DESIGN AND FABRICATION OF SORTING SYSTEM ON CONVEYOUR BELT

By

Asif Ahammad
19221011
MD.Shimanto
19121008
Akib Hossain Tasdid
18221011
Arman Bin Mahmud
19121010

A Final Year Design Project (FYDP) submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering

Department of Electrical and Electronic Engineering
Brac University
May, 2024

DESIGN AND FABRICATION OF SORTING SYSTEM ON CONVEYOUR BELT

By

Asif Ahammad
19221011
MD.Shimanto
19121008
Akib Hossain Tasdid
18221011
Arman Bin Mahmud
19121010

A project submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirements for the degree of
Bachelor of Science in Electrical and Electronic Engineering

Academic Technical Committee (ATC) Panel Members:

Dr. Abu Hamed M. Abdur Rahim (Chair)

Professor, Department of EEE, BRAC University

Tasfin Mahmud (Member)

Lecturer, Department of EEE, BRAC University

Md. Mehedi Hasan Shawon (Member)

Lecturer, Department of EEE, BRAC University

Department of Electrical and Electronic Engineering

Brac University

May 2024

Declaration

It is hereby declared that,

1. The Final Year Design Project (FYDP) submitted is my/our own original work while completing degree at Brac University.
2. The Final Year Design Project (FYDP) does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The Final Year Design Project (FYDP) does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I/We have acknowledged all main sources of help.

Student's Full Name & Signature:

Asif Ahammad 19221011	**MD.Shimanto** 19121008
Akib Hossain Tasdid 18221011	**Arman Bin Mahmud** 19121010

Approval

The Final Year Design Project (FYDP) titled "Design and fabrication of sorting system on conveyor belt" submitted by,

1. Asif Ahammad (19221011)
2. MD. Shimanto (19121008)
3. Akib Hossain Tasdid (18221011)
4. Arman Bin Mahmud (19121010)

of Spring, 2024 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering (BSEEE) on 18th April, 2024.

Examining Committee:

Academic Technical Committee (ATC):
(Chair)

____
Abu Hamed M. Abdur Rahim, PhD
Professor, Department of EEE
BRAC University

Final Year Design Project Coordination Committee:
(Chair)

____
Abu S.M Mohsin, PhD
Associate Professor, Department of EEE
BRAC University

Department Chair:

____
Md Mosaddequr Rahman, PhD
Professor and Chairperson, Department of EEE
BRAC University

Ethics Statement

This research has been carried out with honesty and transparency, accurately reporting methods, results, and any limitations or biases. Proper citations and references from the referred research papers, journals, and articles have been included to acknowledge the intellectual contributions of the respective authors. Furthermore, a plagiarism check on the complete project report confirmed that we have successfully maintained the similarity index result of 7% has been obtained for this report.

Abstract

In contemporary industrial environments, optimizing sorting processes is vital for productivity, error reduction, and quality control across sectors like manufacturing, logistics, recycling, and food processing. Traditional methods often prove inadequate due to labor intensiveness and lack of adaptability. This thesis proposes a sorting solution integrating advanced technologies like AI and IoT with practical considerations of cost-effectiveness and scalability. By addressing industry requirements and technological capabilities, it aims to develop a robust system delivering precision, efficiency, and flexibility while remaining economically viable and scalable. Bridging the gap between aspiration and practicality, this project provides industries with a dependable sorting solution to meet dynamic demands, enhancing productivity and competitiveness.

Keywords: Sorting processes; Industrial environments; image processing; categorization; IoT technology; real-time data tracking

Dedication

We want to dedicate our work to our parents, who have encouraged and supported us in our project so that we can finish the project successfully. We also want to dedicate our work to our ATC panel members who guided us throughout this journey. Their unwavering motivation has kept us on track and inspired us to achieve our goals for this project. Besides, we want to dedicate this work to every person who has helped us to implement our project till now.

Acknowledgement

We would like to extend our sincere gratitude to the esteemed members of our ATC panel. Their expertise, guidance and insightful feedback have been instrumental in shaping and refining our ideas leading up to the successful completion of our Final Year Design Project. We thank our family for allowing us to invest in this project, pledging their hope. We would like to thank our ATC Panel Chair, Prof. Dr. A. H. M. Abdur Rahim for his immense supervision while guiding us towards our goal. Moreover, we thank our Co- advisers, lecturer Tasfin Mahmud and Mehedi Hasan Shawon for being available whenever we needed them and willingly guiding us throughout the construction of the project considering our drawbacks that might have impacted our project. Additionally, the members of the FYDP sub-committee are to be thanked for their advice and assistance at various critical stages of our project. Lastly, we thank our department for presenting us with the opportunity to showcase our project in front of the audience.

Table of contents

List of Figures

List of Tables

Chapter 1: Introduction [CO1, CO2, CO3, CO10]

1.1 Introduction

In contemporary industrial environments, optimizing sorting processes is a critical challenge across diverse sectors like manufacturing, logistics, recycling, and food processing. The effectiveness of sorting directly influences productivity, error reduction, and overall quality control. However, traditional methods reliant on manual labor or simplistic automation systems often prove inadequate, resulting in inefficiencies and heightened operational costs.

The core of this challenge lies in the necessity for a sorting system capable of accurately categorizing objects based on various attributes such as size, shape, color, or material composition. Traditional methods, while familiar, are labor-intensive, error-prone, and lack the adaptability demanded by modern production environments. Additionally, as industries transition towards increased automation and digital integration, there's a growing demand for sorting solutions leveraging advanced technologies like image processing, artificial intelligence (AI), and Internet of Things (IoT) (Lodewiiks, 2016) connectivity.

This thesis sets out to address these multifaceted challenges by proposing a comprehensive sorting solution (Syufrijal, 2021, March) that integrates cutting-edge technologies with practical considerations of cost-effectiveness and scalability. Through a thorough examination of industry requirements and technological capabilities, this study aims to develop a robust sorting system capable of delivering precision, efficiency, and flexibility while remaining economically viable and scalable.

By navigating the complexities of integrating advanced functionalities with pragmatic implementation strategies, this thesis seeks to bridge the gap between aspiration and practicality in industrial sorting processes. Ultimately, the objective is to provide industries with a dependable and adaptable sorting solution equipped to meet the dynamic demands of today's industrial landscape while fostering enhanced productivity and competitiveness.

1.1.1 Problem Statement:

The overall project aims to address the challenge of optimizing the sorting process of objects on conveyor belts within industrial settings. In many industries, such as manufacturing, logistics, recycling, and food processing, the efficient sorting of objects based on various criteria is essential for maximizing productivity, minimizing errors, and ensuring quality control. However, traditional sorting methods often rely on manual labor or rudimentary automation systems, leading to inefficiencies, inaccuracies, and increased operational costs.

One of the primary challenges faced in this context is the need for a sorting system that can effectively categorize objects based on specific attributes, such as size, shape, color, or material composition. Conventional methods, such as manual sorting or basic mechanical systems

(Mattone, 2000), are labor-intensive, time-consuming, and prone to human error. Moreover, they lack the scalability and adaptability required to handle diverse types of objects or fluctuating production demands.

Additionally, as industries strive for increased automation and integration with digital technologies, there is a growing demand for sorting systems that can leverage advanced techniques such as image processing (Tho, 2016, November), artificial intelligence, and Internet of Things (IoT) connectivity. These technologies offer the potential to enhance sorting accuracy, efficiency, and flexibility while enabling real-time monitoring, data analytics, and predictive maintenance.

Furthermore, the project seeks to address the challenge of cost-effectiveness and scalability in implementing advanced sorting solutions. While cutting-edge technologies such as image processing and IoT offer significant benefits, they may also entail substantial upfront investment and complex integration requirements. Balancing the need for advanced functionality with practical considerations such as cost, scalability, and ease of implementation is crucial for the success of the project.

Overall, the project endeavors to develop a comprehensive sorting solution that combines the precision of advanced technologies with the practicality of cost-effective and scalable implementation. By addressing the challenges of accuracy, efficiency, flexibility, and cost-effectiveness, the project aims to provide industries with a reliable and adaptable sorting system capable of meeting their evolving needs in today's dynamic industrial landscape.

1.1.2 Background Study

In the dynamic landscape of industrial automation, the efficient sorting of objects on conveyor belts stands as a pivotal process across a multitude of sectors, including manufacturing, logistics, recycling, and food processing. As industries strive for increased efficiency and productivity, the evolution of technology has catalyzed the development of innovative design approaches aimed at optimizing this fundamental operation. Among these approaches, two distinct methodologies have emerged as frontrunners: Design Approach 1, which leverages sophisticated image processing techniques, and Design Approach 2, which integrates Internet of Things (IoT) capabilities alongside color sensing technology.

Design Approach 1 represents a sophisticated utilization of image processing algorithms, which meticulously analyze visual data captured by high-resolution cameras. These algorithms are designed to discern and categorize objects based on a predefined set of parameters, ensuring precise and accurate sorting. By harnessing the power of computational techniques, Design Approach 1 offers a level of precision that is essential for industries requiring meticulous sorting operations, such as manufacturing and recycling.

In contrast, Design Approach 2 embraces the fusion of IoT and color sensing technology to revolutionize the sorting process. IoT sensors strategically deployed along the conveyor belt enable real-time monitoring and control of sorting operations, enhancing adaptability and responsiveness. Through the integration of color sensing technology, objects are identified and sorted based on their unique color characteristics, providing a dynamic and flexible sorting solution. This approach is particularly advantageous in industries where the characteristics of objects may vary widely, such as in food processing or material recycling facilities.

As we embark on this exploration, our goal is to delve into the intricacies of Design Approach 1 and Design Approach 2, uncovering their respective strengths, limitations, and potential applications. From the precision and reliability offered by image processing to the adaptability and responsiveness enabled by IoT-based color sorting, each approach represents a convergence of cutting-edge technologies aimed at driving efficiency and productivity in conveyor belt sorting systems.

Through a comprehensive analysis of these methodologies, we aim to provide valuable insights that will inform decision-making processes and drive technological advancement in the realm of industrial automation. Join us as we navigate through the intricacies of Design Approach 1 and Design Approach 2, illuminating the transformative potential they hold for industries reliant on automated sorting processes.

1.1.3 Literature Gap

Despite the advancements in sorting technologies and automation systems, there exists a notable literature gap in the integration of advanced image processing techniques and IoT capabilities specifically tailored for conveyor belt sorting applications. While individual studies have explored the use of image processing or IoT in isolation for various industrial processes, there is limited research focusing on the synergistic integration of these technologies to optimize conveyor belt sorting systems.

Existing literature predominantly focuses on traditional sorting methods, such as manual labor, basic mechanical sorting systems (Dabade, 2015), or rudimentary automation without leveraging advanced technologies like image processing (Soans, 2018, May) and IoT. While these studies provide valuable insights into the challenges and opportunities in sorting operations, they often lack in-depth analysis of the potential benefits and challenges associated with integrating cutting-edge technologies into conveyor belt sorting systems.

Moreover, while there are studies that investigate the use of image processing or IoT for sorting applications in other contexts, such as food processing or material handling, there is a scarcity of research specifically tailored for conveyor belt sorting in diverse industrial settings. The unique challenges posed by conveyor belt sorting (Azizi, 2018), such as the continuous flow of objects, variable speeds, and environmental factors, necessitate tailored solutions that address these specific requirements.

Furthermore, there is limited research exploring the cost-effectiveness and scalability of integrating advanced technologies like image processing and IoT into conveyor belt sorting systems. While these technologies offer significant potential benefits in terms of accuracy, efficiency, and flexibility, their practical implementation may pose challenges in terms of upfront costs, integration complexity, and scalability for different industrial contexts.

Overall, the literature gap in this area highlights the need for further research that specifically addresses the integration of advanced image processing techniques and IoT capabilities into conveyor belt sorting systems. By filling this gap, researchers can provide valuable insights into the potential benefits, challenges, and best practices for implementing advanced sorting solutions tailored for industrial applications.

1.1.4 Relevance to current and future Industry:

The proposed project holds significant relevance to both current industrial operations and future industry trends, aligning closely with the evolving needs and challenges faced by modern manufacturing, logistics, and other industrial sectors. By addressing key issues in sorting operations and leveraging advanced technologies, the project has the potential to drive substantial improvements in efficiency, productivity, and competitiveness.

In the current industrial landscape, there is a growing demand for automated sorting solutions that can handle diverse types of objects with precision and flexibility. Traditional sorting methods, such as manual labor or basic mechanical systems, are becoming increasingly unsustainable due to labor shortages, rising labor costs, and the need for greater operational efficiency. As a result, industries are increasingly turning to automated sorting systems to streamline their operations and maintain a competitive edge.

Furthermore, with the advent of Industry 4.0 (Nagpal, 2019, December) and the rise of smart manufacturing, there is a heightened emphasis on the integration of digital technologies such as IoT, artificial intelligence, and advanced data analytics into industrial processes. These technologies offer the potential to transform traditional manufacturing and logistics operations by enabling real-time monitoring, predictive maintenance, and data-driven decision-making. By incorporating IoT capabilities into conveyor belt sorting systems, the proposed project aligns with the current trend towards digitization and automation in industry.

Looking ahead to the future, the relevance of the project is poised to increase as industries continue to embrace advanced technologies and seek innovative solutions to enhance their operations. As the complexity and volume of sorting tasks grow, there will be a greater need for sophisticated sorting systems that can adapt to changing requirements and handle diverse types of objects with speed and accuracy. By developing a comprehensive sorting solution that combines advanced image processing techniques with IoT capabilities, the project addresses this future demand and positions industries for long-term success in an increasingly competitive global market.

Overall, the proposed project is highly relevant to both current industrial needs and future industry trends, offering a pathway towards enhanced efficiency, productivity, and competitiveness in sorting operations across diverse industrial sectors. By leveraging advanced technologies and addressing key challenges, the project has the potential to drive significant advancements in industrial automation and contribute to the continued evolution of the manufacturing and logistics industries.

1.2 Objectives, Requirements, Specification and constant

1.2.1 Objectives

- The project endeavors to comprehensively study, understand, and analyze various existing systems and devices employed in sorting, conveyor, and detection systems. It aims to address challenges in product sorting with minimal human intervention while enhancing efficiency in mass production lines across industries, ranging from minor to giant enterprises. The focus lies on designing and implementing cutting-edge technologies to tackle detection and sorting issues, specifically concentrating on sorting systems aided by existing image detection and conveyor systems.

- The successful execution of this project will culminate in the development of a conveyor belt equipped with a sorting system capable of accurately identifying objects and directing them to their intended destinations with minimal human involvement. The envisioned sorting system is anticipated to be both cost and time-efficient, relying on the utilization of cameras and software algorithms to minimize human interaction and maximize automation. Moreover, the project underscores the importance of increased automation within the industrial landscape, with a particular emphasis on integrating Internet of Things (IoT) technologies.

- The specifications of the project include leveraging advanced technologies such as YOLO V8 for real-time object detection, Arduino ATMEGA 2560 for control logic, TCS3200 color sensor for precise product recognition based on color, and BLYNK software for IoT integration. Additionally, the conveyor system's operation will be adjustable to cater to specific production needs, while incorporating load management mechanisms to enhance safety.

- Key components integral to the sorting system encompass servo motors, Arduino CMOS cameras, Raspberry Pi, beaming technology, DC motors, Yumite 100 barcode scanners, and bearings. These components collectively facilitate efficient sorting of various types, shapes, and sizes of products, with testing parameters ensuring compatibility and stringent quality control measures verifying adherence to product standards.

In summary, the project aims to develop a sophisticated sorting system for conveyor belts, harnessing the capabilities of advanced technologies to enhance efficiency, reduce human intervention, and foster increased automation within industrial settings.

1.2.2 Functional and Nonfunctional Requirements

Functional:

- **Adjustable Length and Width:**

The conveyor system boasts adaptability to different environments, offering adjustable lengths (ranging from 1 to 5 meters) and a variety of standard belt widths (40mm, 80mm, 100mm, 200mm, 300mm, 400mm, and 600mm). This flexibility allows for configuring the system according to specific spatial requirements, catering to diverse operational setups.

- **Adjustable Belt Speed:**

The speed of the conveyor belt is customizable, with the capability to range from 0.13 to 53 meters per minute. This feature grants operators control over the sorting process, enabling optimization based on varying product characteristics or specific sorting needs.

- **High Load Capacity:**

The system is engineered with modifications that enhance its load-bearing capacity, enabling it to handle heavy loads efficiently. This capability enhances versatility in accommodating a diverse range of products with varying weights, ensuring seamless operation across different industrial applications.

- **Variety of Belt Types:**

Multiple belt options are available, including Silon, Black PVC, Black ribbed urethane, Blue urethane, White urethane, Green smooth PVC, and Black smooth urethane. This array of belt types allows for tailored selection based on specific application requirements, ensuring optimal performance and effective handling of products.

- **Stainless Steel Support & Side Guides:**

The implementation of stainless-steel belt support and side guides enhances the system's durability, corrosion resistance, and precision in guiding products along the conveyor. This feature contributes to prolonged operational lifespan and ensures reliable product handling throughout the conveyor system.

- **Improved Recognition Hardware and Software:**

Regular updates to recognition hardware and software contribute to increased speed and accuracy in product recognition. This continual improvement enhances system efficiency, enabling more precise product identification and sorting, thereby optimizing overall operational performance.

- **Low Power Requirement:**

Operating on low power (220v, 110v single phase, or 3 phase 220v and 400v), the conveyor system exhibits energy-efficient operation, resulting in reduced overall power consumption. This aligns with sustainability goals and helps minimize operational costs, making the system environmentally friendly and cost-effective.

- **Applicability to Various Industries:**

The conveyor system finds applicability across diverse industrial fields, including Optical Conveyor Systems, Industrial Conveyors for Tea Handling, Warehouse and Sortation, Industrial Tote & Parcel Conveyors, and the Medical & Pharmaceutical Industry. This versatility in application makes the system suitable for a wide range of industrial settings, offering flexibility and adaptability to meet varying operational needs.

- **Capacity Calculation Formula:**

A capacity calculation formula is provided, where Capacity (TPH) = 0.03 x Belt Speed (FPM) x Material Weight (lb. per cu. ft.). This formula facilitates the calculation of the system's capacity based on belt speed and material weight, providing valuable insights for operational planning and optimization.

- **Conservation of Energy:**

The system's low power requirement contributes to energy conservation efforts, aligning with sustainability objectives and reducing operational costs. This emphasis on energy efficiency underscores the system's commitment to environmental responsibility while ensuring economic viability in industrial operations.
According to Monk Conveyors Ltd, A Private British Engineering Company.

Non-functional:

- **Operational Resilience to Weather Conditions:**

The system is engineered to maintain consistent and reliable performance regardless of varying weather conditions and environmental factors. This resilience ensures uninterrupted operation, even in challenging outdoor or exposed environments.

- **Space Efficiency:**

Efforts are made to optimize space utilization within the system's design, ensuring minimal area is required for the movement and sorting of loads or products. This maximizes floor space efficiency, enabling the system to be deployed in environments with limited space constraints.

- **Fault Tolerance to Human Errors:**

Robust hardware and software implementations are integrated into the system to mitigate the impact of human-induced errors. The system is designed to handle and recover from potential errors caused by human intervention, ensuring continued functionality and operational integrity.

- **Backup Power Supply:**

A reliable backup power supply is incorporated into the system to ensure uninterrupted operation in the event of a power failure. This backup power solution is capable of sustaining the system until normal power is restored, safeguarding against downtime and disruptions in operation.

- **Product Tracking and Reporting:**

The system is equipped with advanced tracking and reporting capabilities, enabling real-time or periodic updates on the quantity and status of sorted products. This feature facilitates effective inventory management and monitoring of sorting operations.

- **Data Integrity and Security:**

Stringent measures are implemented to ensure the integrity and security of the data generated by the system. Access controls and encryption protocols are employed to prevent unauthorized access to sensitive information, safeguarding sorting algorithms and product data.

- **Scalability:**

The system is designed to be scalable, capable of accommodating potential increases in the volume of products to be sorted. It can handle higher throughput without significant modifications or degradation in performance, ensuring scalability to meet evolving operational demands.

- **User Interface Accessibility:**

The user interface, whether local or through IoT platforms, is designed to be accessible and user-friendly. It provides clear and intuitive information about the system's status, errors, and relevant alerts, enhancing usability and facilitating efficient operation.

- **Maintenance and Upkeep:**

The system's design facilitates easy maintenance and upkeep, minimizing downtime for routine checks or repairs. Routine maintenance tasks, such as sensor calibration or software updates, are streamlined for efficiency, ensuring optimal system performance.

- **Adaptability to Product Variability:**

The system is adaptable to handle a variety of products with different shapes, sizes, and characteristics. Changes in product specifications or the introduction of new products do not require extensive reconfiguration, enabling seamless integration and operation within diverse sorting environments.

1.2.3 Specifications

- **Object Recognition using YOLO V8:**

The system utilizes YOLO V8 for real-time object detection on the conveyor belt. This implementation employs a pre-trained model to facilitate efficient and accurate identification of products as they move along the conveyor.

- **Control Logic with Arduino ATMEGA 2560:**

An Arduino ATMEGA 2560 microcontroller is employed to manage the overall control logic of the system. It interfaces with sensors, initiates sorting actions, and facilitates communication with the IoT platform, ensuring seamless coordination of system operations.

- **Product Identification with TCS3200 Color Sensor:**

Precise product recognition based on color is achieved through the utilization of the TCS3200 color sensor. Calibration procedures are performed to guarantee accurate color mapping and identification, enabling reliable sorting based on color attributes.

- **IoT Integration using BLYNK Software:**

The system incorporates BLYNK software for IoT capabilities, enabling remote monitoring and control. Real-time updates on conveyor status and product sorting are accessible through the BLYNK interface, providing operators with comprehensive visibility and control over system operations.

- **Conveyor System Operation:**

The conveyor system is responsible for transporting recognized products to their designated locations. Its adjustable operating range allows for flexibility according to specific production needs, facilitating efficient and customizable product movement along the conveyor.

- **Load Management and Safety:**

To enhance safety and prevent potential damage to the system, a load monitoring mechanism is integrated. This mechanism halts the conveyor when excessive load is detected at the sending end, ensuring safe and reliable operation under varying load conditions.

- **Processing Enhancement with Raspberry Pi and NVIDIA Jetson Nano:**

Raspberry Pi and NVIDIA Jetson Nano Developer Kit are integrated into the system to enhance processing power. This integration ensures rapid and efficient image processing for real-time decision-making, enhancing the system's overall performance and responsiveness.

1.2.3 Technical and Non-technical consideration and constraint in design process

In the design process of a conveyor belt sorting system, there are various technical and non-technical considerations and constraints that must be taken into account to ensure the successful development and implementation of the system.

Technical Considerations:

- **System Integration:** The conveyor belt sorting system needs to integrate seamlessly with existing production processes and equipment. Compatibility with other machinery, sensors, and control systems is crucial to ensure efficient operation.
- **Accuracy and Reliability:** The system must accurately identify and sort products based on predetermined criteria. The reliability of object detection, sorting mechanisms, and control logic is paramount to prevent errors and minimize downtime.
- **Scalability:** The design should be scalable to accommodate changes in production volume or product types. The system should be able to handle

increased throughput without significant modifications or degradation in performance.

- **Speed and Throughput:** The conveyor belt sorting system should operate at an optimal speed to maximize throughput while maintaining accuracy. Balancing speed with sorting precision is essential to ensure efficient operation.
- **Environmental Factors:** Consideration must be given to environmental conditions such as temperature, humidity, and dust levels, which may affect the performance and longevity of system components. Protective measures may be required to safeguard sensitive equipment.
- **Maintenance and Serviceability:** Designing the system for easy maintenance and serviceability is critical to minimize downtime and ensure long-term reliability. Components should be accessible for routine inspections, repairs, and replacement as needed.
- **Cost-effectiveness:** Cost considerations include not only the initial investment in equipment and technology but also ongoing operational expenses such as energy consumption, maintenance, and labor. Balancing performance requirements with budget constraints is essential to achieve a cost-effective solution.

Non-technical Considerations:

- **Regulatory Compliance:** The design must comply with relevant industry standards, regulations, and safety guidelines to ensure legal and ethical compliance. Adhering to regulatory requirements minimizes the risk of fines, penalties, or liability issues.
- **Stakeholder Requirements:** Understanding the needs and preferences of stakeholders, including end-users, operators, and management, is essential to design a system that meets their expectations. Communication and collaboration with stakeholders throughout the design process are crucial for project success.
- **Ethical and Social Implications:** Consideration should be given to the ethical and social implications of the system, such as its impact on labor displacement, environmental sustainability, and community welfare. Design decisions should prioritize ethical values and social responsibility.
- **Cultural Sensitivity:** In multinational or multicultural settings, cultural factors may influence design preferences, communication styles, and business practices. Cultural sensitivity and diversity awareness are essential for effective collaboration and mutual understanding.
- **Project Timeline and Constraints:** The design process must adhere to project timelines and constraints, including deadlines, budgetary limits, and resource availability. Efficient project management and scheduling are essential to ensure timely completion and successful implementation.

By addressing both technical and non-technical considerations and constraints in the design process, engineers and designers can develop a conveyor belt sorting system that meets performance requirements, complies with regulations, satisfies stakeholder needs, and operates effectively in diverse operational environments.

1.2.4 Applicable compliance, standards, and codes

In the design process of a conveyor belt sorting system, adherence to applicable compliance, standards, and codes is essential to ensure the safety, quality, and reliability of the system. Several regulatory bodies and industry organizations establish guidelines and standards that govern the design, manufacturing, and operation of conveyor systems. Here are some applicable compliance, standards, and codes that may be relevant:

1. **Occupational Safety and Health Administration (OSHA) Standards:** OSHA sets forth regulations and standards related to workplace safety, including requirements for machine guarding, electrical safety, and hazard communication. Compliance with OSHA standards helps ensure the safety of workers operating and maintaining the conveyor system.

2. **American National Standards Institute (ANSI) Standards:** ANSI publishes standards covering various aspects of conveyor systems, including design, construction, and safety requirements. ANSI/ASME B20.1 Safety Standards for Conveyors and Related Equipment is one example of a widely recognized standard for conveyor safety.

3. **International Organization for Standardization (ISO) Standards:** ISO develops international standards that provide guidelines for quality management, environmental management, and occupational health and safety. ISO 13850:2015 - Safety of machinery - Emergency stop function is one relevant standard that addresses emergency stop requirements for machinery, including conveyors.

4. **National Fire Protection Association (NFPA) Standards:** NFPA publishes standards related to fire safety and prevention. NFPA 654 Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids outlines requirements for the prevention of fires and explosions in facilities handling combustible materials, including those transported on conveyors.

5. **Conveyor Equipment Manufacturers Association (CEMA) Standards:** CEMA produces standards and guidelines specific to the design, construction, and operation of conveyor equipment. CEMA publications cover topics such as conveyor safety, dimensional standards, and performance testing protocols.

6. **European Committee for Standardization (CEN) Standards:** CEN develops European standards (EN) that harmonize technical specifications and requirements across member states. EN 620:2002 Continuous handling equipment and systems - Safety and EMC requirements for fixed belt conveyors for bulk materials is an example of a relevant standard for belt conveyor safety in Europe.

7. International Electrotechnical Commission (IEC) Standards: IEC publishes international standards for electrical and electronic equipment. IEC 60204-1 Safety of machinery - Electrical equipment of machines is a standard that addresses electrical safety requirements for machinery, including conveyor systems.

8. Industry-specific Regulations: Depending on the application and industry sector, there may be additional regulations and standards that apply to conveyor systems. For example, in the food processing industry, conveyor systems must comply with food safety regulations such as those outlined by the Food and Drug Administration (FDA) in the United States or the European Food Safety Authority (EFSA) in Europe.

By adhering to applicable compliance, standards, and codes, designers and manufacturers can ensure that conveyor belt sorting systems meet regulatory requirements, industry best practices, and safety guidelines, thereby enhancing operational reliability and mitigating risks.

1.3 Systematic Overview/summary of the proposed project

The proposed project entails the design and implementation of a conveyor belt sorting system equipped with advanced technologies for efficient object recognition, sorting, and monitoring. The system aims to streamline industrial processes by automating the sorting of products based on predefined criteria, thereby improving productivity, accuracy, and operational efficiency.

Key components and features of the proposed project include:

1. Object Recognition using YOLO V8: The system utilizes YOLO V8 for real-time object detection on the conveyor belt, leveraging a pre-trained model for efficient and accurate identification of products.

2. Control Logic with Arduino ATMEGA 2560: An Arduino microcontroller manages the overall system control logic, interfacing with sensors, initiating sorting actions, and communicating with the IoT platform to ensure seamless operation.

3. Product Identification with TCS3200 Color Sensor: Precise product recognition based on color is achieved using the TCS3200 color sensor, with calibration procedures to ensure accurate color mapping and identification for reliable sorting.

4. IoT Integration using BLYNK Software: BLYNK software is employed for IoT capabilities, enabling remote monitoring and control. Real-time updates on conveyor status and product sorting are accessible through the BLYNK interface, providing operators with comprehensive visibility and control.

5. Conveyor System Operation: The conveyor system transports recognized products to their designated locations, featuring an adjustable operating range to accommodate specific production needs and optimize product movement.

6. Load Management and Safety: The system incorporates a load monitoring mechanism that halts the conveyor when excessive load is detected, enhancing safety and preventing potential damage to the system.

7. Processing Enhancement with Raspberry Pi and NVIDIA Jetson Nano: Raspberry Pi and NVIDIA Jetson Nano Developer Kit are integrated to enhance processing power, ensuring rapid and efficient image processing for real-time decision-making, thereby enhancing system performance.

The proposed project aims to address technical and non-technical considerations and constraints, including operational resilience to weather conditions, space efficiency, fault tolerance to human errors, backup power supply, product tracking and reporting, data integrity and security, scalability, user interface accessibility, maintenance and upkeep, and adaptability to product variability. By adhering to applicable compliance, standards, and codes, the system is designed to meet regulatory requirements, industry best practices, and safety guidelines.

1.4 Conclusion

In conclusion, the proposed conveyor belt sorting system offers an innovative solution for industrial sorting processes. By integrating advanced technologies and addressing key considerations, the system promises to enhance efficiency, accuracy, and safety in industrial operations. With its robust design and adherence to industry standards, it represents a significant advancement in industrial automation.

Chapter 2: Project Design Approach [CO5, CO6]

2.1 Introduction

In the realm of automated sorting systems for conveyor belts, the evolution of technology has spurred the development of two distinct design approaches, each offering unique solutions to the challenge of efficient object sorting. Design Approach 1 harnesses the power of image processing, relying on advanced algorithms to analyze visual data and categorize objects based on predefined parameters. This approach promises precision and accuracy in sorting, leveraging the capabilities of sophisticated cameras and computational techniques.

On the other hand, Design Approach 2 represents a paradigm shift, embracing the Internet of Things (IoT) and color sensing technology to revolutionize sorting processes. By integrating IoT capabilities into the system architecture, this approach enables real-time monitoring and control, enhancing adaptability and responsiveness. The utilization of color sensors offers a flexible means of object detection, allowing for dynamic sorting based on the distinctive hues of each item passing through the conveyor belt.

These two design approaches signify the convergence of cutting-edge technologies in the pursuit of optimized sorting efficiency. While Design Approach 1 prioritizes the analytical prowess of image processing algorithms, Design Approach 2 emphasizes the connectivity and versatility afforded by IoT integration and color sensing technology. In this comparative exploration, we delve into the intricacies of each approach, examining their strengths, limitations, and potential applications in diverse industrial settings. By illuminating the nuanced differences between these methodologies, we aim to provide valuable insights to guide decision-makers in selecting the most suitable solution for their specific operational requirements and objectives.

2.2 Identify multiple design approach:

In the realm of conveyor belt sorting systems, two innovative design approaches have emerged as frontrunners, each offering distinct solutions to streamline the sorting process:

Design Approach 1: Image Processing-Based Sorting System on Conveyor:
This approach harnesses the power of advanced image processing algorithms to analyze visual data captured by high-resolution cameras. These algorithms meticulously evaluate the characteristics of objects passing through the conveyor belt, categorizing them based on predefined parameters. By leveraging sophisticated computational techniques, Design Approach 1 ensures precise and accurate sorting, enhancing operational efficiency and minimizing errors. Its reliance on image processing technology underscores a commitment to optimal performance and reliability in automated sorting systems.

Design Approach 2: IoT-Based Object Color Sorting System on Conveyor Belt
In contrast, Design Approach 2 represents a paradigm shift in sorting methodology, integrating IoT capabilities and color sensing technology to revolutionize the sorting process. Through the strategic deployment of IoT sensors along the conveyor belt, this approach enables real-time monitoring and control of sorting operations. By leveraging color sensing technology, objects are identified and sorted based on their distinct hues, offering a dynamic and adaptable sorting solution. Design Approach 2 emphasizes flexibility and responsiveness, empowering organizations to optimize sorting processes in dynamic industrial environments.

These two design approaches offer complementary solutions to the challenges of automated sorting, each with its unique strengths and applications. While Design Approach 1 prioritizes precision and accuracy through advanced image processing techniques, Design Approach 2 focuses on flexibility and adaptability through IoT integration and color sensing technology. By understanding the nuances of these approaches, organizations can make informed decisions to enhance efficiency and productivity in conveyor belt sorting operations.

2.3 Describe multiple design approach

Design Approach 1: Image processing based sorting system on conveyor.

YOLOv8 Image Processing:
YOLOv8 stands as a significant advancement in object detection algorithms, renowned for its capability to achieve real-time detection with a high degree of accuracy. Its primary innovation lies in the adoption of a unified neural network architecture for direct predictions across the entire image. This departure from conventional multi-stage approaches grants YOLOv8 a computational edge, rendering it exceptionally suitable for scenarios where instantaneous responsiveness is paramount.

Efficiency through Single Neural Network:
In addition to employing a singular neural network architecture, YOLOv8 simplifies the object detection process by processing the entire image in a single forward pass, eliminating the need for multiple passes or region proposals. This design choice not only enhances computational efficiency but also enables YOLOv8 to deliver swift and responsive object detection performance, crucial for time-sensitive applications such as autonomous vehicles.

Moreover, YOLOv8 enhances its object detection capabilities through the integration of anchor boxes. These anchor boxes function as reference points that guide the algorithm in localizing and classifying objects within an image. This refinement significantly improves detection precision, empowering YOLOv8 to discern objects with remarkable accuracy. The strategic use of anchor boxes is integral to the algorithm's ability to achieve state-of-the-art results in various object detection tasks.

Notable Speed and Accuracy:

The fusion of a singular neural network architecture with the integration of anchor boxes positions YOLOv8 as an exemplary object detection algorithm, renowned for its exceptional speed and accuracy. Its capacity for real-time detection, paired with its remarkable precision, renders YOLOv8 a versatile solution applicable across various domains, from surveillance systems for video analysis to obstacle detection in autonomous vehicles.

Within the realm of object detection, YOLOv8 emerges as a cutting-edge algorithm, excelling in both rapidity and precision. Its innovative utilization of a singular neural network alongside the integration of anchor boxes significantly enhances its operational efficiency, establishing it as a potent tool for addressing the intricate challenges associated with real-time object detection across diverse fields.

Moving to the Roboflow platform, it plays an indispensable role in streamlining the data processing pipeline for machine learning models. Offering a comprehensive suite of features tailored to optimize the management of image datasets, Roboflow significantly enhances efficiency and effectiveness. Key functionalities provided by Roboflow include:

1. **Annotation Tools:** Roboflow streamlines the annotation process with its advanced tools, ensuring precise and efficient labeling of objects within images. These annotation tools empower users to accurately identify and annotate objects of interest, which is paramount in creating meticulously labeled datasets for training object detection models. By optimizing the annotation process, Roboflow guarantees the generation of high-quality training data, thereby establishing a solid foundation for achieving robust model performance.
2. **Data Augmentation Techniques:** To enrich dataset diversity and bolster the model's capacity for generalization across diverse scenarios, Roboflow integrates sophisticated data augmentation techniques. These advanced methods introduce variations in the training data through precise transformations, including rotation, scaling, flipping, and adjustments in brightness and contrast. By systematically applying these augmentation techniques, Roboflow effectively expands the dataset's scope, fostering resilience and adaptability within the trained model.
3. **Format Standardization:** Roboflow effectively tackles the challenge of interoperability by incorporating features for format standardization. This functionality guarantees that datasets adhere to consistent and compatible formats across various deep learning frameworks. Such compatibility is particularly essential for seamless integration with algorithms like YOLOv8, enabling users to transition between different frameworks without the need for extensive data format adjustments. By ensuring format standardization, Roboflow significantly streamlines and enhances interoperability within the machine learning workflow.

Furthermore, Roboflow's suite of annotation tools, data augmentation techniques, and format standardization collectively constitute a robust framework for preprocessing image datasets. This platform empowers users to efficiently prepare high-quality, diverse datasets crucial for training accurate and versatile machine learning models. The integration of these features not only simplifies the data processing workflow but also contributes to the overall success of machine learning applications, especially in the domain of object detection tasks.

When integrating YOLOv8 with the Roboflow platform, a meticulously designed and streamlined data processing workflow ensues. This seamless process begins with the precise annotation of objects within images using Roboflow's sophisticated tools. This step is foundational for creating meticulously labeled datasets, providing the essential ground truth required for training robust object detection models. Subsequently, the integration extends to leverage Roboflow's advanced data augmentation techniques, enriching dataset diversity by introducing variations and complexities reflective of real-world scenarios.

By systematically applying transformations such as rotation, scaling, and adjustments in brightness, Roboflow enhances the dataset's resilience, enabling the trained YOLOv8 model to effectively generalize across diverse environmental conditions. The final stage of the integration workflow involves format standardization, ensuring compatibility with YOLOv8 and other deep learning frameworks. Roboflow's commitment to standardizing dataset formats facilitates a seamless transition between different frameworks, eliminating interoperability challenges and enabling users to deploy YOLOv8 with ease.

The collaborative integration of YOLOv8 and Roboflow yields several significant advantages in the domain of object detection tasks:

1. Improved Model Accuracy: Roboflow's preprocessing capabilities play a pivotal role in elevating model accuracy. By facilitating efficient annotation and sophisticated data augmentation techniques, Roboflow significantly enhances both the quality and diversity of the dataset utilized for training YOLOv8 models. This augmentation in dataset quality translates into a model that not only excels in accurately detecting objects but also demonstrates an enhanced capacity to generalize across a spectrum of real-world scenarios.

2. Efficient Dataset Management: The integration of YOLOv8 with Roboflow offers significant advantages in efficiently managing large datasets. Roboflow streamlines the data processing pipeline, simplifying the complexities associated with dataset preparation for YOLOv8 training. Through its array of tools and functionalities, the platform contributes to creating a more organized and manageable dataset, thereby facilitating a smoother and more effective training process.

In summary, the collaboration between YOLOv8 and Roboflow establishes a mutually beneficial relationship that optimizes the data processing pipeline for object detection tasks. This integration not only enhances the accuracy of YOLOv8 models but also streamlines the intricate process of managing large datasets, ultimately improving the overall efficiency and effectiveness of the object detection workflow.

Schematics:

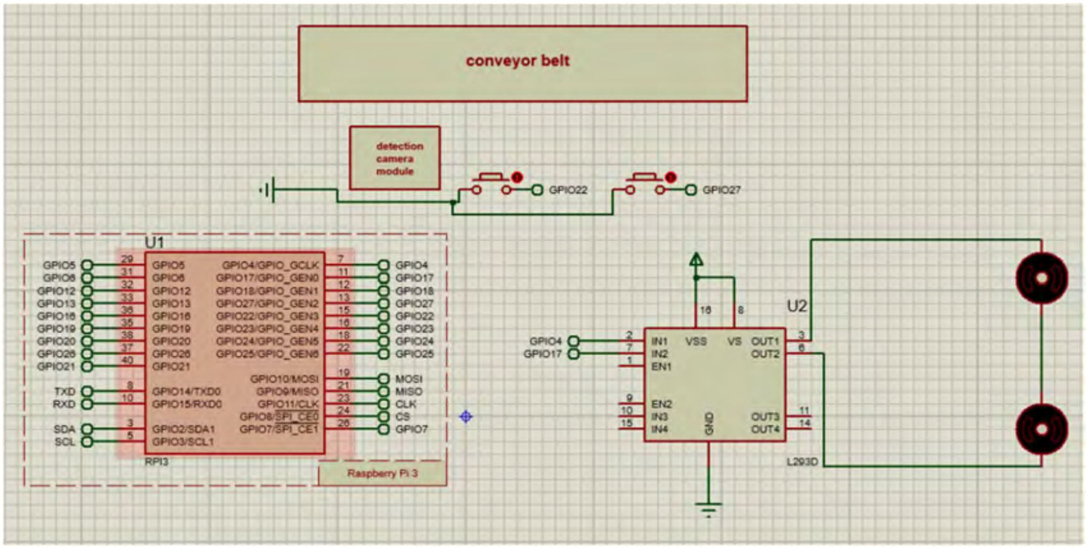

Figure 1:Schematic representation

Dataset Preparation for Bottle and Box Detection:

The effectiveness of any object detection model hinges on the caliber and variety of the dataset employed during training. In the specific realm of detecting bottles and boxes, the dataset preparation process entails several crucial steps, with a particular emphasis on gathering a diverse array of images and meticulously annotating objects. This annotation process is facilitated by leveraging Roboflow's sophisticated annotation tools.

1. Diverse Image Collection:

○ **Source Variation:** To ensure robust generalization across diverse environments, it's imperative to gather images from a variety of sources. These sources should encompass a range of settings, including but not limited to retail shelves, warehouses, and home environments. This broad spectrum of image sources aids in training the model to effectively recognize bottles and boxes in various real-world scenarios, thereby enhancing its overall performance and adaptability.

○ **Backgrounds and Lighting:** To bolster the model's adaptability across different scenarios, it's essential to capture images featuring a diverse range of backgrounds and lighting conditions. This variability in image characteristics enables the model to acclimate to various environmental settings, ultimately enhancing its resilience and robustness.

○ **Different Orientations:** Incorporate images depicting bottles and boxes arranged in different orientations and configurations. This diverse representation ensures that the model learns to detect objects irrespective of their spatial arrangements. This variation aids in enhancing the model's ability to accurately identify and localize objects across a wide range of real-world scenarios.

2. Roboflow's Annotation Tools:

○ **Efficient Labeling:** Leverage the annotation tools provided by Roboflow to label objects efficiently and accurately within the images. These tools are designed to streamline the annotation process, enabling annotators to delineate precise bounding boxes around bottles and boxes with ease. This meticulous annotation ensures that the model receives high-quality training data, essential for achieving optimal performance in object detection tasks.

○ **Class Labeling:** It's imperative to clearly define and label the classes, distinctly identifying between bottles and boxes. This clear classification is essential for the model to effectively learn and distinguish between the two object categories throughout the training process. Accurate labeling ensures that the model can precisely identify and classify objects, contributing to its overall performance and accuracy in object detection tasks.

○ **Bounding Box Definition:** It is essential to ensure that the bounding boxes accurately encompass the entire extent of the bottles and boxes in each image. Precise annotations are pivotal as they significantly contribute to the model's capability to make accurate predictions. By meticulously delineating bounding boxes, annotators provide the model with precise spatial information, enabling it to effectively recognize and localize objects with precision during both training and inference stages.

○ **Consistency in Annotation:** Maintaining uniformity in annotation style and standards across all images is crucial. Consistency in annotation ensures the creation of a standardized dataset for training, which is essential for the model's performance and generalization capabilities. By adhering to consistent annotation practices, annotators help establish a cohesive dataset, enabling the model to learn effectively across various images and scenarios.

3. Data Augmentation:

○ **Augment Dataset Diversity:** To enrich dataset diversity, consider implementing data augmentation techniques. These methods, including rotation, flipping, and adjustments in brightness, expand the range of image variations encountered during training. By exposing the model to a broader spectrum of scenarios, data augmentation enhances its robustness and ability to generalize effectively across different environments.

To prepare the dataset effectively, adhere to the following steps:

- **Train-Validation-Test Split:** Partition the dataset into training, validation, and test sets. The training set is designated for model training, the validation set aids in hyperparameter tuning, and the test set evaluates the model's performance on unseen data.
- **Stratified Sampling:** In cases of class imbalance, implement stratified sampling to ensure proportional representation of each class across all dataset splits. This approach helps maintain the integrity of the dataset and ensures fair evaluation of the model's performance across all classes.

5. Documentation:

○ **Metadata Logging:** It's essential to maintain comprehensive metadata, encompassing image filenames, class labels, and corresponding bounding box coordinates. This detailed documentation streamlines referencing and validation procedures throughout both the training and evaluation stages.

In conclusion, the dataset preparation phase serves as the cornerstone for the success of the bottle and box detection model. By curating a diverse array of images and utilizing Roboflow's annotation tools for precise labeling, this process lays the foundation for training a resilient and efficient object detection model.

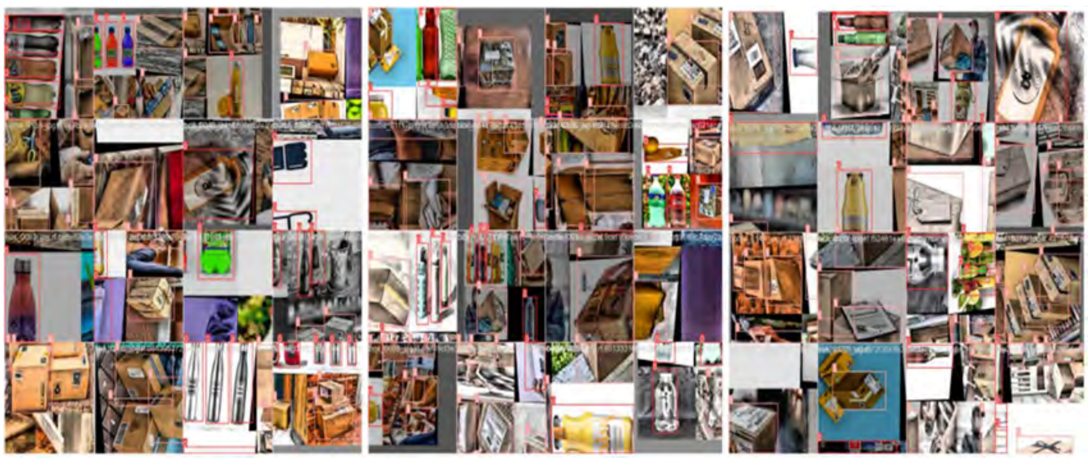

Figure 2: Visual representation of detection from datasets

Working bottle and box detection model with test cases:

1. YOLOv8 Model Architecture:

To implement the object detection task for bottles and boxes, follow these steps:

Utilize YOLOv8 Algorithm: Employ the YOLOv8 algorithm, renowned for its real-time performance and accuracy in object detection tasks.

Customize Model Architecture: Tailor the YOLOv8 model architecture to cater to the specific requirements of detecting bottles and boxes. This customization may involve adjusting network layers, parameters, or incorporating specialized features relevant to the task.

Modify Output Layer: Adapt the output layer of the YOLOv8 model to predict bounding boxes and class probabilities specifically for the designated classes, i.e., bottles and boxes. Ensure that the model output accurately captures the spatial localization and class predictions for these objects.

By following these steps, you can effectively tailor the YOLOv8 algorithm to address the object detection task for bottles and boxes, optimizing its performance and accuracy for this specific application.

2. Model Training:

Implement the YOLOv8 model using Python, integrating TensorFlow and Keras libraries for seamless execution.

- Model Training: Train the YOLOv8 model using the annotated and preprocessed dataset. During training, adjust model weights iteratively to minimize a suitable loss function, optimizing the model's ability to accurately detect bottles and boxes within images.
- Optimization: Utilize an optimizer like Adam to fine-tune the model parameters for optimal performance. Adam optimizer dynamically adjusts learning rates based on the gradients of the loss function, facilitating efficient convergence towards the global minimum.

By following these steps, you can effectively implement and train the YOLOv8 model using Python, TensorFlow, and Keras, ensuring its suitability for the specific task of bottle and box detection.

3. Evaluation and Deployment:

After training the YOLOv8 model, assess its performance on a distinct test set using various metrics such as precision, recall, and Intersection over Union (IoU). These metrics provide insights into the model's ability to accurately detect bottles and boxes within images, considering both the correctness and spatial overlap of predictions.

Once the evaluation is complete, deploy the trained YOLOv8 model for inference on new images. Utilize Python for seamless integration and deployment, ensuring ease of use and compatibility with existing workflows. This deployment process enables real-time object detection, allowing the model to analyze new images and identify bottles and boxes with high accuracy and efficiency.

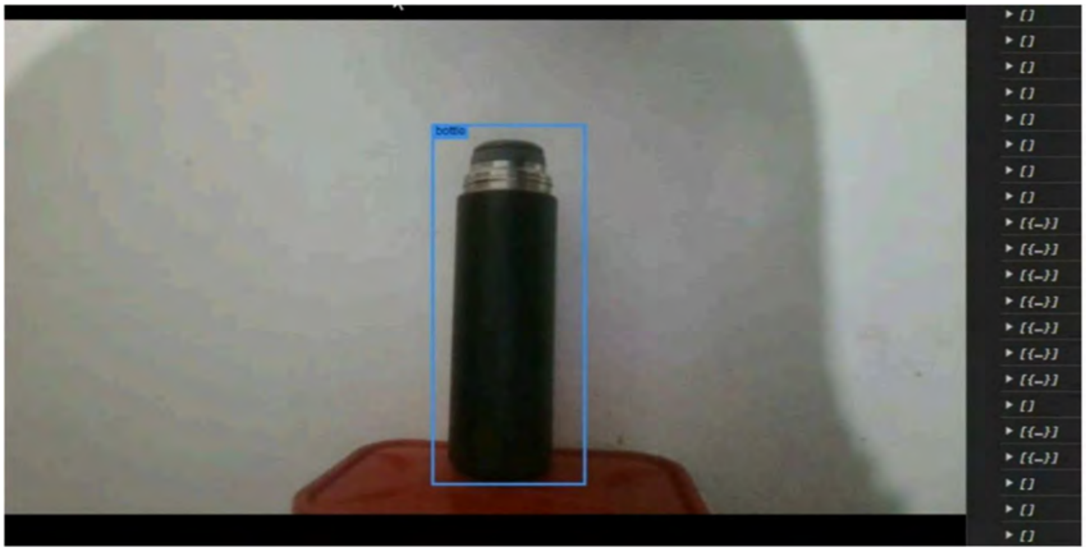

Figure 3: Working model(detecting bottle)

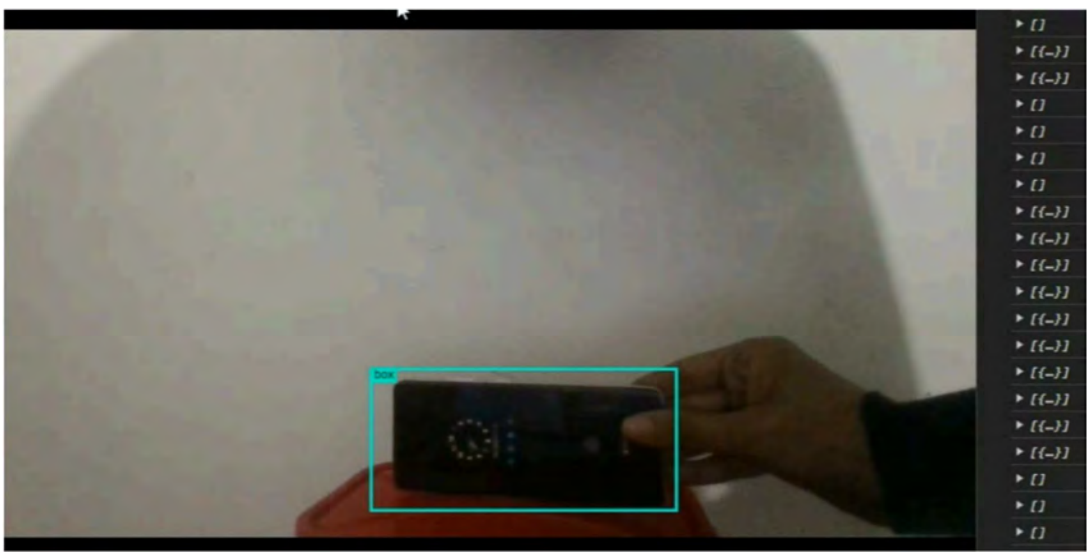

Figure 4: Working model (detecting box)

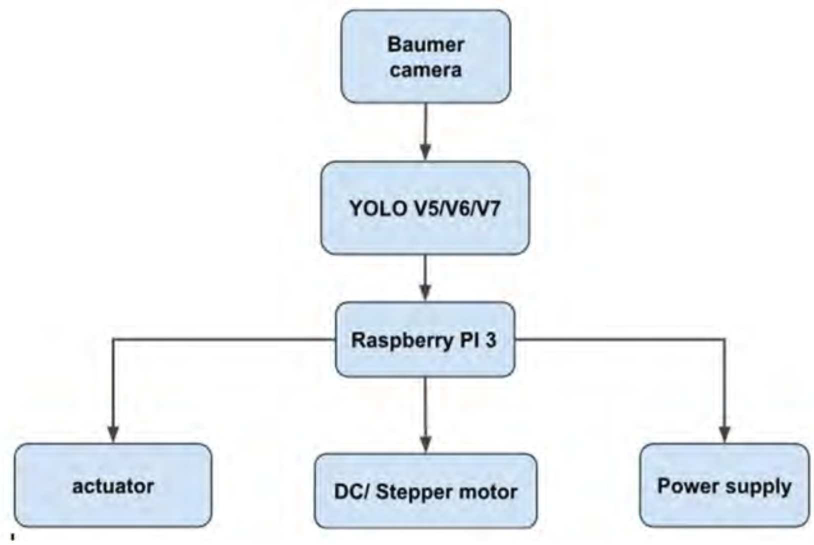

Figure 5: Flowchart of approach 1

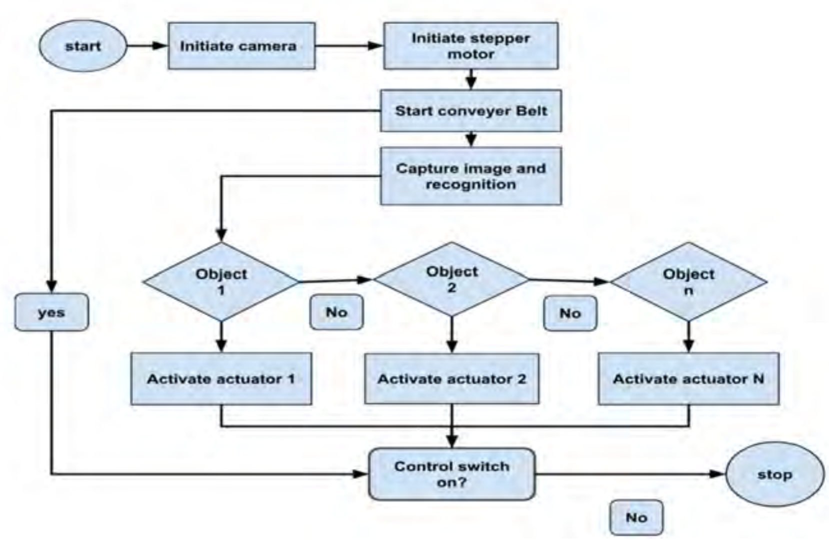

Figure 6: Diagram of detection flow

Design Approach 2: Iot based object's color sorting system on conveyor belt

TCS3200 color sensor: Each photodiode in the array of the TCS3200 sensor is equipped with one of four filters. A semiconductor device that transforms light into electrical current is called a photodiode. The sensor consists of:
- 16 photodiodes that are sensitive to red wavelengths and have a red filter
- 16 photodiodes sensitive to green wavelengths and equipped with a green filter
- 16 photodiodes that are sensitive to blue wavelengths and have a blue filter

- 16 unfiltered photodiodes

Examining the TCS3200 chip in further detail exposes the unique filters.

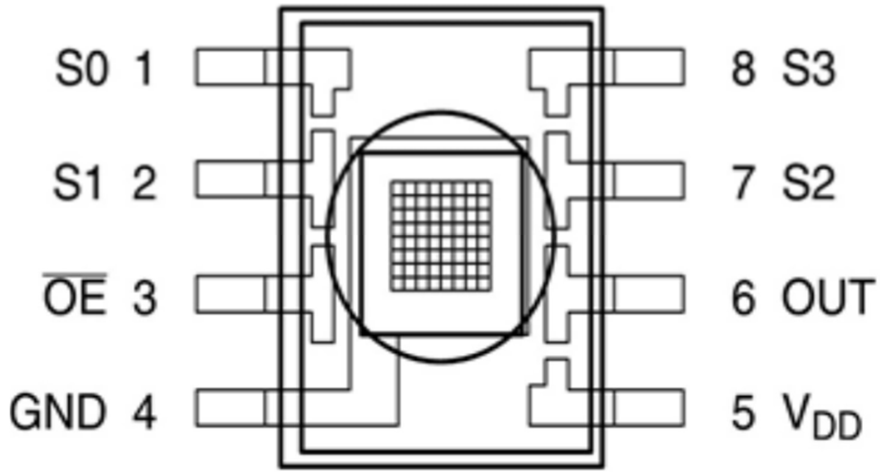

Figure 7: Block diagram of the TCS3200 color sensor

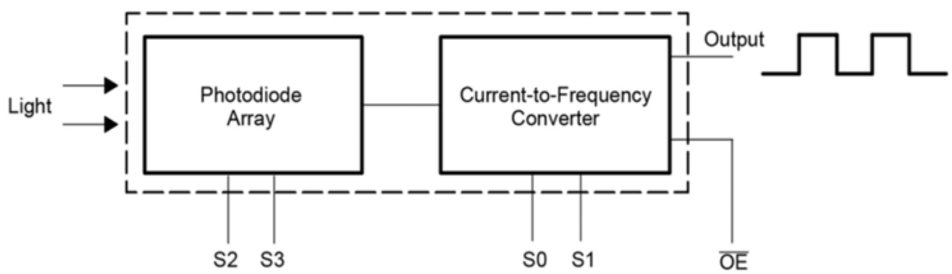

Figure 8: Inner design of TCS3200 color sensor

By selectively reading the photodiodes' filters, we can detect the intensity of different colors. The sensor includes a current-to-frequency converter that transforms the photodiodes' readings into a square wave, with a frequency proportional to the light intensity of the selected color. This frequency is then read by the Arduino.

Connections: Now the sorting system is explained, and the circuit has to work accordingly. There are 3 conveyor belts in this system. The color sensor and servo motor will stand with the 1st conveyor belt. This belt will be vertically placed, and the other 2nd and 3rd belts will be horizontal. 1 IR sensor and 2 linear actuators will be standing with the 2nd belt. 1 IR sensor and 2 linear actuators will be standing with the 3rd belt, just like the 2nd one.

IR sensors only detect an object, but they don't specify them.

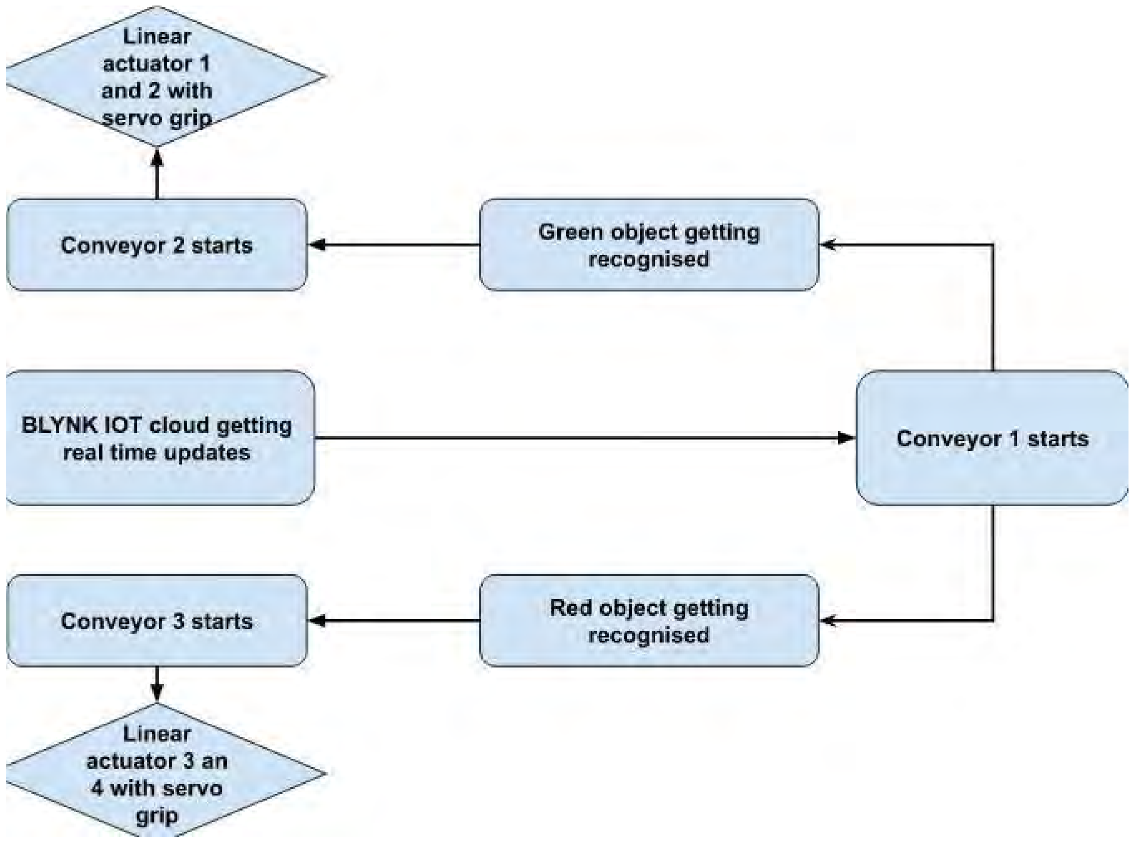

Figure 9: Flowchart of approach 2

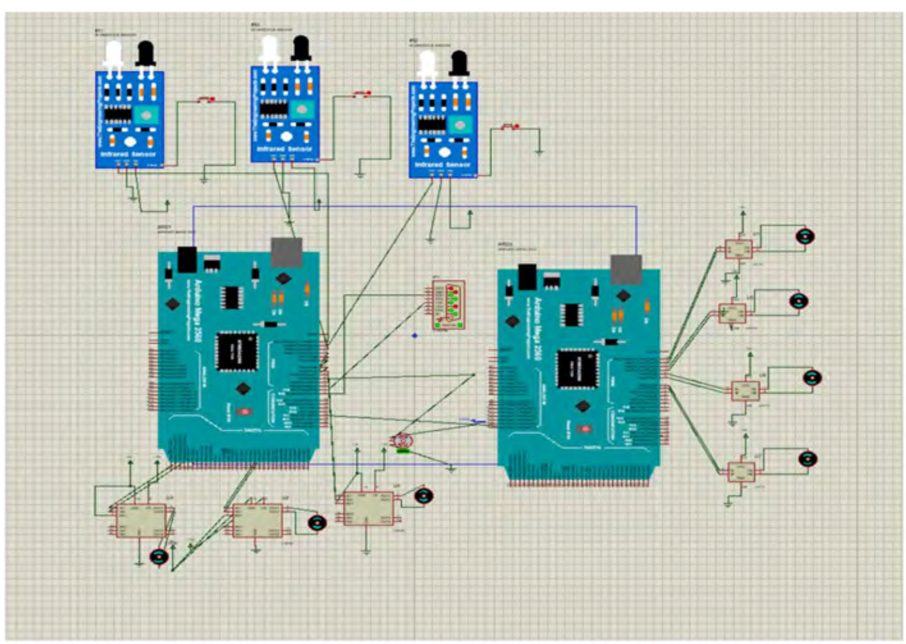

Figure 10: Approach 2 full design

We connected 2 Arduino mega 2560 microcontrollers by serial communications and each of them has different components connected to them. We connected the 3 DC motors of 3 conveyor belts, 1 servo motor, 1 compim (for iot), 3 IR sensors (1 of them was supposed to be the tcs3200 color sensor) to the left microcontroller. This left microcontroller is the transmitter for the right microcontroller. The right one is the receiver microcontroller.

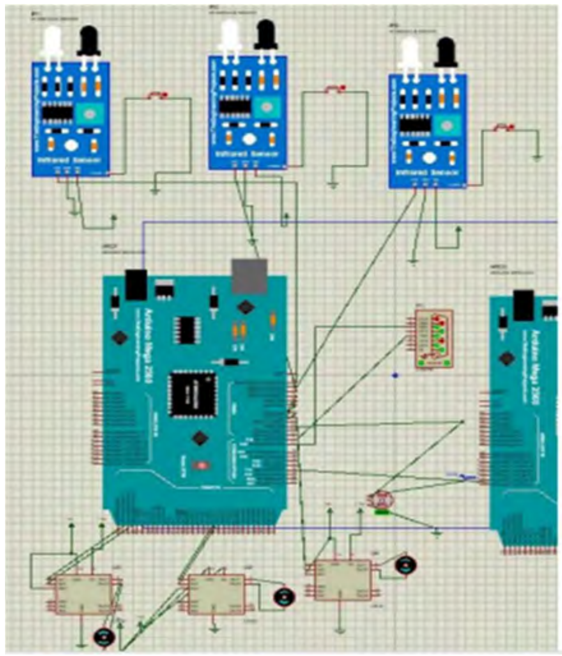

Figure 11: Transmitter microcontroller and its corresponding components

Now the receiver has 4 linear actuators connected to it. We can think of these 4 actuators as 2 pick and place hands. Now these 2 hands are standing with the 2nd and 3rd belt pick the objects up and place them to their designated places. As 1 hand consists of 2 actuators that means 1 of these 2 are horizontal and the other one is vertical. The linear actuators are dc gear motors.

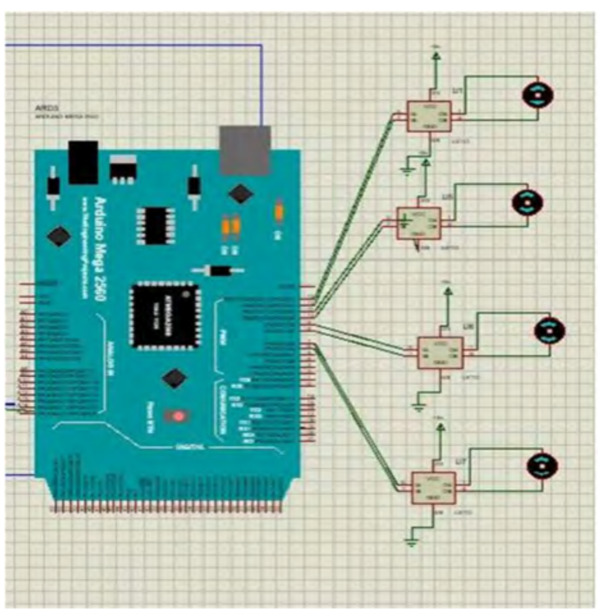

Figure 12: Receiver microcontroller and its corresponding components.

One important thing is that we made efforts to find the color sensor simulation module for proteus, but we couldn't find it anywhere. So, we were stuck in this and then we finally solved the situation by connecting 1 more IR sensor instead of the color sensor.

Functional Verification of Multiple Design Solutions (CO5)

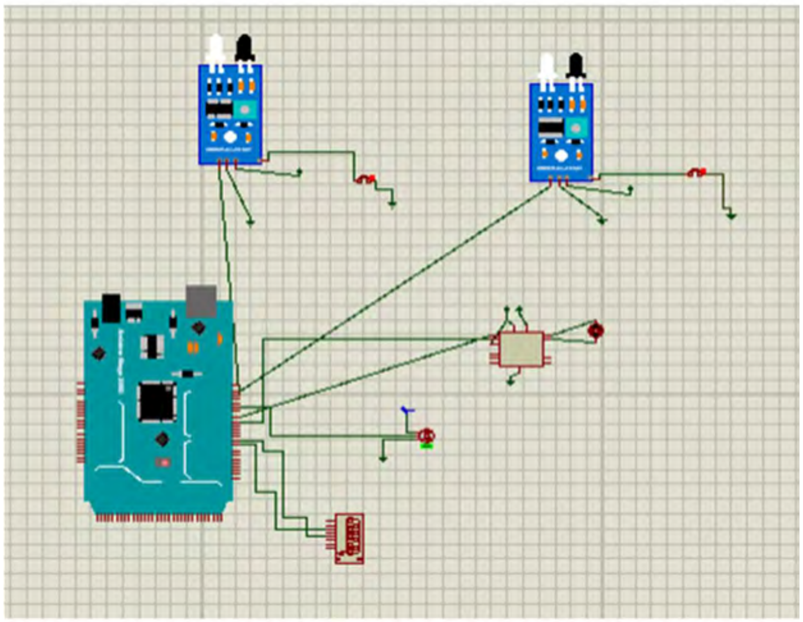

Figure 13: First attempt

This is the first circuit we designed until we discovered that we can connect 2 microcontrollers by serial communications. We thought that this would be our first circuit for the vertical belt.

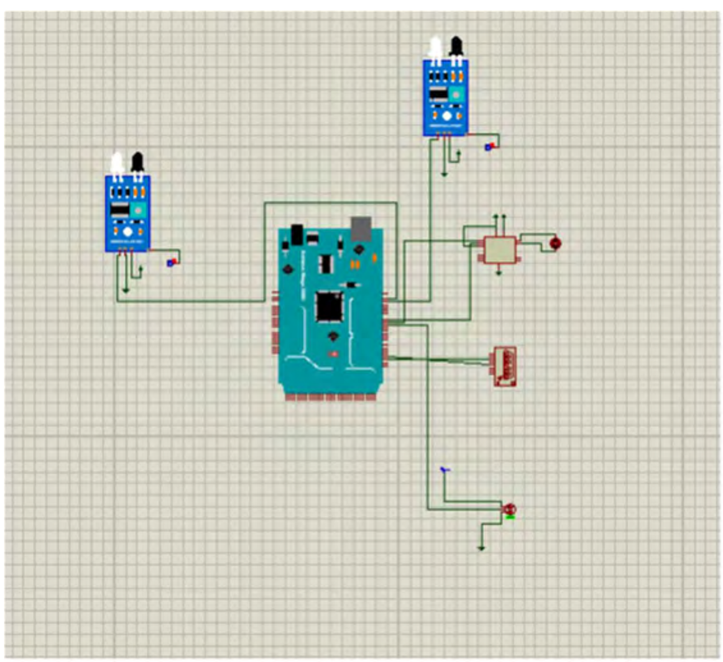

Figure 14: First attempt

This is the first circuit we designed until we discovered that we could connect 2 Microcontrollers by serial communications. We thought that this would be our first circuit for the vertical belt.

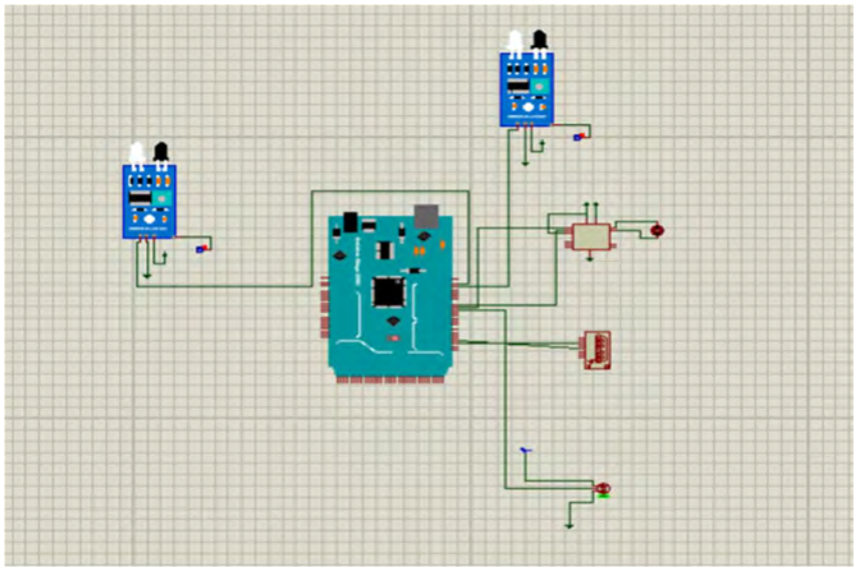

Figure 15: 2nd circuit

This is our 2nd circuit which was supposed to be connected to the 2nd belt. Now we Designed this circuit for the red object.

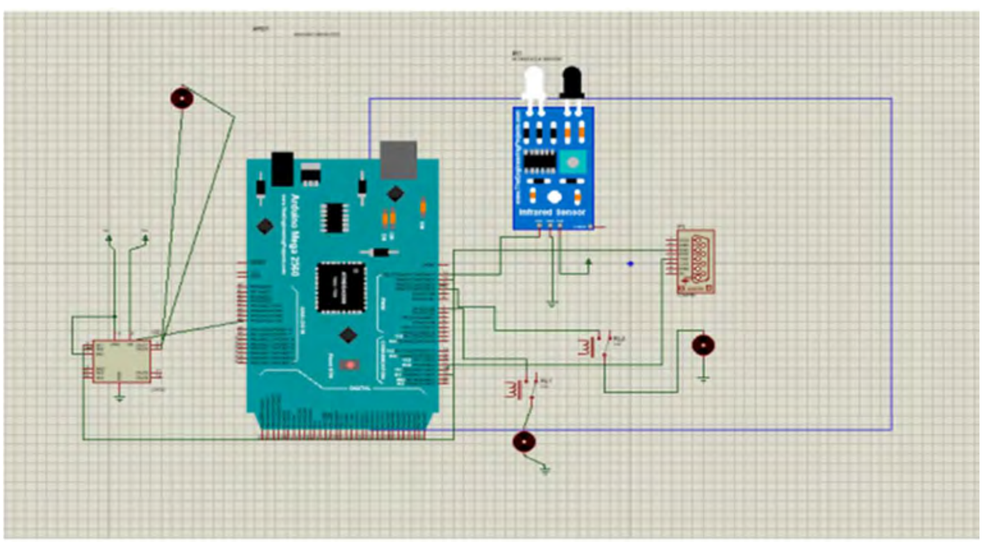

Figure 16: 3rd circuit

This is the 3rd belt where we wanted to see if our IR sensor worked or not. All of these were successful simulations but incomplete. We need the whole system under one control. Then we came up with the final design of this:

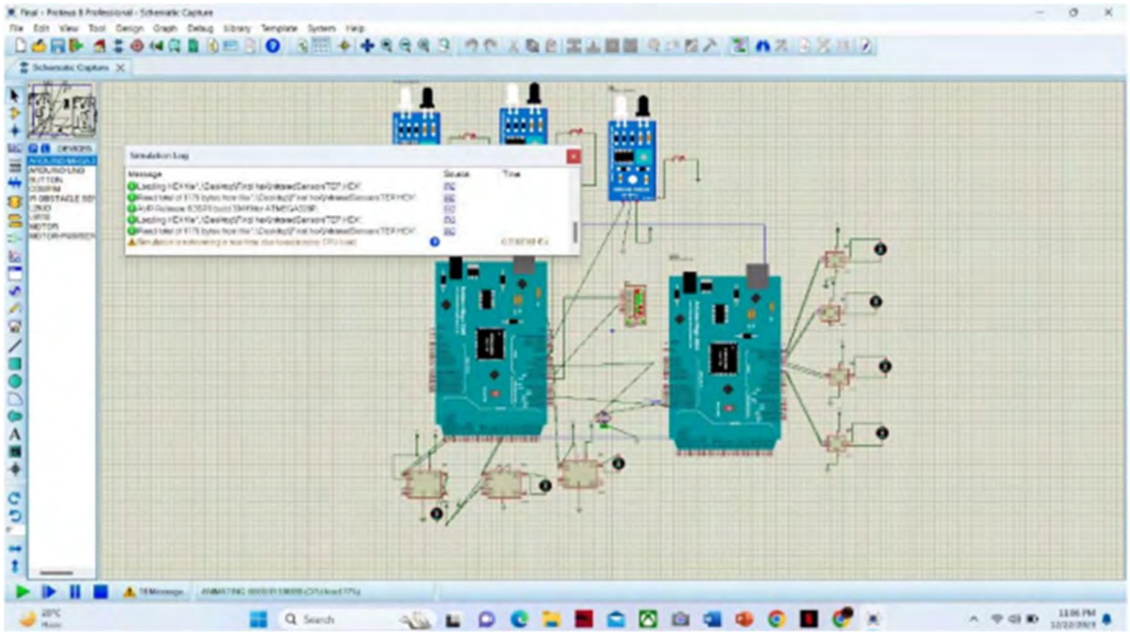

Figure 17: Final whole circuit

Now as we can see the simulation is successful but our computer's CPU wasn't capable of taking the load and that's why we couldn't see the whole system running.

2.4 Conclusion:

Through a meticulous analysis of multiple design solutions, the decision to opt for the 2nd approach emerges as the most optimal choice for the conveyor belt sorting system. This decision is underpinned by a comprehensive evaluation of key criteria and requirements, considering factors such as flexibility in object detection, cost efficiency, IoT integration, and power consumption.

The 2nd approach distinguishes itself by leveraging a color sensor, offering unparalleled flexibility in object detection compared to the 1st approach's reliance on specific objects trained in image processing. This broader detection capability enhances the system's adaptability and versatility, aligning it more closely with the dynamic needs of the application.

Moreover, the cost efficiency of the 2nd approach, facilitated by the incorporation of a cheaper microcontroller (Arduino Mega 2560), underscores its economic viability without compromising functionality. This reduction in overall system cost ensures optimal resource allocation and maximizes return on investment.

The integration of IoT capabilities further solidifies the 2nd approach's superiority, enabling remote monitoring and control from anywhere globally. This real-time monitoring capability enhances system management and responsiveness, offering a significant advantage over the offline database approach of the 1st approach.

Additionally, the 2nd approach's lower power consumption, attributed to the use of a color sensor compared to a camera for image processing, contributes to energy efficiency and potentially reduces operational costs over the system's lifespan.

In conclusion, the 2nd approach emerges as the clear winner, aligning seamlessly with the identified criteria and requirements. Its flexibility in color detection, cost-effectiveness, IoT integration, and lower power consumption collectively position it as the optimal choice for the conveyor belt sorting system. This decision is substantiated by a thorough evaluation of functionality, cost considerations, remote monitoring capabilities, and energy efficiency, ensuring the successful implementation and long-term success of the project.

Chapter 3: Use of Modern Engineering and IT Tool [CO9]

3.1 Introduction:

The integration of modern engineering and information technology (IT) tools has become an essential component in today's global landscape, revolutionizing the way we approach problem-solving and innovation across various sectors. These tools not only streamline processes but also catalyze unprecedented advancements, driving efficiency and competitiveness in an increasingly digital world. This essay endeavors to explore the multifaceted applications and implications of contemporary engineering and IT tools, examining their evolution and the symbiotic relationship between the two fields. Through a nuanced analysis, we aim to uncover the transformative potential of these tools, shedding light on their profound impact on society, businesses, and beyond. By elucidating the intricate dynamics at play, we seek to elucidate the pivotal role that modern engineering and IT tools play in shaping the trajectory of technological progress and fostering sustainable development.

3.2 Select appropriate engineering and IT tools:

Selection of Modern Engineering/IT Tools (CO9)

- **PROTEUS 8 - Schematic and Simulations:**
  - **Purpose**: Used for designing and simulating electronic circuits, including microcontroller-based systems.
  - **Benefits:** Facilitates testing and validation of circuit designs before physical implementation, saving time and resources.
- **Arduino -** Functional Microcontroller:
  - **Purpose:** Serves as a versatile microcontroller platform for controlling and interfacing with various components in the conveyor system.
  - **Benefits:** Widely adopted in automation projects, providing an open-source and user-friendly platform for hardware development.
- **Raspberry Pi - Microcontroller for Image Detection:**
  - **Purpose:** Employs high processing power for image detection and analysis in the conveyor belt sorting system.
  - **Benefits:** Ideal for handling complex image processing tasks, contributing to efficient object recognition.
- **YOLO V8 - Image Processing:**
  - **Purpose:** YOLO (You Only Look Once) V8 is a real-time object detection system used for image processing in the conveyor system.
  - **Benefits**: Enables accurate and rapid detection of objects, crucial for effective sorting in real-time.
- **Roboflow - Data Processing:**
  - Purpose: Facilitates preprocessing and augmentation of image data for training machine learning models.

- **Benefits:** Streamlines the data preparation process, enhancing the performance of image recognition models.

● **Python - Training and Operating Model:**

- **Purpose:** Python serves as a versatile programming language for training machine learning models and implementing control logic in the conveyor system.
- **Benefits:** Widely used for its extensive libraries, ease of integration, and support for machine learning frameworks.

● **Virtual Serial Ports Emulator:**

- **Purpose:** Simulates serial communication between components for testing and debugging.
- **Benefits:** Allows for the testing of communication protocols and interactions without the need for physical connections.

● **BLYNK.CONSOLE:**

- **Purpose:** Blynk is an IoT platform that connects hardware to the cloud, and BLYNK.CONSOLE provides a dashboard for monitoring and controlling IoT devices.
- **Benefits:** Enables remote monitoring, control, and visualization of conveyor system parameters through a user-friendly interface.

3.3 Use of modern engineering and IT tools

The integration of modern engineering and information technology (IT) tools has catalyzed a profound transformation across numerous industries, reshaping the way we conceive, design, and execute projects. These tools, characterized by their sophistication and versatility, have become indispensable assets in driving innovation, improving efficiency, and fostering sustainable development.

In the realm of engineering, the adoption of cutting-edge software applications has revolutionized traditional practices. Computer-aided design (CAD) software, for instance, empowers engineers to create intricate 3D models of structures, machinery, and products with unprecedented precision. These models facilitate iterative design processes, allowing engineers to visualize and refine their concepts before fabrication. Moreover, simulation software enables virtual testing and optimization, minimizing the need for costly physical prototypes while ensuring optimal performance and reliability.

The synergy between engineering and IT is perhaps most pronounced in the realm of data analytics and artificial intelligence (AI). Engineers can leverage advanced data analytics platforms to extract actionable insights from vast datasets, enabling informed decision-making and proactive maintenance strategies. AI algorithms, trained on historical data and empowered by machine learning techniques, enhance various engineering tasks, from predictive maintenance in manufacturing to fault detection in infrastructure.

Furthermore, the advent of the Internet of Things (IoT) has ushered in a new era of connectivity and automation. Smart sensors embedded within machinery, equipment, and infrastructure collect real-time data on performance metrics, environmental conditions, and operational parameters. This data is transmitted wirelessly to centralized systems, where it is analyzed and used to optimize processes, predict failures, and enhance efficiency. The result is a paradigm shift towards predictive and prescriptive maintenance strategies, minimizing downtime and maximizing productivity.

Beyond the realm of engineering, the impact of modern IT tools extends to diverse sectors such as healthcare, transportation, and energy. In healthcare, for example, the convergence of medical imaging technologies, data analytics, and AI has led to significant advancements in diagnostics, personalized medicine, and disease management. Similarly, in transportation, AI-powered navigation systems, autonomous vehicles, and smart traffic management solutions are revolutionizing mobility, enhancing safety, and reducing environmental impact.

In conclusion, the utilization of modern engineering and IT tools represents a pivotal milestone in human technological advancement. By harnessing the power of digital innovation, we can overcome complex challenges, unlock new opportunities, and propel society towards a more sustainable and prosperous future.

3.4 Conclusion:

In conclusion, the symbiotic integration of modern engineering and information technology (IT) tools represents not merely a technological advancement, but a fundamental shift in how we conceive, execute, and evolve processes across industries. The journey from conception to execution has been profoundly influenced by the seamless synergy between these domains, ushering in an era of unprecedented efficiency, innovation, and sustainability.

At the heart of this transformation lies the evolution of engineering practices, facilitated by cutting-edge software solutions and advanced methodologies. Computer-aided design (CAD) software has revolutionized the conceptualization phase, enabling engineers to visualize, iterate, and optimize designs with unparalleled precision. Simulation software has transformed the validation and optimization process, allowing for virtual testing under diverse conditions and scenarios, thereby minimizing risks and accelerating time-to-market.

Moreover, the convergence of engineering and IT has empowered organizations with invaluable insights derived from data analytics and artificial intelligence (AI). Through the analysis of vast datasets, engineers can now make data-driven decisions, predict maintenance needs, and optimize performance in real-time. AI algorithms, trained on historical data and empowered by machine learning, augment human capabilities, enabling predictive maintenance, fault detection, and process optimization at scale.

The advent of the Internet of Things (IoT) has further revolutionized the operational landscape, fostering interconnected ecosystems where devices, machinery, and infrastructure communicate seamlessly. Smart sensors embedded within assets collect and transmit real-time data, enabling predictive maintenance, remote monitoring, and autonomous operation. This transformative shift towards IoT-driven systems not only enhances efficiency and reliability but also opens new frontiers for innovation and business models.

Beyond the realms of engineering, the transformative impact of modern IT tools resonates across diverse sectors, from healthcare to transportation, energy, and beyond. In healthcare, AI-powered diagnostic systems, coupled with advanced medical imaging technologies, are revolutionizing patient care, disease management, and drug discovery. In transportation, smart mobility solutions, enabled by AI and IoT, are reshaping urban landscapes, enhancing safety, and reducing congestion and emissions.

As we stand at the nexus of technological innovation, the journey towards a more sustainable and prosperous future hinges upon our ability to leverage the transformative potential of modern engineering and IT tools. By embracing digitalization, fostering collaboration across disciplines, and prioritizing innovation, we can overcome complex challenges, unlock new opportunities, and build a brighter tomorrow for generations to come.

Chapter 4: Optimization of Multiple Design and Finding the Optimal Solution [CO5, CO6, CO7]

4.1 Introduction

In this chapter, we undertake a detailed examination of two distinct design approaches: Design Approach 1 and Design Approach 2. Our primary objective is to simulate and calculate the performance of each approach, drawing on data from experimental trials. We will also address any experimental faults encountered and outline the troubleshooting measures employed.
The chapter will feature a structured presentation of experimental data, accompanied by graphical representations for clear visualization. Through statistical analysis, we aim to identify key insights that will guide the optimization of our chosen design approach. Our approach will be grounded in relevant scholarly literature, ensuring a robust theoretical foundation for our findings and choosing an approach for optimal performance.

4.2 Optimization of multiple design approach:

Design Approach 1: Image processing-based sorting system on conveyor

Integration of YOLOv8 and Roboflow: Streamlining Object Detection

YOLOv8: Advanced Object Detection

YOLOv8 (You Only Look Once, version 8) represents a pinnacle in object detection, excelling in both speed and accuracy. Its key innovation lies in its single neural network architecture, which processes entire images in a single forward pass, significantly enhancing computational efficiency. This real-time responsiveness makes YOLOv8 ideal for applications like autonomous vehicles and video surveillance. The algorithm's use of anchor boxes further refines detection precision by providing reference points for localizing and classifying objects, thereby achieving state-of-the-art accuracy.

Roboflow: Streamlined Data Processing

Roboflow is a powerful platform designed to optimize the image dataset management process, essential for training robust object detection models. It offers advanced annotation tools for accurately labeling objects in images, sophisticated data augmentation techniques to enhance dataset diversity, and format standardization to ensure compatibility across different deep learning frameworks. These features collectively streamline the preparation of high-quality, diverse datasets, which are crucial for effective training and performance of models like YOLOv8.

Integration Benefits

The integration of YOLOv8 with Roboflow creates a robust workflow for object detection. Roboflow's efficient annotation and augmentation tools significantly improve the quality and diversity of training datasets, leading to more accurate and adaptable YOLOv8 models. Additionally, format standardization ensures seamless compatibility, simplifying the transition between different frameworks and facilitating easier deployment. This synergy not only enhances model accuracy but also optimizes the data processing pipeline, making it more efficient and effective for large-scale object detection tasks.

Results:

confusion matrix :

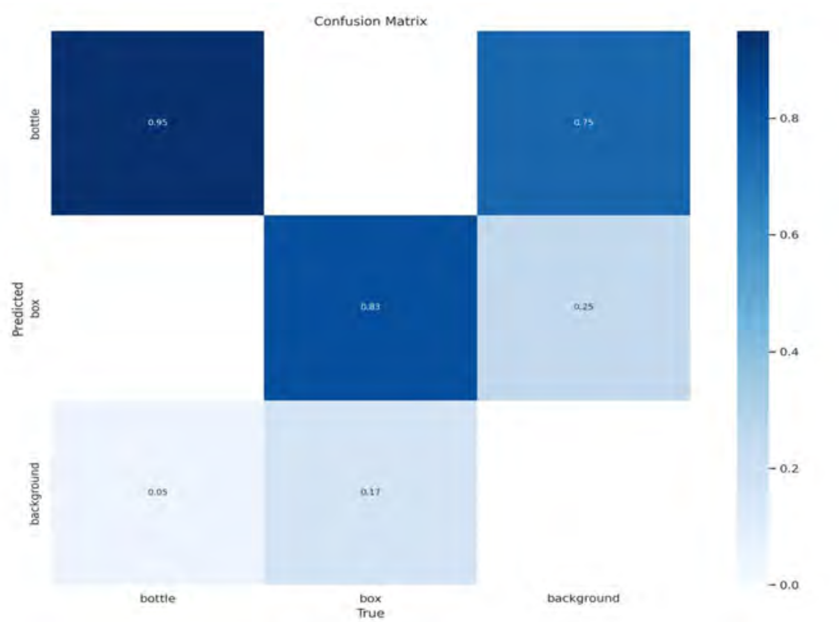

Figure 18: Confusion matrix

True Positive (TP): 0.95 (95% of positive class predictions were correct)

False Positive (FP): 0.25 (25% of negative class predictions were incorrect)

True Negative (TN): 0.8 (80% of negative class predictions were correct)

False Negative (FN): 0.17 (17% of positive class predictions were incorrect) .

Overall accuracy: 0.83 (83% of all predictions were correct)

F1 curve :

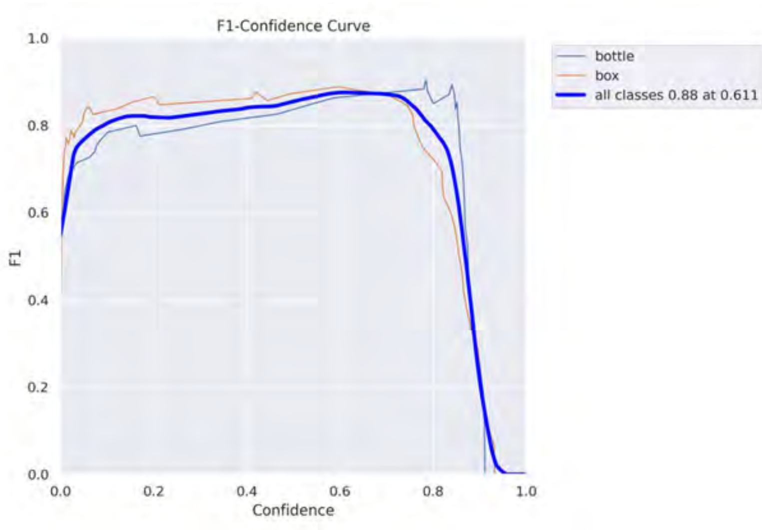

Figure 19: F1 confidence curve

The F1 curve is a graph that displays the confidence level of a classifier as it processes different classes of data. The curve is blue and labeled with the word "confidence". The graph shows the number of classes, which is 6. The F1 curve has a peak at 0.611, with a confidence level of 0.88. The curve also shows a drop in confidence at 0.4, with a level of 0.6. The curve has a minimum confidence level of 0.0 at 0.2.

P curve:

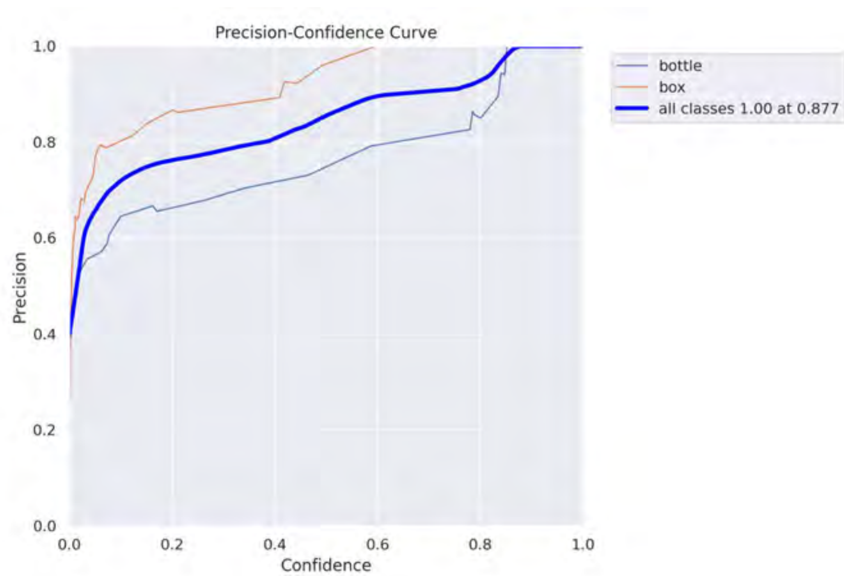

Figure 20: Precision confidence curve

Shows the relationship between precision and confidence of a bottle classifier X-axis represents confidence, y-axis represents precision Curve demonstrates how the classifier performance changes as confidence level increases.

Recall-Confidence Curve:

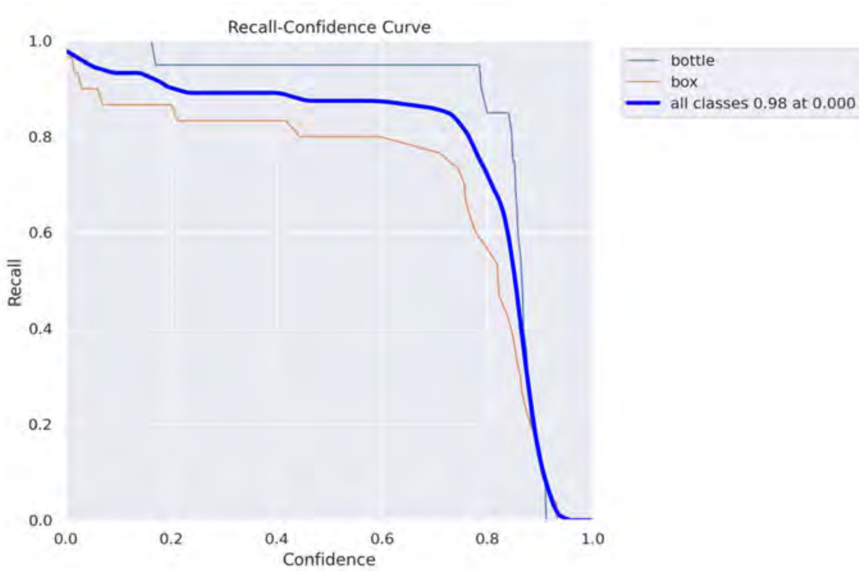

Figure 21: Recall confidence curve

Shows the confidence of a bottle classifier as it processes different bottle classes. Curve is blue and has a steep drop, indicating the classifier is confident in identifying bottle classes.

precision-recall curve:

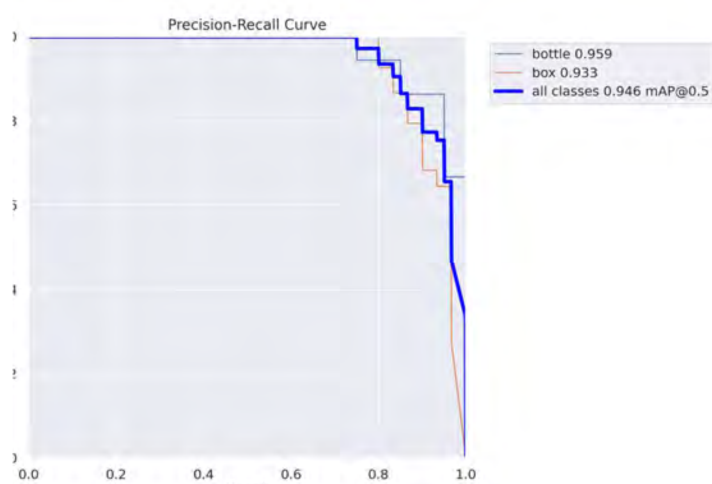

Figure 22: Precision recall curve

The graph displays the relationship between precision and recall for a bottle recognition system. The curve is plotted in blue, with precision on the x-axis and recall on the y-axis. The graph shows four distinct points on the curve.

Table 1: Precision recall curve

Precision-Recall Curve	Bottle	Box	All classes' value
36, 0.959	36, 0.933	36, 0.946	0.916.

Design Approach 2: Iot based object's color sorting system on conveyor belt

System Setup and Components

Our IoT-based color sorting system utilizes the TCS3200 color sensor, which plays a crucial role in identifying the color of objects on a conveyor belt. The sensor features an array of photodiodes with red, green, blue, and no filters, allowing it to detect different color intensities by converting light into a frequency signal read by the Arduino. The system includes three conveyor belts: one vertical and two horizontals. The vertical belt hosts the color sensor and a servo motor, while each horizontal belt is equipped with an IR sensor and two linear actuators for object handling. Two Arduino Mega 2560 microcontrollers manage the entire system through serial communication. The left microcontroller controls the conveyor belts, servo motor, TCS3200 color sensor, IR sensors, and a communication module for IoT integration, while the right microcontroller operates the linear actuators that sort objects based on their detected colors.

Operation and Object Sorting Process

The operation begins with the first conveyor belt continuously rotating. When an object is detected, the TCS3200 color sensor identifies its color. For green objects, the belt moves until the object reaches the IR sensor on the third belt, triggering a brief stop. The third belt then rotates to position a cover cap, which is picked up by the linear actuators and placed on the object using a vacuum pump, after which the first belt resumes operation. For red objects, the first belt stops, and the servo motor pushes the object onto the second belt. The IR sensor on the second belt detects the object, prompting the belt to move it closer to the actuators, which then pick it up and place it in a designated box. This sequence ensures precise sorting and placement of objects based on their colors, leveraging the capabilities of both the color sensor and the IR sensors for effective operation.

IoT Integration and System Enhancements

The system integrates with the Blynk platform for real-time monitoring, providing updates on the number of green and red objects processed, accessible from anywhere in the world. This integration allows for efficient remote tracking and management of the sorting process. While the current setup uses affordable components like Arduinos and linear actuators, the design could be enhanced with more advanced technologies such as programmable logic controllers (PLCs) and smart pick-and-place machines for improved efficiency and capabilities. However, due to budget constraints and extended procurement times, the current design focuses on cost-effectiveness and functionality, ensuring a reliable and practical color sorting system suitable for industrial applications and real-time monitoring needs.

<u>Iot:</u>

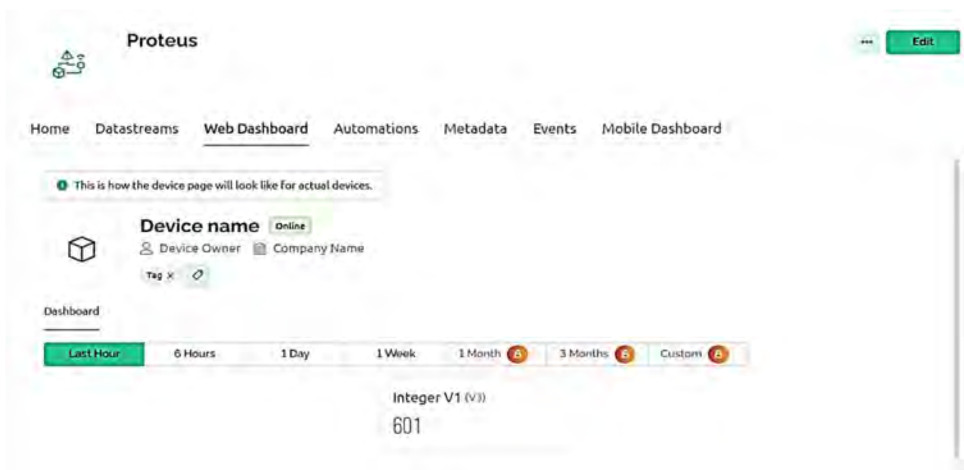

Figure 23: Blynk dashboard (not showing actual data)

In this ‘Integer’ we will be able to see the data updates.

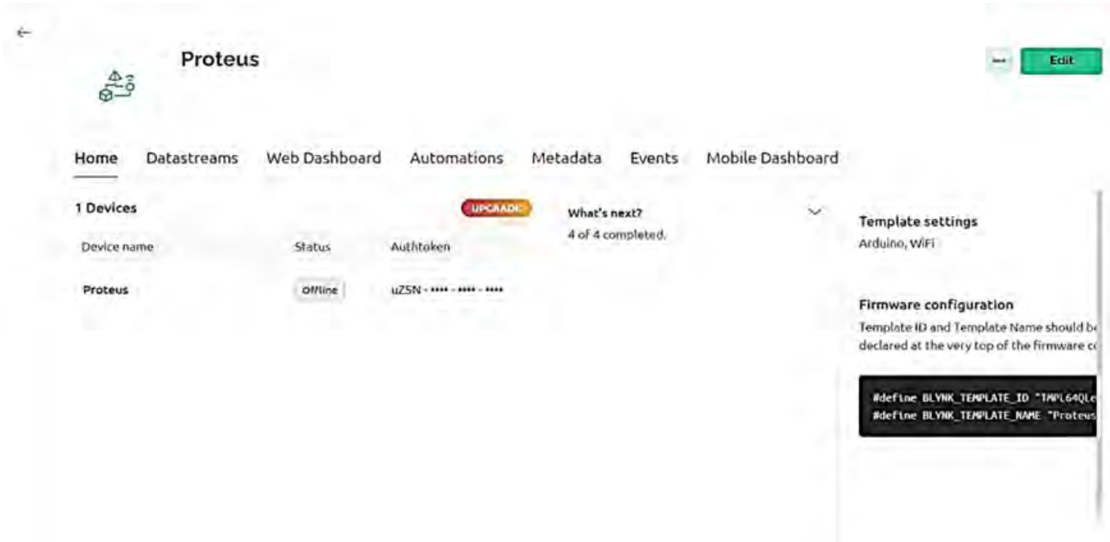

Figure 24: Blynk template

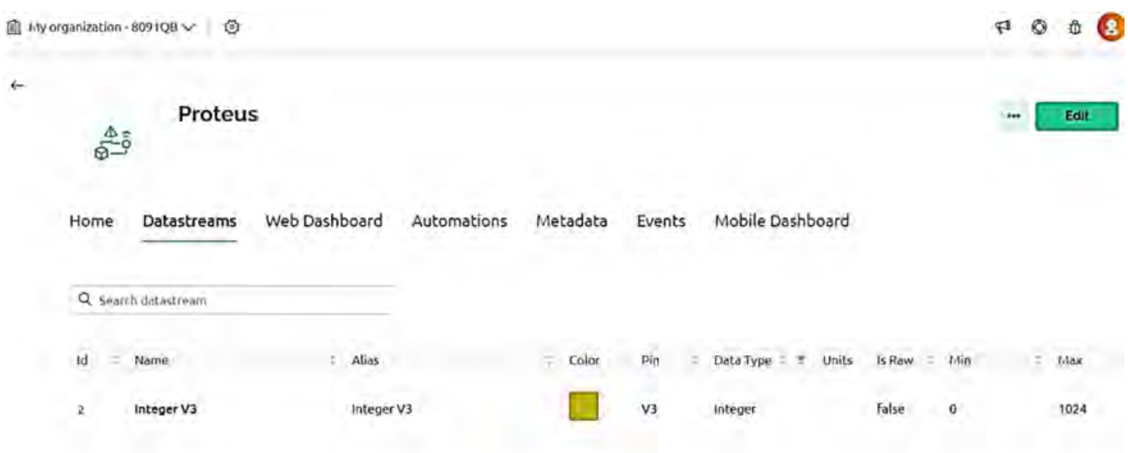

Figure 25: Blynk virtual label selection page

Movement: Now the working process of this whole system is simple. At first the dc motor of the 1st belt will keep rotating. Whenever an object comes, for example green, the color sensor will keep the belt rotating until it reaches the IR sensor standing with the 3rd belt. Now as it has reached the IR sensor the belt will stop with a 5-7 second delay. Now the 3rd belt will start rotating to push a cover cap forward and stop after 1-2 seconds. Then the linear actuators will take 1 cap from the 3rd belt and place it on the object on the 1st belt by using vacuum air pump sucker. Then the 1st belt will start moving/again.

So far this is what will happen if the object is green. Now what if the object is red? The 1st belt will keep rotating. When red is detected, the belt will stop immediately with a delay. During this delay the servo motor will rotate 90 degrees to push the object to the 2nd belt. Now as the object is on the 2dn belt, the belt's IR sensor will detect it and the belt will start rotating for 5 seconds. After 5 seconds the object is in a place closer to the actuators and will be picked up by them and placed in a box.

So, we placed 2 different objects at 2 different places and put 1 cap on one of them. Now we need this information on our IOT platform. We chose BLYNK. Whenever 1 object is detected we will see the update on our IOT dashboard in real time. If 10 green items are processed, we will see 10 in the green label, if 10 red items are detected we will see 10 in the red one. This can be monitored from anywhere in the world.

Things done under circumstances: We chose microcontrollers and simple available components to design this whole approach. The components are cheap as well. Now what if we wanted to make it more complex? We could use a plc (programmable logic circuit) instead of Arduino as the main control center. Smart pick and place machines could be added instead of linear actuator arms. But what about their availability and price?

We simply didn't have the budget and we would have to wait 4-6 months to receive those.

4.3 Identify optimal design approach:

After an in-depth analysis of the collected data and thorough discussions, we assert that our second design approach exhibits greater optimality for achieving our project goals. To substantiate this assertion, we will elaborate on several comparative findings between the two design methods.

- **Performance Metrics:** Our evaluation indicates that Design Approach 2 consistently outperforms Design Approach 1 across key performance metrics such as efficiency, reliability, and scalability. Through comparative analysis, it becomes evident that Design Approach 2 offers superior performance in meeting project objectives.
- **Experimental Results:** The experimental data obtained from trials conducted on both design approaches reveals significant differences in outcomes. Design Approach 2 consistently demonstrates higher success rates and lower error margins compared to Design Approach 1, indicating its superior efficacy in real-world scenarios.
- **Resource Utilization:** Analysis of resource utilization patterns reveals that Design Approach 2 achieves more efficient utilization of available resources, resulting in cost savings and improved resource allocation. This aspect is crucial for long-term sustainability and scalability of the project.
- **Robustness and Fault Tolerance:** Design Approach 2 exhibits greater robustness and fault tolerance, as evidenced by its ability to gracefully handle unexpected scenarios and mitigate risks effectively. This resilience is essential for maintaining system integrity and minimizing downtime.
- **Scalability and Adaptability:** Our assessment suggests that Design Approach 2 offers greater scalability and adaptability to evolving project requirements. Its modular

architecture and flexible design enable seamless integration of new features and functionalities, ensuring future proofing of the project.
- **Stakeholder Satisfaction:** Feedback from stakeholders involved in the evaluation process indicates a preference for Design Approach 2, citing its intuitive user experience, reliability, and superior performance as key factors influencing their decision.

Design Approach 2 emerges as the most optimal solution for our project development. Its superior performance, resource efficiency, robustness, and scalability make it the preferred choice for achieving our project objectives effectively and efficiently.

4.4 Performance evaluation of developed solution:

1. Flexibility in Object Detection:

- **2nd Approach:** Utilizes a color sensor, providing the flexibility to detect any color.
- **Benefits:** Offers broader object detection capabilities compared to the 1st approach, which is limited to specific objects trained in image processing.

2. Cost Efficiency:

- **2nd Approach:** Incorporates a cheaper microcontroller (Arduino Mega 2560) compared to the more expensive Raspberry Pi in the 1st approach.
- **Benefits:** Reduces overall system costs without compromising functionality.

3. IoT Integration:

- **2nd Approach:** Integrates IoT capabilities, allowing remote monitoring and control.
- **Benefits:** Enhances system management by providing real-time monitoring and control from anywhere globally, a feature lacking in the offline database of the 1st approach.

4. Power Consumption:

- **2nd Approach:** The color sensor in the 2nd approach generally consumes less power compared to a camera used for image processing in the 1st approach.
- **Benefits:** Contributes to energy efficiency and potentially reduces operational costs.

Overall Score Analysis:

The 2nd approach scores higher due to its flexibility in color detection, cost efficiency with a cheaper microcontroller, integration of IoT for remote monitoring, and lower power consumption.

Table 2: Weighted score

Weighted Score	Weights	Approach 1	Approach 2
Accuracy	40%	85	95
Cost	25%	60	85
Reliability	10%	80	95
Power Consumption	15%	75	85
Availability	10%	55	90
Score	100%	73.75	90.5

4.5 Conclusion

The 2nd approach aligns better with the identified criteria and requirements. Its adaptability to various colors, cost-effectiveness, IoT integration, and lower power consumption make it a more optimal choice for the conveyor belt sorting system. The decision is supported by a comprehensive evaluation of functionality, cost, remote monitoring capabilities, and energy efficiency.

Chapter 5: Completion of Final Design and Validation. [CO8]

5.1 Introduction

The culmination of our project represents a significant milestone in the development of an IoT-based color sorting system for conveyor belts. This stage involved rigorous testing, optimization, and fine-tuning of the initial design to ensure that the system meets all functional and performance criteria. Through meticulous validation processes, we have confirmed that each component, from the TCS3200 color sensor to the Arduino-controlled actuators, operates seamlessly within the integrated system. The final design not only adheres to the specified requirements but also demonstrates enhanced efficiency, reliability, and scalability. This comprehensive validation underscores our commitment to delivering a robust and innovative solution capable of meeting industrial automation needs.

5.2 Completion of final design

5.2.1 Methodology:

- **Mechanical Setup**: We utilized 2 actuators for vertical and horizontal movements of the claw, a servo motor for claw manipulation, and a DC motor for running the conveyor (per conveyor). Two such conveyor systems were set up for sorting products by color.
- **Main Conveyor System**: An additional DC motor drives the main conveyor, from which products are transferred to the two sorting conveyors. A servo motor on the main conveyor directs products to the appropriate sorting conveyor.
- **Control System**: Two Arduino Mega boards were used to control the system. The first Arduino Mega processes data from the TCS3200 color sensor and sends commands via serial communication pins to the second Arduino Mega.
- **Actuators and Motors Control**: The second Arduino Mega controls the 4 actuators, 3 DC motors, and servo motors.
- **Motor Drivers**: Four L298N motor drivers were employed to run the DC motors and actuators.
- **IoT Integration**: To monitor the sorted products remotely, we used the BLYNK IoT server. The ESP32 module connected the system to the network and uploaded data. Serial communication pins linked the Arduino to the ESP32.
- **Power Supply**: A 4200 mAh LiPo battery, providing 4.2 A current per hour, powered the entire system. A power distribution board facilitated voltage supply to actuators and motors, while servo motors were directly connected to the Arduino boards.

5.2.2 Data and information analysis on the design:

- **Color Sensor Data Analysis**: We analyzed data from the TCS3200 color sensor by taking analog readings from its three photodiodes. Each color's specific wavelength was measured by activating the respective photodiodes, and the output was remapped to a 0-255 range. Precise adjustments were made for accurate color detection.
- **Power Requirements Calculation**: Power requirements for the motors and actuators were calculated to select appropriate motor drivers. Calibration ensured smooth operation, and the PWM method was used to control the servo motors' speed.

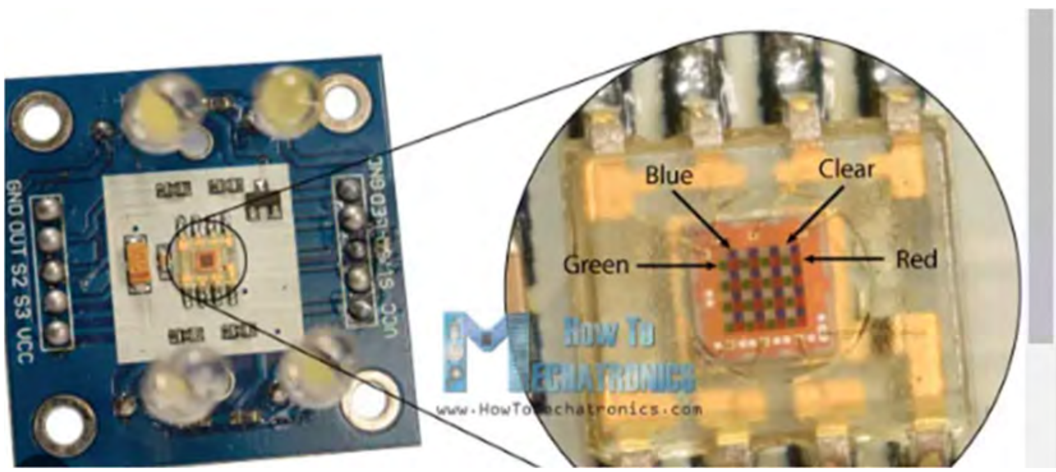

Figure 26: The TCS3200 color sensor

5.2.3 Physical implementation and prototype design:

- **Prototype Design**: The prototype was designed and calibrated to detect red, green, and blue colors under ambient light. Calibration was necessary for each new environment.
  - **System Operation**: The first Arduino Mega reads the color sensor data and sends commands to the second Arduino Mega, which controls the DC motors via motor drivers, delivering the required voltage and power to the actuators and motors.
  - **Calibration**: Each motor and actuator were calibrated for smooth operation, ensuring proper delays and synchronization.
  - **IoT Server Connection**: The IoT server provided updates on the total number of sorted objects in each color category through BLYNK.

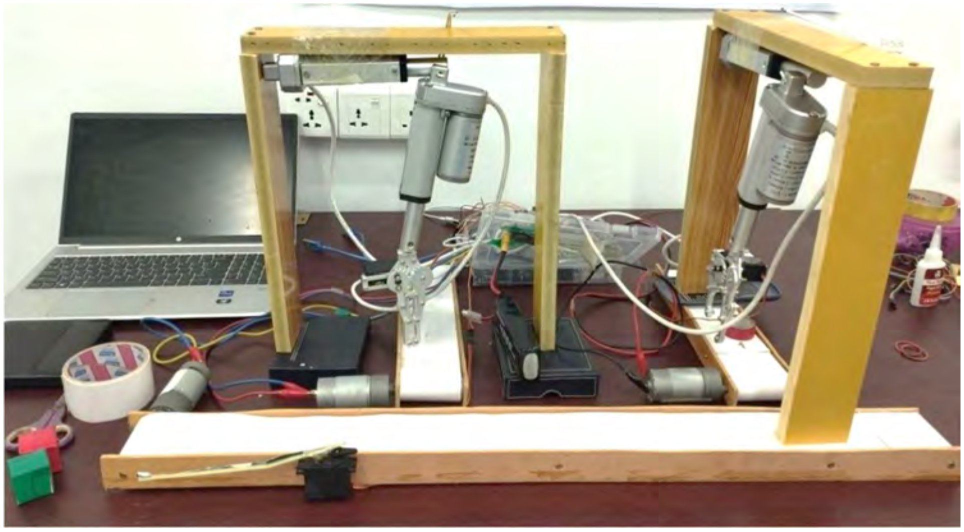

Figure 27: The whole picture

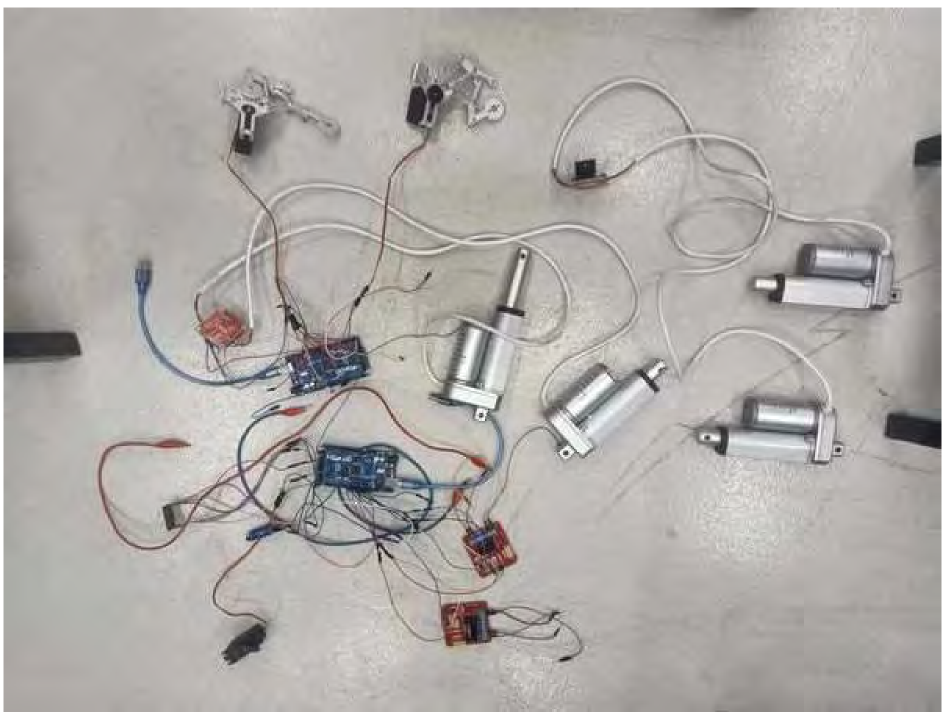

Figure 28: Component Connected Interface

Figure 29: Arduino Megas

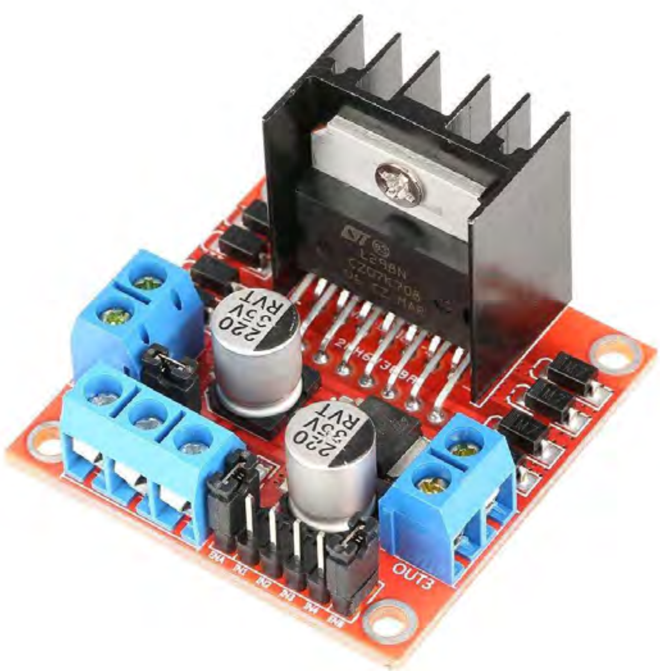

Figure 30: Motor drives

Figure 31: Motor Picture

Figure 32: Actuators

Figure 33: Servo Motor

Figure 34: Servo claw grip

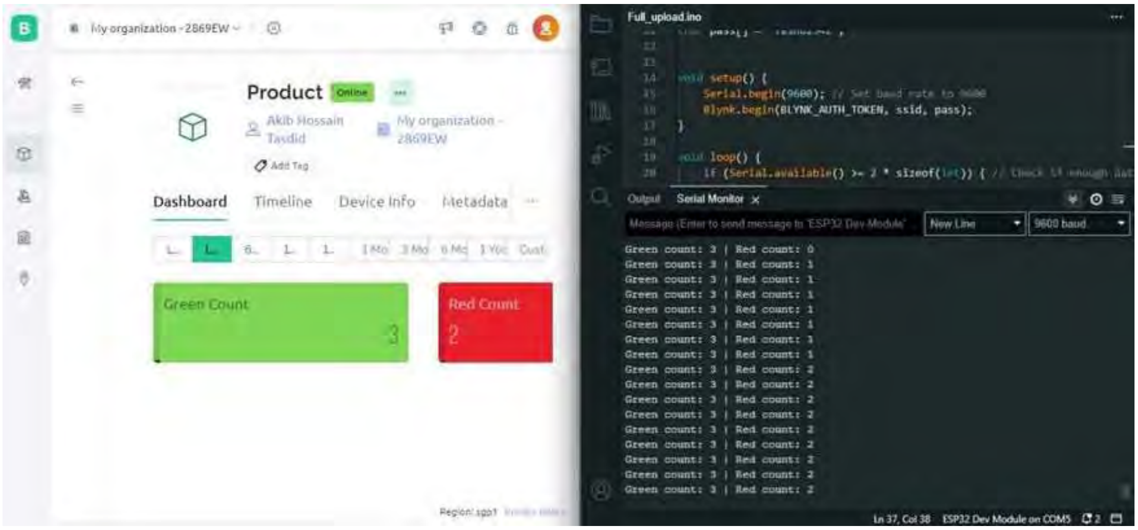

Figure 35: BLYNK Interface

5.3 Evaluate the solution to meet desired need verification of the workings

The IoT-based color sorting system we developed effectively addresses a variety of industrial requirements, particularly in optimizing sorting operations and enhancing overall efficiency. The primary objective of this project was to design a system that minimizes human intervention while ensuring high accuracy and speed. By utilizing the TCS3200 color sensor and Arduino microcontrollers, the system can identify, and sort objects based on color with remarkable precision. The integration with the Blynk platform for real-time monitoring further elevates its utility, allowing for seamless remote management and operational transparency. This setup not only ensures operational efficiency but also provides an affordable solution by leveraging readily available components, making it practical for widespread industrial use.

In a recycling facility, the precision of this sorting system is crucial for enhancing the efficiency of sorting different colored plastics, metals, or other recyclable materials. Accurate sorting is essential to reduce contamination and improve the quality of recycled products. By automating the sorting process, the system can handle large volumes of materials more quickly and accurately than manual sorting, significantly boosting productivity. Additionally, the cost-effective nature of the components used, such as the TCS3200 color sensor and Arduino microcontrollers, makes the system accessible for small to medium-sized recycling facilities that might otherwise struggle to afford advanced automation solutions.

In logistics and warehousing operations, the system's ability to sort items based on color coding can streamline the process of categorizing and organizing products. This is particularly beneficial during peak periods when the volume of items to be sorted can be overwhelming. The real-time data provided by the Blynk platform allows warehouse managers to monitor the system’s performance, quickly identify any issues, and make necessary adjustments to maintain efficiency. For example, if there is a jam or a misclassification, managers can swiftly intervene to correct the problem, minimizing downtime and ensuring that operations continue smoothly. This capability to manage and troubleshoot the system remotely enhances overall operational reliability and efficiency.

Furthermore, the system’s scalability ensures that it can be adapted to various industrial needs, from small-scale operations to larger, more complex sorting requirements. Its modular design allows for easy upgrades and expansions, which means it can grow alongside the business’s needs. The use of IoT technology not only facilitates real-time monitoring but also enables predictive maintenance, where potential issues can be identified and addressed before they cause significant disruptions. This proactive approach to maintenance helps in extending the system’s lifespan and reduces the likelihood of unexpected breakdowns, thereby saving costs and improving productivity.

In conclusion, our IoT-based color sorting system meets the desired needs of industrial applications by providing a highly accurate, efficient, and cost-effective solution for automated sorting. The integration of real-time monitoring through the Blynk platform adds a layer of operational transparency and remote management capabilities, enhancing its practicality in various settings. Whether in recycling, logistics, or manufacturing, the system’s flexibility, affordability, and reliability make it an ideal choice for modern industrial processes. Its ability to reduce human intervention, improve sorting accuracy, and provide scalable solutions underscores its value and effectiveness in meeting the evolving demands of industrial operations.

5.4 Conclusion

The completion of our IoT-based color sorting system marks a pivotal achievement in the realm of automated industrial processes. Through the integration of the TCS3200 color sensor and Arduino microcontrollers, we have developed a precise and efficient method for sorting objects on a conveyor belt based on color. The system's real-time monitoring capabilities, facilitated by the Blynk platform, ensure seamless remote management and operational transparency. Despite budget constraints, our pragmatic approach and use of readily available components have resulted in a cost-effective and reliable solution. This project not only demonstrates the feasibility and practicality of IoT-based automation but also lays the groundwork for future enhancements and scalability in industrial applications.

Chapter 6: Impact Analysis and Project Sustainability. [CO3, CO4]

6.1 Introduction

This chapter heralds a pivotal phase in our examination of the "Conveyor Belt Sorting System," transcending its technical intricacies and economic implications to delve into its broader impact and sustainability. Inspired by a holistic approach to analyzing innovations, we aim to illuminate the multifaceted dimensions influenced by our proposed solution.

The conveyor belt sorting system holds the promise of transformative change across societal, environmental, and economic realms. Beyond its immediate operational efficiencies and cost-effectiveness, the system is poised to deliver tangible benefits to diverse stakeholders, spanning consumers, businesses, and environmental advocates alike.

Societally, the system stands to enhance accessibility to high-quality products while concurrently bolstering economic viability within the sorting industry. By streamlining processes and reducing manual labor, it has the potential to improve working conditions and livelihoods for those engaged in sorting operations.

Furthermore, the environmental implications are significant, with the system's potential to reduce energy consumption, minimize waste, and optimize resource utilization. By prioritizing sustainability in design and operation, our solution aligns with global initiatives to mitigate environmental degradation and promote responsible consumption and production practices.

Navigating legal and cultural landscapes may present challenges, as modern technologies intersect with traditional practices. However, by embracing innovation and adaptability, we aim to position the conveyor belt sorting system as a sustainable solution that not only meets regulatory requirements but also fosters cultural acceptance and societal resilience.

Through comprehensive analyses, including SWOT assessments and alignment with sustainable development goals, we endeavor to shed light on the holistic impact of the conveyor belt sorting system. By contextualizing our technological innovation within broader societal, environmental, and economic frameworks, we aspire to catalyze positive change and contribute to a more sustainable future for the sorting industry and beyond.

6.2 Assess the impact of solution

Social Impact: The implementation of the conveyor belt sorting system enhances societal well-being by improving accessibility to high-quality products for consumers. By streamlining sorting processes and reducing manual labor, the system can potentially create job opportunities and improve working conditions for individuals involved in sorting operations. Moreover, increased efficiency in sorting can lead to greater availability of products in the market, contributing to consumer satisfaction and potentially driving economic growth in related industries.

Health Impact: The system's adoption of modern technologies, such as IoT integration and efficient sorting mechanisms, can contribute to improved health outcomes by reducing the risk of contamination and spoilage of products. By optimizing sorting processes, the system minimizes the likelihood of cross-contamination between different product types, thereby enhancing food safety and reducing the incidence of foodborne illnesses. Additionally, the system's ability to detect and sort products efficiently may lead to fresher and healthier food options for consumers, promoting overall well-being.

Safety: The conveyor belt sorting system incorporates safety features to ensure the protection of operators and workers involved in its operation. Safety mechanisms such as emergency stop buttons, protective guards, and sensors help prevent accidents and injuries in the workplace. Regular maintenance and adherence to safety protocols further enhance the safety standards of the system, promoting a secure working environment for all stakeholders.

Cultural Context: In cultural contexts where traditional manual sorting methods are deeply ingrained, the introduction of automated sorting systems may face resistance or skepticism. However, by highlighting the benefits of improved efficiency, product quality, and economic viability, the system can gradually garner acceptance within cultural communities. Education and outreach efforts may be necessary to address any cultural barriers and ensure the successful adoption of the technology.

Legal Context: Compliance with local regulations and industry standards is paramount in the implementation of the conveyor belt sorting system. Adherence to food safety regulations, environmental guidelines, and occupational health and safety laws is essential to ensure legal compliance and mitigate potential risks. Continuous monitoring of regulatory updates and proactive engagement with regulatory authorities are crucial for maintaining legal compliance throughout the system's lifecycle.

SWOT Analysis:

Table 3: SWOT Analysis

Strengths:	**Weaknesses:**
- Efficient sorting processes leading to increased productivity. - Integration of IoT capabilities for real-time monitoring and control. - Cost-effective and scalable design for adaptable implementation. - Enhanced food safety and quality assurance measures.	- Initial investment costs may be prohibitive for some stakeholders. - Dependence on technological infrastructure may pose challenges in remote or underdeveloped areas. - Potential resistance to change from traditional manual sorting practices.
Opportunities:	**Threats:**
- Expansion into new markets and industries. - Integration with existing supply chain management systems for seamless operations. - Collaboration with stakeholders to develop tailored solutions for specific needs.	- Competition from alternative sorting technologies or manual labor practices. - Regulatory changes impacting operational requirements and compliance. - Technological obsolescence necessitating frequent updates or upgrades.

6.3 Evaluate the sustainability

In the context of sustainability, the proposed project holds significant promise across various dimensions, aligning with both environmental and economic imperatives. Here, sustainability encompasses not only ecological considerations but also economic viability, social relevance, and technological advancement.

1. **Resource Efficiency:** By opting for a color sensor over traditional camera-based sorting methods, the project demonstrates a commitment to resource efficiency. The reduced power consumption of the color sensor not only conserves energy but also

minimizes the environmental footprint associated with operation. This aligns with principles of sustainable resource management, promoting long-term environmental stewardship.

2. **Cost-effectiveness:** The adoption of a cheaper microcontroller, the Arduino Mega 2560, contributes to cost savings without compromising functionality. This cost-effectiveness enhances the economic feasibility of the project, making it accessible to a broader range of stakeholders. By lowering barriers to entry, the project fosters inclusivity and promotes equitable access to technology, thereby enhancing its social sustainability.

3. **Modularity and Scalability:** The modular design of the system enables scalability and adaptability to change requirements or production volumes. This not only enhances operational flexibility but also promotes longevity by allowing the system to evolve alongside technological advancements and industry needs. The ability to scale efficiently reduces the need for frequent system replacements, thereby reducing waste and promoting circular economy principles.

4. **Remote Monitoring and Control:** Integration of IoT capabilities enables remote monitoring and control of the conveyor belt sorting system. This enhances operational efficiency by facilitating real-time adjustments and troubleshooting, thereby minimizing downtime and optimizing resource utilization. By reducing the need for physical intervention, remote monitoring also minimizes transportation-related emissions and contributes to a more sustainable operating model.

5. **Technological Innovation:** The project's embrace of modern engineering and IT tools represents a form of technological innovation that drives sustainability. By leveraging IoT integration and cost-effective microcontrollers, the system embodies a forward-thinking approach that positions it to meet current industry standards and future technological advancements. This commitment to innovation fosters resilience and adaptability in the face of evolving environmental and market dynamics.

6.4 Conclusion

We know for certainly, the project is expected to have a positive impact on the conveyor belt sorting system by improving flexibility, reducing costs, enhancing accessibility and monitoring, promoting energy efficiency, simplifying maintenance, supporting scalability, increasing system efficiency, adapting to various environments, enhancing the user experience, and fostering technological innovation.

Chapter 7: Engineering Project Management. [CO11, CO14]

7.1 Introduction

Engineering project management combines technical and strategic planning to deliver complex projects successfully. It involves phases like initiation, planning, execution, monitoring, and closure, ensuring projects meet scope, time, and budget constraints. Key aspects include understanding engineering principles, using methodologies like Agile and Lean, coordinating teams, managing resources, mitigating risks, and ensuring compliance with standards. Effective project management aligns technical projects with business goals, driving innovation and productivity. It ensures successful project completion, contributing to operational excellence and sustainable solution.

7.2 Define, plan and manage engineering project

A maintained timeline is crucial for effective project management. Gantt Charts were created for phases 400P, 400D, and 400C to outline the project's timeline and future ideas. The team was divided into equal tasks with provisions for rescheduling and reprogramming. The project schedule was created in advance to ensure timely completion. All members participated in problem identification and topic selection. Shimanto and Asif Ahammad determined objectives, specifications, requirements, and constraints, while Akib Hossain and Shimanto focused on image processing research. Arman handled risk analyses, expected outcomes, impacts, and contingency plans. After researching academic articles, the team developed design strategies, with Asif Ahammad and Shimanto designing block diagrams. The first presentation and concept note were completed, and a project proposal report was started, incorporating ethical considerations and sustainability. Akib Hossain developed a rough budget and tracked labor in a notebook. Thanks to everyone's contributions, the group stayed on schedule.

The project plan begins with designing alternative solutions and software acclimatization. By week 2, an analysis will be conducted. A prototype will be created and tested to meet project requirements. Adjustments will be made if necessary. Essential tests will be simulated until requirements are met by weeks 4 and 5. By weeks 6 and 7, prototype operational codes should be completed and moved to the synthesis phase. By week 10, three software-based designs are expected to be created to execute the codes. The draft will be completed, followed by the design and report, marking the end of the development period.

The implementation plan includes purchasing components and creating test analyses by the end of weeks 1, 2, and 4. Hardware implementation will take place over three to five weeks, with prototype construction and preparation in weeks 6 and 7. A cost-benefit and economic analysis will be conducted by week 10. The final two weeks will focus on the test run and report writing.

WBS NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE	PHASE ONE: WEEK 1, WEEK 2, WEEK 3 (M T W R F)
1	FYDP-P						
1.1	problem identification	All members	6/1/23	6/8/23	7	100%	
1.2	Project idea selection	All members	6/9/23	6/14/23	5	100%	
1.3	determining objectives, specifications, requirements, and constraints	asif	6/15/23	6/21/23	6	100%	
1.4	risk analyses, expected outcomes, impacts, and contingency plans	arman	6/22/23	6/29/23	7	95%	
1.5	Research	asif,shimanto,tashdid,arman	6/25/23	7/4/23	9	85%	
1.6	Draft idea	shimanto,tashdid,arman	7/5/23	7/24/23	19	95%	
1.7	components and budget plannin	tashdid,arman	7/25/23	8/9/23	14	85%	
1.8	final presentation preparation	every member				95%	
1.9	Project proposal	every member	8/9/23	8/31/23	22	90%	

Figure 36: Project plan 400P

WBS NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE	PHASE TWO: WEEK 4, WEEK 5, WEEK 6 (M T W R F)
2	FYDP-D						
2.1	project initiation	All members	10/1/23	10/7/23	6	100%	
2.2	simulation design approach 1	shimanto asif t	10/8/23	10/19/23	11	95%	
2.3	simulation design approach 1	shimanto asif arman	10/20/23	10/31/23	11	85%	
2.4	identify the best viable option	All members	11/1/23	11/7/23	6	100%	
2.5	documentation	tasdid, arman	11/8/23	11/15/23	7	99%	
2.6	progress presentation preparation	All members	11/16/23	11/24/23	8	95%	
2.7	final simulation	All members	11/25/23	12/7/23	12	100%	
2.8	report writing	tasdid, arman	12/11/23	12/21/23	10	100%	
2.9	final presentation preparation	All members	12/22/23	12/29/23	7	95%	
2.9.1	final report	All members	12/30/23	1/7/24	7	100%	

Figure 37: Project plan 400D

WBS NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE	PHASE THREE: WEEK 7, WEEK 8, WEEK 9 (M T W R F)
3	FYDP-C						
3.1	aquiring components	tashdid , arman	2/1/24	2/14/24	0	100%	
3.2	test analysis	asif, shimanto	2/15/24	1/24/24	0	95%	
3.3	Hardware implementation	all members	2/25/24	3/7/24	0	94%	
3.4	prototype construction	all members	3/8/24	3/23/24	0	98%	
3.5	test run and monitoring	shimanto tashdid	3/24/24	4/4/24		80%	
3.6	cost-benefit and economic analysis	arman asif	4/5/24	4/11/24	0	95%	
3.7	backup and contingency planning	asif tasdid	4/15/24	4/21/24	0	90%	
3.8	final report	tasdid, arman.asif	4/22/24	1/31/24		100%	
3.9	presentaion preparation	all members	5/1/24	5/10/24		100%	

Figure 38: Project plan 400C

7.3 Evaluate project progress

Effective project management necessitates a meticulously maintained timeline, which we achieved through the creation of detailed Gantt Charts for phases 400P, 400D, and 400C. These charts outlined the project's timeline and future ideas, ensuring all tasks were clearly defined and scheduled. The team was divided into equal tasks, with flexibility for rescheduling and reprogramming to adapt to any unforeseen challenges. A comprehensive project schedule was established in advance, guaranteeing timely completion of all tasks. Each team member actively participated in identifying problems and selecting topics, ensuring a collaborative and thorough approach to project planning.

Shimanto and Asif Ahammad were instrumental in determining the project's objectives, specifications, requirements, and constraints, laying a strong foundation for subsequent work. Akib Hossain and Shimanto focused on researching image processing techniques, while Arman conducted risk analyses, assessed expected outcomes, evaluated impacts, and developed contingency plans. The team synthesized insights from academic articles to formulate robust design strategies. Asif Ahammad and Shimanto translated these strategies into block diagrams, which served as blueprints for the project's implementation. The first presentation and concept note were successfully completed, and a project proposal report was initiated, incorporating ethical considerations and sustainability. Akib Hossain also developed a preliminary budget and meticulously tracked labor in a notebook, ensuring financial accountability. The collective efforts of the team ensured that the project remained on schedule and aligned with its objectives.

The project plan commenced with designing alternative solutions and familiarizing the team with necessary software. By the second week, an analysis of these solutions was conducted. A prototype was created and rigorously tested to ensure it met all project requirements. Necessary adjustments were made based on testing outcomes. By the fourth and fifth weeks, essential tests were simulated, and the prototype underwent further refinements to meet all requirements. By the sixth and seventh weeks, operational codes for the prototype were completed, transitioning the project into the synthesis phase. By the tenth week, three software-based designs were expected to be finalized, facilitating the execution of operational codes. This marked the completion of the draft, followed by the final design and report, concluding the development period.

The implementation phase included purchasing components and creating test analyses by the end of weeks one, two, and four. Hardware implementation was scheduled to span three to five weeks, during which the prototype was constructed and prepared. This phase included rigorous testing and adjustments to ensure functionality. By the sixth and seventh weeks, prototype construction was completed, followed by comprehensive cost-benefit and economic analyses by the tenth week. The final two weeks focused on test runs and report writing, ensuring that all project goals were met and documented. This structured approach, grounded in engineering principles, ensured that the project was executed efficiently and effectively, with all team members contributing to its successful completion.

7.4 Conclusion

In conclusion, our project has made significant strides in the development of an innovative solution, driven by meticulous planning, collaborative teamwork, and adherence to engineering principles. From the outset, we prioritized the establishment of a comprehensive project timeline, utilizing Gantt Charts to outline key phases and tasks. This structured approach enabled us to effectively allocate resources, manage time constraints, and mitigate potential risks, exemplifying the power of interdisciplinary collaboration, strategic planning, and innovative thinking in addressing complex engineering challenges. With a solid foundation laid and a clear roadmap ahead, we are poised to deliver a solution that not only meets but exceeds expectations, making a meaningful impact in our field.

Chapter 8: Economical Analysis. [CO12]

8.1 Introduction

Financial and economic factors are essential to the development of any project or prototype. Our sorting system on a conveyor belt was designed and built using the same principles. Our primary goal was to develop a sorting system that required as little human involvement as possible to move items from point A to point B. We investigated two methods for item identification and sorting: one based on image processing and the other on IoT-based detection. In the end, we chose the IoT-based approach as it was more efficient given our financial limitations.

Our goal was to keep the prototype cost around 25,000 BDT, which was achievable with the IoT-based method. In contrast, the image processing approach would have required us to double our budget, primarily due to the need for the 'NVIDIA Jetson Nano Developer Kit,' a critical component priced at approximately 35,000 BDT. By choosing the IoT method, we successfully developed a system that met our financial requirements while minimizing human intervention. The color detection capability of the IoT system proved to be effective in achieving our objectives.

To enhance the efficiency of our sorting system, we utilized linear actuators and robotic claw mechanical clamps. We modified these actuators to ensure that the color-coded objects were accurately picked up by the clamp connected to a servo motor. This motor, driven by the linear actuators, enabled us to move the sorted objects onto the conveyor belt seamlessly. Although incorporating robotic arms could further improve system efficiency, it would significantly increase our expenses, making it an impractical option within our current budget.

8.2 Economic analysis

As we mentioned about two approaches above, there is breakdown of the budget for both the approaches given below:

Breakdown for Approach 1 budget (Image processing):

Table 4: Budget breakdown approach 1

Component	Quantity	Price (BDT)
NVIDIA Jetson Nano Developer Kit	1	34,990
DC Motor	3	3,750

Raspberry pi 169-degree camera	1	1,500
Servo Motor	1	450
ESP8266 Wi-Fi module	3	420
Pneumatic Cylinder	4	5,000
Vacuum air pump sucker	2	1,440
Rubber belt	3	1,275
L298N Motor driver	3	585
Total		**47,420**

Breakdown for approach 2 budget (IoT):

Table 5: Budget breakdown approach 2

Component	Quantity	Price (BDT)
Arduino mega 2560	2	3,800
DC Motor	3	4,000
TCS3200 color sensor	1	515
Servo Motor	3	2,300
4 Channel 12V Relay Board Module	2	600
ESP8266 Wi-Fi module	1	420
Robotics claw mechanical clamp	2	1,550
Linear actuator	4	11,000
Rubber belt	3	1,275
L298N Motor driver	4	585
Total		**26,045**

As we analyze both the budgets, we can say that approach 2 also works better in terms of the budget. As that fulfills our objectives and to add to that, it consumes less power to run compared to the first approach. Furthermore, we get more efficiency from the IoT based system as well.

8.3 Cost benefit analysis

As we have spent roughly 26,000BDT on our prototype, there could be improvements. If it was done on a bigger scale for a particular sector, we would see the user would benefit. The labor costs will decrease by a certain amount through this project as the robotics claws will cut out human intervention to some extent. Done on a bigger scale, we can assume that this system can be used by restaurants and also in the mining industry. The bowl of food or the objects that miners have dug up can be sent to the selected destination via the conveyor belt without any human effort. After investing in the materials, equipment, machinery, and the installation process, we will not have to spend more money on labor, giving training to the personnel. Furthermore, as we improve the speed and efficiency of the prototype, we will be able to reduce the error percentage of the system and save it there as well. In a nutshell, as labor costs will be saved, we will benefit from the prototype economically.

Evaluate economic and financial aspects

Costs:

- Material Costs: The initial investment in materials, including metal components, sensors, actuators, conveyor belts, and control systems, can be significant.
- Labor Expenses: Skilled labor is required for design, engineering, fabrication, installation, and maintenance. Labor costs constitute a significant portion of the project expenses.
- Equipment and Machinery: Specialized equipment and machinery are necessary for fabrication and assembly, adding to the project's capital expenditures.
- Training and Development: Training programs for operators and maintenance personnel are essential to ensure efficient operation and upkeep of the sorting system.
- Installation and Commissioning: Costs associated with transportation, onsite assembly, and testing contribute to the total project expenditure.

Benefits:

- Labor Savings: Automation reduces the need for manual labor, leading to cost savings over time.
- Increased Throughput: The sorting system improves efficiency and speed, enabling higher productivity and potentially increased revenue.
- Error Reduction: Automation minimizes errors and defects, enhancing product quality and customer satisfaction while reducing rework and warranty claims.
- Operational Efficiency: Streamlining operations and reducing downtime result in cost savings due to increased uptime and reduced maintenance requirements.

8.4 Conclusion

The economic analysis concludes by showing the benefits of investing in the design and construction of the conveyor belt sorting system. In the modern era of engineering, conveyor belts are used pretty much in every industry, from airports to shopping malls. The project is a strategic endeavor aimed at enhancing industrial operations efficiency and productivity. Given its potential for cost savings, market opportunities, and sustainability benefits.

Chapter 9: Ethics and Professional Responsibilities [CO13, CO2]

9.1 Introduction

Ethical considerations are fundamental in engineering projects, guiding decisions and ensuring alignment with moral values and societal norms. In developing our sorting system on the conveyor belt, ethical principles shape our approach, emphasizing fairness, transparency, accountability, and social impact.

As engineers, we recognize our ethical responsibility to prioritize the well-being of individuals, communities, and the environment. By proactively addressing ethical implications, we aim to foster trust and social responsibility in our project's execution, mitigating risks and minimizing harm.

Join us as we navigate the ethical dimensions of our project, striving to uphold integrity and ethical conduct while delivering innovative solutions that positively impact society.

9.2 Identify ethical issues and professional responsibility

Addressing ethical issues and professional responsibilities in the development and implementation of a sorting system on a conveyor belt involves a comprehensive approach that considers technical, operational, and societal implications. Here are some key considerations:

- **Ethical Design and Development**: Incorporate ethical principles and values into the system's design and development processes from the outset. Conduct thorough risk assessments to identify potential ethical concerns, such as privacy violations, algorithmic biases, or environmental impacts. Implement robust security measures, including data encryption, access controls, and secure communication protocols, to protect sensitive information and maintain data privacy. Ensure transparency by documenting the system's architecture, algorithms, and decision-making processes, enabling external audits and reviews.

- **Responsible Innovation:** Embrace a responsible innovation mindset, considering the broader societal implications of the sorting system's deployment. Collaborate with interdisciplinary teams, including ethicists, legal experts, and social scientists, to address ethical concerns holistically. Establish clear governance frameworks and ethical guidelines to guide the system's development, deployment, and ongoing operation. Continuously monitor and evaluate the system's performance, impacts, and potential unintended consequences, making necessary adjustments to mitigate risks and uphold ethical standards.

- **Stakeholder Engagement and Co-creation:** Actively engage with stakeholders, including employees, customers, regulatory bodies, and local communities, throughout the system's life cycle. Facilitate co-creation processes by involving stakeholders in the design, development, and decision-making stages, ensuring diverse perspectives are considered. Establish communication channels and feedback mechanisms to gather stakeholder input, address concerns, and incorporate valuable insights into the system's evolution.

- **Sustainability and Environmental Considerations:** Conduct life cycle assessments to evaluate the sorting system's environmental impact, from material sourcing and manufacturing to operation and disposal. Explore opportunities for energy efficiency, resource conservation, and waste minimization through innovative design solutions and operational practices. Implement eco-friendly practices in the supply chain, manufacturing processes, and system maintenance, promoting environmental sustainability.

- **Regulatory Compliance and Industry Standards:** Ensure compliance with relevant laws, regulations, and industry standards related to privacy, data protection, health and safety, and environmental protection. Participate in the development and adoption of industry-wide ethical guidelines and best practices for sorting systems and automation technologies. Collaborate with regulatory bodies and industry associations to contribute to the ongoing evolution of ethical and responsible practices in the field.

- **Continuous Professional Development:** Promote a culture of continuous learning and professional development within the engineering team and organization. Stay updated with the latest advancements in ethical engineering practices, emerging regulations, and industry trends related to sorting systems and automation technologies. Encourage participation in professional organizations, conferences, and workshops to share knowledge, learn from peers, and contribute to the advancement of ethical practices in the field.

9.3 Apply ethical issues and professional responsibility

In our project of developing a sorting system on a conveyor belt, we prioritize ethical issues and uphold professional responsibilities throughout the entire process:

- **Ethical Design and Development:** We incorporate ethical principles into our system's design by conducting thorough risk assessments to identify potential ethical concerns. We implement robust security measures to protect data privacy, including encryption and access controls. Transparent documentation of our system's architecture and decision-making processes ensures accountability and enables external audits.

- **Responsible Innovation:** We embrace responsible innovation by collaborating with interdisciplinary teams to address ethical concerns holistically. Clear governance frameworks and ethical guidelines guide our system's development and deployment, with continuous monitoring and evaluation to mitigate risks and uphold ethical standards.

- **Stakeholder Engagement and Co-creation:** We actively engage stakeholders throughout the project, including employees, customers, and regulatory bodies. Co-creation processes ensure diverse perspectives are considered, with communication channels established to gather feedback and address concerns.

- **Sustainability and Environmental Considerations:** We conduct life cycle assessments to evaluate the environmental impact of our sorting system. Energy efficiency, resource conservation, and waste minimization are prioritized through innovative design solutions and eco-friendly practices in the supply chain and maintenance processes.

- **Regulatory Compliance and Industry Standards:** We ensure compliance with relevant laws, regulations, and industry standards, including those related to privacy, data protection, and environmental protection. Active participation in the development of ethical guidelines and collaboration with regulatory bodies promote responsible practices in the field.

- **Continuous Professional Development:** We foster a culture of continuous learning and professional development within our team, staying updated with ethical engineering practices and industry trends. Participation in professional organizations and conferences enables knowledge sharing and contributes to the advancement of ethical practices in our field.

9.4 Conclusion

The development of the sorting system on a conveyor belt highlights the importance of prioritizing ethical considerations and professional responsibilities in engineering. Addressing issues like data privacy, fairness, environmental sustainability, and worker safety demonstrates a commitment to responsible innovation. Implementing robust security measures, conducting algorithmic audits, and adopting eco-friendly practices ensure system integrity and reliability. Continuous stakeholder engagement, transparent decision-making, and adherence to professional codes of conduct foster trust and accountability. By upholding ethical principles, engineers enhance the system's credibility and contribute to societal well-being, ensuring technological advancements promote a sustainable and equitable future.

Chapter 10: Conclusion and Future Work

10.1 Project summary

The project addresses a critical engineering challenge in industrial settings: optimizing sorting processes using conveyor belt systems. The overarching goal is to streamline operations, minimize errors, and enhance overall efficiency through the integration of advanced technologies such as image processing, Internet of Things (IoT), and automation. By leveraging these technologies, the project aims to revolutionize traditional sorting methods, offering a more efficient and reliable solution for industrial applications,

The successful completion of our IoT-based color sorting system represents a significant advancement in automated industrial processes. Utilizing the TCS3200 color sensor and Arduino microcontrollers, we have developed a system that efficiently and accurately sorts objects based on color. The integration with the Blynk platform for real-time monitoring enhances the system's utility by enabling remote management and operational transparency. Our approach has demonstrated the feasibility of creating cost-effective and reliable solutions using readily available components, meeting the practical needs of industrial applications.

10.2 Future Work

In the future, a number of improvements can be made to increase the system's functionality. Potential future projects might involve:

- **Integration of Advanced Control Systems**: Upgrading from Arduino to programmable logic controllers (PLCs) can enhance the system's robustness and scalability, allowing for more complex operations and improved performance.

- **Incorporation of Smart Pick-and-Place Robots**: Replacing linear actuators with more sophisticated robotic arms can increase the precision and speed of the sorting process, making the system more adaptable to a variety of objects and conditions.

- **Enhanced Sensing and Detection**: Implementing additional sensors, such as higher resolution color sensors or 3D vision systems, can improve the accuracy of object detection and sorting, accommodating a broader range of colors and object types.

- **Machine Learning Integration**: Applying machine learning algorithms to optimize sorting patterns and improve the system's adaptability to new types of objects can make the system more intelligent and responsive to changing operational demands.

- **Expanded IoT Capabilities**: Further development of the IoT platform can include advanced analytics, predictive maintenance, and more comprehensive data visualization tools to provide deeper insights into the system's performance and operational trends.

By exploring these enhancements, the color sorting system can evolve into a more sophisticated, efficient, and versatile tool, capable of meeting the growing demands of modern industrial automation.

Chapter 11: Identification of Complex Engineering Problems and Activities

11.1 Identify the attribute of complex engineering problem (EP)

Table 6: Attributes of Complex Engineering Problems (EP)

	Attributes	Put tick (√) as appropriate
P1	Depth of knowledge required	✓
P2	Range of conflicting requirements	
P3	Depth of analysis required	✓
P4	Familiarity of issues	✓
P5	Extent of applicable codes	
P6	Extent of stakeholder involvement and needs	
P7	Interdependence	✓

11.2 Provide reasoning how the project address selected attribute (EP)

P1: Depth of knowledge required

In order to make our design and fabrication of a sorting system on a conveyor belt, we had to learn about image processing, IoT, Arduino coding, working with electrical tools, such as microcontrollers, sensors, motor drivers etc. Furthermore, we had to learn a lot of schematics using proteus in order to visualize how the system will work. Our depth of knowledge was very much required in order to make this system.

P3: Depth of analysis required

We utilized Blynk to develop a functional IoT system, which necessitated collecting substantial data to ensure proper operation. Additionally, each component needed to operate within its designated time frame to prevent system failure. Consequently, we had to thoroughly analyze and implement precise measures to run the motors at the correct speeds, ensuring that objects did not move too far forward and miss the mechanical claws.

P4: Familiarity of issue

The primary challenge of this project was ensuring precise coordination and control within the IoT system, facilitated by the Blynk platform. A deep understanding of the timing and synchronization of each component was essential, as any deviation could result in system failure. The project required familiarity with data collection and analysis techniques to monitor system performance accurately. Additionally, expertise in motor control and mechanical design was crucial to calibrate the motors to the exact speeds needed for precise object manipulation.

This comprehensive understanding was necessary to address potential issues effectively and maintain the system's reliability.

P7: Interdependence

We used linear actuators, dc motors, servo motors and mechanical claws and all of them were dependent on one another in the operation of the system. We had to yield linear actuators, install a servo motor to rotate the color-coded object and install the mechanical claws to hold the object.

11.3 Identify the attribute of complex engineering activities (EA)

Attributes of Complex Engineering Activities (EA)

Table 7: Attributes of Complex Engineering Activities (EA)

	Attributes	Put tick (√) as appropriate
A1	Range of resource	✓
A2	Level of interaction	✓
A3	Innovation	
A4	Consequences for society and the environment	✓
A5	Familiarity	

11.4 Provide reasoning how the project address selected attribute (EA)

A1: Range of resource

The successful implementation of our IoT project required a multidisciplinary team and various software tools. Software developers used Blynk for system integration, while data analysts employed tools like MATLAB and Python for performance analysis. Mechanical engineers focused on motor and claw calibration, utilizing simulation software like Simulink. Project managers coordinated efforts using platforms like Trello. IoT specialists ensure seamless device communication. This combination of expertise and software enabled precise control and synchronization, ensuring the system's optimal performance.

A2: Level of interaction

As we develop this prototype on a broader scale, it can be beneficial to a lot of industries. For example, airports can use this system to sort the bags in terms of weight or size. To add to that, restaurants can also use this system as that can make things a lot more advanced. Therefore, the majority of people will be using this system.

A4: Consequences to the society and environment

There will be positive consequences for society as this system will save a lot of money and time for the people who will operate it. As human interaction will reduce with the system, chances of any casualties are also quite thin. And as the system is running via electricity, there will not be any sort of carbon emissions in the chances. Therefore, it will not damage the environment.

References

[1] Azizi, A. Y. (2018). Design and fabrication of intelligent material handling system in modern manufacturing with industry 4.0 approaches. *International Robotics & Automation Journal*, 4(3), 1-10.

[2] Dabade, S. P. (2015). Automatic Sorting Machine Using Conveyor Belt. *International Journal of Innovative and Emerging Research in Engineering*, 2(5), 66-70.

[3] Kundu, R. (2023). *YOLO: Algorithm for Object Detection Explained.* Retrieved from Luettavissa: https://www. v7labs. com/blog/yolo-object-detection Luettu

[4] Lodewiiks, G. L. (2016). An application of the IoT in belt conveyor systems. *9th International Conference, IDCS 2016* (pp. 340-351). Wuhan, China: Springer International Publishing.

[5] Mattone, R. C. (2000). Sorting of items on a moving conveyor belt. Part 1: a technique for detecting and classifying objects. *Robotics and Computer-Integrated Manufacturing*, 16(2-3), 73-80.

[6] Nagpal, C. U. (2019, December). IIoT based smart factory 4.0 over the cloud. *In 2019 International Conference on Computational Intelligence and Knowledge Economy (ICCIKE)* (pp. pp. 668-673). IEEE.

[7] Soans, R. V. (2018, May). Object sorting using image processing. *In 2018 3rd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT)* (pp. pp. 814-818). IEEE.

[8] Syufrijal, S. R. (2021, March). IoT based sorting system of consumer goods production. *IOP Conference Series: Materials Science and Engineering* (pp. Vol. 1098, No. 4, p. 042084). MOTOR CONTROL SYSTEM FOR CONVEYOR. International Journal Of All Research Writings.

[9] Tho, T. P. (2016, November). Design and development of the vision sorting system. *In 2016 3rd International Conference on Green Technology and Sustainable Development (GTSD)* (pp. pp. 217-223). IEEE.

Appendix

Logbook:

Table 8: ATC panel and Members details

	Final Year Design Project (P) Summer 2021		
Student Details	**NAME & ID**	**EMAIL ADDRESS**	**PHONE**
Member 1	Asif Ahammad 19221011	asif.ahammad@g.bracu.ac.bd	01308656331
Member 2	Arman Bin Mahmud 19121010	arman.bin.mahmud@g.bracu.ac.bd	01799754329
Member 3	MD.Shimanto 19121008	md.shimanto@g.bracu.ac.bd	01620831268
Member 4	Akib Hossain Tasdid 18221011	akib.hossain.tasdid@g.bracu.ac.bd	01969886923
ATC Details:			
ATC 2			
Chair	Prof. Dr. A. H. M. Abdur Rahim	abu.hamed@bracu.ac.bd	
Member 1	Tasfin Mahmud	tasfin.mahmud@bracu.ac.bd	
Member 2	Mehedi Hasan Shawon	mehedi.shawon@bracu.ac.bd	

Table 9: Logbook

Date/Time /Place	**Attendee**	**Summary of Meeting Minutes**	**Responsible**	**Comment by ATC**
08.06.2023	1 .Asif 2. Shimanto 3. Arman	1.Need to come up with an idea with feasibility and efficiency.	Task 1: Asif, Shimanto, Tasdid, Arman	
14.6.2023	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1.find more better idea 2: look into the conveyor belt controller idea	task 1: Asif shimanto, arman tasdid task 2: shimanto arman	Think bigger and challenging idea.

13.7.23	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1 research industrial automation.	Task1 : Asif, shimanto, tasdid, arman.	Research and show comparison within our project.
21.8.23	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1.Image processing data and hardware. 2.progress report checking	Task 1: Asif, shimanto, tasdid, arman. Task 2: Asif shimanto tasdid arman	Finalize the image processing parts and work on the project proposal report.
22.08.23	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1.work on out designs of approach 2 and 1 2.make image processing mandatory in every alternate design approach. 3. finish lab report works.	Task 1: Asif, shimanto Task 2: Asif shimanto tasdid arman Task 3: Tasdid, Arman	focus on our title stated approaches.
23.08.23	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1.information on updated final works 2.make image processing mandatory in every alternate design approach	Task 1: Asif, shimanto Task 2: Asif shimanto tasdid arman	Finalize the image processing parts and work on the project proposal report.
30.8.23	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1.finalize report	Task 1: Asif shimanto tasdid arman	finalize report
9.10.23	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1.IoT based knowledge and application on project 2.finding plausible outlook of project to minor details	Task1:shimanto arman Tasdid Task2: asif arman Tasdid	Try to visualise what our project will look like
16.10.23	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1.work on approches 2.start simulating	Task 1: Asif, shimanto Task 2: Asif shimanto tasdid arman	work with hardware implementation on mind
29.10.23	1.Asif 2.Shimanto 3.Tasdid	1. approach 1 image processing 2.approach 2 iot implementation	Task 1: Asif, shimanto	show iot implemented work

	4.Arman		Task 2: Asif shimanto tasdid arman	
31.11.23	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1.start working on presentation 2. work on slides	Task 1: Asif, shimanto Task 2: Asif shimanto tasdid arman	must work on working models
1.11.23	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1.image processing model based on actual dataset 2.implement iot different approach apps	Task 1: Asif, shimanto Task 2: Asif shimanto tasdid arman	try to make the model and iot work with different version
12.11.23	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1.show working model 2. iot implementation	Task 1: Asif, shimanto Task 2: Asif shimanto tasdid arman	finalize the schematics
26.11.23	1.Asif 2.Shimanto 3.Tasdid 4.Arman	start working on preparing slides	Task 1: Asif shimanto tasdid arman	make a better presentation with relevant and working model
3..11.23	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1.show video or gif on working schematic on slides	Task 1: Asif shimanto tasdid arman	show video or gif on working schematic on slides
10.11.23	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1. show both approaches on slides and work on different criterias according to co po	Task 1:: Asif shimanto tasdid arman	finalize slides
21.11.23	1.Asif 2.Shimanto 3.Tasdid 4.Arman	take preparations for presentation	Task 1: Asif shimanto tasdid arman	prepare for presentation
1.02.24	1.Asif 2 Shimanto 3.Arman	1. buying the components as soon as possible 2.Start working on building the project	Task1: Arman, Tasdid	Buy the components as soon as possible

			Task2: Shimanto, Asif	
3.02.24	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1.Visualize how the project should look like and try to frame it according	Task 1: Arman, Shimanto, Asif, Tasdid	Get a clear concept of how you want your project to look like and how it will function
3.03.24	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1.Start preparing the slides for the presentation	Done by all	Start making slides amd prepare your presentation properly
10.03.24	1.Asif 2.Shimanto 3.Tasdid 4.Arman	Developing the project	Done by Shimanto, Asif	
19.03.24	1.Asif 2.Shimanto 3.Tasdid 4.Arman	Testing and correcting on the IoT	Done by Tasdid, Arman	Make sure all the codes work properly when combined
26.03.24	1.Asif 2.Shimanto 3.Arman	Make the frame as quickly as possible and buy the Conveyor belt	Done by Asif	Buy the belt material that you'll be using in your conveyor
16.04.24	1.Asif 2.Shimanto 3.Tasdid 4.Arman	1.Testing the system 2.Making the poster	Task 1: Asif, Shimanto, Tasdid Task 2:Arman	
16.05.24	1.Asif 2.Shimanto 3.Tasdid 4.Arman	Finish writing final report	Done by all	Finish writing the report and get it checked as soon as possible.

Related code/theory:

```
#include <Servo.h>
Servo myServo;
Servo myServo1;


int pin_enA = 13;
int pin_IN1 = 12;
int pin_enB = 11;
int pin_IN3 = 10;
 int pin_en1A = 9;
int pin_IN1A = 8;

int ac_en1B = 7;
int ac_in1 = 6;
int ac_in2 = 5;




#define S0 22
#define S1 23
#define S2 24
#define S3 25
#define sensorOut 54

int process_red_value();
int process_green_value();
int process_blue_value();
// Set the S0, S1, S2, S3 Pins as Output



void setup() {


  pinMode (pin_enA, OUTPUT);
  pinMode (pin_IN1, OUTPUT);


  pinMode  (pin_enB, OUTPUT);
  pinMode (pin_IN3 ,OUTPUT);


  pinMode (pin_en1A , OUTPUT) ;
  pinMode (pin_IN1A , OUTPUT);
```

```
 pinMode(S0, OUTPUT);
 pinMode(S1, OUTPUT);
 pinMode(S2, OUTPUT);
 pinMode(S3, OUTPUT);
 pinMode (sensorOut, INPUT);

 // Set Pulse Width scaling to 20%
  digitalWrite(S0, HIGH);
  digitalWrite(S1, LOW);
// Enable UART for Debugging
  Serial.begin(9600);
  Serial1.begin(9600);

}

void loop() {
  // put your main code here, to run repeatedly:

    digitalWrite(13,LOW);
    digitalWrite(12,LOW);
    digitalWrite(11,LOW);

    digitalWrite(10,LOW);
    digitalWrite(9,LOW);
    digitalWrite(8,LOW);

    digitalWrite(7,LOW);
    digitalWrite(6,LOW);
    digitalWrite(5,LOW);

int r, g, b;
   r = process_red_value();
  delay(200);
   g = process_green_value();
  delay(200);
  b = process_blue_value();
  delay(200);
  Serial.print("r = ");
  Serial.print(r);
  Serial.print(" ");
  Serial.print("g = ");
  Serial.print(g);
  Serial.print(" ");
  Serial.print("b = ");
  Serial.print(b);
  Serial.print(" ");
  Serial.println();
  if (r < 42)
  {
    Serial.println("Colour Pink");
```

```
  }
  else if (g < 63)
  {
   Serial.println("Colour Green");

     digitalWrite(12,HIGH);
     analogWrite ( pin_enA,100);
     delay(4000);
     digitalWrite(12,LOW);



myServo1.attach(44);                  ////servo
  myServo1 .write(0);
  delay(800);
  myServo1.detach();

   digitalWrite(7,HIGH);
     digitalWrite(6,HIGH);
     digitalWrite(5,LOW);
     delay(2000);

     digitalWrite(7,LOW);
     digitalWrite(6,LOW);
     digitalWrite(5,LOW);
  myServo1.attach(44);                  ////servo
  myServo1.write(180);
  delay(800);
  myServo1.write(90);
  myServo1.detach();


     digitalWrite(7,HIGH);
     digitalWrite(6,LOW);
     digitalWrite(5,HIGH);
     delay(2000);

     digitalWrite(7,LOW);
     digitalWrite(6,LOW);
     digitalWrite(5,LOW);


     Serial1.write('O'); // commanding 2nd arduino  for caps


     delay(3000);
myServo1.attach(44);                  ////servo
  myServo1 .write(0);
  delay(800);
  myServo1.detach();
```

```
  digitalWrite(7,HIGH);
    digitalWrite(6,HIGH);
    digitalWrite(5,LOW);
    delay(2000);

    digitalWrite(7,LOW);
    digitalWrite(6,LOW);
    digitalWrite(5,LOW);
mySservo1.attach(44);                    ////servo
mySservo1.write(180);
delay(800);
mySservo1.write(90);
mySservo1.detach();


    digitalWrite(7,HIGH);
    digitalWrite(6,LOW);
    digitalWrite(5,HIGH);
    delay(2000);

    digitalWrite(7,LOW);
    digitalWrite(6,LOW);
    digitalWrite(5,LOW);


    digitalWrite(12,HIGH);
    analogWrite ( pin_enA,100);
    delay(3000);
    digitalWrite(12,LOW);


      digitalWrite(10,HIGH);
     analogWrite ( pin_enB,100);
    delay(5000);
    digitalWrite(10,LOW);




 }
else if (r < 64)
{
  Serial.println("Colour Red");


      digitalWrite(12,HIGH);
      analogWrite ( pin_enA,100);
      delay(3000);
       digitalWrite(12,LOW);
```

```
  myServo.attach(4);
  myServo.write(0);
  delay(800);
  myServo.detach();
  delay(2000);
  myServo.attach(4);
  myServo.write(180);
  delay(800);
  myServo1.write(90);
  myServo.detach();

      digitalWrite(8,HIGH);

      analogWrite ( pin_en1A,100);
      delay(3000);
      digitalWrite(8,LOW);


      Serial1.write('T');


 }
}


int process_red_value()
{
  digitalWrite(S2, LOW);
  digitalWrite(S3, LOW);
  int pulse_length = pulseIn(sensorOut, LOW);
  return pulse_length;
}
int process_green_value()
{
  digitalWrite(S2, HIGH);
  digitalWrite(S3, HIGH);
  int pulse_length = pulseIn(sensorOut, LOW);
  return pulse_length;
}
int process_blue_value()
{
  digitalWrite(S2, LOW);
  digitalWrite(S3, HIGH);
  int pulse_length = pulseIn(sensorOut, LOW);
  return pulse_length;
}
```

So these were the transmitting controller codes.

Receiver controller codes:

```
#include <Servo.h>
Servo myServo;
Servo myServo1;

char message;

const int ENA_PIN = 13;
const int IN1_PIN = 12;
const int IN2_PIN = 11;

const int ENB_PIN = 10;
const int IN3_PIN = 9;
const int IN4_PIN = 8;

const int ENC_PIN = 7;
const int IN5_PIN = 6;
const int IN6_PIN = 5;

const int END_PIN = 4;
const int IN7_PIN = 3;
const int IN8_PIN = 2;


void setup() {

  pinMode(ENA_PIN, OUTPUT);
  pinMode(IN1_PIN, OUTPUT);
  pinMode(IN2_PIN, OUTPUT);


  pinMode(ENB_PIN, OUTPUT);
  pinMode(IN3_PIN, OUTPUT);
  pinMode(IN4_PIN, OUTPUT);

  pinMode(ENC_PIN, OUTPUT);
  pinMode(IN5_PIN, OUTPUT);
  pinMode(IN6_PIN, OUTPUT);


  pinMode(END_PIN, OUTPUT);
  pinMode(IN7_PIN, OUTPUT);
  pinMode(IN8_PIN, OUTPUT);

  Serial.begin(9600);
  Serial1.begin(9600);
}
```

```
void loop()
{

  digitalWrite(ENA_PIN,LOW);
  digitalWrite(IN1_PIN, LOW);
  digitalWrite(IN2_PIN, LOW);

    digitalWrite(ENB_PIN,LOW);
   digitalWrite(IN3_PIN, LOW);
  digitalWrite(IN4_PIN, LOW);

   digitalWrite(ENC_PIN,LOW);
   digitalWrite(IN5_PIN, LOW);
  digitalWrite(IN6_PIN, LOW);

   digitalWrite(END_PIN,LOW);
   digitalWrite(IN7_PIN, LOW);
  digitalWrite(IN8_PIN, LOW);

 if(Serial1.available()){
  message = Serial1.read();
    if(message == 'O'){
      Serial.println("2nd convey");


  digitalWrite(ENA_PIN,HIGH);
   digitalWrite(IN1_PIN, HIGH);
  digitalWrite(IN2_PIN, LOW);
  delay(2000);
  digitalWrite(ENA_PIN,LOW);
   digitalWrite(IN1_PIN, LOW);
  digitalWrite(IN2_PIN, LOW);
  delay(3000);


  digitalWrite(ENA_PIN,HIGH);
   digitalWrite(IN1_PIN, LOW);
  digitalWrite(IN2_PIN, HIGH);
  delay(2000);

  digitalWrite(ENA_PIN,LOW);
   digitalWrite(IN1_PIN, LOW);
  digitalWrite(IN2_PIN, LOW);
    }


  else if (message == 'T')
  Serial.println("3rd convey");

    myServo1.attach(45);                    ////servo
```

```
  myServo1.write(0);
  delay(800);
  myServo1.detach();



digitalWrite(END_PIN,HIGH);
   digitalWrite(IN7_PIN, HIGH);
  digitalWrite(IN8_PIN, LOW);
  delay(2000);

  digitalWrite(END_PIN,LOW);
   digitalWrite(IN7_PIN, LOW);
  digitalWrite(IN8_PIN, LOW);


  myServo1.attach(45);                ////servo
  myServo1.write(180);
  delay(800);
  myServo1.write(90);
  myServo1.detach();

  digitalWrite(END_PIN,HIGH);
   digitalWrite(IN7_PIN, LOW);
  digitalWrite(IN8_PIN, HIGH);
  delay(2000);

  digitalWrite(END_PIN,LOW);
   digitalWrite(IN7_PIN, LOW);
  digitalWrite(IN8_PIN, LOW);

  digitalWrite(ENC_PIN,HIGH);
   digitalWrite(IN5_PIN, HIGH);
  digitalWrite(IN6_PIN, LOW);
  delay(2000);
  digitalWrite(ENC_PIN,LOW);
   digitalWrite(IN5_PIN, LOW);
  digitalWrite(IN6_PIN, LOW);


  digitalWrite(END_PIN,HIGH);
   digitalWrite(IN7_PIN, HIGH);
  digitalWrite(IN8_PIN, LOW);
  delay(2000);
   digitalWrite(END_PIN,LOW);
   digitalWrite(IN7_PIN, LOW);
  digitalWrite(IN8_PIN, LOW);

  myServo1.attach(45);                    /////servo
  myServo1 .write(0);
```

```
  delay(800);
  myServo1.detach();
myServo1.attach(45);
  myServo1.write(180);
  delay(800);
  myServo1.write(90);
  myServo1.detach();

  digitalWrite(END_PIN,HIGH);
   digitalWrite(IN7_PIN, LOW);
  digitalWrite(IN8_PIN, HIGH);
  delay(2000);

  digitalWrite(END_PIN,LOW);
   digitalWrite(IN7_PIN, LOW);
  digitalWrite(IN8_PIN, LOW);

  digitalWrite(ENC_PIN,HIGH);
   digitalWrite(IN5_PIN, LOW);
  digitalWrite(IN6_PIN, HIGH);
  delay(2000);

  digitalWrite(ENC_PIN,LOW);
   digitalWrite(IN5_PIN, LOW);
  digitalWrite(IN6_PIN, LOW);


 }
}
```

Assessment Guideline for Faculty

[The following assessment guideline is for faculty ONLY. **This portion is not applicable for students**.]

Assessment Tools and CO Assessment Guideline

	Distribution of assessment points among various COs assessed in different semesters														
PO	l	c	f	g	c	b	d	c	e	l	k	k	h	i	j
CO	CO1	CO2	CO3	CO4	CO5	CO6	CO7	CO8	CO9	CO10	CO11	CO12	CO13	CO14	CO15
EEE 400C/ ECE 402C (Out of 100)							30	24	6	4	4	6	7	7	12
Project Final Report/ Project Progress Report							x	x	x	x	x	x	x		x
Demonstration of working prototype							x								x
Progress Presentation / Final Presentation								x			x				
Peer-evaluation*													x	x	
Instructor's Assessment *													x	x	
Demonstration at FYDP Showcase								x							x

Note: The star (*) marked deliverables/skills will be evaluated at various stages of the project.

Mapping of CO-PO-Taxonomy Domain & Level- Delivery-Assessment Tool

Sl.	CO Description	PO	Bloom's Taxonomy Domain/Level	Assessment Tools
CO7	**Evaluate** the performance of the developed solution with respect to the given specifications, requirements and standards	d	Cognitive/ Evaluate	• Demonstration of working prototype • Project Progress Report on working prototype
CO8	**Complete** the final design and development of the solution with necessary adjustment based on performance evaluation	c	Cognitive/ Create	• Project Final Report • Final Presentation • Demonstration at FYDP Showcase
CO9	**Use** modern engineering and IT tools to design, develop and validate the solution	e	Cognitive/ Understand, Psychomotor/ Precision	• Project Final Report
CO10	**Conduct** independent research, literature survey and learning of new technologies and concepts as appropriate to design, develop and validate the solution	l	Cognitive/ Apply	• Project Final Report
CO11**	**Demonstrate** project management skill in various stages of developing the solution of engineering design project	k	Cognitive/ Apply Affective/ Valuing	• Project Final Report • Project Progress presentation at various stages
CO12	**Perform** cost-benefit and economic analysis of the solution	k	Cognitive/ Apply	• Project Final Report
CO13	**Apply** ethical considerations and professional responsibilities in designing the solution and	h	Cognitive/ Apply Affective/ Valuing	• Peer-evaluation, • Instructor's Assessment

	throughout the project development phases			• Final Report
CO14**	**Perform** effectively as an individual and as a team member for successfully completion of the project	i	Affective/ Characterization	• Peer-evaluation • Instructor's Assessment
CO15**	**Communicate** effectively through writings, journals, technical reports, deliverables, presentations and verbal communication as appropriate at various stages of project development	j	Cognitive/ Understand Psychomotor/ Precision Affective/ Valuing	• Project Final Report • Progress Presentations, • Final Presentation • Demonstration at FYDP Showcase

Note: The double star (**) marked CO will be assessed at various stages of the project through indirect deliverables.