REAL TIME WATER QUALITY AND E-COLI MONITORING SYSTEM

CERTIFICATE

This is to certify that the project entitled

"REAL TIME WATER QUALITY AND E-COLI MONITORING SYSTEM"

Is a Bonafide work done by:

BLAISE NAZARETH

and

SUNANDA SAHANI

of M.Sc. part II, Department of Electronics, 2019-2020

The candidates themselves have worked on the project during the period of study under my guidance and to the best of my knowledge it has not previously formed the basis of award of any previous degree or Diploma at Goa University or elsewhere.

_____	_____	_____
H.O.D (Electronics)	Examiner	Project Guide

Acknowledgement

Many hours of hard work and sincere efforts of our team have gone into the success of this project. All this would have not been possible without the timely assistance and guidance of some very important people.

First and foremost we would like to thank God for giving us the strength, courage and determination to complete our project.

Secondly our sincere gratitude goes to our H.O.D Dr. Rajendra Gad, our lecturer's Dr. Gourish Naik , Dr. Jivan Parab and Dr. Narayan Vetrekar for their constant encouragement and guidance from the start till the end of our project.

Also, a word of appreciation to our lab technician Sir Vishant Malik and office in charge Sir William and our dear classmates for their much-needed help and support whenever required.

Lastly, a big thank you to our parents for their support, blessings and financial help.

We owe the success of our entire project to all people mentioned above.

DECLARATION

We solemnly declare that this project has been composed by us and to the best of our best knowledge has not formed the basis for the award of any degree or Diploma.

M.Sc. Electronics

2019-2020

Miss. Blaise Nazareth _____

Miss. Sunanda Sahani _____

"REAL TIME WATER QUALITY AND ECOLI MONITORING SYSTEM"

Blaise Nazareth and Sunanda Sahani
Dept. of Electronics
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Abstract— **Water quality plays an important role in the wellbeing of humans which includes consumption of clean water. A system for sampling water, displaying the water quality parameters such as pH and turbidity and checking the presence of bacteria such as E. coli in water sample is developed in this project. This is detected by the colour change due to the reagent which is X-Gal which is mixed with the sampled water which either displays blue or white colonies. Depending on the colour change it helps us to identify whether the bacteria is present in the sampled water or not. A Raspberry Pi board which acts as the main processor is used to which motor drivers like L293D are interfaced to control self-priming DC water pumps. pH and turbidity sensors are also interfaced to the raspberry pi which display the parameters that describe the quality of the water. When the system is turned On, the motors perform their tasks of sampling water , mixing the reagent and later after certain time images are captured of the colour change detected with the help of pi camera interfaced to the raspberry pi during the test carried out which display a message saying whether the water is infected or not and the message is also be made available to the user. All the results are sent to real time database from where android application fetches the data and displays it. A Chromogenic enzyme substrate test is used for testing the presence of harmful bacteria present in water which is rather labour intensive and have to be done repetitively. In a factory setting, the number of diagnosis samples may be large and handling daily portions is likely to be labour intensive. Here, our system can be put into work giving a accurate result.**

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CHAPTER 1

INTRODUCTION

1.1 Water: An important source

Water plays an irreplaceable part in food of life and it may be a key column of wellbeing determinant, since 80% of maladies in creating nations are due to need of great quality water. Destitute water quality proceeds to posture a major risk to human wellbeing. Diarrhoeal illness alone sums to an assessed 4.1 % of the full Disability-Adjusted Life A long time (DALY) worldwide burden of malady and is dependable for the passing's of 1.8 million individuals each year .

Subsequently, water borne illnesses such as cholera and typhoid regularly have their episode particularly amid dry season. Tall predominance of loose bowels among children and children can be due to the utilization of hazardous water and unhygienic hone. Hence, numerous irresistible infections are transmitted by water through faecal verbal defilement.

Diseases due to drinking of contaminated water leads to the death of five million children annually and make 1/6 of the world population sick . Water which is treated by different Municipal bodies, meets all drinking water quality standards at treatment plant and at the point where the water enters the distribution system. Water quality falls apart in dissemination systems and amid collection, capacity so it gets to be required to screen water quality at each organize. Separated from all observing and reconnaissance, drinking water at tap may not be consumable. By the time water comes to the buyer, its quality could be exceptionally diverse from what it was when it cleared out the plant The management of distribution systems has become one of the most difficult challenges to providing safe drinking water as pipes are buried and not subject to the direct control of water utilities.

Microbial defilement in dispersion frameworks could be a potential danger to open wellbeing. Pathways for the passage of contaminants into dissemination frameworks incorporate: living beings that survive the treatment handle; sullied ground-water that streams in from exterior when weight in a pipe drops; defilement amid the establishment or repair of water mains; and backflow from non-potable frameworks associated to consumable water framework.

Whereas the chemical contamination can occur in the distribution system as a result of corrosion reactions, the accumulation of contaminated sediments, and the intrusion of chemical compounds into the pipes. Intentional contamination is also a potential threat.

The water through the treatment plant is supplied to the consumer through Continuous water supply system or Intermittent water supply. The water passes through sump tanks and overhead tanks before reaching the consumer tap. In some cases due to irregular or insufficient supply of water, additional storage of water is done in loft tanks in individual household. Cleaning of these tanks is often neglected. Since the tanks are not regularly or properly cleaned, there is an accumulation of organic matter in the tanks due to which the different microorganisms grow in water which leads to spread of various diseases.

The water quality doesn’t change much in other chemical and physical characteristics, but there may be variance in the microbial quality of water coming out of distribution system and finally that of consumer tap. The objective of the study is to assess the bacterial quality of water which actually reached the people through their taps.

1.2 Water Pollution

Water pollution is the contamination of water bodies, usually as a result of human activities. Water bodies include for example lakes, rivers, oceans, aquifers and groundwater. Water pollution results when contaminants are introduced into the natural environment. For case, discharging insufficiently treated wastewater into characteristic water bodies can lead to corruption of oceanic environments. In turn, this may lead to open wellbeing issues for individuals living downstream. They may utilize the same contaminated waterway water for drinking or washing or water system. Water contamination is the driving around the world cause of passing and infection, e.g. due to water-borne diseases.

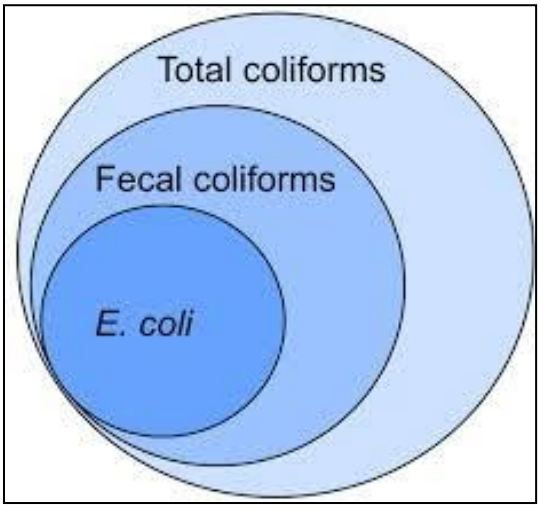
Water contamination can be classified as surface water or groundwater contamination. Marine contamination and supplement contamination are subsets of water contamination. Sources of water contamination are either point sources or non-point sources. Point sources have one identifiable cause of the contamination, such as a storm deplete or a wastewater treatment plant. Non-point sources are more diffuse, such as agricultural runoff. Pollution is the result of the cumulative effect over time. All plants and organisms living in or being exposed to polluted water bodies can be impacted. The effects can damage individual species and impact the natural biological communities they are part of.

The causes of water pollution include a wide range of chemicals and pathogens as well as physical parameters. Contaminants may include organic and inorganic substances. Elevated temperatures can also lead to polluted water.

A common cause of warm contamination is the utilize of water as a coolant by control plants and mechanical producers. Lifted water temperatures diminish oxygen levels, which can slaughter angle and change nourishment chain composition, diminish species biodiversity, and cultivate intrusion by modern thermophilic species.

1.3 Coliforms

Coliforms are a bunch of oxidase-negative microbes that deliver corrosive from lactose or express β-galactosidase, and frame yellow colonies of differing shapes and sizes on film channels . They can be found within the oceanic situations and in soil and vegetation as well as within the digestion tracts of warm-blooded creatures . Discovery of coliforms in water or nourishment tests is imperative as they serve as a great marker for measuring the nearness of other fecal root pathogenic microbes such as Salmonella spp. or Listeria spp . Escherichia coli (E. coli) could be a agent species among coliform microscopic organisms bunches. Properties such as quick developing time, moo natural risks at tall concentrations after culture (whereas certain strains of E. coli can be pathogenic by and large they are not), and well-studied physiological characteristics make E. coli a great marker microscopic organisms for coliform detection.



1.4 Escherichia coli

The Escherichia coli are microscopic organisms that are commonly found within the human and creature stomach related tract (Standridge, 2008). Most of them live in a advantageous relationship with the people or creatures and are portion of the basic microflora inside the system. They are among the foremost studies microorganisms on soil, their revelation dating back within the 1980s (Law, 2000). This paper talks about the history of E. coli with specific thought being agreed to E. coli O157: H7, a pathogenic strain of the E. coli microscopic organisms. The the study of disease transmission of the microbes is additionally examined as well as its malady causation in people, avoidance, and control.

History of E. coli

The Escherichia coli is a group of Gram-negative bacteria that are facultative anaerobes that were first isolated and described by Theodor, a German bacteriologist, Escherich in 1985 (Law, 2000). Initially, the E. coli were referred to as Bacterium coli but their name changed to E. coli in honor of the discoverer, Dr. Escherich. It was Dr. Escherich who also associated some infant diarrhea as well as child gastroenteritis to the colonization of the digestive system by E. coli (Law, 2000). Most of the strains of E. coli are harmless and form part of the normal microflora in the digestive systems of humans and animals.

With time, in any case, a few E. coli strains turned out to be infection causing microorganisms whose pathogenicity was obtained through destructiveness components (Taylor et al., 2013). Harmfulness variables upgrading infection causation in people were credited to plasmids, transposons, pathogenicity islands and bacteriophages. Afterward on, E. coli were classified into different strains by their instruments of pathogenicity, destructiveness variables or clinical indications.

Such classifications were recognized as serogroups (Wileman et al., 2011). Ever since E. coli have become some of the most studied bacterial microorganisms with more than 700 serogroups being isolated. Various serotypes of E. coli have been distinguished through the identification of the O and H antigens present in the bacteria as well as the presence or absence of flagella (Law, 2000).

In most cases, the transmission of E. coli O157: H7 is connected to nourishments of the bovine root, particularly considering the truth that most of the primary cases of diseases related to enterohemorrhagic E. coli (EHEC) were related to utilization of meat items (Wileman et al., 2011). Other nourishment sources have too been cited as vital within the transmission chain, a few of which incorporate apple juices and cider, drain, cheese, yogurt, lettuce, tomatoes, soybeans, natural products and vegetables among other nourishment items.

Apparently, any food crop that is grown in proximity to herds of cattle acts as a possible contaminant and can transmit the pathogen to humans (Espina, Somolinos, Pagán, & García-Gonzalo, 2010). Transmission may also be through consumption of contaminated water in lakes, ponds, and other reservoirs, eliciting gross outbreaks of E. coli O157: H7 related diseases. Transmission of such diseases may also occur through the fecal-oral route from person to person, especially amongst children in day care facilities (Taylor et al., 2013).

Disease in Humans

Expansive locales of North America, Europe, and Japan have experienced a awesome challenge in handling contaminations caused by E. coli, particularly those caused by pathogenic strains such as O157: H7. In spite of the truth that the illnesses caused in people by such strains of E. coli are less in number compared to illnesses caused by other enteric pathogens such as the Salmonella and Campylobacter spp., more hospitalizations are detailed with cases of E. coli O157: H7 contaminations.

Moreover, more fatalities are associated with pathogenic E. coli infections as compared to the fatalities caused by other enteric bacterial infections (Taylor et al., 2013). Human infections with E. coli present in the form of asymptomatic cases to more serious cases that may lead to detrimental effects.

In most cases, the pathogenic E. coli diseases start with free loose bowels without blood and now and then resolve without restorative consideration whereas others conclusion up in genuine complications (Wileman et al., 2011). Within the genuine complications of the infections, the understanding closes up with wicked loose bowels or hemorrhagic colitis, frequencies which will result in around one to three days taking after disease. In more genuine cases, almost five to ten percent of the detailed cases advance to life-threatening sequelae, Hemolytic Uremic Disorder or in a few cases endure from thrombocytopenic purpura (TPP) (Espina et al., 2010). In reality, the commonest case of HUS within the Joined together States is E. coli O157: H7 whereas both children and individuals with progressed ages stand a better chance of enduring from serious side effects such as HUS.

Prevention and Control

In the event that the infection conditions caused by diseases with pathogenic E. coli don't create complications, they may resolve on their claim inside a period of almost ten days (Wileman et al., 2011). Anti-microbials that were at first utilized are as of now contraindicated due to the potential of expanding resistance, irritated kidney complications, and an modification of the course of the illness (Law, 2000). The patients that inevitably create HUS are prompted to experience a kidney dialysis or consider a blood transfusion.

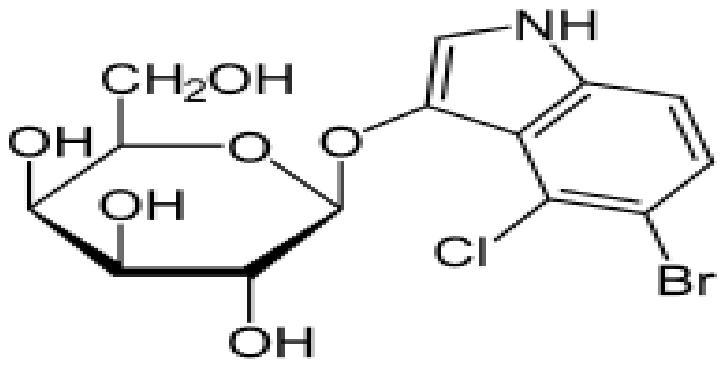
Effective treatment of such diseases can be achieved through a timely diagnosis of the infection, especially when a bloody diarrhea is noticed which most of the time precedes HUS.

In preventing the incidence of E. coli infections such as those caused by E. coli O157: H7, it is advisable to maintain good hygiene and sanitation within the social surroundings. Washing of fruits and vegetables before consumption also prevents the incidence while properly cooking meat is advisable, if possible cooking it at temperatures above 70oC.

Legitimate and sterile butchering strategies ought to be practiced to anticipate fecal defilement (Wileman et al., 2011). Since the microbes living in have cattle does not cause diseases to the cattle, it isn't fitting to inoculate the cattle.

After all, the cattle will never evoke any safe reaction in the event that no malady is caused by the microscopic organisms. Once more, all patients with bloody loose bowels got to be tried for Enterohemorrhagic E. coli for early conclusion and treatment of human illnesses (Espina et al., 2010).

1.5 X-Gal Reagent and Why it is used?



Purpose of using X-Gal

X-Gal reagent X-gal (also called as BCIG for 5-bromo-4-chloro-3-indolyl-β-D-galactopyranoside) is an natural compound comprising of galactose connected to a substituted indole is used in our system for the dection of bacteria present by forming blue and white screening of bacterial colonies, that allows for the rapid and convenient detection of recombinant bacteria. Such that, the blue colonies shows the presence of bacteria and the white colonies produced does not contain bacteria as it cannot metabolize X-Gal to produce the blue color. This method is usually performed using a suitable bacterial strain of our interest. Accordingly we are able to classify whether the bacteria is present or not in the given sample of water.

X-gal (moreover shortened BCIG for 5-bromo-4-chloro-3-indolyl-β-D-galactopyranoside) is an natural compound comprising of galactose connected to a substituted indole. The compound was synthesized by Jerome Horwitz and collaborators in Detroit, MI, in 1964.

The formal chemical title is regularly abbreviated to less precise but moreover less lumbering expressions such as bromochloroindoxyl galactoside. The X from indoxyl may be the source of the X within the X-gal compression. X-gal is regularly utilized in atomic science to test for the nearness of an enzyme, β-galactosidase. It is additionally utilized to distinguish action of this chemical in histochemistry and bacteriology.

X-gal is one of numerous indoxyl glycosides and esters that surrender insoluble blue compounds comparative to indigo color as a result of enzyme-catalyzed hydrolysis.

X-Gal is a mainstay in molecular biology cloning applications in which it is used to detect the activity of β-galactosidase. X-Gal is used to detect the insertion of foreign DNA into the lacZ region of a plasmid DNA. Insertion of DNA into the lacZ region results in the loss of β-galactosidase activity.

Bacteria cells that retain active β-galactosidase will result in characteristic blue colonies. Successful disruption of the *lacZα* gene disrupts the α-complementation of the β-galactosidase gene and the precipitate does not form, resulting in white colonies.

Many other applications also use X-Gal as a substrate to detect β-galactosidase activity. These include β-galactosidase -antibody linked immunoassays and immunohistochemistry, coliphage detection based on β-galactosidase induction and the detection of micrometastasis formation during tumor progession.

X-gal is commonly used in conjunction with IPTG (GoldBio #I2481) for blue-white screening.

1.6 Project Goals

Waterborne illnesses are caused by drinking contaminated or dirty water having a part of microscopic organisms present in them, causing numerous sorts of illnesses. Contaminated water can cause numerous sorts of diarrhoeal illnesses, counting Cholera, and other genuine sicknesses such as Guinea worm malady, Typhoid, and Diarrhoea. In this extend we expected to construct a module where within the water quality parameters and the nearness of E.Coli microscopic organisms is observed.

Objective

1. To create a module which monitors the water quality and Ecoli present in the water with sensors such as ph and turbidity sensors interfaced to it which will display the water quality parameters. Self priming DC motors are also interfaced to the raspberry pi which performs the different tasks of sampling and purging the water out after the test is carried out. Based on the color change it will decide whether the water in infected or not. We call it “Real time water quality and Ecoli monitoring System”.
2. To create an android app so that the user can be notified whether the water is infected or not.

CHAPTER 2

LITERATURE SURVEY

Literature Survey

Sensor Node for Remote Monitoring of Waterborne Disease-Causing Bacteria

Sensors (Basel). 2015 May; 15(5): 10569–10579.

PMCID: PMC4482013
PMID: 25951340

Kyukwang Kim and Hyun Myung

Abstract:-A sensor node for sampling water and checking for the presence of harmful bacteria such as *E. coli* in water sources was developed in this research. A chromogenic enzyme substrate assay method was used to easily detect coliform bacteria by monitoring the color change of the sampled water mixed with a reagent. Live webcam image streaming to the web browser of the end user with a Wi-Fi connected sensor node shows the water color changes in real time. The liquid can be manipulated -on the web-based user interface, and also can be observed by webcam feeds. Image streaming and web console servers run on an embedded processor with an expansion board. The UART channel of the expansion board is connected to an external Arduino board and a motor driver to control self-priming water pumps to sample the water, mix the reagent, and remove the water sample after the test is completed. The sensor node can repeat water testing until the test reagent is depleted. The authors anticipate that the use of the sensor node developed in this research can decrease the cost and required labor for testing samples in a factory environment and checking the water quality of local water sources in developing countries.

Concentration Detection of the E. coli Bacteria in Drinking Water Treatment Plants through an E-Nose and a Volatiles Extraction System (VES)

A section of ***Water*** (ISSN 2073-4441).

Jeni_er Carrillo-Gómez 1,*, Cristhian Durán-Acevedo 2 and Ramón García-Rico 3

Abstract: Water quality control remains an important topic of public health since some diseases, such as diarrhoea, hepatitis, and cholera, are caused by its consumption. The microbiological quality of drinking water relies mainly on monitoring of Escherichia coli, a bacteria indicator which serves as an early sentinel of potential health hazards for the population. In this study, an electronic nose coupled to a volatile extraction system (was evaluated for the detection of the emitted compounds by E. coli in water samples where its capacity for the quantification of the bacteria was demonstrated). To achieve this purpose, the multisensory system was subjected to control samples for training. Later, it was tested with samples from drinking water treatment plants in two locations of Colombia. For the discrimination and classification of the water samples, the principal component analysis method was implemented obtaining a discrimination variance of 98.03% of the measurements to di_erent concentrations. For the validation of the methodology, the membrane filtration technique was used. In addition, two classification methods were applied to the dataset where a success rate of 90% of classification was obtained using the discriminant function analysis and having a probabilistic neural network coupled to the cross-validation technique (leave-one-out) where a classification rate of 80% was obtained. The application of this methodology achieved an excellent classification of the samples, discriminating the free samples of E. coli from those that contained the bacteria. In the same way, it was observed that the system could correctly estimate the concentration of this bacteria in the samples. The proposed method in this study has a high potential to be applied in the determination of E. coli in drinking water since, in addition for estimating concentration ranges and having the necessary sensitivity, it significantly reduces the time of analysis compared to traditional methods.

Low-cost Turbidity Sensor for Low-power Wireless Monitoring of Fresh-Water Courses

Published in: IEEE Sensors Journal (Volume: 18 , Issue: 11 , June1, 1 2018)
INSPEC Accession Number: 17752432

Youchao Wang, S M Shariar Morshed Rajib, Chris Collins and Bruce Grieve

Abstract—This Paper reports on a low-cost turbidity sensor design for continuous on-line water quality monitoring applications. The measurement of turbidity by agricultural and environmental scientists is restricted by the current cost and functionality of available commercial instruments. Although there are a number of low-cost turbidity sensors exploited within domestic 'white-goods', such as dishwashers, the lack of sensitivity and power-usage of these devices make them unsuitable for fresh-water quality monitoring purposes. The recent introduction of wireless protocols and hardware, associated with the 'Internet-of-Things' concept for machine-to-machine autonomous sensing and control, has enabled the large-scale networked intelligent water turbidity monitoring system that implements relatively low-cost sensors to be developed. The proposed sensor uses both transmitted light and orthogonal (90 degrees) scattered light detection principles, and is 2-3 orders of magnitude lower in cost as compared to the existing commercial turbidity sensors. With an 850nm infrared LED, and dual orthogonal photodetectors, the proposed design is capable of measuring turbidity within the range of 0-1000 Nephelometric Turbidity Unit (NTU) with improved accuracy and robustness as compared to the existing low cost turbidity sensors. The combination of orthogonal and transmitted light detection unit provide both 0-200 NTU high resolution and accuracy sensing and 0-1000 NTU lower resolution and accuracy sensing capability. Results from calibration experiment are presented, which proved that the proposed sensor design produced a comparable turbidity reading as a commercial turbidity sensor.

Research on the Water Quality Monitoring System for Inland Lakes based on Remote Sensing.

2011 3rd International Conference on Environmental Science and Information Application Technology ESIAT 2011

ZhengZhou

Abstract:-At present, the problem of water resources and environment especially on inland lakes has attracted increasingly attention of researchers. Remote Sensing technology have been widely used to monitor the water resources and environment with high-frequency, large-scale, multi-spectral characteristics. This paper presented a vision of the Water Quality Monitoring System for Inland Lakes (WQMSIL). The WQMSIL aims to reflect the trend of inland lakes environment quality by making full use of advantages of remote sensing data, combined with ground-based observation data. The WQMSIL provided a variety of information to reflect the problems of water quality of inland lakes and to make it convenient for the experts to make a further decision-making and the public to participation. In the paper, the design of the WQMSIL is presented including system requirements, system framework, system structure and system features. The WQMSIL will be tested contains three significant components. The improvement of the system in the future is also presented in the paper.

ASSESSMENT OF WATER QUALITY

International Journal of Scientific and Engineering Research , volume 5 , issue12 , December-2014

ISSN 2229-5518

Pooja. D. Somani1, Siddharath Ray2, Sanjay Singh3

Abstract: Potable water when passes through the distribution system deteriorates in its microbial quality. Further the quality of water deteriorates as it is stored in sump tanks, overhead tanks and loft tanks. Since the tanks are not regularly cleaned the quality of water is affected as it reaches the end user. Due to irregular and improper cleaning of the tanks there is an accumulation of organic matter in the tanks due to which the different microorganisms grow in water which leads to spread of various diseases. In this study different sampling sites from Navi Mumbai have been selected which are tested for free residual chlorine and microbial contamination. Study indicates that there is successive increase in the microbial contamination as water passes from sump tank to overhead tank. Maximum contamination is observed in case of water stored in loft tanks. Disinfection of tank can prove to be one of the measures to check the increase in MPN values in water.

The Detection Method of Escherichia coli in Water Resources:

Journal of Physics: Conference Series, Volume 995, International Seminar on Mathematics and Physics in Sciences and Technology 2017

M. R. Nurliyana1,2, M.Z. Sahdan1,2, K.M. Wibowo1,2, A. Muslihati1, H. Saim1, S.A. Ahmad3, Y. Sari4 and Z. Mansor4

Abstract:-This article reviews several approaches for Escherichia coli (E. coli) bacteria detection from conventional methods, emerging method and goes to biosensor-based techniques. Detection and enumeration of E. coli bacteria usually required long duration of time in obtaining the result since laboratory-based approach is normally used in its assessment. It requires 24 hours to 72 hours after sampling to process the culturing samples before results are available. Although faster technique for detecting E. coli in water such as Polymerase Chain Reaction (PCR) and Enzyme-Linked Immunosorbent Assay (ELISA) have been developed, it still required transporting the samples from water resources to the laboratory, high-cost, complicated equipment usage, complex procedures, as well as the requirement of skilled specialist to cope with the complexity which limit their wide spread practice in water quality detection. Recently, development of biosensor device that is easy to perform, portable, highly sensitive and selective becomes indispensable in detecting extremely lower consolidation of pathogenic E. coli bacteria in water samples.

Specific Color Detection in Images using RGB Modelling in MATLAB

International Journal of Computer Applications (0975 – 8887) Volume 161 – No 8, March 2017

Vishesh Goel , Sahil Singhal , Tarun Jain

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Silica Kole Asst. Professor Department of Computer Science and Engineering, Bharati Vidyapeeth's College of Engineering, Paschim Vihar, New Delhi.

Abstract:- This paper gives an approach to recognize colors in a twodimensional image using color thresh-holding technique in MATLAB with the help of RGB color model to detect a selected color by a user in an image. The methods involved for the detection of color in images are conversion of three dimensional RGB image into gray scale image and then subtracting the two images to get two dimensional black and white image, using median filter to filter out noisy pixels, using connected components labeling to detect connected regions in binary digital images and use of bounding box and its properties for calculating the metrics of each labeled region. Further the color of the pixels is recognized by analyzing the RGB values for each pixel present in the image. The algorithm is implemented using image processing toolbox in MATLAB. The results of this implementation can be used in security applications like spy robots, object tracking, segregation of objects based on their colors, intrusion detection.

DIFFERENT COLOR DETECTION IN AN RGB IMAGE

International Journal of Development Research

ISSN:2230-9926

***Arshi Prabhakar, Neeti and Rakhi Devi**

Abstract:- This paper presents the methodology for extracting different colors from an RGB image. RGB image have different colors with different values of color contents for each pixel. As red, Green and blue are the fundamental colors for every color formation and these can be extracted by simply using MATLAB commands. But in real life applications like face detection or skin detection or some applications in floriculture, detection of different fruits of vegetables etc. other colors have to be detected. So this paper presents the dignified approach to extract the concerned color from an image.

Comparing the Performance of L*A*B* and HSV Color Spaces with Respect to Color Image Segmentation

International Journal of Emerging Technology and Advanced Engineering (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Issue 2, February 2015) 192

Dibya Jyoti Bora1 , Anil Kumar Gupta2 , Fayaz Ahmad Khan3 1 ,2,3Department of Computer Science & Applications, Barkatullah University, Bhopal, India

***Abstract*—** Color image segmentation is a very emerging topic for image processing research. Since it has the ability to present the result in a way that is much more close to the human eyes perceive, so today's more research is going on this area. Choosing a proper color space is a very important issue for color image segmentation process. Generally L*A*B* and HSV are the two frequently chosen color spaces. In this paper a comparative analysis is performed between these two color spaces with respect to color image segmentation. For measuring their performance, we consider the parameters: mse and psnr . It is found that HSV color space is performing better than L*A*B*.

Digital Image Processing Analysis using Matlab

American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN : 2320-0936 Volume-5, Issue-12, pp-143-147

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Abstarct:- The intelligent analysis of video data is currently in wide demand because a video is a major source of sensory data in our lives. Text is a prominent and direct source of information in video, while the recent surveys of text detection and recognition in imagery focus mainly on text extraction from scene images. Here, this paper presents a comprehensive survey of text detection, tracking, and recognition in video with three major contributions. First, a generic framework is proposed for video text extraction that uniformly describes detection, tracking, recognition, and their relations and interactions. Second, within this framework, a variety of methods, systems, and evaluation protocols of video text extraction are summarized, compared, and analyzed. Existing text tracking techniques, tracking-based detection and recognition techniques are specifically highlighted.

Third, related applications, prominent challenges, and future directions for video text extraction (especially from scene videos and web videos) are also thoroughly discussed. To this aim, a supervised DNN is trained to project the input samples into a discriminative feature space, in which the blur type can be easily classified. Then, for each blur type, the proposed GRNN estimates the blur parameters with very high accuracy. Experiments demonstrate the effectiveness of the proposed method in several tasks with better or competitive results compared with the state of the art on two standard image data sets.

CHAPTER 3

SYSTEM BLOCK DIAGRAM WITH DESCRIPTION

3.1 SYSTEM BLOCK DIAGRAM

Our system consists of three tubes and a water reservoir as shown in Fig 1 with tube one kept as the testing tube two having the reagent in it which is used for the chemical to reaction to happen. Tube three is used to hold the purged water out. The water reservoir is used to hold the sampled water which is used as a water sample for testing and then for cleaning purpose of the testing tube.

It consists of raspberry pi module which acts as the main processor of the full system. three self-priming dc motors performing different tasks are connected to L293D motor drivers which are then interfaced to the raspberry pi .Motor one samples the water from the water reservoir and pours it into tube one which is the testing tube.

Motor two fetches fixed amount of regent from the tube two and pours it into tube one. After certain time when the reaction has taken place and the colour change in the liquid present in tube one is detected, the pi camera which is interfaced to the raspberry pi clicks the images of the colour change and makes it available to the user through a mobile app.

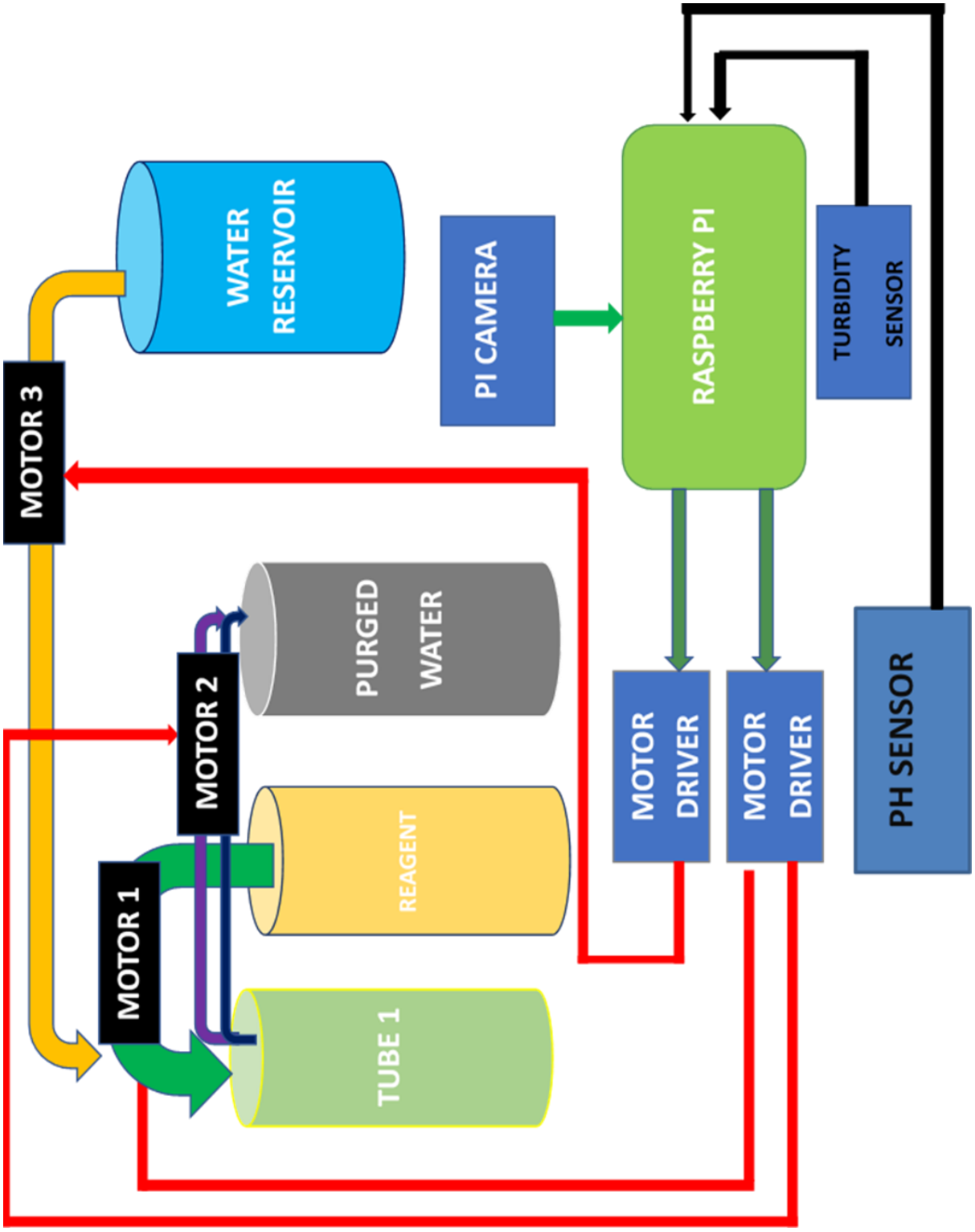


Figure1: Block Diagram

Motor 3 then purges the liquid into the purge tube that is tube 3. Again motor 1 samples the water from water reservoir into tube 1 this is for cleaning purpose and then motor 3 again purges the water out into the purge tube. pH and turbidity sensors are also interfaced to the system which displays the reading on the mobile app indicating whether the water is suitable for drinking or not.

3.2 SYSTEM LAYOUT

Figure 2 shown below is simplified layout of complete working project. This shows the sensors, motors, motor drivers and controller used to build the entire system circuit.

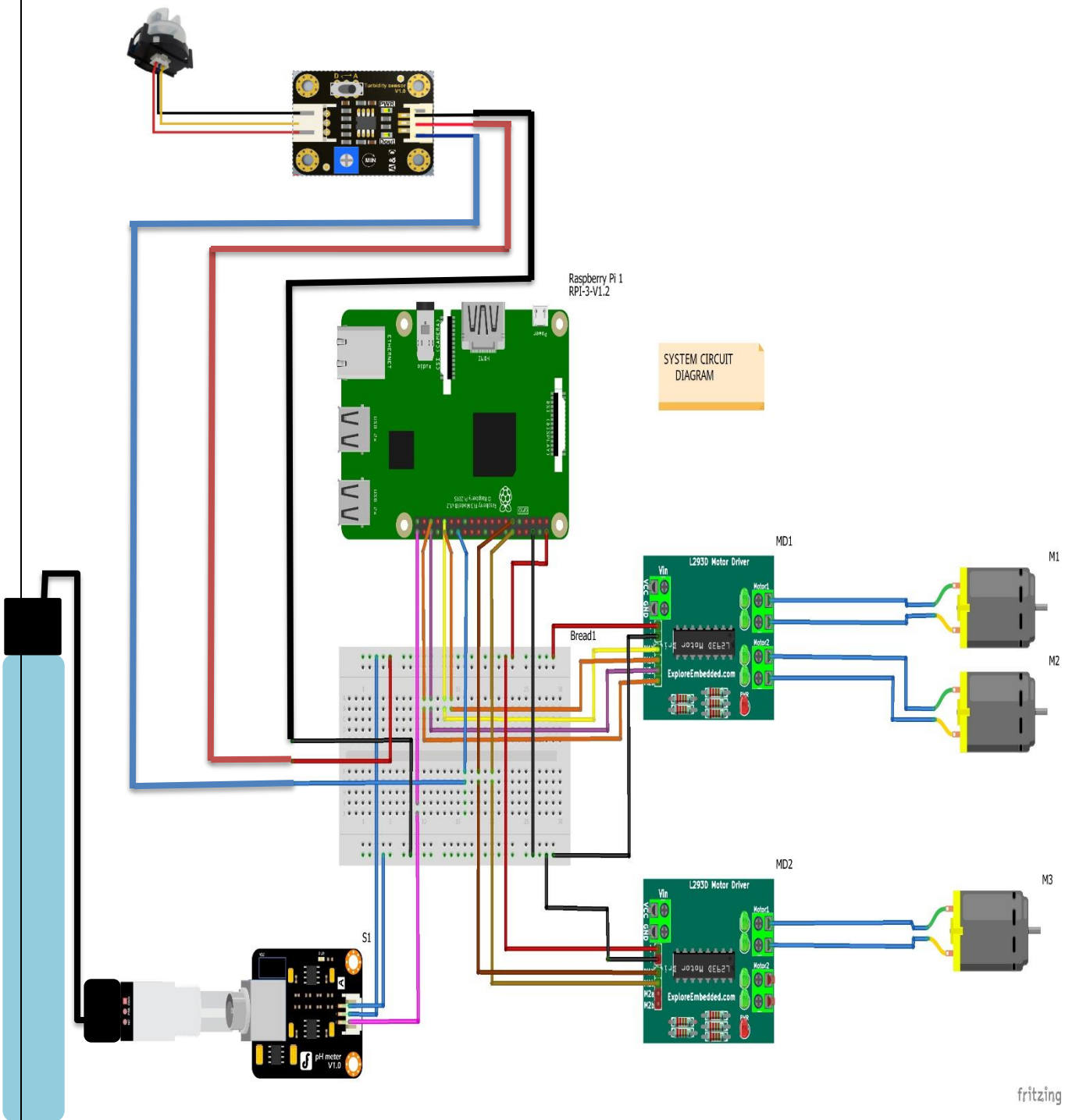


Figure 2. System Layout

3.3 SYSTEM CIRCUIT DIAGRAM WITH WORKING

Figure 3 below shows the detailed circuit diagram of the whole project, connection of power supply and Ground has been shown for the better understanding of system circuit connections. The diagram will give the brief idea on how the components used are connected to the main controller i.e. Raspberry pi 3 model B+.

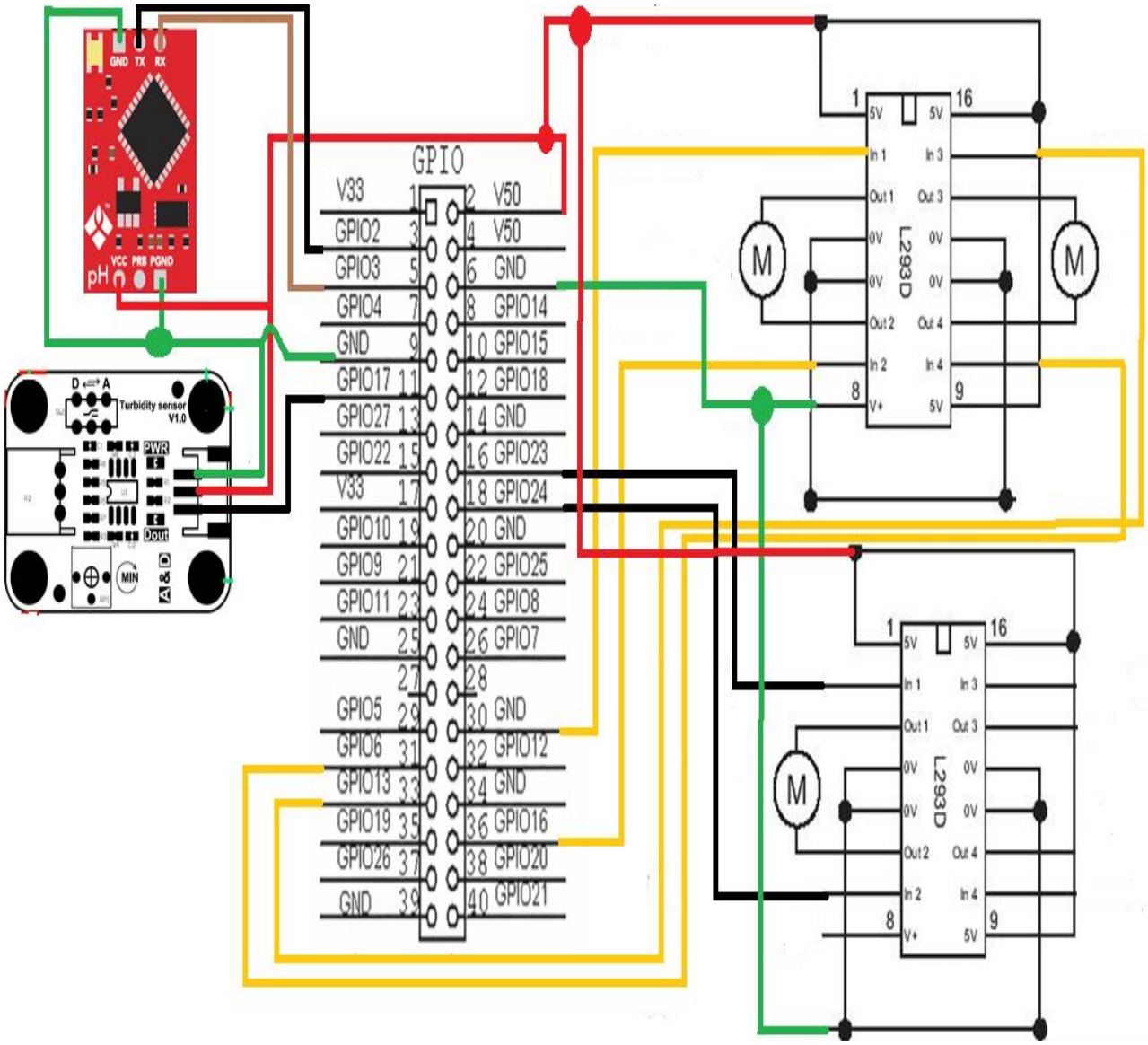


Figure 3. Circuit Diagram

Here self-priming motors are used to distribute water sample and reagent into required tubes/container. The motors will carry out the Biological reaction to perform the E-Coli checking. Here the presence or absence of bacteria is indicated according to Chromogenic Enzyme Assay technique wherein colour change takes place to indicate the final result.

Motor one is named as mixing motor, this acts as the reagent motor which transfers the required amount of reagent named X-GAL from the tube two which is reagent tube in tube one that is testing tube where sample water is collected prior.

The amount of reagent is controlled using Pulse width Modulation (PWM). As reagent is transferred into testing tube, reaction will take place, it takes minimum eight hours to reflect the result through colour change caused by the bacterial growth.

Raspberry Pi camera is then interfaced to Pi will capture the image of colour changed water, this is them processed in MATLAB. Here camera is placed exactly In front of testing tube so that it can capture image accurately the way needed.

Second motor here acts as the purging motor. Since for next round of testing the testing tube (tube one) should be clean, this motor purges out the tested water in tube 3 that is tested water collecting tube. Third motor is named as cleansing motor, this pours fresh clean water from tube 4 to deeply cleanse the testing tube so that no strain is remaining of previously tested water.

Doing this step allows to get accurate results of preceding tests as no strain of previous test will get mixed with new one.

Simultaneously to measure the amount of suspended particles in the water (Turbidity of water) a sensor named as turbidity sensor is interfaced with module. The result obtained is displayed in terms of voltage because here it is used in Analog mode. The value obtained in terms of voltage is then calculated in terms of NTU or FNU.

Turbidity sensors comes along with Analog to Digital converter, through this converter the output signal can be switched between Analog and Digital.

Under Analog mode the signal via Analog to digital converter goes to the Analog input pin on main controller that is Raspberry Pi. The turbidity is represented by the voltage of output pin here clear water with NTU less than 0.5 give us a voltage around 4.1 volts. The larger the turbidity is the smaller is the output voltage be, it ranges from 0 to 4.5 volts.

The values obtained from sensor is saved as database. The image is processed in MATLAB, where it tells whether the sampled tested water is infected by bacteria or not. The results from MATLAB image processing and turbidity sensor is sent to the user via server on user application or website with an alert message to notify the user about water quality update.

3.4 FLOWCHART

Complete working of Image processing part of project in the form of flowchart shown in figure as given below.

It states that after system is started it motors will starts Pouring reagent, Mixing it with water. Module gets connected to Internet either using Wi-fi or LAN this will help controller to create Real-time cloud database and the module gets access to Image processing network.

After the solution completes with changing of colour camera will click a picture and the module will get connected to image processing network i.e. the snapshot by camera will be taken by OpenCV-python / MATLAB. Our project uses filtering algorithm using OpenCV-python.

After filtering the colour, the result is taken by application. Foe next round of test refilling of reagent is required and whole process starts all over again.

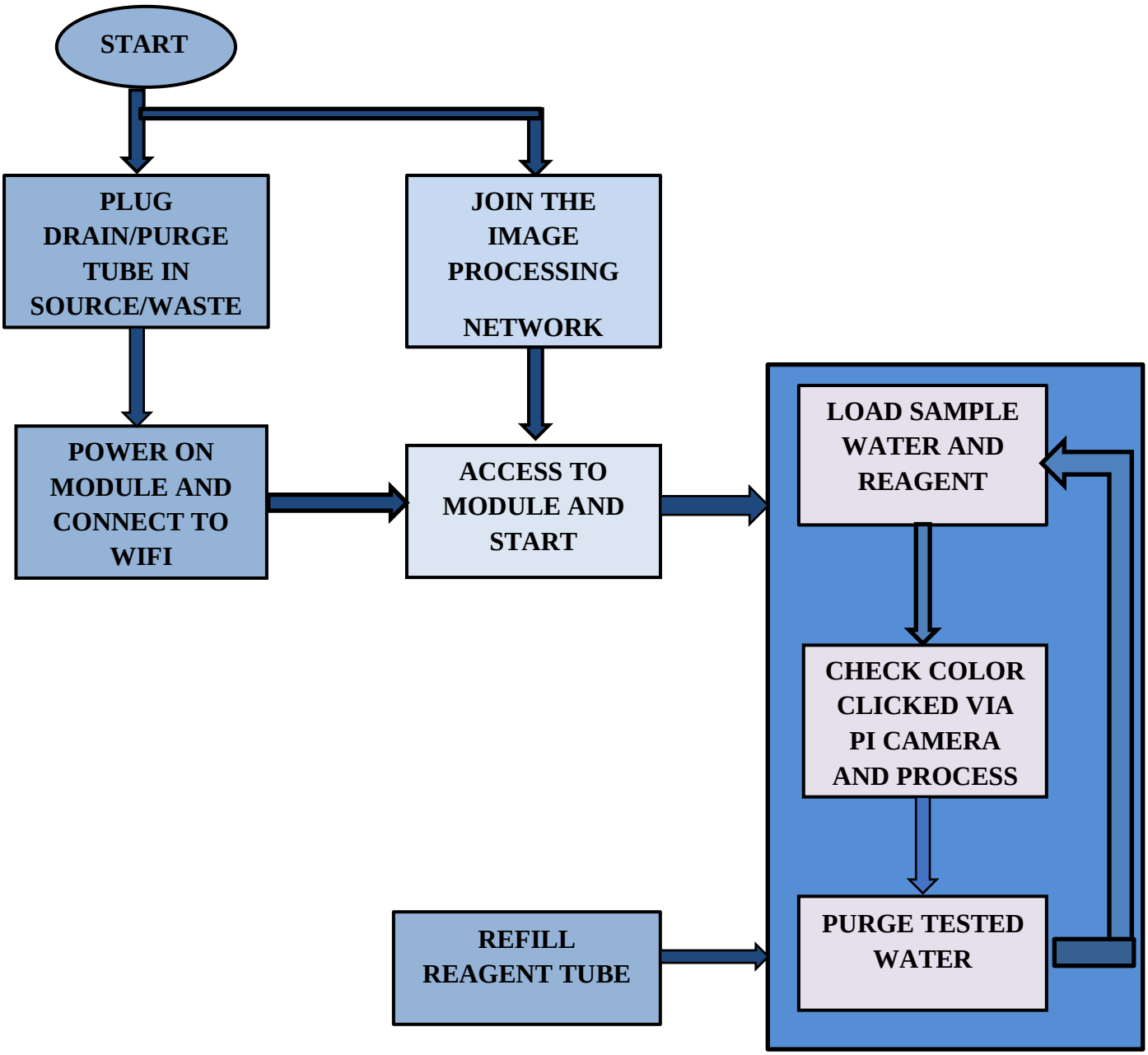


Figure 4: Flowchart

3.4 INTRODUCTION TO RASPBIAN OPERATING SYSTEM

Raspbian is a Debian-based (32 bit) computer operating system for Raspberry Pi. There are several versions of Raspbian including Raspbian Buster and Raspbian Stretch.

Since 2015 it has been officially provided by the Raspberry Pi Foundation as the primary operating system for the family of Raspberry Pi single-board computers.

Raspbian was created by Mike Thompson and Peter Green as an independent project. The initial build was completed in June 2012.

The operating system is still under active development. Raspbian is highly optimized for the Raspberry Pi line's low-performance ARM CPUs.

Raspbian uses PIXEL, Pi Improved X-Window Environment, Lightweight as its main desktop environment as of the latest update.

It is composed of a modified LXDE desktop environment and the Openbox stacking window manager with a new theme and few other changes.

The distribution is shipped with a copy of computer algebra program Mathematica and a version of Minecraft called Minecraft Pi as well as a lightweight version of Chromium as of the latest version.

Downloading and Writing the Raspbian Image to SD Card

1. Go to this page https://www.raspberrypi.org/downloads/noobs/
2. Download the NOOBS zip file
3. Download and install SD Formatter tool from https://www.sdcard.org/downloads/formatter_4/
4. Put SD card into your PC
5. Open SD Formatter

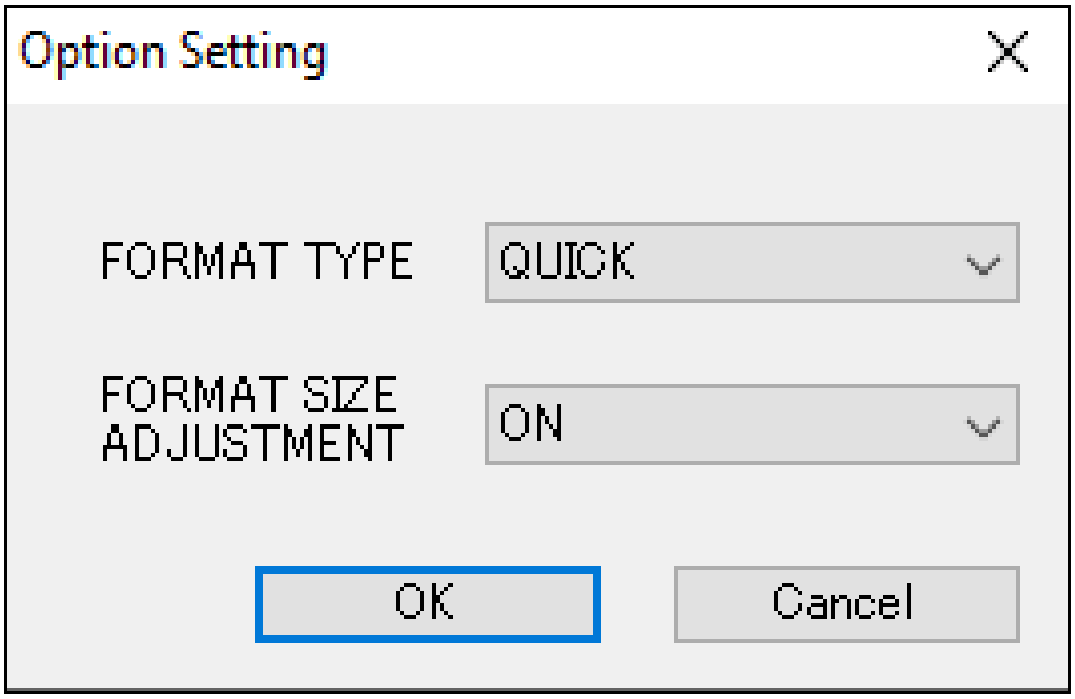


Figure 5: SD Formatter V4.0 Tab

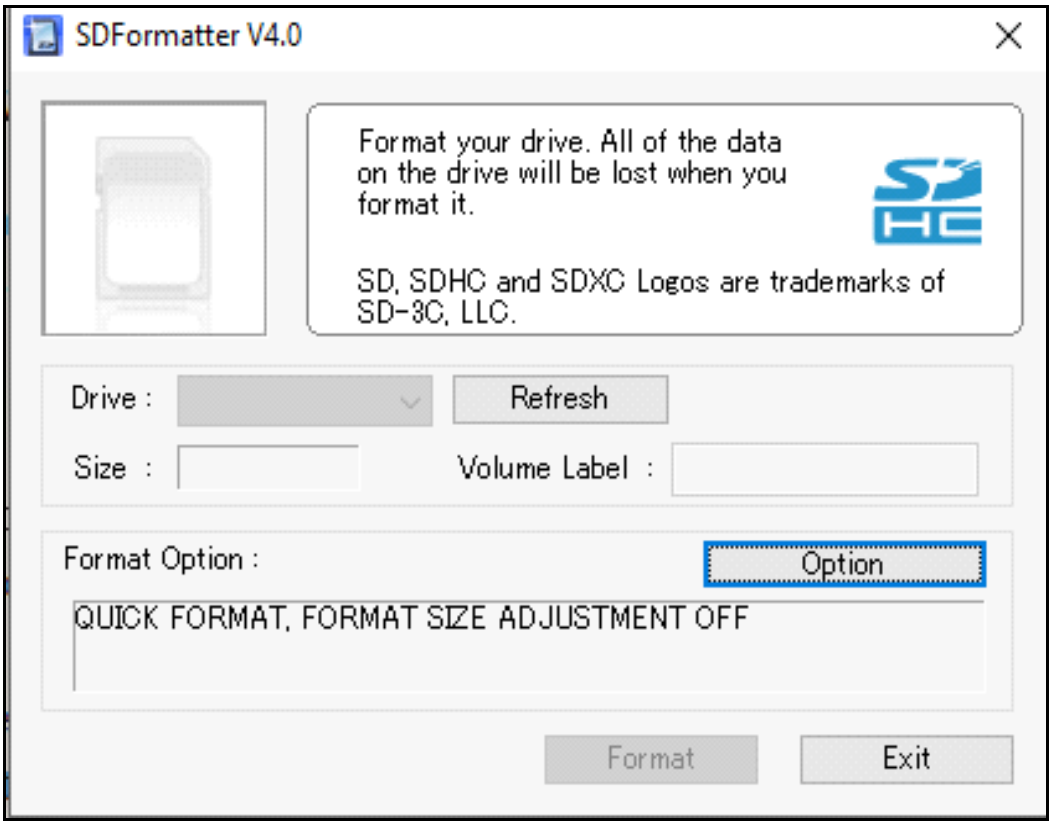


Figure 6: Format Size adjustment Tab

6. Click on options and set "FORMAT SIZE ADJUSTMENT" option to "ON"

7. Select your SD Card and click on Format. Be sure to make your file a .img, otherwise, your Pi will not read it.

8. Then extract the files from the zip file you just downloaded and copy them to your SD Card. Congratulations you have successful setup your SD card for Raspberry Pi.

3.5 HARDWARE COMPONENTS AND ITS WORKING

1)RASPBERRY PI 3 B+

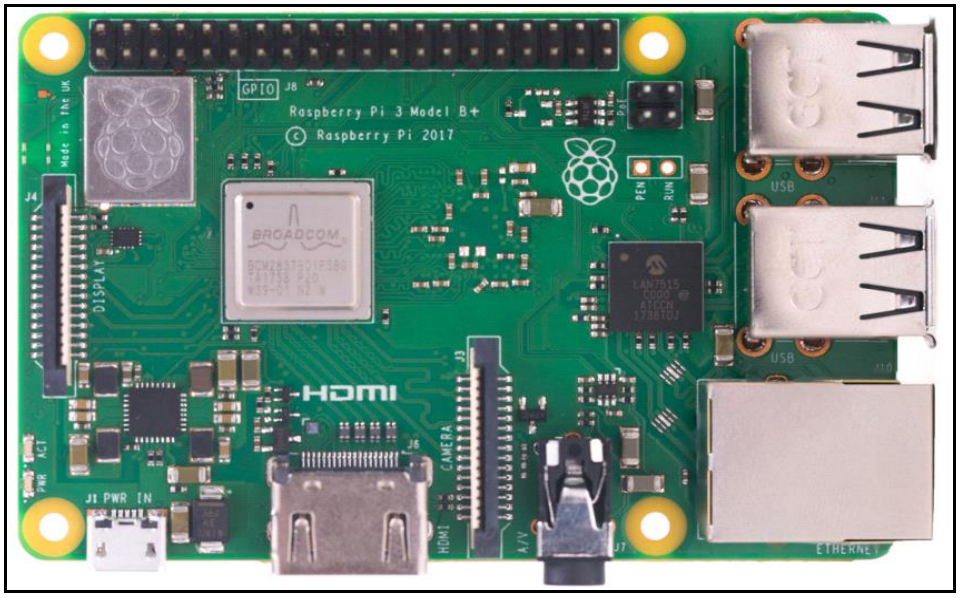


Figure7: Raspberry Pi 3+ Module

RPi is used as the main controller which processes and controls the whole system.

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 spread sheets, word-processing, and playing games.

The system is built using raspberry pi 3b+ model, which works on 1.4GHz 64-bit quad-core processor, dual-band wireless LAN, Bluetooth 4.2/BLE, faster Ethernet, and Power-over-Ethernet support.

It can be operated using many operating systems.

The Raspberry Pi Foundation provides Raspbian, a Debian-based (32-bit) Linux distribution for download, as well as third-party Ubuntu, Windows 10 IoT Core, RISC OS, and specialised media centre distributions.

It promotes Python and Scratch as the main programming languages, with support for many other languages. The default firmware is closed source, while an unofficial open source is available.

Many other operating systems can also run on the Raspberry Pi. Third-party operating systems available via the official website include Ubuntu MATE, Windows 10 IoT Core,

RISC OS and specialised distributions for the Kodi media centre and classroom management.

The formally verified microkernel seL4 is also supported.

Various operating systems for the Raspberry Pi can be installed on a MicroSD, MiniSD or SD card, depending on the board and available adapter

2) SENSORS:

a) TURBIDITY SENSOR

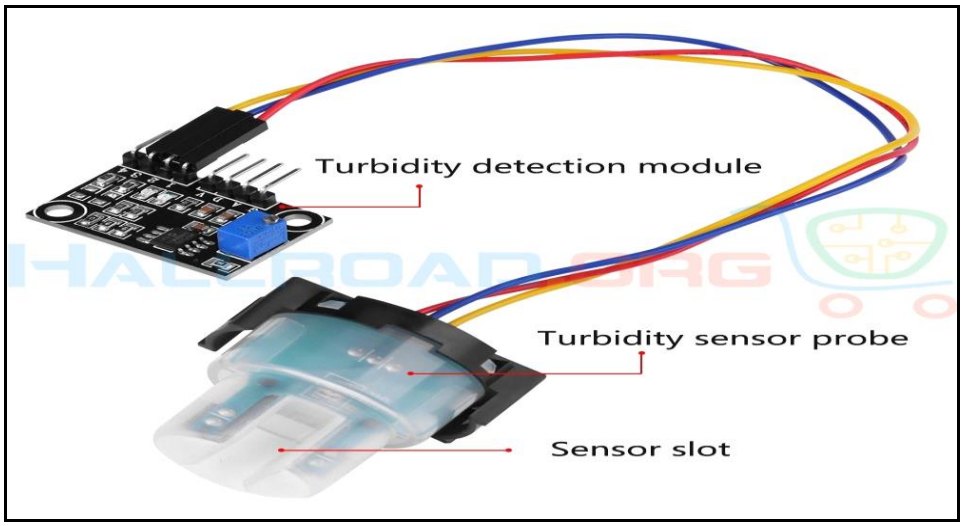


Figure8: Turbidity Sensor

Turbidity sensors measure the amount of light that is scattered by the suspended solids in water.

As the amount of total suspended solids (TSS) in water increases, the water's turbidity level (and cloudiness or haziness) increases.

Turbidity sensors are used in river and stream gaging, wastewater and effluent measurements, control instrumentation for settling ponds, sediment transport research, and laboratory measurements.

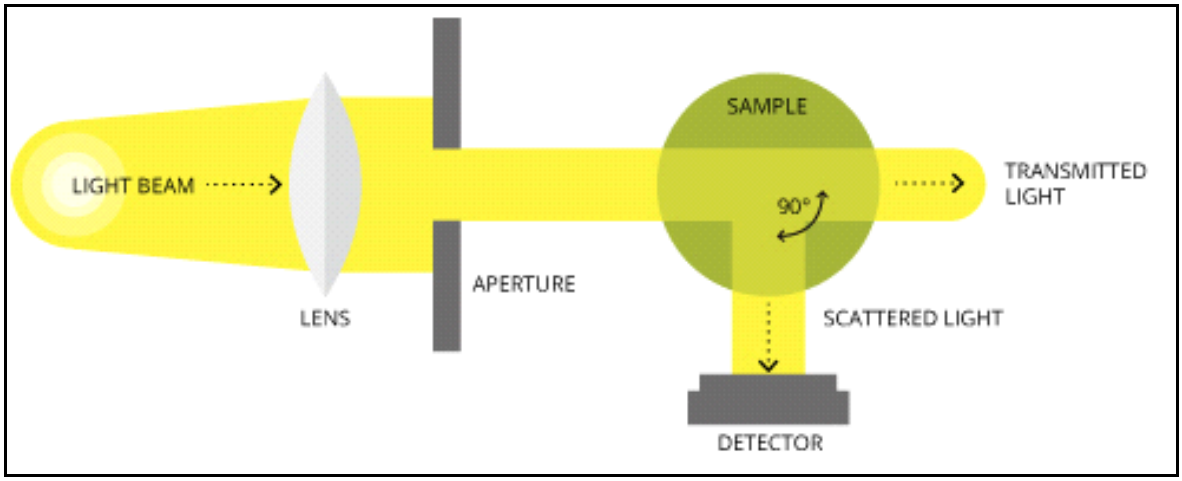


Figure9: Working Of Turbidity Sensor

A turbidity probe works by sending a light beam into the water to be tested. This light will then be scattered by any suspended particles.

A light detector is placed at (usually) a 90-degree angle to the light source, and detects the amount of light that is reflected back at it.

The amount of light reflected is used to determine the particle density within the water.

The more light that is detected, the more particles are present in the water.

Turbidity meters use nephelometry (90 degree scattering) or other optical scatter-detection techniques for fast, accurate turbidity measurements on water samples.

Turbidity sensors also use optical technology, but instead of using sample cells, they can be placed directly in the water source to measure turbidity.

In addition, turbidity sensors can be used for continuous turbidity measurements. However, when using a meter or a sensor, most turbidity data are not inter-comparable.

Turbidity units such as Nephelometric Turbidity Unit (NTU) and Formazin Turbidity Unit (FNU) have “no intrinsic physical, chemical or biological significance”.

Thus, differences in suspended sediment type (e.g. algae, clay or sand) and differences in instrument design will alter a turbidity reading. These instruments can be convenient and accurate tools as long as consistency is maintained. Health Organization, establishes that the turbidity of drinking water should not be more than 5 NTU, and should ideally be below 1 NTU.

Turbidity sensor comes with Analog to digital converter. It can be operated between two modes Analog mode and Digital mode. In Analog mod the output is obtained in terms ofvoltage which is then converted inti NTU form.

Under Digital mode the signal wire of Analog to digital converter goes to the digital pin of the microcontroller. The sensor sends a high volt signal when the turbidity reaches a threshold values. This value can be adjusted by the on-board potentiometer from Analog to digital converter.

(b) pH SENSOR:

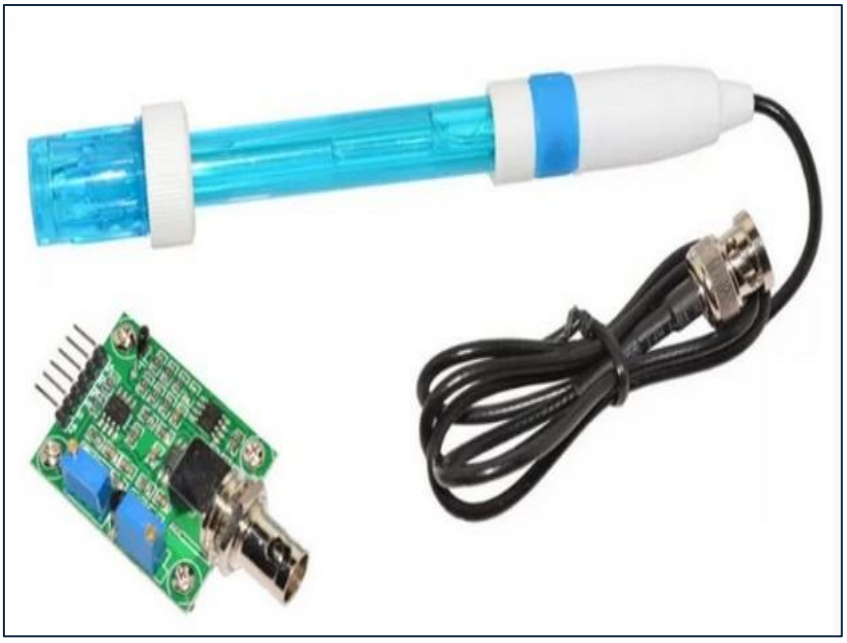


Figure 10. pH Sensor

pH stands for potential hydrogen with the “p” meaning potential and the “H” standing for hydrogen. The pH scale could be a scale that's utilized to rank the relative basicity or causticity of substances to other substances, based on the sum of hydrogen particle movement in a substance.

The scale is logarithmic in nature, meaning that each entirety pH esteem speaks to a alter of 10 times the past esteem.

The pH scale is based around pH 7, which is impartial and speaks to substances that are not one or the other a corrosive nor a base.

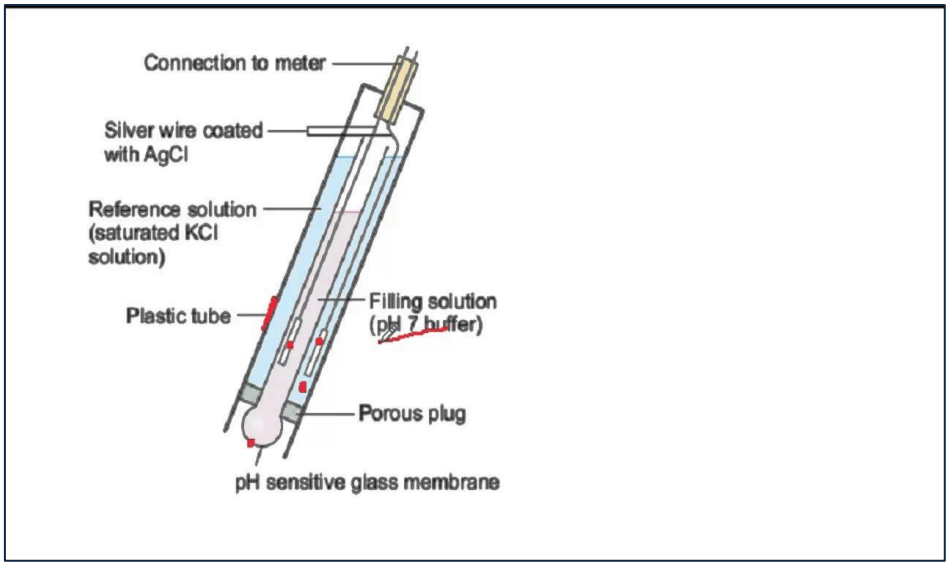


Figure 11. Detailed Diagram of pH Sensor

Every pH electrodes has glass ball that comes in contact with the solution and there is a wire that conducts electricity and is inside of the electrodes which is directly internally connected to an internal microchip surrounding this wire is an electrical conductive solution is called an electrolyte solution. The solution is normally a KCL potassium chloride solution of a concentration near 3.5 molar. The KCL solution can be a gel or a liquid depending on its design use of this KCL solution leaks out of the glass membrane through a junction at a specific rate exam Cloth junction equals 14 micro litre per hour. there are three types of junctions to allow for the leaking of the electrolyte KCL solution into our testing solution ceramic junction normally used in large sized particulate solutions with low concentration for example city water.

1.Cloth junction: normally used in medium to large sized particulate with high concentrated solutions. for eg plant nutrient solution

2. Open junction: normally used in small to large sized particulate with high concentration solution example wine.

On the bottom layer of the glass membrane there has a gel layer that must be hydrated for proper use. The glass membrane will be submerged in a testing or storage solution that will submerge the junction.

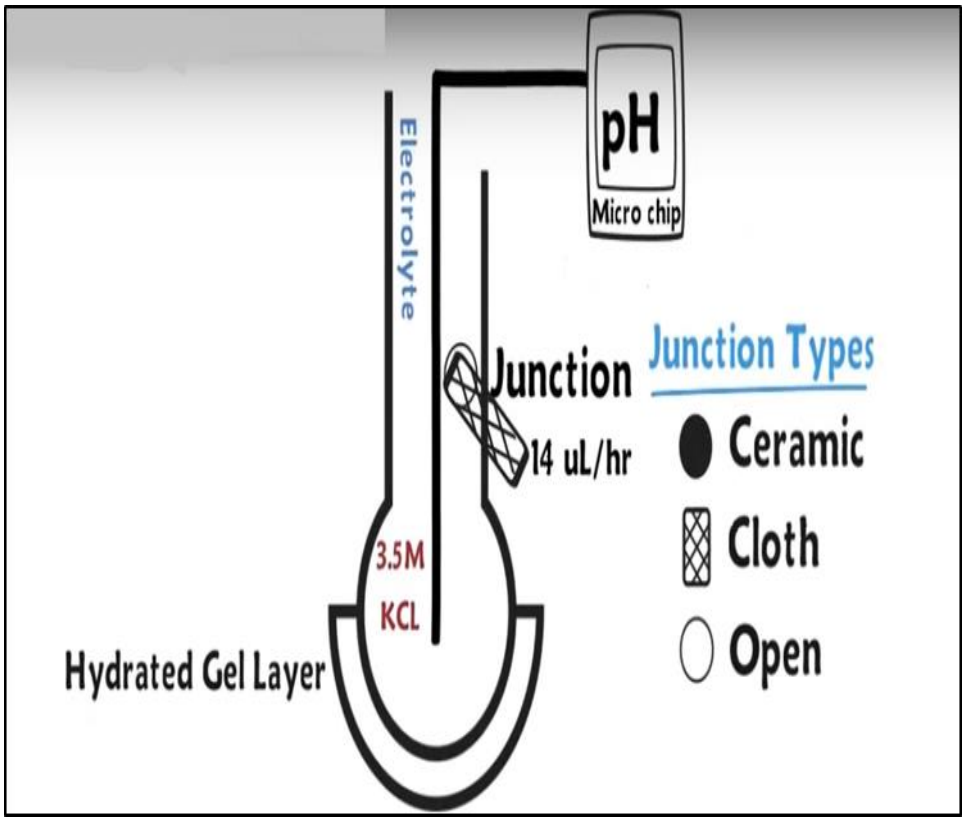


Figure 12. Inner working of pH sensor

After submerging pH electrode in the solution / sample under test so that the junction is in contact with the electrolyte will begin to leak out of the junction at 40 micro litre per hour. A millivolt electrical charge is supplied to the wire from the metres battery the mmv charge will float down the wire through the glass membrane electrifying the hydrated gel layer. The hydrated ions in your solution will migrate towards and attach themselves to the hydrated gel layer .The H+ ions inside the glass membrane versus the number of hydrogen ions attached to the gel layer will ultimately decide the solutions value, this is dependent on the millivolt charge transmitted through the hydrogen ions from the solution/sample. If more hydrogen ions are attached to the gel layer than inside the glass membrane this will create ions from the solution this will indicate a low pH value called acid and if less hydrogen ions are attached this will indicate a base and equal hydrogen on both sides of gel layer and bulb membrane we will create a neutral pH value. This is created by millivolt charge close to zero based on the number of hydrogen ions.

3) SELF PRIMING MOTORS: R365

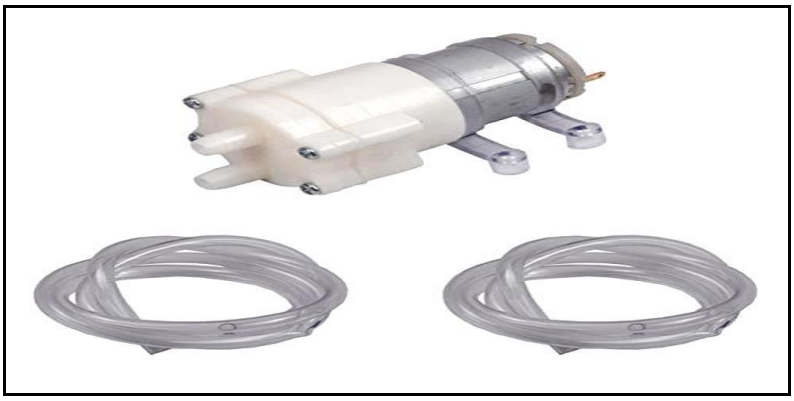


Figure13: Self Priming Dc Motor

Self-priming motors are used to automatically transfer water and reagent as per the requirement after spam of period. The term "self-priming pump" describes a centrifugal pump that can use an air-water mixture to reach a fully-primed pumping condition.

First, let's define a centrifugal pump:

A centrifugal pump is any pump that uses centrifugal force to create a pressure differential in a fluid, thus resulting in pumping action.

The easiest way to visualize this action is to imagine the effect of a car tire flicking water off a wet road.

The pumping action is not from a "scooping" action by the vanes (the blade-like wings) on the impeller, but rather from the centrifugal force.

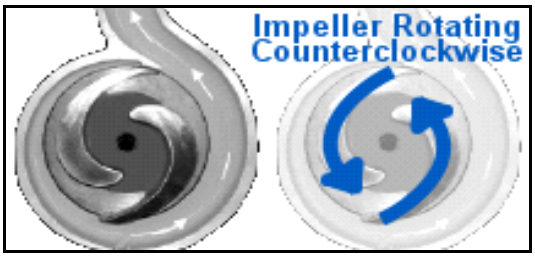


Figure14: Centrifugal Pump(1a)

Standard (non-self-priming) centrifugal pumps come in many types. When they operate on flooded suction lines or in submersible applications, the impeller is surrounded by enough water to create the pressure differential and thus to pump water.

Air is the main enemy of a standard (non-self-priming) centrifugal pump. When the standard centrifugal pump encounters air, it can become air-bound.

It's much harder to pump air than to pump water, so when the air "binds" the pump, the pump can no longer force the water out.

When everything's working right, a standard (non-self-priming) centrifugal pump will work like this:

Figure15: Centrifugal Pump(1b)

When air gets into a standard (non-self-priming) centrifugal pump, the pump becomes air-bound, like this:

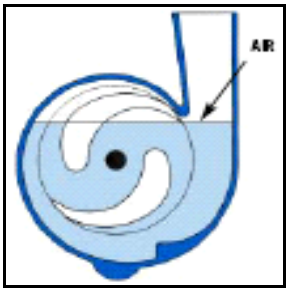


Figure16: Centrifugal Pump(1c)

It is important to understand that self-priming pumps cannot operate without water in the casing.

Here's how it works:

During the priming cycle, air enters the pump and mixes with water at the impeller.

Water and air are discharged together by centrifugal action of the impeller into the water reservoir.

The air naturally tends to rise, while the water tends to sink.

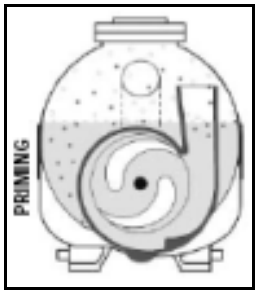


Figure17: Centrifugal Pump(1d)

Air-free water, now heavier than air-laden water, flows by gravity back down into the impeller chamber, ready to mix with more air coming in the suction line.

Once all air has been evacuated and a vacuum created in the suction line, atmospheric pressure forces water up into the suction line towards the impeller, and pumping begins.

Figure18: Centrifugal Pump(1e)

Recirculation of water within the pump stops when pumping begins.

The next time the pump is started, it will "self-prime" -- that is, it will be able to once again mix the water and air in the casing to create a pumpable fluid until the pump is fully primed again.

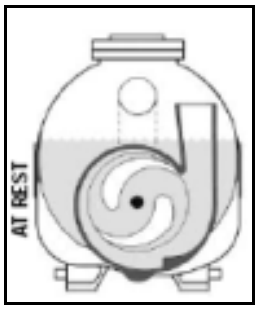


Figure19: Centrifugal Pump(1f)

This type of pump differs from a standard centrifugal pump in that it has a water reservoir built into the unit which enables it to rid pump and suction line of air by recirculating water within the pump on priming cycle. This water reservoir may be above the impeller or in front of the impeller.

In either case, the "self-priming" capability of the pump comes from the pump's ability to retain water after the very first prime.

SPECIFICATION:

1. Model: 365 DC micro diaphragm pump
2. *Main parameters:*

1. Working voltage: DC 12V
2. no-load current: 0.23
3. Load: 450 Haoan
4. Maximum flow: 2-3 liters / minute
5. Maximum pressure at the outlet: 1-2.5 kg
6. Maximum lift: 1-2.5 meters
7. Normal working hours: 2-3 years.
8. Maximum suction: 2 meters
9. Inlet and outlet diameter: 8mm outer diameter
10. Motor length: 32M
11. Motor diameter: 28MM
12. Pump length: 36MM
13. Total length: 69MM
14. Pump diameter: 40MM * 35MM
15. weight amounts: 111 g

4) PI CAMERA

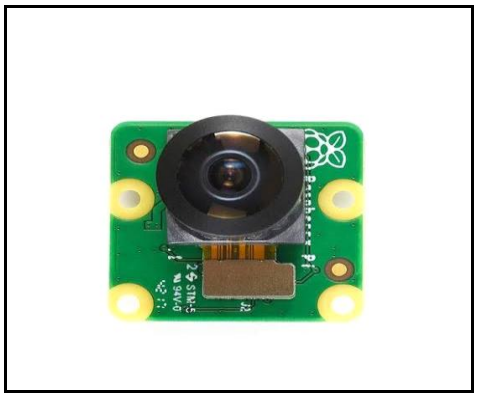


Figure20: Pi Camera

Pi Camera module is a camera which can be used to take pictures and high definition video.

Raspberry Pi Board has CSI (Camera Serial Interface) interface to which we can attach Pi Camera module directly.

This Pi Camera module can attach to the Raspberry Pi's CSI port using 15-pin ribbon cable

Pi camera module interfaced with Raspberry pi can be operated in two methods.

One is using **python program** and secondly using **pi camera module commands.**

SPECIFICATION

1. Resolution – 5 MP
2. HD Video recording – 1080p @30fps, 720p @60fps, 960p @45fps and so on.
3. It Can capture wide, still (motionless) images of resolution 2592x1944 pixels
4. CSI Interface enabled.

Pi Camera Module Interface with Raspberry Pi using Python:

Connect Pi Camera to CSI interface of Raspberry Pi board as shown below

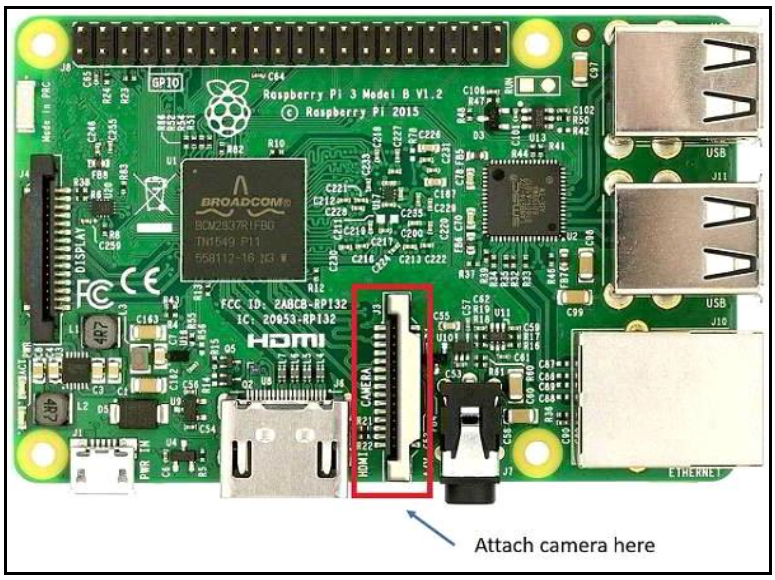


Figure 21. CSI interface of Raspberry Pi

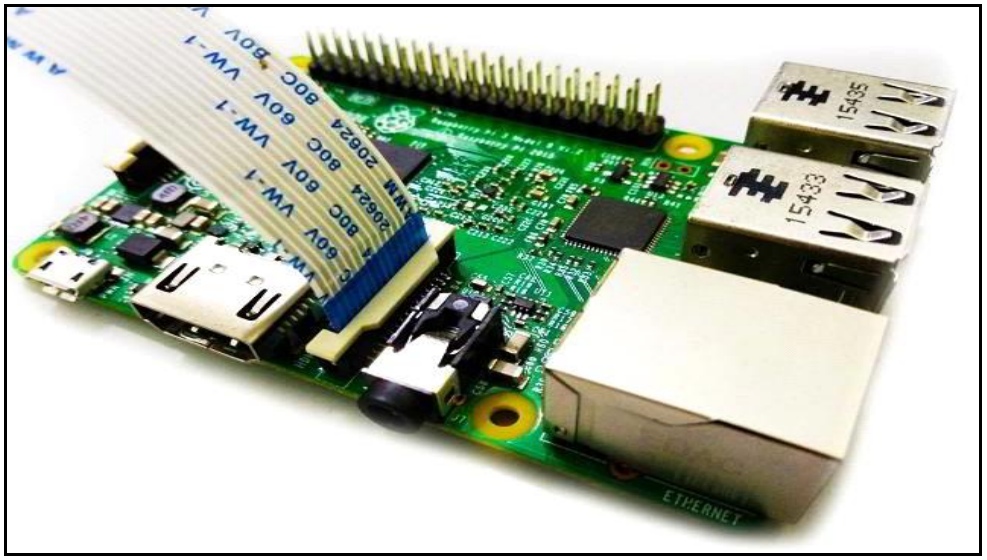


Figure22: Pi Camera Interfaced To Raspberry Pi Module

For enabling camera in Raspberry Pi, open raspberry pi configuration using following command,

sudo raspi-config

then select Interfacing options in which select camera option to enable its functionality.

Reboot Raspberry Pi.

Now we can access camera on Raspberry Pi.

Now we can capture images and videos using Pi Camera on Raspberry Pi

Pi Camera Module Interface with Raspberry Pi using commands:

raspistill, raspivid and **raspiyuv** are command line tools for using the camera module.

Basic Usage of each commands:

With the camera module connected and enabled, enter the following command in the Terminal to take a picture:

raspistill

1. Capturing still photographs with the camera module

raspistill -o cam.jpg

2. Since the image clicked will be displayed upside down the following command can be used flip image vertically and horizontally.

raspistill -vf -hf -o cam2.jpg

raspivid

1. Capturing video with the camera module

raspivid -o vid.h264

2. This will save a 5 second video file to the path given here as vid.h264 (default length of time). Even the desired length of video can be specified by following command

raspivid -o video.h264 -t 10000

3. This will record video of 10 seconds.

Time-lapse

1. Taking pictures at regular intervals and stitching them together in to a video.

raspiyuv

1. Capturing still photographs and generating raw unprocessed image files

5)Motor Driver

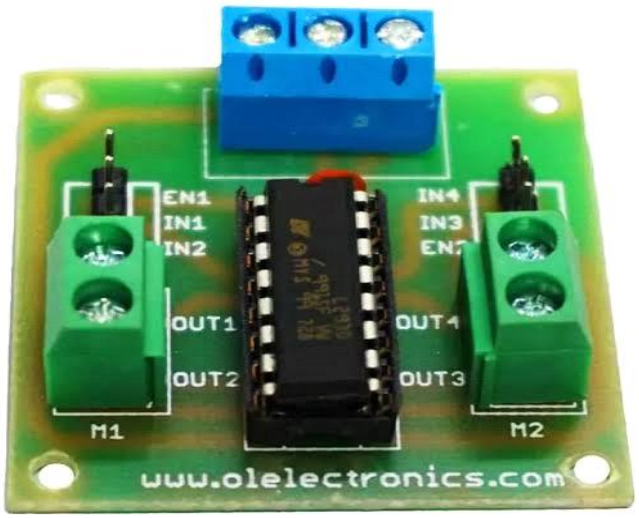


Figure23: Motor Driver

Here L293D motor driver is used to drive the motors used. Motor drivers acts as an interface between the motors and the control circuits. Motor require high amount of current whereas the controller circuit works on low current signals. So the function of motor drivers is to take low-current control signal and then turn it into a higher-current signal that can drive a motor.

CHAPTER 4

TECHNIQUES OF DETECTING E-COLI

4.1 TECHNIQUES OF DETECTING E-COLI

PCR/Polymerase Chain Reaction

PCR is the method of taking a single duplicate of a quality, and through different warming and cooling cycles, duplicating the qualities for simpler location. The PCR strategy was designed in 1985 by Kary B. Mullis, whereas working as a chemist at Cetus Organization.

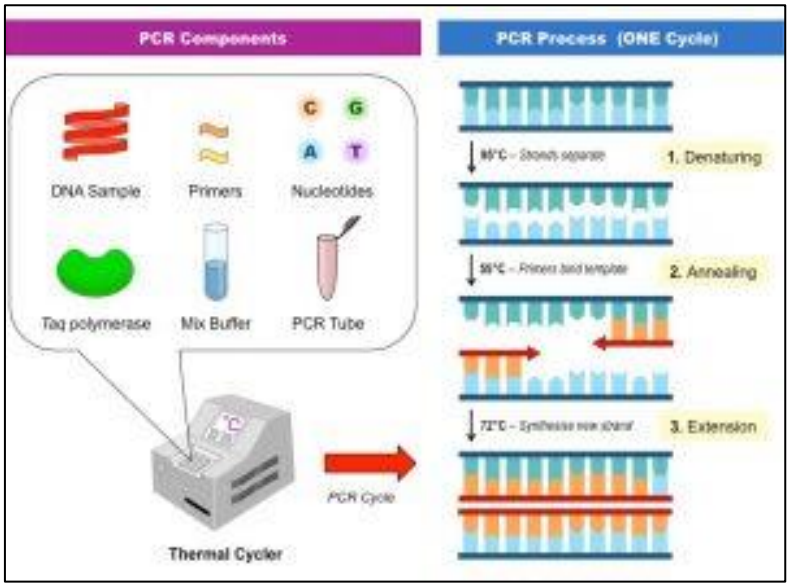


Figure24: PCR Technique

The process of PCR takes place in a thermal cycler due to the various temperatures required to complete a cycle. There are three steps required to complete one cycle of PCR:

1. Denaturation- The DNA strand is heated to around 95^{o}C for 1 minute, to separate the two strands.
2. Annealing- The temperature drops to around 55^{o}C for 1 minute as DNA primers attach to the 3’ end of the DNA strands.
3. Elongation- Taq DNA polymerase bonds to the primer and makes a copy of the strand, the cycle is at around 72^{o}C for 2 minutes. Taq polymerase is a heat resistant enzyme, able to withstand the high temperatures cycles of PCR.

Each ‘cycle’ of PCR pairs the sum of DNA, so 30 cycles of PCR can make generally 1 billion duplicates of the DNA strand. Once the huge amount of DNA has been made, labs can disconnect and identify the grouping of intrigued. This can be utilized in numerous places for fast infection discovery, such as water defilement for E. coli. Due to the specificity of this system, PCR could be a effective apparatus to assist screen and distinguish the E. coli of intrigued (such as O157:H7) from the moderately safe natural strains.

The benefits of PCR are:

1. The assay is extremely specific (it relies on unique DNA for typing).
2. The assay is extremely sensitive, functional with fragments of DNA.
3. Cost per test is in the order of fractions of cent.

The cons of PCR are:

1. Knowledge of the specific sequence of target DNA.
2. Very specific to targeted *coli* only.
3. Expensive initial capital investment.
4. Requires trained personnel.

Gold Nanoparticles

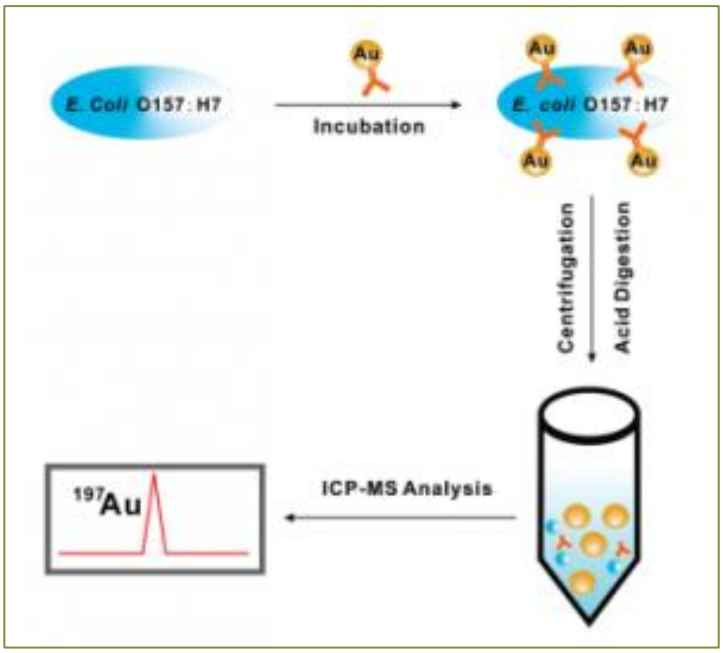


Figure25: Gold Nanoparticle Technique

Introduction to E. coli serotype O157:H7 (indeed follow sums in your nourishment) can lead to infection or indeed passing. Gold nanoparticles (Au NPs) can be utilized for the location of E. coli, through inductively coupled plasma mass spectrometry (ICPMS). ICPMS is utilized for location for follow basic examination, being able to quickly analyze information. [3] In brief, a tall particular monoclonal counter acting agent against E. coli O157:H7 is bound to the target analyte (the microbes of intrigued) and brooded. The arrangement is at that point centrifuged to partitioned the unbound from the bound Au NPs. Upon expulsion of the supernatant, the remaining cell pellet is processed with an corrosive arrangement and the arrangement is analyzed through ICPMS.

The signal intensity (CPS) vs CFU/mL is plotted; an increasing trend is observed with an increase in bacterial concentration.

The benefits of gold nanoparticles are:

1. The assay is very specific (it relies on unique monoclonal antibodies raised against target antigens usually expressed on the surface of the organism).
2. The assay is very sensitive.
3. Cost per test is in the order of cents per test.

The cons of gold nanoparticles are:

1. Knowledge of the specific sequence of target antigen
2. Very specific to targeted antigens
3. Requires good conformation and presentation of the target antigens
4. Expensive initial capital investment.
5. Requires trained personnel.

Solid Phase Cytometry

E.*coli* can also be detected through the use of solid phase cytometry (SPC) in conjunction with fluorescent viability staining. The *E. coli* in water samples are filtered over a polyester membrane 0.4 µm pore size filter under vacuum to capture the bacteria. The retained *E. coli* on the filter is then treated with reagents to induce the enzyme β-D-glucuronidase and incubated at 37ºC for 3 hours. The induced cells are then labelled. Only the enzymes on the viable cells can be labelled, causing the bacteria to cleave the non-fluorescent substrate, leaving only the fluorescent end inside the viable cells.

The fluorescence is then read using the ScanRDI® device, a laser scanning device that enumerates cells via fluorescent labelling. Enumeration of fluorescent cells take up to three minutes. Using this method allows for rapid and visual detection of contaminated water. [5] This system has the advantage of detecting viable and potentially non-culturable cells. Simple biochemical tests such as Biomerieux API strips or more complex systems such as Matrix-assisted laser desorption/ionization-time of flight mass spectrometry (MALDI-TOF) performed on isolated pure colonies are further required to positively identify E. coli from other organisms using this technique.

The benefits of Solid Phase Cytometry are:

1. The assay can detect viable organisms
2. The assay is limited to the ability to detect the fluorescent signal
3. Cost per test is in the order of cents per test.

The cons of Solid Phase Cytometry are:

1. The assay can only detect viable organisms
2. The assay is limited to the ability to detect the fluorescent signal
3. The assay consists of a multi-step process.
4. Additional steps are required for confirmation of *coli.*

Viable cell count

There are many ways to enumerate bacterial concentrations, one simple way is through viable cell counting on an agar plate. The bacterial sample is serially diluted (1:10, 1:100, 1:1000 etc.), in sterile water or Phosphate Buffer Saline (PBS), and plated on Tryptic Soy Agar plates or semi-selective media (such as MacConkey agar to selectively isolate Gram-negative enteric organism). The plates are sealed and incubated in a 37˚C incubator overnight. When counting the colonies the next day, a count between 20 and 200 provides an accurate representation of concentration. [6] As with SPC, Simple biochemical tests such or MALDI-TOF is performed on isolated pure colonies are further required to positively identify *E. coli* from other organisms using this technique.

The benefits of Solid Phase Cytometry are:

1. The assay can detect viable organisms
2. The assay is limited to the ability to detect the culturable organisms
3. Cost per test is in the order of cents per test.

The cons of Solid Phase Cytometry are:

1. The assay can only detect viable organisms
2. The assay is limited to the ability to detect the organisms that grow on your chosen media
3. The assay consists of a multi-step process.
4. Additional steps are required for confirmation of *coli.*

4.2 THE CHROMOGENIC ENZYME SUBSTRATE TEST

The chromogenic enzyme substrate test using color indicating chemicals digested by the coliforms is one of the low cost methods used to detect E. coli. During culturing with chemicals called X-gal (also abbreviated as BCIG for 5-bromo-4-chloro-3-indolyl-β-D-galactopyranoside) or variants (Red-gal or Red colored X-gal for 6-chloro-3-indolyl-β-D-galactopyranoside, or MUG for 4-methylumbelliferyl β-D-galactopyranoside), coliforms digest X-gal variants and generate color pigments in a liquid broth, which can be visually detected by a color change of the media. Many commercial kits such as Colitag® (CPI International, Huntington Beach, CA, USA), Colilert® (IDEXX Laboratories, Westbrook, ME, USA), and Coliscan® (Micrology Laboratories, Goshen, IN, USA) are available for testing the presence/absence of coliform bacteria based on this principle, and are widely used and approved by diverse sanitation authorities, including the Republic of Korea Ministry of Environment and the United States Environmental Protection Agency (US EPA) . This method relies on bacterial growth in the edia and digestion of a given substrate, and thus the average time for the test is about 8 to 48 h. The time consumed for this test is relatively long compared to previously introduced methods. However, the chromogenic enzyme substrate method does not require a specific media (API-Analytical Profile Index 20 test or MacConkey) and it involves an easy procedure to prepare the test and a simple culture method that can be performed easily in the laboratory without expensive analysis devices. Intuitive classification of results also helps non-experts in bacterial diagnosis run this test easily.

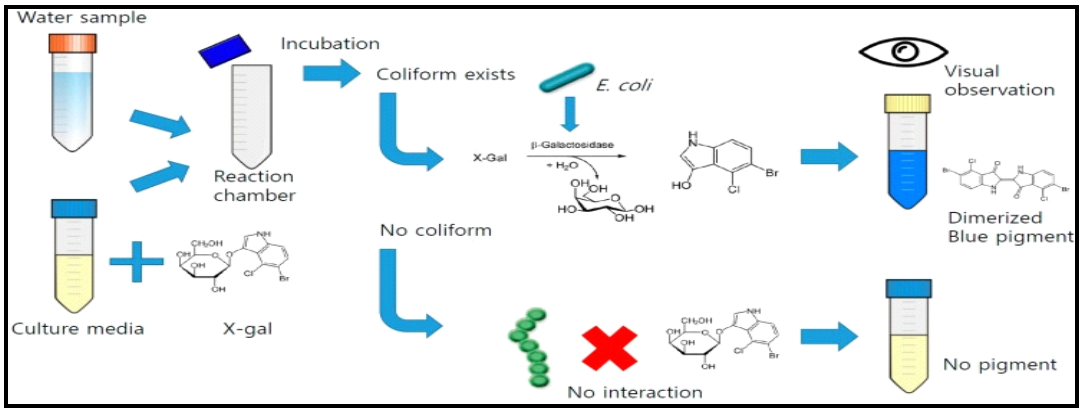


Figure26: Chromogenic Enzyme Substrate Assay Test

Bacterial Culture and Chromogenic Enzyme Substrate Assay

Two *E. coli* strains were used for the experiment. *E. coli* K-12 MG 1655 strain was used as a positive control case; the presence of coliform bacteria in the water sample. *E. coli* DH-5 α strain was used to simulate the case of the existence of non-coliform bacteria (no β-galactosidase) as it has a Δ(*lacZ*) M15 mutation, and cannot digest X-gal and variants . Even when coliform is not present, resident bacterial flora may be present in the water and grow in the testing device. *E. coli* DH-5 α strain was used to check whether false-positive cases can be filtered by a chromogenic enzyme assay. Bacterial strains were kindly provided by the Biomolecular Engineering Laboratory at the Dept. of Biological Science, Korea Advanced Institute of Science and Technology (KAIST), Korea.

X-gal (Takara, Otsu, Japan) was prepared by dissolving it in dimethyl sulfoxide (DMSO, Sigma Aldrich, St. Louis, MO, USA) to make a 0.5 M stock solution. The dissolved X-gal was stored at 4 °C and diluted to 1 mM concentration when used for the test. Five mL of LB broth (Duchefa Biochemie, Haarlem, the Netherlands) with 10 μL of X-gal stock was used as the assay media. Colitag® was used for the control. A single Colitag® pack was dissolved in 100 mL of distilled water (DW) and used to compare the results with the substrate media developed in this research.

Visible and distinguishable color change makes it easy for non-experts in microbial diagnosis (for example, workers in factories or water quality testers in developing countries.) to check for the presence of coliform if an image of the culture bottle is provided to the user without requiring additional sensors or testing devices. Using less sensors for the detection period also increases the stability of the system as the calibration process required for sensor precision can be omitted, and the consumed power is also decreased. Furthermore, both the LB broth with X-gal and Colitag® showed the same response against two *E. coli* strains, and testing reagents can be thus replaced by LB broth with X-gal to reduce the cost of consumable chemicals.

4.3 Colour Detection using open-cv and python

Install open-cv and python on raspberry pi using commands, these commands are easily available.

OpenCV is the huge open-source library for the computer vision, machine learning, and image processing and now it plays a major role in real-time operation which is very important in today's systems. By using it, one can process images and videos to identify objects, faces, or even handwriting of a human. When it integrated with various libraries, such as Numpy, python is capable of processing the OpenCV array structure for analysis. To identify image pattern and its various features we use vector space and perform mathematical operations on these features.

Applications of OpenCV: There are lots of applications which are solved using OpenCV, some of them are listed below

1. face recognition
2. Automated inspection and surveillance
3. number of people – count (foot traffic in a mall, etc)
4. Vehicle counting on highways along with their speeds
5. Interactive art installations
6. Anamoly (defect) detection in the manufacturing process (the odd defective products)
7. Street view image stitching
8. Video/image search and retrieval
9. Robot and driver-less car navigation and control
10. object recognition
11. Medical image analysis
12. Movies – 3D structure from motion
13. TV Channels advertisement recognition

OpenCV Functionality

1. Image/video I/O, processing, display (core, imgproc, highgui)
2. Object/feature detection (objdetect, features2d, nonfree)
3. Geometry-based monocular or stereo computer vision (calib3d, stitching, videostab)
4. Computational photography (photo, video, superres)
5. Machine learning & clustering (ml, flann)
6. CUDA acceleration (gpu)

Image-Processing

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. If we talk about the basic definition of image processing then **"Image processing is the analysis and manipulation of a digitized image, especially in order to improve its quality".**

Digital-Image:

An image may be defined as a two-dimensional function f(x, y), where x and y are spatial(plane) coordinates, and the amplitude of fat any pair of coordinates (x, y) is called the intensity or grey level of the image at that point.

In another word An image is nothing more than a two-dimensional matrix (3-D in case of coloured images) which is defined by the mathematical function f(x, y) at any point is giving the pixel value at that point of an image, the pixel value describes how bright that pixel is, and what colour it should be.

Image processing is basically signal processing in which input is an image and output is image or characteristics according to requirement associated with that image.

Image processing basically includes the following three steps:

1. Importing the image
2. Analysing and manipulating the image
3. Output in which result can be altered image or report that is based on image analysis

Filter Color with OpenCV

Colour segmentation or colour filtering is widely used in OpenCV for identifying specific objects/regions having a specific colour. The most widely used colour space is RGB colour space, it is called an additive colour space as the three colour shades add up to give the colour to the image. To identify a region of a specific colour, put the threshold and create a mask to separate the different colours. HSV colour space is much more useful for this purpose as the colours in HSV space is much more localized thus can be easily separated. Colour Filtering has many applications and use cases such as in Cryptography, infrared analysis, food preservation of perishable foods etc. In such cases, the concepts of Image processing can be used to find out or extract out regions of a particular colour.

For colour segmentation, all we need is the threshold values or the knowledge of the lower bound and upper bound range of colours in one of the colour spaces. It works best in Hue-Saturation-Value colour space.

After specifying the range of colour to be segmented, it is needed to create a mask accordingly and by using it, a particular region of interest can be separated out.

For example, here blue colour has been detected/filtered:

Original Image:

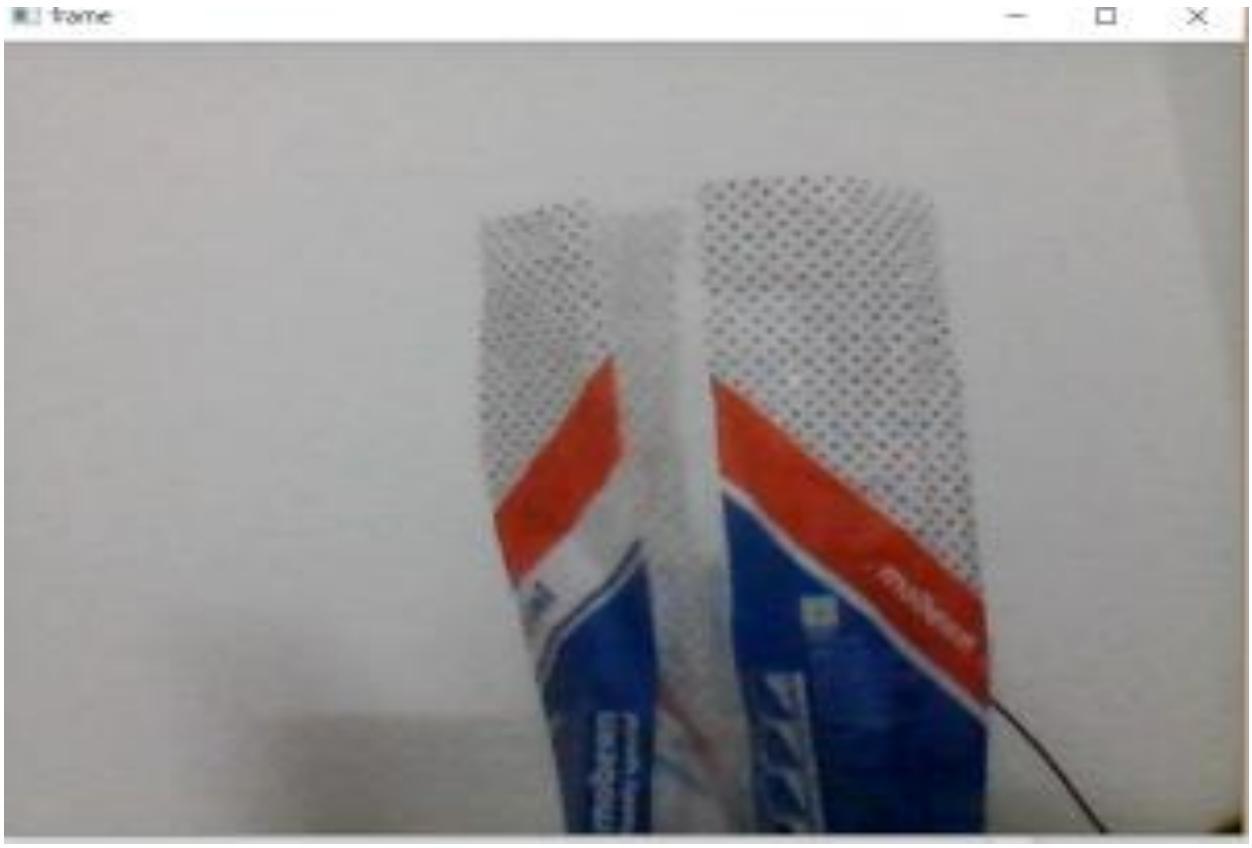


Figure27: Colour Detection Output(1. Original Image)

Masked Output:

Figure28: Colour Detection Output (1. Masked Output)

Blue Colour segmented regions:

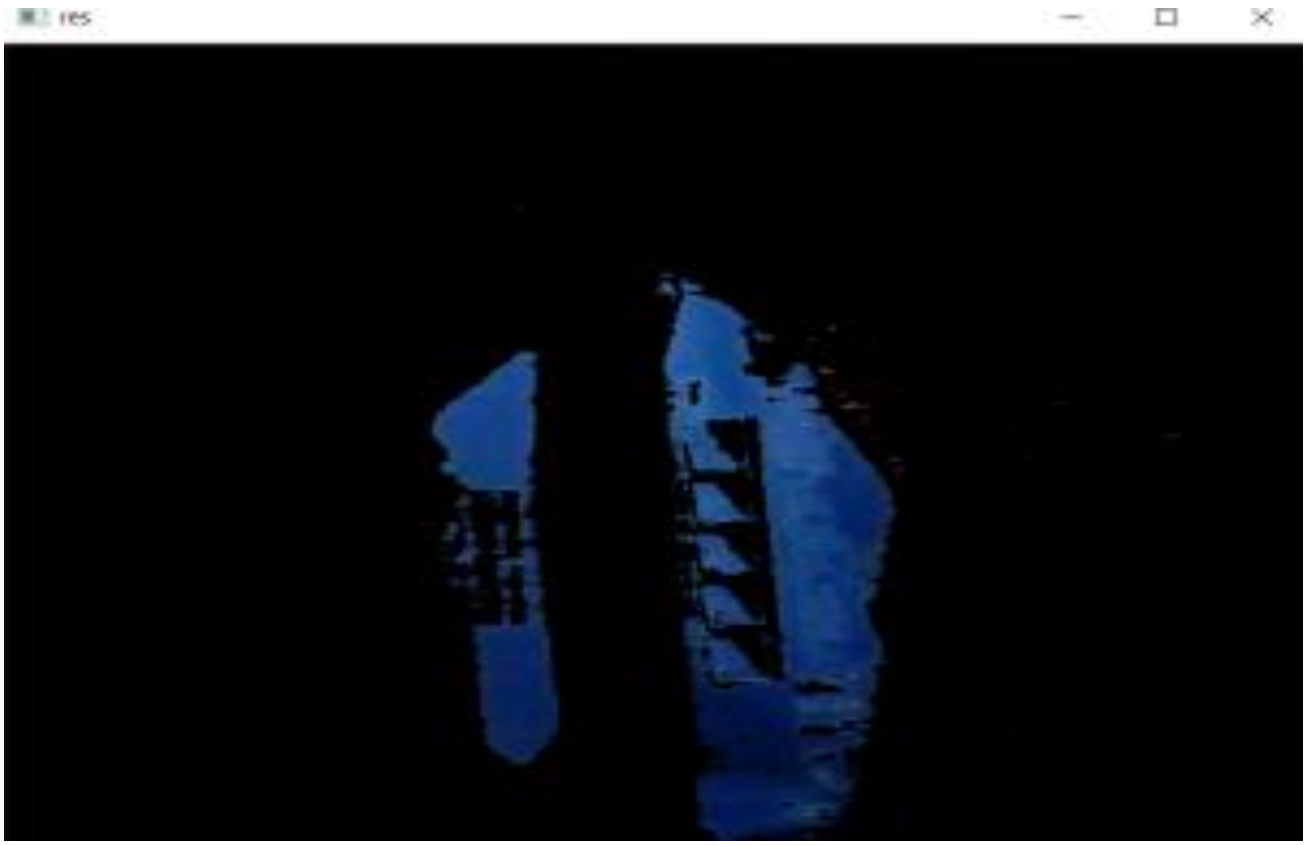


Figure 29: Blue Colour segmented region

The colour segmentations are smoothened using filters. There are two filters used:

Low pass filter:

Low pass filter is the type of frequency domain filter that is used for smoothing the image. It attenuates the high frequency components and preserves the low frequency components.

High pass filter:

High pass filter is the type of frequency domain filter that is used for sharpening the image. It attenuates the low frequency components and preserves the high frequency components.

These filters we have used in both open-cv python image processing and MATLAB image processing.

Unlike MATLAB in open-cv python image processing doesn't require to set network connection, hardware configuration. In this we can directly install the open-cv python on raspberry pi using commands on command terminal of RPi.

Accessing the Raspberry Pi Camera with OpenCV and Python

Firstly we installed Raspberry Pi camera module , Open up a terminal and execute the following command to enable Raspberry Pi camera

$ sudo raspi-config

This will bring up a screen that looks like this:

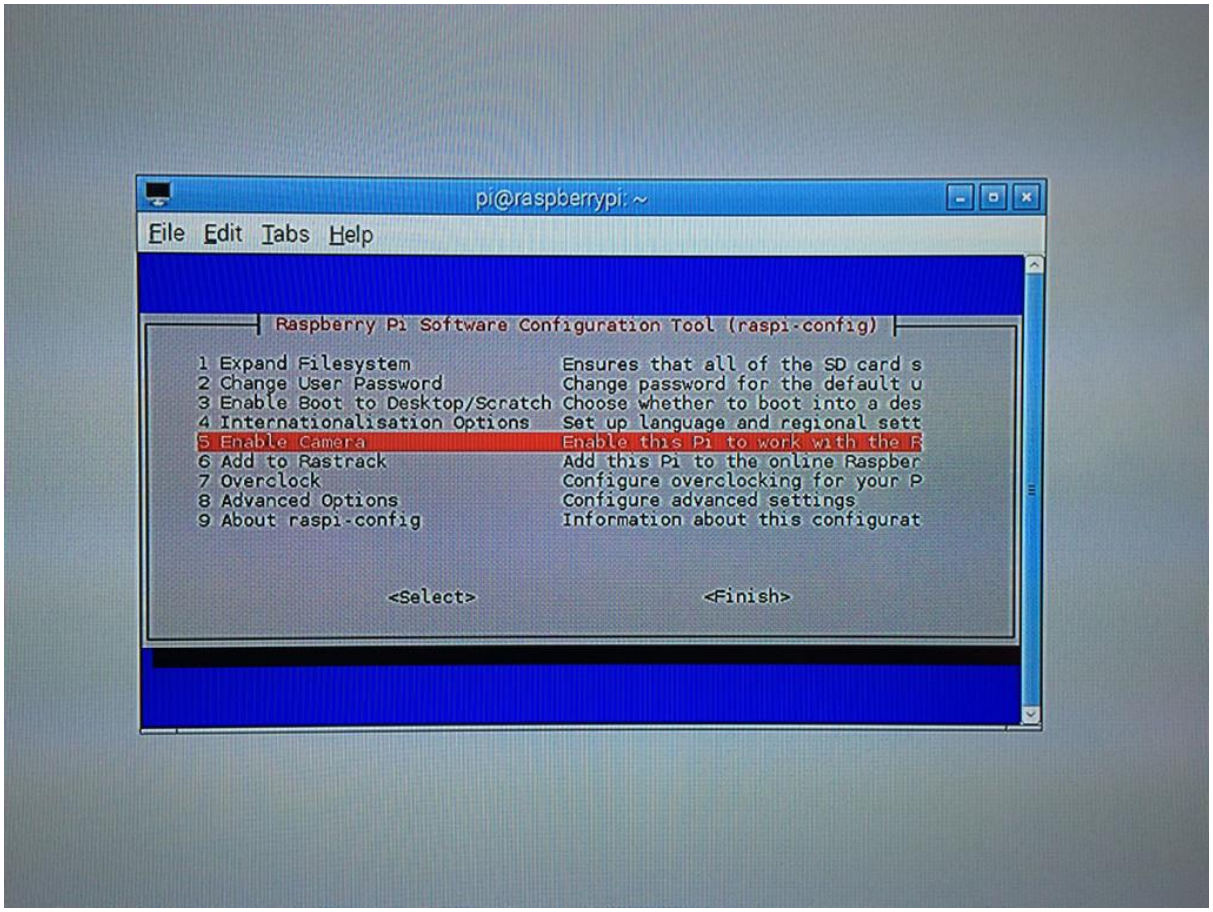


Figure30: Configuration Tab

Scrolling down to **Option 5: Enable camera**, camera c was enabled, and then arrow down to the **Finish** button and hit enter again. Lastly, **Raspberry Pi**

is to be rebooted for the configuration to take effect. The camera is ready to run the test.

Open up a terminal and execute the following command:

$ raspistill -o output.jpg

This command activates your Raspberry Pi camera module, displays a preview of the image, and then after a few seconds, snaps a picture, and saves it to your current working directory as

output.jpg

While writing program for detecting colour from the image we need to specify the location where camera has saved the clicked images on raspberry pi, this will allow to grab the image and filter the colour using the algorithm built.

.

```
# import the necessary packages
from picamera.array import PiRGBArray
from picamera import PiCamera
import time
import cv2

# initialize the camera and grab a reference to the raw camera capture
camera = PiCamera()
rawCapture = PiRGBArray(camera)

# allow the camera to warmup
time.sleep(0.1)

# grab an image from the camera
camera.capture(rawCapture, format="bgr")
image = rawCapture.array

# display the image on screen and wait for a keypress
cv2.imshow("Image", image)
cv2.waitKey(0)
```

Here is the program tested to access the images from pi camera.

rawCapture

This object is especially useful since it gives us direct access to the camera stream and avoids the expensive compression to JPEG format, which we would then have to take and decode to OpenCV format anyway.

Accessing the video stream of your Raspberry Pi using Python and OpenCV.

v2.VideoCapture

This is function using which we can *easily* access the raw video stream using picamera module.

```
# import the necessary packages
from picamera.array import PiRGBArray
from picamera import PiCamera
import time
import cv2

# initialize the camera and grab a reference to the raw camera capture
camera = PiCamera()
camera.resolution = (640, 480)
camera.framerate = 32
rawCapture = PiRGBArray(camera, size=(640, 480))

# allow the camera to warmup
time.sleep(0.1)

# capture frames from the camera
for frame in camera.capture_continuous(rawCapture, format="bgr", use_video_port=True):
   # grab the raw NumPy array representing the image, then initialize the timestamp
   # and occupied/unoccupied text
   image = frame.array

   # show the frame
   cv2.imshow("Frame", image)
   key = cv2.waitKey(1) & 0xFF

   # clear the stream in preparation for the next frame
   rawCapture.truncate(0)

   # if the `q` key was pressed, break from the loop
   if key == ord("q"):
       break
```

The above code is an example of capture video. This algorithm also helps to convert the video into image frames. By using same algorithm, we have performed Colour filtering from image and also colour filtering from video.

Algorithm used:

We have Implemented colour and shape-based object detection and tracking using hue-saturation-value (HSV) colour model. For Choosing the correct upper and lower HSV boundaries for colour detection with`***cv::inRange***` (OpenCV) we have used trackbar.

Firstly we have converted our coloured image into HSV model this simply means that by default coloured images are in RGB format so we have to convert it into HSV format so that it is easy to filter the colour from the image based on its hue, saturation and brightness.

Next lower range and upper range of all the colours are specified in the algorithm, these ranges are defined either by decimal numbers or binary numbers. Here we have defined the ranges in decimal number. Hue value of a colour ranges from 0-255, Saturation value also ranges from 0-255 and value of colour which represents brightness has range 0-255 as well.

Ranges of basic colours are defined below. Derivatives of these colours have ranges derived from basic colour ranges.

Basic colors:

Color	HTML / CSS Name	Hex Code #RRGGBB	Decimal Code HSV
	Black	#000000	(0,0,0)
	White	#FFFFFF	(255,255,255)
	Red	#FF0000	(255,0,0)
	Lime	#00FF00	(0,255,0)
	Blue	#0000FF	(0,0,255)
	Yellow	#FFFF00	(255,255,0)
	Cyan / Aqua	#00FFFF	(0,255,255)
	Magenta / Fuchsia	#FF00FF	(255,0,255)
	Silver	#C0C0C0	(192,192,192)
	Gray	#808080	(128,128,128)
	Maroon	#800000	(128,0,0)
	Olive	#808000	(128,128,0)
	Green	#008000	(0,128,0)
	Purple	#800080	(128,0,128)
	Teal	#008080	(0,128,128)
	Navy	#000080	(0,0,128)

Figure31: Colour Range Table

By defining the ranges of different colour in algorithm didn't give a perfect filtration of selected colour and so we created a trace bar through which we can manually change the HSV range of the colour we required.

Next a threshold to HSV image was provided to get only the components of selected colour for example if we are selecting blue colour it will only select components of blue.

Later the filtered colour is sharpened using high pass filter and smoothened using low pass filter.

Figure 32 shows the filtered colour from image provided.

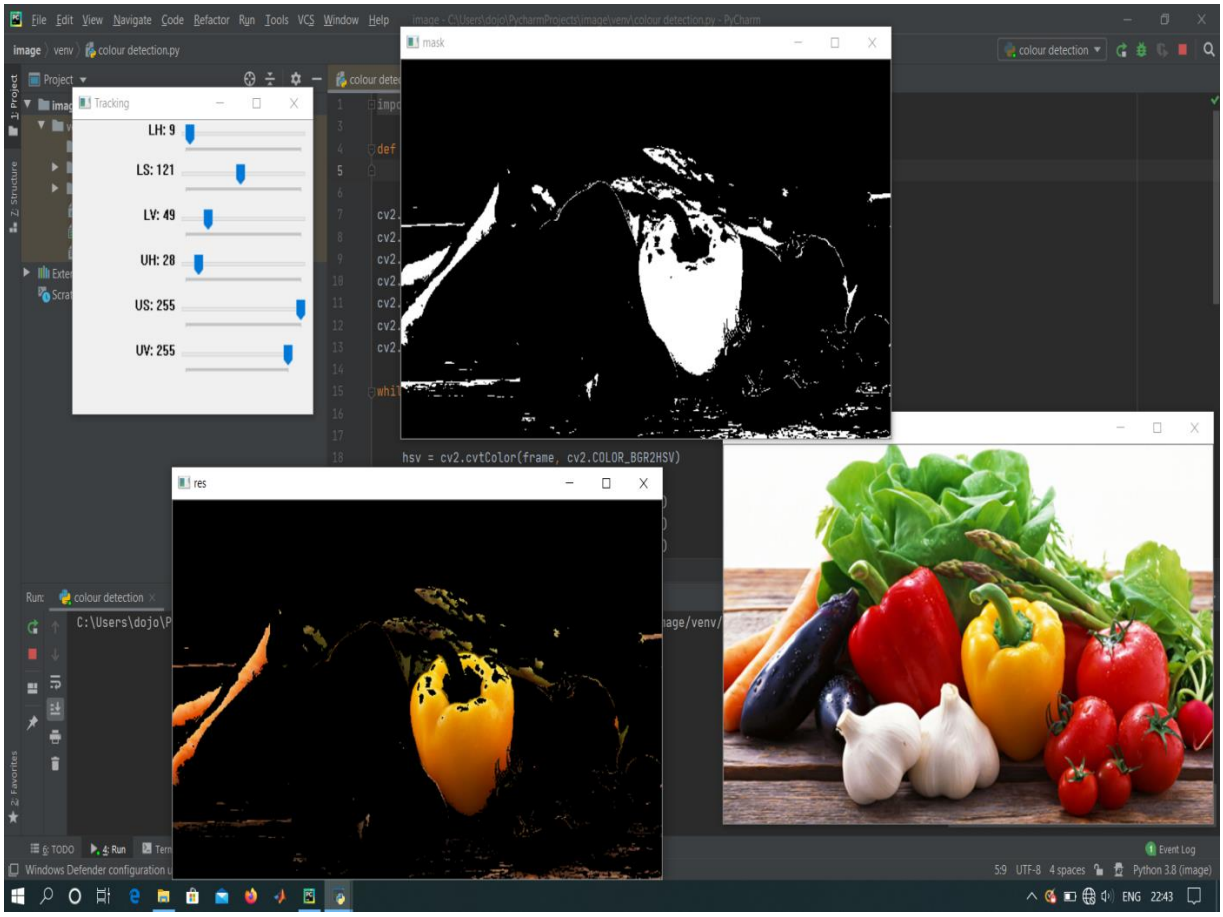


Figure32: Filtered Output

Same algorithm was slightly changed to perform video processing in which we have filtered the specific coloured moving image/ object. The colour can be selected using trace bar where it is allowed to change HSV ranges manually .

The changes we did are we used **cv2.Videocapture(0)** object to capture video from the default camera that is pi camera

4.4 COLOUR DETECTION USING MATLAB ALGORITHM

IMAGE PROCESSING ALGORITHM IN PROJECT

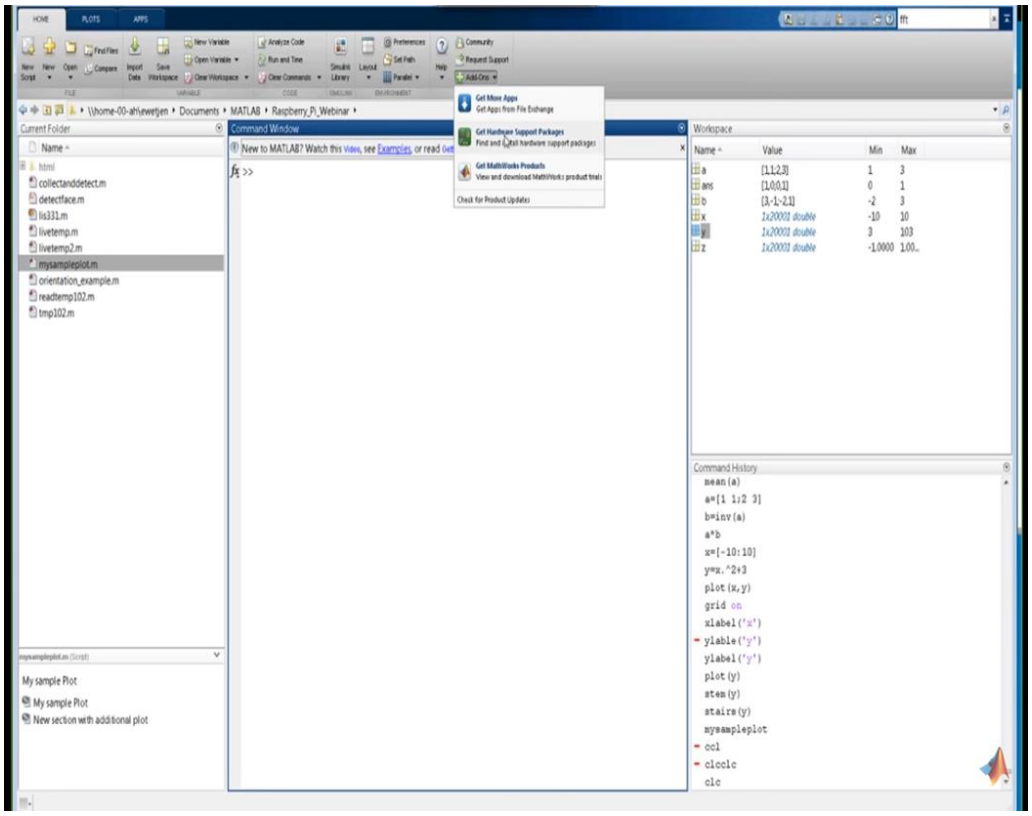
Communication of Raspberry-pi and MATLAB

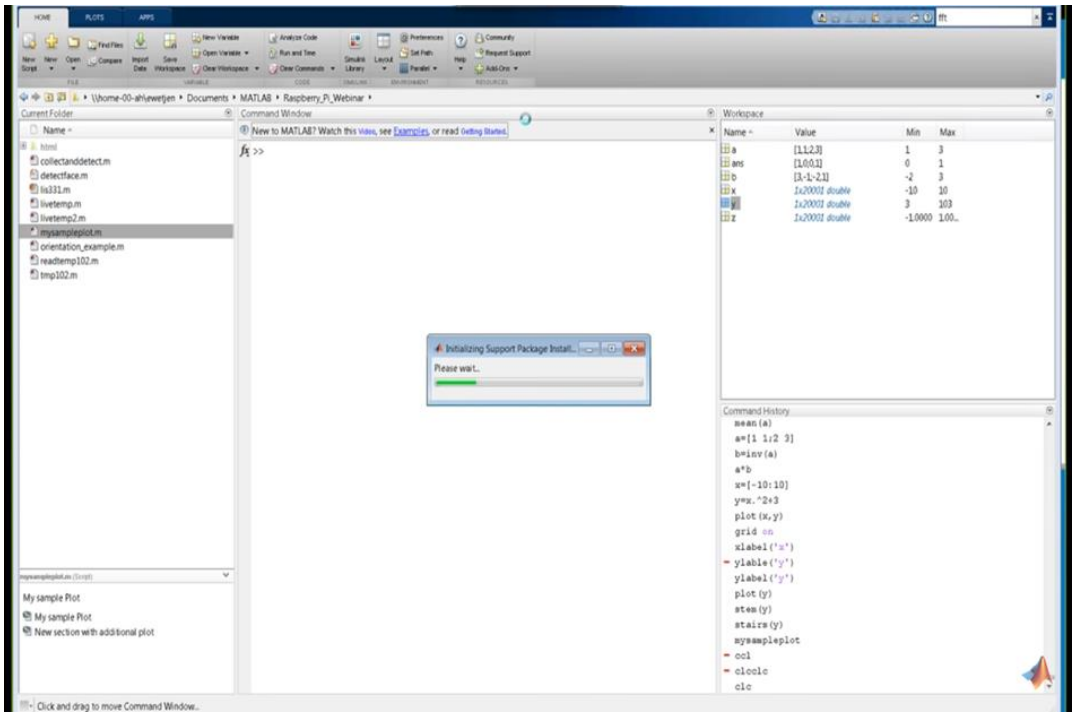
Installation and Setup

To fetch the image captured by pi camera and process it further, MATLAB was allowed to have connection with raspberry pi used in our project.

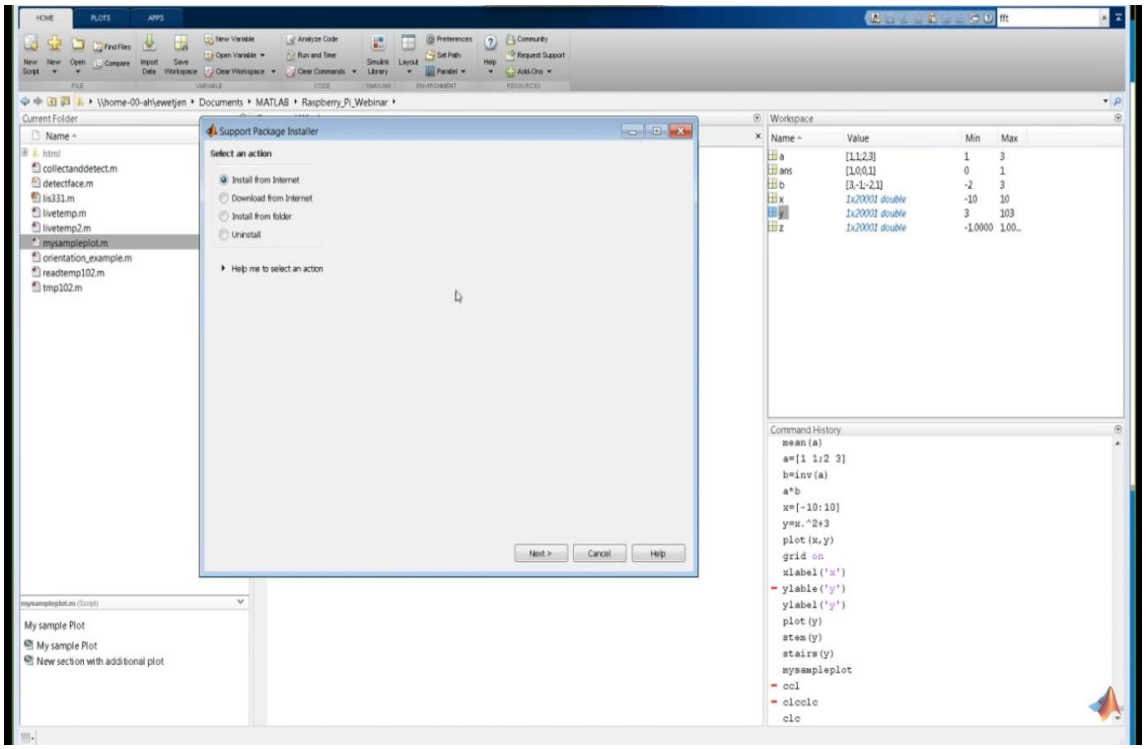
First step was Installing Raspberry pi support package for MATLAB.

1) go to MATLAB→home tab→add-ons→get hardware support packages.

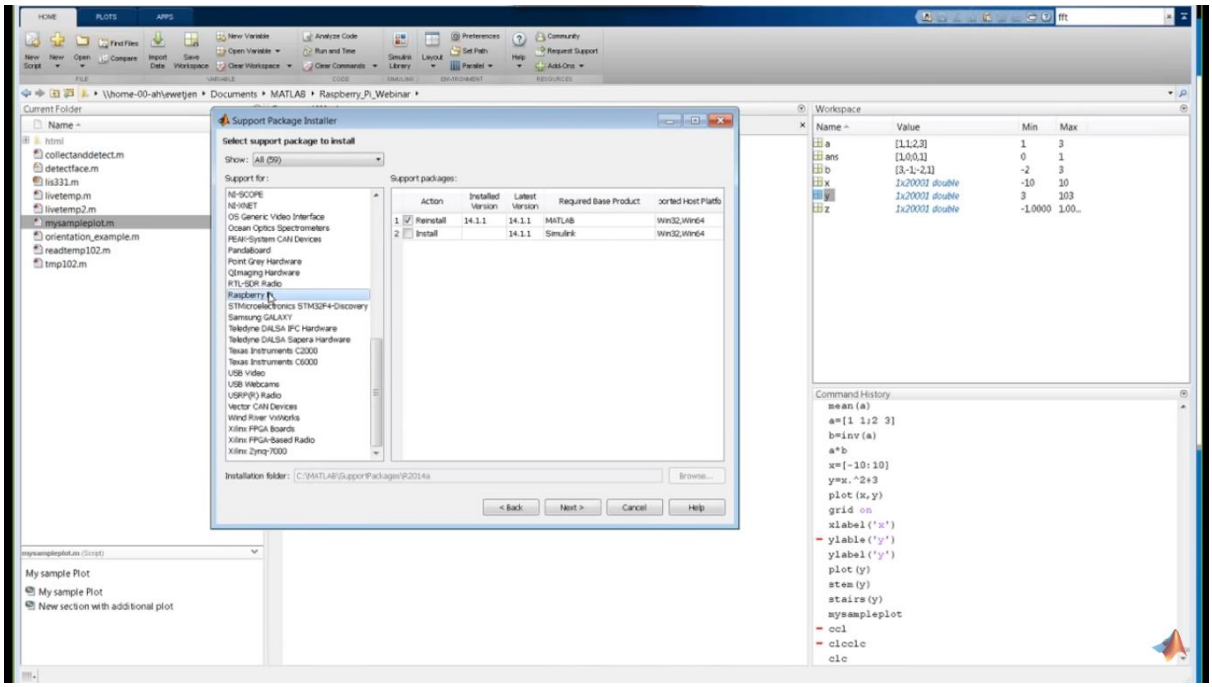




2) Support package installer→ select install from internet radio button→next.



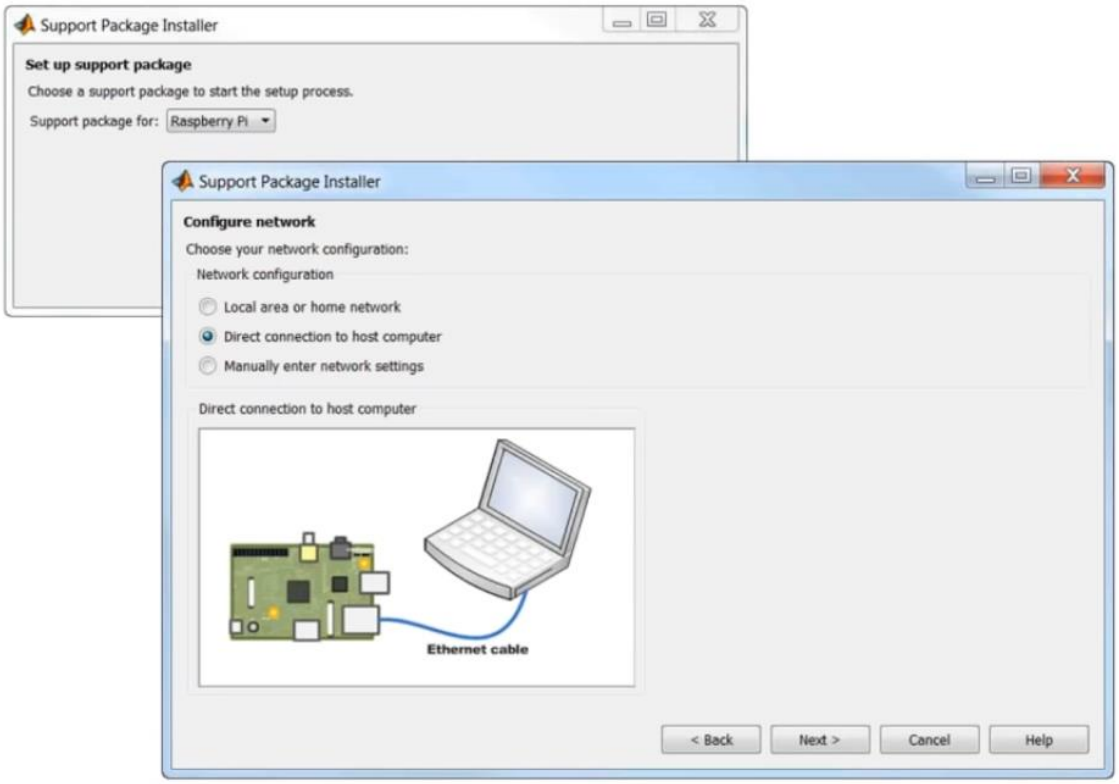
3) Then there comes different hardware that can be installed so in our case we choose RASPBERRY PI option and install.



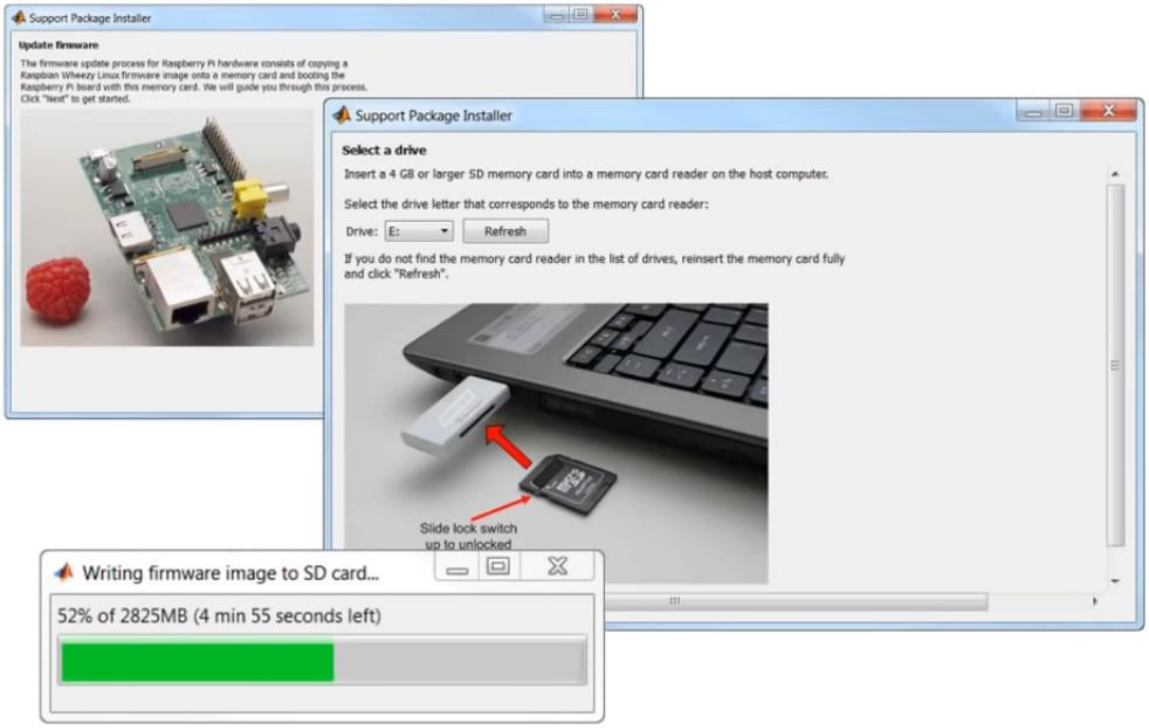
4) The installer will not only download the needed MATLAB components but will also download third required party components.

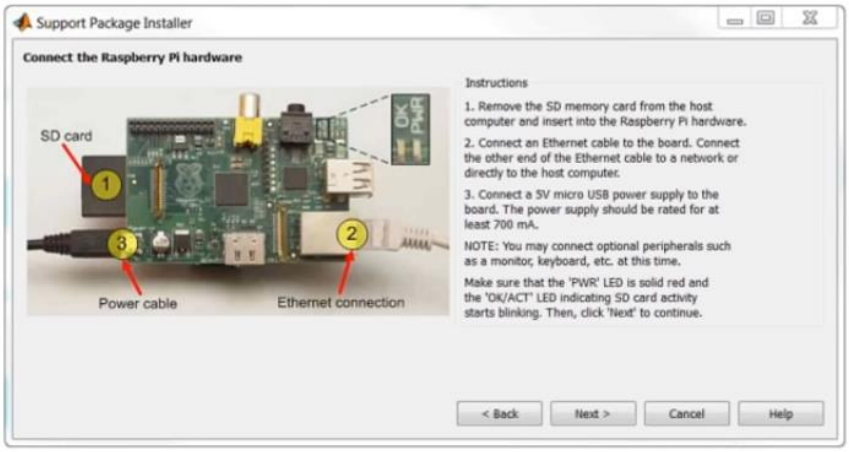
5) Select Raspberry pi→next

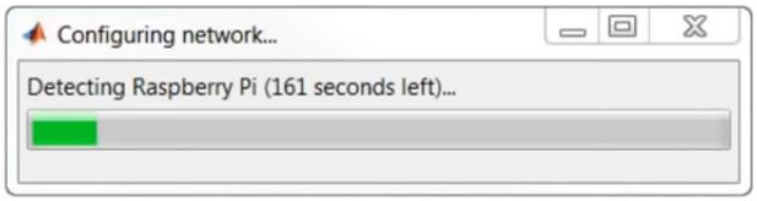
6) Now there is a network configuration. We have connected directly to the raspberry pi from laptop using USB Ethernet adapter.

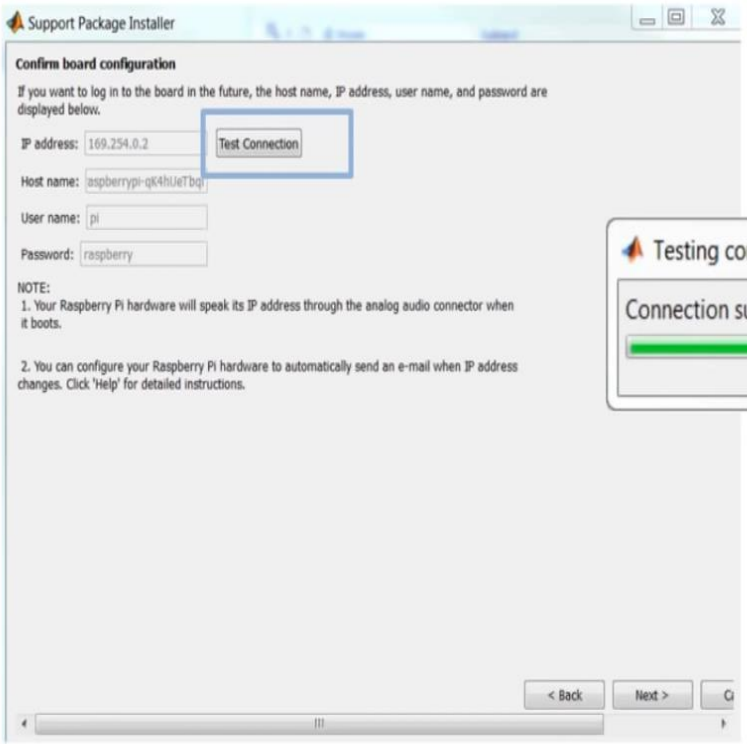


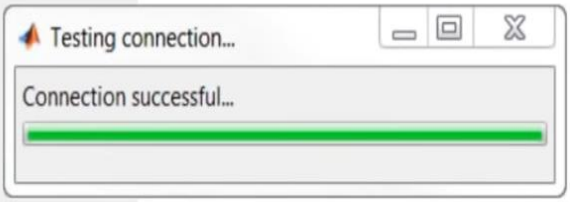
7) For this reason choose Direct connection to host computer.
8) Upload the Firmware.




Support Package Installer
Connect the Raspberry Pi hardware
SD card
Power cable
Ethernet connection
Instructions
1. Remove the SD memory card from the host computer and insert into the Raspberry Pi hardware.
2. Connect an Ethernet cable to the board. Connect the other end of the Ethernet cable to a network or directly to the host computer.
3. Connect a 5V micro USB power supply to the board. The power supply should be rated for at least 700 mA.
NOTE: You may connect optional peripherals such as a monitor, keyboard, etc. at this time.
Make sure that the 'PWR' LED is solid red and the 'OK/ACT' LED indicating SD card activity starts blinking. Then, click 'Next' to continue.
< Back
Next >
Cancel
Help


Configuring network...
Detecting Raspberry Pi (161 seconds left)...


Support Package Installer
Confirm board configuration
If you want to log in to the board in the future, the host name, IP address, user name, and password are displayed below.
IP address: 169.254.0.2
Test Connection
Host name:
User name: pi
Password: raspberry
NOTE:
1. Your Raspberry Pi hardware will speak its IP address through the analog audio connector when it boots.
2. You can configure your Raspberry Pi hardware to automatically send an e-mail when IP address changes. Click 'Help' for detailed instructions.
< Back
Next >


Testing connection...
Connection successful...

Connection to Raspberry Pi Hardware

The syntax used to perform connection is given:

Syntax

mypi = raspi

mypi = raspi(ipaddress,username,password)

mypi = raspi(hostname,username,password)

mypi = raspi(name)

mypi = raspi(serialnumber)

Description

mypi = raspi creates a connection, mypi, from the MATLAB® software to the Raspberry Pi™ board. Use this syntax to connect or reconnect to the same board.

You do not need to supply the user IP address, user name, and password to create a connection. The raspi object reuses these settings from the most recent successful connection to a Raspberry Pi board. These settings must be provided for the first connection created during the setup process.

In MATLAB Online™, the raspi object reuses the settings from the most recent successful connection. If connecting for the first time, this syntax is used to create a connection to the first Raspberry Pi board listed by raspilist with status "Ready to connect".

After connecting to the board, you can use mypi to interact with the Raspberry Pi board and peripheral devices.

To close the connection, use clear to remove mypi and any other connections that use mypi

mypi = raspi(ipaddress,username,password)

overrides the IP address, user name, and password from the previous connection. Use this syntax to connect to a board whose settings are different from the previous successful connection. After changing the password on a board, use this syntax. Or, after connecting from the MATLAB software to a second Raspberry Pi board, use this syntax. You can use this syntax without username and address if a successful connection has been previously created with this syntax. This syntax is not supported in MATLAB Online.

Connect to a Raspberry Pi Board:

Create a connection, mypi, from the MATLAB software to a Raspberry Pi board.

```
mypi =

  Raspi with Properties:

          DeviceAddress: 'raspberrypi-hysdu8X38o'
                   Port: 18735
              BoardName: 'Raspberry Pi Model B Rev 2'
          AvailableLEDs: {'led0'}
    AvailableDigitalPins: [4 7 8 9 10 11 14 15 17 18 22 23 24 25 27 30 31]
    AvailableSPIChannels: {}
      AvailableI2CBuses: {'i2c-0'  'i2c-1'}
       AvailableWebcams: {'USB2.0 PC CAMERA: USB2.0 PC CAM (usb-20980000.usb-1.5):'}
            I2CBusSpeed: 100000
```

Connect to a Board That Has Different Settings

Using host name instead of an IP address to connect from the MATLAB software to a Raspberry Pi board. This syntax is not supported in MATLAB Online.

Support Package Installer generates the Raspberry Pi host name during the setup process.

```
mysecondpi =

  Raspi with Properties:

          DeviceAddress: 'raspberrypi-hysdu8X38o'
                   Port: 18735
              BoardName: 'Raspberry Pi Model B Rev 2'
          AvailableLEDs: {'led0'}
    AvailableDigitalPins: [4 7 8 9 10 11 14 15 17 18 22 23 24 25 27 30 31]
    AvailableSPIChannels: {}
       AvailableI2CBuses: {'i2c-0'  'i2c-1'}
        AvailableWebcams: {'USB2.0 PC CAMERA: USB2.0 PC CAM (usb-20980000.usb-1.5):'}
             I2CBusSpeed: 100000
```

This is how connection was performed so that Raspberry pi can communicate with MATLAB.

Run MATLAB on Target Hardware (RASPBERRY PI) by creating Create a MATLAB Function then Create a Hardware Configuration Object and at last Add the MATLAB Function to Run-on-Boot. You can add or remove a MATLAB function from Run-on-boot by setting the EnableRunOnBoot property using the following MATLAB function:

```
board.EnableRunOnBoot = true

board =

targetHardware with properties:

                Name:  'Raspberry Pi'
       DeviceAddress:  '176.93.236.232'
            Username:  'pi'
            Password:  '**********'
            BuildDir:  '/home/pi'
    EnableRunOnBoot:  1
         BuildAction:  'Build, load, and run'
         CoderConfig:  [1x1 coder.CodeConfig]
```

Fetching camera feeds from Raspberry PI using MATLAB:

Since in this project module MATLAB needs to communicate with Raspberry Pi camera so there are certain settings to connect with Raspberry Pi to **cameraboard.**

Syntax

mycamera = cameraboard(mypi)

mycamera = cameraboard(mypi,Name,Val

Description

mycamera = cameraboard(mypi) creates a connection, mycamera, from the MATLAB software to a camera board on the Raspberry Pi hardware.

mycamera = cameraboard(mypi,Name,Value) uses name-value pair arguments to override the default values of writable camera board properties. You can use these properties to control image properties such as size, resolution, orientation, exposure, and special effects**.**

Use the Camera Board

These are the objects used to record the video, capture the images and stop the video recording.

Record = Record video from Camera Board

stop = Stop video recording from Camera Board

snapshot = Capture RGB image from Camera

```
mycam =

Cameraboard with Properties:

                    Name: Camera Board
              Resolution: '1280x720'       (View available resolutions)
                 Quality: 10               (1 to 100)
                Rotation: 0                (0, 90, 180 or 270)
          HorizontalFlip: 0
            VerticalFlip: 0
               FrameRate: 30               (2 to 30)
               Recording: 0

   Picture Settings
              Brightness: 50               (0 to 100)
                Contrast: 0                (-100 to 100)
              Saturation: 0                (-100 to 100)
               Sharpness: 0                (-100 to 100)

   Exposure and AWB
            ExposureMode: 'auto'           (View available exposure modes)
    ExposureCompensation: 0                (-10 to 10)
                AWBMode: 'auto'            (View available AWB modes)
            MeteringMode: 'average'        (View available metering modes)
```

Import and display a sequence of 10 snapshots on your computer.

```
for ii = 1:10
img = snapshot(mycam)
imagesc(img)
drawnow
end
```

If the image is upside down, change its orientation.

```
mycam.Rotation = 180
```

You can use the same approach to change the values of other cameraboard properties.

Record a 60 second video.

```
record(mycam,'myvideo.h264',60)
```

Stop the recording immediately.

```
stop(mycam)
```

Copy the video from the board to your computer.

```
getFile(mypi,'myvideo.h264','C:\MATLAB ')
```

Delete the video file from the hardware to free up space.

```
deleteFile(mypi,'myvideo.h264')
```

Filtering the colour/ Processing the image fetched from pi camera

Algorithm used:

In this project we used Image Processing Toolbox to detect the required colour from the image fetched. For demo here it is used standard onion, peppers, or kids' image that ships with the Image Processing Toolbox. Later a dialogue box is created which allows to select the fetched image and the algorithm will filter the required colour.

Then the image is separated into its component hue, saturation, and value colour bands. Then the dialogue box approaches where one can select the colour to be filtered (red, green, yellow, white).

A threshold is computed, and ultimately it finds a mask for the regions of the colour which was selected. Later it will Prompt guide through the demo step by step.

This mask is then multiplied by the original image to show the image with only the selected colour showing and everything else blacked out.

The colour processed will confirm whether the sample water is infected by e-coli or not.

This algorithm can be extended for hundreds of colour shades to be filtered.

Colour Detection Using RGB model in MATLAB:

At the beginning we used RGB (RED, GREEN, BLUE) model to recognize colours in a two-dimensional image using colour thresh-holding technique in MATLAB with the help of RGB colour model to detect a selected colour by a user in an image. The methods involved for the detection of colour in images are conversion of three dimensional RGB image into grey scale image and then subtracting the two images to get two dimensional black and white image.

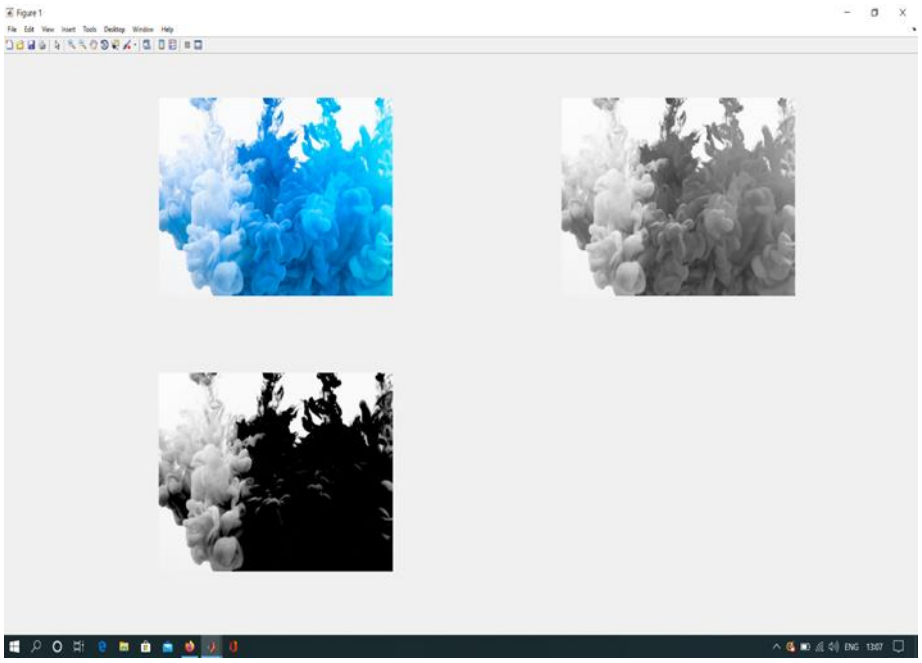


Figure 33:Two dimensional black and white image.

This technique also uses Image Processing Toolbox, but when it comes to detect all shades of single or multiple colour it becomes complicated to select the because the R, G, and B components of an object's colour in a digital image are all correlated with the amount of light hitting the object, and therefore with each other, image descriptions in terms of those components make object discrimination difficult. Descriptions in terms of hue/lightness/chroma or hue/lightness/saturation are often more relevant .

Colour Detection Using HSV model:

The RGB (red, green, blue) colour model is the most popular way to mix and create colours. If you deal with commercial printers, you know about CMYK (cyan, magenta, yellow, key). You might have noticed HSV (hue, saturation, value) in the colour picker of your graphics software. These are schemes that describe the way colours combine to create the spectrum we see.

Unlike RGB and CMYK, which use primary colours, HSV is closer to how humans perceive colour. It has three components: hue, saturation, and value. This colour space describes colours (hue or tint) in terms of their shade (saturation or amount of grey) and their brightness value. Some colour pickers, like the one in Adobe Photoshop, use the acronym HSB, which substitutes the term "brightness" for "value," but HSV and HSB refer to the same colour model.

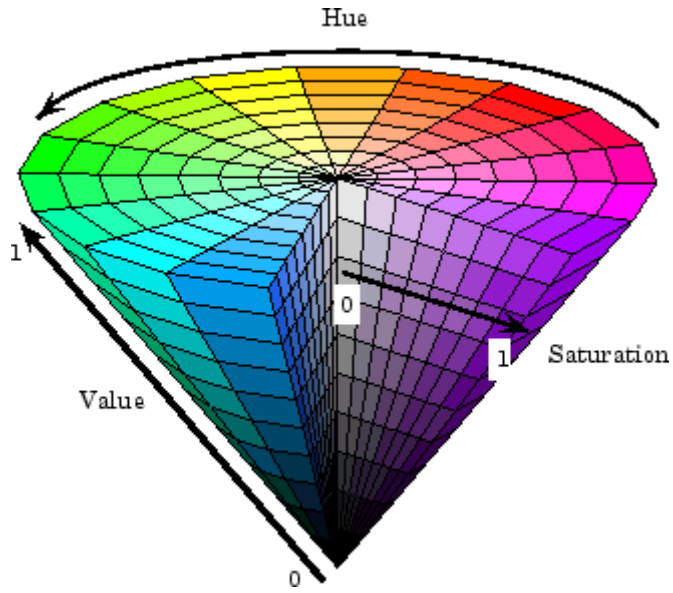


Figure 34: HSV Colour Wheel

The HSV colour wheel sometimes appears as a cone or cylinder, but always with these three components:

Hue

Hue is the color portion of the model, expressed as a number from 0 to 360 degrees:

- **Red** falls between 0 and 60 degrees.
- **Yellow** falls between 61 and 120 degrees.
- **Green** falls between 121 and 180 degrees.
- **Cyan** falls between 181 and 240 degrees.
- **Blue** falls between 241 and 300 degrees.
- **Magenta** falls between 301 and 360 degrees.

Saturation

Saturation describes the amount of grey in a particular colour, from 0 to 100 percent. Reducing this component toward zero introduces more grey and produces a faded effect. Sometimes, saturation appears as a range from 0 to 1, where 0 is grey, and 1 is a primary colour.

Value (or Brightness)

Value works in conjunction with saturation and describes the brightness or intensity of the colour, from 0 to 100 percent, where 0 is completely black, and 100 is the brightest and reveals the most colour.

Results of Detecting colour using HSV model in MATLAB:

Here the dialogue box asks to select Demo or own image that is to be filtered.

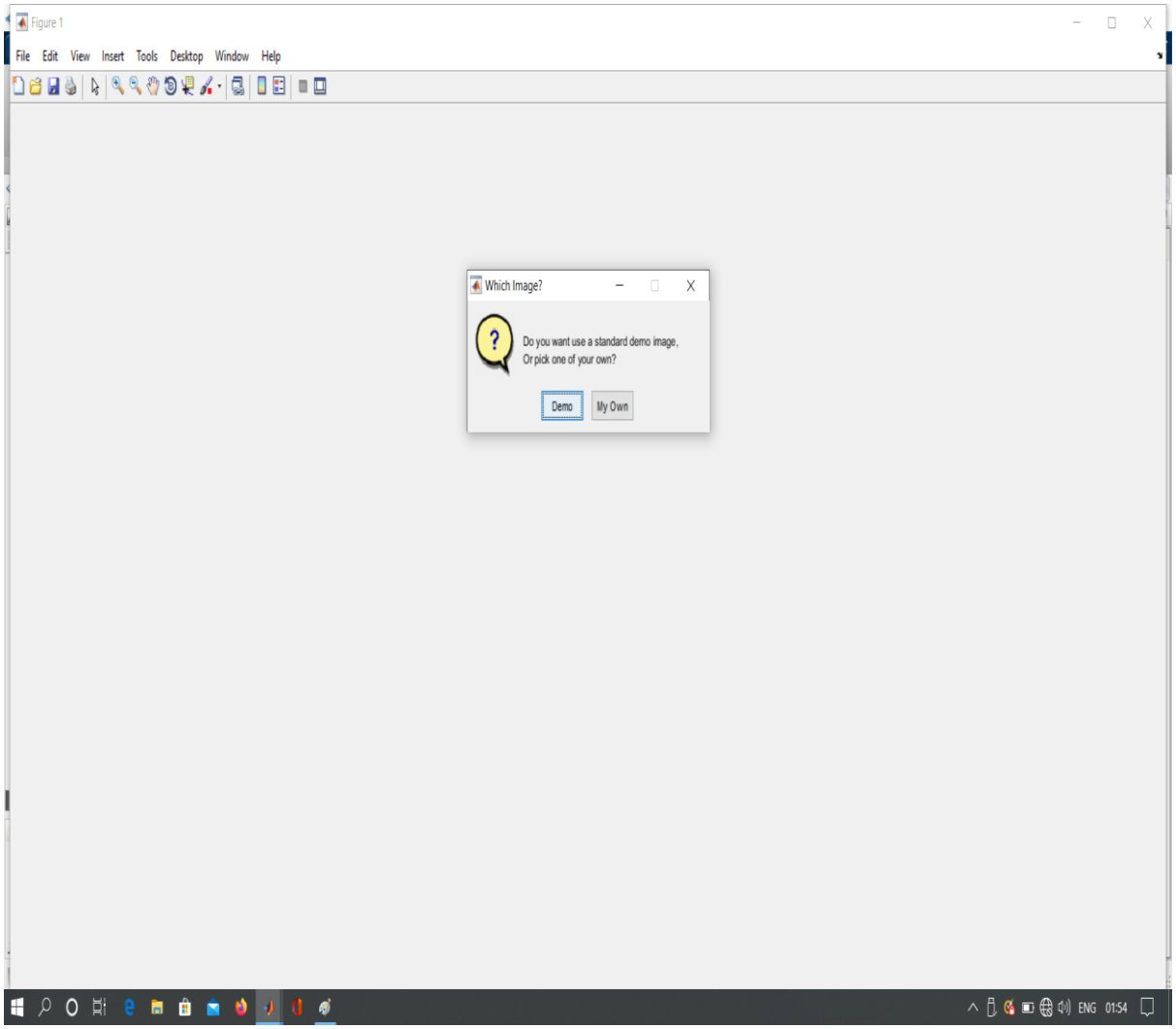


Figure 35: Matlab output screen 1

After the image has been fetched the original image will be separated into three parameters Hue, Saturation and value.

Next one neeeds to select the colour option to be detected and then a threshold is computed, and ultimately it finds a mask for the regions of the colour which was selected.

This mask is then multiplied by the original image to show the image with only the selected colour showing and everything else blacked out.

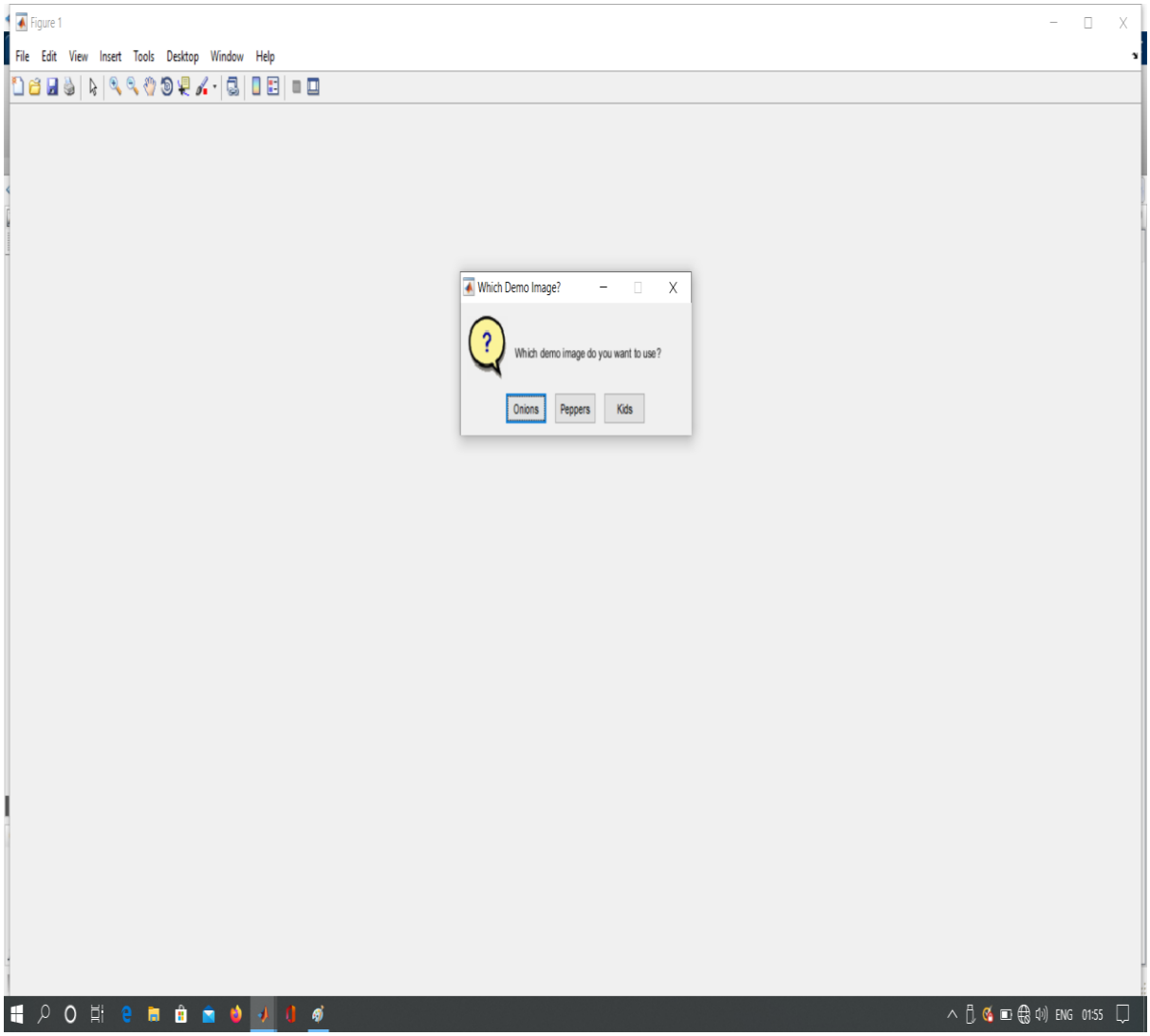


Figure 36: Matlab output screen 2

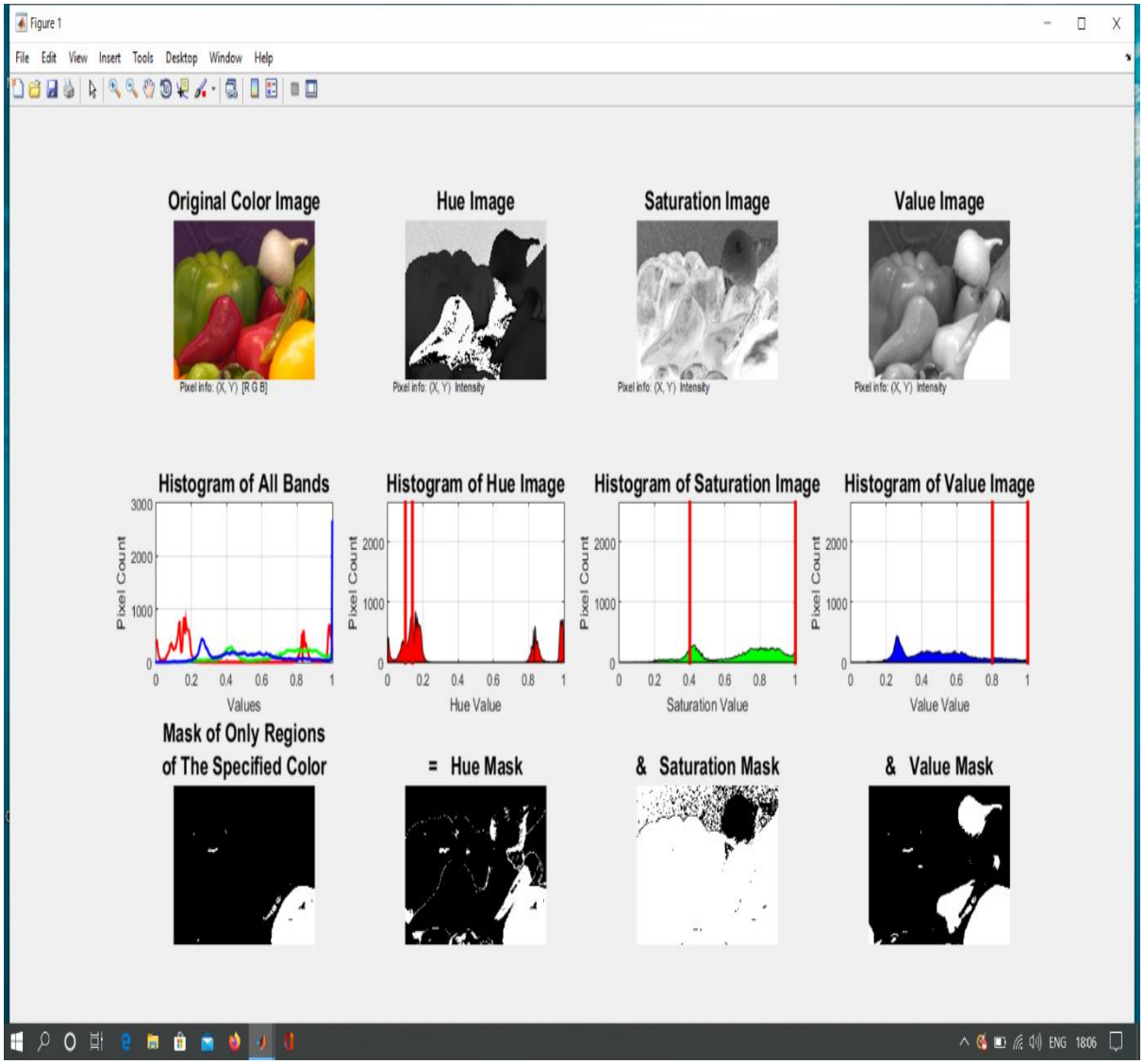


Figure 37: Matlab output screen 3

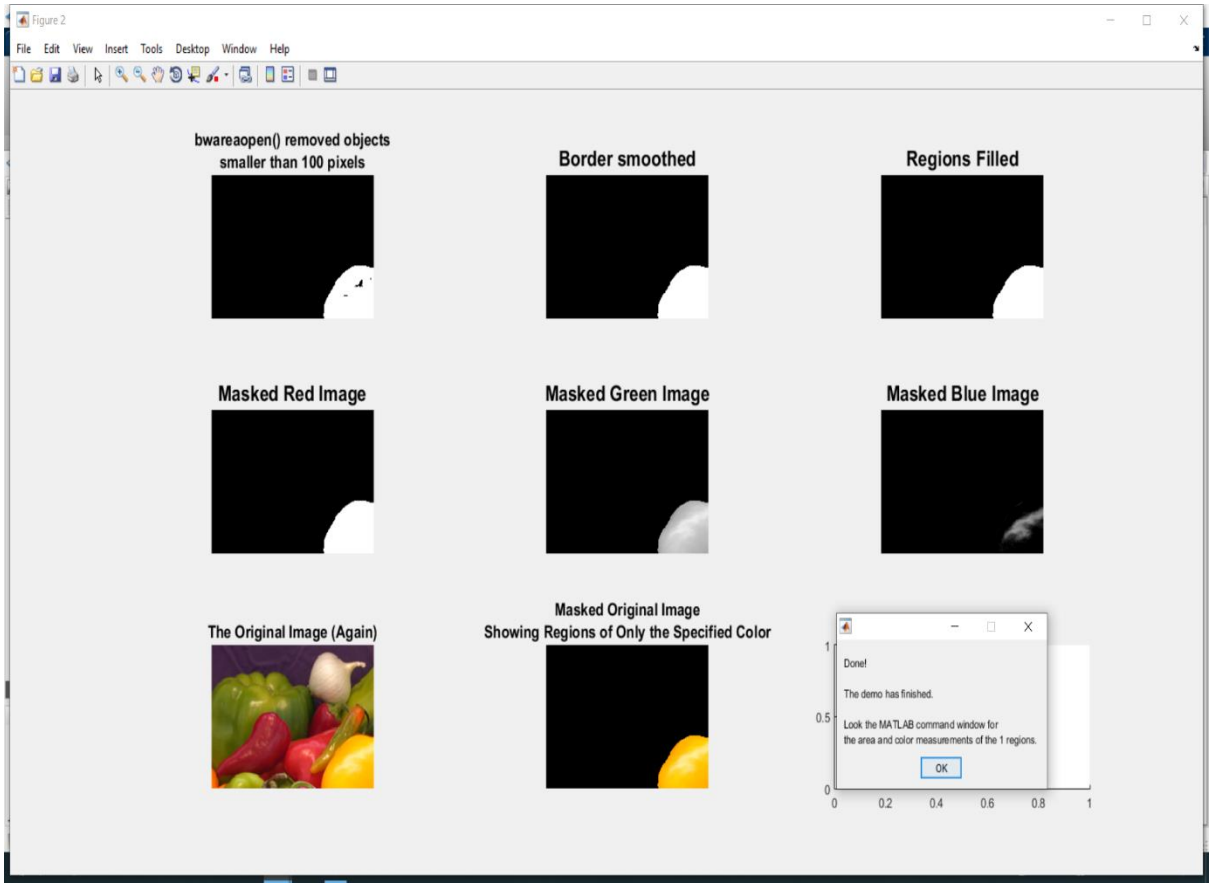


Figure 38: Matlab output screen 4

CHAPTER 5

INTERFACING WITH ANDROID APPLICATION

5.1 ITERFACING FIREBASE WITH ANDROID APPLICATION

Figure 39 : Firebase Logo

To take care of user authentication, security, creating database of all sensor readings and also to store the filtered colour image we have here used Firebase platform.

When one decides to create android app, iOS app or web application, maintaining database is kind of a big problem not because it's tough to design of course it is tricky to design as well as sometimes it consumes lot of bandwidth, trafficking database and android application front end is kind of a big issue. On top the host page is again a problem.

Even managing your own authentication is difficult tricky. So here FIREBASE gives solution to all these problems. It is great platform to maintain your database of videos, login user ID's , images etc. it gives you real time database maintenance this increase debugging level of application.

The database is created regardless of the users location using the application.

Services provided by firebase are:

1. Developing Applications
2. Firebase Cloud Messaging
3. Firebase Authentication
4. Firebase Realtime Database
5. Cloud Firestore
6. Firebase Storage
7. Firebase Hosting

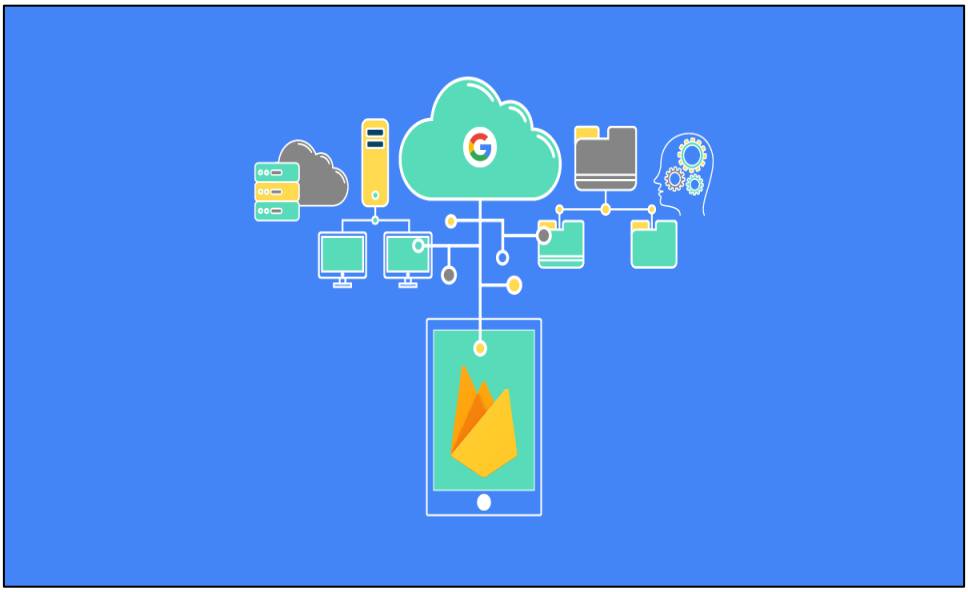


Figure 40: Firebase Layout

We have created a firebase console account and we maintain all our trafficking from there we also maintain all the user's login data, filtered Images from system and also the sensor data values.

To maintain user authentication, we have used Email and Password platform which can be enabled using fibase, it also provides options of logging your app using Facebook, Google, Twitter, phone number, Yahoo, Microsoft. When

choosing any of these options it is necessary to download dependencies for it in Android studio.

We have linked our application using the package name of application with firebase platform and entered all necessary dependencies as well as required credentials.

This how it looks like:

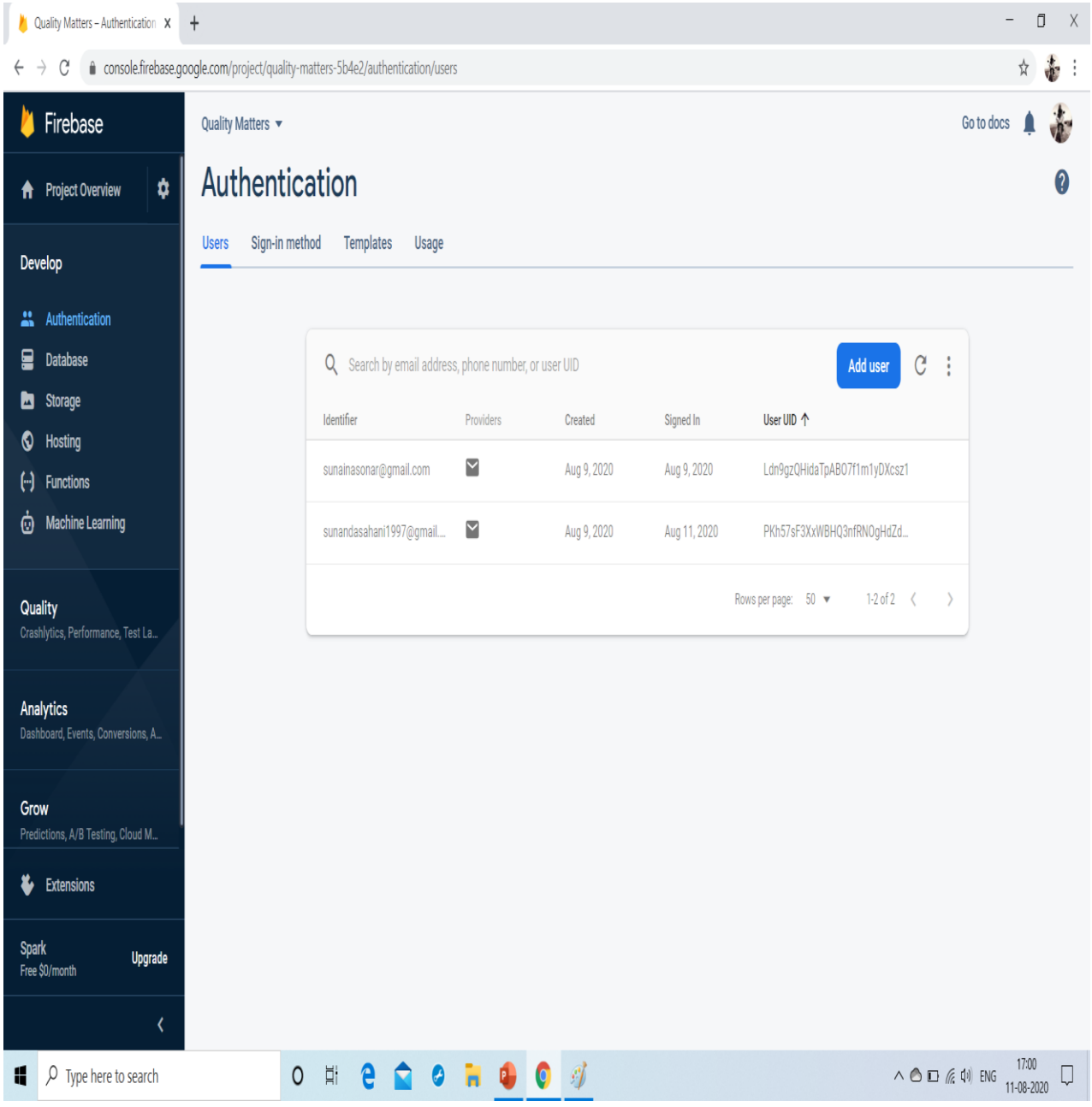


Figure 41 : Firebase Authentication Page

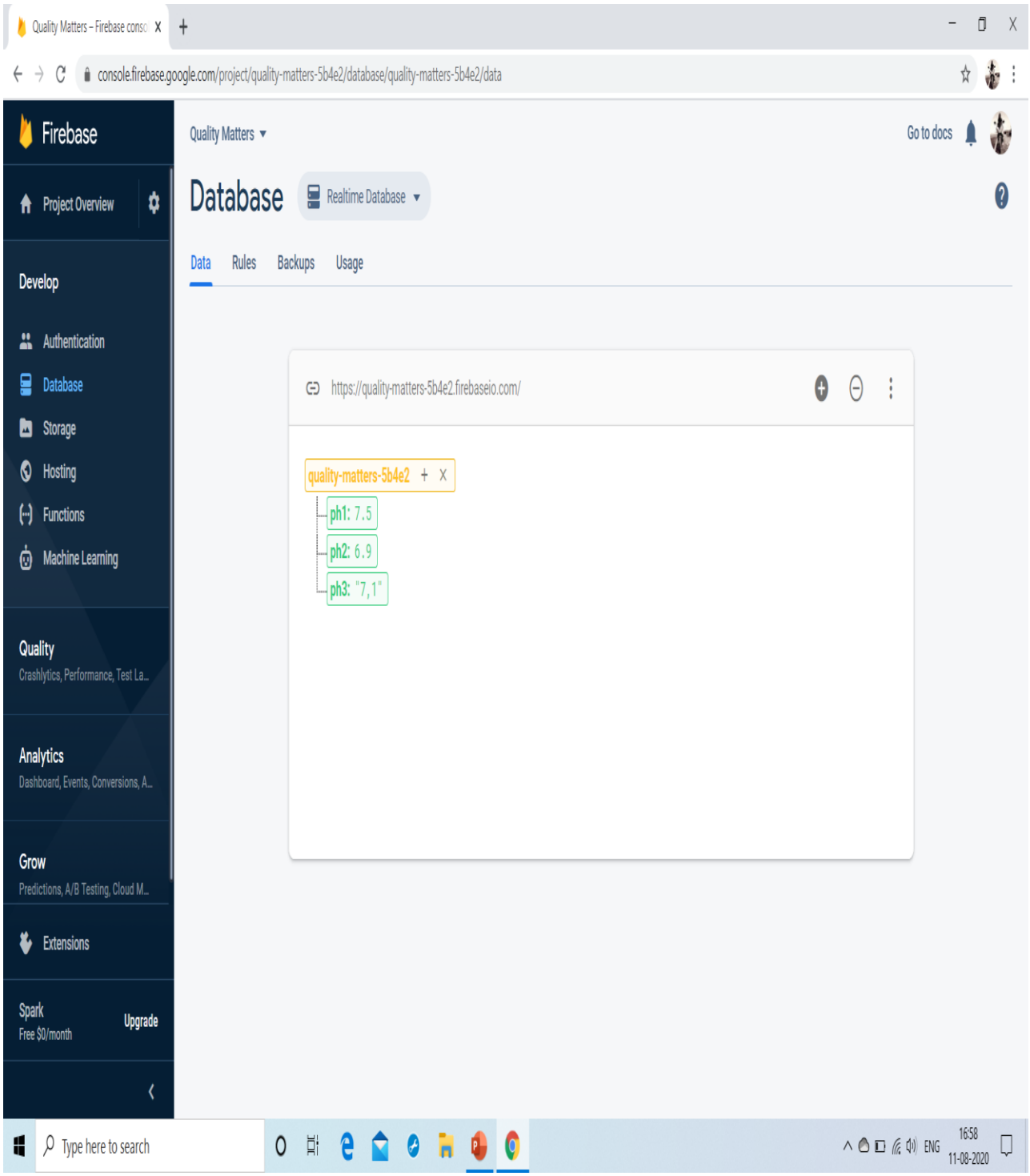


Figure 42 : Firebase Database Page

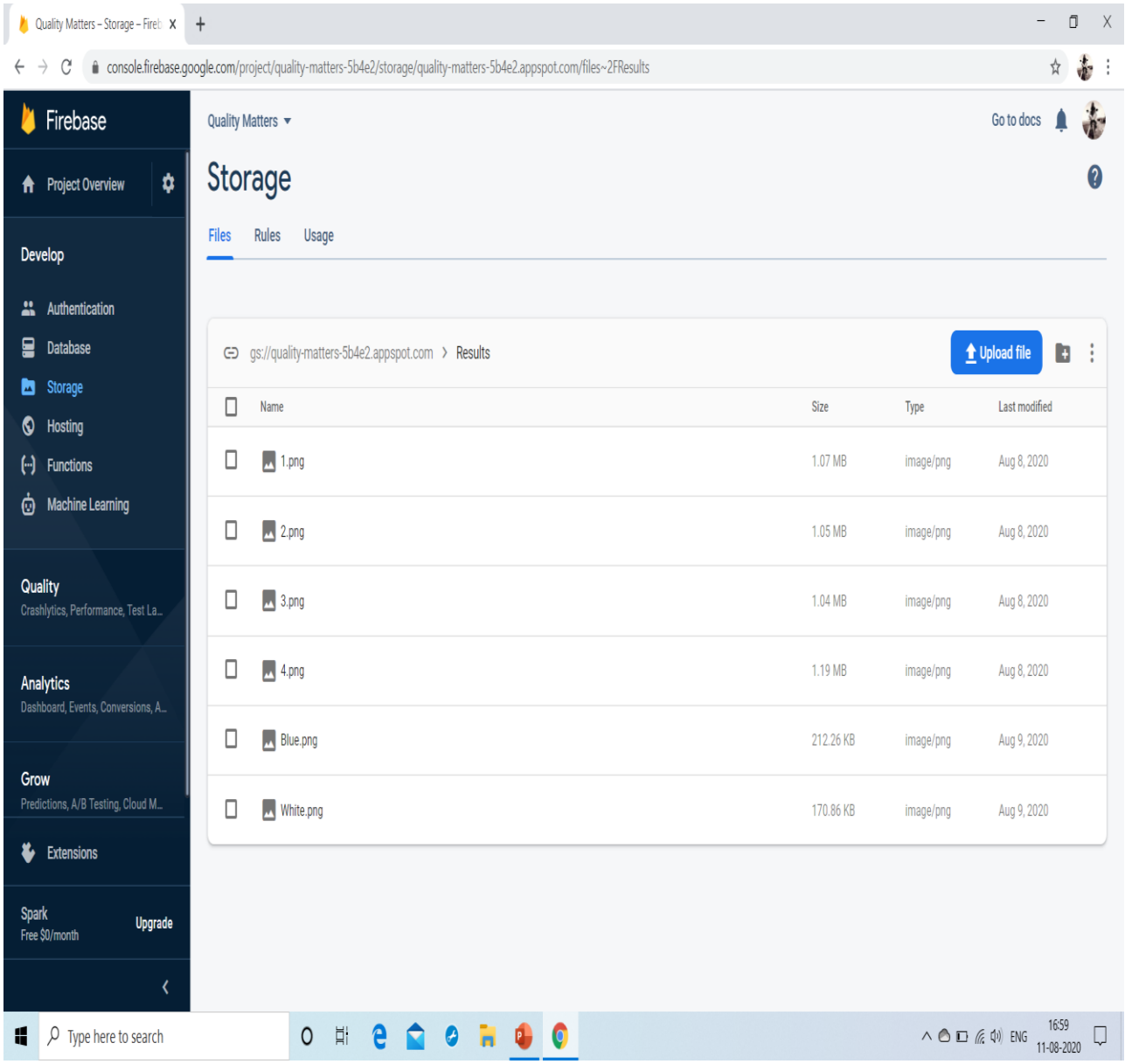


Figure 43 : Firebase Storage Page

Here is the image of android project connected with firebase.

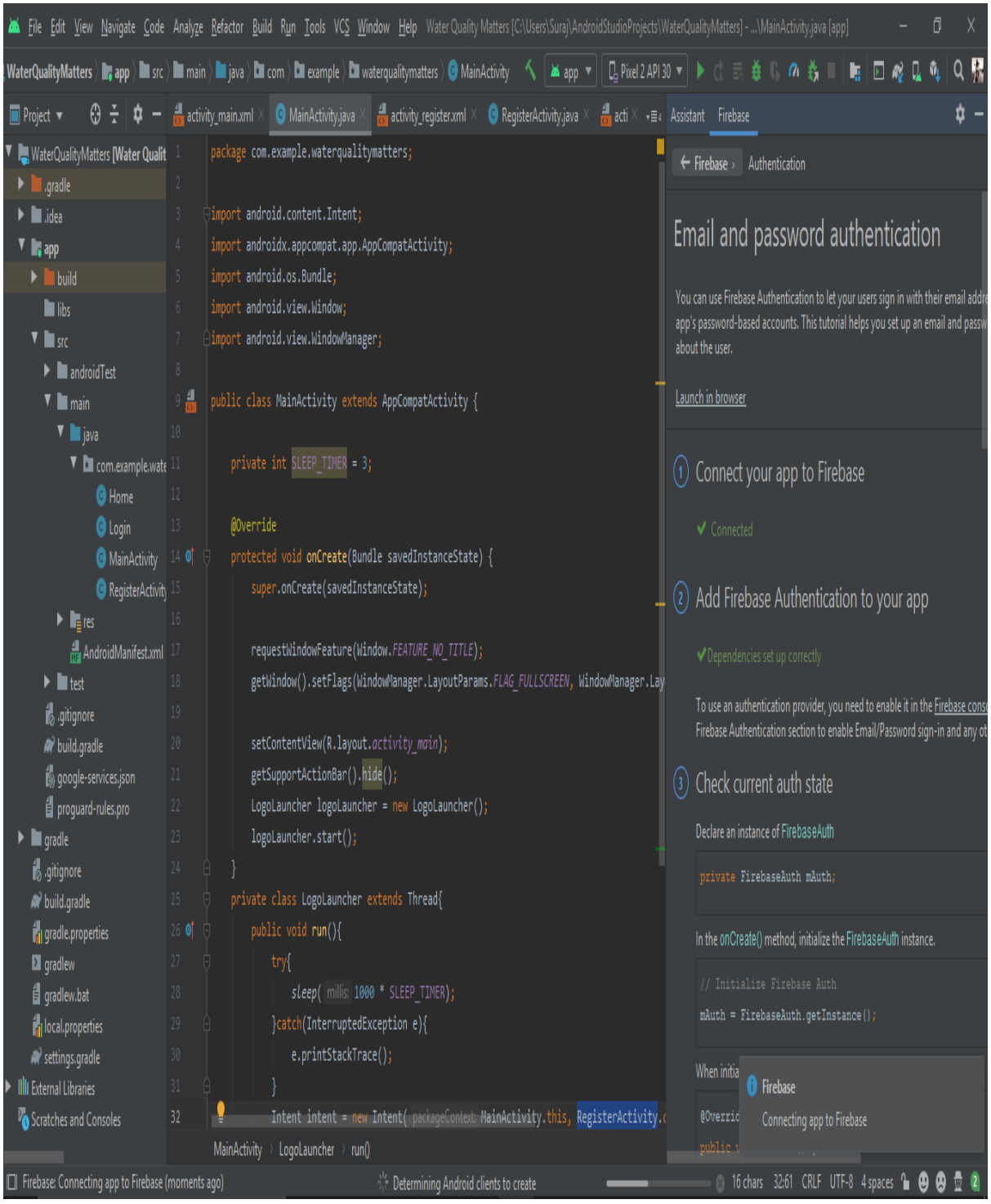


Figure 44 : Firebase connected to Android App.

5.2 SCREENSHOTS OF APPLICATION CREATED

1. Splash Welcome screen with LOGO

Figure 45 : Splash Welcome Screen

2. Registration Screen

Figure 46: Registration Screen

3. Login Screen

Figure 47: Login Screen

4. Home Screen Showing pH value and image fetched from python:

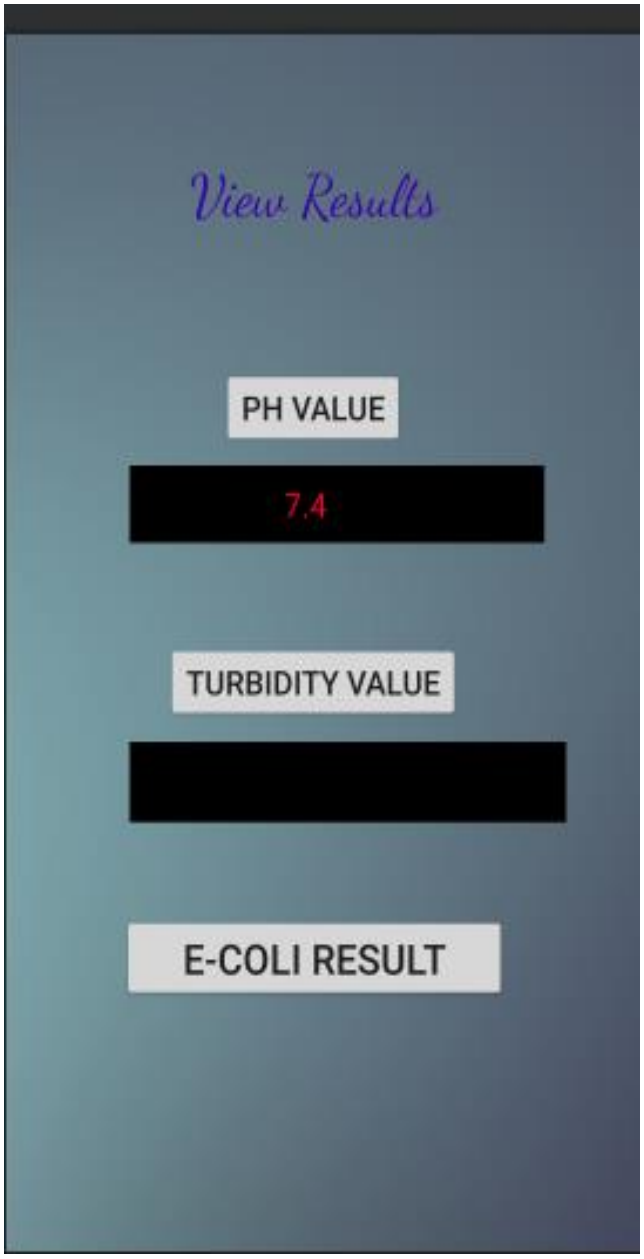


Figure 48 : Home Screen

5. Detected colour fetched from RPi real time database

Figure 49: E-Coli Result Screen

CHAPTER 6

RESULTS AND CONCLUSIONS

Results and conclusion

All three motors are used to perform biological function for e-coli detection are successfully running their functions. Simultaneously the sensors interfaced with system also reads the value (pH and Turbidity value) of sample under test.

After adding reagent to water when colour changes the camera takes a snapshot and saves it in memory.

In MATLAB the snapshot is selected and the algorithm-built processes that image and filters the required colour. After getting the resultant image MATLAB saves the image again on raspberry pi successfully.

Also, OpenCV python is used for image and video processing. So, python will directly take the snapshot after it is clicked by pi camera. It is easy for OpenCV to take picture directly because OpenCV python is interfaced directly to pi camera board. The algorithm-built processes the data and detects only the required colour successfully.

Raspberry pi was interfaced with Google firebase where all the data from controller was saved as real-time cloud database. Using reference database function android application fetched data from firebase database and displayed on it.

MATLAB IMAGE PROCESSING RESULT

In the project two algorithms are implemented to perform detection of colour change and filter the required colour to indicate whether water is infected by E-Coli or not. If E-Coli is present the water will change into white or remain colourless and if it is present water will turn into any shades of blue pigment after biological reaction is performed by the system.

The result from MATLAB colour filtering is attached below, where both demo images and real time camera feeds are used to for colour detection image processing. The image which we need to filter is selected and the required colour is detected by MATLAB algorithm. Here Yellow colour is detected and filtered.

At the first stage of algorithm original image is converted into HSV image as shown in the pictures below hue image, saturation image and value image is displayed at first step in MATLAB. As in Yellow colour is selected for filtration mask of only the region of specified colour is displayed.

The pixels which are smaller than hundred are removed from mask and that region is smoothened. The HSV image is then converted into RGB image and later RGB image is converted into original image from which the selected region is displayed in its original colour form and other colours from that image blackens out. Here yellow colour is displayed.

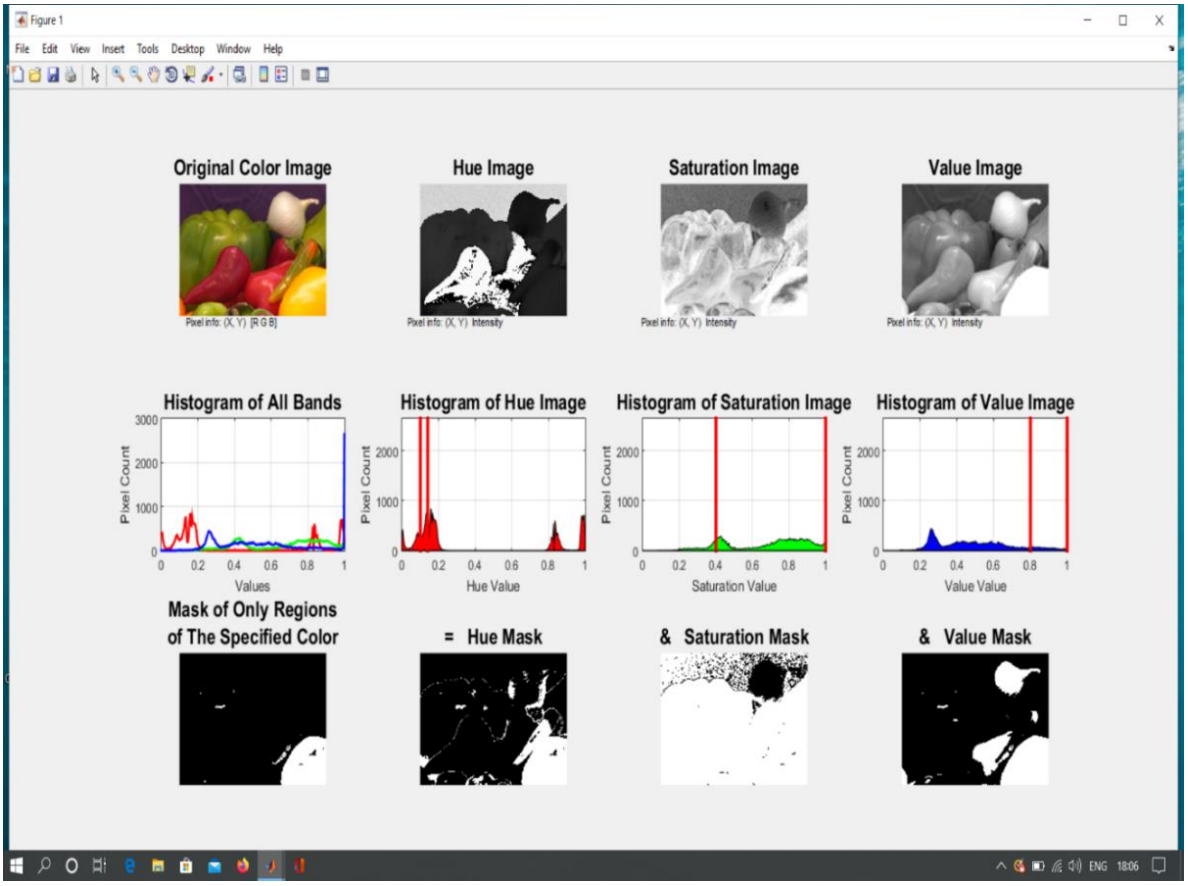


Figure 50: Original image into HSV image (MATLAB)

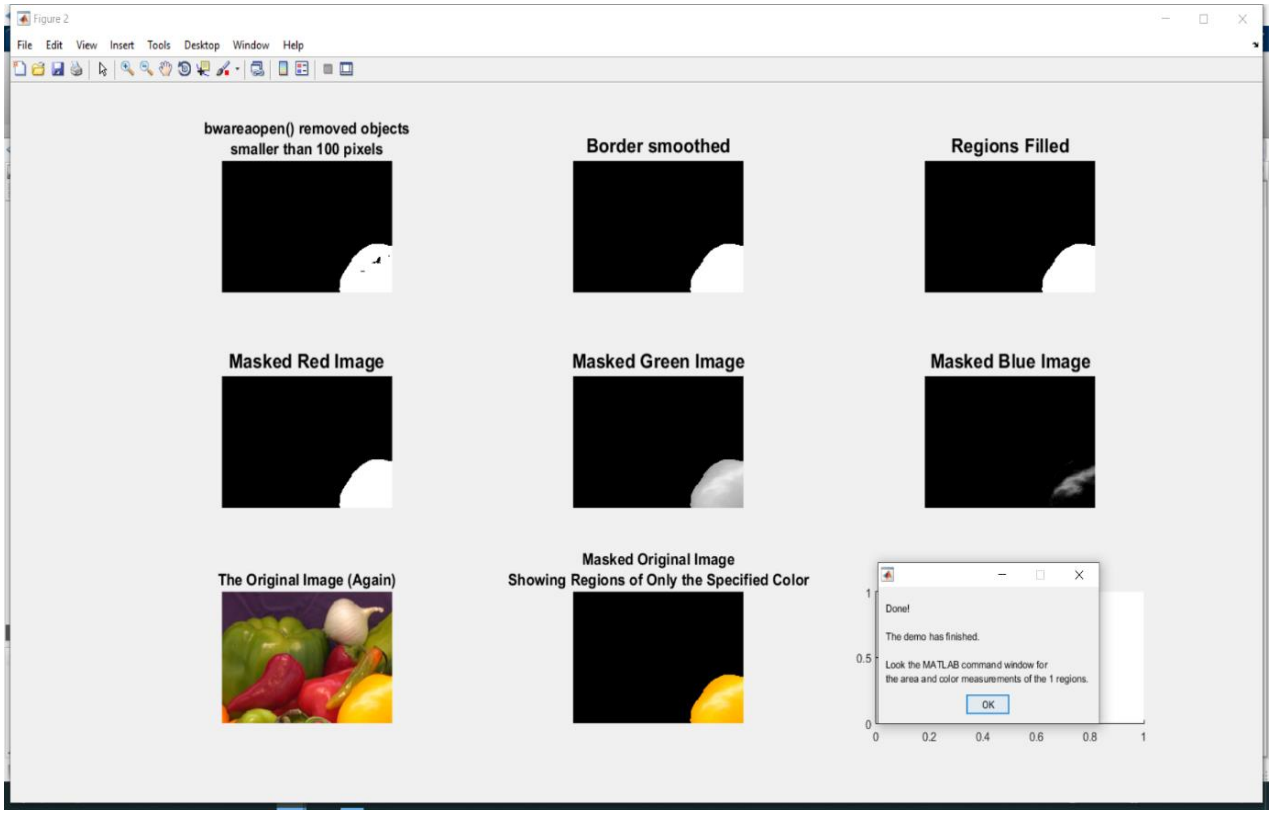


Figure 51: Yellow colour component detected (MATLAB)

II) OPENCV PYTHON IMAGE PROCESSING RESULTS

As mentioned before the second implementation of algorithm for detecting colour is OpenCV-python. This method gives more precise result compared to MATLAB algorithm and is also easy to interface with Raspberry pi.

Here the colour is selected using a trace bar created where the cursor is simply needs to be dragged horizontally left or right for adjustment depending upon the range of colour require to filter. Similar to MATLAB algorithm here also at first step an original image is converted into HSV image.

Using trace bar shown below in the picture lower and higher range hue, saturation and value of a particular colour is set, by doing this the algorithm automatically filters the colour of that particular range. By specifying the lower and higher range of HSV of a colour gives us perfect and precise required result.

Below Red, Yellow, White and Green colours are filtered from the image.

DEMO OUTPUTS:

RED COLOUR FILTERED

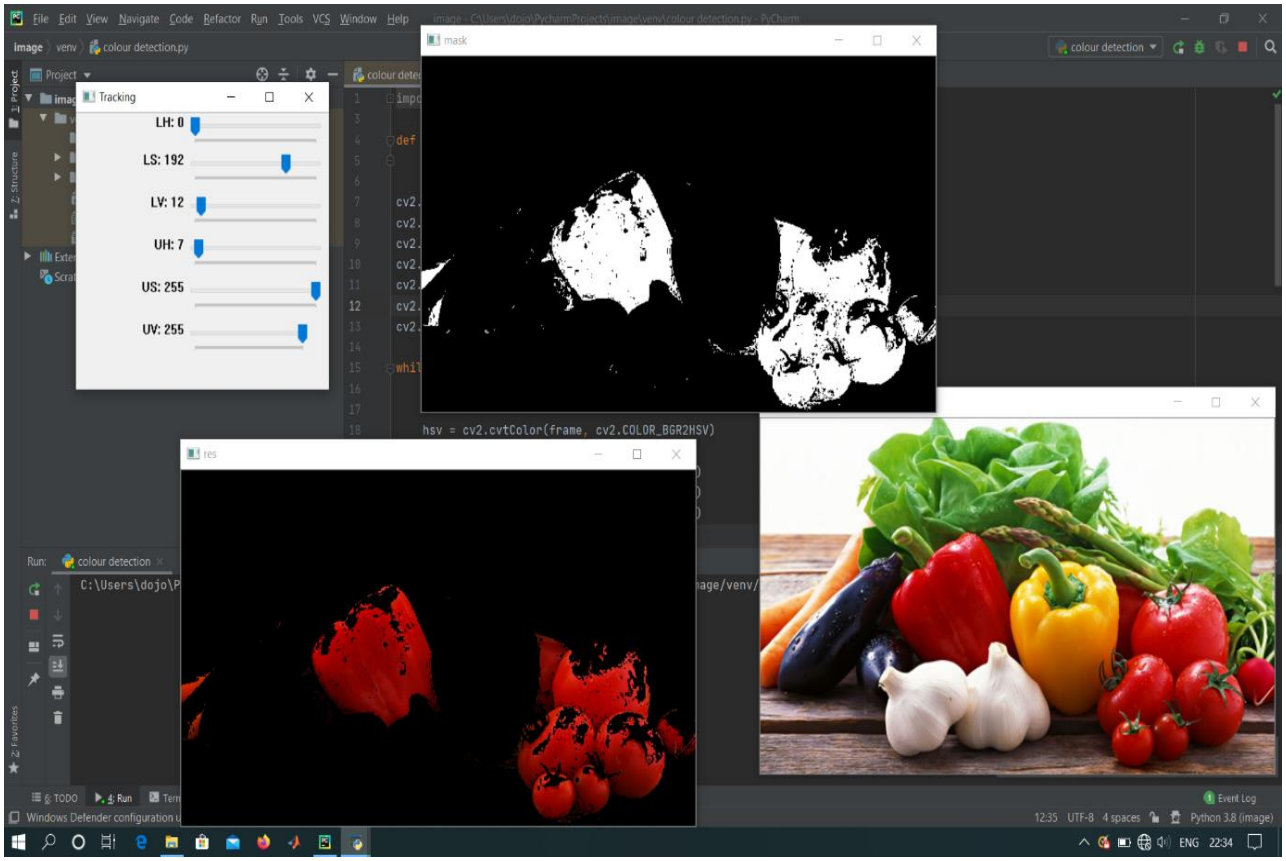


Figure 52 :Red Component detected from image(OpenCV Python)

YELLOW COLOUR FILTERED

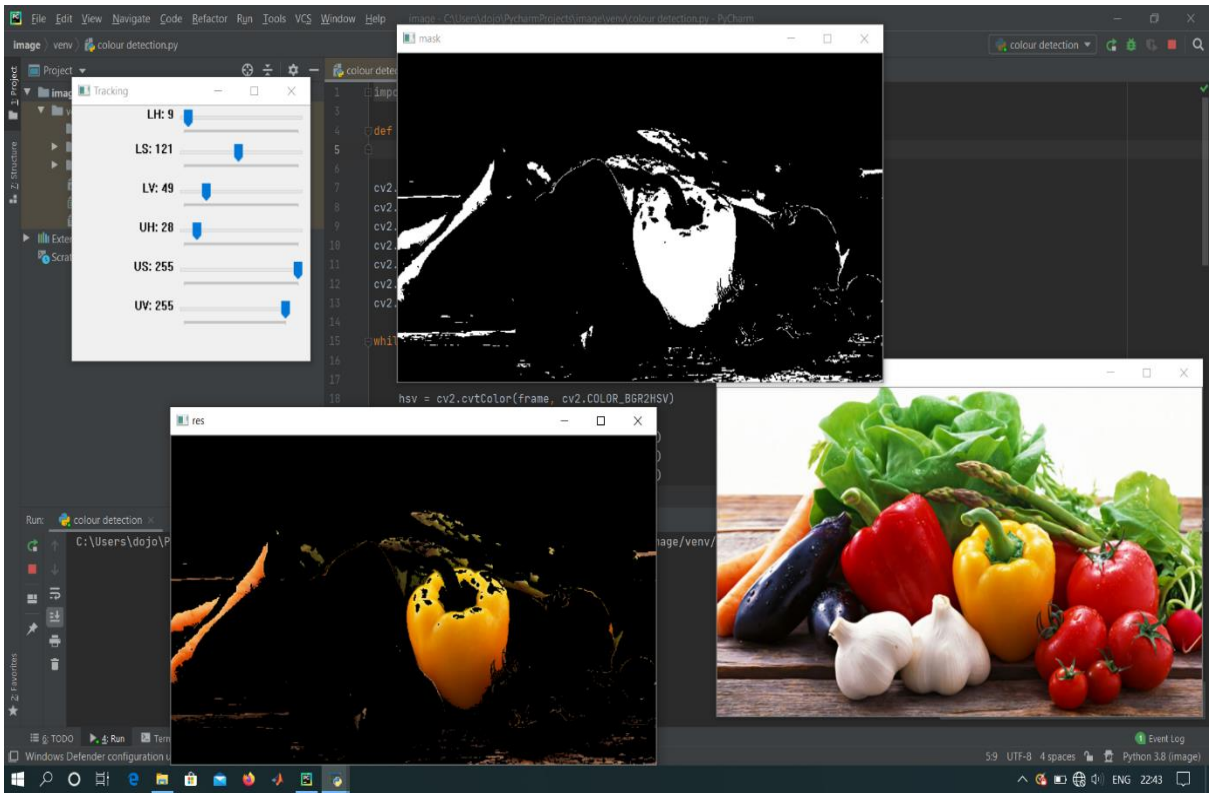


Figure 53:Yellow Component detected from image(OpenCVPython)

WHITE COLOUR FILTERED

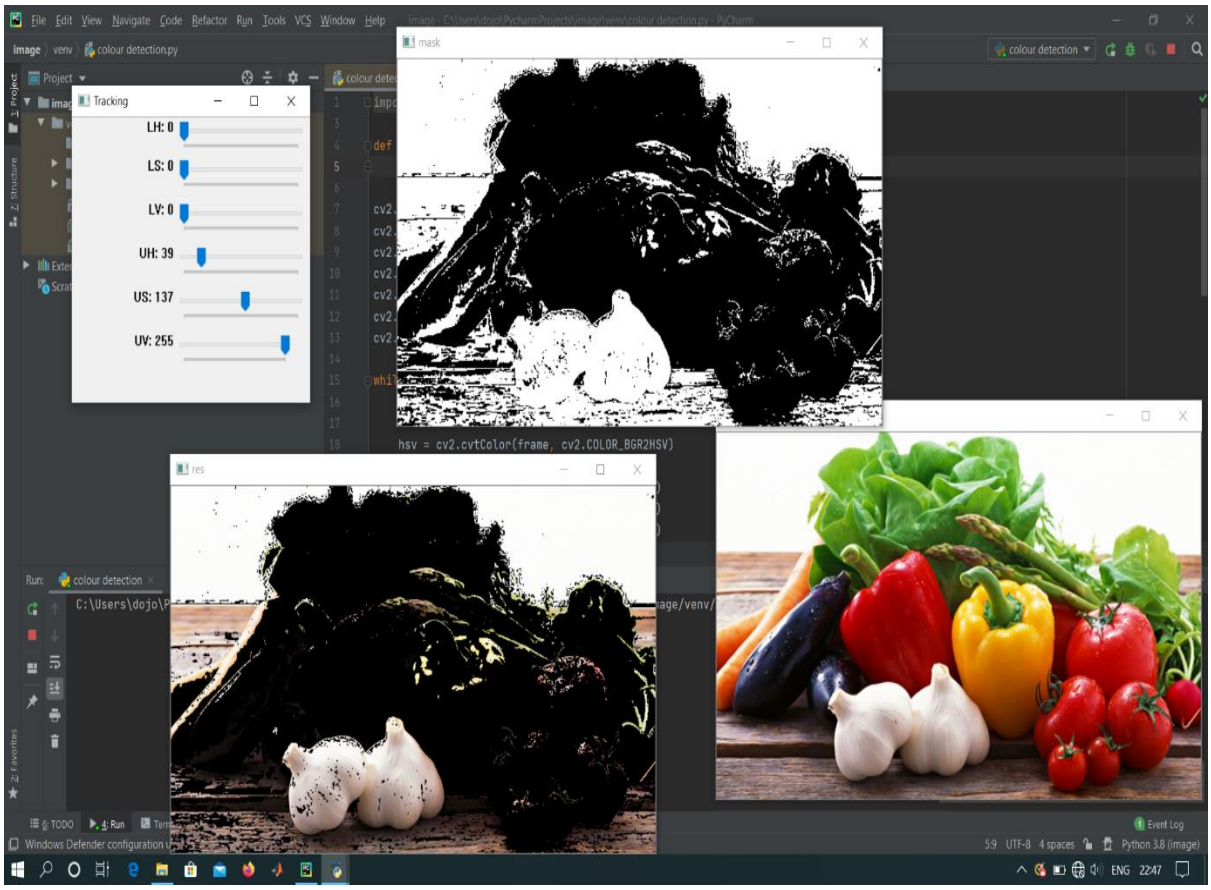


Figure 54: White Component detected from image

(OpenCV Python)

GREEN COLOUR FILTERED

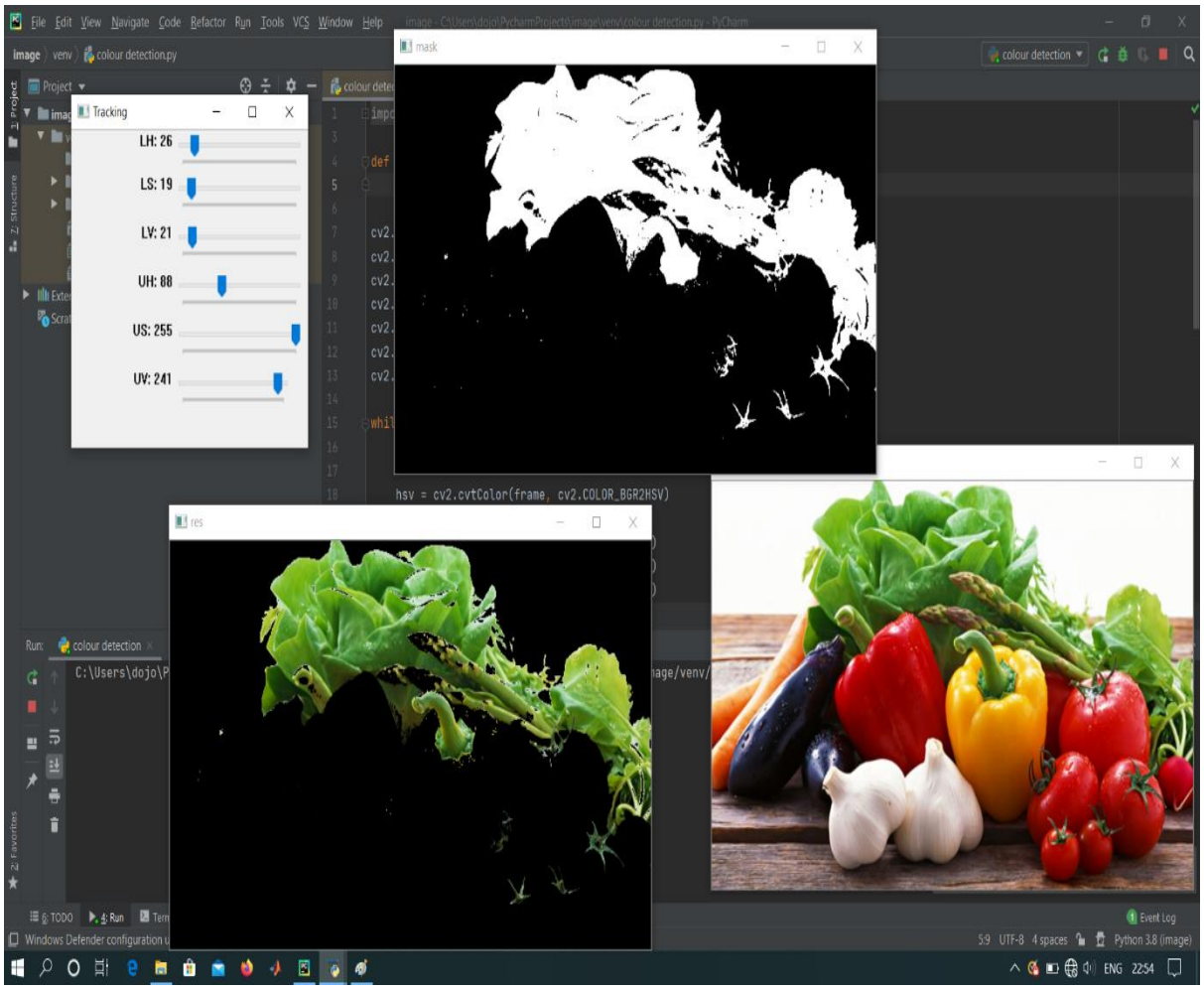


Figure 55 :Green Component detected from image(OpenCV Python)

DETECTION OF COLOUR CHANGE:

WHITE COLONIES

The figure:56 shown below tells that when the colour of water after adding reagent changes into white colonies it indicates the absence of E-Coli bacteria into the sample water. The frame image is the real image shared by controller, mask is the HSV image and res has the real detected colour of water sample.

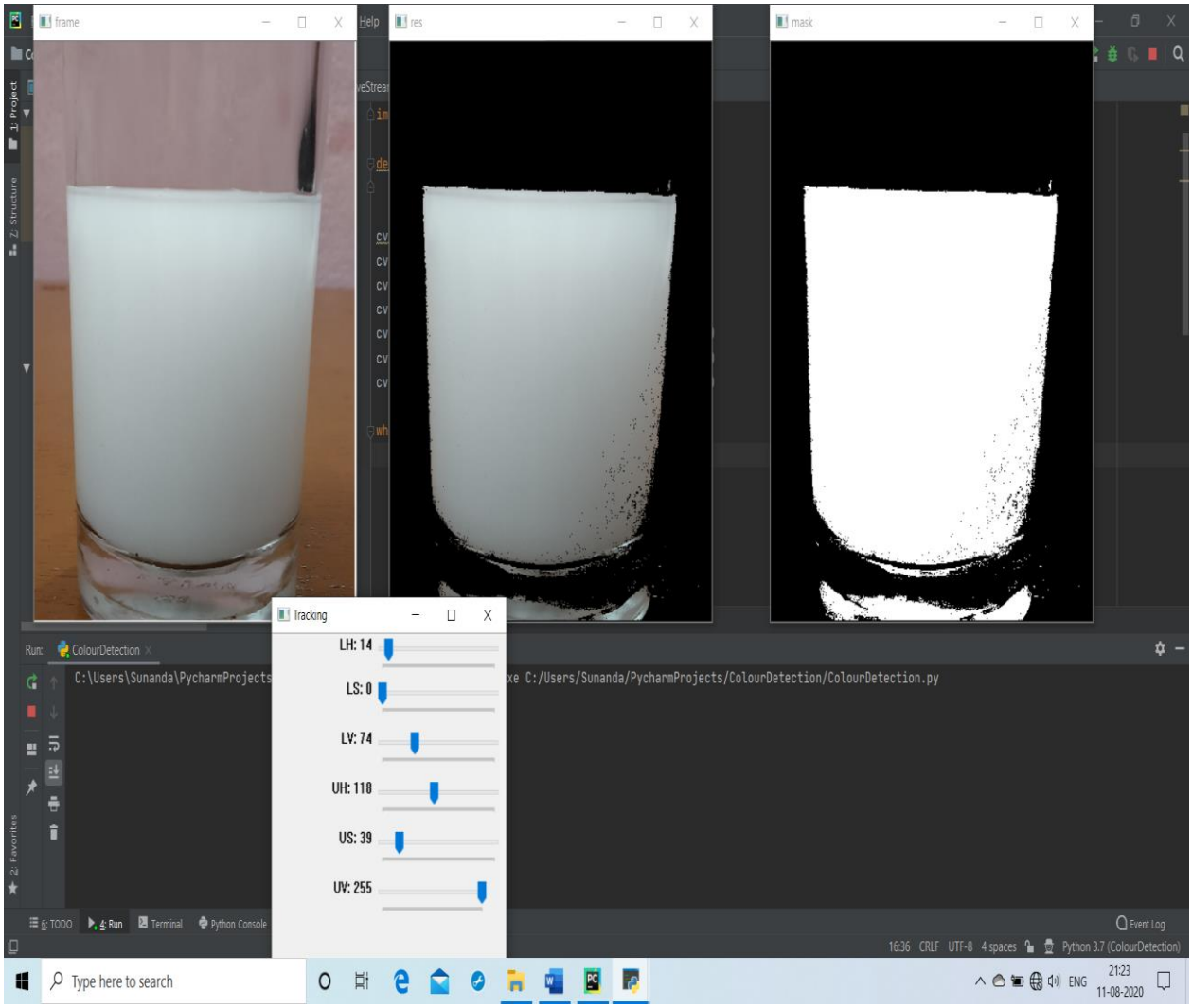


Figure 56: White colonies detected.

BLUE COLONIES

The figure:57 shown below tells that when the colour of water after adding reagent changes into blue colonies it indicates the presence of E-Coli bacteria into the sample water. The frame image is the real image shared by controller, mask is the HSV image and res has the real detected colour of water sample.

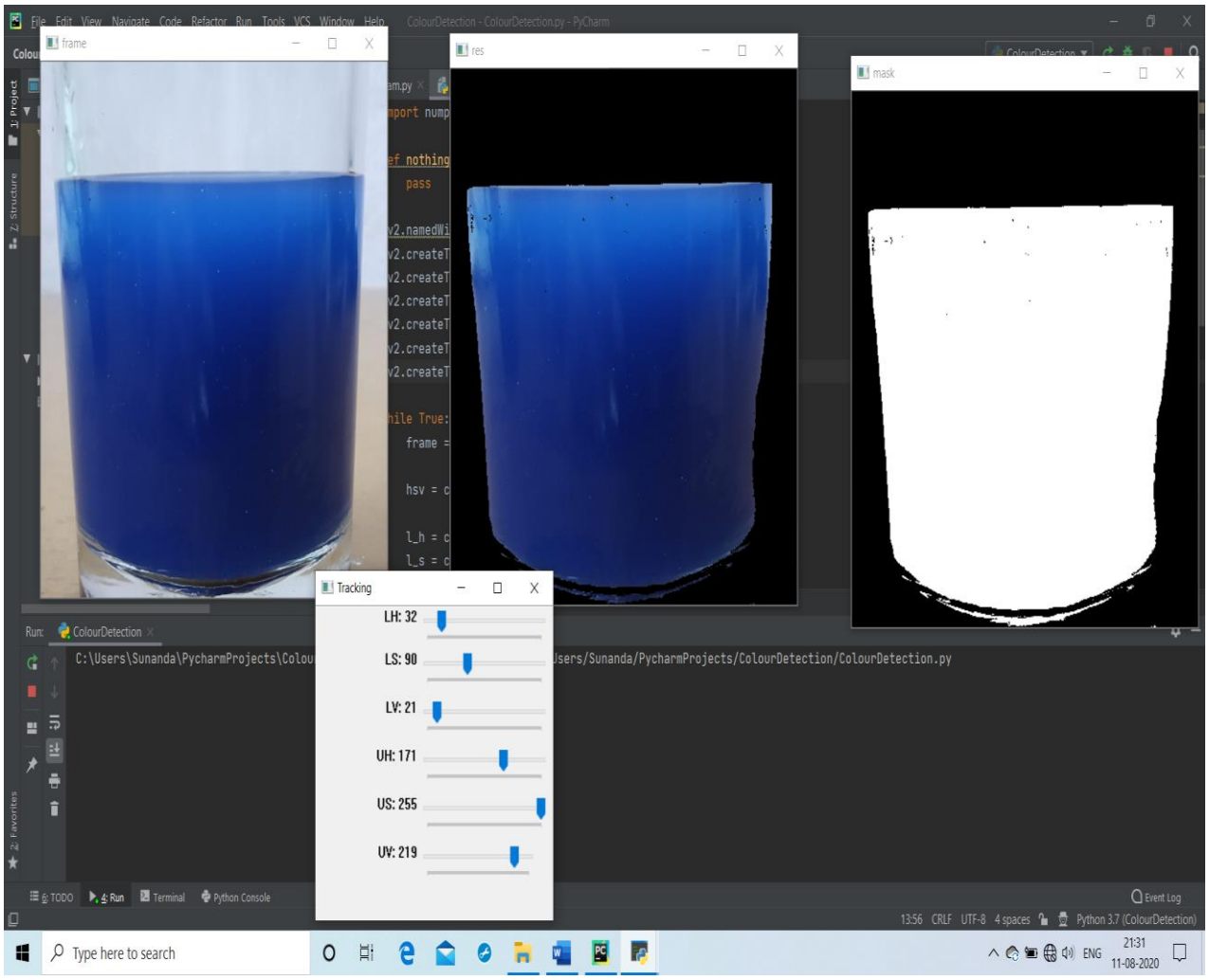


Figure 57: Blue Colonies Detected

APPLICATION DISPLAYING pH Value

Raspberry pi creates Real-time cloud database of filtered images and both sensors data on firebase. Android app fetches those database from firebase and displays results as user clicks on the button. Screenshot of working application showing pH value is attached.

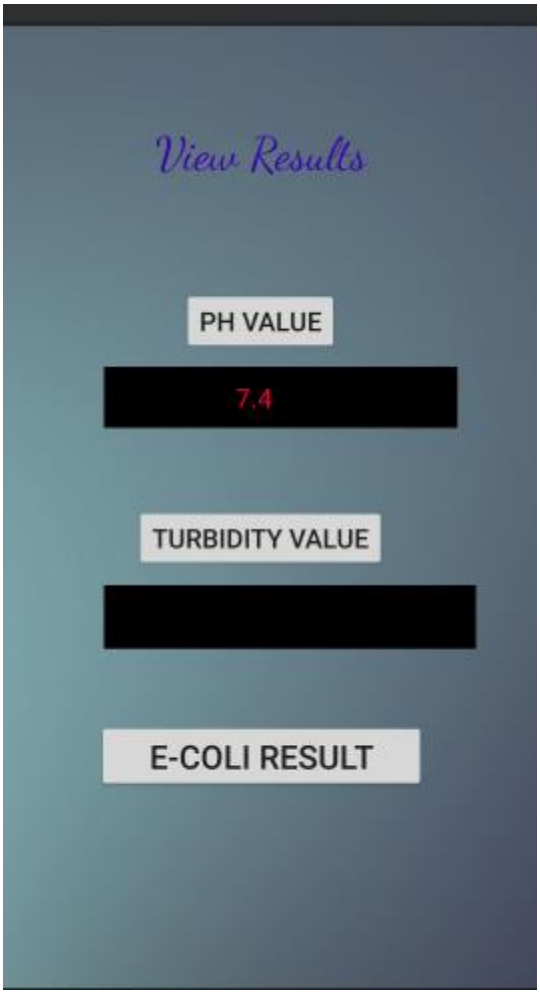


Figure 58 : Android Result Screen

Characteristic curve of PWM v/s Flow rate

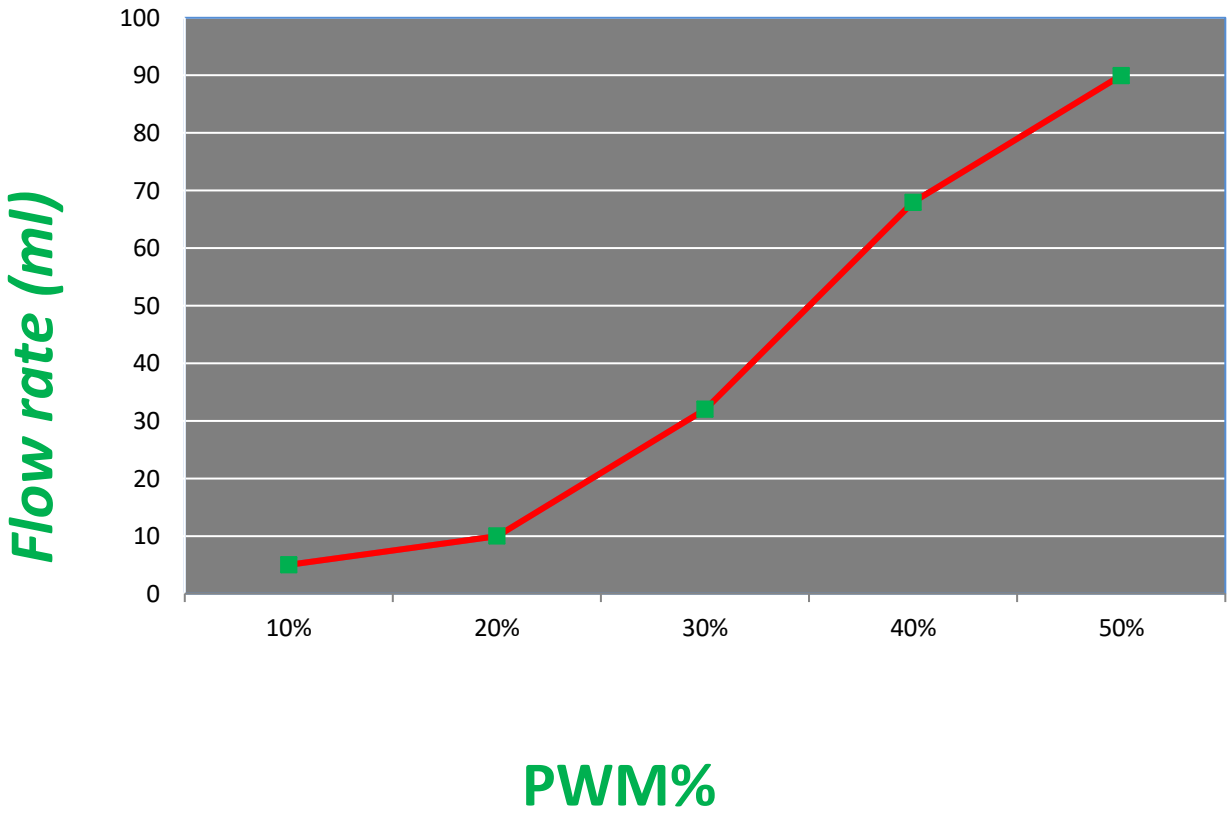


Figure 59: PWM v/s Flow rate of motors

CHAPTER 7

APPLICATION

1.Agriculture

Clearly, water quality is basic to crop production. Destitute quality water in common can moderate plant development and adversely affect appearance. In expansion, certain plants develop superior when certain characteristics are show in water system water; the same is genuine for the converse—plant development may be prevented by the nearness of certain components. For case, water with a too-high pH level (an pointer of sharpness) may be hindering to a few plants, making it troublesome for them to assimilate supplements from the soil; others are less influenced by soil pH and are able to assimilate higher levels of aluminium or magnesium in even very acidic water. So, utilizing our module we are able to decide whether the water quality parameters are appropriate for the crop or not.

2.Drinking Water

Drinking water coming through taps of offices , institutions etc can me frequently monitored for the presence of bacteria and the authority is notified through as SMS sent saying whether the water is suitable for consuming by the people or not.

3.Aquaculture

Aquaculture, or the cultivation of aquatic plants and fish, requires high-quality water to promote production and increase profitability. The module can be used as a water quality monitoring equipment to measure the different factors that can affect the physical condition of aquatic animals.

CHAPTER 8

FUTURE WORK AND MODIFICATION

8.1 FUTURE WORK AND MODIFICATIONS

As a further development plan, we are considering issues such as wireless connectivity, a sustainable thermal control method, self-test functions, and easier UI.

Many local communities in developing countries which have limited internet access use local ad-hoc networks with relay stations.

We will be using the embedded Linux board equipped with a Wi-Fi connection device to allow the node to join local wireless networks.

A solar power system to function without external power and continuous heating for the bacterial cultures is considered for the next development step.

Self-test functions are required to operate the system in the field for a long time. Feedback sensors such as devices for checking the liquid level of the reagent tank or testing the functionality of the pump motors are considered.

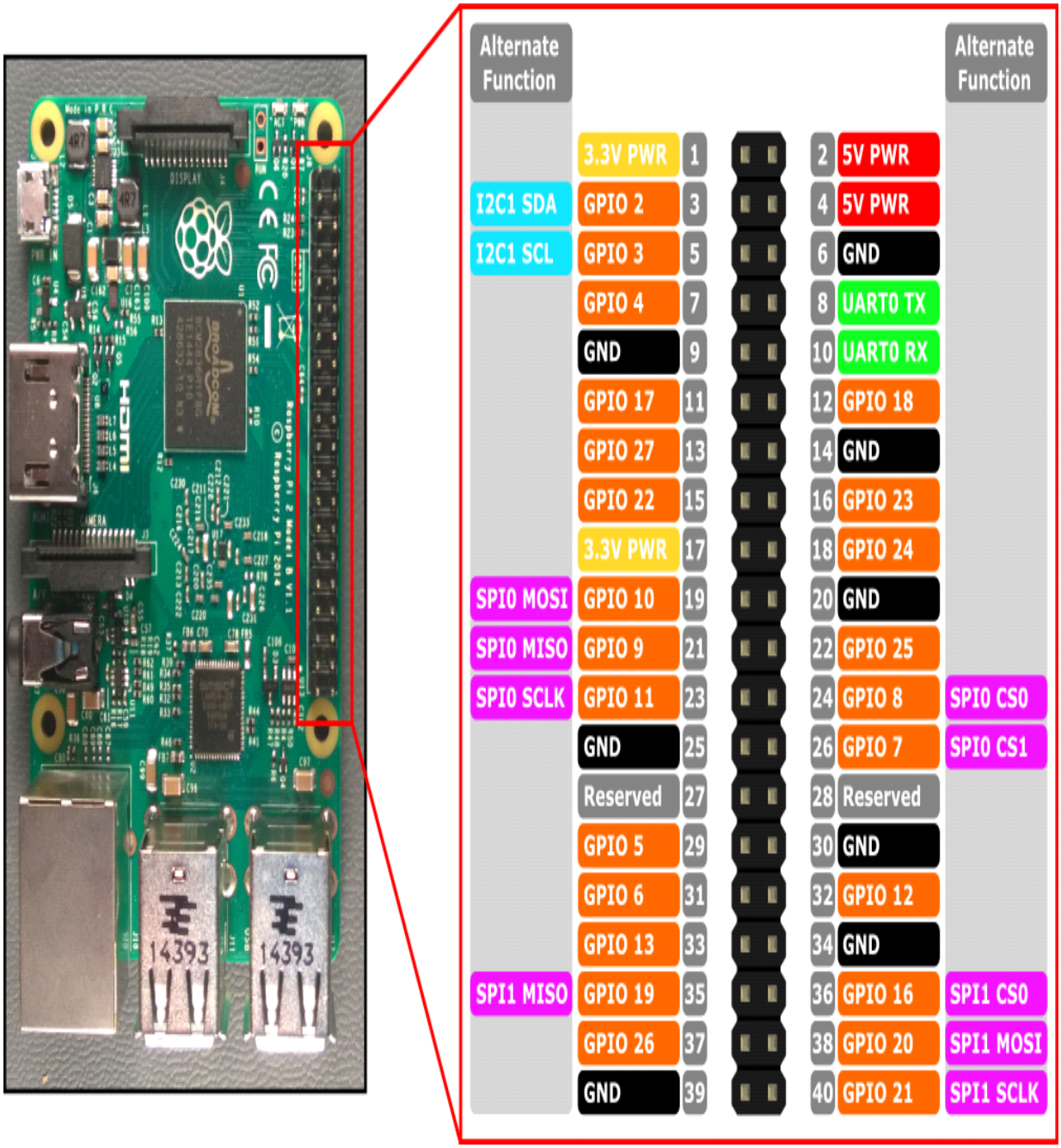
Testing and increasing robustness of the software and circuits are important milestones, too.

CHAPTER 9

APPENDIX

9.1 RASPBERRY PI 3 MODEL B+

Pin Diagram:



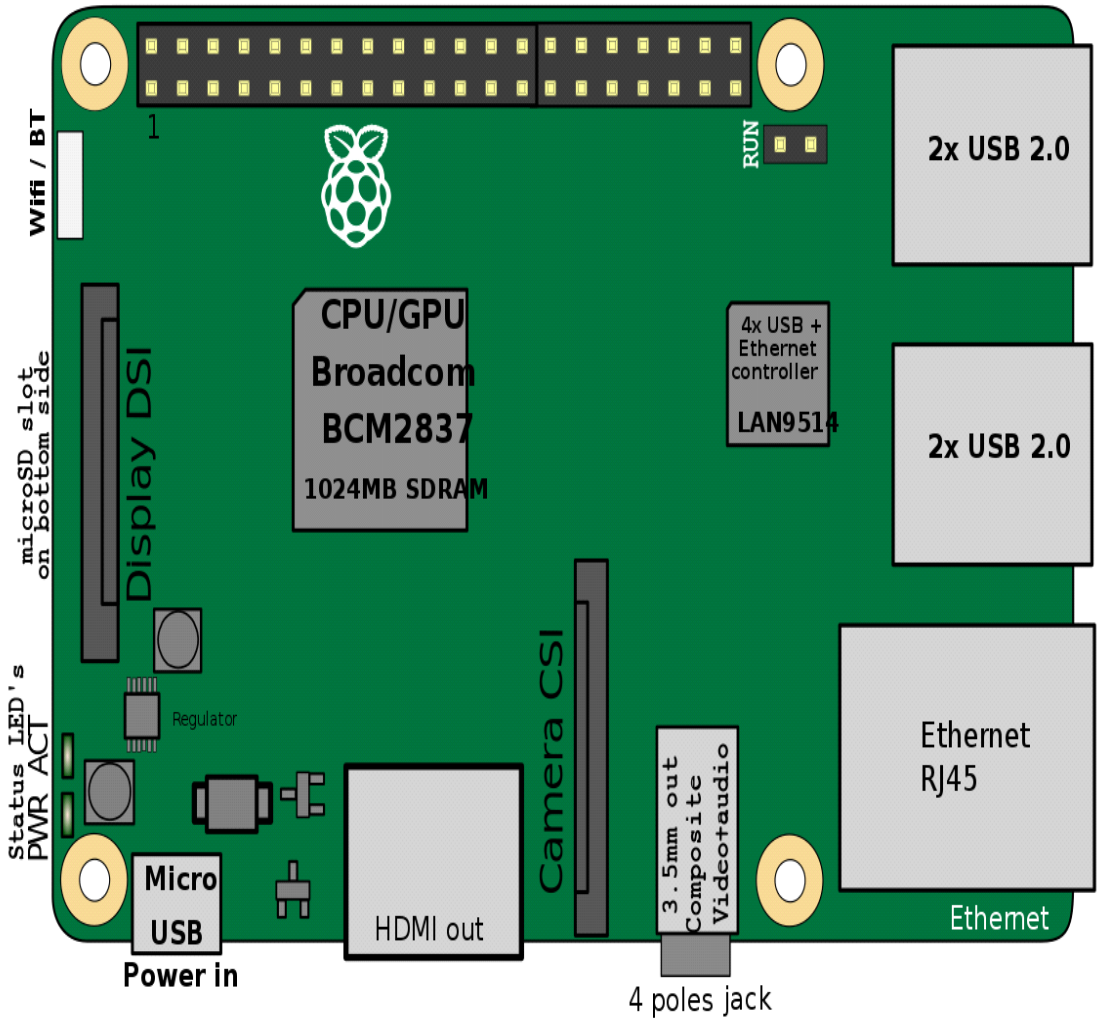
Pin Diagram of RPi 3 b+

Pin Description:

PIN GROUP	PIN NAME	DESCRIPTION
POWER SOURCE	+5V, +3.3V, GND and Vin	+5V -power output +3.3V -power output GND – GROUND pin
COMMUNICATION INTERFACE	UART Interface(RXD, TXD) [(GPIO15,GPIO14)]	UART (Universal Asynchronous Receiver Transmitter) used for interfacing sensors and other devices.
SPI Interface(MOSI, MISO, CLK,CE) x 2 [SPI0-(GPIO10 ,GPIO9, GPIO11 ,GPIO8)] [SPI1--(GPIO20 ,GPIO19, GPIO21 ,GPIO7)]	SPI (Serial Peripheral Interface) used for communicating with other boards or peripherals.	
TWI Interface(SDA, SCL) x 2 [(GPIO2, GPIO3)] [(ID_SD,ID_SC)]	TWI (Two Wire Interface) Interface can be used to connect peripherals.	
INPUT OUTPUT PINS	26 I/O	Although these some pins have multiple functionsthey can be considered as I/O pins.
PWM	Hardware PWM available on GPIO12, GPIO13, GPIO18, GPIO19	These 4 channels can provide PWM (Pulse Width Modulation) outputs. *Software PWM available on all pins
EXTERNAL INTERRUPTS	All I/O	In the board all I/O pins can be used as Interrupts.

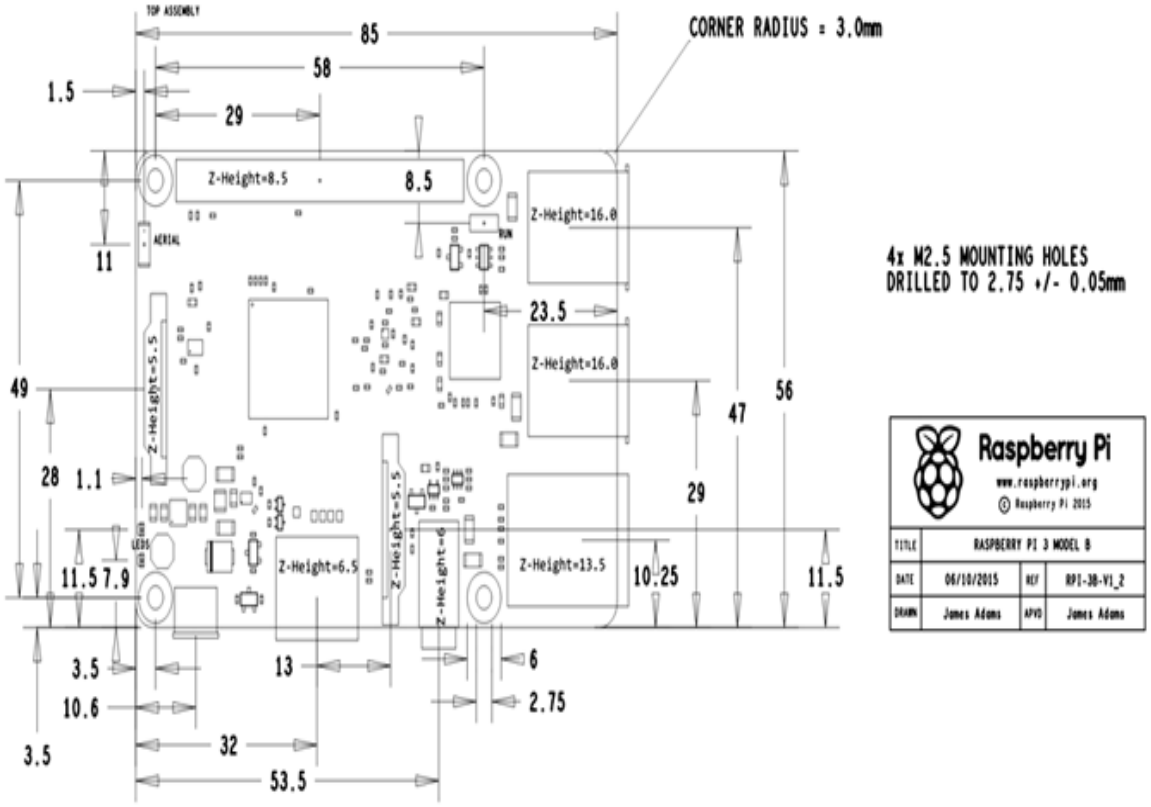
Pin description of pi 3b+

Block diagram:



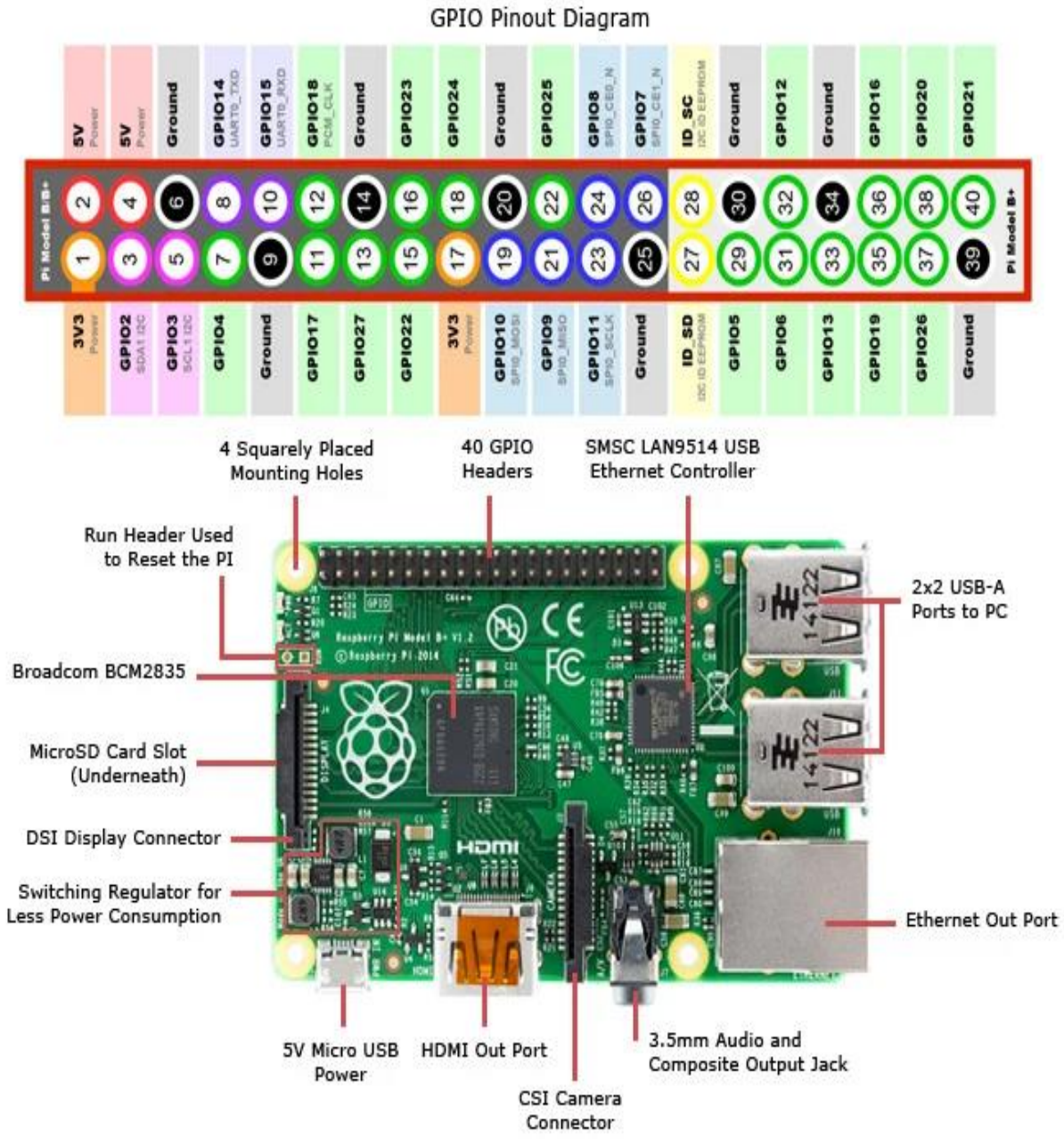
Block outline sketch of RPi 3 b+

Dimensions:



Dimensions of Block

Labelled Picture:



Labelled image of pi

Technical Specification:

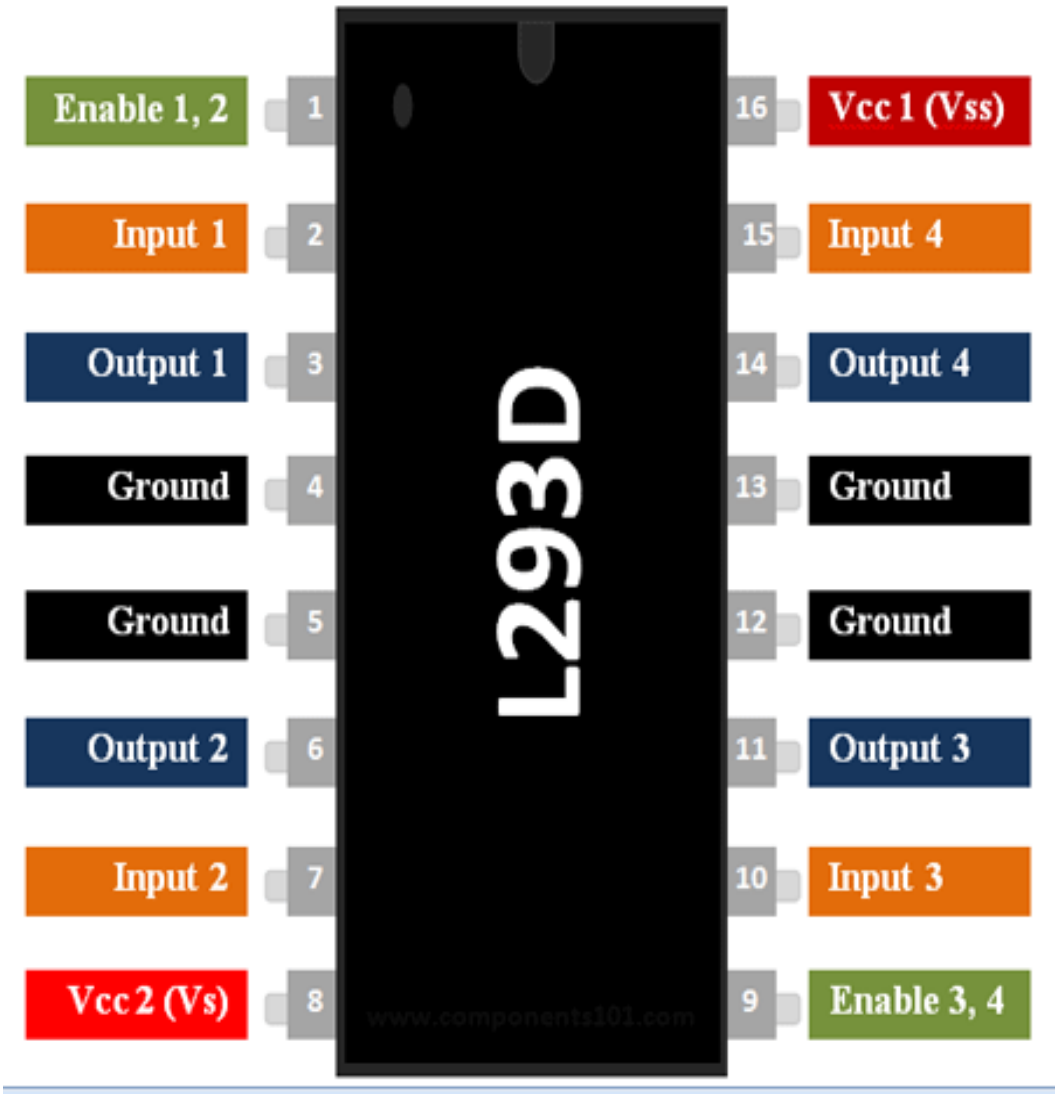
Microprocessor	Broadcom BCM2837 64bit Quad Core Processor
Processor Operating Voltage	3.3V
Raw Voltage input	5V, 2A power source
Maximum current through each I/O pin	16mA
Maximum total current drawn from all I/O pins	54mA
Flash Memory (Operating System)	16Gbytes SSD memory card
Internal RAM	1Gbytes DDR2
Clock Frequency	1.2GHz
GPU	Dual Core Video Core IV® Multimedia Co-Processor. Provides Open GLES 2.0, hardware-accelerated Open VG, and 1080p30 H.264 high- profile decode. Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA infrastructure.
Ethernet	10/100 Ethernet
Wireless Connectivity	BCM43143 (802.11 b/g/n Wireless LAN and Bluetooth 4.1)
Operating Temperature	-40°C to +85°C

Board Connectors:

Name	Description
Ethernet	Base T Ethernet Socket
USB	2.0 (Four sockets)
Audio Output	3.5mm Jack and HDMI
Video output	HDMI
Camera Connector	15-pin MIPI Camera Serial Interface (CSI-2)
Display Connector	Display Serial Interface (DSI) 15 way flat flex cable connector with two data lanes and a clock lane.
Memory Card Slot	Push/Pull Micro SDIO

9.2 **L293D MOTOR DRIVER**

Pin Diagram:



Pin Description:

1. ***Pin1 and Pin9*** are "Enable" pins or the switch pins as you can say. They should be connected to +5V for the drivers to function (for the motor to follow the inputs). If they pulled low (GND), then the outputs will be turned off regardless of the input states, stopping the motors.

2. ***Pin4, Pin5, Pin12*** and ***Pin 13*** are ground pins which should ideally be connected to microcontroller's ground.

3. ***Pin2, Pin7, Pin10*** and ***Pin15*** are logic input pins. These are control pins which should be connected to microcontroller pins or whatever is the input to L293D. Pin2 and Pin7 control the left motor ; Pin10 and Pin15 control the right motor.

4. ***Pin3, Pin6, Pin11***, and ***Pin 14*** are output pins. Tie Pin3 and Pin6 to the left motor, Pin11 and Pin 14 to right motor. Note that there is a bijection between the input pins and output pins.

5. ***Pin16*** powers the IC and it should be connected to regulated +5Volts.

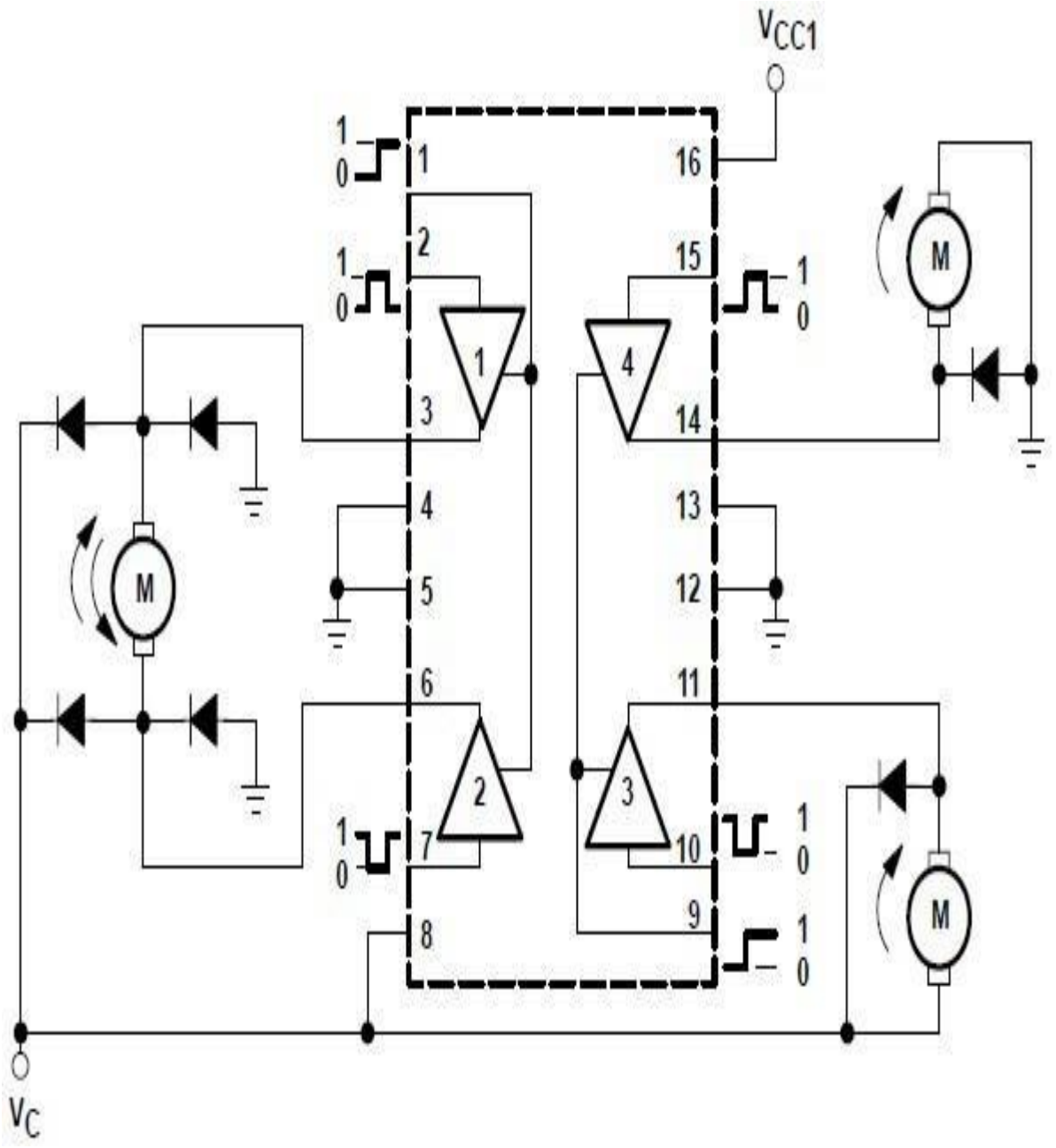
6. ***Pin8*** powers the two motors and should be connected to positive lead of a secondary battery.

Logic Table:

Pin 1	Pin 2	Pin 7	Function
High	High	Low	Turn Anti-clockwise (Reverse)
High	Low	High	Turn clockwise (Forward)
High	High	High	Stop
High	Low	Low	Stop
Low	X	X	Stop

High ~+5V, Low ~0V, X=Either high or low (don't care)

Circuit/Block diagram:

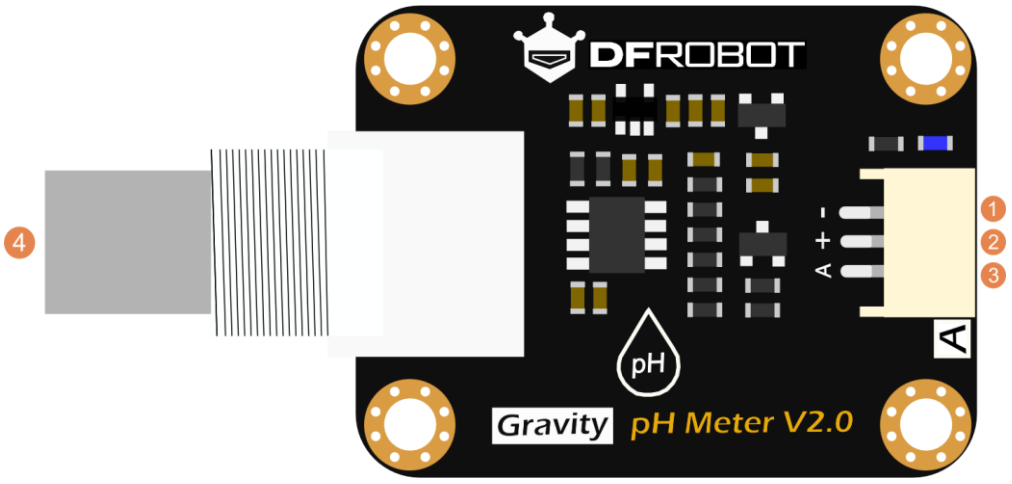


9.3) pH Sensor: SEN0161-V2

pH Probe

- Probe Type: Laboratory Grade
- Detection Range: 0~14
- Temperature Range: 5~60°C
- Zero Point: 7±0.5
- Response Time: <2min
- Internal Resistance: <250MΩ
- Probe Life: >0.5 year (depending on frequency of use)
- Cable Length: 100cm

BOARD OVERVIEW

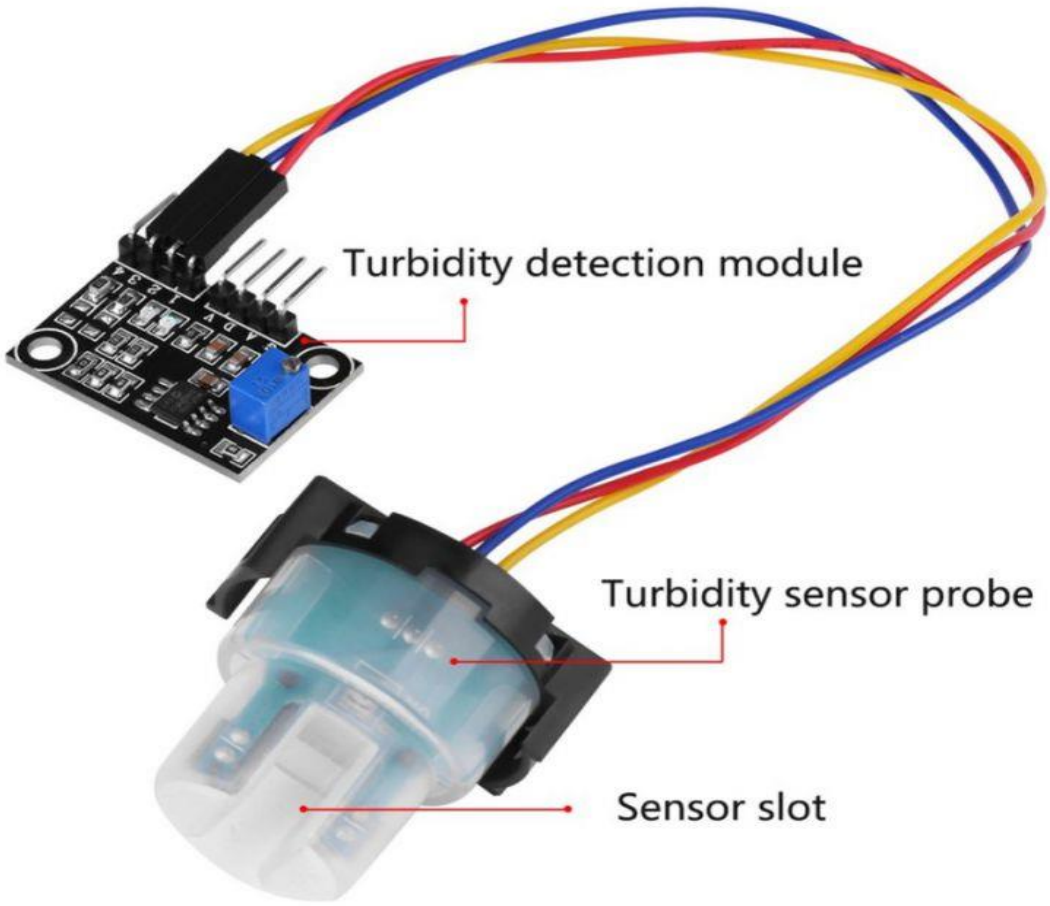


Signal Conversion Board (Transmitter) V2

- Supply Voltage: 3.3~5.5V
- Output Voltage: 0~3.0V
- Probe Connector: BNC
- Signal Connector: PH2.0-3P
- Measurement Accuracy: ±0.1@25℃
- Dimension: 42mm*32mm/1.66*1.26in

Num	Label	Description
1	-	Power GND(0V)
2	+	Power VCC(3.3~5.5V)
3	A	Analog Signal Output(0~3.0V)
4	BNC	pH Probe Connector

9.4) Turbidity Sensor: SEN0189



Labelled diagram

SPECIFICATION

1. Operating Voltage: 5V DC
2. Operating Current: 40mA (MAX)
3. Response Time: <500ms
4. Insulation Resistance: 100M (Min)
5. Output Method: Analog
6. Analog output: 0-4.5V
7. Digital Output: High/Low level signal (you can adjust the threshold value by adjusting the potentiometer)
8. Operating Temperature: 5℃~90 ℃
9. Storage Temperature: -10℃~90℃
10. Weight: 30g
11. Adapter Dimensions: 38mm*28mm*10mm/1.5inches *1.1inches*0.4inche

REFERENCES

[1].https://www.ncbi.nlm.nih.gov/pmc
[2].https://www.raspberrypi.org/tag/developing-world/
[3].https://www.goldbio.com/product/2002/x-gal
[4].https://en.wikipedia.org/wiki/X-gal
[5].https://www.researchgate.net/publication/225065989_Detection_of_-Galactosidase_Activity_X-gal_Staining
[6].https://www.bioline.com/x-gal.html
[7].https://www.epa.gov/sites/production/files/2015-08/documents/method_1604_2002.pdf
[8].https://www.researchgate.net/publication/7848354_New_technology_for_the_detection_of_pH
[9].https://www.researchgate.net/publication/277139515_Soil_pH_Sensing_Techniques_and_Technologies-A_Review
[10].https://www.researchgate.net/publication/260636506_Design_Analysis_and_Realization_of_a_Turbidity_Sensor_Based_on_Collection_of_Scattered_Light_by_a_Fiber-Optic_Probe
[11].https://iopscience.iop.org/article/10.1088/1742-6596/995/1/012065
[12].https://www.academia.edu/14026972/MATLAB_IMAGE_PROCESSING_2015_2016_PROJECTS_FINAL_YEAR_PROJECTS_MICANS_INFOTECH
[13].https://www.researchgate.net/publication/325736179_Color_detection_in_RGB-modeled_images_using_MAT_LAB
[14].https://www.sciencedirect.com/topics/earth-and-planetary-sciences/water-quality-assessment
[15].https://arxiv.org/ftp/arxiv/papers/1506/1506.01472.pdf

[16].https://aem.asm.org/content/56/2/307.short
[17].https://www.sciencedirect.com/science/article/pii/S0956566304003355
[18].https://www.researchgate.net/publication/283122385_RGB_color_sensor_implemented_with_LEDs
[19].https://www.researchgate.net/publication/310462509_Understanding_Digital_Image_Processing_Using_MATLAB
[20].https://www.mdpi.com/2073-4441/11/4/774
[21].https://www.aquaread.com/need-help/turbidity/
[22].https://www.doh.wa.gov/portals/1/documents/pubs/331-181.pdf
[23].https://en.wikipedia.org/wiki/Water_quality
[24].https://components101.com/l293d-pinout-features-datasheet
[25].https://en.wikipedia.org/wiki/Centrifugal_pump