Faculty of Electrial Technology and Engineering

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

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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

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

A project report submitted
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I hereby declare that I have checked this project report and in my opinion, this project reportis adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology((Industrial Automation and Robotics) with Honours.

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ABSTRACT

This project aims to develop a visual monitoring system for the rubber industry, utilizing an industrial automation system integrated with a camera and thermo sensor. The main focus is on detecting thermal abnormalities in the production line. In the rubber industry, manual monitoring processes are often inefficient and prone to errors, leading to production delays and safety hazards. To address these challenges, a visual monitoring system is proposed. The system will be developed using VB.NET, a versatile programming language suitable for creating robust applications. By integrating a camera with a thermo sensor, the system will capture visual and thermal data in real-time. This integration will enable the detection of thermal abnormalities, such as overheating or temperature variations, in critical components of the production line. The system will provide a user-friendly interface that presents visual representations of the production line, aiding operators and maintenance personnel in swiftly identifying and addressing thermal anomalies. Proactive interventions can be taken to prevent equipment failures and optimize maintenance schedules, leading to improved productivity and product quality. The project will involve designing the user interface, integrating the camera and thermo sensor, developing data analysis algorithms, and implementing the system using VB.NET. Rigorous testing and validation will be conducted to ensure the system's accuracy, reliability, and effectiveness in real-world rubber industry settings. By developing a visual monitoring system focused on detecting thermal abnormalities, this project aims to enhance the efficiency, safety, and overall performance of the rubber industry

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ABSTRAK

Projek ini bertujuan untuk membangunkan sistem pemantauan visual untuk industri getah, menggunakan sistem automasi industri yang disepadukan dengan kamera dan sensor termo. Fokus utama adalah untuk mengesan keabnormalan haba dalam barisan pengeluaran. Dalam industri getah, proses pemantauan manual selalunya tidak cekap dan terdedah kepada ralat, yang membawa kepada kelewatan pengeluaran dan bahaya keselamatan. Untuk menangani cabaran ini, sistem pemantauan visual dicadangkan. Sistem ini akan dibangunkan menggunakan VB.NET, bahasa pengaturcaraan serba boleh yang sesuai untuk mencipta aplikasi yang mantap. Dengan menyepadukan kamera dengan penderia termo, sistem akan menangkap data visual dan terma dalam masa nyata. Penyepaduan ini akan membolehkan pengesanan keabnormalan haba, seperti terlalu panas atau variasi suhu, dalam komponen kritikal barisan pengeluaran. Sistem ini akan menyediakan antara muka mesra pengguna yang mempersembahkan perwakilan visual barisan pengeluaran, membantu operator dan kakitangan penyelenggaraan dalam mengenal pasti dan menangani anomali terma dengan pantas. Intervensi proaktif boleh diambil untuk mencegah kegagalan peralatan dan mengoptimumkan jadual penyelenggaraan, yang membawa kepada peningkatan produktiviti dan kualiti produk. Projek ini akan melibatkan mereka bentuk antara muka pengguna, menyepadukan kamera dan sensor termo, membangunkan algoritma analisis data, dan melaksanakan sistem menggunakan VB.NET. Ujian dan pengesahan yang ketat akan dijalankan untuk memastikan ketepatan, kebolehpercayaan dan keberkesanan sistem dalam tetapan industri getah dunia sebenar. Dengan membangunkan sistem pemantauan visual yang tertumpu pada mengesan keabnormalan haba, projek ini bertujuan untuk meningkatkan kecekapan, keselamatan dan prestasi keseluruhan industri getah

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LIST OF SYMBOLS

°C - Degrees Celsius

kg - Kilogram

g - Gram

µm - Micrometer

m - Meter

mm - Millimeter

cm - Centimeter

% - Percentage

vol - Volume

hrs - Hours

min - Minutes

sec - Seconds

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LIST OF ABBREVIATIONS

PPE - Personal Protective Equipment

PVC - Polyvinyl chloride

PFA - Perfluoroalkoxy

FDA - Food and Drug Administration

ASTM - American Society for Testing and Materials

ISO - International Organization for Standardization

OSHA - Occupational Safety and Health Administration

ANSI - American National Standards Institute

MSDS - Material Safety Data Sheet

HAZCOM - Hazard Communication

PIM - Processed Indicator Method

HACCP - Hazard Analysis Critical Control Points

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CHAPTER 1

INTRODUCTION

The visual monitoring system based on an industrial automation system for the rubber industry aims to detect thermal abnormalities using VB.NET and an infrared camera. By integrating the infrared camera with the automation system, the system can continuously monitor the production line and capture thermal data in real-time. VB.NET provides the programming platform to develop the software application that processes the thermal images and identifies temperature anomalies. This system offers proactive maintenance, improves production efficiency, and enhances product quality by detecting early signs of equipment malfunctions or process deviations.

The visual monitoring system for the rubber industry combines VB.NET and an infrared camera to monitor temperature variations in real-time. It enables proactive maintenance, optimizes production efficiency, and ensures product quality by identifying thermal abnormalities. This system provides a reliable and automated solution for the rubber industry to enhance productivity and reduce costs.

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1.1 Background

Visual monitoring systems have gained in popularity across several sectors in recent years. These systems use computer vision and image processing to continuously track and analyse crucial production metrics, alerting workers to any problems as soon as they occur. The goal of this project is to use Visual Basic.NET, a well-liked language for creating Windows programmes, to create a visual monitoring system. Quality control, assembly line monitoring, and equipment performance are just some of the industrial operations that will be tracked by the system. In addition, the system will have the ability to display data in real time and provide alerts if any abnormalities are detected in the production parameters [1]. We anticipate a rise in productivity and a decrease in waste as a result of the implementation of this visual monitoring system. The technology will not only benefit the rubber production business, but will also serve as a blueprint for the creation of comparable visual monitoring systems in other sectors. [1].

1.2 Problem Statement

The rubber sector plays a significant role in generating many items used in everyday life, but its complicated production process demands continuous monitoring to assure product quality and reduce production downtime. Manual monitoring techniques in the sector are very inefficient, time-consuming, and prone to mistakes, resulting to costly production delays, quality difficulties, and safety dangers for workers. Previous methods to solve monitoring difficulties in the rubber sector include deploying sensors and alarms, but these systems lack real-time data and visual depiction of the production process. This makes it difficult to determine the main cause of deviations and fix the process rapidly, relying significantly on human intervention [7]. The present challenge in the rubber business is the lack of a reliable, real-time, and visual monitoring system that offers full data on the production process, identifies deviations in real-time, and enables speedy troubleshooting of the process. This absence adds to manufacturing inefficiencies, quality concerns, and safety dangers for workers, hurting the industry's total productivity and profitability. The recommended solution is to construct a visual monitoring system using VB.NET that connects with an industrial automation system. This system will offer real-time data on the production process, enabling prompt identification of deviations, and provide visual representations of the process for simple debugging[2].

1.3 Societal and Global Considerations in Rubber Glove Manufacturing

In the context of the rubber glove manufacturing industry, the development of a visual monitoring system based on an industrial automation system requires an understanding of the societal and global issues associated with this sector, as well as the integration of sustainable development principles. This section focuses on exploring the broader implications and considerations related to these aspects.

The rubber glove manufacturing industry holds significant importance in providing essential safety and protective products in various sectors, including healthcare and industrial settings. However, it also faces notable challenges, such as environmental impacts, resource management, and worker welfare. Therefore, it is crucial to incorporate sustainable development principles to foster a more sustainable and responsible industry [4].

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Sustainable development emphasizes meeting present needs while ensuring the ability of future generations to meet their own needs. When developing the visual monitoring system, it is essential to consider how it can contribute to sustainable practices within the rubber glove manufacturing industry. This involves aspects such as minimizing environmental footprints, optimizing resource utilization, and implementing responsible manufacturing processes.

Additionally, societal issues such as worker safety, fair labor practices, and public health considerations should be addressed. With the increasing adoption of automation and advanced technologies in the industry, it is important to prioritize the well-being of workers and mitigate any potential negative impacts on their livelihoods.

By acknowledging and addressing these societal and global issues within the rubber glove manufacturing industry, the development of the visual monitoring system aims to promote sustainable development. This includes minimizing environmental impacts, enhancing worker safety and welfare, and fostering responsible manufacturing practices. The integration of sustainable development principles contributes to creating a more sustainable and socially responsible industrial automation system in the rubber glove manufacturing industry.

Overall, by considering the broader implications and incorporating sustainable development principles, the visual monitoring system aims to optimize operational efficiency, product quality, and the long-term well-being of both society and the environment within the rubber glove manufacturing industry.

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1.4 Project Objective

This visual monitoring system would help the user to simulate a conveyor or process line where the hazard and accident risk is high. The detailed objective of this project is stated such as below:

a) To create a VB.NET-based visual monitoring system to monitor critical processes in a rubber manufacturing plant.

b) To reduce manual inspection and improve efficiency in rubber manufacturing plants through integrating camera sensor and image processing techniques.

c) To establish a system for the rubber industry that enables real-time monitoring and simulation through integration with existing industrial automation systems focusing Thermal Anomalies in Conveyor Systems: Infrared cameras can identify abnormal temperature patterns in conveyor belts or rollers.

1.5 Scope of Project

The scope of this project are as follows:

a) The system will only display the assembly conveyor belts,bearing or roller in the rubber industry plant.

b) The hardware that will be used as a camera with infrared to identify if the conveyor or belt pass the inspection.

c) Using an IoT platform with the support of VB.NET to monitor and collect the data of production in manufacturing line.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter focuses on the implementation of a visual monitoring system in the rubber manufacturing industry, specifically targeting hazardous and critical processes. The aim is to identify the factors that make these processes dangerous for human intervention and explore the need for alternative approaches. By examining existing literature and research, the chapter discusses the selection of an appropriate visual monitoring system for the project and its potential to achieve the objective of enhancing safety and operational efficiency. This literature review establishes a strong foundation of knowledge and understanding, paving the way for the development of an effective solution that ensures the safety of workers in hazardous environments.

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2.2 Rubber manufacturing Industry

The rubber glove manufacturing industry is a vital sector that produces a wide range of gloves for various applications. These gloves are made from natural rubber latex or synthetic materials and are designed to provide protection, comfort, and dexterity for users[4].

The manufacturing process for rubber gloves involves several intricate steps. It begins with the selection and preparation of raw materials, where natural rubber latex is harvested from rubber trees or synthetic materials are produced through chemical processes. The raw materials are then processed and compounded with additives to enhance specific properties such as elasticity, durability, and resistance to chemicals or allergens [19].

The next stage involves the forming of gloves through either the dipping or molding method. In the dipping process, ceramic or aluminum molds are dipped into the rubber compound, creating a thin layer that forms the glove shape. The gloves then go through a series of treatments including coagulation, leaching, and drying to remove excess material and solidify the glove structure. For the molding process, pre-formed rubber sheets or molds are used to shape the gloves, which are then vulcanized to achieve optimal strength and elasticity.

Quality control is a critical aspect of the rubber glove manufacturing industry. Rigorous testing and inspection procedures are conducted at various stages of production to ensure that the gloves meet strict quality standards and regulatory requirements[4]. These tests include checks for physical properties, such as thickness, tensile strength, and elongation, as well as tests for barrier performance, sterility, and resistance to chemicals.

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Safety and hygiene are paramount in the rubber glove manufacturing industry. Manufacturers follow stringent protocols to maintain a clean and controlled production environment to minimize the risk of contamination. Workers are provided with appropriate personal protective equipment (PPE) and undergo training to ensure their safety and well-being during the manufacturing process[3].

The rubber glove manufacturing industry plays a crucial role in various sectors, including healthcare, food processing, laboratories, and industrial applications. These gloves are essential for protecting workers, patients, and consumers from potential hazards, infections, and chemical exposure. The industry continuously strives for innovation, developing gloves with improved features such as enhanced grip, touchscreen compatibility, and antimicrobial properties to cater to the evolving needs of different industries.

In conclusion, the rubber glove manufacturing industry is responsible for producing high-quality gloves that offer protection, comfort, and reliability. Through advanced manufacturing processes, stringent quality control, and a commitment to safety, the industry ensures the production of gloves that meet the stringent requirements of different sectors. The industry's products are essential for maintaining hygiene, safety, and well-being in various applications, making a significant contribution to public health and workplace safety.

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2.2.1Rubber (Glove) Manufacturing Process

The rubber glove manufacturing process involves several stages that transform raw rubber materials into finished gloves. Each stage plays a crucial role in ensuring the production of high-quality gloves that meet safety standards. The following sections outline the key processes involved in the production line:

2.1.1.1 Raw Material Preparation

In the raw material preparation stage, the selection of rubber compounds is based on the desired glove properties, such as elasticity, tensile strength, and chemical resistance. Natural latex obtained from rubber trees or synthetic rubber materials are commonly used. The rubber materials are carefully mixed with various additives, such as accelerators, antioxidants, and pigments, to enhance specific characteristics and provide color to the gloves. The proportions and formulations of these additives are crucial in achieving the desired properties of the final gloves.

2.1.1.2 Latex Dipping

During the latex dipping process, the ceramic or metal formers are immersed in the latex solution. The formers are pre-coated with a thin film of coagulant to promote the solidification of the latex. This coagulant layer aids in the glove removal process later. The dipping process may involve multiple dips to build up the desired thickness of the gloves. After each dip, the gloves are dried using hot air or other drying methods to remove excess moisture.

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2.1.1.3 Vulcanization

Vulcanization is a critical stage in rubber glove manufacturing. The gloves are subjected to heat in ovens or autoclaves to activate the cross-linking process of rubber molecules. This process improves the strength, elasticity, and chemical resistance of the gloves. The temperature and duration of vulcanization are carefully controlled to ensure optimal curing without compromising the glove integrity(5). Vulcanization also plays a crucial role in reducing the residual protein content in natural latex gloves, minimizing the risk of allergic reactions.

2.1.1.4 Leaching and Washing

After vulcanization, the gloves undergo leaching and washing processes to remove residual latex proteins, chemicals, and other impurities. Leaching involves immersing the gloves in hot water or chemical solutions to extract and wash away the residues. The gloves are then thoroughly rinsed to eliminate any remaining impurities. This step is essential to enhance the safety and hypoallergenic properties of the gloves, making them suitable for individuals with latex allergies..

2.1.1.5 Drying

Proper drying of the gloves is crucial to ensure their quality and prevent moisture-related issues. The gloves are dried using hot air dryers or other drying methods to eliminate any remaining moisture. Adequate drying is essential to prevent microbial growth and maintain the physical properties of the gloves. The drying process also contributes to extending the shelf life of the gloves, ensuring they remain in optimal condition until they are used.

2.1.1.6 Glove Forming and Packaging

In the glove forming stage, the gloves are shaped and sized according to the desired specifications. This process involves stretching and manipulating the gloves to achieve a comfortable fit and proper finger orientation. The formed gloves are visually inspected to ensure they meet quality standards, including checking for defects, thickness consistency, and size accuracy. Once inspected, the gloves are packaged, typically in pairs, and prepared for distribution and sale. Proper packaging helps protect the gloves from contamination and ensures they reach end-users in pristine condition[17].

2.1.1.7 Quality Control

Throughout the entire manufacturing process, stringent quality control measures are implemented to ensure that the gloves meet the required standards. Quality control checks are conducted at various stages, including raw material inspection, dipping process monitoring, vulcanization monitoring, and final glove inspection. These checks involve visual inspection, physical testing, and adherence to specific criteria for dimensions, thickness, tensile strength, and barrier properties. Any gloves that do not meet the quality standards are rejected or undergo further corrective measures[4].

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Table 2.1: Processes and Functions in the Rubber Glove Manufacturing Industry

Station	Function
Raw Material Preparation	Selecting and preparing raw materials such as latex, chemicals, and additives.
Latex Compounding and Chemical Treatment	Mixing and compounding latex with chemicals to enhance its properties and durability.
Dipping and Coagulant Application	Immersing formers into latex and applying coagulant to promote glove formation.

Station	Function
Vulcanization	Curing the latex-coated formers in ovens to transform them into solid rubber gloves.
Leaching and Washing	Removing residual chemicals and impurities from the gloves through thorough washing.
Drying and Curing	Drying the gloves and subjecting them to additional curing processes for optimal strength.
Quality Control	Inspecting gloves for defects, ensuring conformity to quality standards and specifications.
Testing and Certification	Conducting various tests to evaluate the gloves' performance, durability, and safety.
Packaging and Labeling	Packaging gloves in proper containers and applying labels for identification and branding.

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2.2 Comparison with Glass and Metal Manufacturing Industries

The rubber glove manufacturing industry, while distinct from the metal and glass manufacturing industries, shares commonalities and disparities that provide valuable insights into the potential advantages of implementing a visual monitoring system. Similar to the glass bottle and metal industries, a visual monitoring system in the rubber glove sector can enhance process efficiency, reduce waste, improve product quality, and ensure manufacturing safety. By comprehending the convergences and divergences among these industries, we can pinpoint the specific areas where a visual monitoring system can be most advantageous, fostering advancements in process control, defect detection, and overall productivity. By leveraging these shared aspects and addressing the unique challenges of each industry, a visual monitoring system holds the potential to streamline operations and drive continuous improvement in the rubber glove, metal, and glass manufacturing sectors.

2.2.1 Similarities and Differences in Manufacturing Processes

The rubber, metal, and glass industries share similarities and differences in their manufacturing processes. These comparisons offer valuable insights into the production methods employed in each industry and highlight where visual monitoring systems can be beneficial.

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In terms of similarities, all three industries require careful raw material preparation. In the rubber industry, natural or synthetic rubber compounds are prepared by mixing polymers, fillers, and additives. Similarly, the metal industry involves the preparation of metallic materials through processes like melting and alloying different metals. In the glass industry, specific raw materials such as silica sand and soda ash are mixed to create glass batches. This commonality in raw material preparation underscores the importance of precise handling and processing to achieve desired material characteristics.

Shaping and forming processes are also shared among these industries. Techniques like molding, extrusion, and casting are employed to shape materials according to desired specifications. In the rubber industry, rubber compounds are shaped through molding or extrusion, resulting in various forms of rubber products. Likewise, metal components undergo shaping processes such as casting, forging, or machining to achieve the desired shape and properties. In the glass industry, glass is shaped through techniques like blowing or pressing. These similarities in shaping and forming processes highlight the importance of precise techniques in achieving the desired product outcomes.

Despite these similarities, there are notable differences in the manufacturing processes of rubber, metal, and glass. The primary difference lies in the material properties used in each industry. Rubber is an elastic polymer, metal is a malleable and conductive material, and glass is an inorganic, non-metallic material. These material differences necessitate specific manufacturing processes and techniques to shape and treat them effectively.

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Heating and processing methods also vary among the industries. Rubber materials are typically heated and molded using heat and pressure to achieve the desired shape and properties. Metal materials, on the other hand, require specific heating methods such as induction furnaces or electric arc furnaces for melting and shaping. Glass undergoes high-temperature processes in furnaces to melt and form molten glass, which is then shaped into the desired products.

Furthermore, surface treatments differ in the rubber, metal, and glass industries. In the rubber industry, surface treatments like vulcanization and coating may be applied to enhance the material's properties, such as its strength or resistance to chemicals. Metal components often undergo additional processes such as polishing, plating, or coating to improve their appearance, corrosion resistance, or conductivity. Glass, on the other hand, may undergo treatments like annealing or tempering to enhance its strength and safety.

Quality control measures are also tailored to each industry's specific requirements. In the rubber and metal industries, visual inspections, dimensional measurements, and destructive or non-destructive testing techniques are commonly used to ensure product quality. The glass industry employs rigorous quality control measures such as visual inspections, optical testing, and automated systems for defect detection[20].

By comparing the manufacturing processes of rubber, metal, and glass industries, we gain a deeper understanding of their similarities and differences. This understanding allows us to identify areas where visual monitoring systems can be applied to improve process efficiency, enhance product quality, and ensure safety across these industries. By leveraging these similarities and addressing the unique challenges of each industry, visual monitoring systems can serve as valuable tools in streamlining operations and driving continuous improvement in the rubber, metal, and glass manufacturing sectors.

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2.3 Hazardous Processes in Rubber (Glove) Manufactory

The rubber glove manufacturing process involves several hazardous and critical processes that require careful attention to ensure worker safety and product quality. Understanding these processes is crucial for implementing appropriate safety measures and mitigating potential risks. This section highlights some of the key hazardous and critical processes involved in rubber glove manufacturing[6].

2.3.1 Latex Preparation

The latex preparation stage involves the collection and processing of natural rubber latex, which is obtained from rubber trees. During latex collection, workers are exposed to potential hazards such as latex allergens, as some individuals may develop allergies or sensitivities to latex proteins. Additionally, the process of centrifugation to separate impurities from the latex can expose workers to chemicals used for stabilization, such as ammonia or sulfuric acid. Proper handling, storage, and transportation of latex are crucial to minimize the risks associated with these hazards.

2.3.2 Compounding and Mixing

Compounding and mixing is a critical process where various ingredients are blended to create the rubber compound used for glove production. The ingredients include latex, chemicals (such as accelerators and antioxidants), fillers (such as calcium carbonate or silica), and colorants. Workers involved in this process may face hazards related to chemical exposure, as some chemicals used in compounding and mixing can be irritants or sensitizers. Additionally, there may be risks associated with operating heavy machinery, such as mixers or mills, which require proper training and safety precautions[3].

2.3.3 Dipping Process

The dipping process is a key step in which hand-shaped ceramic or metal molds are dipped into the rubber compound to form the glove shape. This process is repeated multiple times to achieve the desired glove thickness. Hazards in this process include exposure to the rubber compound, which may contain chemicals and allergens, as well as the potential for burns from hot dipping baths. Workers need to be cautious when handling the molds and ensure proper ventilation in the dipping area to minimize exposure to fumes or volatile compounds. Additionally, the repetitive nature of the dipping process may pose ergonomic risks, leading to musculoskeletal disorders if not properly managed.

2.3.4 Vulcanization

Vulcanization is a critical process that involves curing the dipped gloves in high-temperature ovens or autoclaves. The gloves are exposed to heat, typically between 150 to 200 degrees Celsius, for a specific duration to achieve cross-linking of rubber molecules and improve the strength, elasticity, and durability of the gloves. Hazards in the vulcanization process include exposure to high temperatures, steam, and pressurized environments[7][8]. Workers must adhere to strict safety protocols, such as wearing heat-resistant gloves and using appropriate tools for handling hot gloves and molds, to prevent burns, explosions, or other accidents related to the vulcanization process[5].

2.3.5 Stripping and Leaching

After vulcanization, the gloves undergo stripping and leaching processes to remove excess chemicals, proteins, and residual latex. Stripping involves mechanically removing the

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gloves from the molds, which can pose hazards such as cuts or punctures if proper handling techniques and tools are not used. Leaching involves washing the gloves in water or chemical baths to remove any remaining impurities. Hazards in this stage include exposure to residual chemicals or leaching agents, which may cause skin irritation or sensitization. Workers need to use appropriate personal protective equipment, such as gloves and goggles, and follow proper handling procedures to minimize these risks. Additionally, the repetitive nature of stripping and leaching processes may contribute to ergonomic hazards, and implementing ergonomic controls and providing proper training is essential to prevent work-related injuries.

2.3.6 Stripping and Leaching

The quality control and packaging stage is crucial to ensure that the gloves meet the required standards and are properly packaged for distribution. Visual inspections are conducted to detect any defects, such as pinholes or irregularities in the gloves' surface. Testing for physical properties, including tensile strength and elongation, is performed to assess the gloves'

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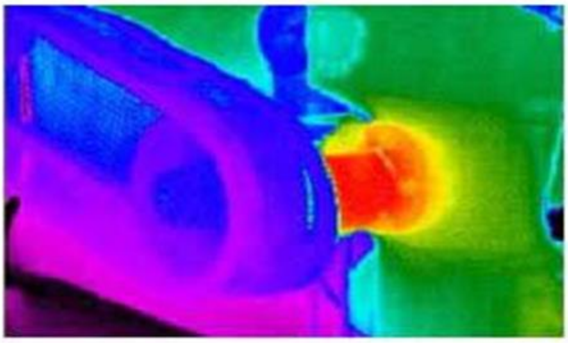
2.3.7 Maintenance and Equipment Handling

In the rubber glove manufacturing industry, maintenance and equipment handling are critical processes that pose various hazards to workers. Electrical hazards can occur during maintenance tasks on machinery, leading to electrical shocks or electrocution. Mechanical failures can result in severe injuries if equipment malfunctions or fails unexpectedly. The risk of falling objects is another hazard, especially when handling heavy equipment and components. Preventive measures can be made profitable. Proactive maintenance techniques can be implemented by visually monitoring anomalous temperature patterns linked with bearing failures[9]. Bearing lubrication decreases friction, reduces heat generation, and increases bearing lifespan. Visual monitoring can assist in detecting inadequate lubrication and urging early re-lubrication to avoid bearing problems.

Following that, real-time bearing temperature monitoring enables operators to observe temperature trends and spot deviations from typical operating circumstances. Implementing condition monitoring programs based on visual monitoring data provides predictive maintenance, allowing bearings to be changed before they fail, hence eliminating unexpected breakdowns. Implementing safety measures such as electrical safety training, regular equipment inspections, lockout/tagout procedures, and the use of appropriate lifting equipment can mitigate these risks and ensure a safe working environment.

Regular inspection and alignment of conveyor belts and rollers ensures correct load distribution and reduces bearing stress. Visual monitoring makes misalignment identification easier and enables for quick corrective measures like as alignment modifications or bearing replacements.

Figure 1.1 Abnormal temperature pattern.



2.4 Visual Monitoring

Visual monitoring refers to the use of visual information and technology to observe and assess various processes, activities, or environments.(6,10) It involves capturing and analyzing visual data to gain insights, detect anomalies, and make informed decisions. Visual monitoring plays a crucial role in industries such as manufacturing, surveillance, healthcare, and transportation, among others.

In visual monitoring, cameras or other imaging devices are employed to capture visual data in real-time or recorded formats. These devices can be strategically positioned to cover specific areas of interest or provide a comprehensive view of an entire environment. The captured images or videos are then analyzed using specialized software or algorithms to extract valuable information.

The primary objective of visual monitoring is to enhance situational awareness and facilitate effective decision-making. By monitoring visual data, operators or analysts can identify abnormalities, detect potential risks or hazards, and take timely action to mitigate them. Visual monitoring also enables the evaluation of process performance, identification of inefficiencies, and improvement of overall operations[11].

In various industries, visual monitoring serves different purposes. For example, in manufacturing plants, visual monitoring systems can be used to oversee production lines, monitor equipment status, and detect any malfunctions or deviations from standard operating procedures. In surveillance applications, visual monitoring enables the monitoring of public spaces, premises, or critical infrastructure to enhance security and prevent potential threats.

The advancement of technology has significantly contributed to the development of visual monitoring systems. High-resolution cameras, intelligent video analytics, and machine learning algorithms have improved the accuracy and efficiency of visual data analysis. Furthermore, the integration of visual monitoring systems with other technologies, such as Internet of Things (IoT) devices or automation systems, enables seamless data exchange and enhanced decision-making capabilities.

In summary, visual monitoring plays a vital role in various industries by leveraging visual data to enhance situational awareness, detect anomalies, and support decision-making processes. The use of cameras, advanced analytics, and integration with other technologies enables real-time monitoring, identification of risks or inefficiencies, and improved overall operations. Visual monitoring systems continue to evolve, providing innovative solutions for enhancing safety, security, and operational efficiency in diverse applications[12].

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2.4.1 Importance of Visual Monitoring in the Rubber (Glove) Manufactory

Visual monitoring is an indispensable aspect of the rubber glove manufacturing industry, offering a range of advantages that contribute to overall efficiency and effectiveness. One key aspect is the ability to monitor the production line in real-time, allowing operators to have a clear and immediate view of the entire manufacturing process. This real-time monitoring empowers them to identify any deviations or abnormalities promptly and take necessary actions to rectify the situation. By addressing issues in a timely manner, visual monitoring ensures that the production line runs smoothly and optimally, minimizing downtime and maximizing productivity.

Quality control is another critical area where visual monitoring systems prove invaluable. They enable continuous inspection and evaluation of glove production, helping to identify and eliminate defects or irregularities. By visually inspecting the gloves at various stages of the manufacturing process, operators can ensure that they meet the required quality standards before they are released for packaging and distribution. This not only ensures customer satisfaction but also safeguards the reputation of the manufacturer and maintains compliance with regulatory requirements.

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In terms of worker safety, visual monitoring systems play a vital role in identifying and mitigating potential hazards. By closely monitoring the manufacturing environment, operators can detect unsafe conditions or practices that could lead to accidents or injuries. For example, visual monitoring can help identify issues such as improper machine operation, equipment malfunctions, or potential ergonomic hazards[13]. By promptly addressing these concerns, manufacturers can create a safer working environment for their employees, reducing the risk of workplace accidents and promoting a culture of safety.

Visual monitoring also provides valuable data and insights for process improvement and optimization. By capturing and analyzing visual information, manufacturers can identify patterns, trends, and areas of improvement in their manufacturing processes[13]. This data-driven approach allows for informed decision-making, targeted problem-solving, and the implementation of process enhancements. By continuously optimizing their processes based on visual data, manufacturers can enhance efficiency, reduce waste, and achieve higher levels of product quality and consistency.

In conclusion, visual monitoring is a vital component of the rubber glove manufacturing industry, offering real-time observation, quality control, safety management, and process optimization. By leveraging visual monitoring systems, manufacturers can enhance productivity, ensure product quality, protect worker safety, and drive continuous improvement. In a competitive industry where efficiency and quality are paramount, visual monitoring provides the necessary tools and insights for manufacturers to thrive and meet the demands of the market.

2.4.1.1 Ensuring Safety and Hazard Rubber (Glove) Manufactory

In the rubber (glove) manufacturing industry, visual monitoring systems play a vital role in ensuring safety and addressing hazards associated with critical processes. These systems utilize advanced camera technologies, real-time monitoring, and intelligent algorithms to enhance safety measures and mitigate risks in hazardous manufacturing environments.

Visual monitoring systems are particularly valuable in critical processes within the rubber glove manufacturing industry, such as mixing and compounding, molding, and vulcanization. These processes involve the handling of hazardous materials, high temperatures, and potential equipment malfunctions, making them prone to accidents and safety hazards[14]. By implementing visual monitoring systems, manufacturers can

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effectively monitor and manage these processes to ensure worker safety and product quality[15].

One key benefit of visual monitoring systems is their ability to provide real-time surveillance of critical processes. Cameras strategically placed within the production line enable operators to remotely monitor the activities and conditions in hazardous areas. This remote monitoring capability allows operators to observe the processes without direct exposure to dangers, such as chemical spills, high temperatures, or equipment failures. It minimizes the risk of injuries and enables quick responses to any potential safety issues.

Visual monitoring systems also employ intelligent algorithms and machine vision technologies to detect abnormalities and potential safety hazards. These systems analyze visual data in real-time and can identify deviations from normal operating conditions. For example, they can detect irregularities in the mixing process, such as abnormal smoke or chemical reactions, which may indicate a safety hazard. Operators receive immediate alerts, allowing them to take prompt action, implement safety measures, or halt the process if necessary.

Furthermore, visual monitoring systems can be integrated with other safety mechanisms and emergency response systems. They can be connected to alarms, automated shutdown systems, or emergency protocols[16]. In the event of an unsafe condition, visual monitoring systems can trigger appropriate responses, such as activating emergency stops, notifying operators, or initiating evacuation procedures. This integration strengthens overall safety measures and enables swift and effective responses to critical incidents.

Visual monitoring systems also facilitate data logging and analysis, which is crucial for post-incident investigations and safety improvements. These systems capture and store visual data from critical processes, allowing manufacturers to review the footage in case of accidents or near-misses. By analyzing the recorded data, manufacturers can identify root causes, evaluate safety protocols, and implement necessary corrective actions[16]. This data-driven approach to safety management enables continuous improvement and the prevention of recurring hazards.

In summary, visual monitoring systems play a vital role in ensuring safety and addressing hazards in the rubber (glove) manufacturing industry. By providing real-time surveillance, early detection of abnormalities, integration with safety mechanisms, and data-driven insights, these systems enhance safety protocols, reduce risks associated with critical processes, and safeguard the well-being of workers. The implementation of visual monitoring systems creates a safer work environment, promotes a culture of safety, and helps manufacturers maintain high standards of worker protection in the rubber glove manufacturing industry.

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2.4.2 Existing Visual Monitoring System in Manufacturing Industry

Visual monitoring systems have become essential tools in the manufacturing industry as companies strive to maintain product quality, process efficiency, and worker safety. These systems utilize advanced imaging technologies and computer vision algorithms to analyze visual data in real-time. By offering valuable insights into production processes, visual monitoring systems enable manufacturers to detect defects, optimize operations, and enhance overall productivity.

The purpose of this literature review is to investigate the existing visual monitoring systems employed in the manufacturing industry. It provides an overview of the technologies, applications, advantages, and challenges associated with these systems. By examining the current state-of-the-art in visual monitoring, this review aims to identify research gaps and suggest potential areas for future development and enhancement[6].

2.4.2.1 Infrared Thermography

Infrared thermography is a powerful visual monitoring technique used in various industries. It involves the use of infrared cameras to capture thermal images of objects or surfaces. By detecting and measuring infrared radiation emitted by objects, infrared thermography can identify temperature variations, hot spots, and thermal anomalies[17][7]. This technology is particularly useful in applications such as electrical inspections, building diagnostics, and equipment monitoring. It enables early detection of issues like overheating, insulation defects, and energy inefficiencies. Infrared thermography enhances safety, prevents equipment failures, and improves energy efficiency in industrial settings.

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2.4.2.2 Camera Vision

Camera vision, also known as machine vision, is a visual monitoring system that utilizes cameras and image processing algorithms to capture, analyze, and interpret visual data in real-time. It is widely used in the manufacturing industry for quality control and inspection purposes. Camera vision systems can detect and identify defects, measure dimensions, verify product integrity, and ensure compliance with specifications. They can be programmed to perform various tasks such as barcode reading, character recognition, and object recognition[18]. By automating the inspection process, camera vision systems improve efficiency, accuracy, and productivity while reducing human error. They are employed in diverse applications, including automotive, electronics, rubber, metal, glass, and packaging industries.

2.4.2.3 In-line Monitoring Systems

In-line monitoring systems are visual monitoring systems that are integrated directly into the production line or manufacturing process. These systems continuously monitor and inspect products at various stages of production, allowing for real-time detection of defects, anomalies, or deviations from specifications. In-line monitoring systems utilize a combination of sensors, cameras, and automated algorithms to capture and analyze data, enabling immediate corrective actions to be taken if any issues are detected[19]. By providing instant feedback and quality control during the production process, in-line monitoring systems help ensure consistent product quality, minimize waste, and optimize overall production efficiency.

2.4.2.4 Motion Analysis System

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Motion analysis systems are visual monitoring systems that analyze and track the motion of objects or individuals in a manufacturing environment. These systems utilize cameras, sensors, and advanced algorithms to capture and interpret the movement patterns, velocity, and trajectories of objects or people. By monitoring and analyzing motion, these systems can detect abnormalities, identify potential safety hazards, and optimize process efficiency. Motion analysis systems are commonly used in industries such as robotics, assembly lines, logistics, and sports analysis. They play a crucial role in improving productivity, preventing accidents, and optimizing workflows by providing real-time insights into motion-related activities within the manufacturing environment.

2.4.2.5 Color Inspection

Color inspection systems are visual monitoring tools used in the industrial sector to assess the color properties of materials or products. To detect and evaluate color properties like hue, saturation, and brightness, these systems make use of color sensors, cameras, and sophisticated algorithms. Color inspection systems can find color variations, inconsistencies, or manufacturing flaws by comparing the measured color values against predetermined standards or specifications. As a result, manufactures can guarantee product quality, maintain color uniformity, and satisfy client demands. In fields like automotive, textiles, printing, and food processing, where precise color matching and quality control are essential, color inspection devices are commonly utilized. They make it possible for producers to produce consistent and aesthetically pleasing goods through efficient and objective color assessment.

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2.5 Recent Development of Visual Inspection and Monitoring System in Industrial Automations

Visual inspection and monitoring systems for industrial automation have advanced significantly in recent years. These systems make use of cutting-edge technology like computer vision, machine learning, and artificial intelligence to improve quality control, efficiency, and safety in manufacturing operations.

Deep Learning and Convolutional Neural Networks (CNNs) are two types of neural networks. CNNs and other deep learning algorithms have revolutionised visual inspection and monitoring systems. CNNs can analyse and interpret images or video streams, allowing for the accurate detection of faults, anomalies, and quality variations. These models are very useful in industrial automation applications because they can be trained on massive datasets and learn complex patterns.

Monitoring and analysis in real time Visual inspection systems increasingly include real-time monitoring capabilities, allowing producers to discover and respond to problems as soon as they arise. Real-time analysis of massive volumes of visual data is possible thanks to high-speed cameras, innovative algorithms, and powerful processing gear. This aids in the detection of flaws or irregularities as they occur, reducing the manufacture of faulty items in the future and minimising downtime.

Traditional 2D visual inspection methods, unlike 3D vision systems, have limitations when it comes to analysing complex objects or spotting faults that arise in the third dimension. 3D vision systems acquire and analyse depth information using technologies such as structured light, laser triangulation, or stereo vision, allowing for more accurate examination and measurement of things[20].

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Visual inspection systems will be able to combine collaborative approaches between human operators and automated systems thanks to Human-Machine Collaboration. These devices help operators make informed judgements during the inspection process by giving real-time visual feedback and advice. This collaboration increases the inspection and monitoring system's overall accuracy and productivity.

Integration with Robotic Systems is being considered. Robotic systems are rapidly being combined with visual inspection and monitoring systems, resulting in seamless automation[18]. Visual examinations can be performed at great speeds and with surprising precision by robots that feature cameras and sensors. They are capable of handling repeated or dangerous inspection jobs, guaranteeing consistent quality while minimising error by humans[18].

Edge computing and IoT integration are on the rise. Edge computing and Internet of Things (IoT) technologies are being used in visual inspection systems to process and analyse data closer to the source. This lowers latency, allows for real-time decision-making, and optimises bandwidth utilization[18]. IoT connection enables centralised monitoring and control of various inspection units spread across multiple sites.

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Table 2.2: List of Development on Visual Monitoring

Title	Author	Method	Summary
Visual Monitoring of Photovoltaic Systems	Workshop on Visualisation in Environmental Sciences (EnvirVis) (2016) A. Middel, K. Rink, and D. Zeckzer (Editors)	Collecting data	• The data collection from online survey questionnaire. • •erformance Parameters • Environmental Parameters • Component Failures • Reporting Errors
Visual Monitoring of Civil Infrastructure Systems via Camera-Equipped Unmanned Aerial Vehicles (UAVs): A Review of Related Works	Youngjib Ham1*, Kevin K. Han2 , Jacob J Lin3 and Mani Golparvar-Fard2 Ham et al. Visualization in Engineering (2016)	A systematic literature review Collecting data	• Real-Time Monitoring: UAVs can transmit live video feeds or images in real-time, providing immediate visual feedback on the condition of infrastructure systems. This enables quick decision-making and facilitates timely maintenance or repairs.
Visualization system for field monitoring data and its effectiveness	Yo-Ming Hsieh ∗, Ya-Sue Lu	Collecting data Analysis and processing techniques to develop an inspection approach that could be applied	• The effectiveness of the visualization system is evaluated by considering factors such as user experience, ease of interpretation, efficiency in identifying important information, and overall impact on decision-making processes

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2.6 Visual Basic.NET (VB.NET)

In the realm of software development, selecting the right programming language is crucial for building efficient and robust applications. This section presents a comprehensive review of Visual Basic .NET (VB.NET), a powerful language that combines the user-friendly syntax of Visual Basic with the extensive capabilities of the .NET framework. By exploring the key features, advantages, and practical applications of VB.NET, this review aims to provide a comprehensive understanding of its potential in streamlining the application development process.

VB.NET offers a wide range of features and advantages that make it a popular choice among developers. Its seamless integration with the .NET framework provides access to an extensive library of pre-built components, tools, and resources. This vast ecosystem simplifies development tasks by offering solutions for common challenges like database connectivity, file handling, and network communication. Leveraging these resources, developers can significantly reduce development time, minimize coding efforts, and enhance application functionality.

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One of the primary benefits of VB.NET is its support for object-oriented programming (OOP) principles. This enables developers to create modular and maintainable code, facilitating code reuse, scalability, and improved code organization. VB.NET incorporates key OOP concepts, including inheritance, polymorphism, and encapsulation, allowing developers to design and implement complex software systems efficiently.

The Visual Basic .NET integrated development environment (IDE), available as part of Microsoft Visual Studio, provides a robust and user-friendly environment for application development. With features like code completion, debugging tools, and visual designers, the IDE enhances developer productivity and facilitates effective application debugging. Its intuitive interface and extensive toolset make VB.NET an ideal choice for individual developers as well as large development team(2,21)s.

VB.NET promotes strong type safety, reducing runtime errors and enhancing overall application reliability. The compiler performs thorough type checks during the compilation process, minimizing the occurrence of runtime exceptions and ensuring greater stability. Moreover, VB.NET supports multiple programming paradigms, including imperative, functional, and event-driven approaches, offering developers the flexibility to choose the most suitable programming style for their projects.

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Efficient database integration is another advantage of VB.NET, with seamless compatibility with technologies like ADO.NET and LINQ to SQL. These features enable developers to easily handle data access, manipulation, and storage, facilitating the creation of database-driven applications. VB.NET empowers developers to harness the power of databases for effective data-driven decision-making[21].

Visual Basic .NET (VB.NET) presents a compelling set of features and advantages for efficient application development. Its integration with the .NET framework, support for object-oriented programming, feature-rich IDE, strong type safety, and seamless database integration contribute to streamlined development processes and high-quality software solutions. By utilizing the capabilities of VB.NET, developers can create applications with enhanced functionality, reliability, and maintainability. VB.NET remains a valuable tool for developers, enabling them to meet the challenges of modern software development and deliver efficient solutions across various domains and platforms[21].

Table 2.3 Difference between VB.NET , C#, Java and Python

Feature	VB.NET	C#	Java	Python
Syntax	Natural language syntax, beginner-friendly.	C-like syntax, familiar to many programmers.	C-like syntax, familiar to many programmers.	Simple and expressive syntax, emphasizes readability.
Type System	Strongly typed with explicit type declarations.	Strongly typed with explicit type declarations.	Strongly typed with explicit type declarations.	Dynamically typed, with type inference.
Platform	Developed for the .NET framework, primarily for Windows.	Developed for the .NET framework, primarily for Windows.	Platform-independent, runs on the Java Virtual Machine (JVM).	Platform-independent, widely used.
Performance	Slightly slower than C# due to additional runtime features.	Slightly faster than VB.NET with more optimizations.	Performs well on the JVM.	Moderate performance, enhanced with compiled libraries.

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Feature	VB.NET	C#	Java	Python
Learning Curve	Easier for beginners with English-like syntax.	Requires some familiarity with C syntax.	Requires some familiarity with C syntax.	Beginner-friendly and easy to learn.
Language Features	Rich built-in features, database access, RAD tools.	Rich built-in features, modern language features.	Rich built-in features, extensive enterprise libraries.	Supports extensive libraries and modules.
Tooling & IDEs	Strong support in Visual Studio IDE, integrated tools.	Strong support in Visual Studio IDE, integrated tools.	Good support in IDEs like Eclipse and IntelliJ IDEA.	Good support in IDEs like PyCharm, Jupyter Notebook.
Industry Use	Legacy systems, desktop applications, Windows ecosystem.	Enterprise applications, game development, cross-platform .NET Core.	Enterprise applications, Android development, large-scale projects.	Web development, scientific computing, data analysis, AI.

2.7 Summary

In summary, the literature review focused on the rubber glove manufacturing industry, its processes, and the critical aspects that need to be considered. It highlighted the hazardous and critical processes involved in different stages of glove production, emphasizing the importance of safety measures and risk mitigation strategies[9]. The review also explored the potential benefits of visual monitoring systems in enhancing safety, quality control, and overall efficiency in the glove manufacturing industry. Additionally, the review discussed the utilization of VB.NET programming language in developing software solutions for visual monitoring systems in the rubber glove manufacturing sector. Overall, this literature review provides a comprehensive understanding of the rubber glove manufacturing industry, the significance of visual monitoring systems, and the application of VB.NET in addressing industry-specific challenges

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CHAPTER 3

METODOLOGY

3.1 Introduction

The present chapter provides a comprehensive coverage of the project workflow, exploring the diverse techniques utilised throughout its implementation. The objective of this chapter was to provide comprehensive details and verification pertaining to the execution of the project. The design and development of a visual monitoring system relied heavily on both hardware and software components, which were effectively implemented to produce a viable framework and tool for visual monitoring and analysis utilising VB.net.

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3.1 Project Milestone

The establishment of project milestones precedes the implementation of the research strategy. The objective of identifying these significant points is to showcase the advancement of the project plan. Through the allocation of specific timeframes for individual milestones and the development of a comprehensive project plan featuring a flowchart, milestones serve as a means of estimating the overall duration of a project. Figure 3.1 presents a flowchart that clearly illustrates the milestones.

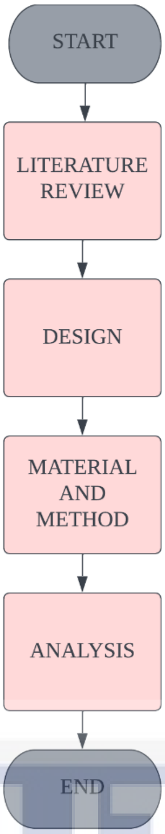

Figure 3.1 Project flowchart

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3.2 Incorporating Societal and Global Considerations in System Development

In the development of a visual monitoring system based on an industrial automation system for the rubber industry, it is crucial to incorporate societal and global considerations. One significant aspect to consider is the integration of environmental sustainability measures. The use of an infrared camera to detect thermal anomalies plays a vital role in this regard.

By utilizing an infrared camera, the system can detect and monitor thermal anomalies in real-time. This capability is essential for identifying potential issues in the rubber manufacturing process, such as overheating or inefficient energy usage. By detecting these anomalies, the system can alert operators or automatically adjust the parameters to optimize energy consumption, reduce waste, and minimize environmental impact.

Moreover, the visual monitoring system can contribute to improved worker safety and well-being. Infrared cameras can detect hotspots or abnormal heat patterns that may indicate equipment malfunctions or potential hazards. By promptly identifying these issues, the system can trigger alerts or automated actions to prevent accidents and ensure a safe working environment for employees.

In terms of global considerations, the visual monitoring system can aid in quality control and waste reduction. By detecting thermal anomalies and potential defects in the rubber manufacturing process, the system can prevent the production of faulty or substandard products. This not only ensures customer satisfaction but also reduces waste and minimizes the environmental impact associated with the disposal of defective items.

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Additionally, the use of a visual monitoring system based on an industrial automation system aligns with the global trend towards digitalization and Industry 4.0. This integration allows for data collection, analysis, and reporting, enabling manufacturers to make informed decisions regarding process optimization, resource allocation, and energy efficiency. It promotes the adoption of advanced technologies and positions the rubber industry as an innovative and sustainable sector in the global marketplace.

In conclusion, the development of a visual monitoring system based on an industrial automation system for the rubber industry, incorporating an infrared camera to detect thermal anomalies, addresses societal and global considerations. By integrating environmental sustainability measures, ensuring worker safety, improving quality control, and aligning with global trends, this system promotes sustainable manufacturing practices, resource efficiency, and competitiveness in the global market

3.3 Literature Review Phase

The project's objectives were initially scrutinised and deliberated with the supervisor. Upon completion of the project's objectives, the literature evaluation phase was initiated. The primary objective of conducting a literature review is to furnish a comprehensive amalgamation of prior research endeavours undertaken by academic scholars or organisations. The aforementioned studies have made noteworthy contributions in terms of conceptual frameworks, valuable insights, and methodological approaches pertaining to the constituent elements of the project, as well as the problem-solving strategies and analytical procedures involved. Upon endorsement of the project's goals, the supervisor granted authorization for the particular scopes that would be employed to achieve said objectives. The graphical illustration presented in Figure 3.2 depicts the procedure of conducting a literature review.

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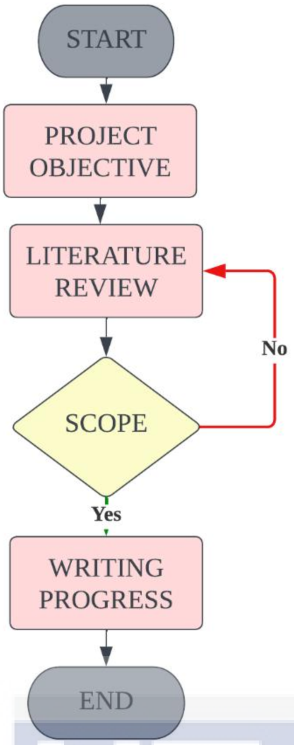

Figure 3.2 The Literature review flowchart

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3.4 Designing Phase

This section presents a detailed analysis of the procedures and methodologies employed in the development of a camera-based visual surveillance system. The primary objective of this project was to develop a real-time monitoring system for rubber manufacturing utilising the VB.net process. The successful attainment of the intended outcome necessitated the execution of crucial procedures such as data acquisition, system setup, experimentation, and troubleshooting. These techniques provided significant assistance in the development of data output and interpretation. Figure 3.3 depicts the sequential procedures that are imperative to accomplish the project efficiently. Through the implementation of these methodologies, the proposed visual monitoring system was effectively developed and assessed utilising VB.net.

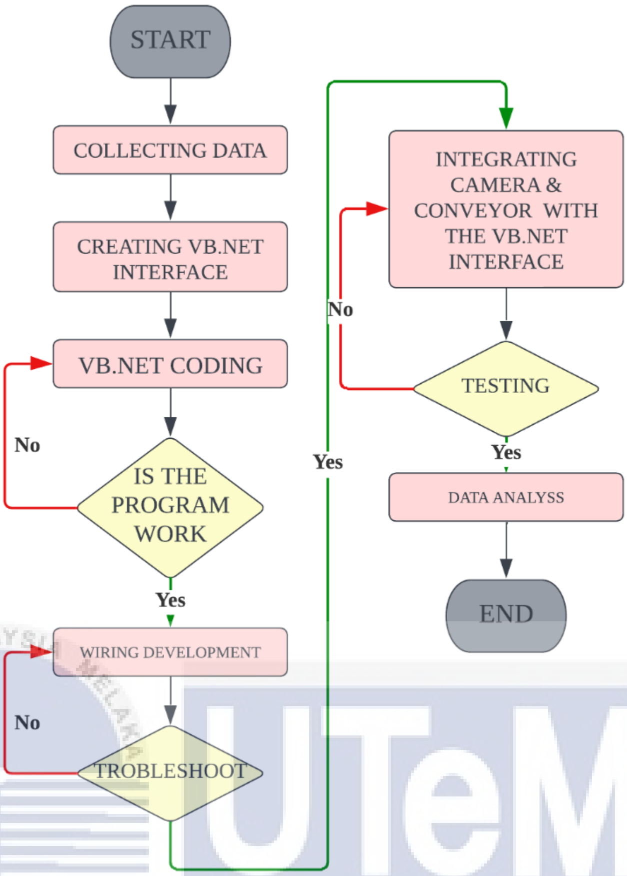

Figure 3.3 Flowchart for project designing

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3.4.1 System Block Diagram

The work depicted in Figure 3.4 endeavours to offer a streamlined and effective visual surveillance mechanism for the manufactured rubber(glove) sector. The diagrammatical representation illustrates the diverse constituent parts and their interrelatedness within the system. The presented illustration showcases the process of capturing, processing, and displaying data in real-time, thereby facilitating efficient monitoring of the fabrication process.

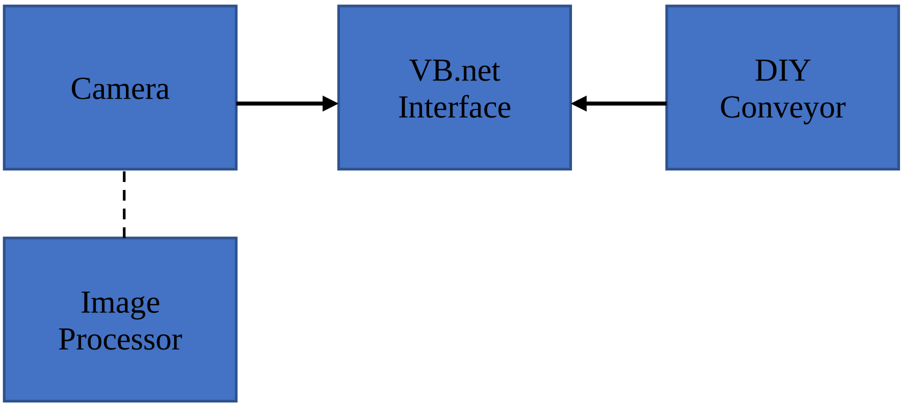

Figure 3.4 Block Diagram of The Designed Project

The present diagram depicts the utilisation of a camera for the purpose of acquiring visual information pertaining to the rubber fabrication procedure. The self-constructed conveyor mechanism facilitates the transportation of the manufactured latex constituents via the surveillance system. The VB.net interface functions as the primary locus for the processing and analysis of the visual data obtained from the camera. The system offers an interface that is easy to use for the purpose of monitoring and controlling industrial automation.

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3.5 Material and Method

The present section delineates the materials and methods utilised in the creation of the visual monitoring system for the industrial automation system in the fabricated rubber industry.

3.5.1 Software and Hardware

The present section pertains to the software and hardware constituents employed in the creation of the visual monitoring system. The software development component centres on the utilisation of the VB.net programming language as the principal instrument for coding and constructing the system. VB.net offers a sturdy framework for developing interfaces that are easy to use, managing data processing, and facilitating smooth interaction with hardware components.

3.5.1.1 Visual Studio

Visual Studio is an Integrated Development Environment (IDE) that is extensively utilised by programmers to construct various types of programmes, such as mobile applications, web applications, and video games. The software in question was developed by Microsoft and is compatible with both the Windows and macOS operating systems. Visual Studio provides a diverse range of programming languages support, such as C++, C#, and JavaScript, in addition to various functionalities like code completion, debugging, and version control.

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Additional functionalities can be incorporated through the integration of extensions and plugins. Visual Studio is a popular choice among programmers due to its user-friendly interface and extensive capabilities. The programming language utilised in this project is VB.net. This particular programming language is utilised within the Visual Studio software development environment. VB.net is considered to be a user-friendly programming language that facilitates ease of learning and operation for novice users.

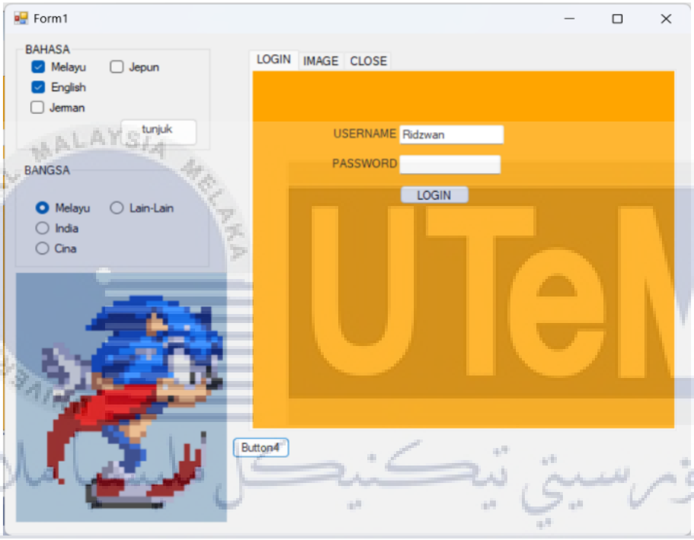

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Figure 3.5 Example of VB.NET function

The function depicted in Figure 3.5 above serves as an illustration of a capability that can be performed by Visual Basic. Figure 3.5 depicts a design that includes various graphical user interface elements such as a picture box, button, radio button, checkbox, timer, and tab control.

3.5.1.2 VB.NET Animation

The utilisation of animation is employed to replicate the operations of a conveyor line within an automated factory, through the portrayal of the progression of a workpiece as it moves from one station to the next. In order to create an animation, the implementation of a 'Timer' would be necessary. This would facilitate the movement of a simulated workpiece, which is represented by an image object frame, in a sequential manner from one direction to another at intervals of one second.

VB.Net offers various alternatives for emulating an animation. One possible approach is to perform a linear translation of an entity, such as a Picture Box. The task can be achieved by programming the direction of movement of the object and the rate of displacement in pixels per millisecond during the interval time. The aforementioned technique can be executed manually, whereby every activation of a button corresponds to the displacement of a pixel by a pre-established magnitude. The diagram depicted in Figure 3.6 demonstrates the movement of a box towards the right direction upon activation of the start button, simulating the operation of a conveyor. Conversely, the box comes to a halt upon pressing the stop button.

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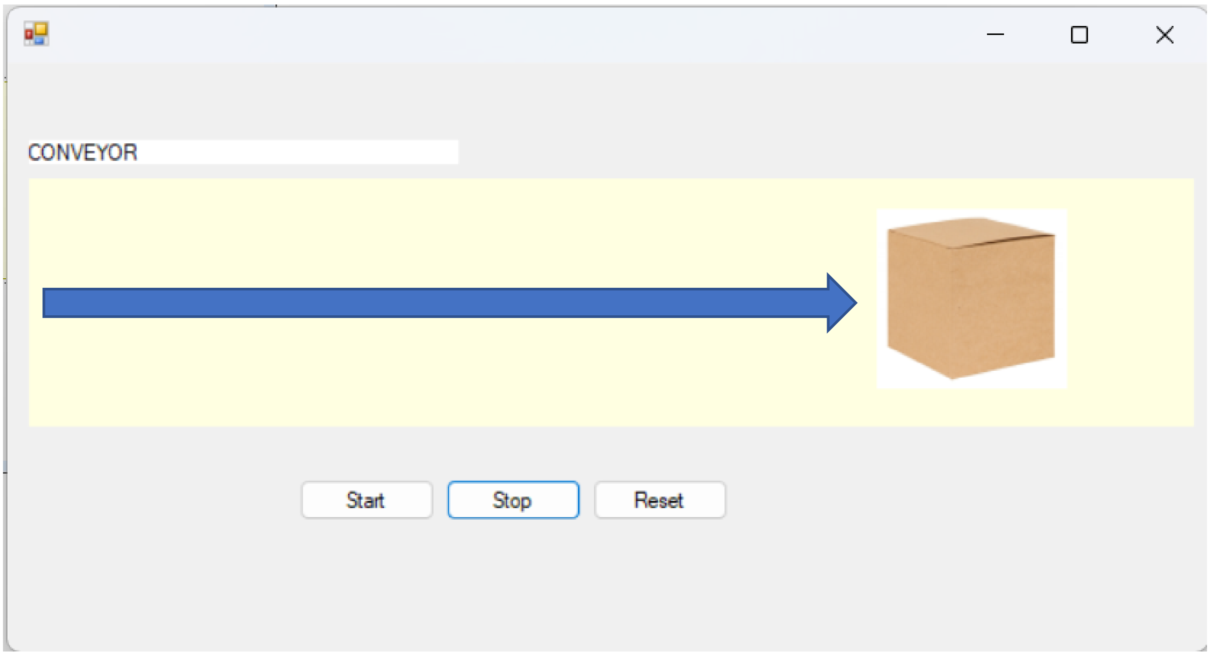

Figure 3.6 Animating the movement of object on the conveyor

The implementation of this approach would result in enhanced animation fluidity and successful project completion, notwithstanding the challenge of altering the animation sequence's direction due to the complex 'If' function utilised in the sub-program.

The Timer function is commonly employed by animation sequences in order to facilitate the movement of an object to a different position at regular intervals.

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```
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 3.7 A Part of Timer Code

The diagram depicted in Figure 3.7 illustrates the coding segment that employs the Timer_Tick event. The movement of the PictureBox is facilitated by the Timer_Tick event handler. During each iteration of the Timer control, the Left property of the PictureBox is incremented by the speed value, resulting in its movement towards the right-hand side of the form. Subsequently, the programme verifies whether the right boundary of the PictureBox has attained or surpassed the form's width. In the event that the PictureBox has undergone a change, the Left property of said PictureBox is assigned a value of 20, thereby resetting its position to the leftmost side of the form. The aforementioned procedure generates a motion effect whereby the PictureBox undergoes a left-to-right movement and subsequently returns to its initial position upon reaching the endpoint.

3.5.1.3 Camera Configuration to VB.Net

The utilisation of the Aforge.Net extension within the Visual Studio environment enables VB.net to effectively employ camera input for a diverse range of processing tasks, including but not limited to image recognition and motion sensing. The objective of configuring the camera input for the purpose of testing, utilising the laptop webcam, is to acquire an image and subsequently store it in a designated directory. This will facilitate the exploration and experimentation of the diverse functionalities of Aforge.Net extensions.

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By configuring the camera input, the Aforge.Net extension can establish a connection with the webcam on the laptop. This connection has been previously established. This linkage facilitates the ingress to the video output of the webcam within the application. Upon successful configuration of the camera input, the resultant output depicted in Figure 3.8 can facilitate a multitude of operations on the video stream, including but not limited to capturing and processing individual frames.

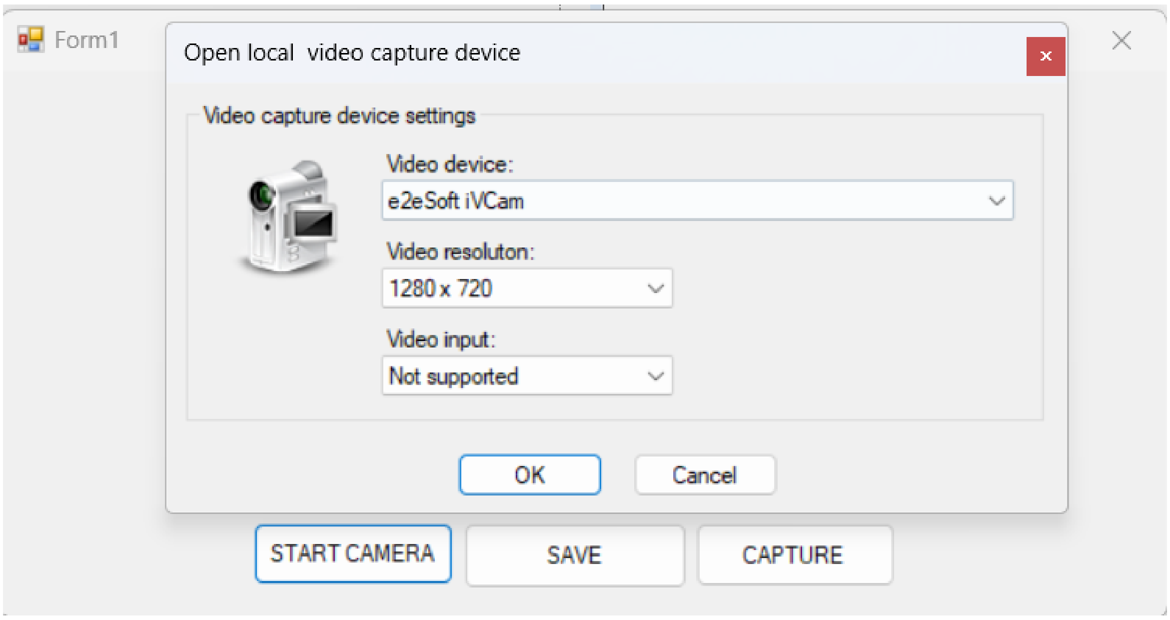

Figure 3.8 The VB.net Interface to Select Camera

The aim of the testing procedure is to acquire an image from a webcam and store it in a designated directory. The implementation of the necessary code can be achieved through the utilisation of the Aforge.Net extension. The procedure involves the acquisition of a frame from the video transmission at the designated time and preservation of the frame as an image file in a predetermined directory on the laptop.

This procedure for configuring and capturing images has broad applicability across various contexts. As an illustration, the utilisation of AI algorithms on the captured image can facilitate the development of a rudimentary image recognition system. One potential approach is to utilise motion sensing methodologies, which involve the ongoing analysis of frames extracted from a video stream to identify any changes or movements.

In general, the Aforge.Net extension for Visual Studio possesses the ability to employ a laptop's webcam for a diverse array of functions, spanning from rudimentary tasks such as acquiring images for evaluative purposes to more intricate applications such as image identification and motion detection.

3.6 Result Analysis Phase

The analysis component was formulated with reference to the second objective of the project, which involves the integration of camera sensor technology and image processing techniques into the existing monitoring system. The collected data will undergo evaluation to determine the camera's ability to detect the designated colour. In the event that the system exhibits suboptimal performance or fails to yield the intended outcome, it will undergo modifications to enable the attainment of the desired result. The analysis process flowchart is depicted in Figure 3.10.

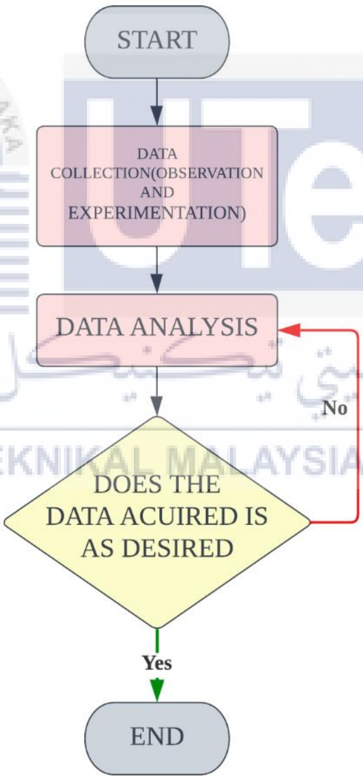

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Figure 3.9 Flowchart of Analysis Process

3.7 Summary

The methodology commences with an introductory section, which is succeeded by the identification of significant project milestones and the development of a project flowchart. The present discourse delves into the phase of literature review, wherein emphasis is placed on the amalgamation of antecedent research works and their respective contributions to the project.

The subsequent chapter provides an elaborate exposition of the process of design. The present study delineates the procedural framework employed in the creation of a VB.net-based visual monitoring system. The framework encompasses various stages such as data acquisition, deployment, experimentation, and troubleshooting. The sequential steps required for the successful completion of the project are depicted in a flowchart.

Subsequently, the materials and methodologies employed in the creation of the visual surveillance system are delineated. The software module centres on the utilisation of the VB.net programming language, with Visual Studio serving as the principal platform for software development. The salient features of Visual Studio and the user-friendly nature of VB.net are emphasised. The discourse delves into the utilisation of animation in VB.net, specifically in emulating the locomotion of entities on a conveyor. Furthermore, the present discourse expounds upon the setup of the camera input through the utilisation of the Aforge.Net extension in VB.net, thereby demonstrating its efficacy in applications such as image identification and motion detection.

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The final stage of the chapter entails the examination phase, which centres on the amalgamation of camera sensor technology and image processing methodologies into the surveillance system. The collected data is analysed to evaluate the performance of the system, and adjustments are implemented as deemed necessary.

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CHAPTER 4

Result and Discussion

4.1 Introduction

The creation of a visual monitoring system for the rubber industry that is based on an industrial automation system, employs the VB.NET programming language, and makes use of an infrared camera to identify temperature abnormalities is a major project that may result in a variety of positive outcomes. During the manufacture of rubber products, this system's goals are to improve both the efficiency of the process and the quality control, as well as the safety of the workers. It does this by merging cutting-edge technology and automation, which enables it to provide real-time monitoring and analysis of heat patterns, so enabling early diagnosis and avoidance of any problems. In this section, the results and discussion of the study are presented. Particular emphasis is placed on the most important conclusions, problems, and consequences for the rubber sector.

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4.2 Project Prototype Hardware

Using VB.NET as the programming language and an infrared camera intergrate with thermal camera sensor to detect thermal anomalies on the conveyor production line, the visual monitoring system based on an industrial automation system for the rubber industry has produced significant results and provided valuable insights for the sector.

The conveyor manufacturing line's thermal patterns can now be monitored and analysed in real time thanks to the visual monitoring system's successful integration of the infrared camera with the industrial automation system. The device recorded thermal data and identified hotspots and other thermal abnormalities on the conveyor with high precision.

Several major takeaways about the conveyor manufacturing line were gleaned from the examination of the system's performance. The system's capacity to monitor in real time meant that any heat abnormalities along the conveyor belt could be spotted right away. Because of how quickly the problems were identified, the possibility for equipment failure and product failures was greatly reduced. The system's real-time detection and correction of such irregularities enhanced production efficiency and reduced the number of conveyor line stops.

Second, the quality control on the conveyor belt was much improved thanks to the visual monitoring system. The technology detected irregularities in heat patterns that may have been caused by flaws or other variances in the rubber goods being sent. This early diagnosis allowed for timely actions, which guaranteed constant product quality and cut down on waste. In addition to streamlining quality control operations, the system's real-time warnings and automatic actions increased product dependability on the assembly line.

In addition, the visual monitoring system made a big difference in protecting employees along the conveyor belt. The technology improved the safety of the conveyor's operators by alerting them to imminent threats like overheating or broken machinery. By providing alarms and taking immediate action, the system ensured the safety of its users and reduced the likelihood of accidents.

Overall, the findings prove that the VB.NET- and infrared-based visual monitoring system used in the rubber industry's conveyor manufacturing line is successful at identifying heat abnormalities. The system's ability to monitor in real time has a positive impact on productivity, quality assurance, and worker safety. The system's successful deployment exemplifies the possibility of incorporating cutting-edge technology into manufacturing procedures, therefore boosting efficiency, cutting down on waste, and making the rubber sector more competitive, particularly in the area of the conveyor production line.

4.2.1 Thermal Sensor Amg8833 circuit design

The circuit design for the AMG8833 thermal sensor involves integrating the sensor with an Arduino microcontroller using the I2C protocol. Connect the sensor's VCC and GND pins to the Arduino's 3.3V output and ground, respectively, and establish communication through the SDA and SCL pins to enable temperature data retrieval. The Arduino serves as the central processor, and a USB connection is established for real-time data transfer between the Arduino and the computer. Develop a C# program in Visual Studio to receive and process the data, utilizing the System.IO.Ports namespace for USB communication. The program dynamically updates a PictureBox to display the thermal image captured by the AMG8833 sensor. Additionally, ensure a stable power supply for both the Arduino and the sensor, using an appropriate source like a battery or external power supply to complete the circuit.

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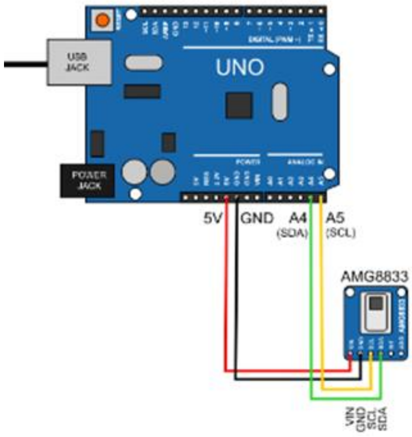

Figure 4.1 Amg8833 Sensor Circuit diagram

4.2.2 Conveyor circuit design

The Arduino Uno is the circuit's "brain," processing orders from an input source and outputting control signals to the motor driver. The L298N motor driver is what connects the DC motor to the Arduino.

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When first powered up, the Arduino goes through an initialization process. The code then enters a loop to patiently await instructions. The programme will examine the kind of the command when it is received. If the instruction is to turn on the motor, the computer will tell the motor driver how fast and which way to spin the shaft.

Once the engine has started, the software will wait for further instructions. When the programme detects an order to stop the motor, it communicates that information to the motor driver so that the motor stops spinning. When the programme receives an order to modify the motor's speed or direction, it modifies the signals delivered to the motor driver appropriately. In order to ensure that the motor is constantly monitored and controlled, the programme loops back after performing the instruction in order to await additional input commands.

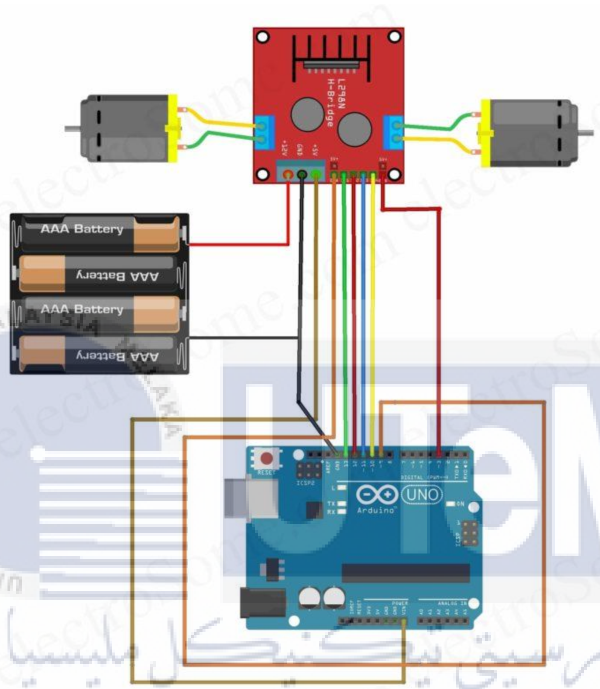

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Figure 4.2 Conveyor circuit diagram

4.2.3 Image detection result

The form's PictureBox fields are used to display the detected images. Webcam images are captured by the Video_NewFrame event listener, which then filters them using an algorithm depending on the minimum and maximum RGB values you provide. This method produces a filtered picture that only contains the specified colour or hues.

The Grayscale filter from the AForge.NET library is used to transform the filtered picture to a grayscale format, which streamlines the processing processes. Next, we utilise the BlobCounter class to locate isolated spots of colour inside the monochrome picture. Using the image's MinHeight and MinWidth parameters, it isolates related areas of a certain size. Colour blotches might form in certain areas.

In a list called RECTS, the recognised blobs have been converted into rectangles for storage. Using the Graphics class, a green rectangle is drawn within each shape. The detected colour blobs are displayed here. The PictureBoxORI control shows the unfiltered, unhighlighted image captured by the camera, whereas the PictureBoxFLTR control does the opposite.

Visualising the outcomes of the camera's image recognition allows for quick and accurate identification of the webcam feed areas or objects that meet the criteria you set. Object recognition, quality assurance, and anomaly detection are just some of the many uses for this data.

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Figure 4.3 Image detection

4.2.4 Thermal Sensor Result

The AMG8833 thermal sensor operates through an 8x8 grid of infrared sensors, detecting and measuring heat signatures to create a thermal image. When integrated with an Arduino, the sensor communicates via the I2C protocol, facilitating temperature data retrieval. This process involves connecting the sensor to the microcontroller, reading temperature values, and establishing a serial communication link to transfer the data to a computer.

For displaying the thermal results on Visual Studio using a PictureBox, the Arduino code reads temperature values, sending them to the computer through USB. In Visual Studio, a C# program processes the incoming data to dynamically update the PictureBox. By assigning colors or intensity values to temperature levels, the PictureBox serves as a real-time visual representation of the heat distribution captured by the AMG8833 sensor. This chapter outlines the integration of the sensor with Arduino, the data transfer process, and the creation of a dynamic thermal image display using Visual Studio and PictureBox.

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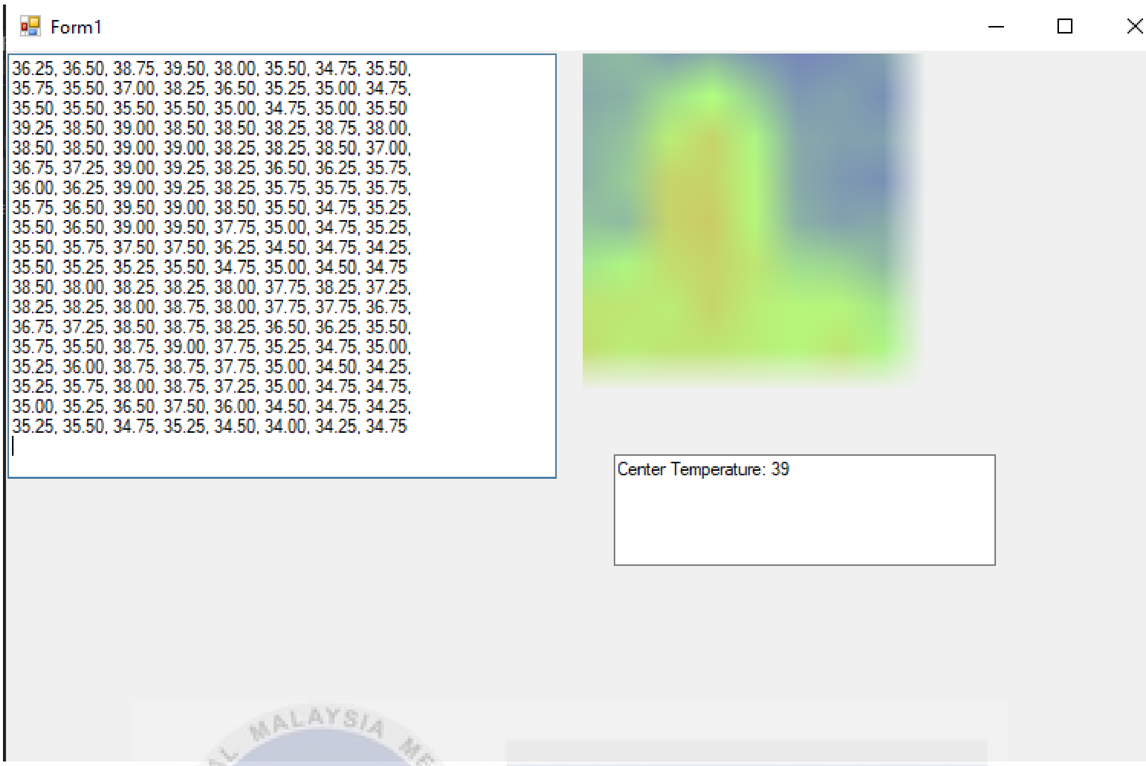

Figure4.4 Thermal Sensor Result

4.3 Summary

The VB.NET color recognition system has been upgraded by adding a thermal sensor, expanding its abilities to also measure temperature. This upgrade is expected to make the system more precise and useful, especially in industries where knowing both color and temperature is important. Combining the information from color and thermal sensors opens up new possibilities for closely watching and understanding industrial processes. To make sure the system works well, it's important to keep testing and improving it. This ongoing process will ensure the system becomes a strong and trustworthy tool for industries, helping with tasks like checking product quality and making processes more efficient.

CHAPTER 5

Conclusion

5.1 Conclusion

The creation of the Visual Monitoring System within the context of an Industrial Automation System, specifically tailored for the rubber industry, has marked a significant milestone. Employing VB.NET as the programming framework, the system incorporates both a camera and the AMG8833 thermal sensor. The integration of the camera is instrumental in precise color recognition, thereby enhancing the quality control processes within the rubber industry. Concurrently, the incorporation of the AMG8833 thermal sensor brings temperature data into the system, addressing the specific needs of the rubber manufacturing environment. This dual-sensor approach not only diversifies the system's utility but also opens up novel possibilities for detailed monitoring and analysis within the rubber industry. Ongoing testing and refinement are crucial for optimizing the system, ensuring its robustness and reliability in contributing to improved product monitoring and automation processes within the unique requirements of the rubber industry.

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5.2 Future Work

We plan to refine calibration methods to ensure precise temperature measurements, especially in challenging manufacturing conditions. Investigating optimal sensor placement and orientation is key for accurate data collection. Additionally, we will explore thermal imaging techniques to improve the visualization of temperature patterns, aiding quick detection of irregularities. Real-time feedback mechanisms based on thermal data will be developed for prompt manufacturing adjustments, contributing to consistent product quality.

Integrating thermal sensor data into broader manufacturing control systems and creating a user-friendly interface will facilitate seamless incorporation into daily operations.

5.3 Project Potential

The project's combination of a visual monitoring system with a thermal sensor, especially in manufacturing, offers significant benefits for everyday applications. Its real-time monitoring, in conjunction with the thermal sensor, enables proactive maintenance scheduling by spotting temperature changes and potential equipment concerns quickly, enabling ongoing and uninterrupted production operations. Furthermore, the system's competent temperature data analysis improves quality control measures inside manufacturing, maintaining constant product quality by quickly recognising discrepancies. The emphasis on energy efficiency analysis is consistent with sustainability goals, assisting in the identification and optimisation of energy-intensive activities. The suggested user-friendly interface and real-time feedback mechanisms empower production operators, promoting increased efficiency, decreased mistakes, and increased overall productivity in day-to-day operations. In addition, the system's capacity to give precise insights on temperature distributions is useful for regulatory compliance is especially important in businesses where certain temperature ranges are required for product quality and safety. In essence, the project's contributions provide a comprehensive set of benefits for everyday use, including proactive maintenance, increased quality control, energy efficiency, operator decision-making, and adherence to industry regulations, all of which contribute to a more efficient, reliable, and sustainable manufacturing environment.

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APPENDICES

Coding for amg8833

```
#include <Wire.h>
#include <Adafruit_AMG88xx.h>

Adafruit_AMG88xx amg;

void setup() {
  Serial.begin(9600);




  Serial.println("AMG8833 Test");

  if (!amg.begin()) {
    Serial.println("Could not find a valid AMG8833 sensor, check wiring!");
    while (1);
  }

  Serial.println("AMG8833 sensor found!");
}

void loop() {
  // Read the temperature data from the sensor
  float pixels[64];
  amg.readPixels(pixels);

  // Print the temperature values to the serial monitor
  Serial.println("Pixel temperatures:");

  for (int row = 1; row <= 8; row++) {
    for (int col = 1; col <= 8; col++) {
      Serial.print(pixels[64 - row * 8 + col - 1]);
      Serial.print("\t");
    }
    Serial.println();
  }

  delay(1000);  // You can adjust the delay based on your needs
}
```

(servo testing coding)

```
#include <Servo.h>

Servo myServo;  // Create a servo object

void setup() {
  Serial.begin(9600);
  myServo.attach(9);  // Attach the servo to pin 9
}

void loop() {
  if (Serial.available() > 0) {
     String command = Serial.readStringUntil('\n');
    Serial.print("Received: ");
    Serial.println(command);

    if (command == "ON\n") {
      // Move the servo to a specific angle (adjust as needed)
      myServo.write(90);
      delay(500);
    } else if (command == "OFF\n") {
      // Move the servo to another angle (adjust as needed)
      myServo.write(0);
      delay(500);
    }
  }
}
```

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Appendix B Mirosoft studio Coding

(Pixel data read in text box)

```
  using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.IO.Ports;
using System.Linq;
using System.Runtime.InteropServices.WindowsRuntime;
using System.Text;
using System.Threading;
using System.Threading.Tasks;
using System.Windows.Forms;

namespace amgdisplay
{
    public partial class Form1 : Form
    {
        SerialPort serialport1;

        public Form1()
        {
            InitializeComponent();
            InitializeSerialPort();

            Thread readThread = new Thread(ReadDataFromSerial);
            readThread.Start();

        }

        private void InitializeSerialPort()
        { serialport1 = new SerialPort();
            serialport1.PortName = "COM6";
            serialport1.BaudRate = 9600;

            try
            {
                serialport1.Open();
            }
            catch (Exception ex)
            {
                MessageBox.Show("Error opening serial port: " + ex.Message);
            }
        }
        private void ReadDataFromSerial()
        {
            while (true)
            {
                try
                {
                    string data = serialport1.ReadLine();

                    // Check if the form is created before updating the TextBox
                    if (IsHandleCreated)
                    {
                        // Update the TextBox on the UI thread
                        BeginInvoke(new Action(() =>
                        {
```

```
                            // Parse the received data and display pixel values
in the TextBox
                            DisplayPixelValues(data);
                        }));
                    }
                }
                catch (Exception ex)
                {
                    MessageBox.Show("Error reading from serial port: " +
ex.Message);
                }
            }
        }
        private void DisplayPixelValues(string data)
        {
            // Parse the received data and display pixel values in the TextBox
            string[] pixelValues = data.Split('\t');

            for (int i = 0; i < pixelValues.Length; i++)
            {
                textBox1.AppendText($"{pixelValues[i]} °C");

                // Add a comma and space after each pixel value, except for the
last one
                if (i < pixelValues.Length - 1)
                {
                    textBox1.AppendText(", ");
                }

                // Display a new line after every 8 pixels
                if ((i + 1) % 8 == 0 && i != pixelValues.Length - 1)
                {
                    textBox1.AppendText(Environment.NewLine);
                }
            }

            // Clear the TextBox after every 8 lines
            if ((pixelValues.Length + 1) % 8 == 0)
            {
                textBox1.Clear();
            }
        }
        private void Form1_Load(object sender, EventArgs e)
        {

        }
        private void Form1_FormClosing(object sender, FormClosingEventArgs e)
        {
            // Close the serial port when the form is closing
            if (serialport1.IsOpen)
            {
                serialport1.Close();
            }
        }
    }
}
```

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New coding include picture box

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.IO.Ports;
using System.Linq;
using System.Runtime.InteropServices.WindowsRuntime;
using System.Text;
using System.Threading;
using System.Threading.Tasks;
using System.Windows.Forms;

namespace amgdisplay
{
    public partial class Form1 : Form
    {
        SerialPort serialport1;

        public Form1()
        {
            InitializeComponent();
            InitializeSerialPort();

            Thread readThread = new Thread(ReadDataFromSerial);
            readThread.Start();

        }

        private void InitializeSerialPort()
        { serialport1 = new SerialPort();
            serialport1.PortName = "COM6";
            serialport1.BaudRate = 9600;

            try
            {
                serialport1.Open();
            }
            catch (Exception ex)
            {
```

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```
            MessageBox.Show("Error opening serial port: " + ex.Message);
        }
    }
    private void ReadDataFromSerial()
    {
        while (true)
        {
            try
            {
                string data = serialPort1.ReadLine();


                    BeginInvoke(new Action(() =>
                {
                    DisplayPixelValues(data);

            }));
            }
            catch (Exception ex)
            {
                MessageBox.Show("Error reading from serial port: " + ex.Message);
            }
        }
    }


    private void DisplayPixelValues(string data)
    {
        // Parse the received data and display pixel values in the TextBox
        string[] pixelValues = data.Split('\t');

        // Clear TextBox
        textBox1.Clear();

        // Clear PictureBox
        pictureBox1.Image = null;

        // Clear Temperature PictureBox
        pictureBoxTemperature.Image = null;

        // Create Bitmap for PictureBox
        Bitmap bitmap = new Bitmap(8, 8);

        // Create Bitmap for Temperature PictureBox
        Bitmap temperatureBitmap = new Bitmap(8, 8);

        try
        {

            for (int i = 0; i < pixelValues.Length; i++)
            {
```

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```
            // Display the value in TextBox
            textBox1.AppendText($"{pixelValues[i]} °C");

            // Add a comma and space after each pixel value, except for the last one
            if (i < pixelValues.Length - 1)
            {
                textBox1.AppendText(", ");
            }

            // Convert temperature to color
            if (int.TryParse(pixelValues[i], out int temperature))
            {
                Color pixelColor = GetColorForTemperature(temperature);

                // Set the corresponding pixel in PictureBox
                int x = i % 8;
                int y = i / 8;
                bitmap.SetPixel(x, y, pixelColor);

                // Set the corresponding pixel in Temperature PictureBox
                temperatureBitmap.SetPixel(x, y, pixelColor);
            }
            else
            {
                // Handle the case where parsing fails (e.g., non-numeric input)
                MessageBox.Show($"Invalid temperature value: {pixelValues[i]}", "Error");
            }
        }
    }
    catch (Exception ex)
    {
        MessageBox.Show($"An error occurred: {ex.Message}", "Error");
    }


    // Display the bitmap in PictureBox
    pictureBox1.Image = bitmap;

    // Display the temperature-colored bitmap in Temperature PictureBox
    pictureBoxTemperature.Image = temperatureBitmap;

    // Display a new line after every 8 pixels
    if ((pixelValues.Length + 1) % 8 == 0)
    {
        textBox1.AppendText(Environment.NewLine);
    }
}

private Color GetColorForTemperature(int temperature)
{
    // Define the temperature range for the gradient (0 to 80 degrees Celsius)
```

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```
            int minTemperature = 0;
            int maxTemperature = 80;

            // Interpolate the color based on the temperature
            int red = (int)(255 * (temperature - minTemperature) / (double)(maxTemperature - 
minTemperature));
            int blue = 255 - red;

            // Return the color
            return Color.FromArgb(red, 0, blue);
        }



        private void Form1_Load(object sender, EventArgs e)
        {

        }
        private void Form1_FormClosing(object sender, FormClosingEventArgs e)
        {
            // Close the serial port when the form is closing
            if (serialport1.IsOpen)
            {
                serialport1.Close();
            }
        }

        private void pictureBox1_Click(object sender, EventArgs e)
        {

        }
    }
}
```

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Full functioning coding

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.IO.Ports;
using System.Linq;
using System.Runtime.InteropServices.WindowsRuntime;
using System.Text;
using System.Threading;
using System.Threading.Tasks;
using System.Windows.Forms;
```

```
namespace amgdisplay
{
  public partial class Form1 : Form
  {
    SerialPort serialport1;
    float[] pixels;
    string[] values;
    public Form1()
    {
      InitializeComponent();
      InitializeSerialPort();


    }

    private void InitializeSerialPort()
    { serialport1 = new SerialPort();
      serialport1.PortName = "COM6";
      serialport1.BaudRate = 9600;
      serialport1.DataBits = 8;
      serialport1.Parity = Parity.None;
      serialport1.StopBits = StopBits.One;
      serialport1.DataReceived += SerialPort_DataReceived;
      pixels = new float[64];
      values = new string[64];
      try
      {
        serialport1.Open();
      }
      catch (Exception ex)
      {
        MessageBox.Show("Error opening serial port: " + ex.Message);
      }
    }
    private StringBuilder receivedData = new StringBuilder();
    private void SerialPort_DataReceived(object sender, SerialDataReceivedEventArgs e)
    {


      try
      {
        string data = serialport1.ReadExisting();
        receivedData.Append(data);

        // Process the received data whenever a newline character is found
        while (receivedData.ToString().Contains("\n"))
        {
          int newlineIndex = receivedData.ToString().IndexOf("\n");
          string completeData = receivedData.ToString(0, newlineIndex + 1);
```

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```
            // Remove the processed data from the StringBuilder
            receivedData.Remove(0, newlineIndex + 1);

            BeginInvoke(new Action(() =>
            {
                DisplayPixelValues(completeData);
            }));
        }
    }
    catch (Exception ex)
    {
        Console.WriteLine($"Error reading from serial port: {ex.Message}");
    }

}
private void DisplayPixelValues(string data)
{
    // Parse the received data and display pixel values in the TextBox
    string[] pixelValues = data.Split('\t');
    if (pixelValues.Length != 64)
    {
        Console.WriteLine("Invalid data format: " + data);
        return;
    }


    for (int i = 0; i < pixelValues.Length; i++)
    {
        try
        {
            if (!string.IsNullOrEmpty(pixelValues[i]))
            {

                textBox1.AppendText($"{pixelValues[i]}");

                // Add a comma and space after each pixel value, except for the last one
                if (i < pixelValues.Length - 1)
                {
                    textBox1.AppendText(", ");
                }


                // Display a new line after every 8 pixels
                if ((i + 1) % 8 == 0 && i != pixelValues.Length - 1)
                {
                    textBox1.AppendText(Environment.NewLine);

                }
            }

            else
```

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```
                {
                    textBox1.AppendText("N/A");
                    // Handle the case where parsing fails (e.g., non-numeric input)
                }




                // Clear the TextBox after every 8 lines
                if ((pixelValues.Length + 1) % 8 == 0)
                {
                    textBox1.Clear();
                }

                values = data.Split('\t');
                UpdatePictureBox(Array.ConvertAll(pixelValues, x => float.TryParse(x, out float result) ?
result : float.NaN));
            }

            catch (Exception ex)
            {
                Console.WriteLine($"Error displaying pixel values: {ex.Message}");
            }
        }
    }


        private void UpdatePictureBox(float[] values)
        {
            try
            {
                if (pixels.Length != 64)
                {
                    Console.WriteLine("Invalid values array length");
                    // Ensure that the array has the correct length
                    return;
                }

                Bitmap bitmap = new Bitmap(8, 8);

                // Map temperature values to colors
                for (int row = 0; row < 8; row++)
                {
                    for (int col = 0; col < 8; col++)
                    {
                        int pixelIndex = row * 8 + col;
                        float temperature = values[pixelIndex];

                        // Map temperature to color (adjust the mapping based on your needs)
                        int colorValue = (int)((temperature / 80) * 255);
                        Color color = Color.FromArgb(colorValue, 0, 255 - colorValue);
```

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```
                bitmap.SetPixel(col, row, color);
              }
            }

            // Update PictureBox with the new image
            pictureBox1.Image = bitmap;

          }
          catch (Exception ex)
          {
            Console.WriteLine($"Error updating PictureBox: {ex.Message}");
          }
        }



        private void Form1_Load(object sender, EventArgs e)
        {

        }
        private void Form1_FormClosing(object sender, FormClosingEventArgs e)
        {

          if (serialport1.IsOpen)
          {
            serialport1.Close();
          }
        }

      private void pictureBoxTemperature_Click(object sender, EventArgs e)
      {

      }

      private void pictureBox1_Click(object sender, EventArgs e)
      {

      }
    }
  }
```

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