UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Development of Sorting System Based on Colour Segregation Using Programmable Logic Controller (PLC)

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

by

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TAJUK: **Development of Sorting System Based on Colour Segregation Using Programmable Logic Controller (PLC)**

SESI PENGAJIAN: **2017/18 Semester 1**

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfilment of the requirements for the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours. The member of the supervisory is as follow:

……

(Project Supervisor)

ABSTRAK

Pada masa kini, kebanyakan industri, komersil dan dunia domestik menggunakan teknologi automasi untuk memainkan peranan yang penting dalam usaha untuk mengawal, merasa, dan mengarahkan dirinya untuk mencapai keputusan yang dikehendaki. Matlamat saya adalah untuk mencipta sistem pengasingan berdasarkan warna untuk penggunaan dalam industri. Sistem pengasingan adalah sistem yang mempunyai keupayaan untuk menempatkan objek berdasarkan warna objek. Programmable Logic Controller (PLC) telah digunakan sebagai sistem kawalan utama, objek berwarna akan dimasukkan dalam sistem penghantaran secara automatik. Warna pada objek tersebut akan ditentukan oleh pengesan warna dan mencetuskan lampu mengikuti warna yang dikesan. Sistem penghantaran akan bergerak dan menghantar objek. Sistem pengasingan telah lengkap apabila sensor optimum mengesan objek. Bahagian terpenting dalam projek ini adalah pengesan cahaya (LDR). Kebolehan pengesan ini adalah mengenalpasti objek berdasarkan warna objek. Terdapat empat warna objek digunakan dalam sistem pengasingan warna ini. Secara keseluruhan, pengesan warna akan mengesan warna objek dan membuat keputusan lampu yang mana akan diaktifkan. Hasil yang dijangka dalam projek ini ialah prototaip sistem ini dapat beroperasi dalam gerakan sederhana. Prototaip dapat menyelesaikan masalah kekurangan kesilapan manusia dalam sistem pengasingan. Selain itu, automatik sistem pengasingan berdasarkan warna dapat dicipta.

ABSTRACT

Nowadays, majority of industrial, commercial and domestic world used the automation technology to control, sense, regulate and instruct itself to accomplish the tasks. My aim is to create a sorting system based on colour for the use in industry. The sorting system is a system which sorts the object according to their colour. With the Programmable Logic Controller (PLC) as a main controller for the system, the object which is colouring box places on the conveyor automatically using the double acting cylinder A. Cylinder B acts as an actuator to block or prevent the box from passing through so that the colour sensor has enough time to determine the colour of object. The main part for the colour sensor is Light Dependent Resistor (LDR) which detects light intensity. The output voltage sensed by the LDR also decides which pilot lamp should activate according to colour determined. After completed colour sensor part, the conveyor will turn on and move the box. The sorting system completed once the optimal sensor sensed the object and sort box in place. In this project, there are four different colour objects used for demonstrating the sorting system. The result shown that the prototype of colour sorting system able to run in moderate motion. The prototype project can help to eliminate the human error in the sorting process. Besides that, automatic sorting system based on colour is created.

DEDICATIONS

To my parents,

All my lectures, especially, Mr. Ir. Nik Azran Bin Ab. Hadi
All my friends and relatives

Thousands of thanks and appreciates for their supports, encouragements and understands.

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First, I would like to express my appreciation to my supervisor, Mr. Ir. Nik Azran Bin Ab. Hadi which gives a lots of advices and guidances to complete this final year project. Besides that, he also pointed my project to the correct path for development. He also helps me set the mile stone in order to make sure my project finish on time.

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I appreciate my parents' sacrifice, love, and dream in my life. There no any suitable sentences that may appropriately portray my gratefulness for their assistance, commitment and confidence in my capacity to accomplish my aims.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

A/D	-	Analog to Digital
AC	-	Alternating Current
ADC	-	Analog to Digital Converter
AREF	-	Analog Reference
AVR	-	Advanced Virtual RISC
BLDC	-	Brushless DC
C	-	Celcius
CCP	-	Capture/Compare/PWM
CH	-	Channel
cm	-	Centimeter
CMOS	-	Complementary Metal-Oxide Semiconductor
DC	-	Direct Current
FPGA	-	Field Programmable Gate Array
GUI	-	Graphical User Interface
I/O	-	Input Output
IDE	-	Integrated Development Environment
IR	-	Infrared
kΩ	-	Kilo ohm
KB	-	Kilobyte
LCD	-	Liquid-Cystal Display
LD	-	Ladder Diagram
LDR	-	Light Dependent Resistor
LED	-	Light Emitting Diode
m	-	Meter
mA	-	Milliampere
mcd	-	Millicandela
MHz	-	Megahertz
mm	-	Millimeter

PC	-	Personal Computer
PCB	-	Printed Circuit Board
PLC	-	Programming Logic Controller
PIC	-	Peripheral Interface Controller
PWM	-	Pulse-Width Modulation
RISC	-	Reduced Instruction Set Computing
RX	-	Receive
TX	-	Transmit
USB	-	Universal Serial Bus
V	-	Voltage

CHAPTER 1
INTRODUCTION

1.0 Introduction

Nowadays, the capacity to differentiate colour is crucial for human's life as it gives us the awareness surrounding through eyesight. Hence, colour is one of the most important features for accurate classification in the sorting system. Since 1990s, the sorting system in production lines for the food processing industries such as coffee, nuts and oil crops was performed manually (Sujata and Dr. Padole, 2014). However, the manual inspection is slow and inconsistent. This is because employee who has been performing the repeating manual inspection task may fail to recognize the colour of product due to fatigue of long term working hour without rest. In 1895, Taylor proposed an automatic bruise detection system. With the aid of colour capture, an automatic colour sorting system able to differentiate, sort and organize. The sorting system mostly used to ensure quality can be up to mark. The process can be progressed by using mechanical or pneumatic ejection (Sujata and Dr. Padole, 2014).

1.1 Project Background

For this project, a sorting system combines electronics and programming to run the whole system. It is about assembly systems with DC motor, colour sensor and cylinders along with major connections. The automation sorting system has a capability to determine the colour of the object. The object can be defined by determining colour of the box and the system will decide which pilot lamp activated for the box.

The colour sensor senses the colouring box by using the Programmable Logic Controller (PLC) which acts as a main controller for the sorting system. The conveyor which is controlled by the PLC will bring the box that sensed by both Light Dependent Resistor (LDR) sensor and 4 super ultra brightness LED to the exact location. The circuit that consists of LDR sensor and super ultra brightness LED is able to determine the light intensity level on the box.

The colour sensor and pneumatic cylinders are also programmed by PLC. Pilot lamp will turn on after read the information which transmitted by the colour sensor. In this sorting system, there are four pilot lamp which used to indicate different colour. The indicator for the sensed colour for each pilot lamp are shown below:

Green Pilot Lamp 1 = White
Green Pilot Lamp 2 = Blue
Red Pilot Lamp = Red
Yellow Pilot Lamp = Black

This colour sorting system has marketing purpose due to low cost, increment productivity and reduction human resources. Figure 1.1 shows the entire process flow of this project.

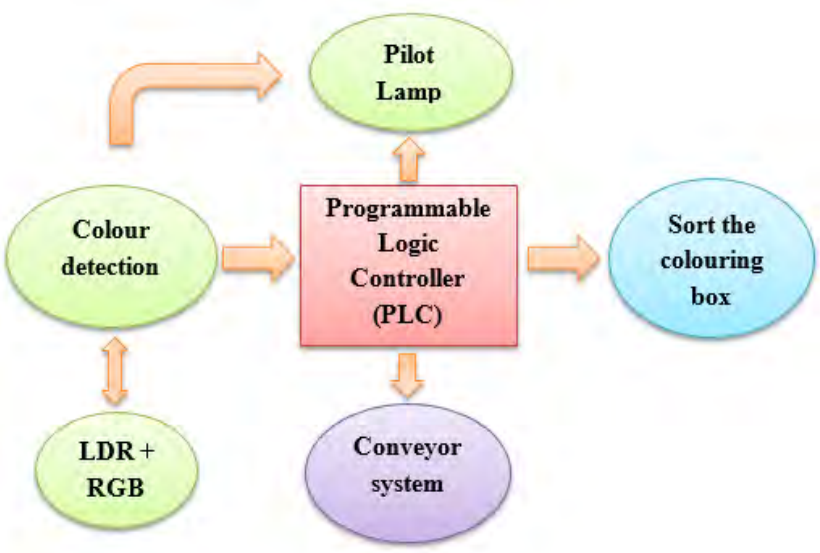

Figure 1.1: Entire process flow

1.2 Problem Statement

There are some issues that often happen in the industry that can be cleared out by using this project are:

i. The limitation of time response for human eye caused the colour sorting process by a worker is very slow. Besides, mostly operator will feel tired after a long day working. It will cause the operator unable to perform well as usual and lower down the performance for an operator. However, this limitation can be avoided by using an automatic system that can reduce the time spent for the sorting process. The automatic sorting system will maintain the same speed during sorting process.

ii. Worker usually make mistakes easily during the colour sorting process can affect the productivity of the company. This is because an operator needs to handle thousand of products each day caused them feel sleepy and tired. Hence, it is common if operator makes a mistake. By using the automatic sorting system, the operators just have to operate the system which gives accurate result even it has been repeated for billions of times.

iii. The colour sorting process requires large amount of human resources to differentiate, sort and organise the product. This disadvantage increases the cost of a product. Hence, a low price colour sorting system is designed so that it can speed up the process time, increase the accuracy and produce a low cost product.

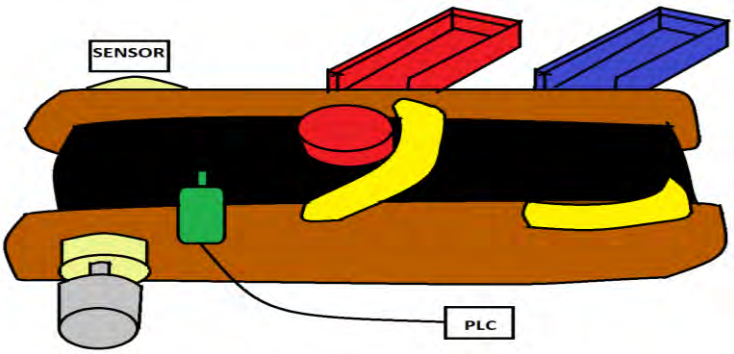

Figure 1.2: Automatic sorting hardware design

1.3 Objectives

The intention of this project is to create a sorting system which can achieve the following objectives:

i. To make sure that the sorting system runs continuously with less rest.
ii. To eliminate the human error during sorting process.
iii. To design and develop a low cost colour sorting system using Programmable Logic Controller (PLC).

1.4 Scope of Work

This work requires a few scopes and guidelines to assure that this project able to conduct around the expected borderline and right direction for achieving those objectives. Hence, the project work scope are as below:

i. Research and study on the Light Dependent Resistor for colour sensor.
ii. Research and study on Programmable Logic Controller.
iii. To design circuitry for the overall system.
iv. To create a ladder diagram that can interface and manipulate the whole system.

1.5 Report Structure

Five chapters are combined in this report which are introduction, literature review, methodology, result & discussion and conclusion & recommendation of the project.

Chapter 1 is an introduction for the whole project. This chapter will briefly explain the background of sorting system and important objectives of the project. Besides that, the problem statement and scope of the project are also added in this topic.

Chapter 2 compiles the literature review, generally on the existing projects and components that used in this project. This part concentrates on the theory of all aspects of the sorting system. Sources from journals, books, thesis and website that covering all the information connected to the project are included.

Chapter 3 is about the methodology of the project which shows steps and flow for the problem solving in designing the interface of the project to combine with Programmable Logic Controller (PLC). This part concentrates on the procedure to execute the project from the primary design until the end. Strategy and time management are presented in this part. The project's gantt chart also added here.

Chapter 4 describes the expected result from this project and ensures the objectives of the project is achieved.

Chapter 5 concludes all chapters from chapter 1 to chapter 5. The conclusion of the whole project and recommendation will be concluded in this part.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

Chapter 2 is to review some fundamental ideas from the research. It is necessary to study on journal that related to the project because knowledge and skills needed to complete the project. In other word, this chapter is the brief or idea on published journal that similar as this project. All the components using for this project will discuss in this chapter as well.

2.1 Existing Project for Sorting System

2.1.1 Development of an automated colour sorting system for recycle glass containers

The intention of this project is to design a colour sorting prototype to recycle glass containers. The components used are photovoltaic sensor, high intensity light emitting diode (LED), vertical sensing chute and diversion gate and digitized sensor. Photovoltaic sensor is chosen due to greater voltage output, larger surface area and quicker time response compare to photocell. The system has a vertical sensing chute that sort the clear container out of a mixed colour glass container as shown in Figure 2.1 (Lewis and Newell 1991). Initially, the glass container enters the system via downward sloping trough and the chute. Then, bottles pass through the alignment hopper which serve

three purposes: (a) vertical alignment of the bottles; (b) put the bottles at centre so that pass through the light beam; (c) speed reduction of the bottles to facilitate a longer sensor reading. After pass through light beam and light transmittance is sensed and passed to control circuits. A high intensity light emitting diode (LED) with a luminous intensity 500 mcd functions as the light source. The optical sensor used as input data for computer coded mathematical model of control circuit. After sensed by the sensor, the diversion gate will control the degree of opening gate to sort the glass container accurately. For the automated and manual sorting, this project achieved 100% success rate and 70% rate at 1.25 ton/hr/chute. According to Lewis and Newell (1991), they recommended that the colour sorting should occur near to the generator to increase the handling process. For this project, cost and success rate are the critical factors in evaluating the colour sorting system (Lewis and Newell, 1991).

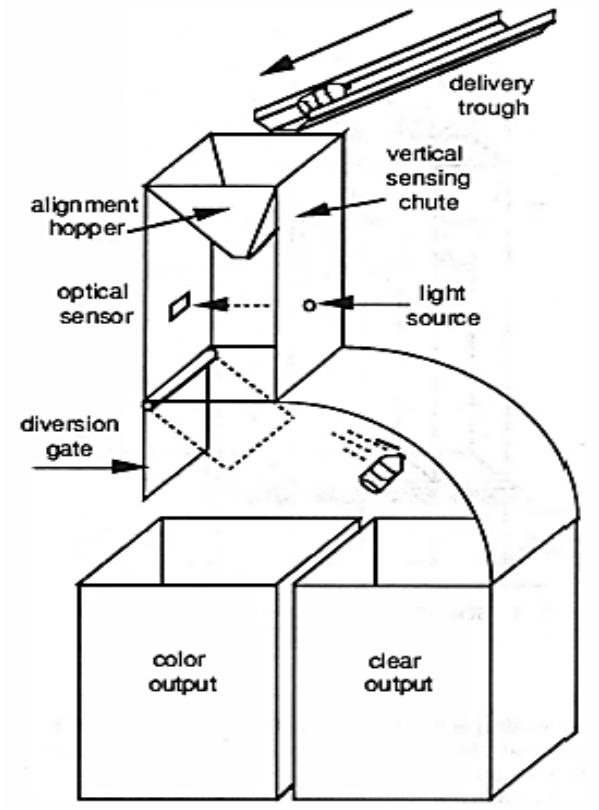

Figure 2.1: Recyclable glass containers sorting prototype (Lewis, 1991)

2.1.2 Design and development of colour sorting robot

This paper shows a colour sorting robot is designed using the colour processing via Arduino UNO. The programming code enable the system to array the colour ball using the colour sensor in minimum time. The components used are microcontroller, TCS3200D colour sensor, servo motor and other basic electronic components. The method for TCS 3200D to determine the colour is by using the RGB filters and compare the value that reflected on it. The RGB values checked by using Adobe Photoshop software. Irda and Lim (2015) shows the system overview on the highest value in colour filter send to Arduino. Arduino UNO receives the analog signal from the sensor that detects the colour of the object and triggers the slider at servo motor to move different angle of 10°, 70° or 170° depending on the colour sensed.

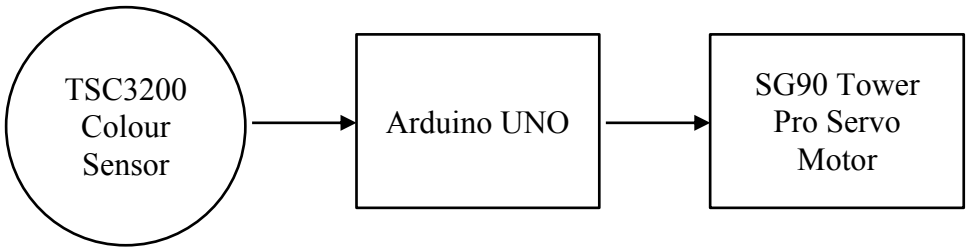

Figure 2.2: System overview (Irda and Lim 2015)

The colour stations are classify into red, green and blue. After placed the ball, the slider return back to original position to await the colour ball. For this project, the collected data analysis includes the light intensity test and colour ball selection test. Table 2.1 and Table 2.2 shows that RGB values taken indoor are greater than outdoor due to more than single light at outdoor (Irda and Lim 2015). Irda and Lim (2015) also mentioned that the Arduino-powered sorting robot is more profitable compared to the current sorting system. They also recommended that the RGB values should be display on the Arduino Serial Monitoring Screen to benefit people to intend to observe. Figure 2.3 (Irda and Lim 2015) captures the robot hardware design.

Table 2.1: RGB filter during indoor test (Irda and Lim 2015)

Ball Colour	Average Filter Value		
	Red filter (R)	Blue filter (B)	Green filter (G)
Red	17	6	5
Blue	3	11	6
Green	3	3	7

Table 2.2: RGB filter during outdoor test (Irda and Lim 2015)

Ball Colour	Average Filter Value		
	Red filter (R)	Blue filter (B)	Green filter (G)
Red	18	16	9
Blue	7	12	10
Green	2	5	6

Figure 2.3: Colour sorting robot product design (Irda and Lim, 2015)

2.1.3 Lego bricks colour sorting machine

The automation lego brick machine designed to classify the different colour. Initially, power supply will turn on the servo motor, microcontroller and sensor at the same time. Uno ATmega328P acts as a main controller sends signal to the servo motor while microcontroller reads signal from Pixy sensor.