

Efficient Automated Fruit and Vegetable Sorter Based on Colour Detection (June 2016)

¹Ramaprasad Poojary, ²Ravishankar Dudhe, ³Adithya Rajan, ⁴Sheetal Radhakrishnan
^{1,2,3,4} School of Engineering & IT, Manipal University Dubai Campus, Dubai, UAE.

Abstract

Middle East and Dubai in particular is well known for large number of Hypermarkets, Supermarkets and Groceries in the world. Hence there is a huge demand for consumables such as vegetables and fruits. This paper proposes a Simple and Cost effective fruit and vegetable sorter which can automatically sort the objects as per their quality (colour). The proposed method uses Open CV library for Colour detection. Entire algorithm is programmed using Python 2.7 IDE. The system makes use of Atmega 328 microcontroller for its working. Algorithm has been tested for various varieties of products and gives best result. Accuracy of the algorithm is 98%.

Index Terms—Image Processing, Open CV, Stepper Motor, Actuator.

I. INTRODUCTION

The Object Sorting Machine based on colour can be used for Industrial purposes, for sorting skittles, colored balls and M&Ms. Can be used in Automobile Industries. Food Processing industries, pharmaceutical industries, automotive industries, agriculture industries, pharma industry, logistic industry, separation of rotten vegetables, In food industries to identify the rotten or damaged fruits, separation of ripe or unripe fruits, packing of tablets having different colours where this system reduces the human effort, labour cost and also time of operation. In bio medical field, color and shape analyzing algorithm can be used for recognition of cancer cells. [1,2]

The objective is to implement a simple object sorting system based on colour. Here system will identify the colour of object and sends signal to the conveyer belt operated by stepper motor and appropriate actuators push the object for sorting the colour objects. The system uses Arduino UNO board having Atmega328 microcontroller and programmed using Python IDE 2.7. Open CV library has been used for image processing. Firmata protocol is made use for accessing Arduino port. The algorithm is been tested for Blue, White and Red objects.

A. Objective

The objective is to implement a simple object sorting system based on color. Here system will identify the color of object and sends signal to the conveyer belt operated by stepper motor and appropriate actuators push the object for sorting the color objects. The system uses Arduino UNO board having Atmega328 microcontroller and programmed using Python IDE 2.7. Open CV library has been used for image processing. Firmata protocol is made use for accessing arduino port. The algorithm is been tested for Blue, White and red objects.

B. Methodology

The proposed project work colour based object sorting system comprises of following components:

- Conveyer belt
- USB camera
- Actuators
- Arduino UNO Microcontroller

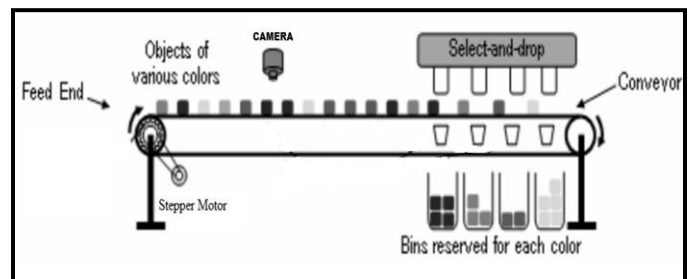


Fig 1. "Prototype of the Proposed Project Work"

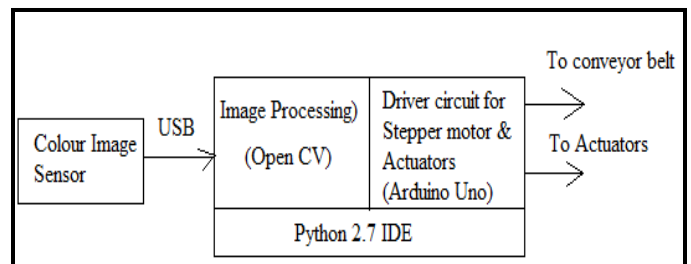


Fig 2. "Block Diagram of Object Sorting System"

1) Conveyer Belt

Objects to be sorted are placed on the conveyer belt. It is operated using stepper motor with

5V, 1A specification. MOSFET based driver circuit drives stepper motor.

2) **USB Camera**

To sense the colour of the objects on the conveyer belt, USB camera has been fitted on to the conveyer belt for sensing the colour of the objects. Open CV library is included in Python IDE to detect the colour.

3) **Actuators**

Solenoid actuators are used to push the objects to the appropriate bins.

4) **Arduino UNO**

Arduino UNO microcontroller acts as the core of the entire system. It provides the required signals to the conveyer belt and actuators. It has been programmed using Python 2.7 IDE.

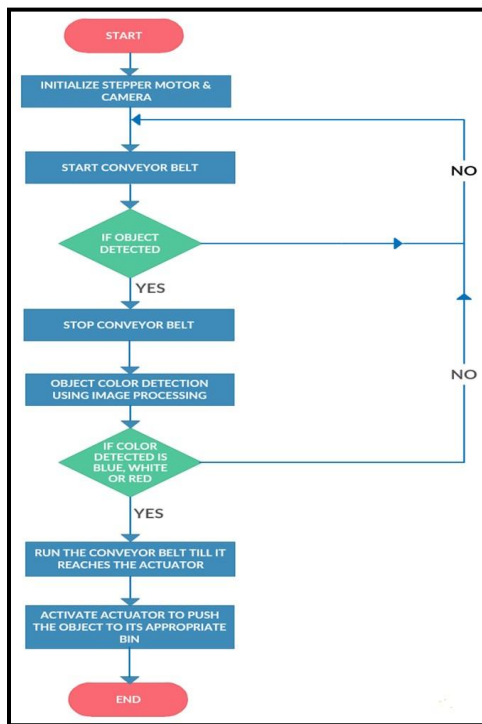


Fig 3. “Flowchart of Object Sorting System”

II. LITERATURE SURVEY

A. **Introduction to Matlab**



Fig 4. “Matlab”

MATLAB(matrix laboratory) developed by Math Works allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces and interfacing programs written in other languages, including C,C++,Java, Fortran and Python.

It is a high-level language for technical computing & has a good development environment to manage code, files, data visualization. It has various toolboxes, which can be downloaded that will help in solving particular class of application problems. Using MATLAB or Simulink and related products, one can control and acquire data from data acquisition hardware, imaging hardware, instruments. It is also possible to communicate with circuit boards and sensors.

During the initial phase of the project, toolbox like ‘image acquisition toolbox’ where downloaded into MATLAB which were used for image processing. By using ‘Add On package’ in MATLAB, installed MATLAB Hardware support package for Arduino in order to interface MATLAB with Arduino. However, was not success in interfacing with Arduino because extra libraries also to be downloaded to use the codes of Arduino in MATLAB which was time taking process and difficult. So switched to Python where interfacing with Arduino was easy.

B. **Introduction to Python**



Fig 5. “Python”

Advantages of Python over MATLAB:

- Free: Python is free to download but MATLAB is expensive.
- Beautiful Programming language: Easier to read and to program than MATLAB programming language. Python was created with the goal of making a beautiful programming language while MATLAB started as a Matrix manipulation package.
- Powerful: Transforming ideas into code we wish is easier in Python than MATLAB.
- Image processing and interfacing with Arduino was found more easy in Python than MATLAB. For image processing just downloaded ‘OpenCV’ library and for interfacing with arduino in order to access the arduino ports ‘pyfirmata’ library was downloaded.

- Semicolon is used in MATLAB where as in Python is not required.
- Portability: Python code can run everywhere since it's a free software. Further it works on Windows, Linux and OS X. But in MATLAB, Mathworks keep restrictions on code portability ie. The ability to run code on someone else computer.

C. Introduction to OpenCV Library

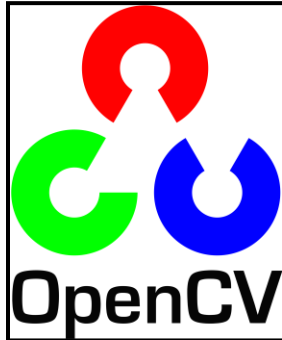


Fig 6. "OpenCV"

OpenCV(Open Source Computer Vision Library) is an open source computer vision and machine learning software library.It supports a wide variety of programming languages such as C++, Python, Java, etc., and is available on different platforms including Windows, Linux, OS X, Android, and iOS.

The library has more than 2500 optimized algorithms, which includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. These algorithms can be used to detect and recognize faces, identify objects, classify human actions in videos, track camera movements, track moving objects, extract 3D models of objects, produce 3D point clouds from stereo cameras, stitch images together to produce a high resolution image of an entire scene, find similar images from an image database, remove red eyes from images taken using flash, follow eye movements, recognize scenery and establish markers to overlay it with augmented reality, etc

Ease of use: If you are a python programmer, using OpenCV (Python) would be very easy. Python is an easy language to learn (especially compared to C++). It is also an excellent first language to learn.

Python has become the language of scientific computing: A few years back MATLAB was called the language of scientific computing. But now, with OpenCV,[numpy](#), [scipy](#), [scikit-learn](#), and [matplotlib](#) Python provides a powerful environment for learning and experimenting with Computer Vision and Machine Learning.When using

OpenCV (Python) you have access to a huge number of libraries written for Python.

D. Introduction to Pyfirmata

PyFirmata is a Python interface for the Firmata protocol. It is fully compatible with Firmata 2.1, and has some functionality of version 2.2. It runs on Python 2.7, 3.3 and 3.4.pyfirmata library in python will help to interface with arduino board & access arduino ports.

Steps to install pyfirmata Protocol in Python in Windows OS:

Step 1: From start menu go to Control Panel. Click on System. In the System window, click on Advanced system settings in the left navigation bar to open a window called System properties. Click on Environment Variables

Step 2: In Environment Variable, you need to update the PATH system variable to add Python to the default operating system's path.

Click on the PATH option as displayed in the following screenshot, which will pop up an Edit System Variable window. Add C:\Python27 or the full path of your custom Python installation directory at the end of your existing PATH variable. It is required to put a semicolon(;) before the Python installation path.

Step 3: Installation of Setuptools.install 'pip.py' from the link www.pip-installer.org/en/latest/&download-get-pip.py

Step4:Go to link <https://pypi.python.org/pypi/setuptools> and download ez_setup.py

Step 5: Go to Start-Accessories-cmd. Type >python ez_setup.py in Python27 folder

Step 6: Type > easy_install.exe pip to install any package

Step 7: > easy_install.exe pyfirmata for accessing pins of Arduino.

E. Introduction to Arduino UNO

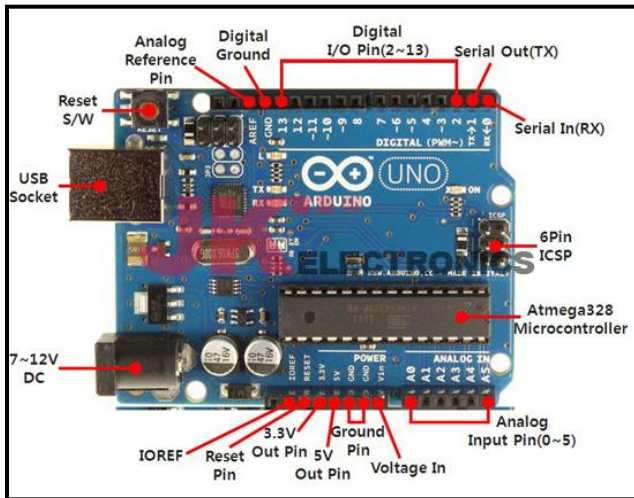


Fig 7. “Arduino UNO Board”

- An Arduino is an open source hardware platform with built in programming support based on simple microcontroller board
- No additional hardware or software (eg.Hex burner) is required to transfer you programs(i.e.. hex file) to the Arduino. There are all the necessary peripherals attached for the basic operation.If we use normal microcontroller board then we will have to use external hardware’s and software’s more.
- Arduino can be used to make a variety of projects taking analogue as well as digital inputs and can easily interface with different hardware like switches, encoders, sensor, motors, relays and many more.
- Arduino has its built in programmer to burn Hex file in it. But compared to the microcontroller boards we need to buy external burner and install separate software to burn program to the processor.
- Larger number of libraries are freely available in Arduino software itself & in our project we have used StandardFirmata which was already internally installed in software.
- Arduino is inexpensive compared to other microcontroller platforms.
- Cross-platform Arduino software runs on Windows, Macintosh OSX and Linux operating systems. Most microcontroller systems are limited to Windows.

Atmega 328 Microcontroller

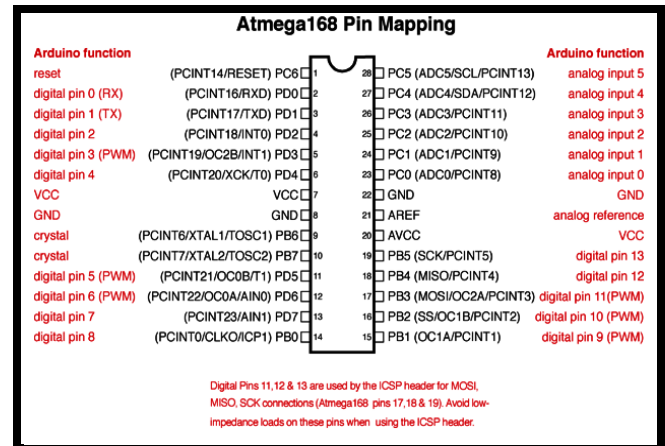


Fig 8. “Atmega328 Microcontroller PIN Diagram”

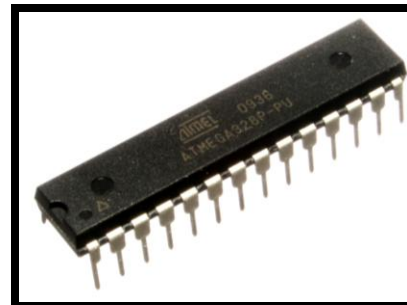


Fig 9. “Atmega328 Microcontroller”

Helps in control of stepper motor and actuators. The ATmega328 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC. By executing powerful instructions in a single clock cycle, the Atmega328 achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed.

The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle.

The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers

- Atmega 328 has inbuilt eeprom, 8051 processor doesn't
- It has ADC inbuilt, 8051 needs external ADC IC.
- It has specific function pins and easy to configure, 8051 doesn't have specific functions

- More ROM & RAM is there compared to 8051
- Atemga is easy to program (good IDE; S), 8051 is old & OK level IDE is need to create library for every functions

F. Web Camera



Fig 10. “Web Camera”

Camera is the color sensor used here .It will take the snapshot of the incoming object for colour sensing purpose. The image captured by the camera will be processed by image processing using MATLAB. We are using simple USB web camera. So Interfacing will become easy with computers. Specifications of camera:

- Image Resolution: 20megapixel
- Frame rate: 30 frames per second
- Camera control: Enhance photos by modify lighting, add a boarder, enlarge, crop, color saturation, brightness, sharpness is adjustable.
- Lens: F=2, f=5.0mm
- View angle: 73 degrees
- Focus range: automatic focus, 10cm to infinity
- Exposure: automatic

G. Stepper Motor

Stepper motor is specially designed DC motor that can be driven by giving excitation pulses to the phase winding. They cannot be driven by just connecting the positive and negative leads of the power supply. They are driven by a stepping sequence, which is generated by a controller. The motor moves in steps according to this sequence.

Typical applications of stepper motor is for accurate positioning of X-Y tables, plotters, printers, facsimile

machines, medical applications, robotics, barcode scanners, image scanners, copiers, etc.



Fig 11. “Stepper Motor”

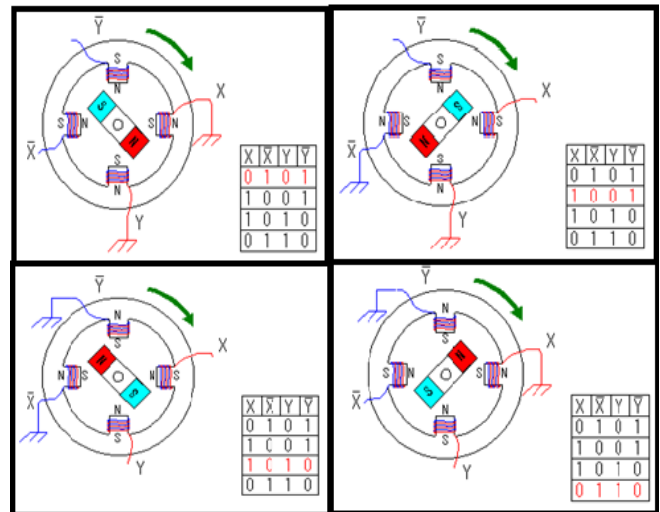


Fig 12. “Working Of Stepper Motor”

Features of stepper motor

- 5V, 1Ampere & handling torque of 500mNm.
- Digital control of speed and position.
- Open loop system with no position feedback required.
- Excellent response to acceleration, deceleration and step commands
- Noncumulative positioning error ($\pm 5\%$ of step angle).
- Excellent low speed/high torque characteristics without gear reduction.
- Inherent detent torque.
- Holding torque when energized.
- Bidirectional operation

H. Introduction to Solenoid Actuator



Fig 13. "Solenoid Actuator"

Solenoids are a great way to induce linear motion for pushing, pulling or controlling switches and levers.

This solenoid is rated for 36V but they work like a charm at 12V itself. With a throw of 10mm these solenoids are great for all kinds of motion applications such as actuating door latches, automating percussion instruments.

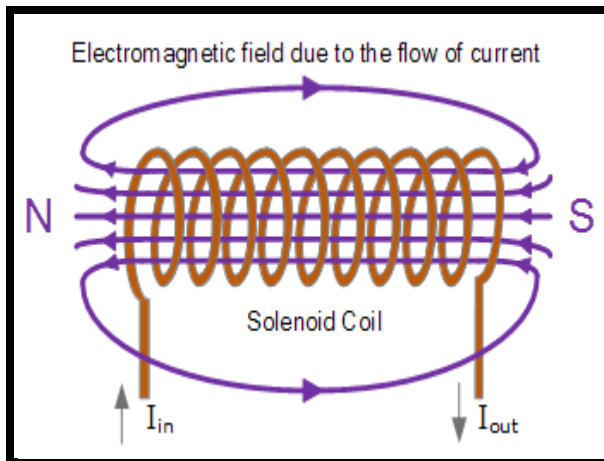


Fig 14. "Working Of Actuator"

A 'Solenoid Actuator' is an electromagnetic device that converts electrical energy into mechanical pushing or pulling force or motion. When an electrical current is passed through the coils windings, it behaves like an electromagnet and the plunger which is located the coil, is attracted towards the center of the coil by the magnetic flux setup within the coils body, which in turn compress a small spring attached to one end of the plunger. The force and speed of the plungers

movement is determined by the strength of the magnetic flux generated within the coil.

III. PHASES OF PROJECT

The following concepts and software's were used in process of undertaking this project. Following are the phases followed for project.

- Introduction to MATLAB & Arduino
- Introduction to Python 2.7 IDE
- Interfacing Python with Arduino
- Driver circuit for stepper motor
- Construction of overall system
- Tested conveyer belt
- Driver circuit for actuator

A. Introduction to MATLAB & Arduino

Learned about MATLAB software having Image acquisition toolbox and wrote program for image processing & where able to detect different coloured objects ie; Blue, white and red by USB camera in MATLAB in order to control stepper motors & actuators used Arduino UNO board which has an Atmega328 microcontroller processor in it. Installed Arduino software in PC and learned more about Arduino. USB cable of Arduino board where connected to PC. Tried interfacing of MATLAB with Arduino and was not success faced many disadvantages.

B. Introduction to Python 2.7 IDE

Switched to Python 2.7 IDE software after understanding the problems while interfacing MATLAB with Arduino software. Learned more about Python 2.7 IDE & installed OpenCV library for image processing. Image processing was done in Python by using OpenCV library and where able to detect different coloured objects ie; Blue, white and blue by using USB camera in Python.

C. Interfacing Python with Arduino

Pyfirmata protocol was installed in Python to access Arduino port. USB cable from Arduino board to PC where connected and uploaded StandardFirmata program in Arduino for interfacing with Python. Tested program for stepper motor & actuators using LEDs and interfacing Python with Arduino was success.

D. Driver Circuit for Stepper Motor

Learned about stepper motor and how to make its driver circuit. MOSFET based driver circuit for stepper motor where made and connected to Arduino board. Tested program with Python and motor shaft starts to move.

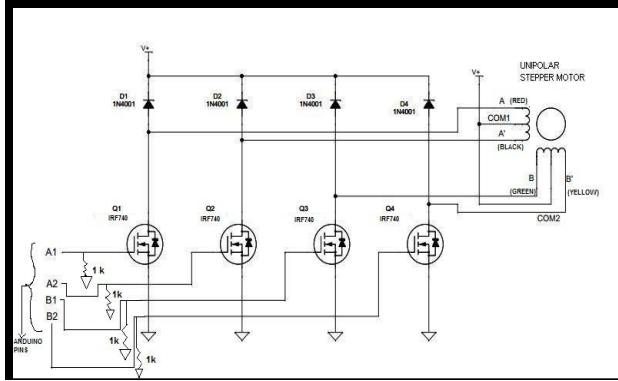


Fig 15. “Driver Circuit Diagram For Stepper Motor”

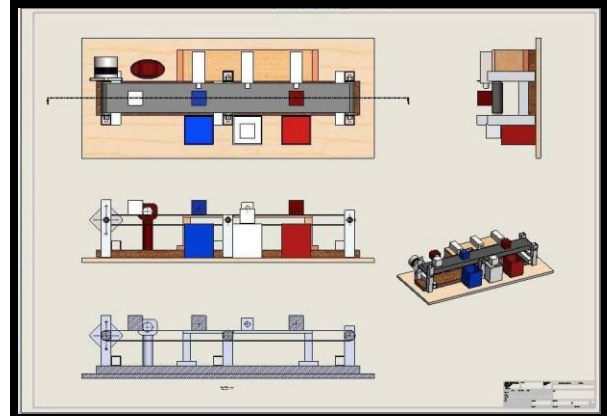


Fig 18. “Planned Overall System Model In Autocad”

E. Construction of Overall System

Planned model of the overall system and made a rough model in AutoCAD and constructed parts of the overall system.

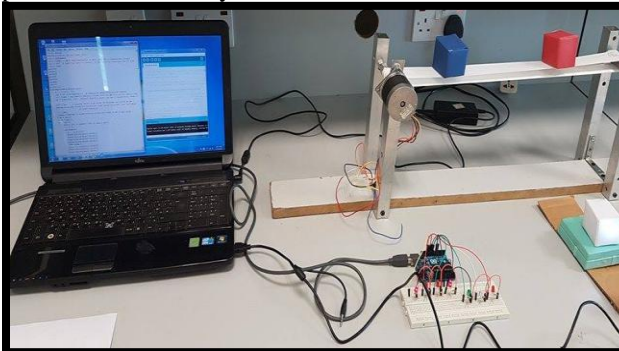


Fig 16. “Overall System Rough Model Made Before”

F. AutoCAD Model

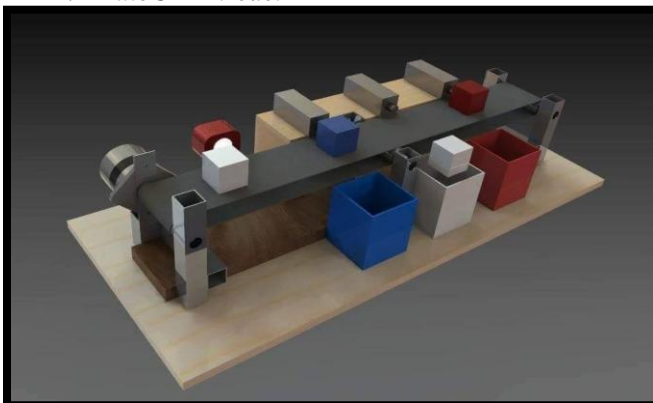


Fig 17. “Planned Overall System Model In Autocad”

G. Tested Conveyer Belt

Conveyer belt was fixed to the pulley that was attached to the shaft of stepper motor and tested the program for motor where the conveyer belt moved.

H. Driver Circuit for Actuator

Learned about actuators and how to make its driver circuit. BJT based driver circuit for actuators where made and connected to Arduino board. Tested program with Python and actuators where working.

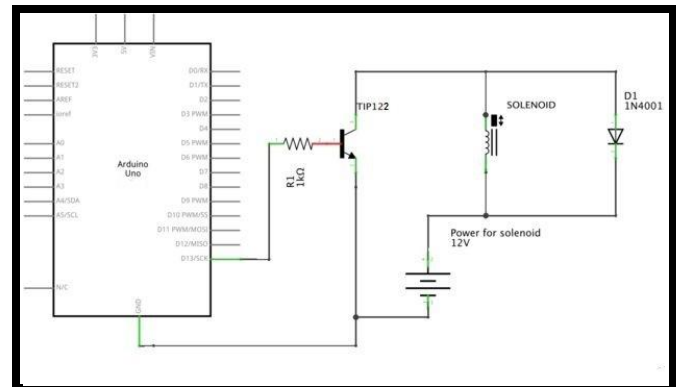


Fig 19. “Driver Circuit Diagram For Actuators”

IV. RESULTS & DISCUSSIONS

Integration of Object Sorting System Final Test & Troubleshooting

Tested the overall object sorting system programming in Python and sorted objects blue, white and red objects.



Fig 20. “Object Sorting System Overall Setup”

Proposed system has been tested for three colors blue, white and red objects & objects has been sorted to its corresponding bins.

V. CONCLUSION

The object sorting system will be capable of sorting objects based on colour and shape. Proposed work makes use of MATLAB software for image acquisition and Arduino microcontroller for the operation of conveyor belt and actuators.

Object sorting system based on the colour has been implemented in this project work. The work uses Python IDE along with Open CV library for Image . Arduino Uno has been used for controlling stepper motor & actuators. Algorithms have been tested and perform well for the 3 primary colours Red, Green and Blue. It has been decided to improve the system for shape detection along with colour detection.

REFERENCES

- [1] Shambhavi Vijay Chhaya, SachinKhera, Pradeep Kumar S, “ Basic Geometric Shape And Primary Colour Detection Using Image Processing On Matlab”, International Journal of Research in Engineering and Technology, Vol. 4, Issue 5, pp 505-509, May 2015
- [2] Prof. D. B. RaneGunjalSagarNikamDevendra, Shaikh Jameer U. “Automation of Object Sorting Using an Industrial Roboarm and MATLAB Based Image Processing” Department of Electronic Engineering, P.R.E.C. Loni, SavitribaiPhule Pune University, India. Volume 5, Issue 2, February 2015
- [3] Abhishek Kondhare,1 Garima Singh2, Neha Hiralkar3 ,M.S.Vanjale. “ColourAnd Shape Based Object Sorting”. International Journal Of Scientific Research And Education. Volume 2, Issue 3, Pages 553-562, 2014
- [4] J. D. Gavade, P. K. Kharat, S. K. Laga. “Cost Effective Approach for Object Sorting”. International Journal of Computer Application. Volume 52– No.16, August 2012
- [5] Vishnu R. Kale, V. A. Kulkarni. “Object Sorting System Using Robotic Arm”. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering. Vol. 2, Issue 7, July 2013
- [6] Dhanoj M, Reshma K V, SheebaV, Marymol P. “Colour Sensor Based Object Sorting Robot Using Embedded System”. International Journal of Advanced Research in

Computer and Communication Engineering. Vol. 4, Issue 4, April 2015

- [7] Panth Shah, Tithi Vyas. “Interfacing of MATLAB with Arduino for Object Detection Algorithm Implementation using Serial Communication”.
- [8] <http://opencv.org/about.html>
- [9] http://www.piclist.com/images/www/hobby_elec/e_step1.htm