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Design and development of a barcode image identification system

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Abstract

Bar Codes have infiltrated every facet of our lives. They have replaced key-data entry as a method of gathering data. This can reduce inefficiencies and improve a company's productivity thereby growing their bottom line.

Barcode is defined as a set of numeric data that are represented by a series of bar of varying thickness and separations [26]. Often, this set these numeric data can be found underneath barcode symbol. There are a few standards in barcode, Namely Code 39, EAN8 and code 128. These standards have different characteristic hence used in different industries. For an instance code 39 is commonly used in non-retail industries. These codes are commonly read by a charge-coupled device (CCD) scanner. These scanners work by converting the intensity of lights that reflected from white and black bars into binary.

In this report, we have developed a system that is able to identify barcode image using image identification. We tested on one type of barcode standard – code 39 without checksum of modulo 43.This technique of identify comparison is assessed based on performances and flexibility that can integrate into existing production line. However this developed project is only a small part as compare to the commercial products. On top of that this project tackles on the issue faced by the production currently.

Acknowledgment

This project could not have been possible without the support of Ms Cynthia Chang who has given me advices and guidance. I am also grateful to the SIM University for providing the facilities means to complete this project. I would like to express my gratitude to all the members in www.lavag.org for their suggestions and feedback. Finally, I must thank all my friends with whom I have shared many good times in school.

Chapter 1.0 Introduction

Bar code, composed of bars and spaces of varying width, provides a means of human-readable characters in a form (bars and spaces) readable. These are often found on packages of snacks, foodstuff, and sundries stacked on supermarket shelves or convenience stores. It can also be found on industrial products.

Traditionally, barcode recognition is done by the scanning barcode either by a CCD scanner or laser scanner. These scanners use analog edge detectors to detect the black and white bars by receiving the reflected light that shine on them. More recently, with the advancement of imaging technology and low cost of hardware such as cameras, more companies are developing barcode imaging detection using image recognition. This introduces a new alternative which comprises of both hardware and software.

1.1.0 Comparison between image technology vs CCD and Laser

As mentioned earlier, although reading barcode using CCD technology has been in this industry for many years, it does not use of a true laser. It measures light reflected back to it from light-emitting diodes, or LEDs, and the light is decoded as data (electric signal). This requires user to point at the barcode at a close proximity and the quality of the printed barcode is one of the main criteria for accurate reading. According the test [37], CCD scanner takes approximately 100 to 200 scan per second

A technology was introduced to resolve the disadvantage of using CCD scanner. That is the laser technology. It works by using laser light is shone on the label surface and its reflection is captured by a sensor (laser photo detector) to read a bar code. A laser beam is reflected off a mirror and swept left and right to read a bar code. Laser technology allows reading of distant and wide bar code labels. Generally this technology is more expensive than CCD scanner as this laser scanner has oscillating mirrors that are subject to wear and mechanical failure. Secondly, Laser scanner has difficulty reading barcodes in bright sunlight and barcode that printed on some rough surfaces. It is subject to wear and damage from shock. Last of all, Laser diodes are expensive and in the case of long range (high power) scanners, may cause eye damage if shone directly into an eye.

On the other hand, using image recognition technology for reading barcode is relatively new in the industry. However it has gained high recognition through its proven track record. The key characteristics distinguishing image recognition system with other conventional barcode reading system are that they are free from any moving parts or burned diode and at the same time flexible enough for any expansion or future development. For an instance, other than barcode reading, the image technology is also able to detect any defects within the component. In addition to that, no human involvement is needed when used image recognition technology, this results in minimum error caused by human.

After comparing with existing technology such as CCD and laser technology, image recognition technology is still overall the best option for barcode reading.

1.2.0 Project planning

1.2.1 Project Objective

The aim of the project is to develop and design a barcode image identification system to identify and transfer the PC chassis to the appropriate assembly line. Generally, the system to be developed will capture the barcode image on the chassis as an input. Next, the system read the barcode and identify the part belongs to which product and convey it to the appropriate assembly line.

1.2.2 Overall objective

Currently, the PC chassis is manually input by operator on to the conveyor line. The process is time consuming and human dependable very often resulted in error.
The overall objective of this project is to reduce any human error and increase efficiency of production.

1.3.0 Proposed approach and method to employed

1.3.1 Project management

Project management skill is the most important element. In this project, most of the work is focused on software based. There are a few approaches in developing software. The popular approaches are System Development Life Cycle (SDLC) and Rapid Application Development (RAD)

System Development Life Cycle (SDLC) is defined as a model used in project management that describes the stages involved in software development project. [33] It starts from initial feasibility study till maintenance of the completed application. They are mechanisms to assure that software systems meet established requirements (DOJ, 2000). These methodologies impose various degrees of discipline to the software development process with the goal of making the process more efficient and predictable. It is used as guidance in developing this system and provides the project progress in a systematic approach and in turn fulfils its objectives.

System Development Life Cycle (SDLC) is a waterfall model as shown in Figure A. It consists of project planning, requirements definition, design, development, integration & test and installation and acceptance.

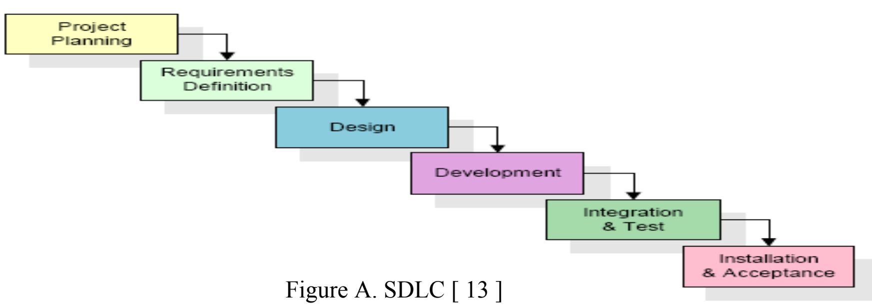


Figure A. SDLC [13]

This approach allows the output of the previous stage is served as the input of the next stage. In this way, more information is gathered and developed as it progress from one stage to another.

On the other hand, Rapid Application Development (RAD) is a spiral model. The idea is to build a basic system and allow user to comment and provide feedback. In this way, improvement is made based on their feedback. This ensures minimum error to be missed out during the process. This biggest drawback for this approach is that the developer and end user are easily caught in the trap of endless cycle of enhancement.

As SDLC is a waterfall approach, each stage has to be completed or agreed upon before moving into next phrase. This helps the project to make progress and move on timely without compromise the deadline given by SIM. While RAD is an iterative approach, this approach can easily fall into the trap of endless improvement cycle.

To conclude, System Development Life Cycle will be adopted for this project.

1.3.2.0 SDLC's eight stages

SDLC consists of project planning, requirements definition, design, development, integration & test and installation and acceptance.

1.3.2.1 Project Planning

This is the first phrase of developing the project. This stage is used to establish the basic project structure, evaluate feasibility and risks associated with the project, and describe management and technical approaches for this project.

1.3.2.2 Requirements Definition

In this stage project goals are defined into detailed and specific function such as the operation of the software. To do that, surveys have been conducted to collect and analyze end-user information needs, management requirements and expectation from this system. Mr. McKeen had conducted studies and found that systems which spent more time in the analysis phase required less time to code. This in turn resulted in greater user satisfaction, and were developed the system within budgets and meet deadlines [35].

1.3.2.3 Design

This stage is to develop overall plan for proposed system. Detailed features and requirement will be listed out in this stage. Diagrams such as functional hierarchy diagrams and screen layout diagrams are used to describe the system. This helped programmer to develop such software with minimal additional input.

1.3.2.4 Development

This stage takes in the requirement set in the previous stage (design) when developing the project. Test cases will be developed for each set of functionally related software function. This is to ensure that all the requirements and reliability of this piece of software is met. Recently, there has been a trend in software development and testing to engage testers earlier in the development process [34]. Mr. Tyan commented that the advantage of testing early in the life cycle is that it is able to catch and fix defects early in software development. Such practice is encouraged and cost saving. This is because fixing a defect detected in later phases tends to cost 10 to 100 times more [36].

1.3.2.5 Integration & test

During the integration and test stage, the software will move on from the development environment to user environment. In this case, this user environment will be located at the production floor. Another round of tests are conducted to ensure that the software's capability of being able to integrate to the existing production system.

1.3.2.6 Installation & Acceptance

As the design of the software has completed and test are carried out in the previous stage in order to minimize any bug found in the system. In this stage, test on the software in production environment will be conducted. This stage is a prerequisite to acceptance of the software by the "customer". Here customer will be referred to the developer. In this stage, the software is able to test and proved with satisfactory results.

Table A. below summaries the approached and method used.

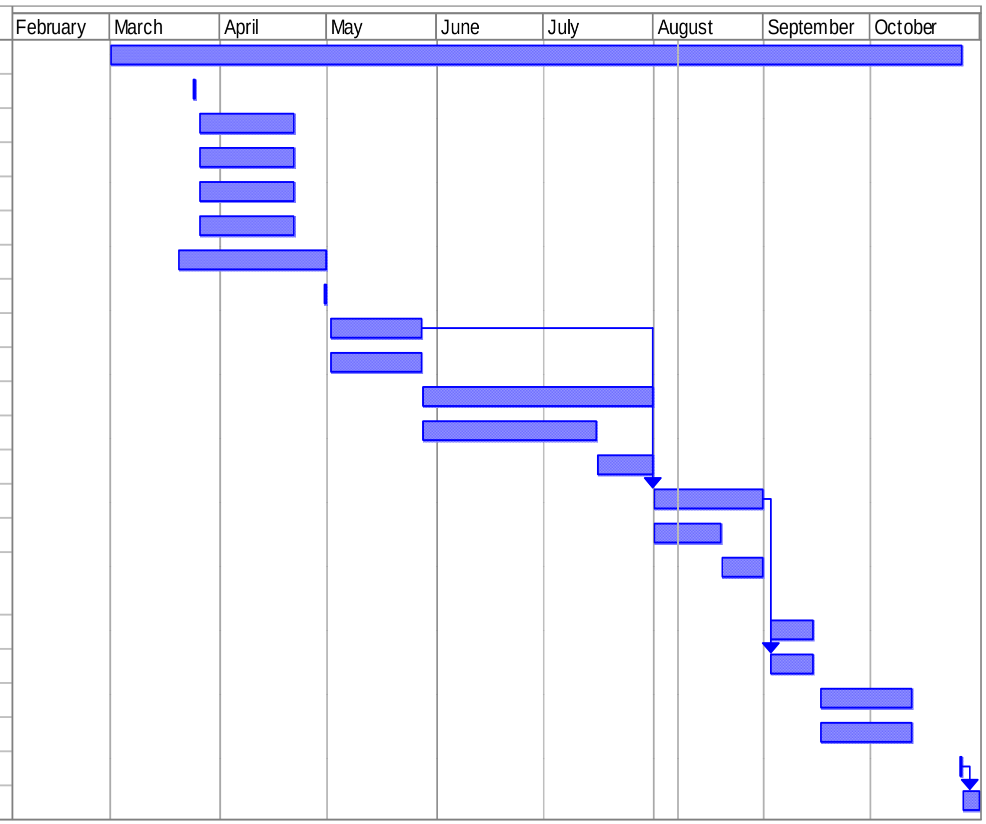
Table A. Approached and Method

System Development Life Cycle	**Approach**	**Method**
Project Planning	Gathering of information at production	• Focused group interview.
	Literature Reading & Review	• Read books and internet search.
	Study of assembly line process flow	• Time study.
	Root cause analysis	• Ishikawa diagram.
	Proposed solution	• Market research.
	Learning software	• Read books and internet search.
	Assess Project progress	• Gantt Chart
Design	Design proposed solution	• New process flow chart.
Development	Software programming	• Writing of inspection algorithm.
	Hardware design	• Research on the proposed solution.
Integration and test	Design of experiment	• Do a mock up inspection system. • Refine the algorithm and hardware system. • Retest the improve version.
	Benchmark testing against other existing identification systems.	• Research and compare.
Installation and acceptance	Design of assembly line with the inspection system	• Draw the design of the assembly line.
Project closure	Final Report Preparation	• Report writing using MS word.
	Oral presentation	• Power point

1.4 Project Planning

There are few milestones in this project. They are: TMA01 submission, Design stage and Integration and test stage. These are important check point in this project. For an instance, TMA01 allows to walk through the whole process flow and all possibilities. Design stage includes design and learns the software programming. This is the major portion of the project. Integration and test stage is the real test to the software that is developed for this project. Missing these milestones will mean a delay of project progress.

ID	Task Name	Start	Finish
4	1.2 Literature reading and review	Thu 01/03/07	Fri 26/10/07
5	1.3 Meet tutor	Sat 24/03/07	Sat 24/03/07
6	1.4 TMA01 preparation	Mon 26/03/07	Sat 21/04/07
7	1.5 Study of assembly line process flow	Mon 26/03/07	Sat 21/04/07
8	1.6 Root cause analysis	Mon 26/03/07	Sat 21/04/07
9	1.7 Proposed solution	Mon 26/03/07	Sat 21/04/07
10	1.8 Learning of software	Tue 20/03/07	Mon 30/04/07
11	1.9 TMA01 due date	Mon 30/04/07	Mon 30/04/07
12	**2.0 DESIGN**	Wed 02/05/07	Sun 27/05/07
13	2.1 Design proposed solution	Wed 02/05/07	Sun 27/05/07
14	**3.0 DEVELOPMENT**	Mon 28/05/07	Tue 31/07/07
15	3.1 Software programming	Mon 28/05/07	Sun 15/07/07
16	3.2 Hardware design	Mon 16/07/07	Tue 31/07/07
17	**4.0 INTEGRATION AND TEST**	Wed 01/08/07	Fri 31/08/07
18	4.1Design of experiement	Wed 01/08/07	Sun 19/08/07
19	4.2 Benchmark testing against other existing identification systems.	Mon 20/08/07	Fri 31/08/07
20	**5.0 INSTALLATION AND ACCEPTANCE**	Mon 03/09/07	Fri 14/09/07
21	5.1 Design of assembly line with the inspection system.	Mon 03/09/07	Fri 14/09/07
22	**6.0 PROJECT CLOSURE**	Mon 17/09/07	Fri 12/10/07
23	6.1 Final Report Preparation	Mon 17/09/07	Fri 12/10/07
24	6.2 Final Report due date	Fri 26/10/07	Fri 26/10/07
25	6.3 Oral presentation	Sat 27/10/07	Sun 11/11/07



1.5 Risk Analysis

The risk of doing this project is low as it does not involve in using any dangerous equipment.

1.6 Project Resources

In this project, most of the hardware equipments are available in the market. For programming software such as LabVIEW and Mathlab, they are also available in SIM Lab.

1.7 Summary

This chapter discussed on the topic of this project that will be worked on. Project management such as resources and planning are discussed in this chapter. SDLC approach has been discussed and advantages of using this approach are also discussed in this chapter.

Chapter 2.0 Investigation of Project Background

2.1 Project Background

In the PC assembly line, the chasses are differentiated by the interior design and barcode tag. The identification of each type of chassis is vital as the assembly of the PCBA is dependent on the design of chassis. The differentiation of the chassis is currently carried out by the operator through physical inspection of the chasses' interior or bar code scanning, before feeding the chassis to the correct production line. This differentiation method however frequently results in mistakes and caused the chassis to be placed onto the incorrect conveyor.

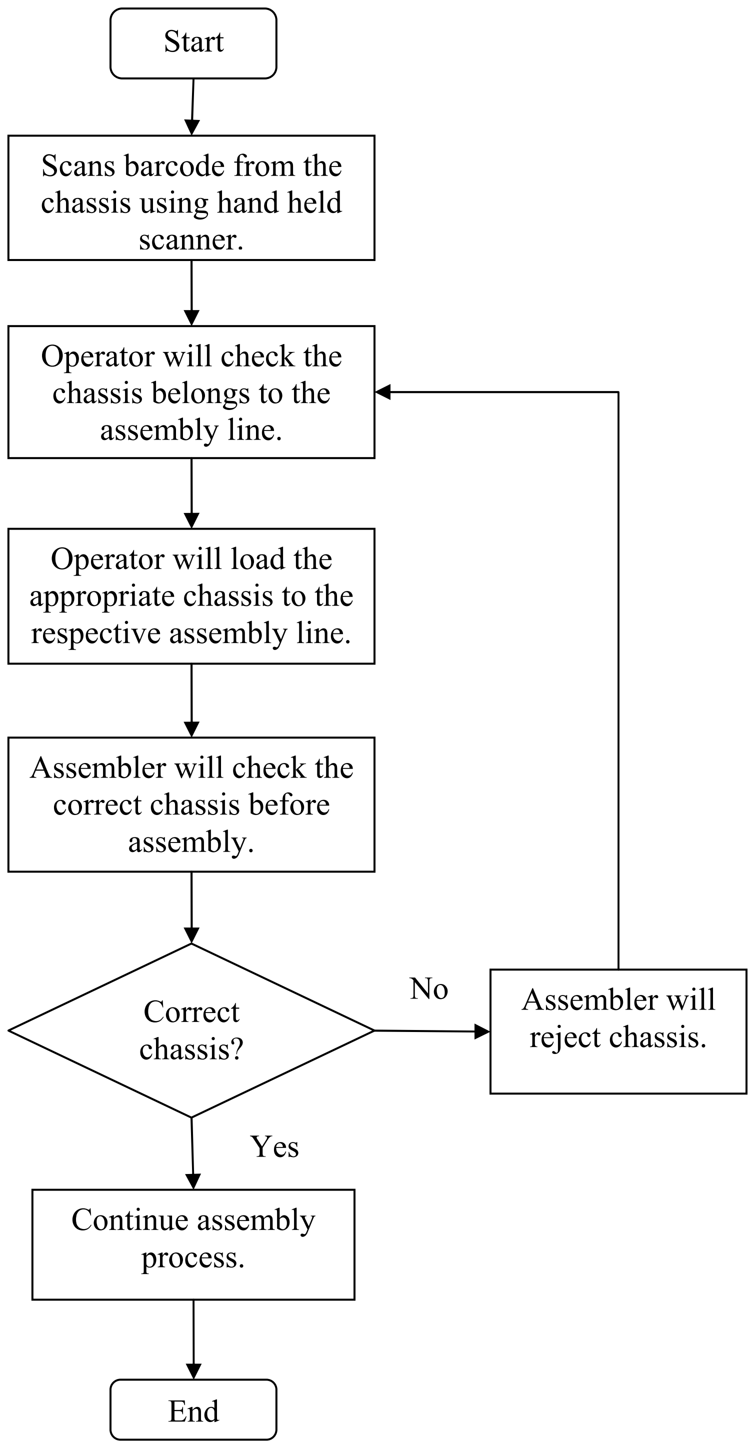
Currently, the procedure of scanning barcode is semi-automated. Operator has to be present to scan the barcode using infrared red scanner.

There are two purposes of scanning barcode. First of all, it is used as a record for the quantity being loaded into the assembly line. Secondly, this data collected is served as a secondary inventory check.

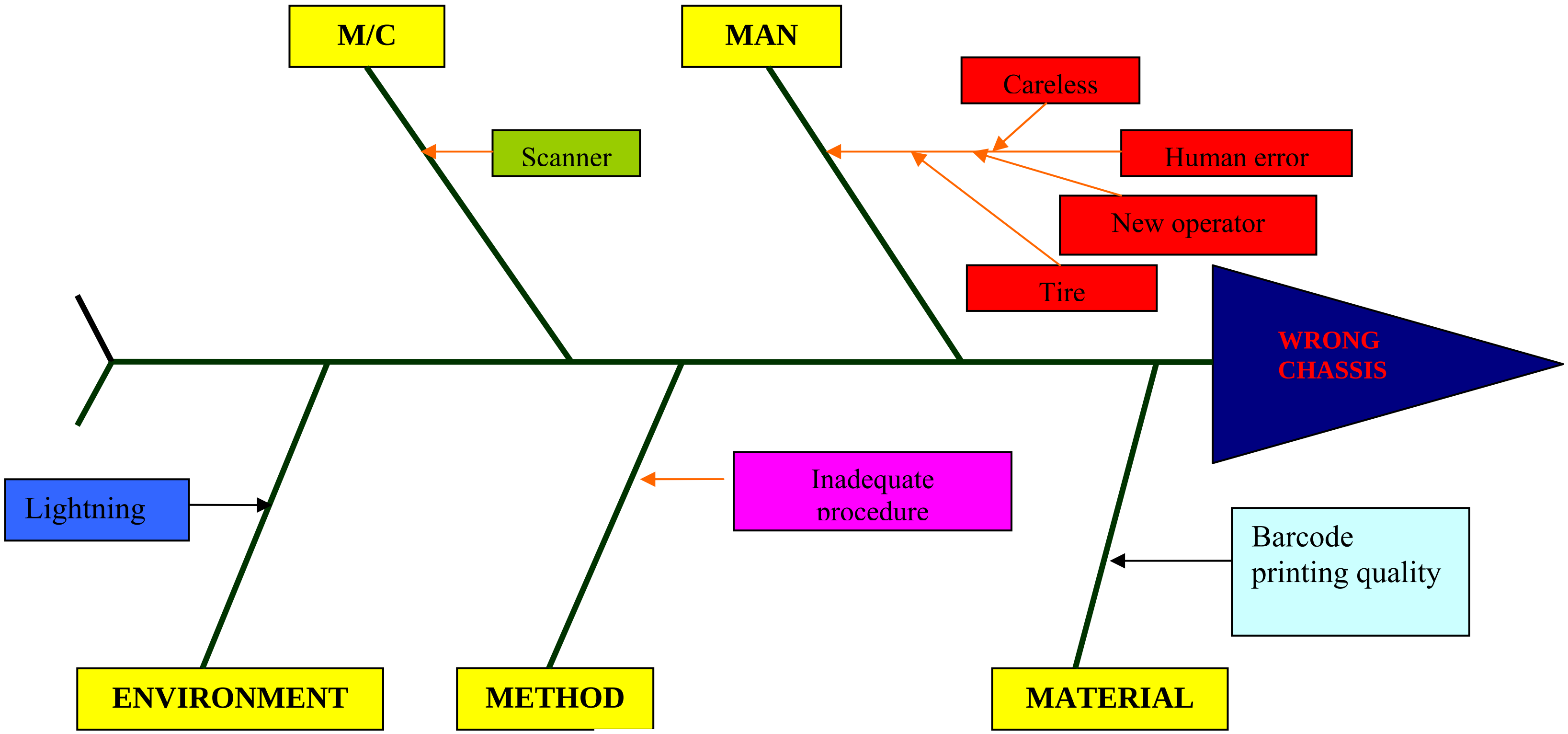
The barcode scanning has the following disadvantages:-

A. When the operator scans barcode from the chassis, the operator has to point the cursor at the centre of barcode tag. Any deviation of angle may cause inaccuracy or the scanner to not be able to read the barcode.
B. Sometimes the laser light of the scanner did not appear and the operator needs to reactivate the scanner by shaking it. This may result in damaging the equipment or bodily stress to the operator.
C. The amount of time to scan one chassis can take up to 30 seconds which will increase the cycle time.
D. Inspection results in terms of number of passes or failure cannot be generated from the barcode scanner system.

2.2 Current process flow



2.3 Root cause analysis



Ishikawa Diagram

The Ishikawa [20] method is used for root cause analysis. Ishikawa consolidate the root cause under five factors namely Man, Machine, Method, Material and Environment. The cause of each factor has been identified in the above Ishikawa diagram. To determine the root cause of the problem, further action is taken to verify and confirm the cause identify in the Ishikawa diagram. The verification results have been documented in the table under 2.2.1.

2.3.1 Verification of probable root cause

Item	Probable root cause	Verification method	Verification results	Root Cause?
1	Scanner	Calibration is carried out monthly to ensure it accuracy. This calibration exercise is done by the supplier	The report shows no out of calibration sensor. All the sensors are well within the specification.	✗
2	Inadequate procedure	Review the SOP.	The SOP has instruction and photographs to show the operator the correct position to hold the scanner. There is no inadequacy in the SOP.	✗
3	Lighting	Digital lux meter is used to determine the brightness of the environment	The brightness value for the production environment is 570 lux which conforms to factory standard	✗
4	Barcode printing quality	Visual inspection on the quality of the barcode printing	No deviation was found in the printing.	✗
5	Human error	Monitor the operator for each shift and observed them.	Reported from the line leader the operator has been complaining about hand pain due to too much scanning, eyes tire to read the barcode number from the computer screen.	√

From the verification results, the most probable root cause identified is due to human error. Huber's study has found that human operators working in the mill is able to recognize and located defects up to 68% accuracy. [38]

2.4 Summary

Investigation was carried out by identifying current process. Tools such as Ishikawa [20] method are used to determine the root cause of this problem. There are five areas have been identify that may contribute this problem. They are Machine (M/C), Man, environment, method and material. Result has shown that the possible root cause is due to human error. Another round of verification was conducted to ensure human error is the main possible cause for this problem.

Chapter 3.0 Literature Review

3.1 Research in Image Processing Technology

Image processing has been widely used in many industries. This is because over the years, the advancement of camera and video technology has reduced the initial cost of implementing such technology to the industries.

The main component of this proposed system is the camera. There are several parameters when selection the suitable camera for the system. They are resolution, field of views, working distance, sensor size and depth of field. Each parameter plays an important role in selection of suitable camera for the system. The formula for each parameter can be found in [2] will help in determine the suitable camera.

There are two main technologies for capturing image digitally. They are Complementary Metal Oxide Semiconductor (CMOS) and Charge Coupled Device (CCD) sensors both have their unique advantages.

In CMOS sensor, each pixel has individual charge to voltage conversion, amplifiers, noise-correction and digitization circuits. The output for this sensor is digital. CMOS sensors perform inferior at poor lit areas such as indoor. This is because researches have shown that, the pixel’s sensitivity to light decrease and the noise-correction worsen the situation if the lightning is insufficient.[3] As each pixel has its own charge-to-voltage conversion, and the sensor also includes amplifiers, noise-correction, and digitization circuits. These other functions increase the design complexity and reduce the area available for light capture. With each pixel doing its own conversion, uniformity is lower as compare to CCD sensors.

CCD sensors on the other hand, are more expensive than CMOS sensors. This is because the applications are limited hence their production is lower than CMOS sensors. In a CCD sensor, every pixel's charge is transferred through limited number of output nodes to convert into voltage and sent off-chip as an analog signal. All of the pixel can be devoted to light capture, and the output's uniformity is high. Hence the quality is higher as compare to CMOS technology.

In one paper published by Institute of Electrical and Electronics Engineers IEEE [19], the researchers discuss on the novel principle of pixel parallel image processing in the pulse domain for CMOS vision chip using low voltage. This novel principle uses suppression and promotion of output pulses which is very good for edge detection and enhancement. From this paper has demonstrated the effectiveness of using edge detection and enhancement. This will help very much in the project as the distance between each bar critical when reading it through an image.

Another paper stated that the researchers use varies sensors such as brightness sensor, contrast sensors and pattern sensors to detect barcode or image. This system makes use of the light reflection on the barcode to map out the image. This approach is commonly used in manufacturing process. However it requires good quality of barcode label printing. [21]

3.2 Summary

To Summaries, the main difference between CCD and CMOS sensor are as below:

1. CCD is more sensitive and expensive than CMOS mainly because the CCD chips generally have 100% fill factor where the CMOS not more than 70% active sensor as report
2. CCD is better in low contrast images as compare to CMOS sensor. This is due to the lower inherent noise in the sensor.
3. CMOS has the advantage of being much more flexible than CCD. CMOS sensor is able to read out less data at a higher frame rate
4. CMOS sensors have much lower power consumption and therefore are ideal for small digital cameras.

3.3 Research on Barcode Technology

Barcode technology has been used in many industries. This technology is used for identification and data collection purposes. The purpose of implementing this technology is to improve data management and reduce cost.

The advantages of using barcode technology as below:

1. Minimum error cause by human
2. Cost effectiveness
3. Ease of Implementation

Operator is able to learn this equipment effectively in less than 15 seconds. System costs are lower than other means of data entry because of the existence of interfacing hardware and software. Barcode labels which cost less than a dollar are easily read by scanners that are readily available in the market.

3.3.1 Barcode standard

As more and more industries recognize the importance and usefulness of barcode system, this has lead to the development of numerous industry standards such as AIAG (Automotive), EIA (Electronics), HIBCC (Healthcare), and HAZMAT (Chemical). This allows companies to develop equipments that can be used across different industries.

Barcode consists of lines and spaces of varying thicknesses and printed in different combinations. Hence there must be accurate printing and adequate contrast between the bars and spaces. There are several barcode specifications commonly used in the industry [4].

The Standards are as follow:

a. **EAN8 (ISO/IEC 15420)**[5][8]

0 44000 88301 0

EAN is the acronym for European Article Numbering. This standard is a compact version of EAN13. It consists of 8 digit numbers where the first two characters is the country code. The limitation of this barcode is that it can only permit up to 100,000 items.

b. Code 39 (ISO/IEC 16388) [6] [8][9][10][27]

CODE 39

This is a very high density alphanumeric bar code and commonly used in shipping and packaging industry. Although there are only 43 data characters in Code 39's character set, there are 128 ACSII character. Every character has five bars and four spaces. Of these nine elements, 3 are wide and 6 are narrow. A Code 39 symbol begins and ends with symbol “START” and “END” code. There is leading quiet zone and trailing quiet zone. Modulo 43 check character can be included in the barcode for increased data security. However this is normally done if the print quality is not optimum.

For a scanner able to scan barcode and decode from it, the reflectivity has to be at a wavelength of 633 manometers with illuminating and viewing axes separated by 45 degrees, with one of the axes positioned perpendicular to the sample surface.
The minimum reflectance difference (MRD) is equal to the reflectivity difference between the darkest space and the lightest bar. The minimum value of MRD is 37.5 percent if X is less than 40 mils, and 20 percent if X is equal to or greater than 40 mils. [27]

c. Code 128 (ISO/IEC 15417) [8][11]

CODE 128

This is a very high density alphanumeric bar code and commonly used in shipping and packaging industry. There are 128 ACSII character. Each data character encoded in a Code 128 symbol is made up of 11 black or white modules

d. EAN 13 (ISO/IEC 15420) [4] [7][31]

0 32886 67318 4

This barcode can be found commonly in retail goods. There are 13 characters in the barcode. The first two characters identify which country the manufacturer registers. EAN-13 barcode always begins and ends with a black white-black pattern, which is known as the left hand guard pattern and the right hand guard pattern. From the above picture, there are three guard patterns that are slightly longer than others.

3.3.2 Barcode label

There are many type labels such as Asset tags, Labels for oily surfaces and Heat resistant labels. In our application, the material used for labels have smudge and wear resistances, Thermal paper is considered the best option as it has both smudge and wear resistances. There are two type of thermal paper. They are thermal transfer labels and Direct Thermal labels. Here we will be using thermal transfer labels. The biggest advantage is that this method provides good density for printing bar code labels. This will help the camera to detected barcode easily hence obtaining highest accuracy. Commercial website has detailed information of the difference between these two materials hence this area will not be verified in this project. [12]

3.3.3 Technologies of reading barcode

There are a few technologies that are able to read barcode. Namely laser technology, CCD technology, and camera based technology. [14][15] The common one found widely in the market is using laser technology.

a. Laser technology [14][15]

As light is being absorbed by dark bars while light reflect white bar, this technology makes use of photo diode to measures the insensitivity of the light being reflected back from the barcode. The diode will then generate a voltage waveform.

b. CCD technology [14][15]

This technology uses Charge Coupled Devices sensor to read barcode. There several hundreds of sensors. They are lined up in rows. When scanning, each sensors will measure the emitted ambient of light from the barcode.

c. Camera based technology [14][15]

This technology uses camera to capture digital picture of a bar code. This requires digital image processing techniques such as edge detection, filters to decode barcode. The sensors in camera are arranged in rows in order to create a two dimensional array.

3.4 Computer Algorithm

There are few important algorithms in image processing. There are:

a. **Image subtraction** [17]

The idea of image subtraction is to subtract pixel by pixel. This is a useful method if the system has a master copy image that they need to compare.

b. **Threshold** [18]

It is the simplest method of image segmentation and commonly used in black and white image. The idea is to compare the highest value either set by the user or the image itself with the image.

c. Edge detection [16]

The purpose of edge detection is to determine the edge of shape in a picture. The idea is to go through pixel by pixel and compare pixel with the neighbour pixel. If the difference between each pixel is too big, it will become white. Similarly if the difference is too small, it will become black.

There are several ways of recognize barcode using imaging. They are as follow;-

1. Neural networks
2. Zero crossing detection
3. Finding the peak locations

However these approaches require high quality of barcode image. In the journal, the researchers found that using the formula that proposed is able to reconstruct blur image. [19] Although In the experiment that conducted, high accuracy is achieved when using external imaging edition software, the experiment has shown that it is feasible to detect barcode using a low resolution camera.

One of the important aspects in this project is to obtain image from the camera. The lens distance between the camera and barcode play a vital role. The formula is shown as below:

Calculation lens distance:

$$f = v \times \frac{D}{V} \quad \ldots(1) \qquad\qquad f = h \times \frac{D}{H} \quad \ldots(2)$$

[20]

f : focal length of lens

V: Vertical size of object

H: Horizontal size of object

D: Distance from lens to object

v : vertical size of image (Refer to Table B.)

h : horizontal size of image (Refer to Table B.)

Table B.

Format	1 inch	2/3 inch	1/2 inch	1/3 inch
v	9.6mm	6.6mm	4.8mm	3.6mm
h	12.8mm	8.8mm	6.4mm	4.8mm

Size of object [20]

The size of the barcode is 2.27 inches x 0.83 inches. Hence the minimum distance from lens to object is 30mm.

The distance of from the camera to the barcode must not be less than 30 mm. Anything less than the calculated distance will unable to cover the whole barcode image. This calculation will determine the lens used and the camera distance from the targeted object.

3.5 Summary

The chapter discussed about the background knowledge and information that are required for this project. These reviews included other form of barcode recognition technology such as laser technology. This chapter also discussed on other barcode standards available in the market. Code 39 is discussed with great detail as this standard is used for this project.

Chapter 4.0 Designs

4.1 Propose Solution

The proposed action to enhance the assembly line at the barcode scanning section is using imaging technology to read barcode. The system will indicate the type of chassis and which production line the chassis should be fed into. The solution will help to minimize the error of feeding the wrong chassis to the conveyor line, and overcome the disadvantages of using handheld barcode scanner. The imaging technology can also be developed for other inspection purposes.

4.2 Proposed software vs. market software

Most barcode system available in the markets are using scanner to detect barcode. This technology is very mature and able to obtain high accuracy. However this technology is unable to incorporate into inspection vision technology as this scanning action requires manual action. On the other hand, vision inspection system is fully automated system.

There are two parts in this system. They are

1. Software
2. Hardware.

4.2.1 Hardware evaluation

As this system is designed to integrate into the existing production lines, most of the hardware will be pegged onto the existing lines. This include the solenoid value

- Power consumption. It should consume power no more than DC24V.
- Interface / Data transfer: the data transmission speed must be fast enough from the camera to Personal computer (PC).
- User-friendliness: The equipment must be ease to use and easily be understood by the user.
- Image resolution: this feature is more applicable to camera. The image taken must be visible for PC to decode the barcode.
- Affordability: It should be less than $50.
- Function capability: it should provide more functions and features for future uses.

As mention earlier, the heart of this project is the camera. Hence selection of camera is an important part of the whole process. This is because the quality of the camera is the main factor of producing high quality image and this in turn higher accuracy of barcode reading.

There are three categories of cameras available in the market. They are colour cameras, thermal camera and monochrome camera. Thermal camera are camera that made used of thermal hence it is totally unsuitable for this project.

Monochrome camera

This type of camera is generally cheaper than their colour counterpart. They are commonly used for inspection application such as dimensional or shape and sizes. These inspections require the edge of the object to be as sharp as possible and good contrast of background colour. These images take up less space in term of bytes as compare to colour image. Hence, the system response is generally faster than their colour counterpart.

Colour camera

On the other hand, colour camera has a matrix colour filter across monochrome sensors. Filters could potential cause to degrade the sensor sensitivity up to 30%. [39] Hence more lightning are required to compensate this drawback.

Secondly for single chip colour camera, the resolution of the colour image maybe different from the real world. This is because of the filter colour for one pixel will be different from its neighbour. There are two ways of overcoming it. First, using three chip colour camera will resolved this issue. Second, the use of software to correct the error, but, software correction is an assumed correction. That is to say that there is also a possibility that the software may “guess” wrongly.

In this project, we will be concentrated on using colour cameras. This is because a colour camera allows great flexibility in working on future enhancement and the cost difference between monochrome camera and colour camera is below 10%.

There are two types of technologies that allow cameras to capture fast moving objects. They are Progressive Area Scan and Line scan.

Progressive Area Scan

This technology allows camera to read the image as a whole. It reads images every 40ms and read all lines within the same scan. Hence it does not result in bur image. Unlike interlaced camera, it produces blur image when capture moving image. But this type of technology is suitable for slow moving object.

Line Scan

Line scan technology will compensate the shortcoming of progressive area scan. This technology allows capture moving object speed up to tens of meter a second. This is very useful in paper or textile industry. This technology uses linear image sensor to read moving image. Line scan technology read data at many thousand of lines per second hence it can use in detect defect in very fast moving objects.

There are a few means of transfer image taken from camera to the PC.
They are:

FireWire (IEEE1394) or USB 2.0

It is one of the popular solutions for transfer image from the camera to PC. The data transmission rate for USB 2.0 is around12-Mbps [40]. However the real output is slightly lower.

Connection type	Transfer rate (Megabits/second)
Serial port	.92 Mbps
Standard parallel port	.92 Mbps
USB 1.0/1.1	12 Mbps
USB 2.0	12 Mbps

ECP parallel port	24 Mbps
IEEE1394 (Firewire)	400 Mbps
Hi-speed USB 2.0	480 Mbps

Obtained from [http://h10025.www1.hp.com/ewfrf/wc/document?lc=en&cc=us&dlc=en&docname=bpu03056]

The above table depicts the speed of each connection type.

Ethernet network- Gig-Ethernet

This interface is relatively new in the market but it slowly grows its popularity as it allows huge amounts of information to be transferred quickly and over long distance. However for using such features, the plant has to build up its Ethernet infrastructure. Problem often occurred when the image is corrupted due to the transmission error or the network is shutdown due to hardware issue.

Serial port interface RS232 / RS485

This is commonly used in older camera where image frame grabber card is needed to convert camera image data. This interface is relatively slow as compare to Firewire or USB technology. The price of image frame grabber card is also expensive. The estimate of each card is around one hundred dollars.

Connection type	Transfer rate (Megabits/second)
Serial port	.92 Mbps
Standard parallel port	.92 Mbps
USB 1.0/1.1	12 Mbps
USB 2.0	12 Mbps
ECP parallel port	24 Mbps
IEEE1394 (Firewire)	400 Mbps
Hi-speed USB 2.0	480 Mbps

Obtained from [http://h10025.www1.hp.com/ewfrf/wc/document?lc=en&cc=us&dlc=en&docname=bpu03056]

The above table depicts the speed of each connection type. Although firewire technology has higher speed than USB technology, high initial cost of purchasing such as firewire card failed one of the requirements that was set in the earlier chapter.

USB port will be use as the interface between the camera and PC. This is because USB is commonly available in the every PC and the rate of data transfer for USB as mentioned above is sufficient for this project.

Camera	Sensor	Power consumption	Interface / Data transfer
Creative Live! Cam Video IM Pro (VF0410)	VGA	DC5V	High-Speed USB 2.0
Creative WebCam Vista Plus	CMOS	DC5V	High-Speed USB 2.0
Creative Live! Cam Vista IM (VF0260)	VGA Sensor	DC5V	High-Speed USB 2.0
Genius Look 316	VGA (640 x 480) CMOS Image Sensor	DC5V	High-Speed USB 2.0

The above table depicts some Web cameras that fit the requirements. Genius Look 316 Web Camera is selected for this project for its low cost.

In this project, we will be concentrated on using colour cameras. This is because a colour camera allows great flexibility in working on future enhancement and the cost difference between monochrome camera and colour camera is below 10%.

4.2.2 Software evaluation criteria

Software evaluation criteria are as below:

- Reliable; it should function accurately for a long period of time and also function correctly over all ranges and combination of data.
- Robust; unwanted inputs or data should be identified and proper error message should be flashed. It should never crash.
- User friendly with enough comments, tips, on-line help and short cut options.
- Efficient, with minimum memory and quality output in acceptable time span.
- Readable i.e. it should be simple so that it can be understood to make changes and enhance it if required.
- Portable so that program can be executed on different machines and environment.

There are several programming tools that are able to develop this system namely, visual basic (VB), java, hp Vee and LabVIEW. All of these programming languages have their pros and cons.

First VB and Java have strong track record of reliability and stability for developing systems. Both of them have comprehensive information on all libraries and tutorials available in the web. Hence they are easy to learn and develop.

Second there are many third party tools that are able to integrate or work for these programming. And VB and Java are able to integrate into windows based PC easily.

There are some differences with between these two programs. First of all, Java has been developed based on object oriented language while Visual Basic is just starting to integrate this feature. Secondly, Visual basic always has problem with their security features such as active X. while Java's security features such as integrity checking and strong typing are built right into its core design. Last of all, Java is able to work across different hardware and operation system while Visual Basic only able to work on windows platform. [28]

On the other hand programming tools such as HP Vee and LabVIEW are graphical programming. They are belonging to different category as compared to textual based language.
For an instance, the data flow and execution flow are managed graphically. Lines represent data flow from one object to another. The greatest advantage of graphical language is that it is easy for any programmer to comprehend and support future development. As these traditional lines codes are represented by icon or image. This will reduce the number of human error.

LabVIEW has more control of display and interface object attributes while HP VEE can only sent limited attributes. HP VEE attributes are set using pop-up menus and cannot be set programmatically. LabVIEW graphs are able to accept arrays as input hence is is more suitable for multiple curve display. Thirdly, LabVIEW is able to integrate into different platform such as Linux. Last of all, LabVIEW has faster execution as compare to HP VEE. [29]

To conclude, LabVIEW will be used to develop system for this project. First of all, LabVIEW is more approachable as compare to textual based language such as Java. Secondly, Comprehensive tutorials [www.lava.com.org or www.ni.com] and guides are available in the Net which will help in learning more about the software. There are also forum that developers exchange and share their view and knowledge.

Last of all, the LabVIEW is able to perform software simulation that will help to debug any mistake make during development of project.

4.3 Summary

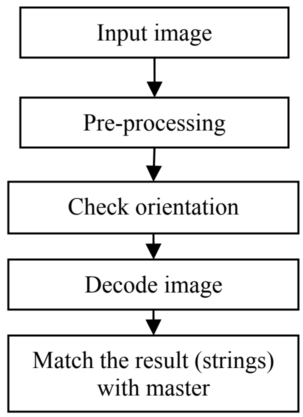
This chapter reviewed the hardware and software that will be used to developed this project. In software section, softwares are compared based on their nature. For instance, Java and C++ programming are compared together as they are textual based programming. While HP VEE and Labview are placed side by side for comparison, as they are graphical programming.

In hardware section, types of cameras are compared and review based on the performances stated in their manual.

Chapter 5.0 Development

5.1.0 Software Programming

5.1.1 Overview of source code

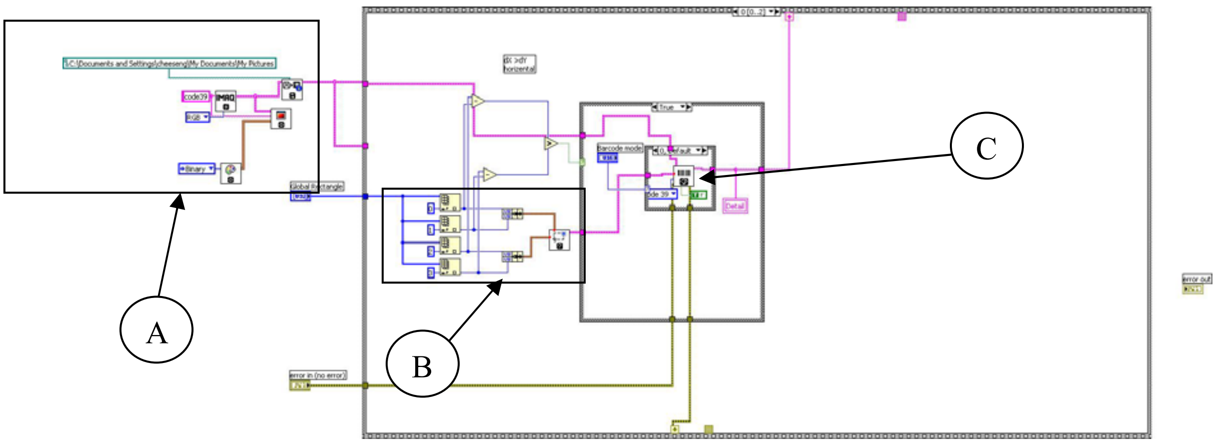


The above flow diagram depicts overall process flow of the entire program.

First, the program obtained the image from the folder that the image be stored. This folder is determined by the Web Camera. Second, the program does some pre-processing work such as size up the area of the image. Third, it checked the orientation of the barcode by trying to read it. Lastly, it will compare the result with predetermine serial number that is set in the program.

The main core of this program is reading barcode from the image taken. It is built on three scenarios. In the first scenario, the barcode orientation is in the correct position. Barcode engine is able to read it directly without any amendment in position. Second and third scenarios are activated when the label is not in their right orientation. The software will then have to rotate the image in order to read the image.

Lastly once the data is obtained, the software then compare the output with the strings of serial number that has preset in the program. These serial numbers as mention earlier on, determine which chassis category it belongs to.

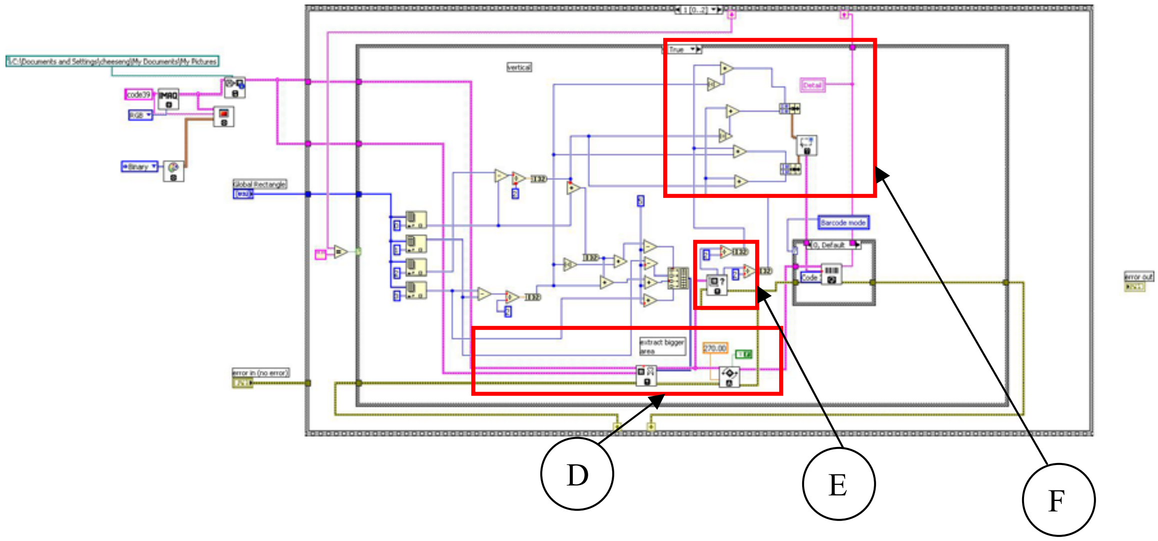


The sequence frame contains most of the program logic and controls. The purpose of this frame is to enable the switch after information has been processed by IMAQ barcode. IMAQ barcode is one of many advanced add-on libraries in IMAQ vision. This library is able to process different type of barcode standard such as code 39.

In Section A the system obtained the picture from a destined location. This is the location where picture will be kept after camera has taken the picture. The system will locate the picture and display it.

In section B, the Region of interest (ROI) is created. It is an area of image in which IMAQ barcode will concentrate for barcode analysis. This is done by using IMAQ draw rectangle. The location of the rectangle edge is built up the array function. These locations will consolidate into two points as x-y coordinate. These coordinates are the main input to build rectangular ROI library where it will define the bounding box in the image. The purpose of ROI will allow IMAQ barcode read and identify the barcode easily and in shorter time.

In Section C, IMAQ barcode processed the information of ROI with the image to be analyzed. This barcode library is able to recognize different barcode standard. The author has pretest the library to recognize code39 standard. Other barcode standard will be treated as error.

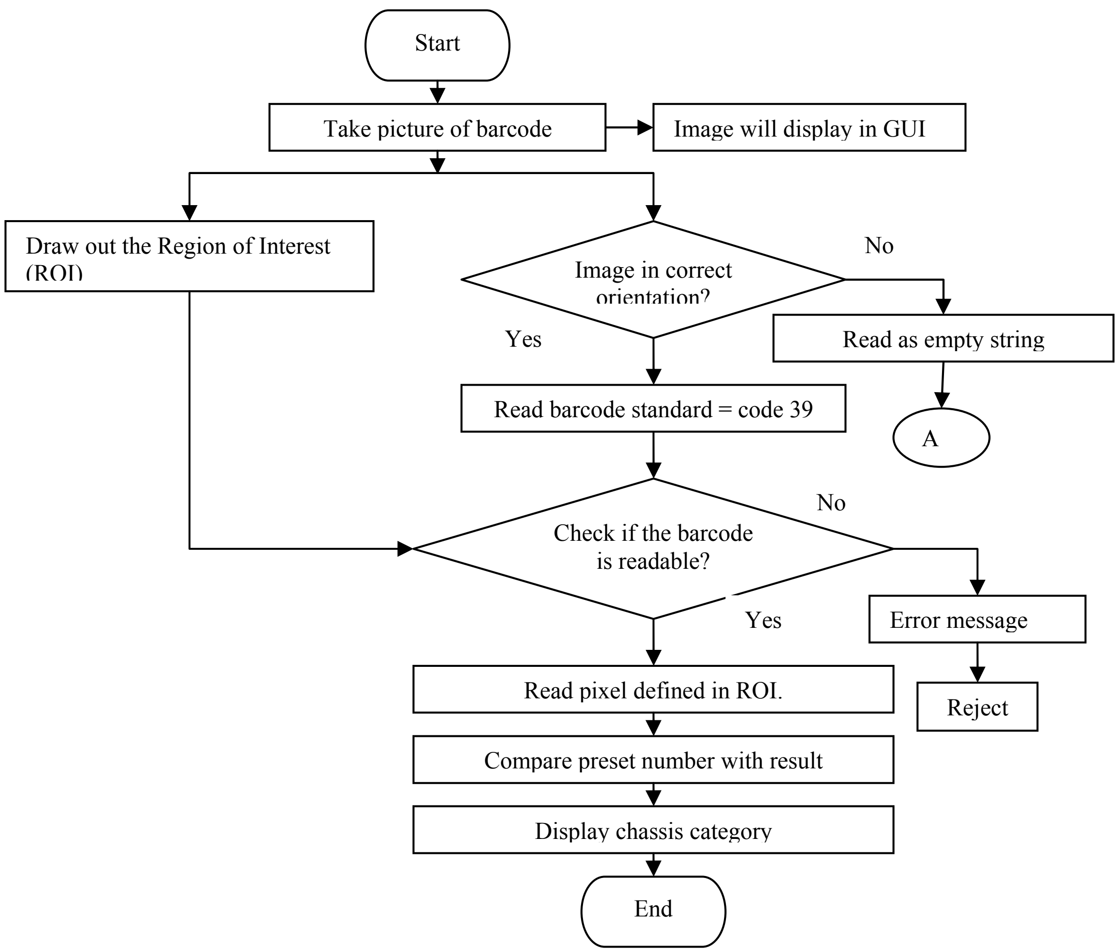


This scenario becomes true when the barcode image is upright shown as the above figure. As this program is only able to read barcode when it is in horizontal position, hence image has to rotate before it is able to read.

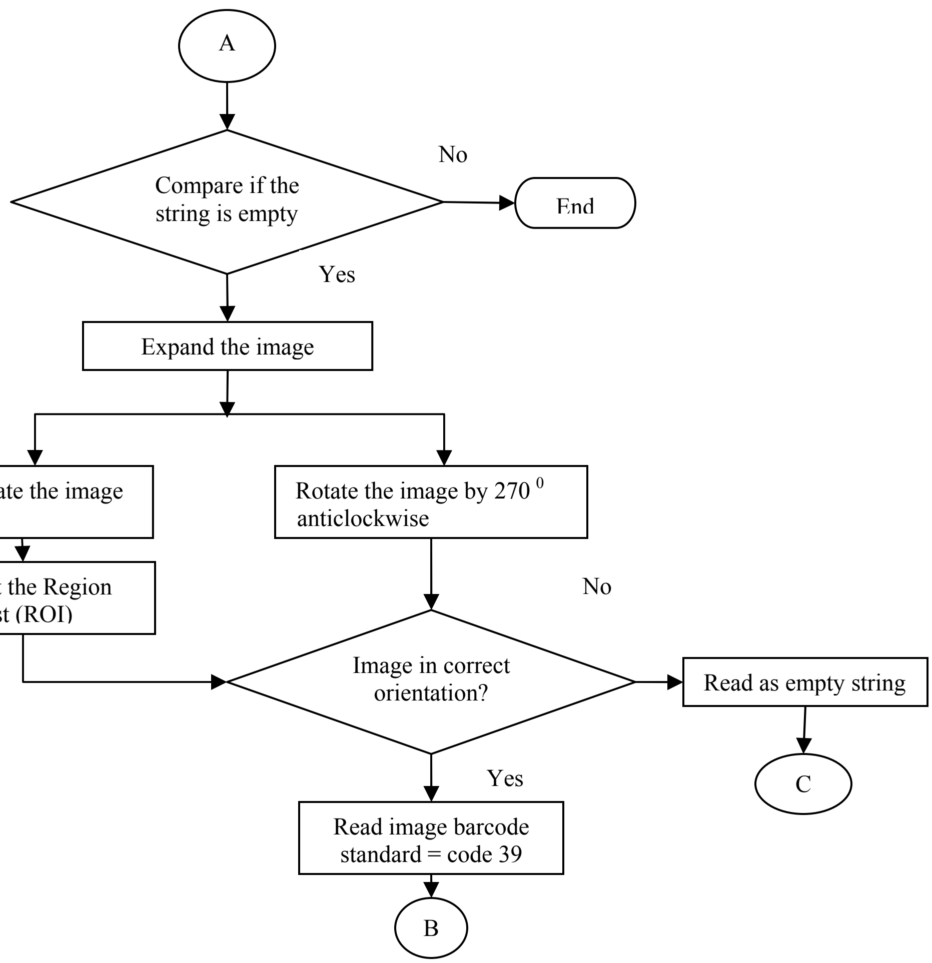
In section D, the image being magnified and rotate 270° anticlockwise direction, in order for the program to decode the image. The values of the magnified image are provided to IMAQ GetImageSize library. IMAQ GetImageSize library in section E process the data and input the overall size of the image to build rectangular ROI library found in section F. here GetImageSize library plays an important role as the system does not have any overall size information of the expanded image. In section F, the library will resize the ROI before it passes the information to IMAQ barcode library.

5.2.0 Programming Process flow

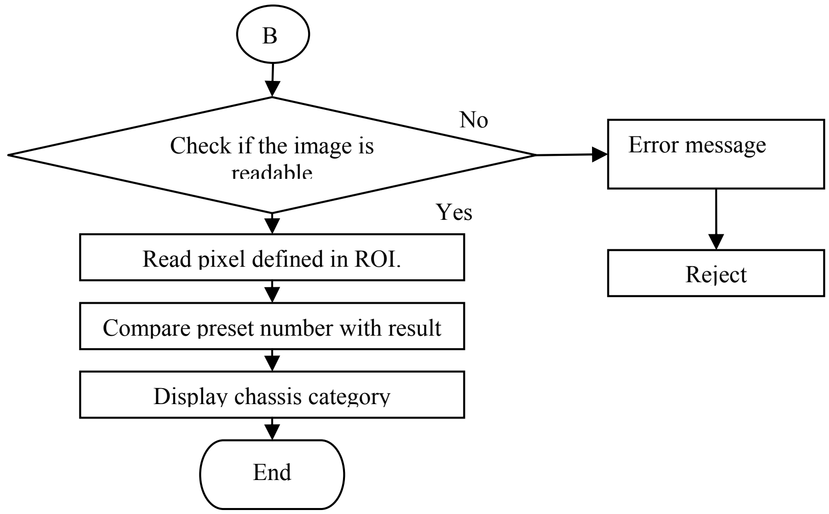
The camera located at the front of the assembly line is captured the image of the barcode on the chassis. Once activated the program, the image of the barcode display on the computer screen. This is to allow engineer to troubleshoot the program if there is any alert raised by the system. As the region that we are interested is the barcode, the program will define the region of interest (ROI) and box out a rectangle on the barcode. Next the program will check if the barcode image is in the correct orientation. If the orientation is correct, the program will read barcode else it will read as empty string and move to “A”. Next the program will check if the barcode is readable. The barcode will be read and compare with the preset barcode number and display the chassis type in the control panel. If the barcode is not readable an error message will appear.



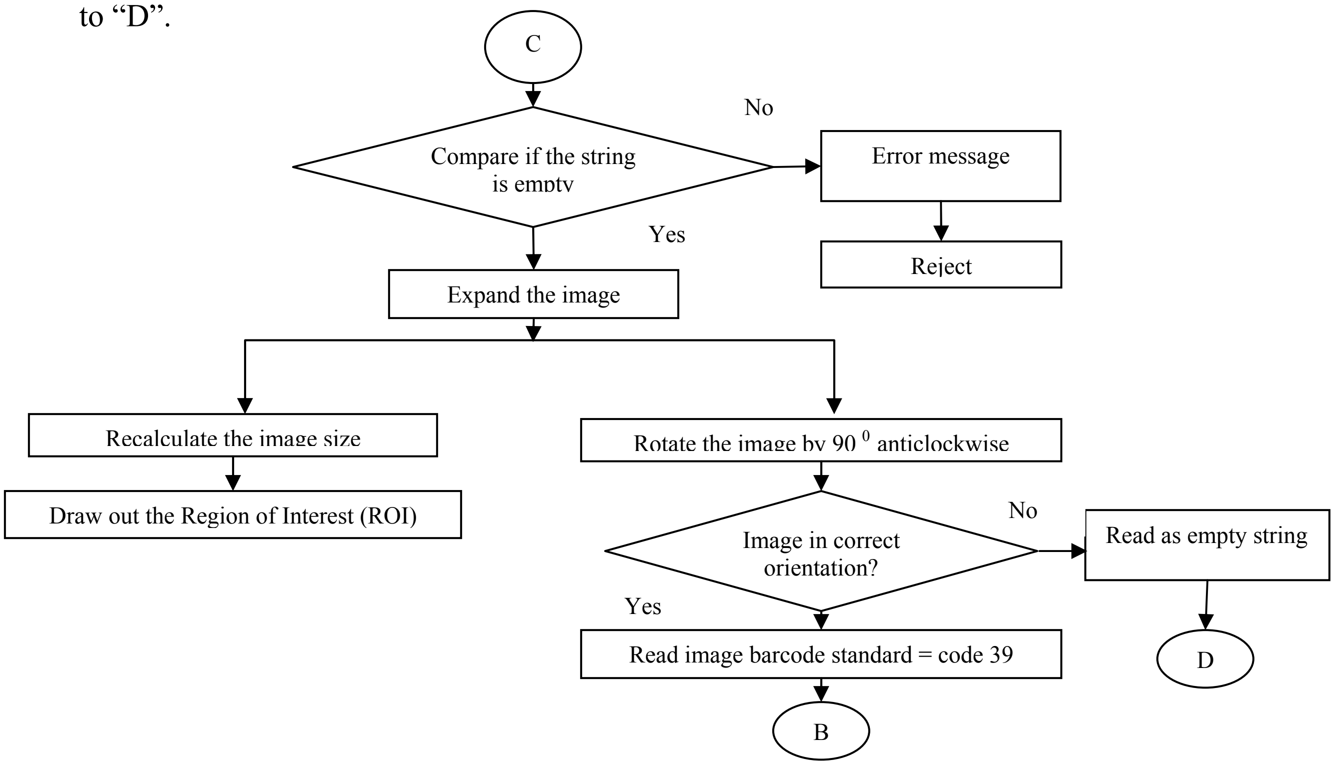
There are two possible scenarios that "A" will be activated. It is either barcode is in the incorrect orientation or there is no barcode image. The program will compare if the string is empty. If the string is empty the program will perform few actions in parallel. The image will be rotated to 270 ^{0} anticlockwise first and expanded by recalculate the image size. After which the program will identified the ROI and the program will check if the barcode image is in correct orientation. If the result is "Yes" then the program will read the barcode and move to "B" else it will read as empty string and move to "C".

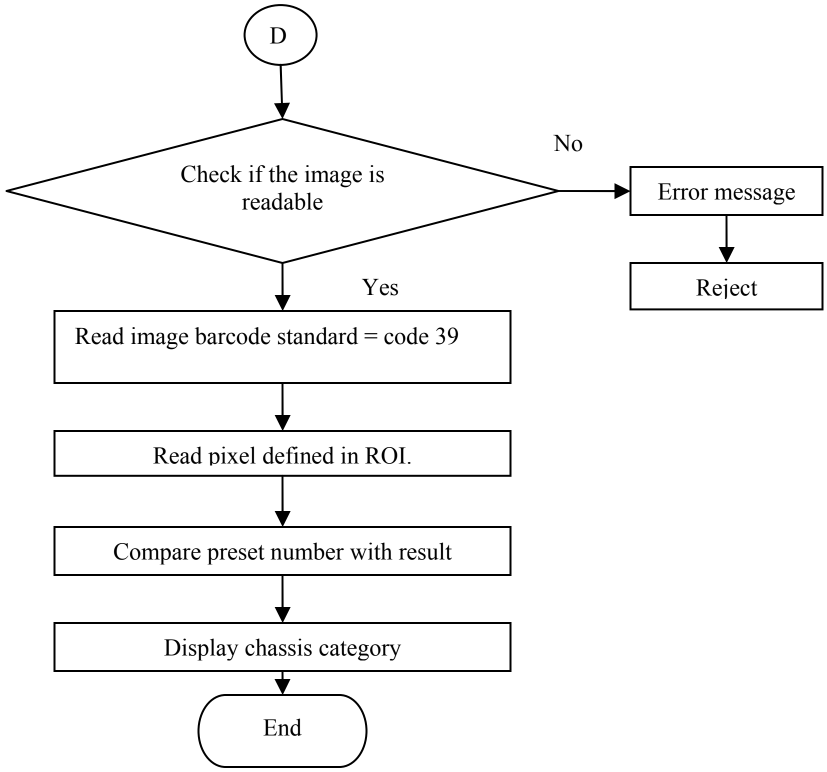


At "B", the program will check if the barcode is readable. The barcode will be read and compare with the preset barcode number and display the chassis type in the control panel. If the barcode is not readable an error message will appear and reject the chassis.



At “C”, the image will be rotated to 90 ^{0} anticlockwise first and expanded by recalculate the image size. After which the program will identified the ROI and the program will check if the barcode image is in correct orientation. If the result is “Yes” then the program will read the barcode and move to “B” else it will read as empty string and move to “D”.

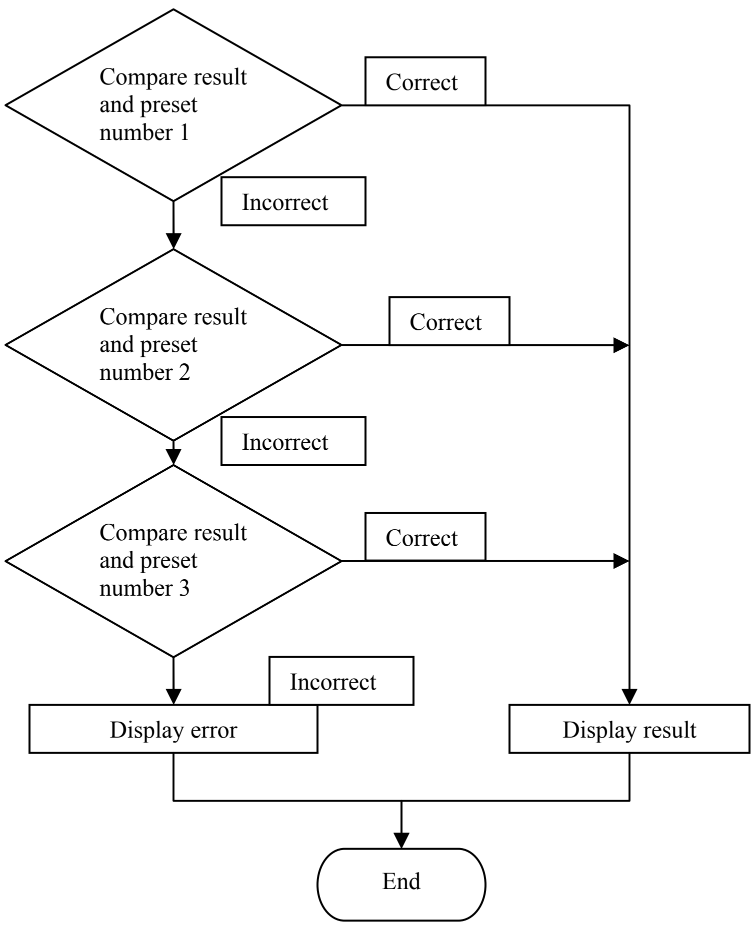




At “D”, the program will check if the barcode is readable. The barcode will be read and compare with the preset barcode number and display the chassis type in the control panel. If the barcode is not readable an error message will appear and reject the chassis.

Compare preset number with result

There are two ways of comparing the result. It is either compare by image or by strings. Comparing image will means of compare the raw picture taken from the camera with the master image. On the other hand, it can also compare by strings. It will be the comparison between the resultant from the barcode engine and preset number store in the system.
In this project, the comparison comes after decoding image. The data will be in string format hence, the comparison will be between strings of characters. The comparison will start with the first preset number and continue until the last number. When all failed, it will display an error message.

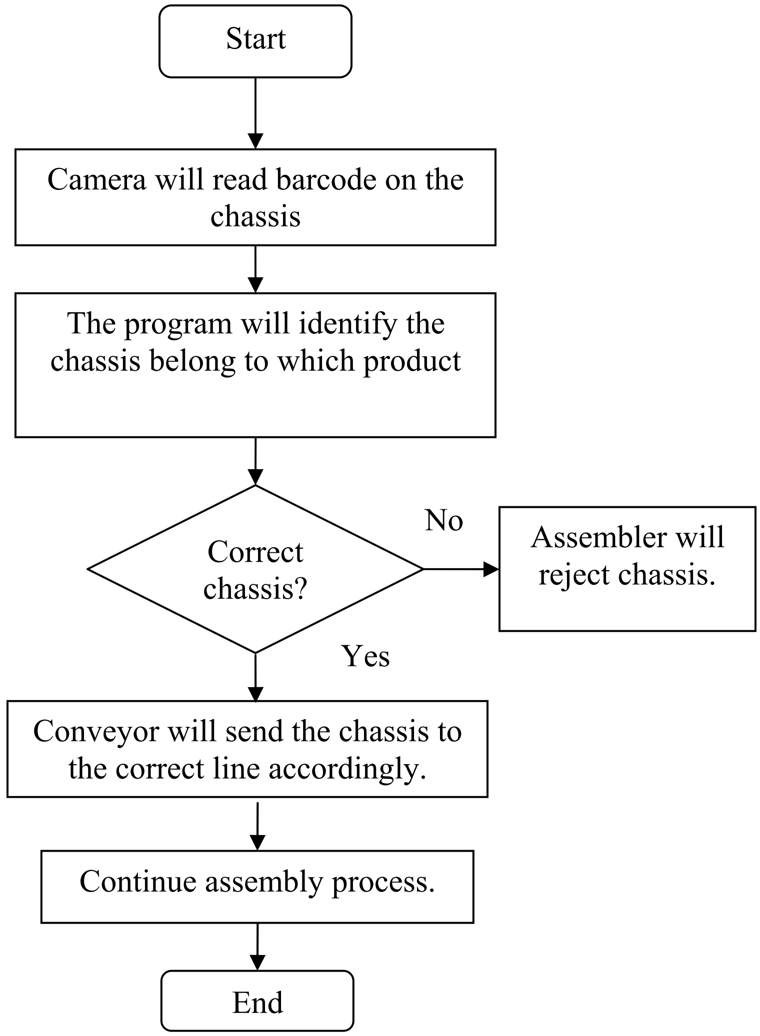


5.3 Summary

This chapter explains in detail how the software is being developed using LabView program. Additional flow charts are used to explain the work in much detail.

Chapter 6.0 Hardware design

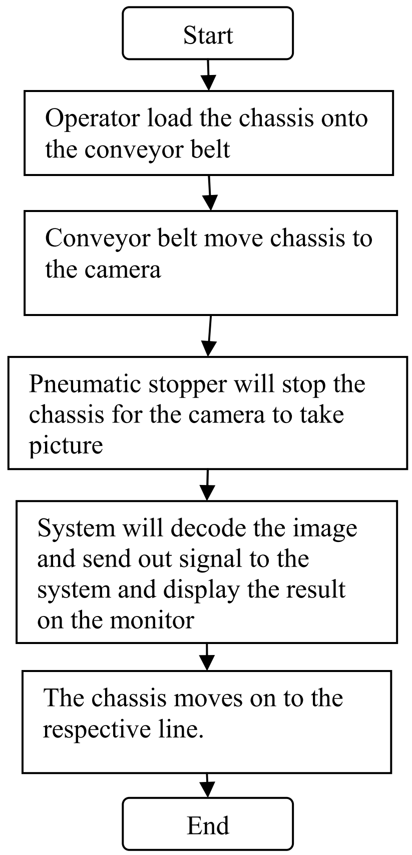
6.1 Proposed process flow chart



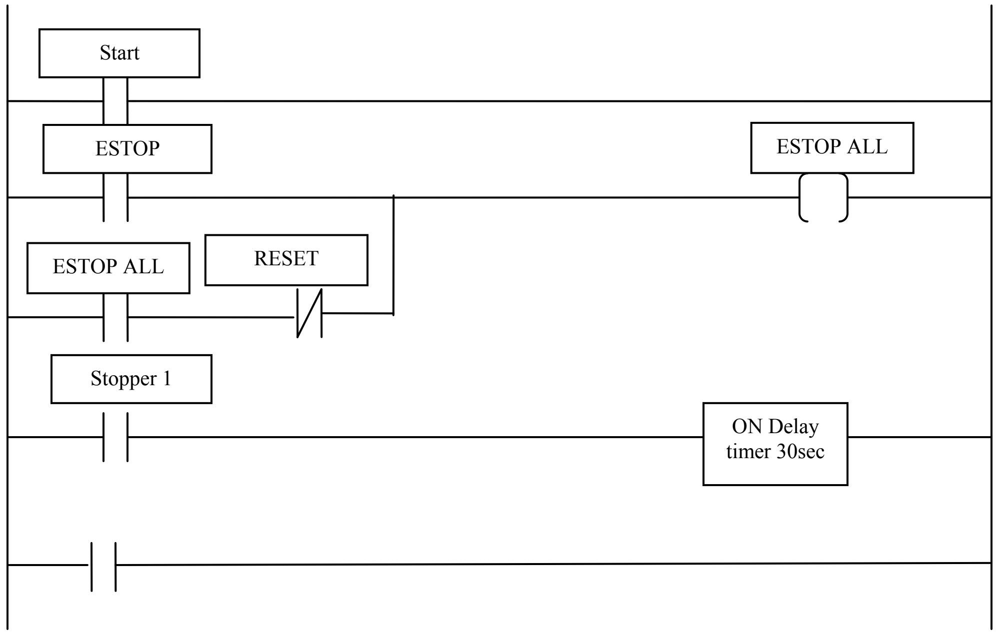
The above flow chart shows the process of the production flow how it is being done after integration of barcode recognition system.

6.2 Integration of barcode system to existing line

In this section, a brief description explains of how barcode system integrates into the existing line. The equipments used for the project included addition equipment such as solenoid value for stopping the moving chassis on the conveyor belt, emergency stop button for safety purpose



The above flow chart depicts the sequence of how barcode recognition system is integrated into the existing system. This sequence is used as reference when designing the new system.



The above figure shows the PLC ladder diagram that is required for the barcode recognition system to be in place with the existing production line.

The emergency stop (ESTOP) is a safety feature for the new add-on system. It is meant for the operator to put a stop when there is any danger. Once the operator hits the button, the operation will stop and continue to move on after the operator release the button.
In normal circumstance, the solenoid stopper (Stopper 1) is charged and stopped moving chassis for 30 sec for the camera to take barcode image and send signal to the next program.

6.3 Summary

This chapter briefly describes the integration of hardware to the existing line. This hardware include emergency stop for safety measure and solenoid stopper for the stopping moving chassis. There is a minor edit of PLC programming to the existing program.

Chapter 7.0 Integration and Test

7.1 Design of experiment to determine the camera working distance

The purpose of this experiment is to determine the appropriate working distance between barcode to camera. In this test, 20 different barcode samples are being used and distance between them will be set as 70 mm. 75mm and 85 mm. The quality of the image is inspected visually. In this experiment, the result is as follow:

No.	Distance (mm)	Sharp image	Blur image	Accuracy
1	70	15	5	75%
2	75	18	2	90%
3	80	19	1	95%

The result shows that there is little difference when the camera distance from the barcode is 75mm and 80mm. Hence in the system distance will be set as 80mm. The image taken from a distance of 80mm, the length of the image is about 150 pixels. Research has done by conducting an experiment to determine the minimum image distance. The result shows that the ideal distance must be at least 100 pixels. Any distance shorter will have error up to 3 digits. However there is no information on camera‘s resolution that was used during this experiment. Another purpose for this experiment is to verify the mentioned result is still valid in today context. [19]

In this experiment, USB web camera is used to take barcode images. The result has shows that the minimum distance is around 100 pixels. At between 75 to 100 pixels, the error will range from one to three digits and this is largely due to blur image.

Blur image are contributed by external factor such as:-

1. Premature snapshot – this is due to picture is taken before chassis come to a total dead stop.
2. Lightning – the reflection from the label cause the image overexposed.
3. Camera resolution – number of pixel determine the sharpness of the image.

7.2 Design of Experiment (DOE) 1

This experiment marks the first step of the project. The first experiment is verified that the program is able to read barcode in correct orientation. Correct orientation refers to 0° as shown in the figure below:

CODE 39

The equipments required for this experiment are as below:

1. Web camera
2. Sample barcode. (These barcodes samples are printed on the thermal paper.)
3. Windows XP Professional SP2 PC with software (labview) installed.

The ten samples of barcode image are used for this experiment. As mentioned in section 7.1, the distance will be set at 80mm.

Table A.

Barcode sample number	Expected result	Actual result	Pass/Fail
1.	Test8052	Test8052	PASS
2.	1234	1234	PASS
3.	CODE39	CODE39	PASS
4.	123456	123456	PASS
5.	1234567890	1234567890	PASS
6.	barcodesoft	barcodesoft	PASS
7.	ABC123	ABC123	PASS
8.	123ABC	123ABC	PASS
9.	P-A27-AB	P-A27-AB	PASS
10.	12345ABCDE	12345ABCDE	PASS

7.2.1 Conclusion of experiment 1

The table above shows that the software is able to read the image with 100% accuracy. These barcodes images are taken with highest quality of resolutions. The graphical result for each test is found Appendix A-1

7.3 Design of Experiment (DOE) 2

After verified the ability to read barcode in normal condition, the next test is to verify if rotation image will cause any drop in the accuracy when reading the barcode. The orientation of barcode will be at 0°, 90° and 270°. The purpose of having such features is that the orientation of the barcode on the chassis can change due to some external circumstances. And this change can be immediate hence such feature is essential. The detail steps of conducting the experiment are found in appendix A. In this software, there is a rotation of image at a preset degree of 90° and 270°. This rotation action will take place once the barcode engine has detected the image as an empty string. There are three scenarios that the image taken as an empty string. They are:

1. The image orientation is not right.
2. The image is empty
3. The image is not sharp for recognizing hence it cannot read anything out of the image.

Figure 7.3.1

Figure 7.3.2

Figure 7.3.1 depicts a sample barcode image in 90° orientation while figure 7.3.2 depicts the barcode in 270° orientation. These images are one of the images that used to test on the system. These images are taken with 3 mega pixel resolution camera for this experiment.

Table A.

Barcode sample number	Expected result	Actual result	Pass/Fail
1.	Test8052	Test8052	PASS
2.	1234		FAIL
3.	CODE39	CODE39	PASS
4.	123456	123456	PASS
5.	1234567890	1234567890	PASS

6.	barcodesoft	barcodesoft	PASS
7.	ABC123	ABC123	PASS
8.	123ABC	123ABC	PASS
9.	P-A27-AB	P-A27-AB	PASS
10.	12345ABCDE	12345ABCDE	PASS

7.3.1 Conclusion of experiment 2

The result above has showed that the accuracy is 90% for correct barcode which meet our requirement. From visual inspection, failed barcode images are not as sharp as the rest of the samples that have passed. After using external image edition software to sharpen the image, the system is able to read the barcode correctly. Use of external image editing software has been shown to improve the success of reading barcode images. [25]

7.4 Summary

In this chapter, experiments had conducted on these two features.

1. readiness of reading barcode image
2. readiness of reading barcode image after rotation

Both experiment results have shown that for high accuracy of accurate reading requires high resolution. Hence selection of camera is very important in the system. The first experiment (DOE 1) is to determine the readiness of the software that developed for this project. The experiment was successful as it manages to read barcode given.

In the second experiment (DOE 2) shows that those images that have poor quality are unable to detect it correct. The system is able to detect accurately only after sharpening these images.

8.0 Benchmark testing against other existing identification systems.

As mentioned earlier, there are several companies that developed similar products for industry. Many companies have standalone system by developed their own hardware and software. Comparison with similar product helps to identify the standard of project as compare to industries.

There are three parts for this review. They are:
1. Software
2. Hardware
3. Integrated system

8.1 Software

There are many softwares available in the industry. Most of which are software development kit (SDK) which requires the users to develop their own application using this tools and free for research purpose or freeware. Such free software requires a lot of manual work and no official support is given.

a. Bokai Java Barcode Server Component (servlet) 3.1

It uses barcode java bean to generate barcode images in PNG or JPEG format without requiring any web server. The features include supports rotation, fonts, colors, text positions, method to save a barcode image to a file. It is able to support 25 barcode types such as Code 39 or Code 128.
The programmer has tried out that this tool only worked well with server such as apache or tomcat environment [22]. Hence this limits the applications

b.Technoriver Free Barcode SDK

It is an award winning barcode software. This software is developed in Visual C++.Net, Visual Basic.Net, Visual C#.Net and hence it is able to work in a .Net framework (version 2.0). It supports the following bar code: Code39, Code39ASCII, Interleaved 2 of 5 and ITF14.

c. Pegasus Imaging

Pegasus Imaging has developed its own high-speed barcode recognition engine empowering software developers to accurately read, write and process virtually any barcode. Read and write 1D and 2D barcodes. Use advanced image clean-up technology to preprocess and increase recognition rates.

One of the biggest advantages of Pegasus imaging is that it is able to recognize noisy or poor quality barcode image which many companies did not mentioned in their products. Second benefit Pegasus own set of mathematical algorithms used in its barcode detection, which is able to refine and verify candidate barcodes. [23]

d. Clear Image Barcode 1D Basic

Inlitersearch has a barcode imaging software named ClearImage Barcode 1D Basic. This software is using imaging technique to read barcode. It is able to read image from common format such as TIFF and JPG. It is able to read maximum up to two barcode in a single image. The data can be output as text file. [24]

8.2 Hardware

The most important hardware for this system is camera. There are many industrial cameras in the market that are suitable for this application. However cost of these cameras is the main drawback.

There are few categories in reviewing cameras. They are as follows

1. Resolution: The higher the resolution, the better the quality of image. However it will take longer time for PC and camera to process.

2. Sensitivity: the higher sensitivity the camera the shorter time it takes to capture the image. This is very important for camera that used to take moving objects.

3. Color: there are two type of camera for industrial uses. They are either colour or monochrome. Colour camera has more data to process as compare to monochrome.

4. Interface: This refers to the camera communication across PC. Firewire, USB or Ethernet interface are more popular choice for suppliers. Careful selection of camera will reduce maintenance cost. For an example USB interface is much less maintenance cost as compare to frame grabber camera.

5. Software: there are two categories of software. It is either using third party software or software development kit (SDK) to interface the camera. Usually the manufacturer will provide free SDK. Integration of camera into the system play an important role and most complex when developing own system

Integrated system

Label vision system is one of the few that has barcode imaging system - LVS INTERGRA 9500 Barcode Verifier. This product has high accuracy and repeatability. This system does not require involvement with operator. As this system is using imaging system, hence there is no wear and tear with moving parts and no burnt laser diode.

The INTEGRA 9500 Bar Code Station is the most reliable system on the market. There are no moving parts to wear out, no laser diode to burn out. The lights used with the INTEGRA™ 9500 are computer monitored and controlled. They automatically adjust to a NIST traceable calibration standard.[21]

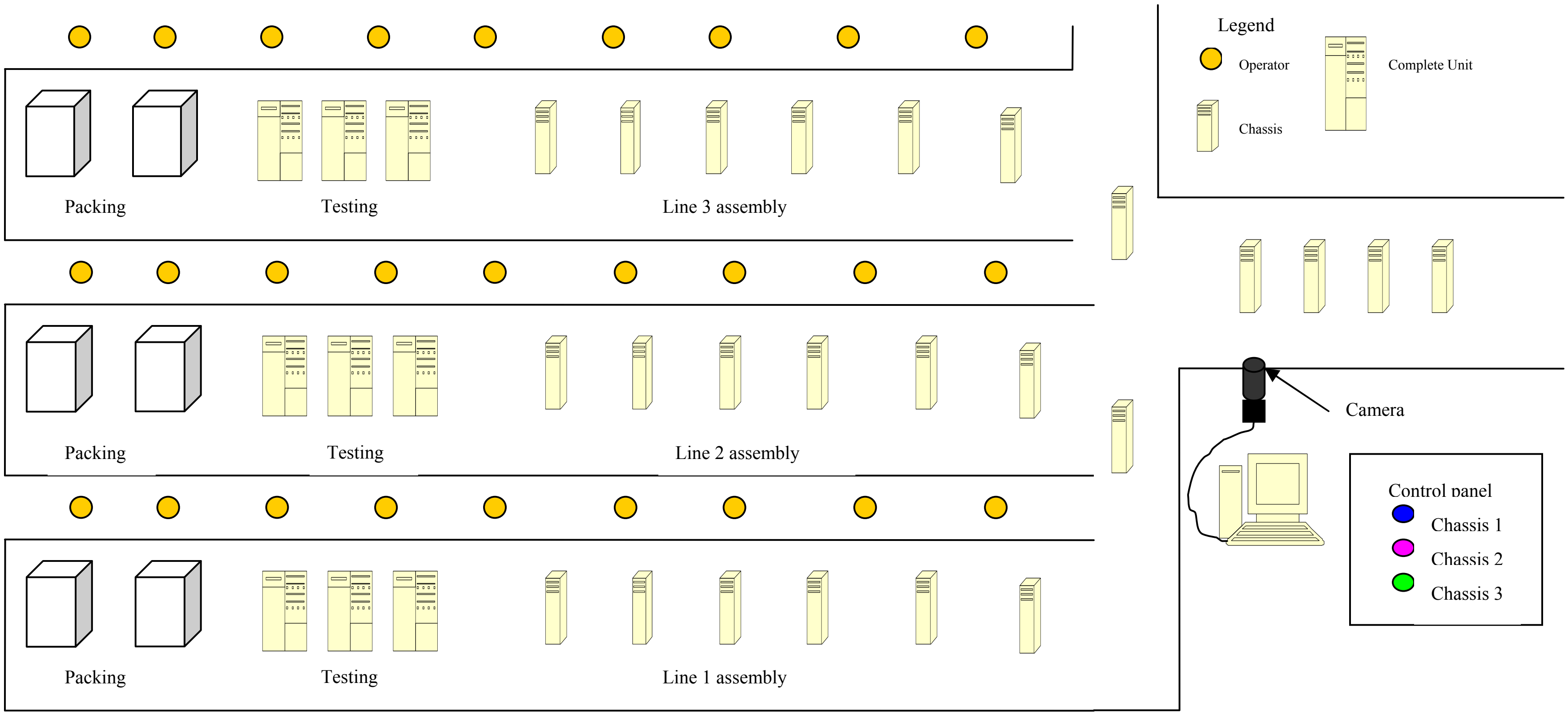
Disadvantage

The biggest disadvantage as compare to other system in the market is the ability to read multiplier barcode in the same image. This requires the system to locate the barcode within a single image before giving the resultant.

Secondly, all the systems in the industries are able to read 2D barcode. Although, it is not required in the system, it appears to be the tread in the market now. 2D barcode is able to contain more information of than 1D barcode as the data is encoded in both height and width of the barcode. [25]

Chapter 9.0 Installation and Acceptance

9.1 Design of assembly line



There is main conveyor belt in the centre of all production lines. This system will be installed in at the end of the junction. It will send a signal to the automation and move the chassis to production line depending on the chassis type.

9.2 Machine vision system

The main objective is to capture barcode image. The system was setup based on the study made earlier on. The proposed system is divided into three parts.

1. Image capturing system
2. Barcode imaging system
3. Moving the chassis to respective line system.

The image capturing system consists of digital camera which is located close to the chassis. As mentioned in earlier chapter, the distance between the camera and chassis must not more than 100mm. The camera is powered by PC through Universal Serial Bus (USB) cable. This cable provides power and transmits image information to PC. This camera is equipped USB2.0 which has the maximum up to 480mps [32]. All images taken from the camera are saved into the designed folder.

Barcode imaging system and LabVIEW program are installed into the PC located at the side of the conveyor belt as shown in the diagram above. This is to facilitate engineers or technicians for troubleshoot system in the event of any failure.

Moving chassis to respective line system is the last portion of the whole integrated system. The actuator will stop the conveyor belt such that the barcode in chassis is in front of the camera. The system will process the image and determine which line this chassis type it belongs to.

9.3 Summary

This chapter shapes the “ideal” layout of the integration of new barcode recognition system into the existing system.

Chapter 10.0 Critical Review and Reflections

The first meeting with my tutor Ms Chang was held on 10th February 2007. During the first meeting, we discussed about the project that I have thought off initially. The project was to design the system that is able to differentiate different colour plates. However after few rounds of discussion and exploration of ideas, we felt that there are some restrictions in obtaining information and the application of this system was limited.

I was told to think of another proposal. I went through another round of brainstorming and talked with friends. During a casual conversation with my friends, I learnt that one of my friends was having a problem in his work. This company is a chemical solution company. Recently they are facing a problem with their solution. The colour of the solution is not correct. Hence I thought of designing a system that is able to recognize the colour of the solution.

I email Ms Chang with my new proposal. A series of phone discussions and emails were made to discuss on this new proposal. This proposal was rejected as the access of defect solution and facilities will be difficult and dangerous.

I was threw back again for another round of brainstorming. The idea stuck to me when I was buying my grocery at the supermarket. The idea was to explore different ways of scanning the barcode. This new proposal will be develop and design a barcode image identification system. A lot of studies have been done to ensure that this system feasible.

This time, Ms Chang agreed with this proposal. This discussion was made on the direction and approach of this project.

After received the approval from SIM, I began to work on the project based on the target set in the gantt chart. I have studied and came out with several proposed solutions for this project. After few rounds for evaluations, I have decided to work on two proposed solutions.

No	Skill Requirement	Rating	Priority	Remark(s)
1	Reading and understanding literature review	Weak	1	Comprehend papers and review is my weakest link among all requirements.
2	Report writing	Average	2	There are many areas that I will have to improve on. Such as reporting techniques.
3	Component evaluation Skill	Strong	6	In my course of work, I need to evaluation many equipments before advice management
4	Project management skill	Average	4	In my course of work, I am involved several projects. These projects help me gain practical management experiences.
5	Programming skill	Average	5	I have basic knowledge programming knowledge of java and c++ programming.
6	Mathematical skill	Strong	7	MZS121 and MZS221have help me laid strong foundation.
7	Interview skill	Weak	3	This is the first attempt that I conduct focus group interview. I will have relearn this technique from my course book. [1]

Note: Rating:- Strong/Average/Weak

On top of that, I have also come up with a matrix above to gauge my capability on different areas that are required for this project. From this table, I am able to know which area requires more time to strengthen my weakness.

The next phrase will be learning LabVIEW from scratch. LabVIEW is a graphical programming language which I have not learnt before. I was a textual based programming trained person. The learning skew is very steep as the time is very limited.

Fortunately, SIM's self learning approach has helped me overcome this problem. I am able to learn through the tutorials and examples found in the program and WEB. There are also forums that users discuss the use of this software and their experiences.

Development of the system is the main part of this project. In the course of developing the system, there are many obstacles to overcome. First, the software USB webcam driver and library needed in developing this software. In SIM, these software libraries are not found in SIM lab. I also contact National Instrument for help. I was told that those libraries that I needed are professional version and SIM didn't have it at that point of time. I was also introduced to another LabVIEW module – Machine Vision System. This application is ready package for barcode reading. I was given a WEB link to download some trial versions. As for USB webcam driver, I found several website that developed for such purpose. However many of these tools are not reliable and often "crash" my application in the midst of developing this system. These incidents slow down the pace of development. I have no option but to use digital camera that uses IEEE1394 cable to develop this system before I found a reliable driver for web cam.

When the basic program has developed, there was another problem arises, the software is unable to read barcode effectively and at time, it will gives error telling that it is not a barcode. After long research and debugging, I found that it is the Region Of Interest (ROI) that will solve this knotty issue. There are several ways to define such area. Again, the process of evaluation has to take place to find out which the best options for this system. There are many suggestions that bring up to me when I asked. Many of them did not work or not efficiency. It is endless rounds of evaluation and trial and error that I learn from my mistakes and gain more knowledge in the labVIEW programming.

The disaster did not end soon. The dimension of ROI has to be done through many experiments in order to determine the best dimension that fits all images. But the use of ROI is not what has shown in the tutorial. It is after the advice from one of the member in the forum, that I realized there should be changes in the parameter in order to make it works.

Writing a report is another challenge to me. To improve my report writing skill, I have read up good example of past year reports done by other local and overseas universities. There are many good examples of reports. They have some similar characteristic between them such as concise information and flow between each segment.

During the course of developing this system, my tutor Ms Chang has given suggestions and valuable comment on the system.

Chapter 11.0 Conclusion

This report includes two parts: software development and hardware (resources integration).

The first part, software development involves selection for programming language, background research and experiments have conducted to test of developed software's reliability and functionality.

There are three parts in this software. They are:

1. Reading image

This is the most challenging part. The main function in the portion is retrieving the image that is store in the PC and send it to the developed software for decode the image., there are many obstacles in this portion especially it involves interface with hardware such as WebCam with the software. Many times, there is limit information and driver to interface these components together. There problems are overcome using third party drivers. However these drivers have to be validated before implement in many instances, these software drivers often provide limited support.

2. Decoding barcode image

This is the main part of the software. It is designed such that the barcode image is able to read if it is in three different preset orientations. This is to adapt changes in the barcode orientations. The decoding barcode engine is making use of existing LabView library. Many trials have done to ensure the settings are set correctly of each orientation. Experiments have also conducted to ensure that the accuracy. Many researches have demonstrated many methods in conducting this type of experiment.

3. Display the result

The design of the layout was a simple and easy to understand. This is to ensure that the operator has full understanding of what is happening. There are two results shown to the operator. They are; barcode result and the line that chassis should be going to.

The second part, hardware involves selection of Web Camera. Web camera is the heart of the system. Careful selection, this include stating the requirement of the camera, has been carried out to ensure that the right requirement camera is used for the system. Research studies have carried out to understand each technology used in the camera. Still image quality is the most important for this application.

Chapter 12.0 Recommendation

The project has reached the objective of developing a barcode imaging system. However, there are many areas that are not explored during the course of this project. These areas include both theory and applications.

First of all, there is a lacking of in-depth studies on image processing such as the brightness of image and coordinate position which referred as regions of interest (ROI). These studies are important to the project. These factors determined the reliability and stability of the system especially if the system is going to recognize 2D barcode

Secondly, the present system uses one type of barcode standard which is code 39. This restricts the application for other industries such as healthcare industry uses HIBC code that is more accurate than the normal barcode standard available in the market. [30]

Thirdly, the current system is unable to read two barcode within same image. This feature is common to other system available in the market. To develop such feature, understanding some approaches such as zero detection is important as this will help the system to recognize barcode locations.

Fourthly, there is no much work done for the hardware integration. This is due to the constraint of hardware equipment available. There is also a need to study the existing pneumatic programming before any changes is implemented.

Lastly, integration of information into a database system will be the last stage of this project. In this current system, the information read from the barcode is feedback directly to the panel. There is no information stored for the barcode in this present system.

Chapter 13.0 References

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APPENDIX A - Design of Experiment (DOE) 1

Purpose

The purpose of DOE 1 is to conduct experiment to test on the program's ability to read barcode from barcode image./

Scope

We will challenge the system by using correct barcode. A sample size of 10 correct and 10 incorrect barcodes will be used for the test.

Procedure

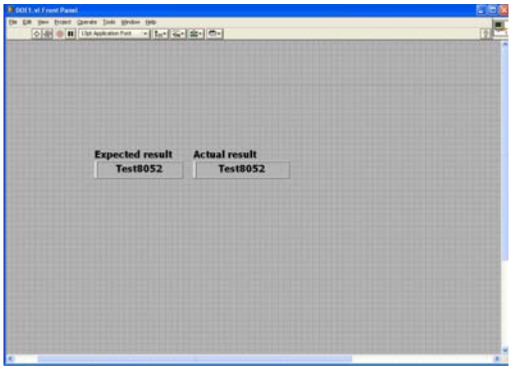
a. Load the first correct barcode sample to the program and record the result in Table A.
b. Repeat the test for the rest of the correct barcode.
c. Load the first incorrect barcode sample to the program and record the result in Table B.
d. Repeat the test for the rest of the incorrect barcode.

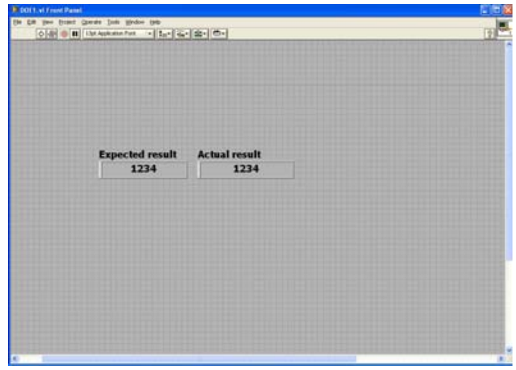
Accuracy level

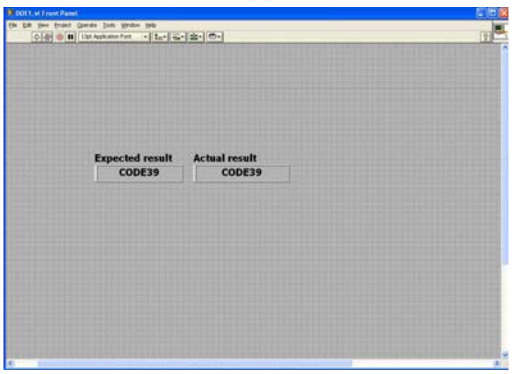
The acceptance level of accuracy should be >90%.

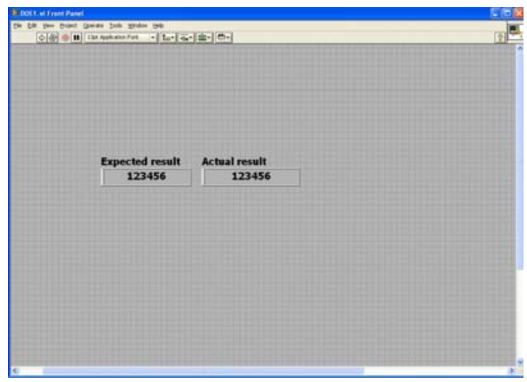
The accuracy of the system is high if the program is able to read the correct barcode label and give an error code for the incorrect label.

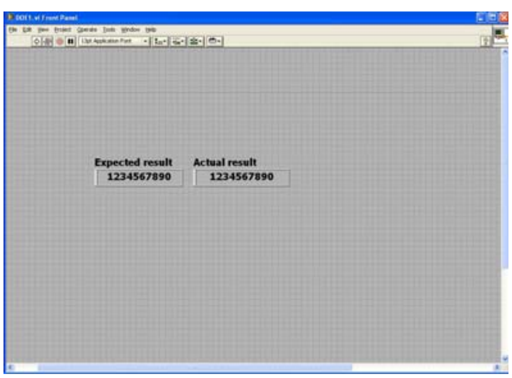
APPENDIX A-1 - Design of Experiment (DOE) 1 result

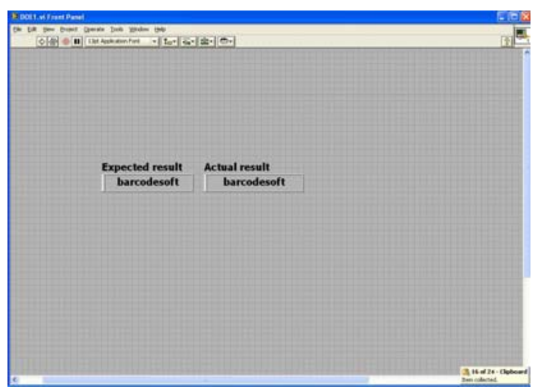




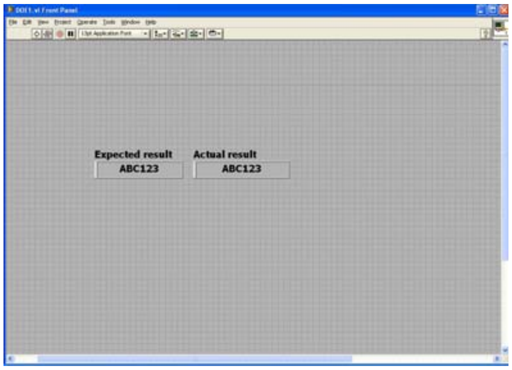


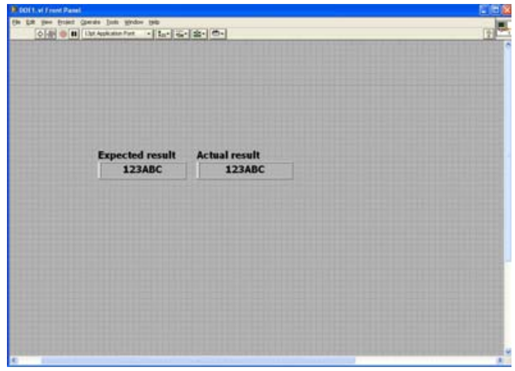


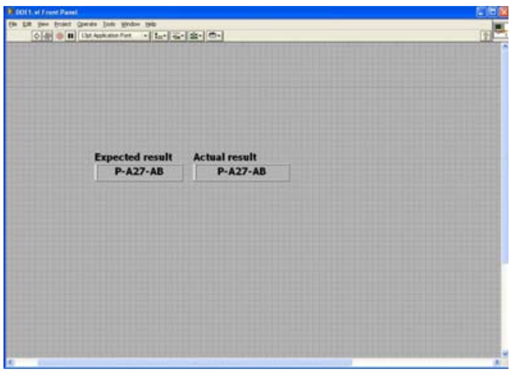


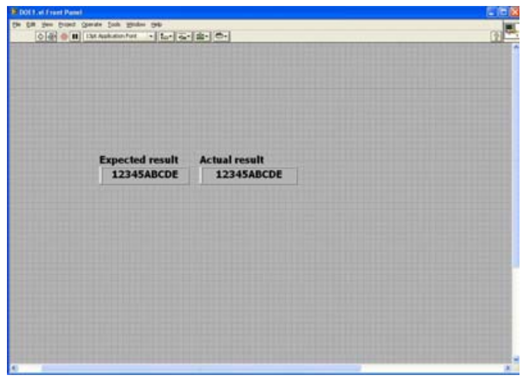


APPENDIX A-1 - Design of Experiment (DOE) 1 result









APPENDIX B - Design of Experiment (DOE) 2

Purpose

The purpose of DOE 2 is to conduct experiment to test on the accuracy of the software program to read the barcode. The orientation of barcode will be at 0°, 90° and 270°

Scope

We will challenge the system by using correct and incorrect barcode. A sample size of 10 correct and 10 incorrect barcodes will be used for the test.

Procedure

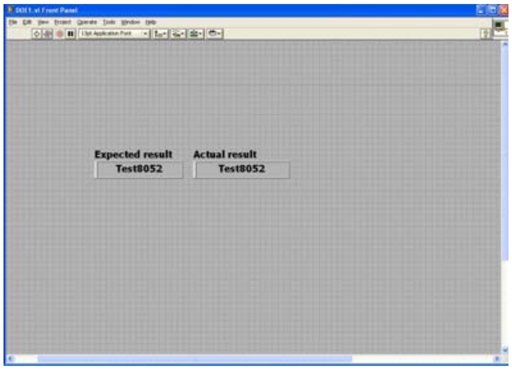
e. Load the first correct barcode sample to the program and record the result in Table A.
f. Repeat the test for the rest of the correct barcode.
g. Load the first incorrect barcode sample to the program and record the result in Table B.
h. Repeat the test for the rest of the incorrect barcode.

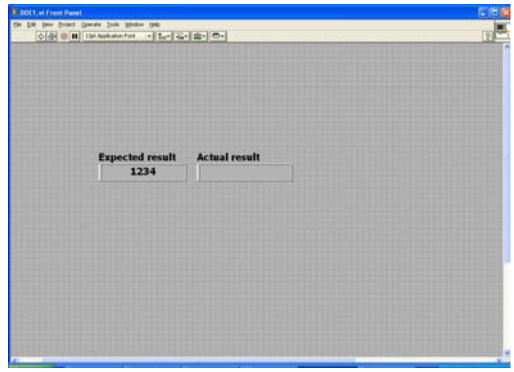
Accuracy level

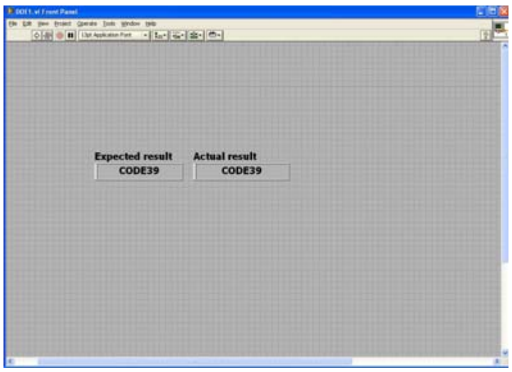
The acceptance level of accuracy should be >90%.

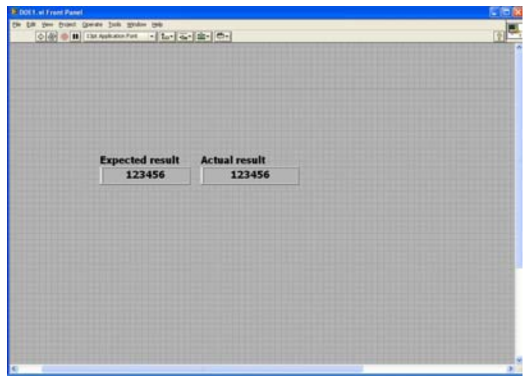
The accuracy of the system is high if the program is able to read the correct barcode label and give an error code for the incorrect label.

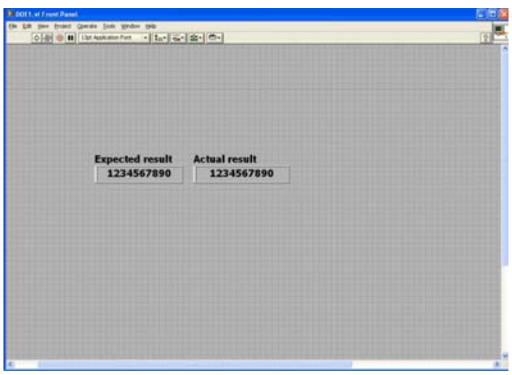
APPENDIX B-1 - Design of Experiment (DOE) 2 result

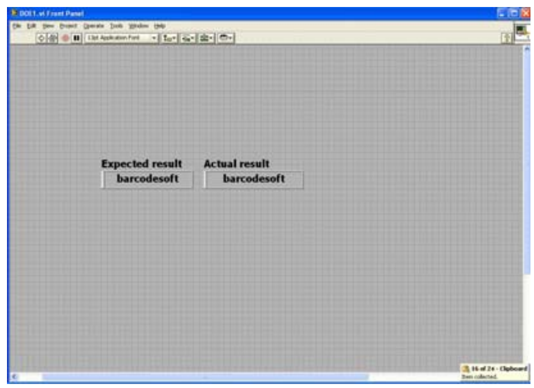












APPENDIX B-1 - Design of Experiment (DOE) 2 result