear Arm connected to MG995 Servo Motor.
7. Data is displayed on monitor and stored locally as well on remote server.
8. Data stored on remote server can be visualized or can be used for further analytics.
9. This process is repeated for every object.

IX. ADVANTAGES

1. Accurate Interpretation.
2. Good repeatability.
3. Reduces labor cost.
4. Less human interference.
5. Data Storage along with analytics.

X. DISADVANTAGES

1. Initial implementation cost is high.
2. Time required for identification is bit high due to multiple parameter detection using a single camera.

XI. APPLICATIONS

The system can be modified such that it can be used for following applications:

1. In food industry to identify rotted fruits and vegetables, in minor scale and big scale productions, to categorize the products established on the several factors.
2. In production units to scan and identify the defects in raw materials.

3. In fruits and vegetable farming areas (rural areas) where installation of expensive sorters is very difficult.
4. In malls (to segregate and separate different clothes, toys, bags etc.) and in small shop.

XII. CONCLUSION

The automated system outlined above provides cost effective, low time consuming and technically simple approach for sorting of objects. This system makes proper use of available technologies which makes the model easy to use and more efficient. Generally, sensing the type, color and shape of the object simultaneously is a big challenge as there is a chance of high uncertainty due to the various factors. Similarly, while collecting objects from conveyor system by a linear actuator, there are variations in weight and size of objects which affects the speed of the system.

XIII. FUTURE SCOPE

1. Multiple conveyor system can be implemented so as to make the complete process automated.
2. Feeder conveyor can be separately placed instead of manual feeding.
3. Size of the conveyor can be increased with increase in weight and size handling capacity of the object.

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XVI. DATA SHEETS

1. Raspberry Pi 3B+
https://static.raspberrypi.org/files/product-briefs/Raspberry-Pi Model-Bplus-Product-Brief.pdf
2. IR Sensor
https://components101.com/asset/sites/default/files/component_datasheet/Datasheet%20of%20IR%20%20Sensor.pdf
3. MG995 Servo Motor
https://www.electronicoscaldas.com/datasheet/MG995_Tower-Pro.pdf
4. L293D Motor Driver
https://login.pcbpower.com/Documents/0bee917f-23fd-4d88-98b5-a8e620ab2a70/PM14047.pdf