Faculty of Electrical Technology and Engineering

DEVELOPMENT OF THE VISUAL MONITORING SYSTEM BASED ON AN INDUSTRIAL AUTOMATION SYSTEM (FABRICATED METAL INDUSTRY) BY USING VB.NET

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Bachelor of Electrical Engineering Technology (Industrial Automation & Robotic) with Honours

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DEDICATION

To my beloved mother, HALIZA BINTI ABDUL WAHAB, and father, MOHAMMAD NIZHAM BIN AHMAD SUM, your unwavering support and encouragement have been the driving force behind every endeavour. Your sacrifices and belief in my journey have shaped my path, and this work is a reflection of the values instilled by your guidance.

To my dearest partner, AFIFAH, your patience, understanding, and constant encouragement have been my pillars of strength. Your belief in my capabilities has fuelled my determination to overcome challenges and reach new heights. This dedication is a small token of appreciation for your unwavering presence on this shared journey.

To my friends, your camaraderie, laughter, and shared moments have added vibrant colours to the canvas of my life. Your support and shared experiences have made every step of this journey memorable and meaningful.

May this work stand as a tribute to the incredible individuals who have been my source of inspiration and strength

ABSTRACT

The fabricated metal industry faces challenges in monitoring and controlling production processes, resulting in inefficiencies and safety hazards. This study aims to develop a visual monitoring system using VB.NET to address these issues. The system incorporates sensor, camera technology and advanced image processing techniques to track and identify errors in real-time, reducing the need for manual inspection and improving worker safety. Integration with existing industrial automation systems and a conveyor system enhances object handling and streamlines workflows. The project successfully implemented color detection using VB.NET, demonstrating its potential for quality control and object identification. The visual monitoring system, in conjunction with the conveyor system, provides a comprehensive solution for the fabricated metal industry, optimizing automation, workflow, and product quality. Further advancements and refinements can unlock the system's full potential, leading to increased productivity and customer satisfaction in the manufacturing process. This research contributes to the advancement of visual monitoring systems in industrial settings, addressing key challenges in the fabricated metal industry and paving the way for future improvements.

ABSTRAK

Industri logam terfabrikasi menghadapi cabaran besar dalam pemantauan dan kawalan proses pengeluaran, yang boleh menyebabkan ketidakcekapan operasi dan risiko keselamatan yang tinggi. Kajian ini dijalankan dengan matlamat untuk membangunkan sistem pemantauan visual menggunakan VB.NET, sebagai langkah ke arah menangani isu-isu ini dengan lebih cekap. Sistem ini merangkumi teknologi sensor, kamera dan teknik pemprosesan imej yang canggih untuk mengesan serta mengenal pasti sebarang kesalahan secara waktu nyata. Dengan ini, keperluan untuk pemeriksaan manual berkurangan, sementara keselamatan pekerja ditingkatkan. Integrasi sistem ini dengan sistem automasi industri sedia ada dan konveyor turut memperbaiki pengendalian objek serta menyusun alur kerja. Kejayaan projek ini terutamanya dapat dilihat melalui implementasi pengesanan warna menggunakan VB.NET, membuktikan potensi besar dalam kawalan kualiti dan pengenalan objek. Keseluruhan, sistem pemantauan visual ini, bekerjasama dengan sistem konveyor, menyediakan penyelesaian menyeluruh untuk industri logam terfabrikasi. Dengan mengoptimumkan automasi, alur kerja, dan kualiti produk, diharapkan dapat meningkatkan produktiviti keseluruhan dan meningkatkan kepuasan pelanggan dalam proses pembuatan. Kemajuan dan penyempurnaan lanjut boleh membuka potensi penuh sistem ini, membawa kepada prestasi yang lebih tinggi dan kepuasan yang lebih besar dalam industri ini. Penyelidikan ini diharapkan memberikan sumbangan yang berarti kepada perkembangan sistem pemantauan visual dalam konteks industri, menyelesaikan cabaran utama dalam industri logam terfabrikasi, serta membuka jalan untuk peningkatan masa depan yang lebih baik.

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LIST OF ABBREVIATIONS

V	-	Voltage
VB	-	Visual Basic
2D/3D	-	Two Dimensional/Three-Dimensional
HVAC	-	Heating, Ventilation, and Air Conditioning
PC	-	Personal Computer
CCD	-	Charge-Coupled Device
PCB	-	Printed Circuit Board
IDE	-	Integrated Development Environment
v	-	Version
USB	-	Universal Serial Bus
DOF	-	Degrees Of Freedom
RFID	-	Radio Frequency Identification
NDT	-	Non-Destructive Testing
AVI	-	Audio Video Interleave
ADO.NET	-	Active Data Objects.NET
LINQ	-	Language-Integrated Query
SQL	-	Structured query language
ORM	-	Object Relational Mapper
AVR	-	Advanced Virtual RISC
MHz	-	Megahertz
ICSP	-	In-circuit serial programming
CPU	-	Central Processing Unit
PWM	-	Pulse Width Modulation
I/O	-	Input/Output
DC	-	Direct Current
A	-	Ampere
CNC	-	Computerized Numerical Control
IC	-	Integrated Circuit
RPM	-	Revolution Per Minutes
KG	-	kilograms
cm	-	centimeter
HD	-	High Definition
NET	-	Network

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CHAPTER 1

INTRODUCTION

The reader will get an overview of the project in this chapter. It includes the study's history, project purpose, problem statement, and scope. It explains the inspiration for this study as well as the factors that led to it.

1.1 Background

The fabricated metal industry plays a crucial role in the global economy, but it is also associated with several hazardous and critical processes, such as welding, cutting, and metal fabrication. These processes can lead to severe accidents and injuries, with a significant impact on workers' safety and the environment. Among the objectives of this project is to enrich the world of monitoring the real critical situation on the manufacturing floor through more detailed information, which will further strengthen the world of monitoring serious or hazardous situations on the manufacturing site. Visual material is a form of data that is more interesting and richer in detailed knowledge if compared to other types of sensing such as sound, touch, and so on. In this project, the visual system is expected to convey important data about the station system so that the process will be more understandable, especially when dealing with relatively odd or rare processes and the need to monitor an unexpected or critical situation. Therefore, implementing a reliable monitoring system that can detect potential hazards and prevent accidents is crucial. The method will use one of the languages in Microsoft Visual Studio, VB.NET, where it has been proven to be able to build Windows-based software effectively.

1.2 Problem Statement

The fabricated metal industry is a critical sector that produces a wide range of products for various applications. However, the industry is characterised by hazardous and demanding working conditions, especially in the 3D (dangerous, demanding, and demeaning) jobs. Despite the use of sensors, alarms, and other indicators to detect errors in the production process, manual monitoring and control are still necessary, leading to inefficiencies and safety hazards.

The current monitoring and control system in the fabricated metal industry is not sufficient to detect and address production deviations in real-time. This manual monitoring process is highly inefficient and can result in costly production delays, quality issues, and safety hazards for workers. Additionally, verbal communication and traditional methods of education may not be effective in helping workers understand critical production processes.

To solve these problems, a visual monitoring system based on an industrial automation system using VB.NET can be developed. The system can track and monitor the production process, identify errors and deviations in real-time, and provide an intuitive and interactive interface for workers to understand the production process. The system can also improve worker safety by reducing the need for manual monitoring and control and minimising exposure to occupational hazards. Overall, the visual monitoring system can increase productivity, efficiency, and safety in the fabricated metal industry.

1.3 Societal and Global Implications of Industrial Automation Systems

The development of an industrial automation system for the fabricated metal industry necessitates a thorough examination of the societal and global issues associated with such systems. This section of the thesis delves into these issues and explores the integration of sustainable development principles into the project.

Industrial automation systems have the potential to significantly impact the environment, society, and economy. Therefore, it is crucial to consider the broader implications and potential consequences of implementing such systems. By addressing societal and global issues, the project aims to minimise negative impacts and promote sustainability in the fabricated metal industry.

Sustainable development principles play a vital role in ensuring that industrial automation systems are designed and implemented in a manner that aligns with environmental, social, and economic sustainability. This section delves into the importance of integrating sustainable practices into the project and highlights the benefits it can bring.

In the context of the fabricated metal industry, specific societal and global issues may arise, such as energy consumption, waste management, and occupational safety. The thesis examines these issues in detail and proposes strategies to mitigate their negative effects. It explores sustainable development frameworks and guidelines relevant to the industry and identifies best practices for incorporating sustainability into the automation system.

By considering societal and global issues and integrating sustainable development principles into the project, the aim is to contribute to the advancement of sustainable practices in the fabricated metal industry. The thesis seeks to provide insights and recommendations that can guide future development and implementation of industrial automation systems, ensuring they are aligned with sustainability goals and promote positive environmental and social outcomes.

1.4 Project Objective

The primary aim of this project is to suggest a proficient and productive approach to design a visual monitoring system that can aid the user in simulating a production line in a fabricated metal industry. More specifically, the objective of the project are:

1. To create and design a visual monitoring system, based on VB.NET programming language, that can monitor essential manufacturing processes using camera.
2. Develop a seamless simulation and real-time monitoring system for integrating with existing industrial automation systems, including conveyor systems.
3. To analyse the image processing performance on the monitoring system.

1.5 Scope of Project

This project will be developed within a specific scope, which sets the boundaries for the final system. The system will need to adhere to the following requirements:

a) Developing a user-friendly interface for the visual monitoring system using one of the languages available in Microsoft Visual Studio, such as VB.NET.

b) Incorporating cameras as the primary sensor hardware, along with a physical conveyor system that simulates the manufacturing process for fabricated metal products.

c) Focusing the system solely on the assembly conveyor for a specific critical process within the fabricated metal production plant.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review in this chapter focuses on the significance of visual monitoring systems in the fabricated metal industry, particularly in hazardous and critical processes. It aims to identify the key factors that contribute to the risks associated with these processes, where human intervention is deemed unsafe. Additionally, the chapter explores the selection and evaluation of suitable visual monitoring systems for the project, assessing their effectiveness in achieving the project's objectives. By examining existing research and studies, this review provides valuable insights into the challenges and potential solutions related to implementing visual monitoring systems for hazardous processes in the fabricated metal industry.

2.2 Fabricated Metal Manufacturing Industry

The fabricated metal manufacturing industry is a vital sector that plays a crucial role in the production of a diverse range of metal products. These products are utilized in various sectors, including construction, infrastructure development, automotive, aerospace, machinery, and many others. The industry encompasses a wide array of activities, including metal fabrication, welding, machining, forming, and assembly.

Fabricated metal manufacturers work with raw metal materials such as steel, aluminum, and alloys. These materials are transformed into finished products through various processes. Cutting and shaping of metal sheets or bars are carried out using techniques like laser cutting, plasma cutting, or waterjet cutting. Bending and forming processes involve the use of specialized machines to achieve the desired shapes and dimensions. Welding is a critical process that joins metal parts together using various techniques such as MIG (Metal Inert Gas) welding, TIG (Tungsten Inert Gas) welding, or arc welding.

The industry is characterized by its focus on precision and quality. Advanced computer-aided design (CAD) and computer-aided manufacturing (CAM) software enable manufacturers to create detailed product designs and efficiently program machinery for production. Additionally, robotics and automation systems are increasingly employed to enhance productivity, improve process control, and ensure consistent quality.

Safety is of paramount importance in the fabricated metal manufacturing industry. The industry involves working with heavy machinery, sharp tools, and high-temperature processes, which pose inherent risks to workers. Manufacturers adhere to strict safety protocols and invest in training programs to ensure a safe working environment. Furthermore, visual monitoring systems and other safety measures are implemented to detect and prevent potential hazards.

The fabricated metal manufacturing industry plays a significant role in driving economic growth and innovation. Its products are essential for infrastructure development, transportation, and the manufacturing of machinery and equipment. As technology continues to advance, the industry strives to adopt new manufacturing techniques, enhance efficiency, and meet evolving customer demands [1].

In summary, the fabricated metal manufacturing industry encompasses a wide range of processes as shown in figure 2.1 involved in transforming raw metal materials into finished products. It is a critical sector supporting various industries and requires a combination of advanced technology, skilled labor, quality control measures, and a strong focus on safety. The industry continues to evolve, embracing automation and innovative manufacturing techniques to stay competitive in a rapidly changing global market.

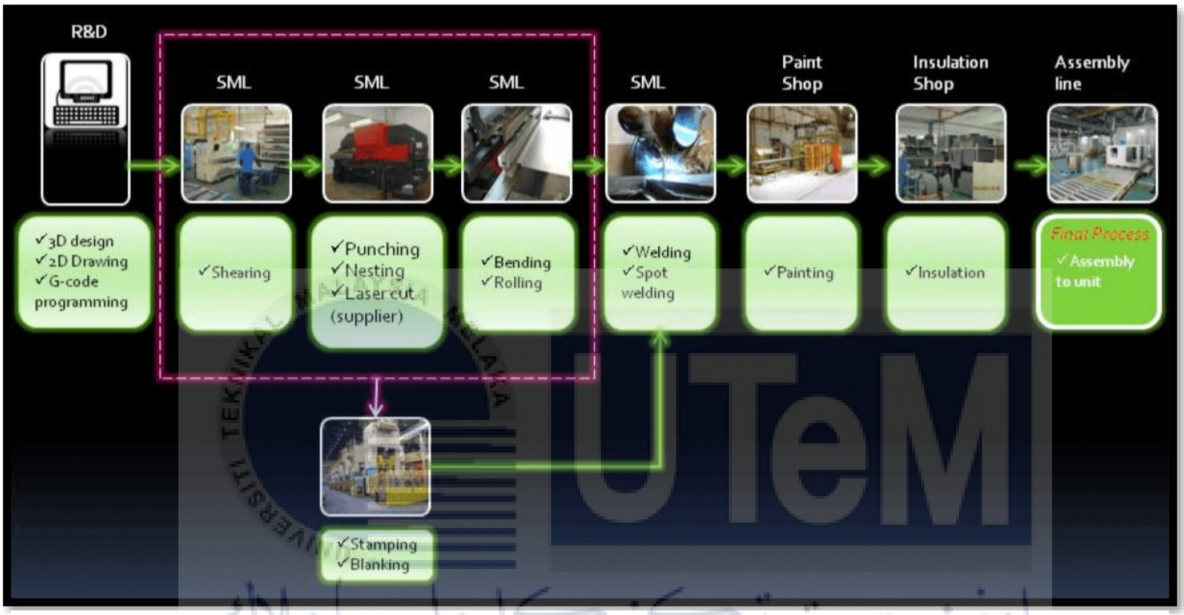


Figure 2.1 Image of whole process

2.2.1 Fabricated Metal (Cans) Manufacturing Process

The fabricated metal industry, specifically in the production of cans, plays a crucial role in packaging and preserving various consumer goods. The manufacturing process involves several key steps, including material selection, sheet metal preparation, forming, joining, and finishing. Each of these processes contributes to the creation of sturdy and functional metal cans.

2.2.1.1 Material Selection and Preparation

In the fabricated metal industry, materials such as aluminium or steel sheets are commonly used for can production. The choice of material depends on factors such as durability, weight, cost, and intended application. Aluminium cans are lightweight, corrosion-resistant, and widely used for beverages, while steel cans are known for their strength and are preferred for packaging goods requiring high rigidity [2].

2.2.1.2 Sheet Metal Preparation:

To begin the manufacturing process, the selected metal sheets undergo preparation, which involves cleaning, degreasing, and surface treatment. These steps ensure proper adhesion and surface quality for subsequent forming processes.

2.2.1.3 Forming

Forming is a crucial step where the flat metal sheets are transformed into the desired can shape. Two common forming methods used in the industry are deep drawing and impact extrusion. Deep drawing involves the use of a die to stretch and shape the metal sheet into a cylindrical form, while impact extrusion uses a punch to force the metal into a mold to create the can shape.

2.2.1.4 Joining

In the joining process, the formed can bodies are joined with the can ends to create a sealed container. This is typically done through a combination of methods such as welding, soldering, or adhesive bonding. Welding is commonly used for steel cans, while aluminum cans are often joined using adhesives or a combination of adhesive and mechanical closures.

2.2.1.5 Finishing

After joining, the cans undergo various finishing processes to enhance their appearance and functionality. These processes may include cleaning, coating, printing, and labeling. Cleaning ensures the removal of any contaminants, while coating provides corrosion resistance and enhances the can's visual appeal. Printing and labeling allow for branding, product information, and regulatory compliance to be displayed on the can's surface.

2.2.1.6 Quality Control

Quality control is an essential aspect of the fabricated metal (cans) manufacturing process. Stringent quality control measures are implemented at various stages to ensure that the cans meet the required standards. Inspection and testing techniques are employed to detect and eliminate defects, ensuring the integrity and functionality of the final product. Quality control protocols may include dimensional checks, leak testing, visual inspections, and performance evaluations to verify that the cans meet the specified requirements.

2.2.1.7 Packaging and Distribution

Once the metal cans have undergone the necessary manufacturing and quality control processes, they are prepared for packaging and distribution. This involves proper stacking, grouping, and labeling of the cans to facilitate easy identification and handling. Packaging materials such as cardboard boxes or shrink wrap are used to protect the cans during transportation, ensuring they reach their destination in optimal condition. Table 2.1 show the all the manufacturing process on their station.

Table 2.1 Fabricated Metal (Cans) Manufacturing Process Stations and Processes

Station	Process
Material Selection and Preparation	Material selection and procurement
	Metal cutting and shearing
	Coil unrolling and flattening
Sheet Metal Preparation	Cleaning and surface preparation
	Sheet metal cutting and blanking
Forming	Deep drawing
	Punching and forming
	Bending and folding
Joining	Seam welding
	Spot welding
	Riveting
	Soldering and brazing
Finishing	Surface finishing and polishing
	Coating and painting
Quality Control	Visual inspection
	Dimensional checks
	Leak testing
	Pressure and strength testing
Packaging and Distribution	Packaging
	Labelling and marking
	Storage and distribution

2.3 Comparison with Glass and Rubber Manufacturing Industries

The fabricated metal industry, similar to the glass and rubber manufacturing industries, exhibits both similarities and differences in its production processes. By comparing these industries, we can gain valuable insights into potential improvements in the fabricated metal sector. Exploring the commonalities and distinctions in terms of materials, manufacturing techniques, and product characteristics enables us to identify areas where the fabricated metal industry can benefit from lessons learned in the glass and rubber sectors. Specifically, implementing a visual monitoring system has the potential to enhance process efficiency, reduce waste, improve product quality, and ensure the safety of manufacturing operations in the fabricated metal industry. By leveraging the shared aspects and addressing industry-specific challenges, the adoption of a visual monitoring system can lead to significant advancements in process control, defect detection, and overall productivity in the fabricated metal manufacturing sector [3][4].

2.3.1 Similarities and Differences in Manufacturing Processes

The production techniques used by the fabricated metal, rubber, and glass sectors are both comparable and distinctive. We can learn a lot about the manufacturing techniques employed in each business by evaluating these parallels and variations, and we can also investigate the possible advantages of visual monitoring systems.

The processing of raw materials is a common practise across all three industries. Metals are made ready for fabrication by procedures like melting, alloying, and shaping. Similar to this, the rubber business mandates the blending of polymers, fillers, and additives to create rubber compounds. In order to produce batches of glass, the glass industry carefully selects and processes raw ingredients including silica sand and soda ash. This highlights how important raw material pretreatment is in obtaining the desired material attributes and product quality.

Processes utilised in both industries for shaping and forming are another similarity. Materials are shaped to meet specific specifications using processes including moulding, extrusion, and casting. Casting, forging, or machining procedures are used in the fabricated metal sector to shape metal components. Rubber compounds are formed into a variety of products by the rubber industry using moulding or extrusion procedures. Glass is formed using methods like blowing and pressing in the glass industry. These shaping procedures emphasise the significance of exact methods for achieving desired product results.

Despite these commonalities, there are observable variances in how fabricated metal, rubber, and glass are made. The distinctive material qualities and properties provide the main distinction. Fabricated metals have qualities like strength, conductivity, and malleability, whereas rubber has qualities like elasticity, flexibility, and resilience. Glass has unique qualities including transparency, brittleness, and thermal stability since it is an inorganic, non-metallic substance. These material variations call for particular manufacturing procedures and methods that are adapted to the characteristics of each material.

The ways that these industries heat and process things also differ. The melting and shaping of metal materials takes place in the fabricated metal sector using a variety of heating techniques, such as induction furnaces or electric arc furnaces. The necessary shape and qualities are often achieved by heating and moulding rubber materials under pressure. High-temperature furnaces are used in the glass industry to melt raw materials into molten glass so that it may be shaped.

Processes for finishing and applying surface treatments vary as well. To improve their look, corrosion resistance, or conductivity, metal components frequently go through additional operations like polishing, plating, or coating. To increase their tensile strength or chemical resistance, rubber products may receive surface treatments like vulcanization or coating. To increase its strength and safety, glass, on the other hand, may go through processes like annealing or tempering.

All three industries employ quality control procedures to guarantee product quality. The fabricated metal and rubber industries frequently utilise visual inspections, dimensional measurements, and testing techniques to identify flaws and confirm conformity with specifications. Visual inspections, optical testing, and automated methods are all used in the production of glass to find and remove flaws.

We obtain a thorough awareness of the similarities and contrasts between the manufacturing processes of the fabricated metal, rubber, and glass industries. With this knowledge, we are able to pinpoint areas where visual monitoring systems can be used to increase process effectiveness, improve product quality, and guarantee worker safety in various industries. Visual monitoring systems can be effective instruments for streamlining operations and promoting continuous improvement in the fabricated metal, rubber, and glass manufacturing industries by capitalising on these parallels and solving the particular difficulties faced by each sector.

2.4 Critical Processes in Fabricated Metal (Cans) Manufactory

The fabricated metal (cans) manufacturing process encompasses various hazardous and critical processes that demand meticulous attention to ensure the safety of workers and the production of high-quality cans. It is essential to understand these processes and their associated risks in order to implement effective safety measures. This section provides an overview of some of the significant hazardous and critical processes involved in fabricated metal manufacturing.

2.4.1 Cutting and Shaping

Metal cutting and machining processes play a significant role in fabricated metal manufacturing, but they also involve potential hazards and critical considerations. The use of cutting tools, such as saws, drills, or milling machines, poses risks of cuts, abrasions, or puncture injuries if not handled with care. The high-speed rotating components of machines can lead to entanglement hazards, where loose clothing or body parts can be caught, resulting in severe injuries. Moreover, the cutting and machining operations generate metal chips or fine metal particles, which can cause eye injuries or respiratory issues if workers are not equipped with proper eye protection and respiratory masks. The cutting and machining processes also involve the use of cutting fluids or lubricants to facilitate the metalworking operation. These fluids may contain hazardous chemicals, such as oils, coolants, or solvents, which can pose health risks if workers are exposed to them without adequate control measures. Prolonged exposure to these substances can lead to skin irritations, respiratory sensitization, or long-term health effects.

2.4.2 Welding and Soldering

Welding and soldering processes are fundamental in fabricated metal manufacturing but pose significant hazards and critical considerations that need to be addressed to ensure worker safety and product quality. These processes involve the joining of metal components through the application of heat and the use of filler materials. However, they also present various risks that can lead to injuries and compromised structural integrity if not properly managed. One of the primary hazards in welding and soldering is the emission of fumes and gases. The heat applied during these processes causes the release of hazardous substances, such as metal oxides, ozone, nitrogen dioxide, and volatile organic compounds. Prolonged exposure to these fumes and gases can result in respiratory issues, eye irritation, and long-term health effects. Additionally, the intense heat generated during welding can pose burn hazards, both for the welders themselves and for nearby workers if proper safety measures are not in place. Welding equipment utilizes high voltages and electrical currents, which can lead to electrical shocks and burns if precautions are not taken.

2.4.3 Machining and Tooling

Machining and tooling processes play a critical role in fabricated metal manufacturing but also involve specific hazards and considerations. These processes involve the use of various machines, tools, and cutting techniques to shape and form metal components. While they are essential for achieving precise dimensions and desired shapes, they pose inherent risks that need to be managed effectively. One of the primary hazards in machining and tooling is the generation of metal chips, shavings, and fine particles. These small metal fragments can become airborne, posing risks of eye injuries, skin abrasions, and inhalation hazards if adequate protective measures are not in place. The high-speed rotating tools used in machining operations can cause these fragments to be forcefully ejected, making proper machine guarding and the use of safety shields crucial for protecting workers.

2.4.4 Finishing and Surface Treatment

Finishing and surface treatment processes in fabricated metal manufacturing are essential for enhancing the appearance, durability, and corrosion resistance of metal components. However, these processes also introduce specific hazards and critical considerations that need to be addressed to ensure worker safety and product quality. One of the primary hazards in finishing and surface treatment is the use of chemicals, such as solvents, acids, and alkalis. These substances can be corrosive, toxic, or flammable, posing risks to workers if not handled properly. Moreover, the use of heat sources, such as ovens, curing chambers, or flame torches, for drying, curing, or heat-treating surface finishes can introduce fire and burn hazards. Additionally, finishing and surface treatment processes often involve manual handling of heavy or awkwardly shaped metal components. Improper lifting techniques or overexertion can lead to musculoskeletal injuries.

2.4.5 Assembly and Joining

Assembly and joining processes in fabricated metal manufacturing involve connecting individual components to create the final product. Techniques such as riveting, bolting, or adhesive bonding are employed to achieve secure and reliable connections. However, these processes introduce potential hazards that must be addressed. Manual handling of heavy or awkwardly shaped metal parts during assembly increases the risk of musculoskeletal injuries. The use of fasteners, such as rivets or bolts, may involve handling sharp-edged materials, which can result in cuts or puncture wounds. Moreover, working at elevated heights or in confined spaces during assembly operations poses additional safety concerns.

2.5 Visual Monitoring

Visual monitoring is a critical component in modern manufacturing processes, providing valuable insights and control over production operations. By harnessing advanced imaging technologies and intelligent algorithms, visual monitoring systems enable real-time visibility into the manufacturing process. These systems capture and analyze visual data, such as images and videos, to detect anomalies, defects, and deviations from predefined standards. This proactive approach allows for immediate identification and resolution of issues, resulting in improved product quality and reduced waste.

One of the key benefits of visual monitoring is its ability to enhance productivity. By providing real-time feedback on the production line, visual monitoring systems enable operators to make informed decisions and take prompt actions to optimize efficiency. They can quickly identify bottlenecks, adjust parameters, and implement process improvements to ensure smooth and uninterrupted production. This proactive monitoring and intervention contribute to increased throughput and reduced downtime, ultimately enhancing overall productivity.[5]

In addition to productivity gains, visual monitoring systems significantly contribute to quality control efforts. They offer a detailed and accurate assessment of product quality by detecting defects and deviations from specifications. By continuously monitoring the production process, these systems ensure that products meet the required standards and minimize the risk of substandard or faulty products reaching the market. Early identification of defects allows for timely corrective actions, reducing the need for rework or product recalls.

Visual monitoring also plays a vital role in ensuring worker safety. By capturing real-time visual data from production areas, these systems can identify potential safety hazards and risky situations. They can detect the presence of unauthorized personnel in restricted zones, monitor compliance with safety protocols, and alert operators to any abnormal conditions that may pose a risk to workers. By providing remote monitoring capabilities, visual monitoring systems enable proactive safety management and minimize the potential for accidents and injuries.

Furthermore, the integration of visual monitoring with data analytics and automation technologies opens up new possibilities for process optimization and predictive maintenance. By analyzing the captured visual data, patterns and trends can be identified, leading to insights for continuous process improvement. Visual monitoring systems can also monitor the condition of machinery and equipment, detecting signs of wear, malfunctions, or potential failures. This allows for predictive maintenance, where maintenance activities can be scheduled proactively to avoid unplanned downtime and optimize equipment performance.[6]

As imaging technologies, machine learning algorithms, and data processing capabilities continue to advance, visual monitoring is poised to revolutionize the manufacturing industry. It offers a powerful tool for enhancing productivity, improving product quality, ensuring worker safety, and driving continuous improvement. By leveraging the insights gained from visual monitoring, manufacturers can make data-driven decisions, optimize their processes, and remain competitive in an ever-evolving market[7].

2.5.1 Importance of Visual Monitoring in the Fabricated Metal (Cans) Manufactory

Visual monitoring plays a vital role in the fabricated metal (cans) manufacturing industry, providing specific benefits that are highly relevant to this sector. One significant importance of visual monitoring in cans manufacturing is its ability to detect and prevent defects in the production process. By employing visual inspection techniques, manufacturers can identify surface imperfections, dents, scratches, or other defects that may occur during the fabrication of metal cans. Early detection of these issues allows for immediate corrective action, ensuring that only high-quality cans are produced and minimizing the risk of faulty products reaching the market.

In addition to defect detection, visual monitoring in the cans manufacturing industry also aids in monitoring critical parameters and process control. By using cameras and sensors, manufacturers can continuously monitor key parameters such as can dimensions, thickness, seam integrity, and coating quality. Any deviations from the specified tolerances can be quickly identified, allowing operators to make necessary adjustments and maintain process consistency. This ensures that cans are produced according to the required specifications, guaranteeing uniformity and reliability in the final products.

Visual monitoring systems also contribute to the overall efficiency and productivity of cans manufacturing. By providing real-time visibility into the production line, operators can monitor the flow of materials, identify bottlenecks, and optimize the production process. This includes monitoring the movement of cans, tracking the filling and sealing processes, and ensuring the smooth operation of conveyor systems. With this comprehensive oversight, manufacturers can identify areas for improvement, streamline operations, and maximize throughput.[8]

Furthermore, visual monitoring enhances worker safety in the cans manufacturing industry. By monitoring the production environment, operators can detect potential hazards, such as equipment malfunctions, improper handling of materials, or unsafe work conditions. Early detection of these risks allows for prompt intervention, minimizing the likelihood of accidents or injuries. Visual monitoring systems can also be integrated with safety protocols, such as detecting the presence of personnel in restricted areas or alerting operators to potential safety violations.

Another advantage of visual monitoring in cans manufacturing is its ability to capture and analyze data for process optimization and quality assurance. By collecting visual data from the production line, manufacturers can gain valuable insights into trends, patterns, and potential areas of improvement. This data-driven approach enables data-driven decision-making, leading to targeted process enhancements, waste reduction, and increased overall productivity. Visual monitoring systems can also integrate with data analysis tools and artificial intelligence algorithms, enabling advanced analytics and predictive maintenance capabilities[9].

In conclusion, visual monitoring systems play a crucial role in the fabricated metal (cans) manufacturing industry, offering specific benefits tailored to this sector. By ensuring defect detection, monitoring critical parameters, enhancing efficiency, promoting worker safety, and facilitating data-driven process optimization, visual monitoring systems contribute to the production of high-quality cans, streamlined operations, and overall success in this competitive industry.

2.5.1.1 Ensuring Safety and Hazard Fabricated Metal (Cans) Manufactory

In the fabricated metal (cans) manufacturing industry, visual monitoring systems play a crucial role in ensuring safety and mitigating hazards associated with critical processes. By utilizing advanced camera systems, sensors, and real-time monitoring technologies, visual monitoring systems provide effective solutions to enhance safety measures and reduce risks in hazardous manufacturing environments.

One key aspect of visual monitoring systems is their ability to monitor critical processes, such as welding, soldering, and machining, where potential hazards exist. These systems enable continuous surveillance of these processes, allowing operators to remotely monitor operations from a safe distance. By providing a real-time visual feed, operators can closely observe the processes without direct exposure to hazardous conditions, such as sparks, fumes, or high temperatures. This remote monitoring capability significantly minimizes the risk of injuries and ensures the safety of personnel.[10]

Visual monitoring systems also incorporate intelligent algorithms and machine vision technologies to detect and alert operators to potential safety hazards. For example, these systems can analyze video feeds and identify abnormal activities or behaviors that may indicate unsafe conditions. Alerts can be generated for situations such as unauthorized personnel entering restricted areas, improper use of equipment, or deviations from established safety protocols. By receiving timely notifications, operators can take immediate action to prevent accidents, initiate emergency protocols, or provide necessary interventions to ensure worker safety.

Furthermore, visual monitoring systems can be integrated with other safety measures and emergency response systems. For instance, they can be connected to alarm systems, emergency shutdown mechanisms, or automated safety protocols. In the event of a hazardous situation, visual monitoring systems can trigger appropriate responses, such as activating emergency stop mechanisms, initiating evacuation procedures, or alerting designated personnel. This integration enhances the overall safety infrastructure and enables swift and effective responses to critical incidents.

In addition to real-time monitoring, visual monitoring systems also offer the advantage of data logging and analysis. These systems capture and store visual data from critical processes, allowing for post-incident analysis and identification of potential safety improvements. By reviewing recorded footage, manufacturers can assess safety procedures, identify recurring hazards, and implement corrective measures. This data-driven approach to safety management enables continuous improvement and the development of proactive safety strategies.

Overall, visual monitoring systems serve as indispensable tools in ensuring safety and mitigating hazards in the fabricated metal (cans) manufacturing industry. By providing remote monitoring, real-time alerts, integration with safety measures, and data-driven insights, these systems enhance safety protocols, reduce risks associated with critical processes, and safeguard the well-being of workers. Through the effective utilization of visual monitoring systems, manufacturers can create a safer and more secure manufacturing environment, fostering a culture of safety and well-being within the industry.

2.5.2 Existing Visual Monitoring System in Manufacturing Industry

In today's manufacturing industry, ensuring product quality, process efficiency, and worker safety is crucial. Visual monitoring systems play a vital role in achieving these goals. By using advanced imaging technologies and computer vision algorithms, these systems capture, analyze, and interpret visual data in real-time. They provide valuable insights into production processes, helping manufacturers identify defects, streamline operations, and improve productivity. This literature review explores various existing visual monitoring systems, discussing their technologies, applications, benefits, and challenges. It aims to identify research gaps and future development opportunities in the field.

2.5.2.1 Machine Vision Systems

Machine Vision Systems are widely used in the manufacturing industry for real-time visual monitoring and inspection. These systems employ cameras, image processing, and pattern recognition to detect defects, measure dimensions, read barcodes, and verify assembly. They offer high-speed and high-precision inspection, surpassing human capabilities, and enable non-contact testing. Machine Vision Systems find applications in automotive, electronics, pharmaceuticals, food, beverage, and packaging sectors, contributing to quality assurance and process control. However, challenges exist in system configuration, lighting variations, and environmental robustness. Overall, these systems enhance productivity, ensure consistent product quality, and drive advancements in manufacturing processes.[11]

2.5.2.2 X-ray Inspection

X-ray Inspection is a visual monitoring technique extensively used in the manufacturing industry for inspecting internal structures and detecting hidden defects in various materials and products. It utilizes X-ray radiation to penetrate objects and capture detailed images that can reveal structural integrity, component placement, and potential anomalies such as cracks, voids, or foreign objects. X-ray Inspection systems are commonly employed in industries like automotive, aerospace, electronics, and food processing, where critical components or safety standards require thorough inspection. These systems enable non-destructive testing, allowing for quick and reliable detection of defects without compromising the integrity of the inspected items. However, considerations should be given to safety protocols and regulations related to radiation exposure. X-ray Inspection plays a vital role in quality control, ensuring the reliability and safety of manufactured products.[12]

2.5.2.3 Thermal Imaging Systems

Thermal Imaging Systems utilize infrared technology to detect and analyze thermal patterns emitted by objects. They identify variations in surface temperature, enabling the detection of hotspots, temperature gradients, and abnormal thermal patterns. These systems are widely used in the manufacturing industry to monitor equipment, electrical systems, and processes. They help identify overheating components, energy inefficiencies, and potential hazards. Thermal imaging systems optimize efficiency, prevent equipment failures, and enhance safety in industries like electrical power, HVAC, and mechanical engineering. They provide non-contact, non-destructive visualization of thermal information for prompt actions and maintenance.[13]

2.5.2.4 Real-Time Monitoring System

Real-time monitoring systems play a vital role in the manufacturing industry by providing continuous and immediate visual insights into production processes. These systems use a combination of sensors, cameras, and data processing technologies to capture and analyze real-time data from various points within the manufacturing environment. By monitoring parameters such as temperature, pressure, flow rates, and machine performance, real-time monitoring systems enable operators to identify deviations, anomalies, or potential issues as they occur. Real-time monitoring systems can be applied in diverse manufacturing sectors, including automotive, electronics, rubber, glass and food processing, to enhance process control, detect abnormalities, and improve overall operational performance. With the ability to provide instant feedback and actionable insights, real-time monitoring systems are essential tools in driving continuous improvement and maintaining a competitive edge in the manufacturing industry.[14]

2.5.2.5 Color Inspection System

Color inspection systems ensure accurate color quality and consistency in manufacturing. They use advanced technology to evaluate color attributes like hue, saturation, and brightness. By comparing captured color data with predefined standards, these systems detect variations, defects, or inconsistencies in real-time. They are widely used in industries that require precise color matching, such as automotive, textile, cosmetics, and printing. Color inspection systems improve efficiency, reduce errors, and streamline production processes. They enhance product aesthetics, customer satisfaction, and manufacturing excellence. Color inspection systems are essential tools for maintaining high-quality color standards, reducing waste, and ensuring consistent product appearance in various manufacturing industries.[15]

2.6 Recent Development of Visual Monitoring and Inspection System in Industrial Automation

2.6.1 A Sensor Based Monitoring System for Real-Time Quality Control: Semi-Automatic Arc Welding Case Study

This project was conducted by Reza Hamzeha, Luke Thomasa, Jan Polzera, Xun W. Xua and Holger Heinzelbaiming. Their aims are to develop a sensor-based monitoring system for real-time quality control in semi-automatic arc welding. The main objective was to create a reliable and cost-effective method to monitor and control the quality of welds, considering their critical influence on product durability and safety. The method employed heterogeneous sensor data, including voltage, current, temperature, a rotary encoder, and a CCD camera, to acquire and integrate welding data. A semi-automatic welding setup was created using a linear track and a Gas Metal Arc Welding (GMAW) power source. The team utilized a data acquisition (DAQ) module to capture welding signatures and developed dedicated software for data storage and visualization. This project offers a testbed for experimental applications and a potential quality control system for arc welding processes in manufacturing shop floors, enabling real-time monitoring, process optimization, and enhanced product quality assurance.[16] A schematic of the system is shown in figure 2.2

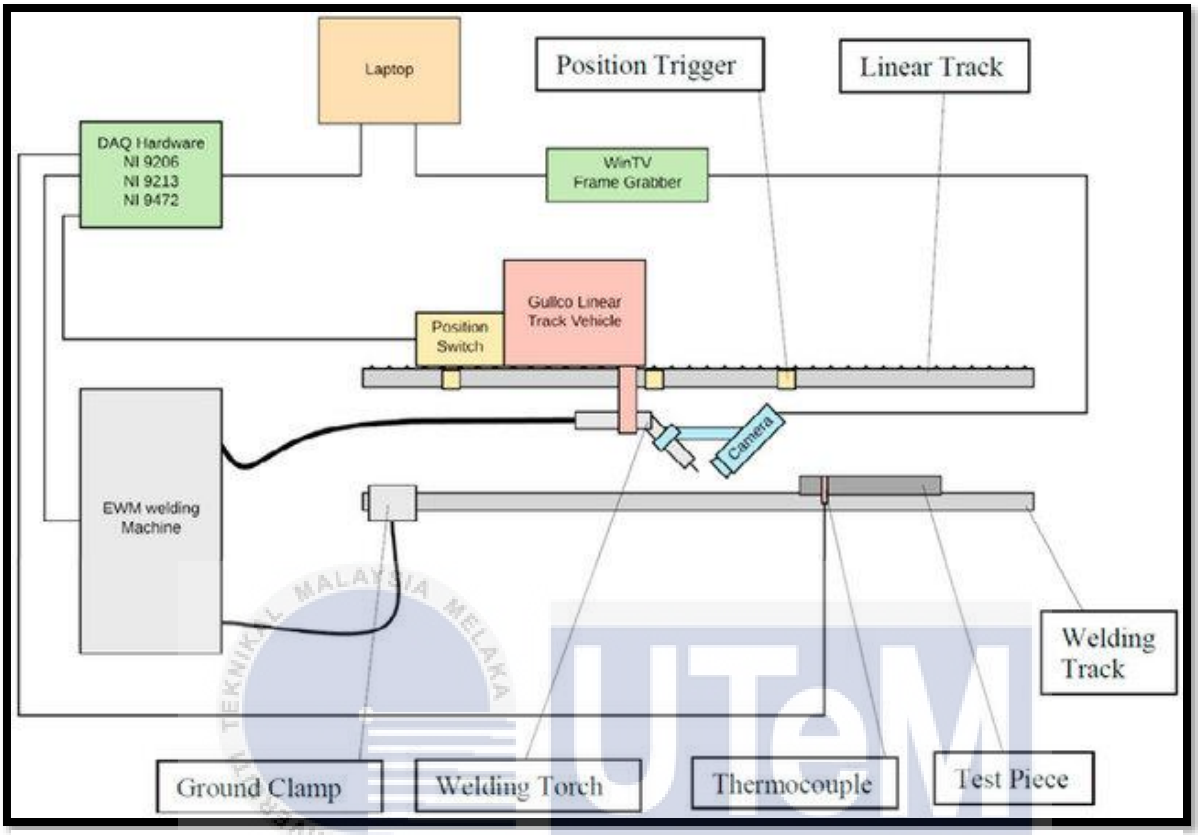


Figure 2.2 Real-Time Weld Monitoring Testbed

2.6.2 Machine vision system: A tool for quality inspection of food and agricultural products

The project described in this paper was initiated by Krishna Kumar Patel, A. Kar, S. N. Jha and M. A. Khan with their aim of addressing the challenges associated with the quality inspection of food and agricultural products. Traditional inspection methods are labor-intensive, subjective, and time-consuming, leading to inconsistencies in identifying quality factors such as appearance, flavor, nutrient content, and texture. The project sought to explore the potential of machine vision as an automated, non-destructive, and cost-effective technique for accurate and objective quality determination in food products. The objective was to provide an in-depth introduction to the machine vision system, its components, and recent research conducted on food and agricultural produce. The method employed image analysis and processing techniques to develop an inspection approach that could be applied to a range of food industry applications. This included the inspection and grading of fruits and vegetables, examination of grain quality and characteristics, and evaluation of quality parameters in various food products such as bakery items, pizza, cheese, and noodles. The project aimed to contribute to the advancement of machine vision technology in the food industry and facilitate improved quality control processes for food and agricultural produce.[17] Figure 2.3 shows the block diagram of the project.

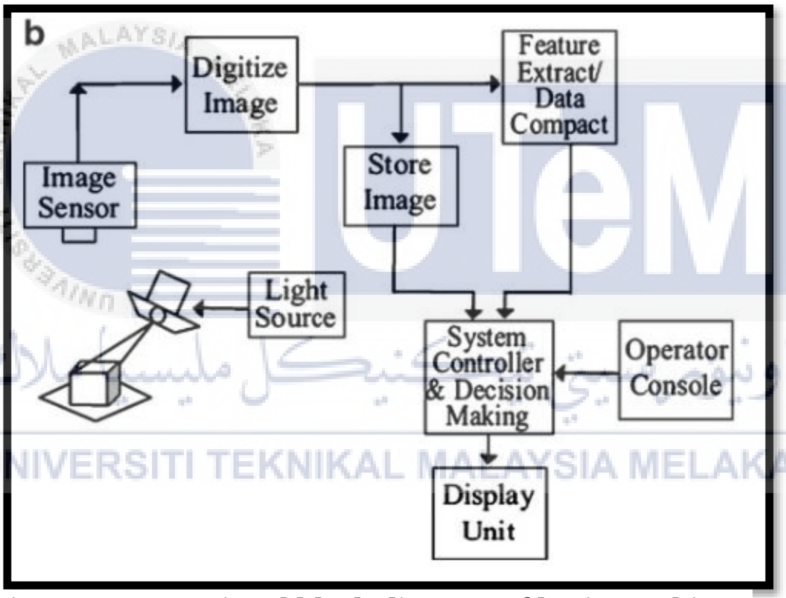


Figure 2.3 Functional block diagram of basic machine vision system

2.6.3 Real-Time Automatic Inspection System for the Classification of PCB Flux Defects

The project on "Real-Time Automatic Inspection System for the Classification of PCB Flux Defects" was conducted by Ang Teoh Ong, Aouache Mustapha, Zulkifilie Bin Ibrahim, Suzaimah Ramli and Boo Chai Eong. The objective was to improve the manufacturing quality of PCBs by accurately identifying and classifying defects in real-time. The Automatic Inspection System for Printed Circuit Boards (AIS-PCB) was developed as a comprehensive automation control system, consisting of a vision inspection station, mechanical loader and unloader, final decision station, and pneumatic system handler. The system utilized segmentation techniques and the Radon transform for feature indexing and line detection based on the gradient field of PCB images. The Feed-Forward Back-Propagation (FFBP) model was employed for classifying the product quality of PCBs using a learning concept. The system underwent training using the FFBP to learn and match the targets, utilizing images of different PCB classes as inputs to the classification module. [18] Figure 2.4, which represents a detailed scheme for the proposed AIS-PCB system in this research.

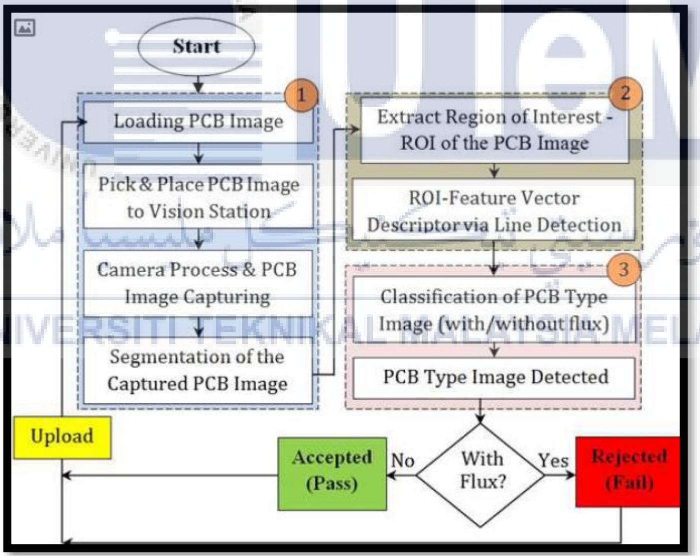


Figure 2.4 Vision Inspection System for Pharmaceuticals

The project on "Vision Inspection System for Pharmaceuticals" was carried out with the objective of developing a low-cost automatic inspection system for quality monitoring of pharmaceutical products on a production line. The project was initiated by N. M. Duong, M. T. Chew, S. Demidenko, Q. H. Pham, D. K. Pham, M. Ooi and Y. C. Kuang. The primary aim of the system was to detect multiple defects of various types in pharmaceutical products.

The method employed was based on utilizing the capabilities of the smart camera to capture high-resolution images of the products as they moved along the production line. The LabVIEW software was programmed to analyze the captured images and apply image processing techniques to identify and classify defects, such as cracks, chips, and variations in shape or color. The system enabled real-time monitoring and automated quality control, enhancing efficiency and reducing the need for manual inspections. The project creators aimed to provide a cost-effective solution for pharmaceutical manufacturers to ensure product quality and comply with industry standards.[19] Figure 2.5 shows that image of the object-under-investigation is reflected up the camera.

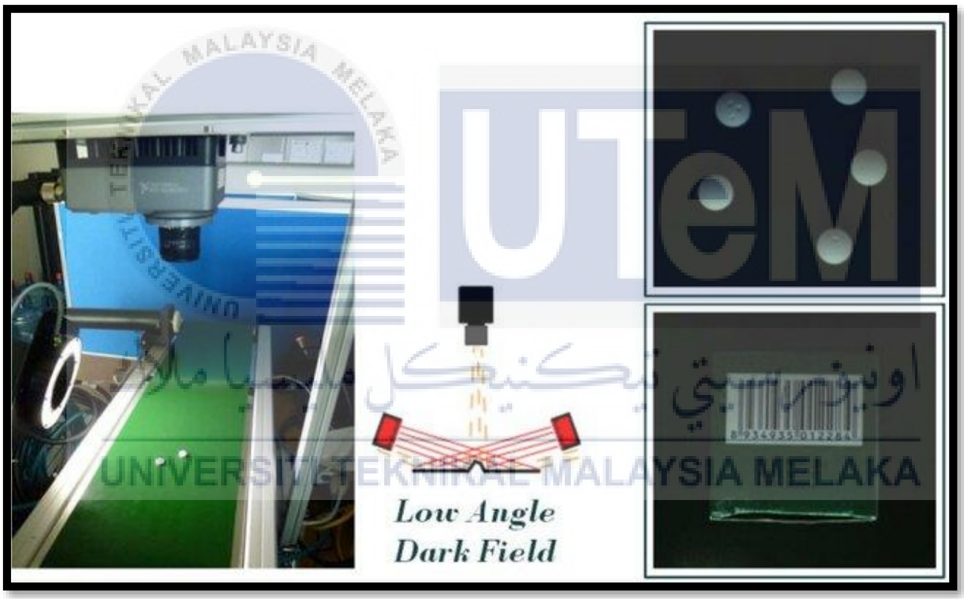


Figure 2.5 Low angle dark field illumination

2.6.4 Design and Development of Object Recognition and Sorting Robot for Material Handling in Packaging and Logistic Industries

The project on "Design and Development of Object Recognition and Sorting Robot for Material Handling in Packaging and Logistic Industries" was undertaken by Vindhya Devalla, Dr. Rajesh Singh, Amit Kumar Mondal and Vivek Kaundal. The objective of the project was to design a robot system capable of recognizing and sorting objects based on their color in order to facilitate material handling in the packaging and logistics industry. The researcher utilized a camera mounted on the robot or within the workspace to capture images of the objects. The color feature was used as the primary means of distinguishing between objects and facilitating their sorting, recognition, and tracking. The project focused on developing the 'Objrec' algorithm written in MATLAB to perform the object recognition task. The algorithm was executed to identify the objects and transmit the appropriate commands via serial communication to a microcontroller. These commands enabled the robot to carry out the sorting operation based on the recognized objects. The project aimed to provide an automated solution for efficient material handling, particularly in scenarios where objects move along a conveyor belt and need to be separated based on their color. The creators combined image processing techniques, algorithm development, and microcontroller programming to achieve the desired object recognition and sorting functionality in the robot system.[20] Figure 2.6 show the block diagram of this research.

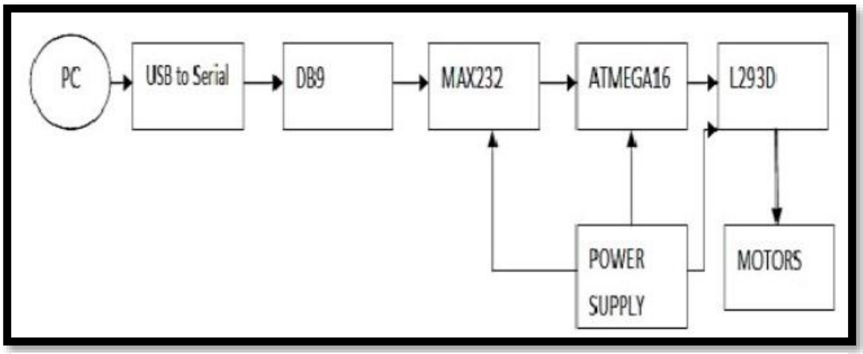


Figure 2.6 The block diagram

2.6.5 Comparison Between Different Methods Used by Previous Researchers

Table 2.2 below shows a comparison between different methods used by previous researchers. Only five most related journals are explained individually, the rest are shown in Table 2.2 to make a comparison with other research's projects.

Table 2.2 The comparison of previous research

No	Author	Year	Title	Method	Advantages	Disadvantages
1	Reza Hamzeha, Luke Thomasa, Jan Polzera, Xun W. Xua and Holger Heinzelbaiming	2020	A sensor-based monitoring system for real-time quality control: semi-automatic arc welding case study	Utilizing multiple sensors such as a rotary encoder, and a CCD camera to collect data during welding processes	Real-time Monitoring Enhanced Quality Control Cost-Effective Data Acquisition and Integration	Initial Investment Complexity Potential Technical Issues

No	Author	Year	Title	Method	Advantages	Disadvantages
2	Krishna Kumar Patel, A. Kar, S. N. Jha and M. A. Khan	2012	Machine vision system: A tool for quality inspection of food and agricultural products	Analysis and processing techniques to develop an inspection approach that could be applied to a range of food industry	Automated Inspection Cost-Effective Objective and Consistent Results	Technical Complexity Potential Equipment Malfunctions
3	Ang Teoh Ong, Aouache Mustapha, Zulkifilie Bin Ibrahim, Suzaimah Ramli and Boo Chai Eong	2015	Real-Time Automatic Inspection System for the Classification of PCB Flux Defects	Utilized segmentation techniques and the Radon transform for feature indexing and line detection based on the gradient field of PCB images	Improved PCB Manufacturing Quality Real-Time Defect Identification	Potential Equipment Malfunctions Technical Complexity
4	N. M. Duong, M. T. Chew, S. Demidenko, Q. H. Pham, D. K. Pham, M. Ooi and Y. C. Kuang	2014	Vision Inspection System for Pharmaceuticals	Utilizing the capabilities of the smart camera to capture high-resolution images of the products as they moved along the production line	Automated Quality Monitoring Detection of Multiple Defects Real-Time Inspection	Requirement for Maintenance and Updates Training and Familiarization with the System Integration with Existing Production Line

No	Author	Year	Title	Method	Advantages	Disadvantages
5	Vindhya Devalla, Dr. Rajesh Singh, Amit Kumar Mondal and Vivek Kaundal	2012	Design and Development of Object Recognition and Sorting Robot for Material Handling in Packaging and Logistic Industries	Utilized a camera mounted on the robot or within the workspace to capture images of the objects. The color feature was used as the primary means of distinguishing between objects and facilitating their sorting, recognition and tracking	Automated Material Handling Enhanced Logistics Operations Reduction in Manual Labor	Technical Challenges in Algorithm Development Maintenance and Upkeep Requirements
6	Anamaria Dogar	2010	Integrating 3D quality control function into an automated visual inspection system for manufacturing industry[21]	Image Processing System Laser Scanner Probe DOF. Robot-Mounted Laser Scanning Device	Standard visual inspection Efficient solution Real-time measurements Integrates a 6 DOF. robot-mounted laser scanning device, providing a 3D solution	The system may require regular maintenance The system may be complex to implement
7	Nof Yasir, Shahzad Anwar and Muhammad Tahir Khan	2022	Machine Vision based Intelligent Breast Cancer Detection [22]	Developed a modified version of the YOLOv5 object detection model specifically for breast cancer detection.	An efficient solution for real-time measurement tasks Standard visual inspection tasks using a 2D vision system	Higher upfront costs. The system may be complex to maintain.

No	Author	Year	Title	Method	Advantages	Disadvantages
8	Erlangga Bayu Setyawan, Ajeng Yunita, Satriana Rasmaydiwa Sekarjatiningrum	2022	Development of Automatic Real Time Inventory Monitoring System using RFID Technology in Warehouse.[23]	Model the initial business process simulation that has been verified and validated. Overview the layout of the RFID system mechanism	RFID technology enables real-time monitoring and improving processing speed. Reducing errors and improving accuracy.	Require upfront investment Require technical expertise RFID systems can raise concerns about data security and privacy
9	Chuyuan Wei and Yongzhen Li	2011	Design of energy consumption monitoring and energy-saving management system of intelligent building based on the Internet of things.[24]	Form with a serial of technique measures for buildings with energy management systems running implementation and intelligent monitoring	Increased energy efficiency and savings. Enabling timely interventions and optimization. Systems can analyze energy consumption data, providing valuable insights for identifying energy-saving opportunities and making informed decisions.	Require technical expertise and complex installation processes. Require regular maintenance and updates to ensure their continued effectiveness Require training and familiarity with the technology.
10	JackC.P. Cheng, Peter Kok-Yiu Wong, Han Luo, Mingzhu Wang and Pak Him Leung	2022	Vision-based monitoring of site safety compliance based on worker re-identification and personal protective equipment classification.[25]	Combination of worker re-identification (ReID) and personal protective equipment (PPE) classification and a deep learning-based approaches are developed for both tasks.	Enables more comprehensive analysis of worker Improved Worker ReID Accuracy. Improves the accuracy of PPE classification Providing practical insights into their performance in real-world	Requires expertise in model development, training, and deployment. Limited availability of training samples may affect the performance. Deep learning models hard to interpret and understand.

No	Author	Year	Title	Method	Advantages	Disadvantages
11	Angela A. Sodemann, Matthew P. Ross and Brett J. Borghetti	2012	A Review of Anomaly Detection in Automated Surveillance[26]	Modeling specific algorithms used for anomaly detection, including deep learning models, clustering algorithms, or other specialized techniques.	Higher accuracy in detecting anomalous behaviors compared to human-based monitoring.	Requiring expertise in multiple areas for effective implementation. Automated surveillance heavily relies on the quality and availability of sensor data.
12	Wjatscheslav Baumung and Viktor Baumung	2020	Application of Machine Learning and Vision for real-time condition monitoring and acceleration of product development cycles.[27]	Design and develop a cost-effective machine vision system using open-source software and adaptable mechanical structures.	Use of a low-cost, modular, and open-source machine vision system. Improving the long-term maintenance planning and performance of the tested objects.	Designing and developing the machine vision system require significant initial effort and resources.
13	João David Daminelli Cabral and Sidnei Alves de Araújo	2015	An intelligent vision system for detecting defects in glass products for packaging and domestic use.[28]	Computer vision system technique allow machines to interpret digital images, imitating some capabilities of the human visual system	Reducing the reliance on manual inspection and increasing efficiency. The automated system provides standardized defect detection.	Requires the setup of a conveyor belt, camera, and PC, which may involve additional costs and infrastructure considerations.
14	A. Iborra, B. Alvarez, C. Jiménez, J. M. Fernández-Merono, C. Fernández and J. Suardiaz	2000	Automated Visual Inspection system (AVI) for crankshaft production processes. [29]	Integrating multiple NDT systems, such as the Automated Visual Inspection system, Optical Roughness assessment system, and Laser	The AVI system allows for thorough and consistent inspection. Allowing for prompt detection and response to any deviations or issues.	System is designed specifically for crankshaft production processes. May require thorough testing and calibration to ensure compatibility and

No	Author	Year	Title	Method	Advantages	Disadvantages
				measurement system		accuracy.
15	Di Li, Lie-Quan Liang and Wu-Jie Zhang	2014	Defect inspection and extraction of the mobile phone cover glass based on the principal components analysis. [30]	Applies pre-processing techniques to the images of mobile phone cover glass to eliminate noise and outliers.	Eliminates the need for manual inspection. Optimizes the time required for defect recognition Versatile and suitable for a wide range of cover glass defects.	The system's performance may be affected by image quality issues. The automatic inspection system may involve initial costs for hardware, software, and training.

2.7 Visual Basic (VB.NET)

In the rapidly evolving landscape of software development, choosing the right programming language is crucial for creating efficient and robust applications. This section delves into Visual Basic .NET (VB.NET), an influential language that combines the user-friendly syntax of Visual Basic with the power and versatility of the .NET framework. This comprehensive review explores the various facets of VB.NET, highlighting its key features, benefits, and practical applications in streamlining application development processes.

VB.NET offers a wide range of features and benefits that make it a popular choice among developers. Firstly, its integration with the .NET framework provides access to a vast array of pre-built libraries, components, and tools. This extensive ecosystem simplifies the development process by offering solutions for common tasks such as database connectivity, file handling, networking, and more. Developers can leverage these resources to accelerate development time, reduce coding effort, and enhance application functionality as shown on the figure 2.7.

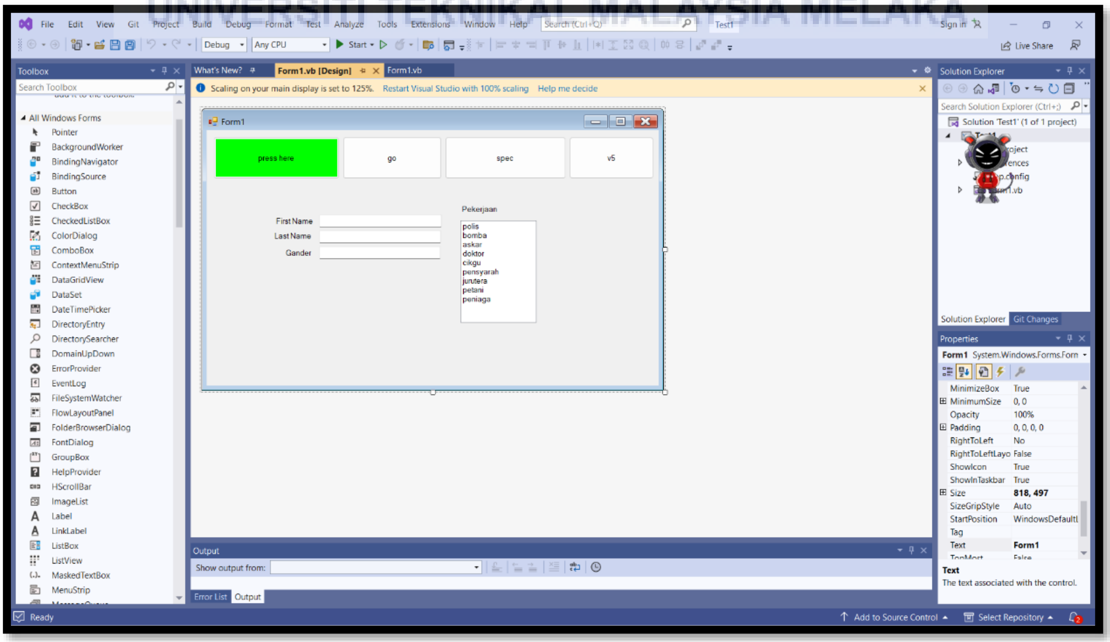


Figure 2.7 The Interface and function on VB.net

One of the key advantages of VB.NET is its support for object-oriented programming (OOP) principles. This allows developers to build modular and maintainable code, promoting code reuse, scalability, and code organization. The language supports concepts like inheritance, polymorphism, and encapsulation, enabling developers to create complex software systems with ease.

The Visual Basic .NET IDE, part of the powerful Microsoft Visual Studio suite, provides a comprehensive development environment. It offers advanced features such as code completion, debugging tools, and visual designers, empowering developers to write code efficiently and debug applications effectively. The IDE's intuitive interface and extensive toolset foster productivity and collaboration, making VB.NET an ideal choice for both individual developers and large development teams.

VB.NET boasts strong type safety, which enhances code reliability and reduces runtime errors. The compiler checks for type mismatches during the compilation phase, reducing the likelihood of runtime exceptions and improving overall application stability. Additionally, VB.NET supports multiple programming paradigms as in table 2.3, including imperative, functional, and event-driven programming, allowing developers to employ different approaches based on the requirements of their projects.

Database integration is seamless in VB.NET, thanks to its compatibility with ADO.NET and LINQ to SQL. These technologies facilitate efficient data access, manipulation, and storage, enabling developers to build applications that interact with various databases. The rich data connectivity capabilities of VB.NET empower developers to create applications that leverage the power of databases for data-driven decision-making.

Visual Basic .NET (VB.NET) offers a host of features and benefits that make it a compelling choice for efficient application development. Its integration with the .NET framework, support for OOP principles, feature-rich IDE, strong type safety, and seamless database integration contribute to streamlined development processes and high-quality software solutions. By harnessing the capabilities of VB.NET, developers can create applications with enhanced functionality, reliability, and maintainability. VB.NET continues to be a valuable tool in the hands of developers, enabling them to meet the demands of modern software development and deliver efficient solutions across a wide range of domains and platforms.[31]

Table 2.3 Comparison of Visual Basic .NET with Other Languages

Programming Language	Visual Basic .NET (VB.NET)	C#	Java	Python
Syntax	Visual Basic .NET offers a simpler and more beginner-friendly syntax.	C# has a similar syntax to VB.NET but with a slightly different style and conventions.	Java uses a C-style syntax with a strong emphasis on object-oriented programming.	Python uses a clean and readable syntax that focuses on simplicity and ease of use.
Integrated Development Environment (IDE)	VB.NET has a dedicated IDE called Microsoft Visual Studio.	C# also uses Microsoft Visual Studio as its primary IDE.	Java developers commonly use IDEs like Eclipse or IntelliJ IDEA for development.	Python offers several IDEs such as PyCharm, IDLE, and Jupyter Notebook, among others.
Windows Form Support	VB.NET has extensive built-in support for creating Windows Forms applications.	C# has the same level of support for building Windows Forms applications as VB.NET.	Java relies on third-party libraries like Swing or JavaFX for Windows Forms development.	Python provides third-party libraries like Tkinter and PyQt for creating Windows Forms applications.
Object-Oriented Programming (OOP)	VB.NET fully supports object-oriented programming concepts like inheritance, polymorphism, and encapsulation.	C# also has robust support for object-oriented programming, including the same OOP concepts as VB.NET.	Java is a language built around OOP principles and offers comprehensive support for OOP concepts.	Python supports OOP to some extent, but it has a more flexible and dynamic approach to programming.
Event Handling	VB.NET uses a built-in event handling model for managing and	C# uses a similar event handling model as VB.NET, making it easy to	Java provides an event-driven programming model with built-	Python utilizes an event-driven programming model with its own

Programming Language	Visual Basic .NET (VB.NET)	C#	Java	Python
	responding to events in Windows Forms applications.	handle events in Windows Forms applications.	in event handling mechanisms.	event handling mechanisms.
Database Integration	VB.NET seamlessly integrates with ADO.NET and LINQ for database connectivity and data access.	C# also integrates with ADO.NET and LINQ, providing the same level of database integration as VB.NET.	Java uses JDBC (Java Database Connectivity) for connecting to databases and executing SQL queries.	Python offers various database libraries such as SQLAlchemy and Django ORM for database integration.
Platform Compatibility	VB.NET is primarily targeted for Windows platforms.	C# is designed to be cross-platform with the introduction of .NET Core.	Java is known for its "write once, run anywhere" principle, making it cross-platform.	Python is highly portable and runs on multiple platforms, including Windows, macOS, and Linux.

2.8 Summary

In summary, the literature review focused on the fabricated metal (cans) manufacturing industry, its processes, and key considerations. It highlighted the hazardous and critical processes involved in different manufacturing stations, emphasizing the importance of safety measures and risk mitigation strategies. The review also explored the benefits and applications of visual monitoring systems in ensuring safety and enhancing efficiency in the industry. Additionally, the review discussed the features and capabilities of the VB.NET programming language, highlighting its relevance in developing software solutions for the fabricated metal manufacturing sector. Overall, this literature review provides valuable insights into the fabricated metal (cans) manufacturing industry, the role of visual monitoring systems, and the significance of VB.NET in addressing industry-specific challenges.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter extensively covered the project workflow, delving into the various methods employed during its execution. The aim of this chapter was to furnish thorough information and validation regarding the project's implementation. Both hardware and software played integral roles in the design and development of visual monitoring system, and these approaches were proficiently executed, yielding a suitable framework and element for the real visual monitoring and analysis using VB.net.

3.2 Societal/Global Issues & Sustainable Development in System Design and Architecture

When designing and architecting systems, it is imperative to take into account societal and global concerns, as well as principles of sustainable development. The present section is centered on the incorporation of said factors into the design and structure of the visual monitoring system, with the objective of guaranteeing its congruence with sustainability objectives.

The impact of the visual monitoring system on society and the environment is largely determined by the decisions made regarding system design and architecture. The integration of sustainable development principles during the design phase enables the optimization of resource utilization, reduction of environmental impact, and improvement of social advantages.

This section delves into the ways in which thoughtful system design and architecture can be employed to tackle societal and global issues. The analysis pertains to critical aspects such as energy efficiency, scalability, modularity, and interoperability that are imperative for the promotion of sustainable development. The objective is to develop a system that reduces its ecological footprint, fosters societal integration, and improves financial sustainability.

Additionally, the aforementioned section underscores the significance of adhering to user-centered design principles. Through the incorporation of stakeholder engagement in the design phase and the integration of their viewpoints, the visual monitoring system can be customized to effectively tackle particular societal issues and make a valuable contribution towards the attainment of sustainable development objectives.

The integration of technological innovations, such as cloud computing and data analytics, is instrumental in facilitating the development of sustainable system design. The aforementioned technologies present prospects for optimizing energy consumption, monitoring in real-time, and making decisions based on data, all of which are crucial for attaining sustainability goals.

The visual monitoring system endeavors to offer a durable and sustainable resolution for the fabricated metal industry by incorporating sustainable development principles and societal and global concerns into the system design and architecture. The discourse presented in this section pertains to the factors that must be taken into account and the suggestions that must be made in order to steer the development process towards a direction that optimizes the system's beneficial effects on society and the environment, while simultaneously tackling the difficulties that arise in the context of industrial automation.

3.3 Project Milestone

Prior to implementing the research strategy, the project milestones are established. The purpose of locating these milestones is to demonstrate how the project plan is progressing. By designating deadlines for each milestone and creating a comprehensive project plan with a flowchart, milestones also provide a method for estimating the duration of the project. Then, in Figure 3.1 the milestones are displayed in an easy-to-read flowchart.

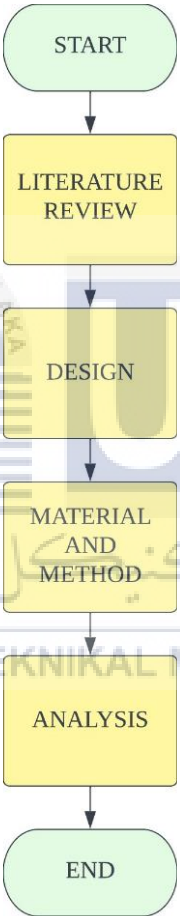


Figure 3.1 The project flowchart

3.4 Literature Review

Initially the project's objectives had been examined and discussed with supervisor. After finalising the project's objectives, the literature evaluation phase began. The purpose of the literature review is to provide a comprehensive synthesis of previous studies conducted by academic researchers or institutions. These studies have contributed significant concepts, insights, and methodologies regarding the project's component, problem-solving strategy, and analytical procedures. After approving the project's objectives, the supervisor authorised the specific scopes that would be used to accomplish these objectives. Figure 3.2 is a graphical representation of the literature review procedure.

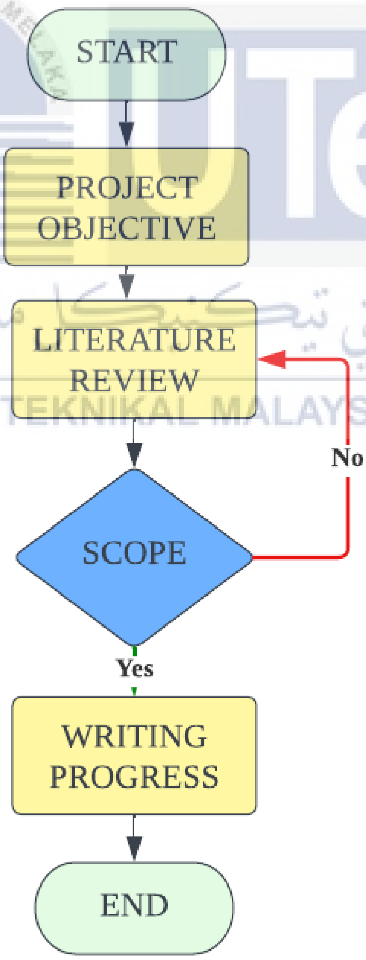


Figure 3.2 The Literature review flowchart

3.5 Designing

This section provided a comprehensive breakdown of the processes and steps that were carried out during the creation of the visual monitoring system that relied on camera detection. The creation of a real-time monitoring system for the metal manufacturing using VB.net process was the primary intention behind this project. The completion of essential steps such data collecting, installation, testing, and problem solving was essential in order to get the desired result. The development of output and interpretation of the data were both significantly aided by these techniques. The sequential steps that must be completed in order to successfully finish the project are illustrated in figure 3.3. By utilizing these methodologies, it was able to successfully construct and evaluate the suggested visual monitoring system using VB.net.

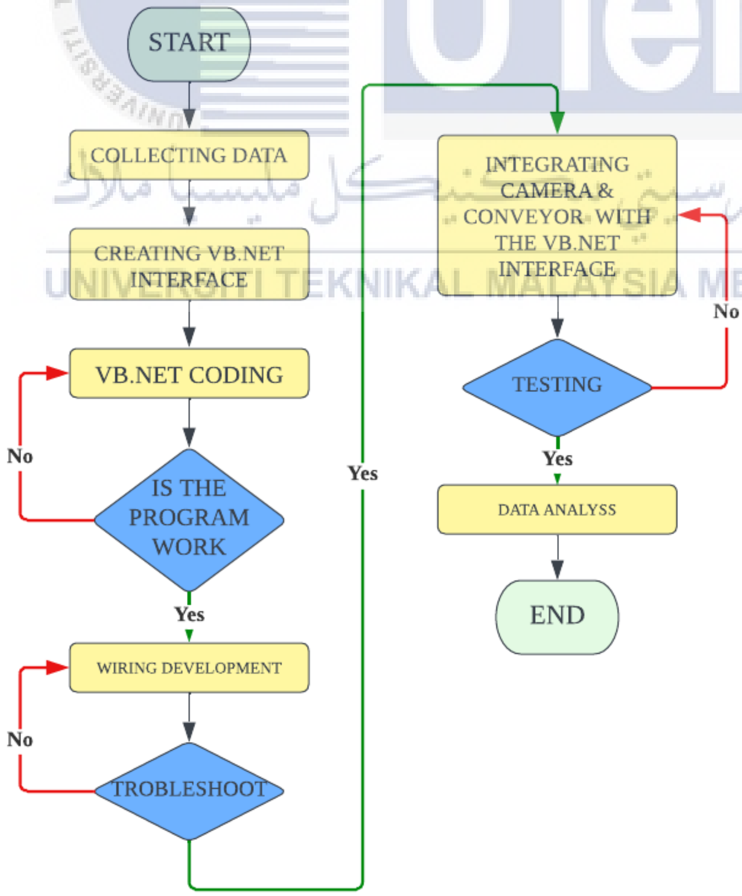


Figure 3.3 Flowchart for project designing

3.5.1 Block Diagram

Block Diagram The designed work in Figure 3.4 aims to provide a simplified and efficient visual monitoring system for the fabricated metal industry. The block diagram represents the various components and their interconnections in the system. It illustrates how data is captured, processed, and displayed in real-time, enabling effective monitoring of the fabrication process.

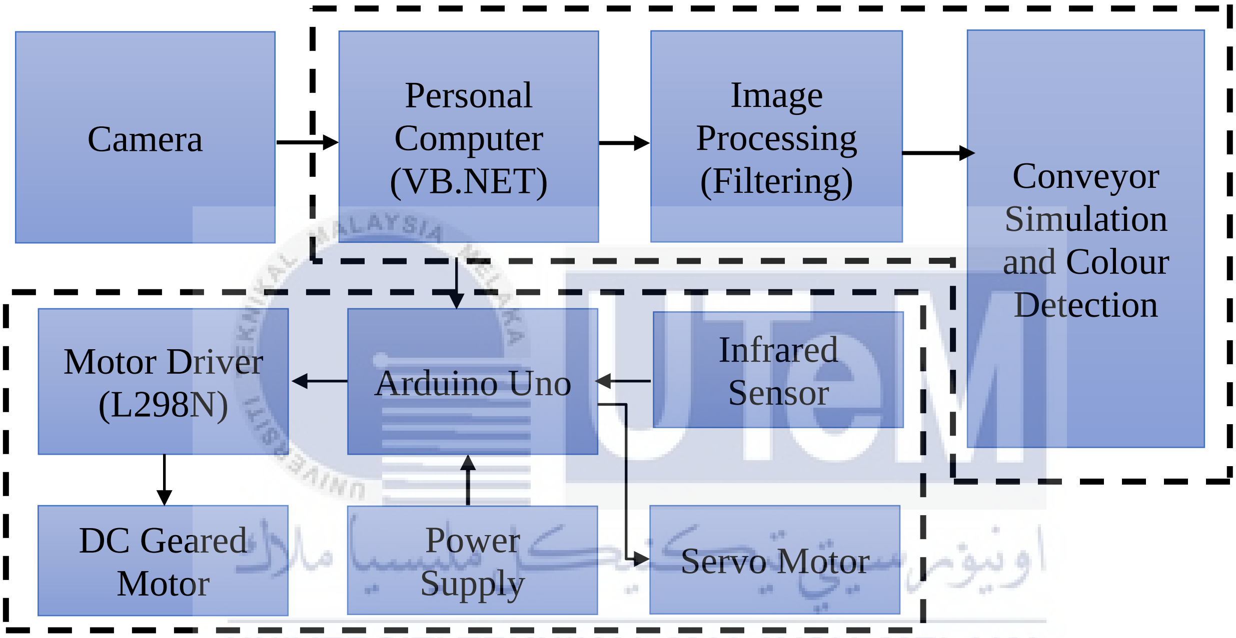


Figure 3.4 Block Diagram of The Designed Project

In this diagram, the camera is used to capture visual data of the metal fabrication process. The DIY conveyor system transports the fabricated metal components through the monitoring system. The VB.net interface serves as the central hub for processing and analysing the visual data received from the camera. It provides a user-friendly interface for monitoring and controlling the industrial automation system.

3.6 Material and Method

This section describes the materials and methods employed in the development of the visual monitoring system for the industrial automation system in the fabricated metal industry.

3.6.1 Software and Hardware

This section covers the software and hardware components used in the development of the visual monitoring system. The software development aspect focuses on VB.net programming language as the primary tool for coding and developing the system. VB.net provides a robust platform for creating user-friendly interfaces, handling data processing, and enabling seamless communication with hardware components.

3.6.1.1 Arduino Uno

The Arduino Uno is centred around the Atmega328 AVR microcontroller and is a microcontroller board developed by Arduino.cc. It incorporates key components such as 6 analogue inputs, a 16 MHz quartz crystal, 14 digital input and output connections, a USB port, a power jack, an ICSP header, and a reset button. The ATmega328P microcontroller encompasses a range of built-in features like timers, clocks, interrupts, CPU, PWM, I/O pins, and a 16MHz clock that enhances processing speed and the execution of tasks in each cycle. To program the Arduino Uno, the dedicated Integrated Development Environment (IDE) software, designed specifically for Arduino programming, can be connected to a computer via USB to transfer code. The Arduino Uno board includes all the necessary components to power the microcontroller, providing a complete package for seamless operation. The Integrated Development Environment (IDE) software, designed exclusively for Arduino programming, is used to programmed the Arduino Uno. The IDE works with Windows, MacOS X, and Linux, with Mac OS providing the most streamlined user experience. Developers may work in a comfortable coding environment by utilising the C and C++ languages to programmed the Arduino Uno. Figure 3.5 below shows its labelled diagram.

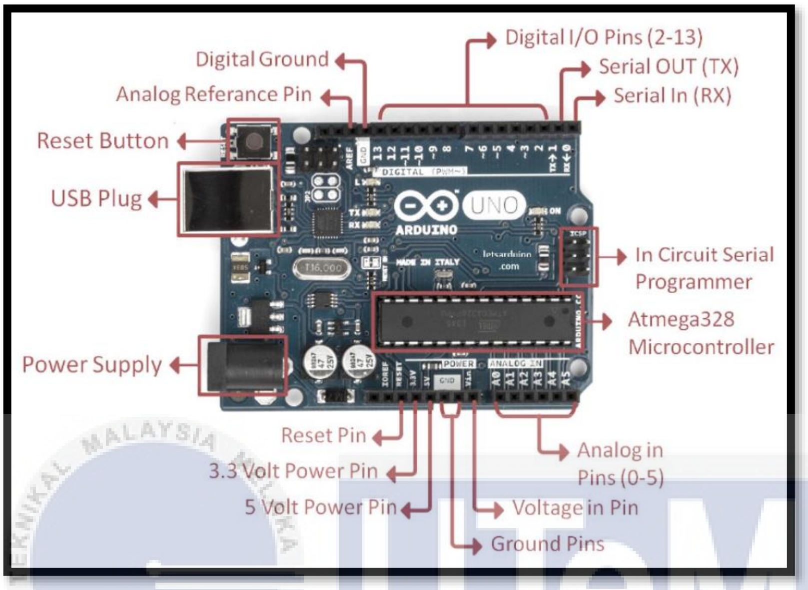


Figure 3.5 Labelled Diagram of Arduino UNO

3.6.1.2 Arduino Nano

The Arduino Nano, a small yet powerful microcontroller board created by Arduino.cc, embodies the qualities of adaptability and effectiveness in electronics. The Nano is a popular option for applications where space is important, as it has a small size of about 18.5 x 43.2 mm. Powered by an Atmel ATmega328P microprocessor, it functions smoothly on 5V USB power, supporting external power sources within defined voltage ranges. The Nano is known for its many digital and analogue input/output pins, which allow for versatile connections to a wide range of electrical components. This makes it useful for a variety of applications. By supporting communication protocols like as UART, I2C, and SPI, it effortlessly interfaces with a variety of sensors and devices. Programming the Nano is an easy task with the Arduino IDE, and its USB connection makes programming and power supply simpler. The Nano utilises flash memory for programme storage, SRAM for data, and EEPROM for non-volatile storage, ensuring efficient execution and data processing. The Arduino Nano is commonly used in a wide range of projects, from simple DIY tasks to more advanced robots. Its versatility is highlighted by its ability to work with different sensors and modules. The Nano is supported by a lively community that provides significant help through libraries and forums. This demonstrates the collaborative and accessible character of the Arduino platform, making it an essential tool for both electronics hobbyists and experts.

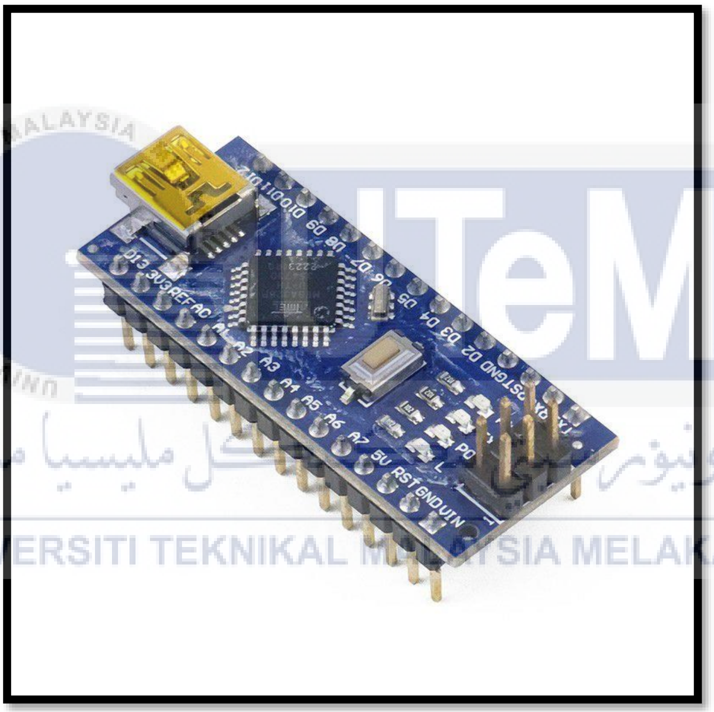


Figure 3.6 Arduino Nano Microcontroller

3.6.1.3 L298N motor driver

The L298N motor driver is a versatile integrated circuit (IC) commonly used for motor control. It is designed to drive DC motors or stepper motors with a voltage range of 5V to 35V. With two H-bridge circuits, it enables bi-directional control of two motors independently, handling continuous currents of up to 2A and peaking at 3A. The L298N module incorporates protection features like diode protection and thermal overload shutdown. It offers various control options, including direct control and PWM control for speed regulation, with separate enable inputs for individual motor activation. These features make the L298N motor driver suitable for a wide range of applications, including robotics, CNC machines, and automated systems. Its reliability, robust design, and flexibility have made it as a choice for motor driver in this project to be used to control the motor for conveyor. Figure 3.6 shows L298N motor driver IC pinout.

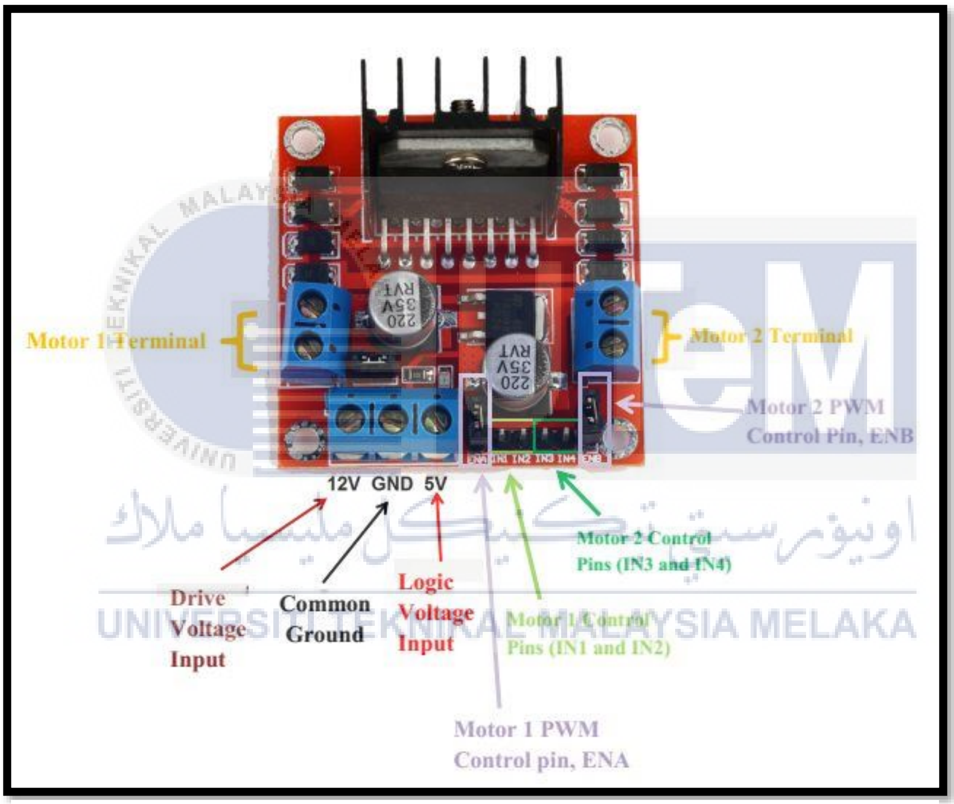


Figure 3.7 The L298N pinout

3.6.1.4 JGA25-370 DC Geared Motor

The JGA25-370 High Torque High-Speed Metal Gear DC Gear Motor in figure 3.7 is a robust and reliable motor known for its durability, high torque output, and metal gears. It operates at a rated voltage of 6V-12V DC with a rated current of 0.3A-0.5A. The motor offers a wide range of output speeds from 16 to 620 RPM, making it suitable for applications that require higher power and speed. It has a rated output torque ranging from 0.16 to 7.3 kg.cm, allowing it to handle heavy loads effectively. The motor's metal gears provide enhanced durability and strength, ensuring reliable performance even in demanding working conditions. Additionally, it features thermal protection to prevent overheating during prolonged use. Whether it's for robotics, electric vehicles, or industrial machinery, the JGA25-370 motor is an excellent choice due to its high power, speed, and reliability.

Figure 3.8 The JGA25-370 DC GEARED MOTOR

3.6.1.5 IR Infrared FC-51 Obstacle Sensor

An often used module for infrared obstacle detection in the vicinity is the IR Infrared FC-51 Obstacle Sensor. Infrared light is emitted by an infrared transmitter (IR LED), and the reflected light is detected by an infrared receiver (photodiode) in its working principle. A LOW (0) signal from the sensor indicates the existence of an obstruction within its effective range, which is typically 2 to 30 centimetres. The sensor normally provides a digital output signal. Users may tailor the detection range of some models thanks to an adjustable sensitivity potentiometer. The three pins on the sensor are labelled VCC (power supply), GND (ground), and OUT (digital output). The sensor functions between 3.3V and 5V. Proximity sensing in interactive projects, obstacle detection in robots, and object-based action triggers are common uses.

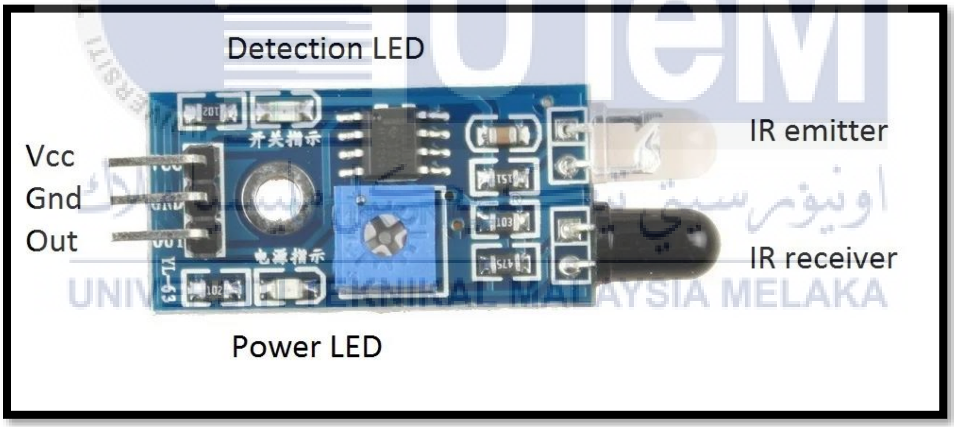


Figure 3.9 IR Sensor

3.6.1.6 SG90 9G Micro Servo Motor

The SG90 9G Micro Servo Motor is a compact and lightweight electromechanical component widely employed in electronics projects, particularly in robotics and remote-controlled systems. Operating on the principle of feedback control, this micro servo motor features a small DC motor, gears, and a feedback potentiometer for precise position control. The SG90 is renowned for its effective performance, with a torque of around 1.8 kg·cm at 4.8V and a speed of about 0.1 seconds every 60 degrees of rotation. It reacts to pulse width modulation (PWM) impulses and is intended to function within the voltage range of 4.8V to 6V. This feature enables precise control over the motor's position. With a rotation range of 0 to 180 degrees, it may be used in situations where angular movement is restricted. The SG90's lightweight design and plastic gear construction make it compatible with a wide range of microcontrollers and development boards, making it easy to include into electrical projects. Overall, the SG90 servo motor is a best choice in the making of the project due to its versatility, small form factor, and ease of integration into a wide range of projects.

Figure 3.10 SG90 Servo Motor

3.6.1.7 GY 906 BAA Infrared Thermometer

The GY-906 BAA sensor module features the MLX90614 infrared thermometer, renowned for its non-contact temperature measurement capabilities. Specifically designed to provide accurate and swift temperature readings without physical contact, the MLX90614 incorporated in the GY-906 BAA module boasts a broad measurement range spanning from -70°C to +380°C (-94°F to +716°F). Outputting temperature data in digital format, typically through communication protocols like I2C, this sensor module is known for its high precision and resolution in temperature sensing. With two sensors—one for object temperature (TO) and another for sensor temperature (TA)—the GY-906 BAA finds applications in diverse fields such as industrial temperature control, non-contact thermometers, home automation, and robotics. The module itself is a compact integration of the MLX90614 sensor with additional components, featuring pins for power supply, ground, and microcontroller communication.

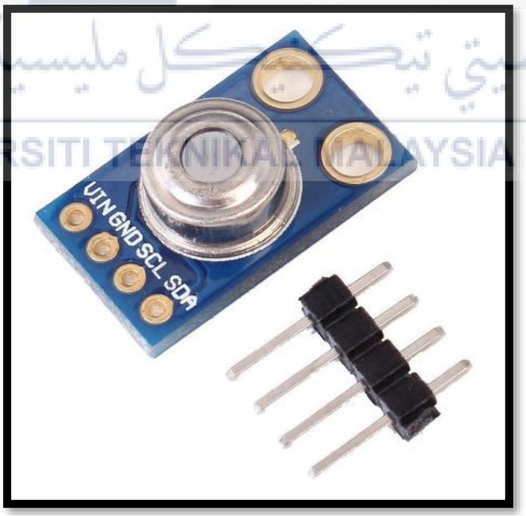


Figure 3.11 GY-906 Non-Contact Temperature Sensor

3.6.1.8 Arduino IDE

The Arduino IDE is an open-source software designed by Arduino.cc for writing, compiling, and uploading code to various Arduino modules. Since it is an official Arduino program, even those without a technical background can use it. The Java-based IDE, which works with MAC, Windows, and Linux operating systems, has built-in tools and instructions for debugging, editing, and compiling code. It is compatible with a variety of Arduino modules, including the Uno, Mega, Leonardo, and Micro, each of which has a microcontroller that runs the software. Within the IDE, code is created as a sketch and compiled into a Hex File before being uploaded to the board's controller. The IDE consists of two main components: the Editor for code writing and the Compiler for code compilation and uploading to the selected Arduino module. Supporting both C and C++ languages, the Arduino IDE offers a user-friendly environment for Arduino development. Figure 3.8 shows the the software interface.

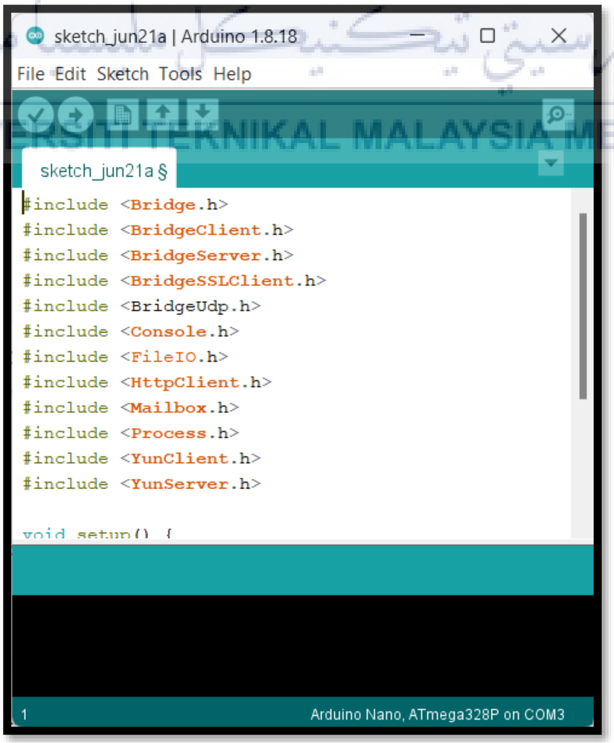


Figure 3.12 The Arduino IDE Interface

3.6.1.9 Visual Studio

The software used is a Visual Studio, it is an Integrated Development Environment (IDE) that is widely used by programmers to build all sorts of programmes, including mobile apps, web apps, and video games. Microsoft created it, and both Windows and macOS may use it. Code completion, debugging, and version control are just some of the many capabilities offered by Visual Studio, which also supports a wide variety of programming languages including C++, C#, and JavaScript. Extensions and plugins are included to further expand its capabilities. Because of its intuitive design and robust functionality, Visual Studio has widespread adoption among programmers. The programming language that used in this project is VB.net. It is one of the programming languages that are used in the Visual Studio. VB.net is simple to learn and make the new user easy to operate.

Figure 3.12 below shows an example of a function that visual basic can do. The design in the figure 3.12 comprised of picture box, button, radio button, checkbox, timer and tab control.

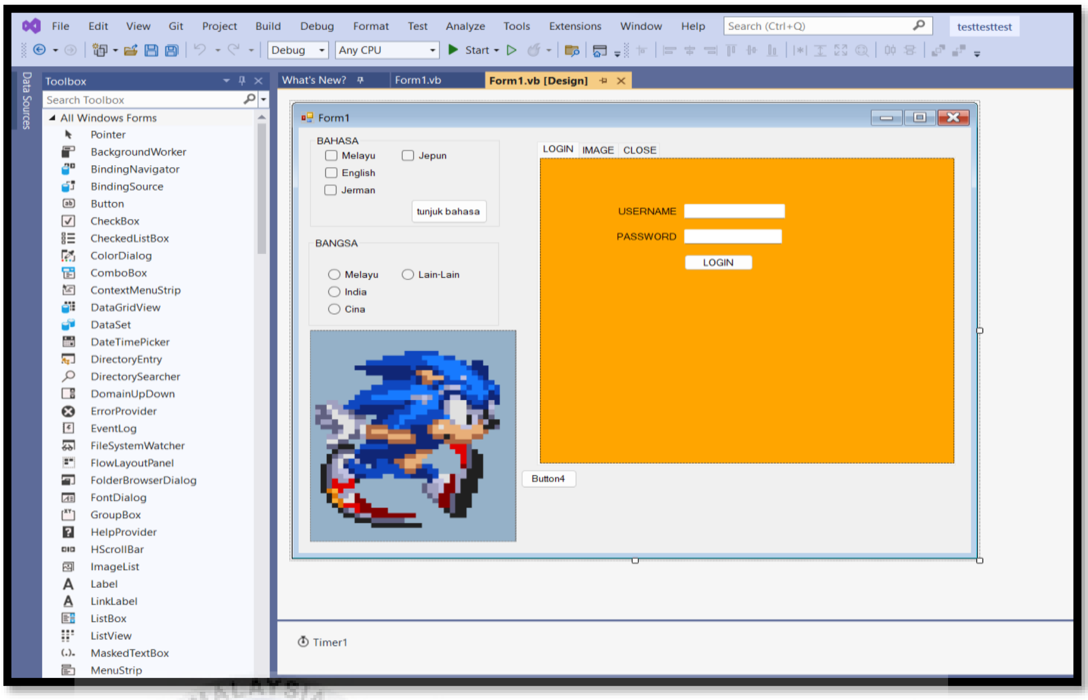


Figure 3.13 Example of VB.net Function

3.6.1.10 Wiring Connection

The project setup as shown in figure 3.14 involves utilizing an Arduino Uno to control a geared motor, functioning as a conveyor system for tin/cans. The Arduino Uno is intricately connected to four IR sensors, with IR 1 and IR 3 serving as position monitors for the tin/cans. Meanwhile, IR 2 collaborates with the camera for defect detection, and IR 4 acts as a trigger to move the servo motor. The servo motor, integral to the setup, is employed to remove defective tin/cans identified by the system. Additionally, an Arduino Nano is integrated into the system, linked to a GY-906 IR temperature sensor. This arrangement allows the system to detect and monitor the temperature of tin/cans during the fabrication process. Together, these components establish a comprehensive hardware configuration for efficient conveyor control, defect detection, and temperature monitoring in the visual monitoring system for the fabricated metal industry.

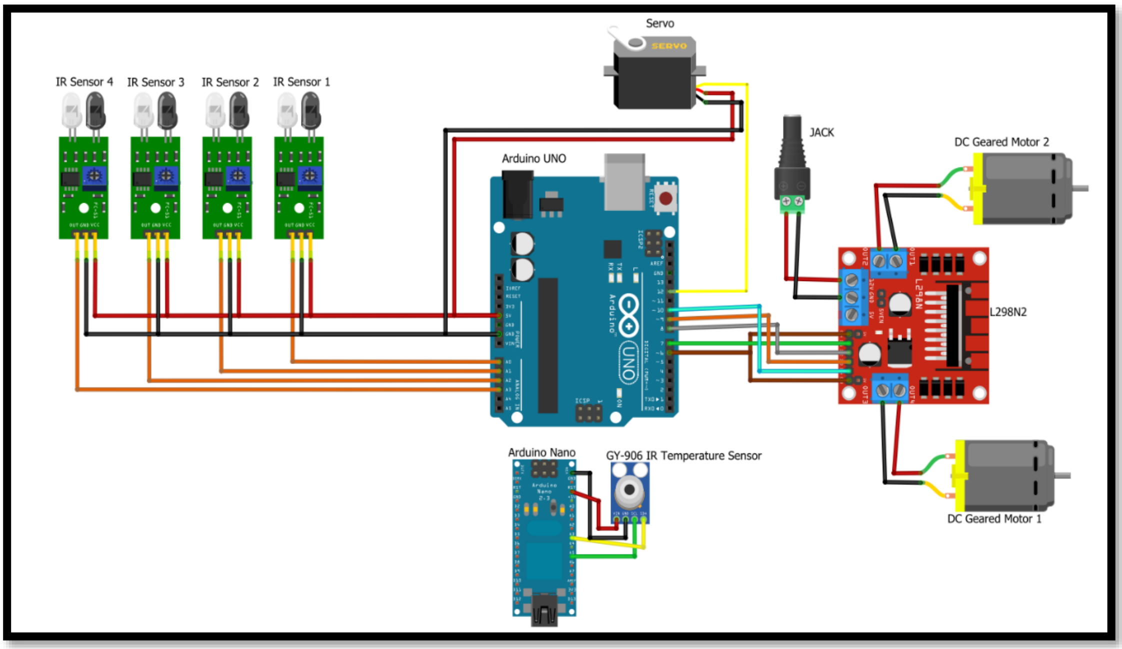


Figure 3.14 Cuircuit Connection of the project

3.6.1.11 VB.NET Animation

Animation is used to simulate the process of a conveyor line in an automation factory by depicting the movement of a workpiece from one station to another. To simulate an animation, 'Timer' would be employed, as the position of the simulated workpiece, visualised using an image object frame, would be shifted from one direction to another every second.

VB.Net provides multiple options for simulating an animation. The first is to linearly move an object, such as a Picture Box. This can be accomplished by programming the object's movement direction and the number of pixels it will move per millisecond of the interval time. This method can also be performed manually, with each button press controlling a pixel movement to a predetermined value. Figure 3.13 illustrate the box that move to the right when the start button is pressed as if it animating a conveyor and stop when the stop button is pressed.

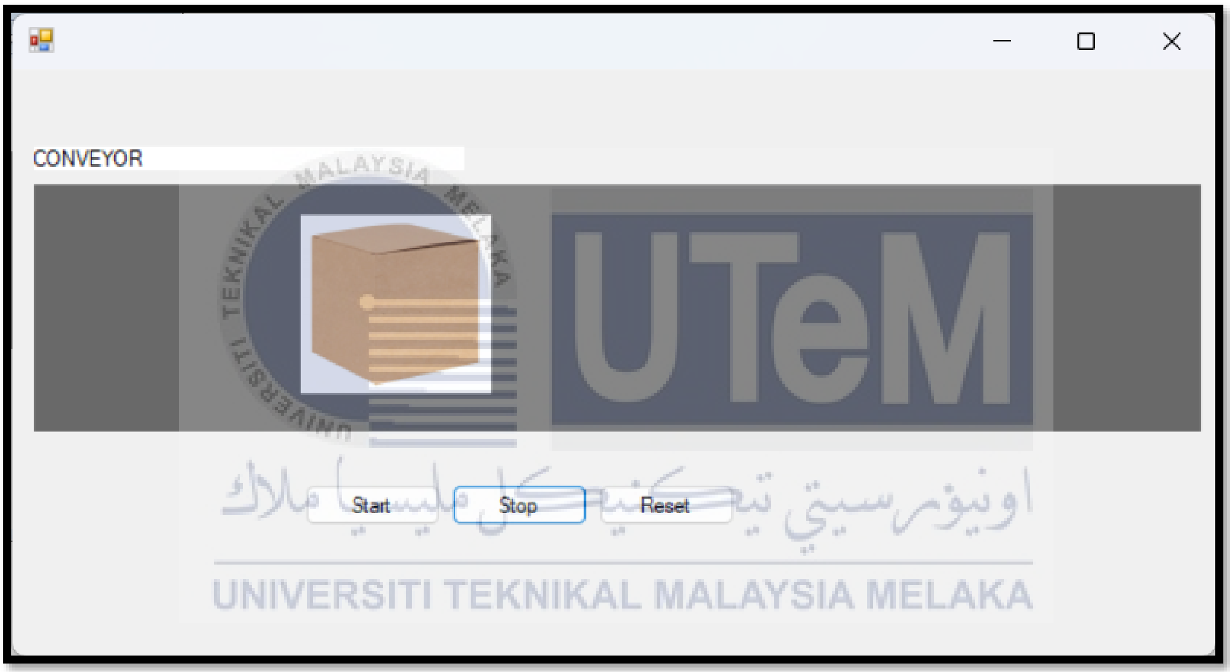


Figure 3.15 Animating the movement of object on the conveyor

By using this method, the animation would be smoother, the project would be completed using this method, despite the difficulty to change direction, as the sub-program for the animation sequence is written in a difficult-to-break ‘If’ function.

The Timer function would be utilised by animation sequences for these methods, as animation involves the movement of an object to a different position at regular intervals.

```
0 references
Private Sub Timer_Tick(sender As Object, e As EventArgs) Handles timer.Tick
    Me.pictureBox1.Left += speed

    ' Check if the box reaches the end
    If Me.pictureBox1.Right >= Me.ClientSize.Width Then
        Me.pictureBox1.Left = 20
    End If
End Sub
```

Figure 3.16 A Part of Timer Code

The figure 3.14 above show the coding section that utilize the Timer_Tick event. The Timer_Tick event handler is responsible for the movement of the PictureBox. On each tick of the Timer control, the PictureBox's Left property is incremented by the speed value, causing it to move towards the right side of the form. The code then checks if the right edge of the PictureBox has reached or exceeded the width of the form. If it has, the PictureBox's Left property is set to 20, effectively resetting its position to the left side of the form. This creates a motion effect, with the PictureBox moving from left to right and looping back to the beginning when reaching the end.

3.6.1.12 Logitech C270 HD Webcam

A dependable and small webcam that provides high-definition video and crystal-clear audio is the Logitech C270 HD Webcam. It is appropriate for a variety of applications, such as video conferencing, live streaming, and content creation, thanks to its simple setup and interoperability with many operating systems. The webcam's built-in microphone records crystal-clear audio without the use of additional devices, and it has automatic light correction and autofocus to ensure the best possible image quality. The Logitech C270 offers an affordable and convenient option for high-quality video communication and content production with added capabilities like face tracking and motion detection. So, this is the reason of the selection of this camera to detect colour. Figure 3.12 shows the webcam.

Figure 3.17 Logitech C270 HD Webcam

3.6.1.13 Camera Configuration to VB.NET

By using the Aforge.Net extension for Visual Studio, VB.net can use camera input for a variety of processing tasks, such as image recognition and motion sensing. The goal of configuring the camera input for testing purposes using the laptop webcam is to capture an image and save it to a specified directory. This will make it easy to investigate and experiment with the various Aforge.Net extension functionalities.

The established connection between the laptop's webcam and the Aforge.Net extension by configuring the camera input. This connection enables access to the webcam's video output within the application. After configuring the camera input, the output show in figure 3.16 can perform various operations on the video stream, such as capturing and processing individual frames.

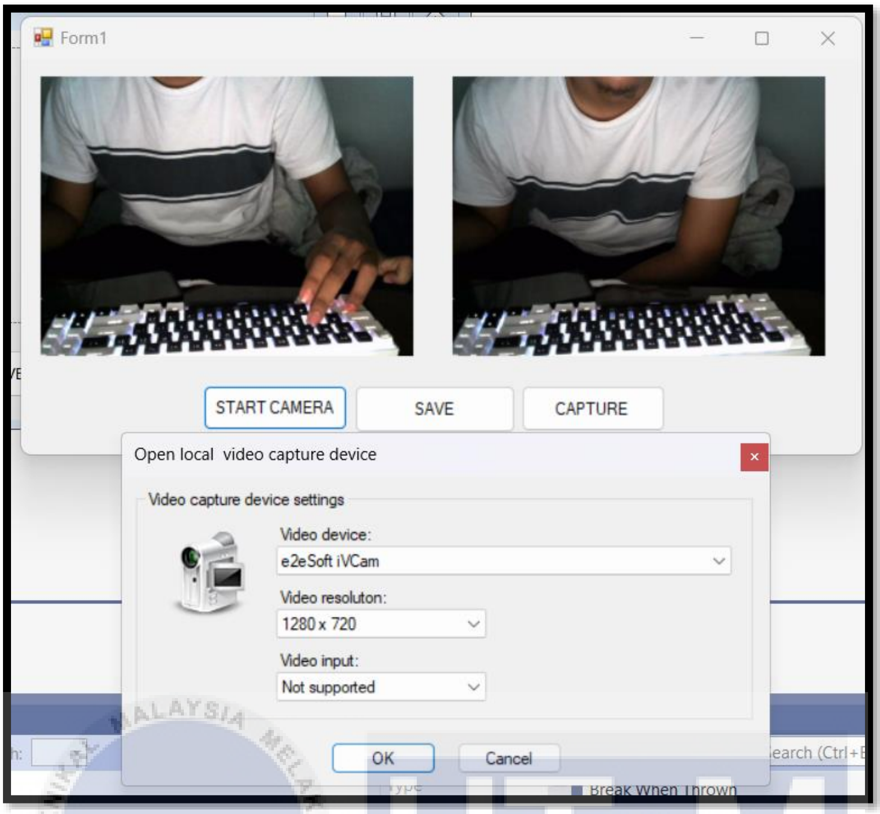


Figure 3.18 The VB.net Interface to Select Camera

For the testing, the objective is to capture a webcam image and save it to a directory. This can be accomplished by utilizing the Aforge.Net extension to implement the essential code. The code would entail capturing a frame from the video broadcast at the specified time and storing it as an image file in a specified folder on the laptop.

This configuration and image capture procedure is applicable in numerous situations. For instance, it can be used to construct a basic image recognition system by applying AI algorithms to the captured image. You could also employ motion sensing techniques by continuously analysing frames from a video stream and detecting alterations or motions. Overall, the Aforge.Net extension for Visual Studio have the capabilities to utilize laptop's webcam for a variety of applications, ranging from basic duties such as capturing images for testing purposes to more complex applications such as image recognition and motion sensing.

3.6.1.14 Colour Detection using VB.NET

The implementation of a webcam, the system can detect colours within the industrial environment. This feature is particularly useful for quality control purposes, where specific colours may indicate the presence of defects or deviations from desired standards. The colour detection algorithms developed in VB.NET allow the system to analyse the captured video feed from the webcam, identify colour patterns, and trigger appropriate actions or alerts based on the detected results. Figure 4.2 shows the expected form that had been made using Visual Studio in VB.NET.

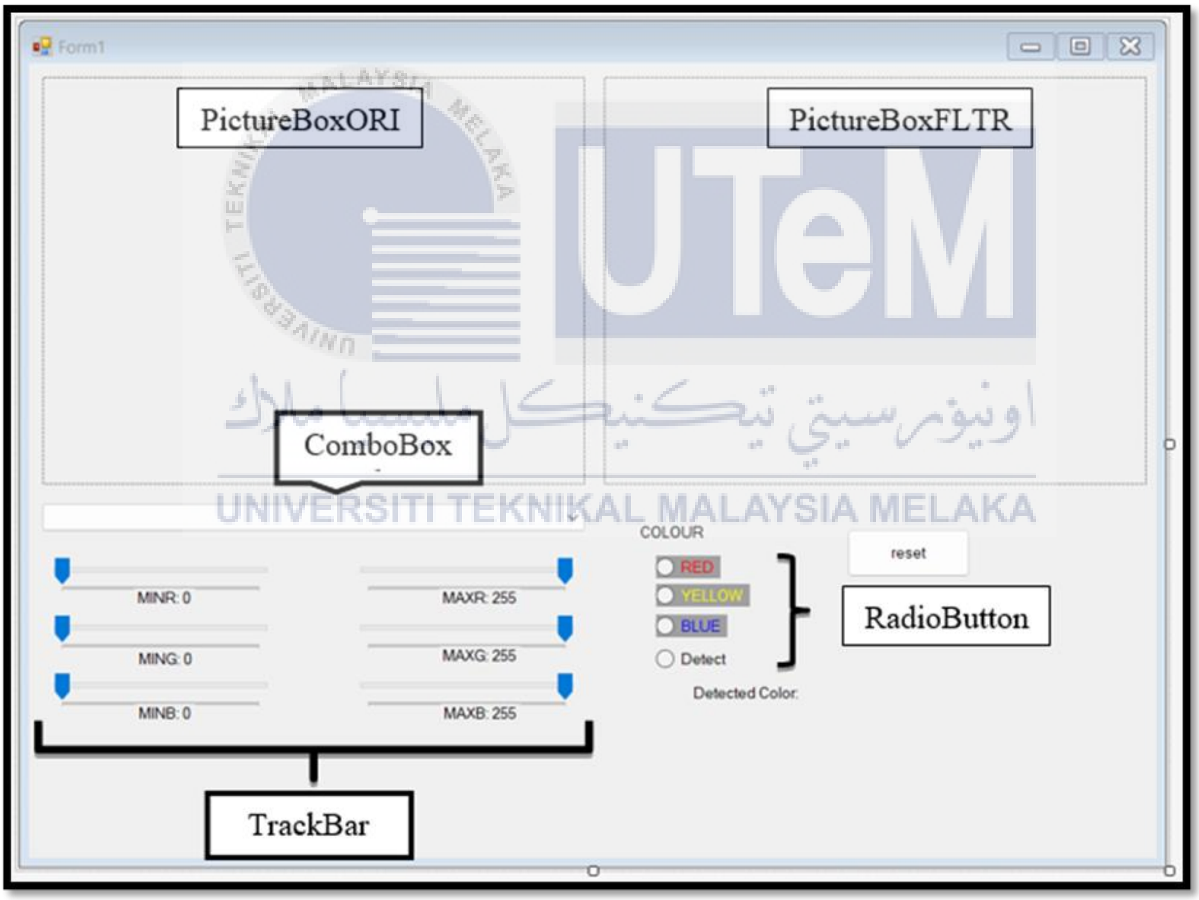


Figure 3.19 The Colour Detection Interface Design

The form design consists of various elements that facilitate the control and display of the system's functionalities. The form contains a PictureBox control named

"PictureBoxORI" and another PictureBox control named "PictureBoxFLTR." These picture boxes are used to display the original camera image and the filtered image, respectively.

There is also a ComboBox control named "ComboBox1" that allows the user to select the desired camera from a list of available cameras. The ComboBox is populated with camera names retrieved using the FilterInfoCollection.

The form includes six TrackBar controls, namely "TrackBarMINR," "TrackBarMING," "TrackBarMINB," "TrackBarMAXR," "TrackBarMAXG," and "TrackBarMAXB." These TrackBars enable the user to adjust the minimum and maximum RGB colour values for colour filtering. The current values of these TrackBars are displayed using corresponding Label controls.

Furthermore, there are three RadioButton controls, "RadioButton1," "RadioButton2," and "RadioButton3." These radio buttons provide predefined colour filtering settings for easy selection by the user. When a radio button is checked, the associated TrackBar values are automatically updated to the predefined values.

The form also includes event handlers for the TrackBar controls and radio buttons. These event handlers update the respective colour filtering values based on the user's interaction with the TrackBars or radio buttons. Overall, the form design provides a user-friendly interface for configuring and monitoring the visual detection and filtering process for colour detection.

3.7 Analysis

The analysis part developed by referring to the second objective of this project, which is to incorporate the camera sensor technology and image processing technique into the monitoring system used. The data that had been gather will be evaluated to see whether the camera can detect the colour assigned. If the system's performance is poor or did not give the desired result, it will be modified to make it able to archive the desired result. Figure 3.17 shows the flowchart of analysis process.

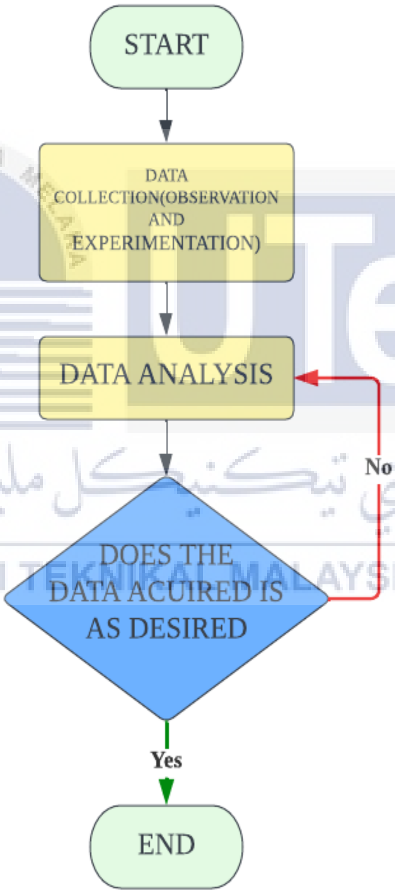


Figure 3.20 Flowchart of Analysis Process

3.8 Progress Flowchart of The System

The system flowchart depicted in the figure 3.18 shows a visual monitoring process for the fabricated metal industry. It begins with the initialization of the visual monitoring system and the activation of the conveyor system. The system captures real-time video feed from camera sensors and applies pre-processing techniques to enhance the quality of the feed. The processed images undergo image processing algorithms for error detection and object identification, including color detection for quality control. Upon detecting an error, the system alerts the operator, activate the servo to remove the defected product, and displays error count on the user interface. If no errors are detected, the system continues monitoring and updating the user interface with good product count. This loop persists until either the conveyor system or the camera is turned off, at which point the process concludes. This system flowchart enables efficient and automated monitoring, error detection, and defect handling in the fabricated metal industry, ultimately enhancing productivity and product quality.

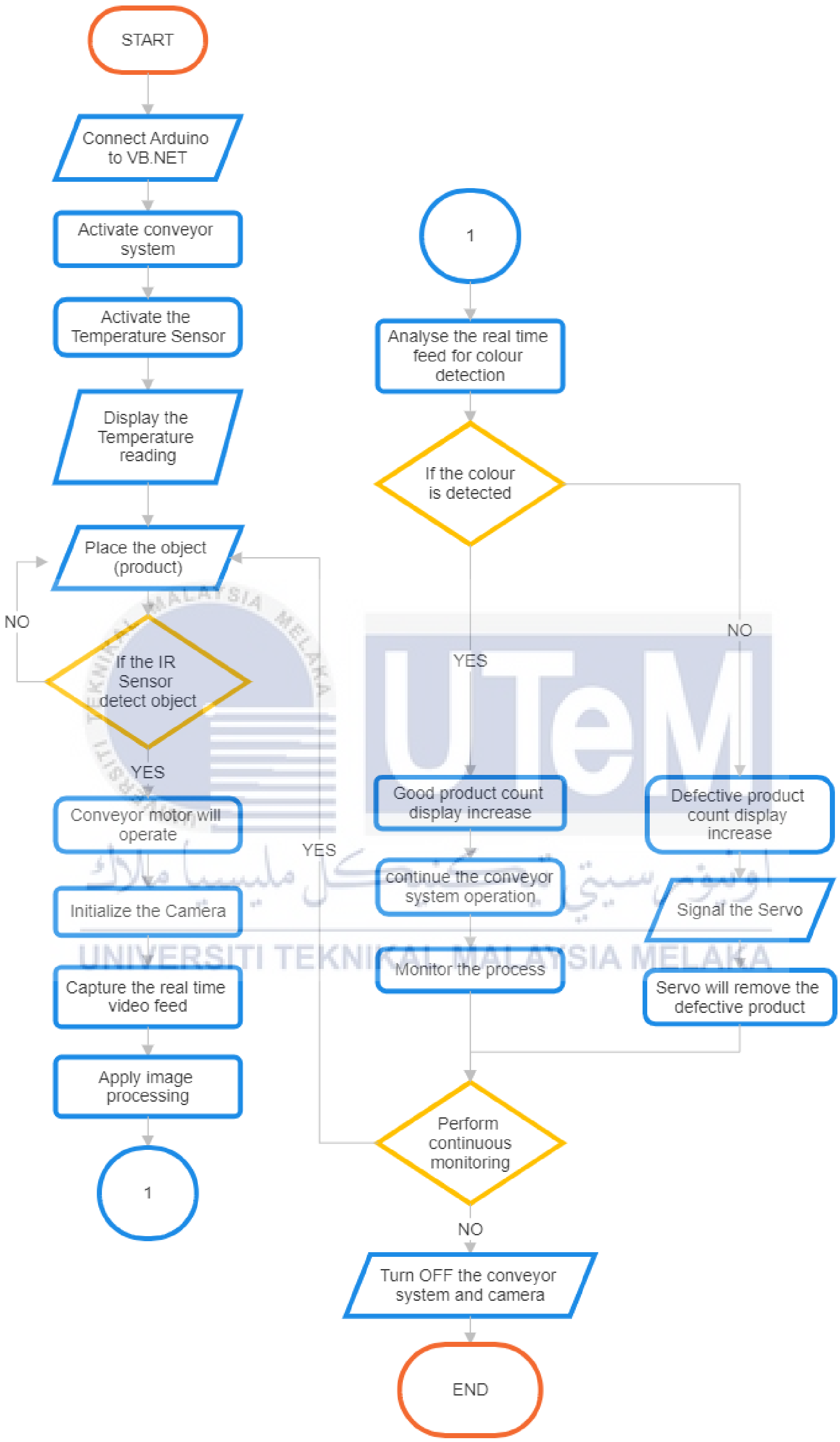


Figure 3.21 The System Flowchart

3.9 Summary

Methodology starts with an introduction, followed by the identification of project milestones and the creation of a project flowchart. The literature review phase is then discussed, highlighting the synthesis of previous studies and their contributions to the project.

The chapter proceeds with a detailed explanation of the design process. It outlines the steps undertaken in the development of the visual monitoring system using VB.net, including data collection, installation, testing, and problem-solving. A flowchart is provided to illustrate the sequential steps involved in successfully completing the project.

Next, the materials and methods used in the development of the visual monitoring system are described. The software component focuses on VB.net programming language, with Visual Studio as the primary development environment. The capabilities of Visual Studio and the simplicity of VB.net are highlighted. The usage of animation in VB.net, particularly for simulating the movement of objects on a conveyor, is also discussed. Additionally, the configuration of the camera input using Aforge.Net extension for VB.net is explained, showcasing its potential for tasks such as image recognition and motion sensing.

The chapter concludes with the analysis phase, which focuses on the integration of camera sensor technology and image processing techniques into the monitoring system. The gathered data is evaluated to assess the system's performance, and modifications are made if necessary.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

In this session, the outcomes of the implemented methodologies are demonstrated. This system integrates camera sensor technology and image processing techniques to enhance monitoring, error detection, and defect handling in real-time. The project workflow encompassed comprehensive hardware and software approaches, including the utilization of VB.net, Visual Studio, Arduino boards, and various sensors. The emphasis on societal and global issues, coupled with sustainable development principles, underscored the project's commitment to responsible technology integration.

As we delve into the results, this section aims to present a detailed examination of the system's performance. The analysis involves evaluating the camera's ability to detect assigned colors, the reliability of the error detection algorithms, and the effectiveness of the overall monitoring process. The system's response to defects, user interface functionality, and the integration of hardware components, such as the Arduino Uno, Arduino Nano, and various sensors, will also be scrutinized.

4.2 Project Hardware

4.2.1 Prototype

The project prototype underwent several phases, featuring key components such as an Arduino Uno, Arduino Nano, and a custom-designed 3D-printed circuit box to house these components. The power supply transitioned to a 12V, 2A adapter with a secure jack connection. This circuit box serves as a centralized hub for the Arduino boards and motor driver, optimizing the arrangement as in figure4.2 for efficient operation. Before activating the system, meticulous attention was given to ensuring robust connections within this customized setup.

The tailored casing, designed using SolidWorks for wire concealment and improved aesthetics, reflects the commitment to precision and reliability. In a tangible demonstration of the project's practical application, the system utilized two conveyors to move tin/cans in an L-shaped position. The setup incorporated four IR sensors, a camera, a servo motor, and a temperature sensor. This showcased the prototype's of monitoring in the manufacturing process.

Figure 4.1 Designed Casing Box

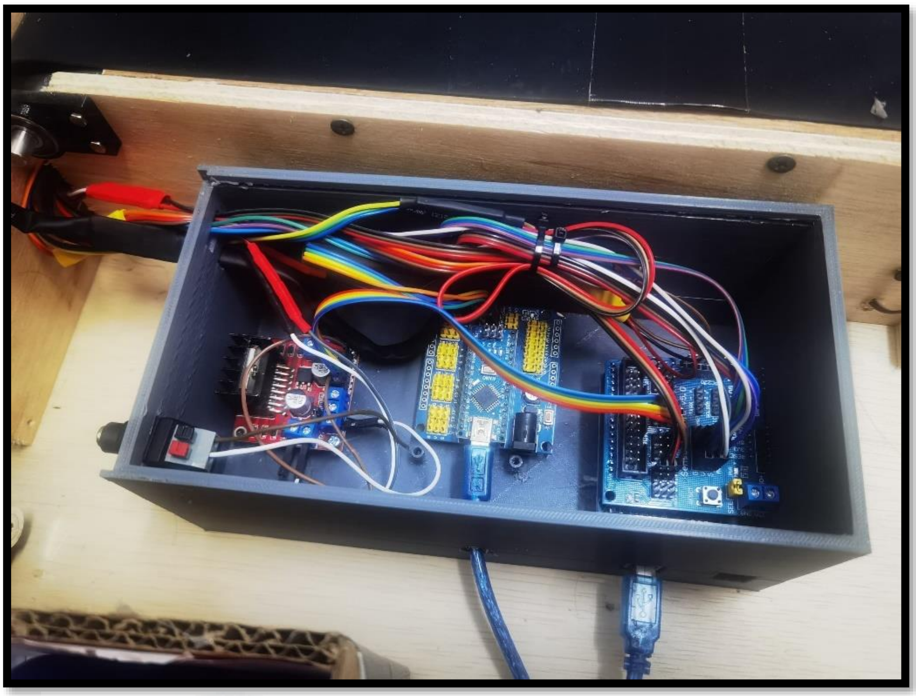


Figure 4.2 Connection Inside Circuit Box

4.2.2 Conveyor Design

The conveyor circuit design incorporates various components, including 12V DC geared motor, power supply, motor drivers, and microcontroller (Arduino Uno). These elements work together to enable precise control over the conveyor's speed, direction, and functionality. By utilizing a Arduino Uno, the circuit can execute complex instructions, monitor inputs, and respond dynamically to changes in the production environment. Figure 4.1 shows the circuit diagram of the conveyor component.

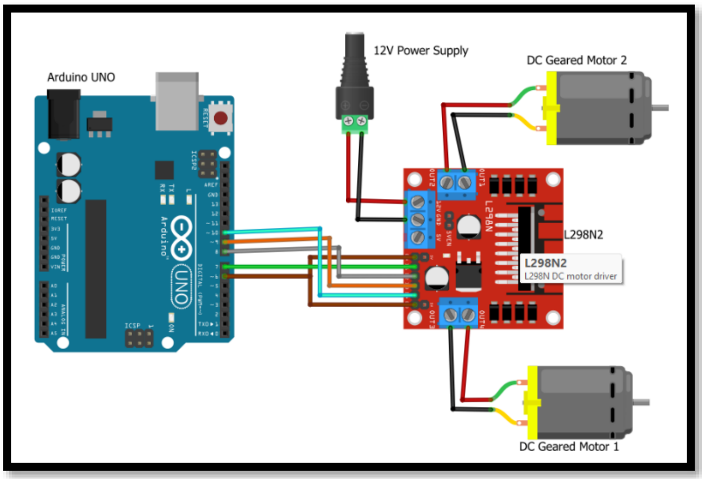


Figure 4.3 Circuit diagram for Conveyor part

In constructing the conveyor body as in the figure 4.4, a robust and practical design was employed. The body framework was crafted using plywood, measuring 40cm x 10cm, providing a sturdy and durable foundation for the conveyor system. For the conveyor rollers, 3D printed parts were utilized, ensuring precise dimensions and smooth rotation. This not only contributed to the overall structural integrity but also facilitated ease of movement for the tin/cans along the conveyor. To enhance the grip and efficiency of the conveyor, a rubber sheet was employed as the conveyor belt. This choice of material offered a reliable surface for transporting the items, minimizing slippage and ensuring a consistent and controlled flow along the conveyor system. The combination of plywood, 3D printed parts, and a rubber sheet underscored a thoughtful approach to design, promoting both functionality and reliability in the conveyor body.

Figure 4.4 The Frame of the Body Conveyor

4.2.3 VB.NET Interface

The VB.net Interface presented in the figure 4.5 encompasses a graphical user interface (GUI) designed using Windows Forms. Central to its functionality is the establishment of serial communication with an Arduino board, facilitated by the SerialPort class, enabling bidirectional data exchange. The GUI features buttons for connecting and disconnecting from the Arduino, leveraging the Arduino class through the cal object. The program reads analog values from Arduino pins, interpreting them as sensor inputs, including infrared sensors and a temperature sensor. Actuators such as motors and a servo motor respond to sensor readings, illustrating a closed-loop control system.

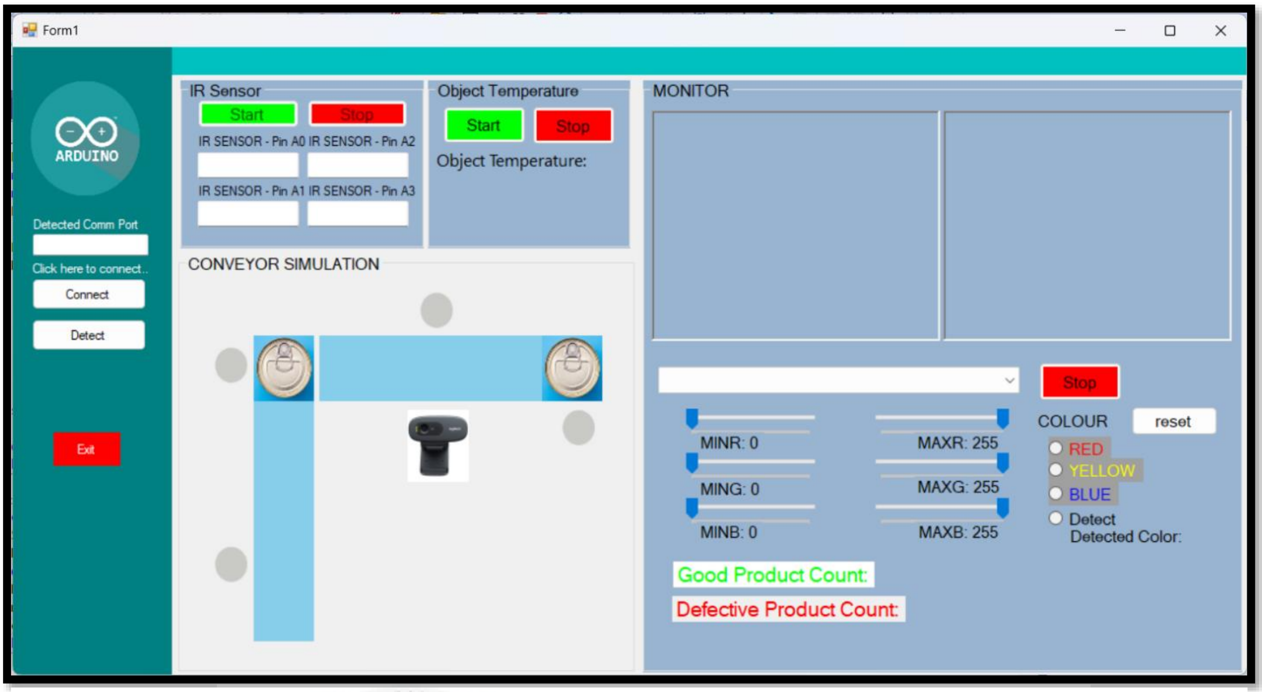
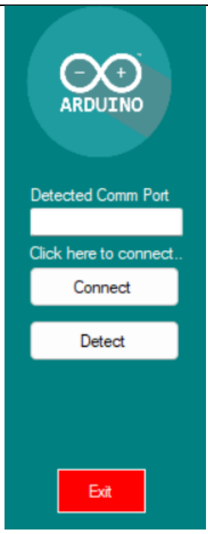
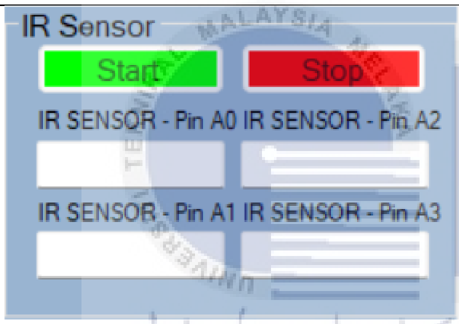
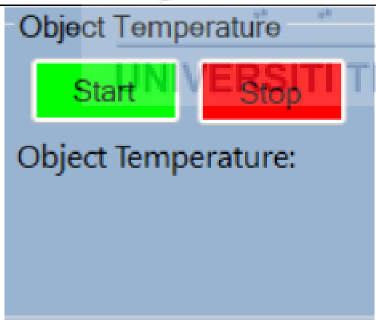
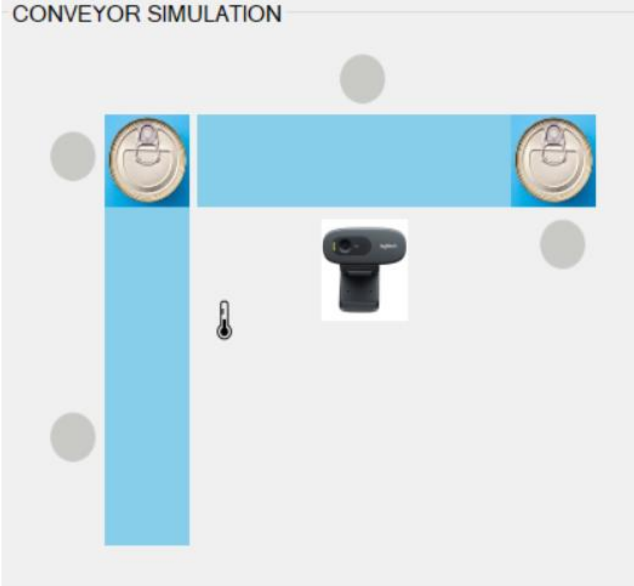
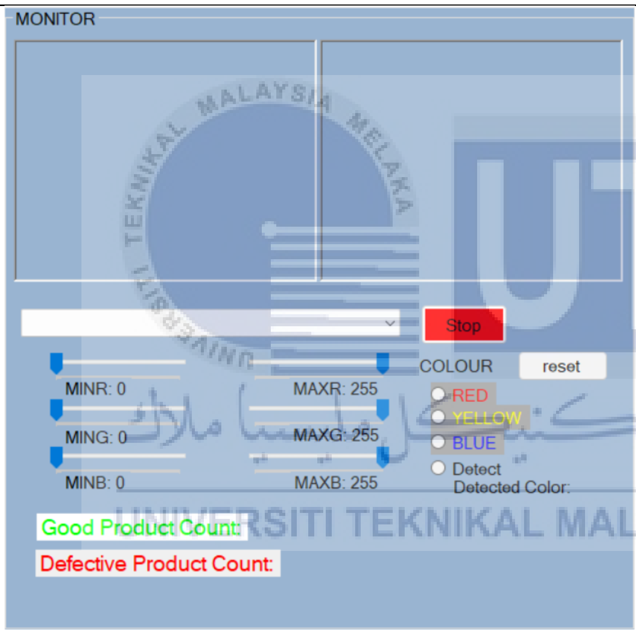


Figure 4.5 The Visual Basic Interface Design

Image processing capabilities are incorporated using the AForge.NET library, allowing the application to capture and analyze video frames from a camera. Defective product detection and counting, as well as temperature monitoring, are integral components of the program's functionality. The GUI provides user controls such as buttons for starting and stopping temperature monitoring, and radio buttons for adjusting color filter settings dynamically. Timers control the simulated movement of objects on the GUI, simulating conveyor-like motion. Additionally, proper form closing events are implemented to ensure the serial port is appropriately closed before exiting the application. The combination of these features results in a comprehensive and user-friendly application for monitoring, controlling, and analyzing data from an Arduino-based system equipped with sensors, actuators, and a camera. Table 4.1 shows the list of interface used in developing the software part of this project. Each of the interface used have their own functions in making this project a success.

Table 4.1 Interface Function

No.	Interface	Function
1		The interface funtion is to detect the COM port of available arduino port, then display the detected COM port. Conect button is to coonect to the COM port. Exit is for close the window form.
2		The START and STOP button is for operate the conveyor sytem or stop it. It also funtion to start and stop display the reading of Infrared Sensor.
3		The section is for starting or stoping the temperature sensor from operating and display the reading.

4		The interface is for the displaying the conveyor simulation. It consist of the movement of the object, ir sensor detection indicator, camera and temperature sensor indication.
5		The section is for monitoring the object colour and filtering all colour except the colour we want to set. The section also able to display all camera that are available to be use.

4.2.4 Conveyor Development

The conveyor system in this project as in figure 4.6 has undergone significant development, featuring an L-shaped design for efficient material handling. The conveyor structure is constructed with a sturdy 40cm x 10cm plywood base, and the conveyor rollers are 3D printed, ensuring precise and reliable movement. A rubber sheet serves as the conveyor belt, providing traction and smooth transportation of tin or cans along the L-shaped path. The system incorporates four IR sensors strategically positioned along the conveyor. IR sensors 1 and 3 are dedicated to monitoring the position of tin or cans, while IR sensor 2 collaborates with a camera for defect detection. IR sensor 4 acts as a trigger for the servo motor, which is utilised to remove defective tin or cans. Additionally, the conveyor system includes a Gy-906 IR temperature sensor connected to an Arduino Nano, enabling real-time temperature monitoring of the transported items. This comprehensive setup ensures precise control, effective defect detection, and temperature management throughout the conveyor process. A 3D-printed circuit box houses the Arduino Uno, Arduino Nano, motor driver, and power supply, providing a streamlined and organised configuration for seamless operation.

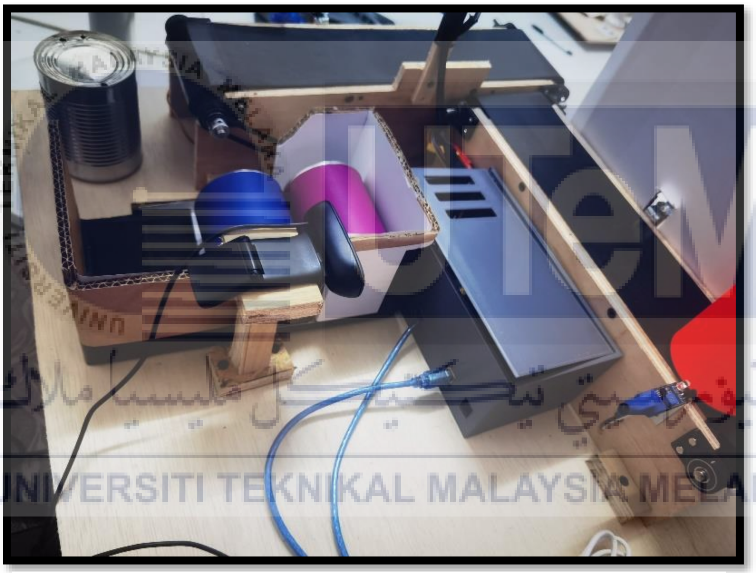


Figure 4.6 The Complete Project Assembled

4.3 Results

The result was obtained through usage of the camera to detect colour that had been set in the Visual Basic interface with the help of the infrared sensor to help the camera to differentiate between a defective product and a good product. In addition, two conveyors combined to make a L- shaped conveyor help it make more like a real monitoring in the manufacturing process manufacture although the project is just a small scale or prototype of it.

The outcome is determined by the information gathered from testing the entire project process, including whether the conveyor is activated by pressing a button, and if the conveyor moves when a can is recognised by infrared sensor 1. The next thing to consider is if the camera detects the colour we have set. If the colour of the cans does not match the predetermined colour, it will be counted as a faulty product. Next, we need to check if the sensor detects the temperature and then show it on the Visual Basic interface. This serves as an illustration for monitoring potential dangers in the product to prevent injuries caused by high temperature cans or metal objects. Lastly, we need to check if the servo is functioning well in order to remove defective cans as the number of defective products increases.

Table 4.2 The Result of the Conveyor System

No.	**Colour Setting**	**Cans Colour**	**IR Sensor 1 (Conveyor Start)**	**Colour Detected**	**Temperature (ºC)**	**Servo**
1	Orange	Orange	Yes	Yes	33 ºC	OFF
2		Reddish Purple	Yes	No	33 ºC	ON
3		Blue	Yes	No	33 ºC	ON
4	Reddish Purple	Orange	Yes	No	33 ºC	ON
5		Reddish Purple	Yes	Yes	33 ºC	OFF
6		Blue	Yes	No	33 ºC	ON
7	Blue	Orange	Yes	No	33 ºC	ON
8		Reddish Purple	Yes	No	33 ºC	ON
9		Blue	Yes	Yes	33 ºC	OFF

The extensive testing of the conveyor system produced definitive findings at different important milestones. To begin with, the system flawlessly engaged when the button was pressed, and the infrared sensor 1 accurately detected the existence of a can. The following evaluation focused on identifying colours, with the camera system successfully detecting the predetermined colours as in the figure 4.7.

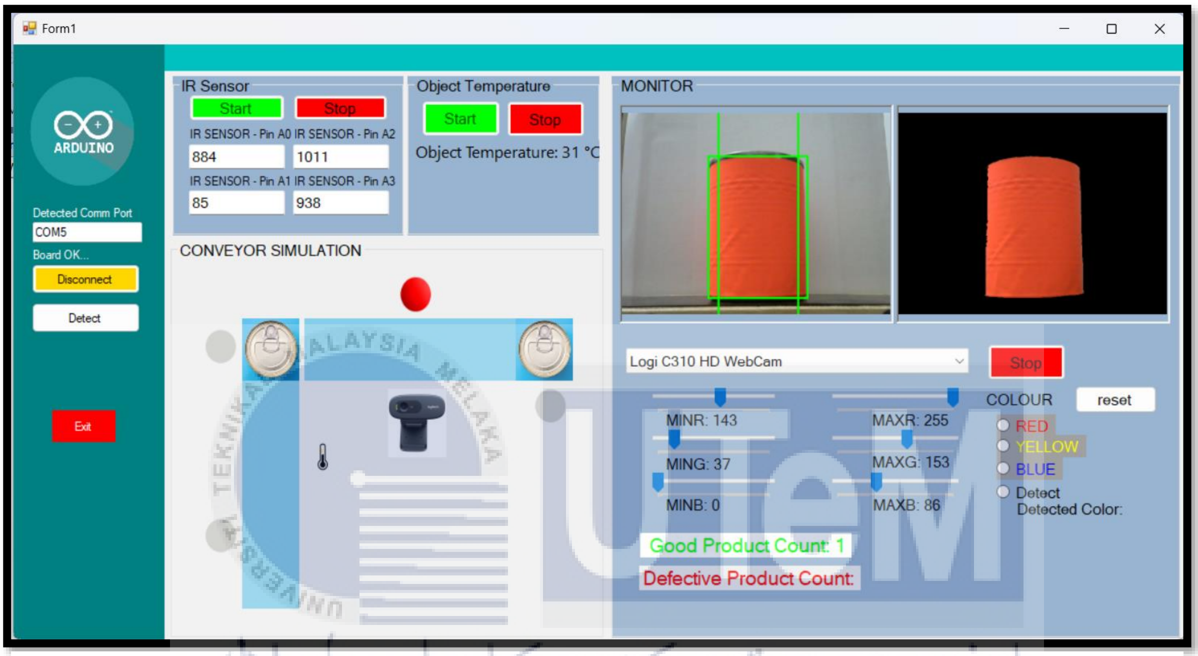


Figure 4.7 Orange Colour Detected as Good Product

Significantly, any departure from the pre-established colour led to the detection of defective items and it will be separated by the servo as shown in figure 4.8. In addition, the temperature monitoring feature was successful in obtaining useful data that was shown on the Visual Basic interface. This function acts as a precautionary step against possible dangers, especially in situations involving cans or things made of metal that are at high temperatures. At last, the servo system showed dependable performance, effectively eliminating faulty cans as their number grew.

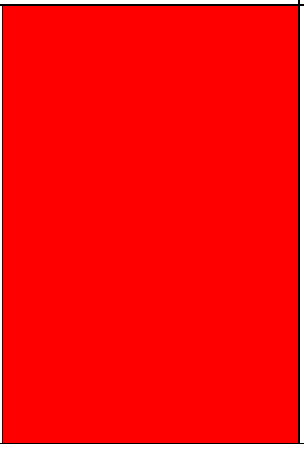
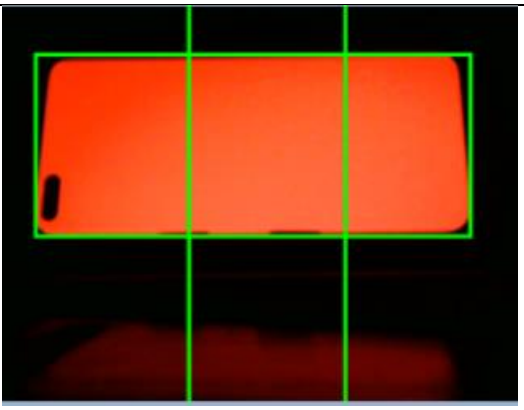
Figure 4.8 The Servo Operated to seperate the defective cans

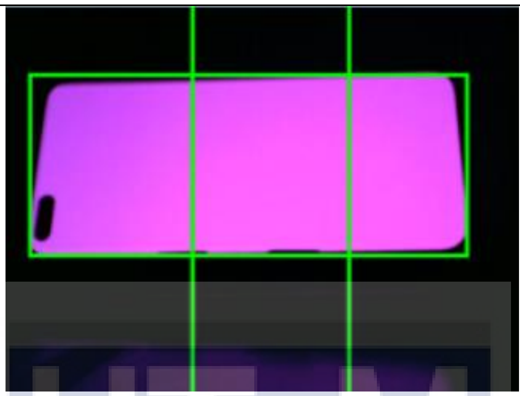
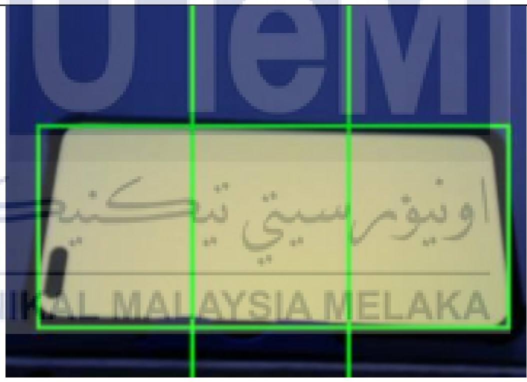
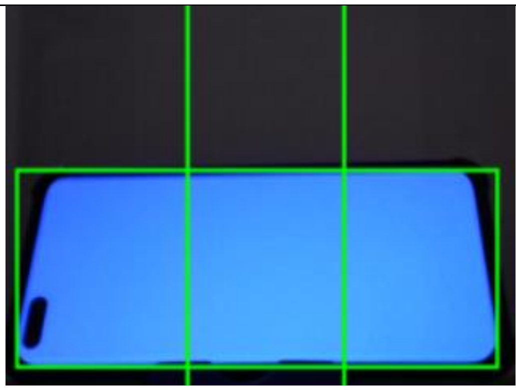
4.4 Data Analysis

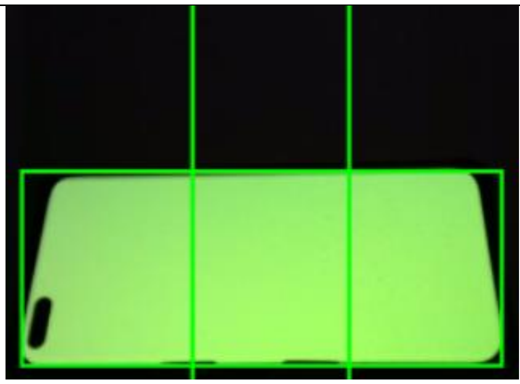
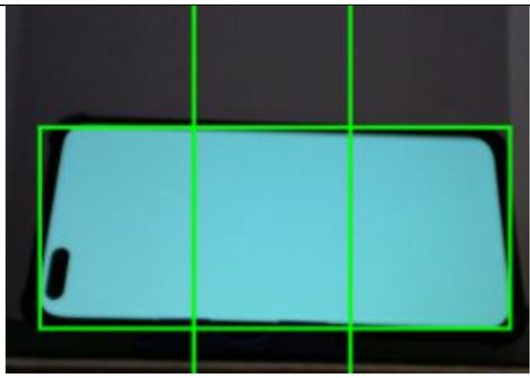
4.4.1 Colour Range

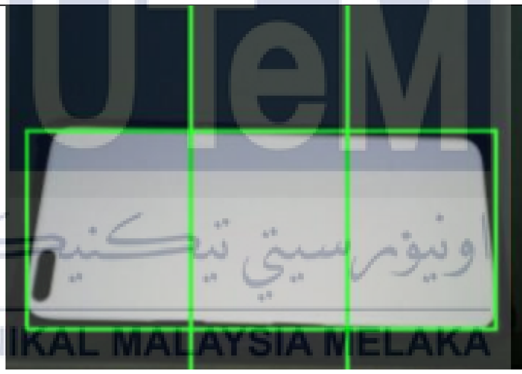
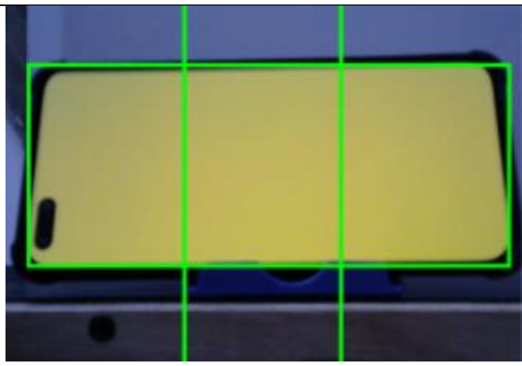
The data acquired from this analysis is to determine the range of colour for each colour that the camera and image processing able to detect. The table 4.3 below is the result of the colour that has been detected.

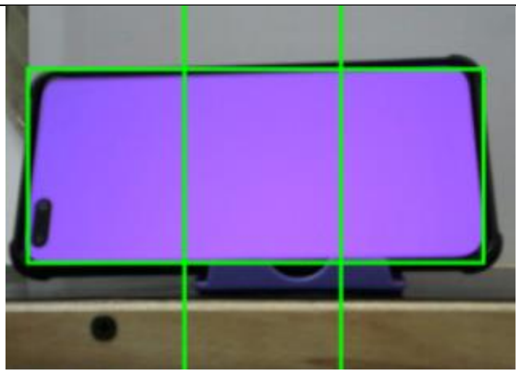
Table 4.3 The list of Colour Detected

No.	Colour		Colour Detected
1.	Red		

2	Orange		
3	Purple		
4	Yellow		
5	Blue		

6	Green		
7	Black		
8	Pink		
9	Cyan		

10	Brown		
11	Maroon		
12	Lavender		
13	Olive		

14	Indigo		
15	Coral		

4.4.2 Lighting Effect to The Colour Detection

The result for lighting effect detection aims to identify instances where the specified color is not recognized, as depicted in Figure 4.9. The color detection method incorporated into the system should be employed for this purpose. Records must be taken by the differentiate the different lighting condition that can be measured using the illuminance value. The illuminance value that are setup is 10lx, 50lx and 100lx for each colour. The data obtained in this context is organized and presented in Table 4.4.

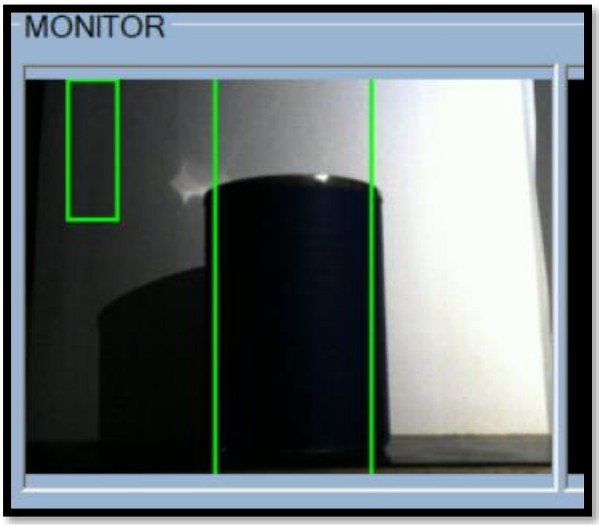


Figure 4.9 The Blue Tin Colour Not Detected Due To Low Light

Table 4.4 Color Detection Analysis Based on Lux Values

Colour Setting	Lux Value (10)	Lux Value (50)	Lux Value (100)	Colour Detected	Successful Count (Lux 10)	Successful Count (Lux 50)	Successful Count (Lux 100)
Blue	Yes	Yes	Yes	Blue	8	10	10
Black	No	Yes	Yes	Black	0	10	10
Orange	Yes	Yes	Yes	Orange	10	10	10
Purple	Yes	Yes	Yes	Purple	9	10	10
Red	Yes	Yes	Yes	Red	10	10	10
Green	No	Yes	Yes	Green	0	10	10
Yellow	No	Yes	Yes	Yellow	0	10	10
Cyan	No	Yes	Yes	Cyan	0	10	10

The analysis of the provided data reveals consistent and impeccable color detection performance for blue, orange, purple and red across varying lux values (50lx, 100lx). The successful counts for these colors reached the maximum value of 10lx, resulting an almost 100% success rate for each illuminance setting. This consistency underscores the system's robust capabilities in accurately identifying these colors under different lighting conditions. However, notable challenges were encountered in detecting green, yellow, black and cyan under low-light conditions (illuminance value 10lx), as indicated by a consistent count of 0 for these colors. Despite subsequent successful counts at illuminance values 50lx and 100lx, the system's difficulty in detecting these colors in low-light environments suggests potential limitations in recognizing them under specific lighting situations. Addressing these challenges through adjustments to the system's sensitivity or improvements in low-light color detection may be necessary to enhance overall performance. In summary, while the color detection system excels in most scenarios, further refinements are needed to achieve consistent and reliable performance across all colors and lighting conditions.

4.4.3 Count of Accepted Colours

For this part result is by keep track of the counts of good product for each detected color using the color detection system. Record the data to understand the distribution of accepted colors and the success rates related to color. Table 4.5 show the data that has been taken.

Table 4.5 Result of Accepted Colour

Colour Setting	Total Expected Counts	Colour Detected	Successful Counts	Failure Counts	Success Rate	Possible Reasons for Failure
Blue	11	Blue	11	0	100%	-
Black	11	Black	0	11	0%	IR sensor limitations
Orange	11	Orange	11	0	100%	-
Purple	11	Purple	11	0	100%	-
Red	11	Red	11	11	100%	-
Green	11	Green	11	11	100%	-
Yellow	11	Yellow	11	11	100%	-
Cyan	11	Cyan	11	11	100%	-

While the system successfully identified all the colors with counts of 11 each as shown in the figure 4.12, figure 4.13 and figure 4.14. The color detection system performed exceptionally well in identifying several colors, including blue, orange, purple, red, green, yellow, and cyan, achieving a 100% success rate for each as shown in the figure 4.12, figure 4.13 and figure 4.14. This success underscores the system's robust capabilities in accurately recognizing and counting these specified colors. However, a notable challenge emerged in the detection of black, where the system recorded a 0% success rate as shown in the figure 4.15 that the colour count for it to determine as a good product is not counting. The identified reason for this failure points to limitations in the IR sensor, raising concerns about its effectiveness in detecting certain colors. To ensure comprehensive and reliable color recognition, it is imperative to address these limitations through potential sensor enhancements or alternative technologies. Overall, while the system demonstrated commendable performance across a range of colors, improvements in the detection of black are essential for enhancing the system's overall accuracy and reliability.

Figure 4.10 Blue tin Detected and Counted

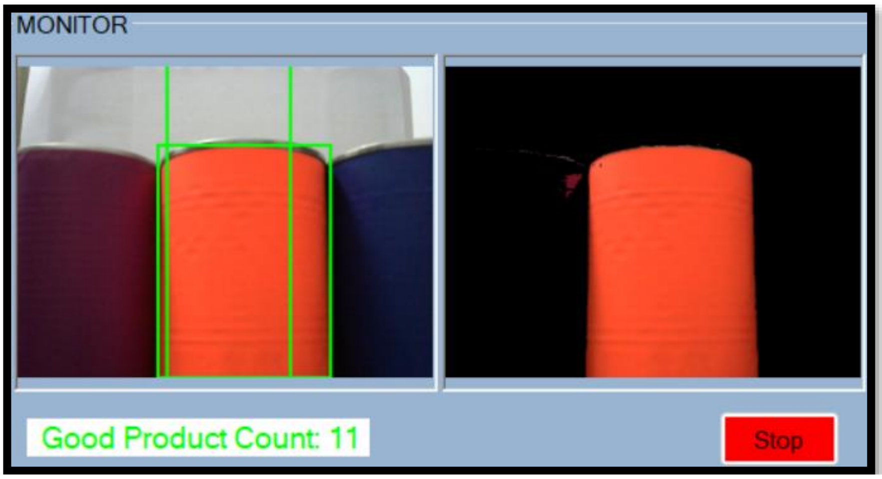


Figure 4.11 Only the Orange Tin are detected and Counted

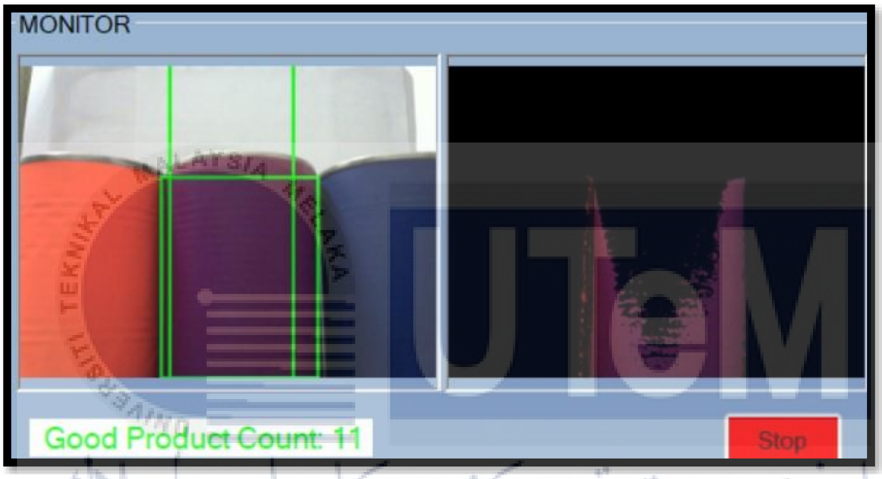


Figure 4.12 The Purple Tin Is Detected And Counted

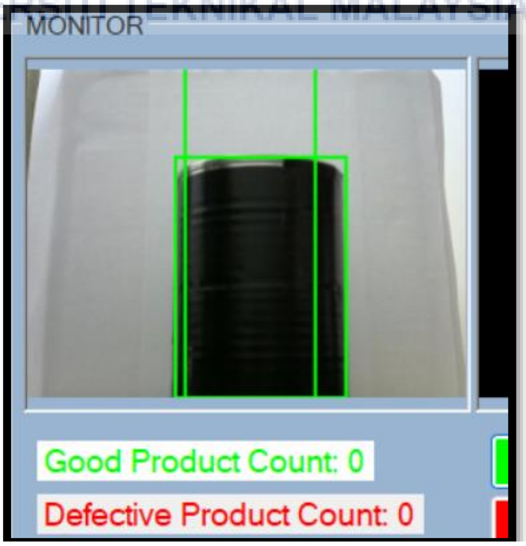


Figure 4.13 Tbe Black Tin Is Detected And Not Counting

4.4.4 Temperature Data

The analysis of colour changes in correlation with temperature data and defect rates is crucial for understanding the dynamic interactions within the color detection system. By closely examining how variations in colour impact temperature value, the system's sensitivity colour type becomes apparent.

Table 4.6 The Temperture Data obtined

Tin Colour	Setup Temperature (ºC)	Detected Temperature (ºC)
Orange	33	32
	100	93
Blue	33	31
	100	96
Purple	33	31
	100	95
Black	33	31
	100	98
Yellow	33	31
	100	93
Cyan	33	32
	100	94
Red	33	31
	100	97
Green	33	31
	100	95

Table 4.6 presents temperature data obtained during the testing of different tin colors under varying conditions. The first column identifies the tin color, followed by two sets of temperature values: the setup temperature (ºC) representing the initial state and the detected temperature (ºC) during the test. The data is organized based on the temperature on the room

that the data is collected (around 33ºC) and a heated scenario (100ºC), mimicking elevated environmental conditions.

In the room temperature setting, where the ambient temperature is around 33ºC, the detected temperatures for each tin color are relatively close to the setup temperature. For Orange, Blue, Purple, Black, Red, Green, Yellow and Cyan tins, the detected temperatures exhibit minimal variation from the setup values, ranging from 31ºC to 32ºC. This indicates a stable temperature detection performance under normal room conditions as in figure 4.16.

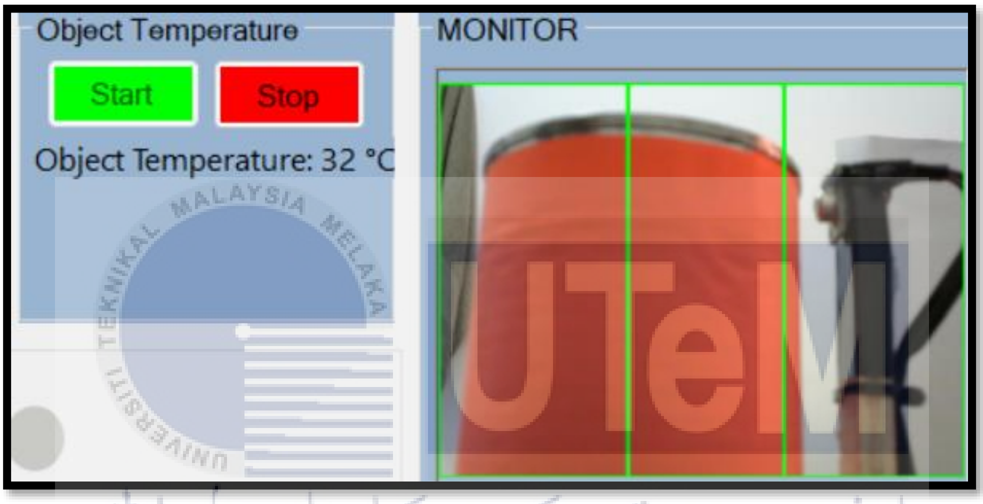


Figure 4.14 The Temperature in Room Temperature

In contrast, when exposed to elevated temperatures (100ºC), simulating a heated object, variations in detected temperatures become more noticeable. The detected temperatures for orange, blue, cyan, red, green, yellow and purple tins demonstrate a decrease compared to the setup values, suggesting a potential impact of increased temperature on the color detection system as shown in figure 4.17.

Figure 4.15 The Blue Tin Temperature Value After Heating

However, the Black tin shows an increase in detected temperature as in the figure 4.18. These variations may indicate that the color detection system is influenced by the temperature changes, leading to shifts in the detected color or potential challenges in accurately assessing color under extreme thermal conditions.

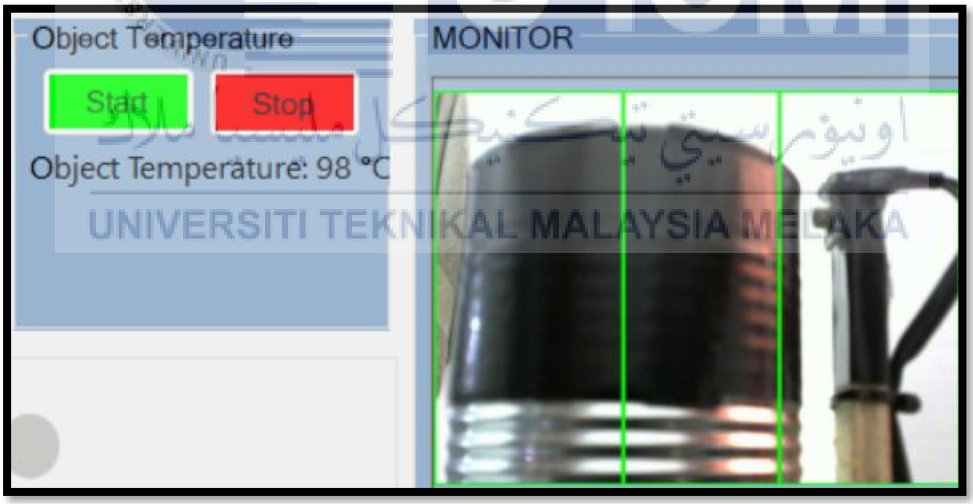


Figure 4.16 Temperature Vlue of Black Tin

This data serves as a foundation for further analysis, allowing for a comprehensive understanding of how temperature fluctuations may affect the color detection system's performance and its subsequent impact on defect rates.

4.4.5 Servo Activation Events

The result obtained in table 4.7 by recording the instances when the defect count increases to a predetermined threshold, triggering the activation of the servo to separate defect products. Log timestamps, defect counts, and details of servo activation events.

Table 4.7 Servo Activation Result

Test	Colour Setting	Product	Defect Count Increase	Servo Activation
1	Orange	Orange Tin	False	No
2		Purple Tin	True	Yes
3		Blue Tin	True	Yes
4		Black Tin	True	Yes
5		Cyan Tin	True	Yes
6		Red Tin	False	No
7		Yellow Tin	False	No
8		Green Tin	True	Yes

In the servo activation tests detailed in Table 4.7, the objective was to assess the performance of the servo system in response to various scenarios. Each test involved a specific color setting, corresponding to different tin products. Notably, when defects were detected and the defect count increased, the servo system demonstrated successful activation, thereby initiating the removal of faulty products. For instance, tests involving purple, blue, black, cyan, and green tins resulted in an elevated defect count as in the figure 4.21, leading to the activation of the servo mechanism. In contrast, tests with orange, red, and yellow tins, where the defect count did not increase, saw no servo activation. The unexpected detection of red and yellow colors as shown in figure 4.19 and 4.20 in the tests, even though the set color was Orange, may be attributed to factors such as color variation, lighting conditions, or the sensitivity threshold of the color detection system. Color sensors often interpret colors within a certain range, and subtle differences in shades or lighting can influence the perceived color. These findings underscore the effectiveness of the servo system in addressing identified defects promptly, contributing to the overall efficiency of the conveyor system.

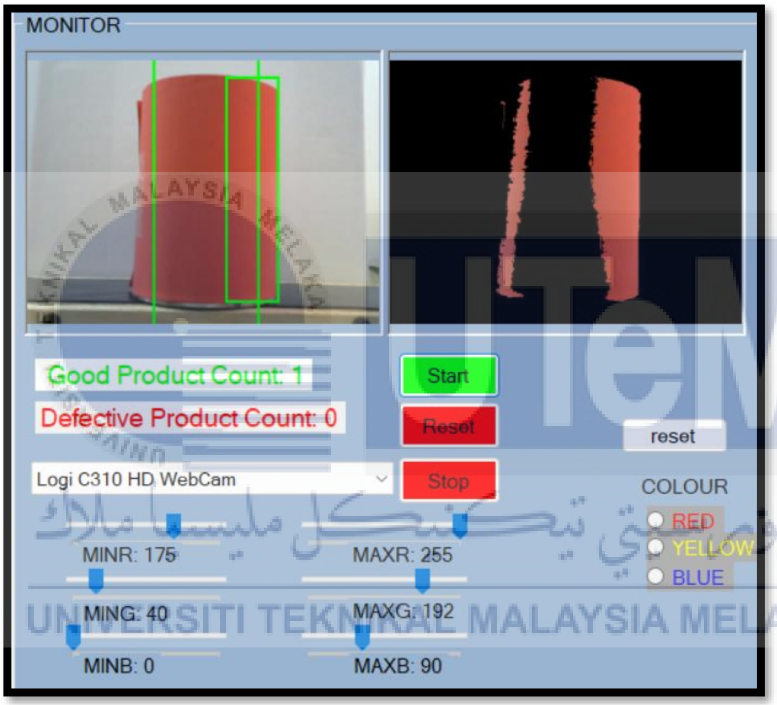


Figure 4.17 The Red Tin Colour are Detected On The Orange Colour Setting

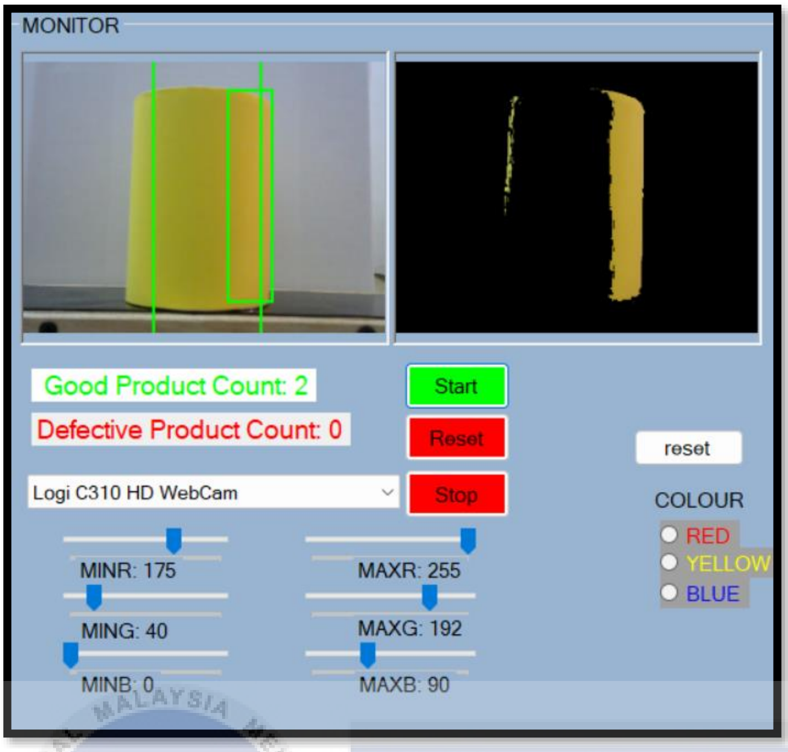


Figure 4.18 The Yellow Tin Colour are Detected On The Orange Colour Setting

Figure 4.19 The Green Tin Is Not Detected

4.5 Summary

The analysis of the conveyor system revealed critical insights into defect detection, color acceptance, and operational efficiency. Defect detection mechanisms effectively identified instances where the specified color was absent, aiding in understanding defect rates and associated types. The count of accepted colors provided valuable information on product distribution, while the conveyor speed analysis unveiled patterns in operational efficiency. Furthermore, the examination of color information allowed for a detailed assessment of color-related trends and correlations with defects.

In specific test scenarios, the system's response to color settings and defect occurrences was thoroughly evaluated. Surprisingly, instances of red and yellow detection, despite an orange color setting, were observed. Potential factors influencing these discrepancies include variations in color, lighting conditions, and sensor sensitivity. Recommendations for enhancement involve refining color detection parameters and implementing regular calibration processes to improve overall accuracy. These findings collectively form a foundation for refining and optimizing the conveyor system, ensuring improved performance and reliability in diverse operational scenarios.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This thesis outlines the successful development of a visual monitoring system tailored for the fabricating metal industry, utilizing VB.NET and incorporating a webcam for real-time color detection. In contrast to preliminary findings, the system has demonstrated its efficacy in improving quality control and automation processes.

The conclusive results affirm the system's capability to accurately detect and analyze colors in real-time, offering crucial insights for quality assurance. The integration of the conveyor system further elevates production line efficiency by facilitating the seamless transport of objects through the manufacturing process.

The amalgamation of the conveyor system and visual monitoring system empowers manufacturers with enhanced automation, streamlined workflows, and elevated product quality. The conveyor guarantees a consistent flow of materials, while the visual monitoring system's color detection prowess allows for the identification of faulty or misaligned objects. This integration proves instrumental in meeting strict color specifications and upholding uniform product standards.

In summary, the real results of the visual monitoring system coupled with the conveyor system present a comprehensive solution for the fabricating metal industry, ensuring efficient object handling, precise color detection, and reliable quality control. As technology evolves, ongoing refinements and optimizations hold the potential to maximize the system's capabilities, ultimately contributing to heightened productivity and customer satisfaction in the manufacturing process.

5.2 Potential for Commercialization

The visual monitoring system integrated with a conveyor presents significant potential for commercialization in the fabricating metal industry. By incorporating color detection capabilities and streamlining workflows, this innovative solution enhances quality control, improves operational efficiency, and provides a competitive advantage. Its customizable nature, scalability, and cost-effectiveness make it suitable for various manufacturing processes and facility sizes. Embracing this technology offers manufacturers the opportunity to achieve higher product quality, increased productivity, and reduced costs. With further research and development, this visual monitoring system has the potential to transform the fabricating metal industry, positioning manufacturers for success in an increasingly competitive market.

5.3 Future Works

For future improvements, accuracy and versetilelity of the colour detection results could be enhanced as follows:

i) Enhanced Image Processing Algorithms: Continued research and development in image processing algorithms can improve the accuracy and speed of color detection, allowing for more precise and efficient sorting of products on the conveyor. By refining the algorithms, the system can handle complex color variations and better adapt to different lighting conditions.Include study to find a better and accurate value of load and loss factor.

ii) Integration of Machine Learning: Implementing machine learning techniques can enable the system to learn and adapt to new color patterns and variations over time. By training the system with a large dataset, it can enhance its ability to identify and classify colors accurately, even in challenging scenarios.

iii) Multi-Sensor Integration: Apart from color detection, integrating additional sensors such as depth sensors or infrared sensors can provide supplementary information about the products on the conveyor. This integration can enhance the system's capabilities for quality control, defect detection, and dimensional analysis, ensuring that only products meeting all criteria are accepted.

iv) Scalability and Flexibility: Designing the system with scalability and flexibility in mind will enable its implementation in various manufacturing setups and adapt to changing production requirements. This includes modular hardware design, seamless integration with existing conveyor systems, and the ability to handle different product sizes and conveyor speeds

. By considering these future improvements, the visual monitoring system integrated with a conveyor can continue to evolve, providing even greater value to manufacturers in the fabricating metal industry.

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APPENDICES

Appendix A GANTT CHART PSM 1

Task ID	Task Name	WK01	WK02	WK03	WK04	WK05	WK06	WK07	WK08	WK09	WK10	WK11	WK12	WK13	WK14	WK15	WK16
	Discussion with Supervisor																
	Project Title Selection																
1.0	Chapter 1: Introduction																
1.1	Identify the problem statement																
1.2	Identify objective and scope project																
1.3	Chapter 1 report progress																
2.0	Chapter 2: Literature Review																
2.1	Research																
2.2	Chapter 2 report progress																
2.3	Perform comparison with existing research																
3.0	Chapter 3: Methodology																
3.1	Implement method and milestone																
3.2	Design of system																
3.3	Run a basic coding testing																
3.4	Chapter 3 report progress																
4.0	Chapter 4: Preliminary result report progress																
5.0	Chapter 5: Conclusion report progress																
6.0	Project 1 presentation																
6.1	Finalize the report																
6.2	Presentation slide preparation																
6.3	Final report submission																
6.4	Presentation PSM 1																

Appendix B GANTT CHART PSM 2

Task ID	Task Name	Duration (In Days)	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14
T01	Details calculation and theory concept	2														
T02	Project design finalization	2														
T03	Hardware and sensor finalization	2														
T04	Assemble hardware part	7														
T05	Collecting the data	4														
T06	Final documentation and report writing	3														
T07	PSM 2 draft submission	1														
T08	Preparation and Presentation	2														
T09	Submission of final report	2														

Appendix C   The Preliminary VB.NET Coding Result

```
Imports AForge
Imports AForge.Video
Imports AForge.Video.DirectShow
Imports AForge.Imaging.Filters
Imports AForge.Imaging
Imports System.Windows.Forms

Public Class Form1

    ' Declare variables
    Private CAMERAS As FilterInfoCollection ' All available cameras
    Private CAMERA As VideoCaptureDevice ' The selected camera

    ' Initialize filter values
    Private MINR As Integer = 0
    Private MING As Integer = 0
    Private MINB As Integer = 0
    Private MAXR As Integer = 255
    Private MAXG As Integer = 255
    Private MAXB As Integer = 255

    Private Sub Form1_Load(sender As System.Object, e As System.EventArgs)
Handles MyBase.Load
        ' Load available cameras into the ComboBox
        CAMERAS = New FilterInfoCollection(FilterCategory.VideoInputDevice)
        If CAMERAS.Count > 0 Then
            For Each ITEM In CAMERAS
                ComboBox1.Items.Add(ITEM.Name.ToString())
            Next

            CheckForIllegalCrossThreadCalls = False ' Enables writing to labels during
Video_NewFrame thread

            Me.Location = New System.Drawing.Point(Me.Location.X, 0) ' Places the form
at the top of the screen
        Else
            MsgBox("NO AVAILABLE CAMERA")
        End If
    End Sub
```

```
            ' Handle ComboBox selection change event
    Private Sub ComboBox1_SelectedIndexChanged(sender As System.Object, e As
System.EventArgs) Handles ComboBox1.SelectedIndexChanged
        ' Start capturing images from the selected camera and execute the
Video_NewFrame thread
        CAMERA = New
VideoCaptureDevice(CAMERAS(ComboBox1.SelectedIndex).MonikerString)
        AddHandler CAMERA.NewFrame, New NewFrameEventHandler(AddressOf
Video_NewFrame)
        CAMERA.Start()
        ComboBox1.Visible = True
    End Sub

    ' Video_NewFrame event handler
    Private Sub Video_NewFrame(sender As Object, eventArgs As
AForge.Video.NewFrameEventArgs)
        Dim ORI As Bitmap = DirectCast(eventArgs.Frame.Clone(), Bitmap) ' Original
camera image
        Dim FILTER As Bitmap = DirectCast(eventArgs.Frame.Clone(), Bitmap) '
Filtered image

        ' Apply color filtering
        Dim FILT As New ColorFiltering
        FILT.Red = New IntRange(MINR, MAXR)
        FILT.Green = New IntRange(MING, MAXG)
        FILT.Blue = New IntRange(MINB, MAXB)
        FILT.ApplyInPlace(FILTER)

        ' Convert filtered image to grayscale for blob processing
        Dim GRAY As New Grayscale(0.2125, 0.7154, 0.0721)
        Dim IMAGEGRAY As Bitmap = GRAY.Apply(FILTER)

        ' Blob classification
        Dim BLOBS As New BlobCounter()
        BLOBS.MinHeight = 10 ' Only takes blobs of a specific size
        BLOBS.MinWidth = 10 ' Only takes blobs of a specific size
        BLOBS.ObjectsOrder = ObjectsOrder.Size ' Take the largest blob
        BLOBS.ProcessImage(IMAGEGRAY) ' Execute the classifier

        Dim RECTS As New List(Of Rectangle) ' Collection of blobs converted to
rectangles

        For Each blobRect As Rectangle In BLOBS.GetObjectsRectangles()
            RECTS.Add(blobRect)
        Next

        If RECTS.Count > 0 Then ' If there is more than one blob...
            Dim GRAPH As Graphics = Graphics.FromImage(ORI) ' ...draw rectangles on
the original image
```

```
        Dim PEN As New Pen(Color.Lime, 5)

        For Each rect As Rectangle In RECTS
            GRAPH.DrawRectangle(PEN, rect) ' Draw the blob's rectangle
        Next

        GRAPH.Dispose() ' Release the graphics object
    End If

    PictureBoxORI.Image = ORI ' Display the original image
    PictureBoxFLTR.Image = FILTER ' Display the filtered image
End Sub

' Handle changes in trackbar values
Private Sub TrackBarMINR_Scroll(sender As System.Object, e As
System.EventArgs) Handles TrackBarMINR.Scroll
    MINR = TrackBarMINR.Value
    LabelMINR.Text = "MINR: " & MINR
End Sub

' Repeat the above code for the remaining TrackBar scroll events

' Handle form closing event
Private Sub Form1_FormClosing(sender As Object, e As
System.Windows.Forms.FormClosingEventArgs) Handles Me.FormClosing
    Try
        CAMERA.SignalToStop() ' Close the Video_NewFrame thread
    Catch ex As Exception
    End Try
End Sub

End Class
```