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| Module Code: PUSL 2021 | Module Name: Computing Group Project | |
| Coursework Title: Interim Report | | |
| Deadline Date: 27/02/24 | | Member of staff responsible for coursework: Mr.Chamara Attanayake |
| Programme: Bsc. (Hons) in Computer Science | | |
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* Introduction

Overview of the project

To maximize the efficiency in sorting object in an industrial level, we took a step to develop a prototype of an object sorting system. By using color recognition method using a camera module and Open CV software utilities, the prototype will recognize the object’s color when the object is passed on a conveyor belt. A servo motor will direct the direction of the object according to the color of the object to the baskets placed on the end of the conveyor belt. To add more benefit to the user, the user can edit the number of sorted objects in a basket according to the color after the sorting process. The sorted details like number of objects in the basket, time of the sorting, and the total number of objects that have been sorted are displayed in an Arduino dashboard to users. Also, the details can be retrieved from a mobile application that was developed to users with admin privileges.

To add more security to the project, we have added an emergency stop button to pause the ongoing process until the user starts the sorting process again.

Purpose of the project

The main purpose of the project is to get an experience about IOT components, Color detection methodologies, and mobile application development. The team members will get experience of finding alternative solutions to a problem as going on with the project. This project is also developed to increase the increase the efficiency of sorting process in the industry level. To increase the accuracy of the sorting process we have come up with a solution to ultrasonic sensor to keep track of the distance between the object and the camera. If the object is too far away from the camera the conveyor belt will increase the speed to increase the processing speed.

As going through the development, we faced a problem about the color detection failure in the camera. After finding the cause of the problem we realized that this problem was caused due to the speed of the belt. So, we have added an ultrasonic sensor to the project to track the distance. By that the speed of the conveyor belt is balanced.

* + - * Real-time Monitoring and Tracking: IoT sorting systems frequently provide real-time monitoring and tracking features that let companies keep tabs on the whereabouts and conditions of things as they are being sorted. Improved quality control, logistics planning, and inventory management are made possible by this visibility.
* Accuracy Improvement: When compared to manual sorting procedures, IoT sorting devices can provide greater accuracy. These systems can precisely recognize and sort things according to predetermined criteria by combining sensors and data analytics, which lowers errors and improves sorting quality.
* Scalability and Flexibility: Businesses can adjust to fluctuating volumes and needs thanks to the scalability and flexibility of IoT sorting systems. IoT solutions are easily customizable to match changing business needs, such as rearranging sorting criteria or scaling up operations during peak seasons.
* Efficiency Improvement: Using Internet of Things (IoT) devices like sensors, actuators, and networked machinery to automate sorting activities is one of the main goals. This may result in shorter sorting times, less manual work, and higher levels of productivity all around.

Justification of the project

This protype can be very important to the industry as this sorting process is well monitored and tracked Realtime. A business owner can retrieve the needed information by using the mobile application anywhere anytime. This will also straightforward the employees in the industry to reduce the risk of human errors like miscounting and misdirection of objects. Because of the speed control in the conveyor belt the sorting process is effective and time efficient.

* Enhanced Quality and consumer Experience: The project has the potential to improve both the quality of products and the consumer experience. Businesses can maintain product quality standards, detect problems early, and better meet consumer requests with the use of real-time monitoring and data analytics, all of which increase customer satisfaction.
* Operational Efficiency: By using this project, procedures can be streamlined, jobs can be automated, and human interaction is decreased. Tasks are completed more rapidly, precisely, and error-free as a result, increasing operational efficiency.

Scope and Objectives

The main objective of the project is to increase the efficiency of the sorting project by using IOT components. In some cases, the sorting project will fail due to the failure of not identifying the color of the object correctly. This error can be minimized if there is a human interaction with the machine. The user can examine the process if there are any mistakes in the sorting process. User can also edit the sorting details after the sorting process. This can increase the accuracy of the sorted details.

* Technological Infrastructure: Determine whether IoT gadgets, sensors, actuators, and networking options are needed to automate sorting. This will increase the effectiveness of the process.
* User Interface: Define the specifications for the dashboard/user interface that will be used to track and manage the sorting process. To guarantee precise and effective sorting, think about incorporating quality control procedures into the sorting process.
* Automation: Sorting should be done automatically to cut down on processing time, errors, and manual work. Also, the accuracy should be Increase the sorting efficiency and accuracy by using data analytics and IoT devices to monitor and make decisions in real-time.
* Speed: To fulfill production goals and maximize workflow efficiency, increase sorting speed and throughput.
* Background

Literature study

To arrive at a better understanding of the project, we have done a large amount of research. To get a fundamental understanding about the sorting process, we researched about the process of the conveyor belt. The belt should hold the weight of the objects. To do so, the power that should be given to the belt by the motor should be sufficient. We closely examined the number of cylinders that should be added to the belt as it would be supportive to the movement of the belt.

To get the color of the object, we researched about the efficient color detective method that can be used to the project. By using the “Open CV” software which is an environment build using python came handy. We decided to use a small camera to get the visual of the object to the laptop to get the color of the object. We decided to detect only three colors blue, red, and green using the AI technology by the Open CV software. To take this step, we had to gather a lot of resources about color detection. After some discussion we completed the color detection phase of the project.

To direct the object to the correct colored basket, we used a servo motor to direct the object to the corresponding basket. This process will be time based because after detecting the color of the object, the servo motor should turn in to the corresponding direction of the colored basket. And arrive at the initial stage. So, we coded to program using Arduino IDE to turn the hand of the servo motor with the specific time gaps. To control the of the conveyor belt, the ultrasonic sensor is used. It will update the program with the distance between the object and the basket. If the object is too far from the baskets, conveyor blet’s speed will be increased. As the object is closer to the sensor, the speed will be reduced. The count of the sorted object will be counted according to the movement of the servo motor. The real-time results will be displayed on the Arduino dashboard.

Theoretical framework for the solution

As we were developing the protype of the project, we determined that we should use small components to demonstrate the process rather than using the project for the real industry level process. The design is common to human interaction such as sorting the objects according to the color of the objects to the corresponding basket manually. To reduce the human errors and increase the effectiveness of the sorting process we have developed the project.

To interpret the process of an industrial level machine process, we have added the real-time procced quantity of the processed object details.

* User Interface Design: Create an intuitive user interface that allows administrators and operators to see system status, manage exceptions, change sorting parameters, and keep an eye on the color sorting process. To ensure that the color sorting IoT system is operated, maintained, and troubleshooted efficiently, provide operators and maintenance staff with the necessary training and assistance.
* Actuation System: Create and put into place an actuation system (such as robotic arms or conveyor belts) that can be used to reroute sorted goods according to color characteristics. Using system feedback and real-time color sensor data, feedback control mechanisms to dynamically modify sorting parameters.
* Color Sensors: Determine which color sensing technologies—such as RGB sensors and colorimeters—are suitable for precisely identifying and differentiating between various colors. create calibration protocols to guarantee the precision and uniformity of color sensor readings in a variety of locations and lighting scenarios.
* User requirement

Identification of users

As this protype will be used in industrial level machines, the business owners can integrate this machine into the industry to increase the effectiveness and accuracy of the sorting process. Also, for the business wise by implementing this technology, owners can reduce the employment salary expenses as machines can be used to do the work done by the employes. The profit margins can be increased due to the effectiveness added to the industry.

For the employes, the workload is reduced as the process is automated using the machines. A user can observe the process. In an emergency, the user can pause the sorting process. Also, if there are miss separations in the sorting process, the user can edit the count of the object. Mainly this project can be used in logistic companies, fruit exports, and airports.

User interviews

For the fact gathering process, we mainly used internet-based information. For get the ideas and expectations about the project, we gathered video demonstrations about the sorting process. By referencing the information, we noted the main user requirements that should be fulfilled by the project. The color detection and sorting should be the main objective of the project as the counting and detail viewing will be secondary options.

Persona Development

The main personnel that can be attracted to this project can be business owners with industrial level companies. To gain the attraction of the owners, we have come up with an idea of introducing the project to the owners by presenting the project as gathering their requirements and adapting and making changes to the project.

* Maximize Output and Optimize Production Efficiency: Main objective is to maximize output and uphold high standards of quality.
* Introduce Innovative Solutions: To increase sorting accuracy and expedite the manufacturing process, it is keen to introduce innovative solutions like the IoT color sorting project.
* Maintain Quality Control: dedicating to making sure that all products satisfy legal and quality standards, and she views the IoT color sorting project to improve quality control procedures.

Challenges:

* Employee Training: understanding how crucial it is to give staff members who will be using and maintaining the IoT system proper training.
* Budget Restrictions: Been aware of the financial limitations and will have to convince higher management of the value of the IoT color sorting project.
* User-Friendly Interface: User requires an interface for the system that is simple to use so that they can monitor, control, and modify the sorting parameters.

A diagram of a project

Description automatically generatedUse case analysis.

Requirements Prioritizations

* Accurate color identification is the main need for efficiently classifying objects according to their color characteristics. To minimize sorting errors and meet quality standards, this criterion is essential.
* Real-Time Sorting: As items travel along the conveyor belt, the system should be able to sort them in real-time. Maintaining manufacturing efficiency and throughput requires real-time sorting.
* Scalability: To handle changing production quantities and potential future growth, the system must be scalable. Scalability guarantees that the system can accommodate growing demand without compromising dependability or performance.
* connection with Current Systems: Streamlining operations and data flow throughout the company depends on a seamless connection with current manufacturing systems, such as production control and inventory management systems.
* User Interface Design: To monitor sorting processes, modify parameters, and resolve problems, operators and administrators need an intuitive interface. User adoption and productivity are increased by intuitive design and simplicity of usage.
* Stability and Reliability: There should be little downtime or production interruptions in the system. In addition to avoiding expensive delays or interruptions in the manufacturing process, reliability guarantees consistent sorting performance.
* Flexibility in Handling Various Object Sizes and Shapes: The system must have the capacity to handle objects with a range of dimensions, forms, and compositions. Sorting criteria that are flexible can handle a wide range of products or components and provide production adaptability.
* Cost-Effectiveness: The system should be economical in terms of original investment, maintenance costs, and operating expenses while guaranteeing high-quality performance. Cost-effectiveness fits within budgetary restrictions and optimizes return on investment.
* Training and assistance: For effective implementation and user adoption, operators and maintenance staff must receive thorough training as well as continuous assistance. Training guarantees that users can optimize the system's capabilities, troubleshoot problems, and run it successfully.

Functional requirements

* Color Identification:   
  The sorting procedure requires the system to precisely identify and distinguish between various colors on items.  
  It should be able to accurately discriminate between a large variety of hues and tones.
* Sorting in real time:   
  As items go along the sorting line or conveyor belt, the system should be able to sort them in real time.   
  For production throughput to be maintained, sorting decisions need to be made fast and effectively.   
  Configuration of Sorting Criteria:
* Sorting criteria ought to be configurable by operators according to certain color properties and sorting rules.   
  It should be possible to modify and customize parameters like acceptable color ranges, thresholds, and sorting destinations.
* Flexibility Regarding Object Properties:   
  In order to retain correct color recognition, the system should be able to adjust to changes in object sizes, shapes, and surface textures. It must be able to handle items with varying finishes and materials without sacrificing the precision of its sorting.
* Mechanisms for Feedback Control:   
  In order to dynamically modify sorting parameters in response to system feedback and real-time sensor data, the system should have feedback control mechanisms.   
  This guarantees that the judgments made during sorting are optimal and adaptable to modifications in the surroundings or attributes of the objects.
* Combining Actuation Systems Integration:   
  To physically separate sorted objects, the sorting system must work in unison with actuation systems like diverters, robotic arms, or conveyor belts.   
  Precise control over item routing and support for many actuation mechanism types should be provided by integration.
* Exception Management and Error Handling:  
  Errors or exceptions that arise during sorting, such as incorrectly classified objects or sorting failures, should be detected, and handled by the system.  
  It should have systems in place for notifying operators of problems, recording mistakes, and taking immediate corrective action.
* Remote Management and Entry:   
  Via a secure network connection, operators should be able to view and manage the sorting system remotely.   
  Remote access increases operational flexibility and efficiency by making it easier to monitor and troubleshoot the system from any place.
* Expandability & Scalability:   
  In order to support future growth or changes, such adding more sorting stations or connecting with more sensors, the system architecture should be scalable.   
  Modular parts and adjustable configurations should be supported so that it can adjust to changing manufacturing needs.

Non-functional requirements

* Performance:  
  At least 50 objects should be able to be sorted by the system per minute.
* Dependability: At least 10 hours should elapse between system failures.  
  In fewer than one minute, it should be able to automatically recover from malfunctions or faults without the need for human involvement.
* Availability: During regular business hours, the system needs to maintain an uptime of at least 90%.  
  Less than 2 hours of maintenance and planned downtime should occur each month.
* Scalability  
  To accommodate a minimum 30% increase in production volume without experiencing a decrease in performance, the system ought to scale horizontally. It ought to allow for the addition of more sensors or sorting stations without requiring a large amount of modification.
* Usability:   
  Operators should need little training to operate the user interface efficiently since it should be simple to use and intuitive. System’s alerts and error messages should be easy to read and comprehend in order to facilitate troubleshooting and problem solving.
* Sustainability:   
  Modularity and encapsulation in the system design will make maintenance and future upgrades easier.   
  The provision of diagnostic tools and logging capabilities is necessary to help maintenance staff locate and fix problems.
* Compatibility:   
  A large variety of object types, materials, and sizes that are frequently encountered in the manufacturing process should be compatible with the system.   
  It ought to facilitate integration with current manufacturing systems, including Manufacturing Execution Systems (MES) and PLCs (Programmable Logic Controllers).
* Environmental Factors to Be Considered   
  The system's components ought to be built to function in a manufacturing environment's typical temperature, humidity, and other environmental constraints.  
  Energy-saving techniques ought to be used to reduce electricity usage and its negative effects on the environment.
* Functional specification
* Architecture of the System:
* Describe the necessary hardware, such as the color sensors, controllers, actuators (such as conveyor belts), and communication modules.
* Describe the software's user interface, control algorithms, data processing modules, and integration with cloud or IoT systems.
* High Importance level.
* Color Identification:
* Specify the color detecting technology that will be utilized.
* Provide specific calibration steps to guarantee precise color recognition in a variety of lighting scenarios.
* Explain the color space representation and the feature extraction and color analysis techniques.
* High Importance level.
* Mechanism for Sorting Objects:
* Describe the actuation mechanism that sorts things according to color characteristics.
* Define feedback control techniques to dynamically modify sorting parameters according to current sensor data.
* Indicate the destinations and sorting criteria for various item colors or categories.
* Medium importance level.
* Sorting in Real Time:
* Indicate what is needed to sort items as they travel over the conveyor belt in real time.
* Specify the latency needed to recognize colors and make sorting judgments.
* High Importance level.
* Designing User Interfaces:
* Describe the operator and administrator interface that allows them to examine system status, change parameters, and monitor sorting activities.
* Describe the user interface's design concepts, such as responsiveness, clarity, and ease of use.
* Low importance level.
* Combining with Current Systems:
* Describe the prerequisites for a smooth integration with the production control and inventory management systems that are currently in place in the manufacturing industry.
* Indicate the APIs for integration, communication protocols, and data formats.
* Medium importance level.
* Instruction and Assistance:
* Describe the conditions under which operators and maintenance staff must be trained in system operation, troubleshooting, and maintenance techniques. To handle any problems or downtime promptly and effectively, specify support and maintenance services.
* Adherence to Regulations:
* Indicate what must be done to ensure adherence to industry norms and laws, such as those pertaining to data protection, the environment, and safety.
* Specify certification and testing processes to guarantee adherence to relevant standards.
* Low importance level.
* Technical Specification

We are developing a color sorting Arduino project designed to sort the object according to the color. The main technology that is used is Arduino and Open CV. The user can view the number of sorted objects as well as edit the misplaced objects. Users can also have a mobile application to view the details of the object’s quantity after the sorting process.

User Interface Design

The main user interface that the user will interact with is Arduino dashboard. This dashboard will display the number of objects sorted in the process.

A screenshot of a computer

Description automatically generated

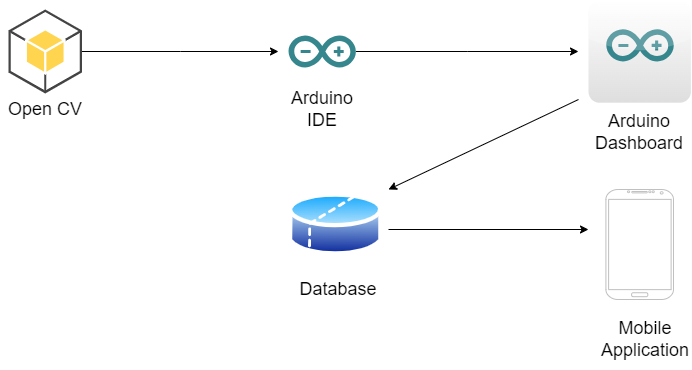
The color detection will be done by the Open CV software. Mainly red, green, and blue colors will be detected and sorted through the software. Then the output will be sent to the Arduino IDE. The Arduino code will be triggered for the respective color of the object. The past sorting details will be saved in a database that can be retrieved in a mobile application.

Data Model

A diagram of a computer

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System Architecture



Deployment and Infrastructure

All the components will be deployed on an Arduino uno board and a breadboard. The Arduino board will be connected to a device to display the current sorting details to the user. The sorting will be done on a conveyor belt, while the objects are moved through the belt. The camera will detect the color and the servo motor will direct the object to the respective color bucket. After the sorting, the sorting details will be saved on to the database. User can retrieve the sorting data through the mobile application.

Testing Strategy

The sorting process can be tested by a sorting round. If the object is placed correctly according to the color, the accuracy of the project can be determined. Users can stop the conveyor belt in an emergency and start again. The current sorting details can be read on the Arduino dashboard. We can test the accuracy of the reading by checking the details of the sorted object with the actual sorted quantity of the objects.

Dependencies

For the application, Arduino IDE is used with respective libraries called stepper, Servo, and ultrasonic. For the color detection operation Open CV software will be used to detect the color of the object. The output will be received by Arduino IDE to sort the object into the correct color basket. Arduino dashboard will be used to display the current sorting process. The sorting details will be saved to a database. The mobile application will display the past sorted details by retrieving data from the database.

Main Operating systems will be used in the project will be windows and android. The Arduino IDE and Open CV software will be run on the windows operating system and mobile application will be run on android operating system.

* Work Breakdown Project Timeline:

Project Phases and Deliverables

|  |  |
| --- | --- |
| **Phase** | **Deliverables** |
| Identify the Problem | Problem statement, initial requirements. |
| Research | Detailed project plan, research findings. |
| Planning | Project plan, resource allocation, timeline. |
| Information Gathering | Complete requirements document. |
| Build the Project | Prototype of the sorting machine with color detection. |
| Testing 01 | Initial testing report. |
| Discuss the Issues and Developing | Updated prototype. |
| Final Testing | Final testing report, updated prototype. |
| Quality Assurance | QA report, final prototype. |
| Submit the Project | Final documentation, submitting the project. |

**Tasks Breakdown at Each Phase:**

|  |  |
| --- | --- |
| **Phase** | **Tasks** |
| Identify the Problem | Forming the project team, conducting initial research, defining the project scope. |
| Research | Conducting in-depth research on sorting machines, color detection, and conveyer belts. |
| Planning | Assigning roles, setting up communication channels, creating a detailed project plan. |
| Information Gathering | Gathering detailed requirements from stakeholders, finalizing the design. |
| Build the Project | Developing the hardware, coding the software, assembling the machine. |
| Testing 01 | Conducting initial tests on the prototype, identifying issues. |
| Discuss the Issues and Developing | Addressing issues found in testing, making necessary improvements. |
| Final Testing | Conducting final tests, ensuring all requirements are met. |
| Quality Assurance | Ensuring the quality of the prototype, making any final adjustments. |
| Submit the Project | Preparing final documentation, submitting the project. |

**Project Timeline:**

|  |  |
| --- | --- |
| **Phase** | **Duration** |
| Identify the Problem | 10 days |
| Research | 10 days |
| Planning | 1 week |
| Information Gathering | 10 days |
| Build the Project | 6 weeks |
| Testing 01 | 2 weeks |
| Discuss the Issues and Developing | 7 weeks |
| Final Testing | 2 weeks |
| Quality Assurance | 3 weeks |
| Submit the Project | 1 week |

**Task Duration & Dependencies:**

Phase 1 - Identify the Problem - 10 days.

(depends on completion of Project Proposal)

Phase 2 - Research - 10 days.

(depends on completion of identify the problem)

Phase 3 - Planning - 1 week.

(depends on completion of the research)

Phase 4 - Information Gathering - 10 days.

(depends on completion of the planning)

Phase 5 - Build the Project - 1 month & 2 weeks.

(depends on completion of the information gathering)

Phase 6 - Testing 01 - 2 weeks.

(depends on completion of building the project)

Phase 7 - Discuss the Issues and Developing - 1 month & 3 weeks.

(depends on completion of the testing)

Phase 8 - Final Testing - 2 weeks.

(depends on completion of correcting the issues)

Phase 9 - Quality Assurance - 3weeks.

(depends on completion of the final testing)

Phase 10 - Submit the Project - 1 week.

(depends on completion of the quality assurance)

**Gantt Chart:**

**Critical Path & Total Time Duration:**

**Critical Path: Phase 1 -> Phase 2 -> Phase 3 -> Phase 4 -> Phase 5 -> Phase 6 -> Phase 7 -> Phase 8 -> Phase 9 -> Phase 10**

**Total Time Duration: 22 weeks**

**Resource Allocation:**

Project and Group Leader: 20%

Planning Leader: 20%

Technical Leader: 15%

Programming Leader: 15%

Quality Leader: 15%

Testing and Maintenance Leader: 15%

**Milestones Aligned with Deliverables:**

Project Proposal (End of Identify the problem, Research, Planning Phases)

Project timeline (End of Information gathering phase)

Prototype Development (End of building the project phase)

System Assembly (End of testing 01 phase)

Final Prototype (End of discuss issues and development, Final testing phases)

Final Project Documentation (End of all phases)

**Current Status**

**Project Timeline Highlighting the Status:**

Identify the Problem Phase: Completed

Research Phase: Completed

Planning Phase: Completed

Information Gathering Phase: Completed

Build the project Phase: Completed

Testing 01 Phase: Completed

Discuss the Issues and Developing Phase: In Progress

Final Testing Phase: Pending

Quality Assurance Phase: Pending

Submit the Project Phase: Pending

**Progress Update:**

The project is currently in the build phase, where the hardware and software components are being developed and assembled. The team is working on coding the software, assembling the machine, and conducting initial tests.

**Key Achievements:**

Hardware components have been assembled successfully.

Software implementation is progressing as planned.

Initial testing has been successful.

**Work Completed:**

Identified the problem and conducted research.

Gathered detailed requirements and finalized the project plan.

Started building the project prototype.

Started developing mobile applications.

Successfully completed the first testing and identified issues.

**Work in Progress:**

**Discuss the Issues and Developing Phase**

after the first testing,

1. Correcting the issues with the prototype.
2. Correcting and developing the issues with the mobile application.

**Current Issues, Risks & Mitigation Strategy:**

Issue: Some hardware components are working with a delay.

Mitigation: Move into alternative components.

Issue: Delays in the build phase due to technical challenges.

Mitigation: Regular team meetings to address challenges, seeking external expertise if needed.

Issue: Software testing is taking longer than expected.

Mitigation: Allocate more resources to testing and prioritize critical tests.

Issue: Some bugs have been identified during testing.

Mitigation: Prioritize and fix critical bugs first. Allocate more resources to debugging**.**

**Next Steps and Resource Allocation for Them:**

Phase 7: Discuss the Issues and Developing

Resource Allocation: Project and Group Leader, Programming Leader, Technical Leader, Planning Leader

Phase 8: Final Testing

Resource Allocation: Testing and Maintenance Leader

Phase 9: Quality Assurance

Resource Allocation: Quality Leader

Phase 10: Submit the Project

Resource Allocation: Project and Group Leader, Planning Leader

* **Conclusion / Summary**

In summary, this project aims to develop a prototype sorting machine with color detection using Arduino technology and IoT principles. The machine will be able to detect the color of objects using a camera, and sort them into the correct sorting places based on their color. The project is currently in the build phase, with the hardware and software components being developed and assembled.

**Key Points and Importance:**

* The project addresses the need for a more efficient and organized sorting process in industries.
* It aims to minimize the pressure faced by employees and improve their safety.
* The project is expected to speed up the sorting process and provide real-time information about object quantities.
* It also aims to minimize human errors and improve the overall effectiveness of the sorting process.

**Recommendations and Suggestions for Deviations:**

* Regularly review the project plan and timeline to ensure that the project stays on track.
* Communicate any deviations from the plan to the project and group leader, and work together to find solutions.
* Seek external expertise or resources if needed to address any technical challenges or issues.

**Recommendations and Suggestions:**

* Conduct regular team meetings to discuss progress, challenges, and next steps.
* Encourage open communication and collaboration among team members.
* Document lessons learned and best practices for future projects.

**Lessons Learned:**

* The importance of thorough research and planning in the early stages of a project.
* The value of effective communication and collaboration among team members.
* The importance of being flexible and adaptable in the face of challenges or changes.

In conclusion, this project has the potential to significantly improve the sorting process in industries and provide real-time information about object quantities. With careful planning, communication, and collaboration, the project team can overcome any challenges and achieve success.