Specification report for project
‘Chromatic monitoring system’

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Project Supervisor: Bryant Paul

Declaration of academic integrity

The standard University of Liverpool statement of academic integrity [6] should go here as follows:

I confirm that I have read and understood the University’s Academic Integrity Policy.

I confirm that I have acted honestly, ethically and professionally in conduct leading to assessment for the programme of study.

I confirm that I have not copied material from another source nor committed plagiarism nor fabricated, falsified or embellished data when completing the attached piece of work. I confirm that I have not copied material from another source, nor colluded with any other student in the preparation and production of this work.

SIGNATURE………DaiJin…………………………………………….......

DATE………………11/10/2018…………………….........................

Abstract

This report is about a chromatic monitoring system, which is used for colour sensing. The system consists of a colour-to-frequency sensor, a proximity sensor, a raspberry Pi and a LCD screen. The final product with functions of colour monitoring and proximity detecting can be applied into colour recognition areas. For example, food safety area.
In the project, a colour sensor is used to receive light from objects, then turn the light information into RGB colour system and output to raspberry pi. A proximity sensor is used to detect distance between object and device to hint users the best working distance of device. Output of colour sensor (in form of RGB colour system) and proximity sensor(in unit of centimetre) will finally be shown on the LCD screen.

Catalog

1. Introduction

The visible spectrum is the portion of electromagnetic spectrum that can emit visible light by electromagnetic radiation. There are three primary colors also called spectrum colors from which all other colors can be derived. These are red, blue and green. In this project, a MAZeT color sensor is used to detect the frequency of received light and output the frequency to raspberry pi. Raspberry pi will be programmed to deal with the output, which is in frequency form, then turn it into RGB color system and display onto a LCD screen.
Because there always exists interference caused by background light or ambient light, the device need to be operated in a proper distance. This best detection range should be less than 15 cm. To ensure the device can be operated in proper distance, a hint will be provided on a LCD screen to user. By controlling a proximity sensor, distance between probe and object can be detect. The output of proximity sensor, which is a square waveform in voltage, will be processed by raspberry Pi and out put to LCD screen in unit of centimetre.
The chromatic monitoring system will be helpful in many modern common technologies such as RGB LED backlight control and color-temperature monitor systems. In this project, a chromatic monitoring system will be tested by a fruit ripening monitoring experiment. The details including methodology, project specification, milestone, industrial relevance and results will be shown in the following sections.

2. Project Description

2.1 Background Information and Working principle

As mentioned above, visible light is that part of the EM spectrum that is most sensitive to the human eye. Usually most people can perceive the wavelengths between 400-700nm. According to the definition, centre wavelengths of the spectrum colors, red, green and blue are respectively 700nm, 546nm and 435 nm [1].

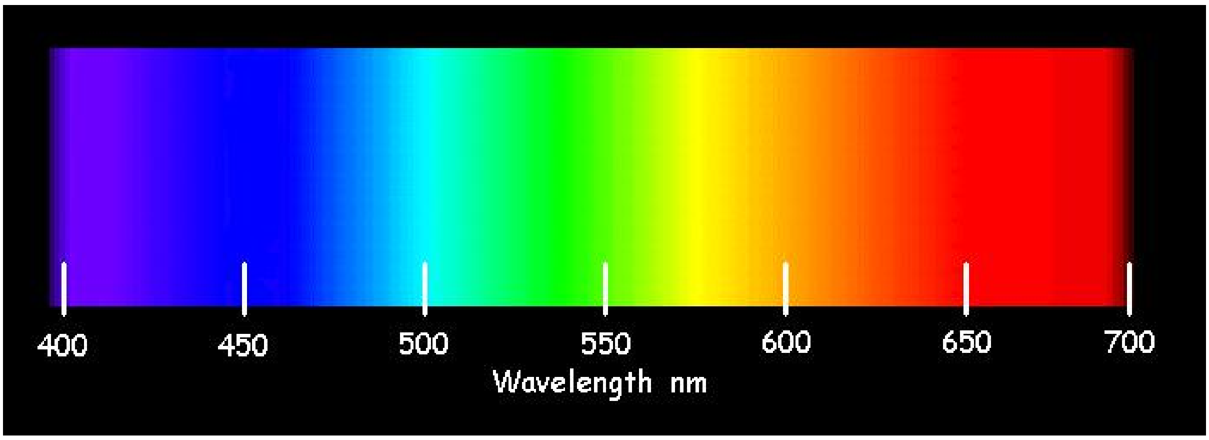


Figure 1: Wavelength of visible light between 400nm to 700nm.

A MAZeT RGB color sensor, TCS3200, is composed of an array of RGB filters, photodiodes, amplifier and an A/D converter. When an object is placed under sun light or room light, reflected light will go through red, green and blue color filters which is inside the sensor. Red filter mask will filter other colors and let red light through only. The red light will finally reach photodiode, whose output current is in proportion to the light intensity. In this channel, after through an A/D converter, final output will be square wave representing frequency of red. The other two color channel work in the same way.

In programming stage, output of square wave (in frequency form) will be transmitted into RGB color system and finally be quantized into 255 levels in each channel. That is, brightness of red, green and blue will be a number between 0 to 255. The combination of three number can represent different colors.

A proximity sensor, TSL26721, is used to detect the distance between object and device. It should be operate with an external IR emitter. By transmitting the received energy of IR light, the sensor can output a square wave to raspberry pi.

The product will be tested by a fruit ripening monitoring experiment. For example, for a certain breed, apple will have different colors during different stages. For example, ripe stage, growing stage and decayed stage. The color information during different stages can be collected by repeated experiments. If the product can be widely use, there will be more databases of color information in different stages about more type of fruits/vegetables in the future.

Figure 2: Color of apple in different stages.

A raspberry Pi is used in this project to program and control the sensors and screen. It has 1GB random memory and high operation speed, which is enough to finish required task. Raspberry pi will carry program including functions of analyzing outputs (from color sensor and proximity sensor), and logging data. The product will carry basic chromatic monitoring function, while at same time the development board provides flexible software/hardware interfaces for user to reprogram or add peripheral devices. For example, it includes 40 GPIO pins, 4 USB interfaces, HDMI and audio interfaces to be compatible with peripheral devices.

2.1.1. Raspberry Pi 3B+

Brand name	Raspberry Pi
Product Dimensions	12.2 x 7.76 x 3.4 cm
Processor speed	1.2 GHZ
Processor Count	4
RAM Size	1 GB
Voltage	5 volts

Table 1: Parameters of Raspberry Pi.

2.1.2. TCS3200(light-frequency converter)

TCS3200 is a light to frequency sensor with 8 pins. It reads an 8 x 8 array of photodiodes. 16 photodiodes have blue filters, 16 photodiodes have red filters, 16 photodiodes have green filters and the other does not have filters.

The terminal function is listed in table3. Pin diagram of TCS3200 is given in figure3 and recommended operating conditions is given in table 2.

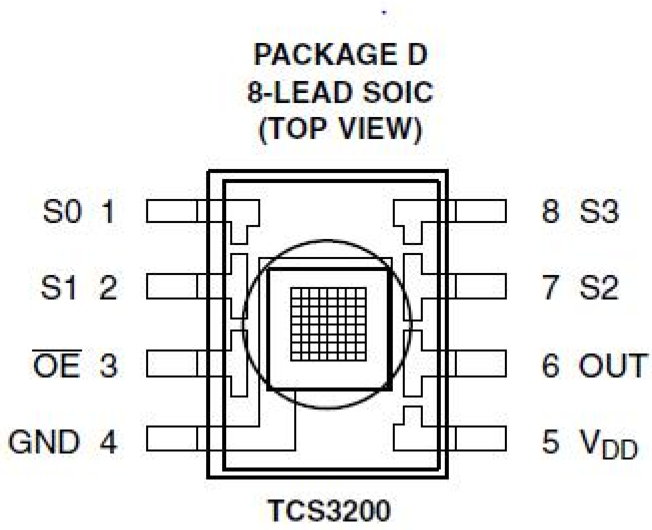


Figure 3: Pin Diagram of TCS3200.

Symbol	Parameter		Min	Nom	Max	Unit
V_{DD}	Supply voltage		2.7	5	5.5	V
V_{IH}	High-level input voltage	V_{DD} = 2.7V to 5.5V	2		V_{DD}	V
V_{IL}	Low-level input voltage	V_{DD} = 2.7V to 5.5V	0		0.8	V
T_A	Operating free-air temperature range		-40		70	℃

Table 2: Recommended Operating Conditions.

Terminal		I/O	Description
Name	No.		
S0, S1	1, 2	I	Output frequency scaling selection inputs
$\overline{OE}$	3	I	Enable for f_o (active low)
GND	4		Power supply ground. All voltages are referenced to GND.
V_{DD}	5		Supply voltage
OUT	6	O	Output frequency (f_o)
S2, S3	7, 8	I	Photodiode type selection inputs

Table 3: Terminal Functions.

2.1.3. TSL26721 (proximity sensor)

TSL26721 proximity sensor has a maximum detection range of 18cm. Its high dynamic range is 16,000:1 and it has a low power 2.2mA sleep state with User-selectable sleep-after-interrupt mode. TSL26721’s wait time is programmable from 2.7ms to more than 8 seconds.
TSL26721 uses I^2C fast mode compatible interface whose data rates up to 400 kbit/s. The input voltage levels of I^2C interface is compatible with VDD or 1.8-Vbus, which is compatible with raspberry pi either. The Package of TSL26721 is given in figure4 and terminal functions is given in table4.

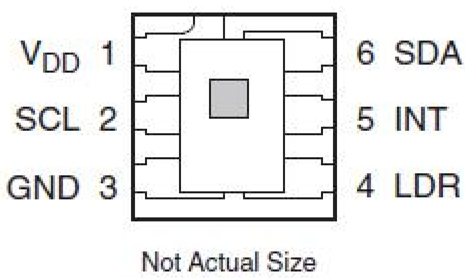


Figure4: Package of TSL26721

Terminal Name	Terminal No	Type	Description
GND	3		Power supply ground. All voltages are referenced to GND.
INT	5	O	Interrupt — open drain (active low).
LDR	4	O	LED driver for proximity emitter — open drain.
SCL	2	I	I^2C serial clock input terminal — clock signal for I^2C serial data.
SDA	6	I/O	I^2C serial data I/O terminal — serial data I/O for I^2C.
V_{DD}	1		Supply voltage.

Table 4: Terminal Functions of TSL26721.

2.2 Specification

At the end of this project, a functioning, tested chromatic monitoring system and a comprehensive thesis about the project should be delivered. The product should be eventually tested by an experiment such as fruit ripening monitoring experiment, and the product should have the following features:

1. Real-time color detecting function.

   This means the product should have the ability of judging the color of a particular object such as a fruit. The product should using a color sensor to detect and output the first-stage color information (in frequency form) and output to raspberry Pi in red, green and blue three channels respectively. Then the raspberry Pi should be programmed to turn the frequency into RGB color system.

2. Proximity detection function.

   This means the product should have the ability of getting the distance between probe and object. The output distance should be shown onto a LCD screen to hint the user about proper device working distance. If the distance is too far, color sensor may be influenced by background light. If the distance is too close, color sensor may shelter from room light to object. The maximum detection distance of TSL26721 is 18 cm.

3. Long-term data logging function.

   This means the product should have the ability of keeping logging data for a period (at least one week).

4. Real-time display function for showing color information and distance.

   This means the LCD screen should display information such as color of object, distance between object and device.

5. Flexible software interface for user to reprogram.

   This means if user in future need additional functions, the product should be reprogrammable.

6. Flexible hardware interface for user to add/connect other device.

This means if user in future need additional functions with hardware devices, the product should provide extra ports for peripheral device connection.

7. Basic interactive functions such as button or switches.
   Button or switch is used to turn on/off the product.

8. The product should be portable and easy to operate.

3. Correlation Theory

3.1 Voltage fluctuation.

The input voltage may have fluctuation originating at power source. The effect of it may influence the work state of electronic device, and it may also add noise to signals. For example, the screen may flicker because of voltage fluctuation. Usually the voltage fluctuations can be reduced by using a voltage regulator [4]. The voltage through a voltage regulator will be fixed at a preset magnitude and keep constant being insusceptible from load conditions and input voltage [5].

3.2 Differential Amplifier

Differential amplifier is used to amplify the difference between two input voltages. It can efficiently suppress the common voltage between the two inputs [7]. Differential amplifier can provide the immunity to noise by generating a negative feedback, so it can be helpful in many applications including audio, data-transmission and telephone systems [8]. In the project, differential amplifier is used to reduce the noise during amplifying the output signal from sensor.

4. Methodology

In this section, the methodology of project will be listed and described in details.

- Background knowledge learning, including:
  1. Chromatic system (HLS, RGB, Lxy system)
  2. Circuit theory (amplifying circuit)
  3. Chromatic monitoring system (precedent)
  4. Working principle of color sensor/proximity sensor.
  5. Applications of chromatic monitoring technology.
- Determine the circuit/physical modules needed, such as:
  1. Voltage regulator
  2. Operational Amplifier
  3. Power source: 5V
  4. Color Sensor: TCS3200
  5. Proximity sensor: TSL26721
  6. LCD screen: 20 x 4 in size
  7. Raspberry Pi 3B+
- Design a simplified circuit according to datasheet of components.

- Calculate parameters according to datasheets of components. For example: resistors and capacitors need in photodiode amplifying circuit.
- Order components.
- Build and simulate a rudimentary sensor using photodiodes and operational amplifiers.
- Test sensors.
  For example: connect sensors to circuit and get an output wave (may be not regular but at least responsible) from a scope.
- Build the whole circuit on breadboard and output to raspberry Pi.
- Program to transmit output from sensors into a proper system such as RGB system.
- Program to display information such as distance between object and device, and color information of object.
- Test the functioning product by a fruit ripening monitoring experiment.
- Draw PCB board using Eagle/Altium Designer and fabricate it.
- Solder components to PCB board.
- Making correction and final test.

5. Literature Review

5.1 Theory of chromatic modulation.

Chromatic detection normally only monitor some special wavelengths. These wavelengths are visible to human eyes. Chromatic detection detects the change in a measurement by monitoring the total amount of contributions, which is caused by relative changes at all wavelengths in a spectral power distribution.

Photodetectors (photodiodes) are used to monitor chromatic changes with overlapping spectral profiles, $R_x(\lambda), R_y(\lambda)$ and $R_z(\lambda)$. To address an optical signal, spectral power distribution $P(\lambda)$ can be used to determine the output currents of photodetectors:

$$I_x = K_x \int P(\lambda) R_x(\lambda) d\lambda$$

$$I_y = K_y \int P(\lambda) R_y(\lambda) d\lambda$$

$$I_z = K_z \int P(\lambda) R_z(\lambda) d\lambda \qquad (1)$$

Where $\mathrm{K}_x, \mathrm{K}_y$ and K_z are proportionality constants.

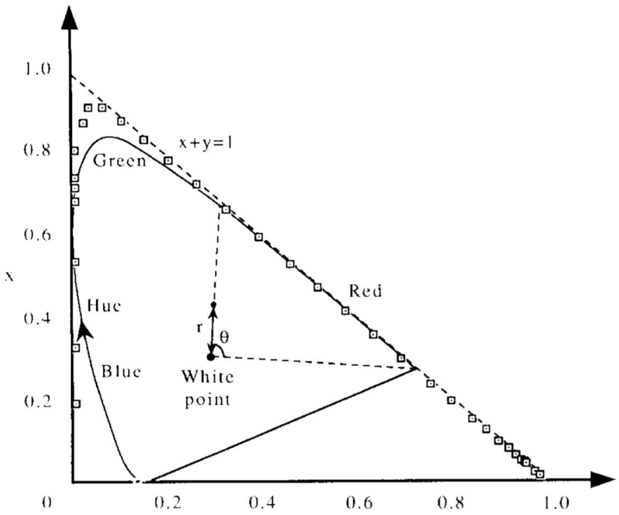
Parameters x, y and z can also be calculated from a set of detectors:

$$x = I_x / (I_x + I_y + I_z)$$

$$y = I_y / (I_x + I_y + I_z)$$

$$z = I_z / (I_x + I_y + I_z) \qquad (2)$$

A plot(Figure 5) of x against y represents the CIE diagram can basically describe the basis of color science.



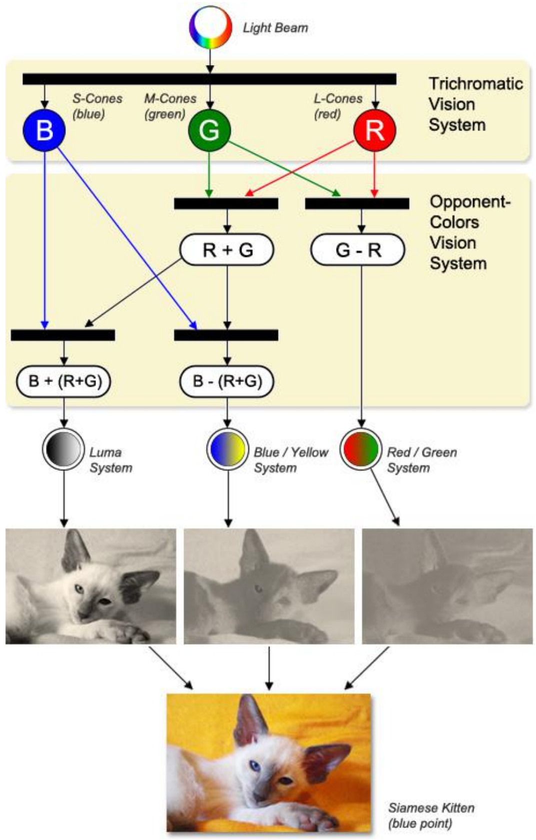


Figure 5: A Plot of x Against y.

Figure 6: Process of dealing with light in RGB Color System

In figure5, x and y is a representation of output of photodectors. 'r' represents saturation and 'θ' represents hue[9].

5.2 Color Theory

The color perceived by human eyes all originate from the three primary colors. Different wavelengths are corresponding to different colors. The retina of a human eye contains two type of cells, cones and rods. Cones are sensitive to color and rods are also sued for night vision. The three primary colors mentioned above is detected by three different types of cones. They are respectively S-type for perceiving maximum to 440 nm blue light, M-type for perceiving maximum to 550 nm green light and L-type for perceiving maximum to 570 nm red light [6]. Figure 6 shows how human eye deals processes light in RGB color system.

6. Results

The project is still in progress. To better realize the working principle of a color sensor, a circuit of photodiode amplifying circuit has been designed.

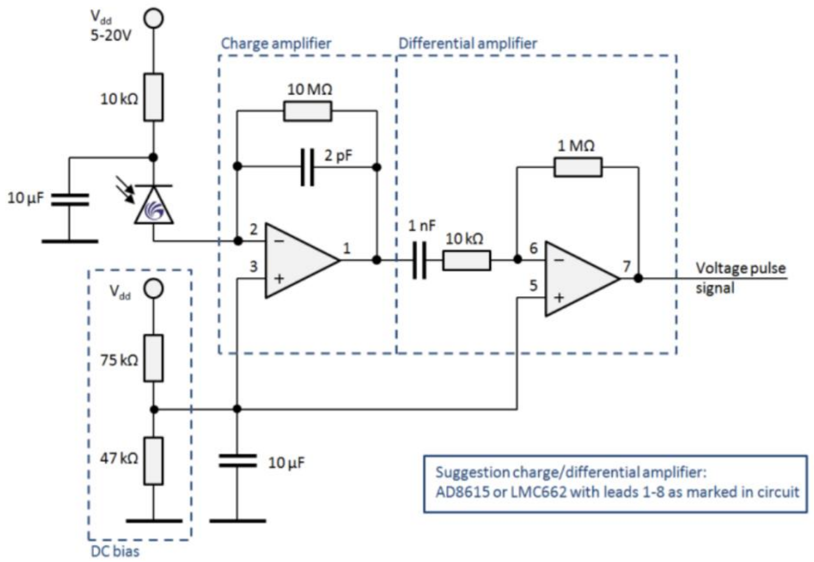
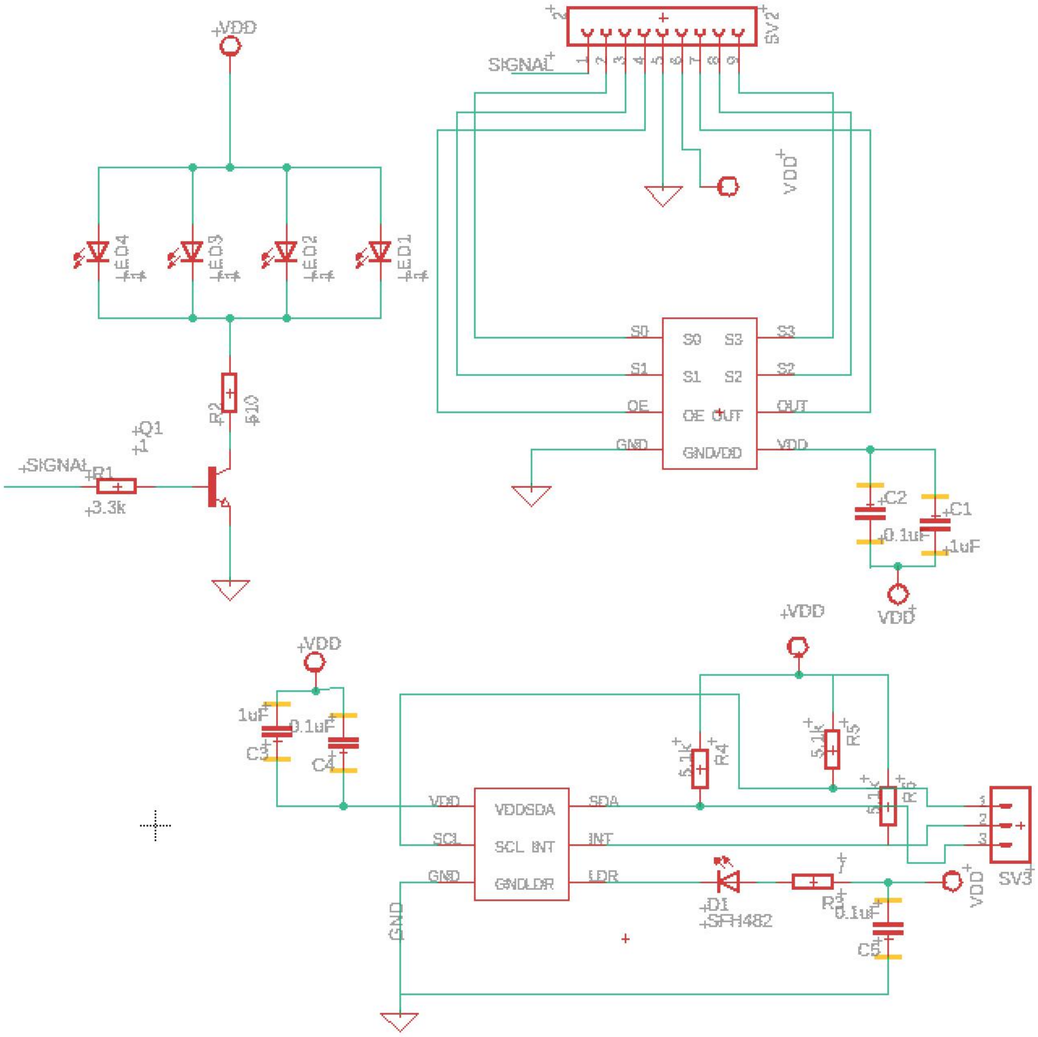


Figure 5: Photodiode Amplifying Circuit.

In this case, output of photodiodes will go through a charge amplifier and a differential amplifier which are both contained in an integral op-amp, LMC662. The amplifier works at single-power supply mode. DC bias is used to ensure the amplifier to work in proper voltage range. Overall gain of the amplifying circuit can be changed by changing the value of resistors in differential amplifier.

Gain= 10M x 1M/10K = 1000M.

A schematic diagram is shown as below. This schematic diagram is temporarily a possible plan of the whole project. The upper block is the color sensor, TCS3200. The other one is TSL26721, which is the proximity sensor.



There is some important points to bear in mind when designing the circuit. First, input power signal is not always stable, which means it could have ripples. So between the sensor and power source, a regulator is needed to ensure stability of the power supply. Second, the colour sensor is vulnerable to the ambient light, which might interfere with the detection. Therefore, there will be a proper distance range for device to operating.

To test the product, a fruit ripening experiment will be performed. In this experiment, a fruit's skin colour will be recorded over time and analysed. For example, for a certain breed, if the colour of an apple is red, it can be judged as 'ripe'. Conversely, brown skin with white pots means the apple is decayed and not edible.

7. Conclusion

The project involves acquiring some colour spectrum knowledge, circuit theory and chromatic system knowledge. By applying the knowledge, the project can achieve the colour recognition function and will be helpful in relevant colour sensing area.

The product should have the functions of colour sensing, proximity detecting and displaying, also it should be flexible and portable. Once the circuit is finished, it will be used in a fruit ripening monitoring experiment to test the function.

The whole project is broke down into small tasks by weeks and is easy to measure the effort. It mainly include the circuit modules construction part, physical modules construction parts, programming parts and testing part. The timeline, milestones and deliverable sections are attached in appendix 2.

8. Reference

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[8] Jim, Karki. ''Fully differential amplifiers remove noise from common-mode signals.'' *Issue of EDN.* p.149, Nov 9, 2000. Available: https://m.eet.com/media/1143022/84302.pdf. [Accessed: Oct 11, 2018]

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Appendix 1: Gantt Chart

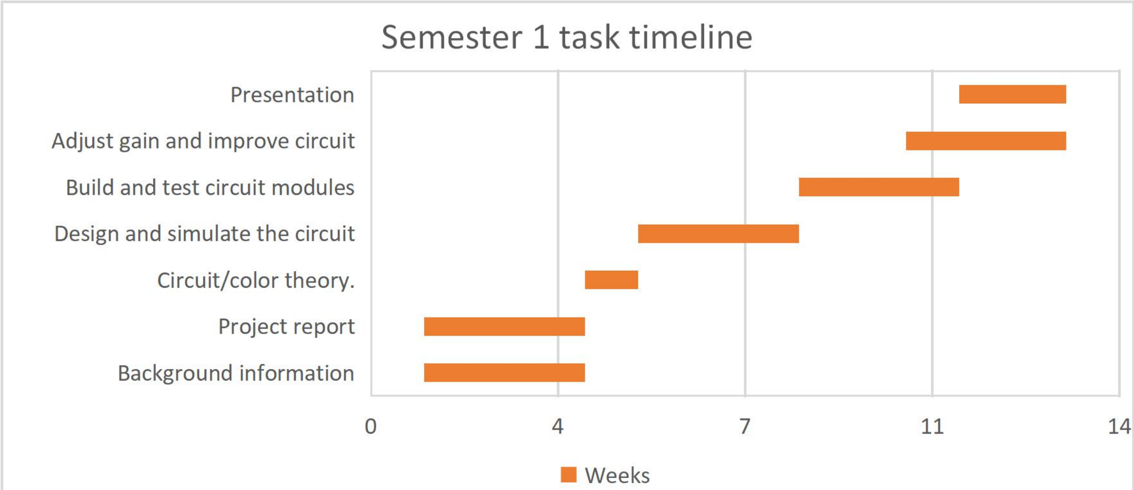

Figure 1: Timeline of task in semester 1

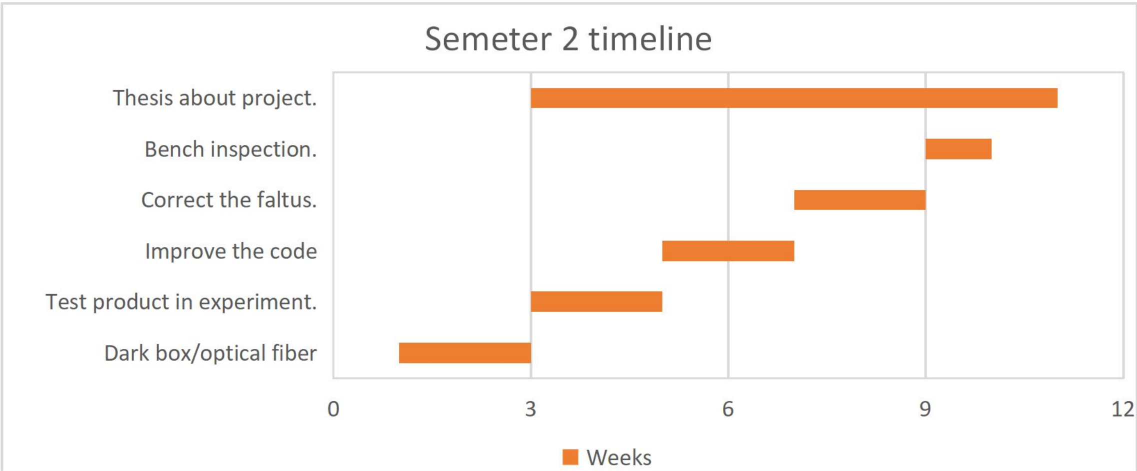

Figure 2: Timeline of task in semester 2

Appendix 2: Project Specification/Plan

DEPARTMENT OF ELECTRICAL ENGINEERING AND ELECTRONICS

Project Specification Form 2018-2019
Final Year BEng (*ELEC340*) and Year 3 MEng (*ELEC440*)

Student Name: Jin Dai____________________ Module: ELEC340

Supervisor: Paul Bryant ________________ Student ID No:201297820________________

Project Title: Chromatic monitor system ____

Project Specification

A. Project Description and Methodology:

(Overall view of the project with proposed route to realization i.e. what are the project aims and objectives and how you are going to do it?)

1. Brief Project Description

The 'Chromatic monitoring system' is used to monitor/analyze the RGB light of a particular object. It is mainly composed of a development board (raspberry pi) , a color sensor (TCS3200), a proximity sensor (TSl26721) and a LCD screen. The final product will have the abilities to log data, display data and recognize color. Once the circuit is designed, the product will be tested by a fruit ripening monitoring experiment.

2. Methodology

1. Background knowledge learning, including chromatic system, circuit theory and chromatic monitoring system.
2. Order the components.
3. Design circuit and calculate parameters of each components according to datasheet of sensors.
4. Build rudimentary color sensor using photodiode and operational amplifier.
5. Test sensor and get an output by using a scope.
6. Build circuit on breadboard and output to raspberry pi.
7. Program to deal with the output information. For example, turn frequency form into RGB color system.
8. Program to display information such as distance and color onto a LCD screen.
9. Make correction and final test.
10. Perform a fruit ripening monitoring experiment to test the product.

3. Function

Finally, the product will have the basic functions:

1. Real-time color detecting function.
2. Proximity detection function.
3. Long-term data logging function.
4. Real-time display function about distance, RGB light data or ripe/decayed (this can be reprogrammed if used in particular area).
5. Some basic interactive functions such as button and light.

B. Project Tasks and Milestones: (indicate the tasks and milestones that should be achieved and their expected dates e.g. understanding of theory, designs of circuits, construction of circuits, software specifications, working demonstrations etc.)

Project Tasks:

Package 1: Background/theory Research

1. Search and learn about the background information of color wavelength sensing, MAZET sensor and chromatic monitoring system.(week 3)
2. Project report (week-3)
3. Learn about chromatic monitoring systems, color systems (RGB, HLS and Lxy), circuit theory (amplifying circuit).(week 4-5)

Package 2: Design and Build

4. Order components.(week 6)
5. Design and calculate the parameters of components according to datasheet.(week 7-8)
6. Build a rudimentary color sensor using photodiodes and op-amp and get an output. (week 9-10)
7. Draw PCB for sensors, solder them and test the sensors.(week 11-12)
8. Presentation(week12)

Package 3: Improve and Test

9. Build whole circuit onto a breadboard, test circuit and output to raspberry Pi. (S2, week 1-2)
10. Program to turn output into a proper form such as RGB color system and distance form. (S2, 2-4)
11. Test product in a food ripening monitoring experiment. (S2, week 5)

Package 4: Final Correction.

12. Test the final functioning circuit and correct the faults/make improvement.(S2 week 6-8)
13. Bench inspection(S2 week 9)
14. Finish the thesis about the project by April 29th.

Milestones

- ✓ Background knowledge, design and calculations by week 6.
- ✓ Design and construct circuit modules (on breadboard) by week 12
- ✓ Presentation at week 12.s
- ✓ Program and test by week 2 semester 2.
- ✓ Fabricate final PCB board and solder components onto it by week 4.
- ✓ Complete the product in food ripening monitoring experiment by week 6 semester 2.

- ✓ Make final correction by week 8 semester 2.
- ✓ Bench inspection and thesis by week 9 semester 2.
- ✓ Thesis work by April 29.

C. Project Deliverables: (Indicate what should be completed at the end of the project e.g. this list should indicate what would be presented / demonstrated at the final bench inspections)

1. Fully functioning and tested real-time chromatic monitor system, which include the required function mentioned in specification.
2. Experience/knowledge of designing a product in the area of chromatic monitoring/color sensing.
3. Comprehensive thesis about the project in color sensing area.

D. A section on Project Rationale and Industrial Relevance must be included in the preliminary report (deadline midnight Friday 14th October 2016). This should explain how and why the project was devised, e.g. it may be a project sponsored by a company or linked to a research project.

The product will integrate the basic real-time color sensing function and real-time display function. It is capable to carry a long-term real-time monitoring work or an immediate color sensing work. The chromatic monitoring system is applied widely in various area involving color detecting, and the most common and simple application is to analyze the detailed color parameter of a particular object. This could be used in applications such as jewelry authentication, material recognition or food ripening detection etc.

The product will also be a flexible former device, which can be directly used for simple color sensing and provides ports for peripheral device connection and reprogramming. For example, vision-tracking system based on color sensing system can be achieved by adding extensive logic arithmetic, and color temperate monitor system can be achieved by adding an IR blocking filter.

Because of the high sensibility and large dynamic range of light recognition, the product could also be favorable in currently advanced application, such as RGB LED backlight control (e.g. in smart phone monitor) [3].

Appendix 3: Ethical Approval Form

UNIVERSITY OF LIVERPOOL

DEPARTMENT OF ELECTRICAL ENGINEERING AND ELECTRONICS

Ethical Approval Questionnaire 2017-2018

Final Year BEng (ELEC340) and Year 3 MEng (ELEC440)

Student Name: Dai Jin. Module: ELEC340 / ELEC440 (delete one)

Supervisor: Bryant Paul. Student ID No: 201287820.

Project Title: Chromatic monitoring system. (Real-time).

Formal ethical approval must be obtained for all research projects *'involving research on human subjects or human tissues or databases of personal information to be carried out by University staff or students on University premises, or at any location, where there is no other acceptable provision for ethical consideration'*. Final year projects (ELEC340) and year 3 MEng projects (ELEC440) involving human participation must be undertaken in a way that safeguards the dignity, rights, health, safety, and privacy of those involved.

It should be noted that this policy covers **all** research methodologies including such activities as informal interviews, accessing personal files in an archive, or on-line data gathering. The requirement to obtain ethical review applies with equal force to projects undertaken by undergraduate students. For these projects, it is the responsibility of the supervisor to ensure that the ethical issues of the research are fully assessed and that formal ethical approval is obtained before the project commences.

Does your project involve any human participants (including situations where you are a participant as well as the investigator)?	YES	NO ✓
Does your project involve any human tissues (including your own)?	YES	NO ✓
Does your project involve any databases of personal information (including your own personal information)?	YES	NO ✓
Does your project involve experiments using animals?	YES	NO ✓

Delete either YES or NO on each line above

If any of the answers given above are YES then you, along with your project supervisor, must investigate the requirement to apply for ethical approval. Details of how to apply for ethical approval can be found at www.liv.ac.uk/intranet/research-support-office/research-ethics/ (for human participation) and at https://www.liv.ac.uk/research-integrity/biomedical-research/ (for use of animals).

Student Signature: Dai Jin. Date: 27. Sep. 2018

Supervisor's Signature: Paul Bryant Date: 27/9/18

Appendix 4: Risk Assessment Form

UNIVERSITY OF LIVERPOOL

RISK ASSESSMENT FORM

School/Department: Electrical Engineering and Electronic	**Building: Electrical Engineering and Electronic**
Task: Real time Chromatic monitoring system	
Persons who can be adversely affected by the activity: Dai Jin	

Section 1: Is there potential for one or more of the issues below to lead to injury/ill health (tick relevant boxes)

People and animals/Behaviour hazards

Allergies		Too few people		Horseplay		Repetitive action		Farm animals	
Disabilities		Too many people		Violence/aggression		Standing for long periods		Small animals	
Poor training		Non-employees		Stress	✓	Fatigue		Physical size, strength, shape	
Poor supervision	✓	Illness/disease		Pregnancy/expectant mothers		Awkward body postures		Potential for human error	✓
Lack of experience	✓	Lack of insurance		Static body postures		Lack of or poor communication		Taking short cuts	✓
Children		Rushing	✓	Lack of mental ability		Language difficulties		Vulnerable adult group	

What controls measures are in place or need to be introduced to address the issues identified?

Identified hazards	CURRENT CONTROLS	RISK SCORE	ADDITIONAL CONTROLS REQUIRED (To include responsibilities and timescales)	RESIDUAL RISK SCORE
1.Lack of experience 2. Human error 3. Poor supervision 4. Rushing 5. Short cuts 6. Stress	Close supervision / guidance by supervisor. Weekly meetings. Supervisor will visit lab/check circuit. Lab tech' will ensure safety standards/offer advice in lab. In event of serious issues Lab tech will inform supervisor/ Project halted pending investigation.	2		4

Section 2: Common Workplace hazards. Is there potential for one or more of the issues below to lead to injury/ill health (tick relevant boxes)

Fall from height		Poor lighting		Portable tools	✓	Fire hazards		Chemicals		Asbestos	
Falling objects		Poor heating or ventilation		Powered/moving machinery		Vehicles		Biological agents		Explosives	
Slips, trips, falls	✓	Poor space design		Lifting equipment		Radiation sources		Waste materials		Genetic modification work	
Manual handling		Poor welfare facilities		Pressure vessels		Lasers		Nanotechnology		Magnetic devices	
Display screen equipment		Electrical equipment	✓	Noise or vibration		Confined spaces		Gases		Extraction systems	
Temperature extremes		Sharps		Drones		Cryogenics		Legionella		Robotics	

Home working	✓	Poor signage		Overseas work		Overnight experiments		Unusual events		Community visits	
Late/lone working		Lack of/poor selection of PPE		Night work		Long hours		Weather extremes		Diving	

What controls measures are in place or need to be introduced to address the issues identified?

Identified hazards	CURRENT CONTROLS	RISK SCORE	ADDITIONAL CONTROLS REQUIRED (To include responsibilities and timescales)	RESIDUAL RISK SCORE
1. Electrical Equipment Including Oscilloscopes, benchtop power supplies, Signal generators etc	Must follow the Electricity at work regulations in the Lab. Lab technicians / supervisor will be vigilant. No Live Working is permitted at any time. Never remove the covers from equipment containing a source of high voltages and/or currents. Check the PAT test labels on equipment before use and ensure they are in date. Visually inspect equipment for signs of fault damage before use.	10	Always practice good housekeeping and keep all experimental areas clean and tidy. Seek advice if unsure.	5
2. Home working	Student informed they are not allowed to take hardware home. Project must be done in 4th floor lab.	8		
3. Slips, trips, falls	Work area must be kept clean and tidy. No coats, bags and other personal items should be left in the area around the workbenches Use the coat hangers provided at the ends of the laboratory No cables to be trailed on the floor	8	Lab tech/supervisor will remind student to remove trip hazards etc.	2
4. Portable tools	Hand tools may be used by any competent person. Tools to be inspected for wear or damage before use. PPE is provided along with various clamping methods.	5		

Section 3: Additional hazards: are there further hazards NOT IDENTIFIED ABOVE that need to be considered and what controls are in place or needed? (list below)

Additional hazards	CURRENT CONTROLS	RISK SCORE	ADDITIONAL CONTROLS REQUIRED (To include responsibilities and timescales)	RESIDUAL RISK SCORE
1. Soldering- Fumes, burns, Fire, materials, chemicals. Specifically asthma triggered by colophony sensitization	Use fume extractor if available. Do not inhale fumes. Use lead and/or colophony free solder where appropriate. Use of temperature controlled soldering station with stand. Solder sponge (wet or brass) to remove excess solder & clean tip. Do not hold soldering iron by the hot element.	10	Novices to be supervised until competent. Always use the soldering iron stand. Do not place soldering iron directly onto the bench	3
2. Food and drink spillage and contamination	No food or drink allowed In the laboratory at any time	6	Take refreshment breaks outside the laboratory. Confiscate and dispose of food and drink found around the workbenches	1

Section 4: Emergency arrangements (List any additional controls that are required to deal with the potential emergency situation)

Emergency situation	Additional control required
Student gets injured	Close supervision by the supervisor and lab technicians.
	Keep vigilant when working. If unsure seek advice.
	First aiders in the 4th floor lab.
	In the event of emergency, project will be stopped. Incident investigation. Recommendations implemented before project restarted.

Person undertaking activity)........Dai Jin........Date..27..Sep. 2018

Risk assessor (signature)........Dan Bryan........Date....28/9/18 Authorised by (signature)........Dan Bryan........Date..28/9/18