**(DL-Powered Quality Control with a Rotatable Sorting Bin)**

**Capstone Project Proposal**

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**Mentor Consent Form**

I hereby agree to be the mentor of the following Capstone Project Team

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**1. Project Overview**

The objective of this project is to design a hardware system that utilizes machine learning to semi-automate the sorting of spoiled chips/chocolates from good ones. The machine will be controlled by a microprocessor and will use a combination of hardware design, software programming, and machine learning techniques to improve overall efficiency in chips/chocolates production.

**Hardware Design:** The hardware design of the machine will involve designing and building a conveyor belt system that can transport chips and chocolates to the sorting mechanism. The sorting mechanism will consist of a set of sensors and cameras that will collect data about the size, shape, and color of the chips and chocolates. This data will be fed to the microprocessor, which will use machine learning algorithms to classify and sort the spoiled chips/chocolates.

**Software Programming:** The software programming aspect of the project will involve developing the machine learning algorithms that will be used to classify and sort the spoiled chips/chocolates. The algorithms will be trained on a dataset of chips and chocolates with known characteristics to identify patterns and make predictions about the characteristics of new chips and chocolates. The microprocessor will also be programmed to control the conveyor belt system and the sorting mechanism based on the output of the machine learning algorithms.

**Machine Learning Techniques:** The machine learning techniques used in this project will involve supervised learning algorithms such as decision trees, logistic regression, and neural networks. The algorithms will be trained on a labeled dataset of chips and chocolates, where each chip and chocolate is labeled with its corresponding characteristics. The machine learning algorithms will use these labels to learn how to classify new chips and chocolates based on their characteristics.

**2. Problem Statement**

In contemporary manufacturing, the assurance of product quality is paramount to meet consumer expectations and uphold industry standards. However, the conventional quality control (QC) processes for products, such as chips and chocolates, often face challenges in terms of efficiency and precision. This project addresses these challenges through a comprehensive exploration of advanced technologies, specifically focusing on the identification and categorization of defective items. The primary issue at hand is the need for a more sophisticated and automated QC system that can efficiently detect and classify products. Conventional methods may fall short in providing real-time and accurate results, leading to potential delays, increased wastage, and the delivery of subpar products to consumers. The integration of the YOLO (You Only Look Once) algorithm, particularly YOLOV5, and deep learning models offers a promising solution to enhance the QC process. The primary goal is to overcome the limitations of traditional methods by implementing a system that can not only detect products promptly but also classify them accurately based on predefined criteria. By addressing these challenges, the project aims to revolutionize the manufacturing industry's approach to QC, ensuring the efficient production of high-quality products while minimizing wastage and meeting the demands of discerning consumers.

**3. Need Analysis**

In today's competitive market, the importance of efficient and reliable quality control systems has become increasingly evident across various industries, particularly in the food sector. With consumers demanding high-quality products, companies constantly seek ways to reduce costs and minimize waste. As a result, the need for advanced quality control methods has become a top priority.

This is where the proposed project comes into play. This project aims to tackle the challenges of quality control by using a combination of object detection and deep learning models.

It is true that sorting machines can be expensive, particularly those that use advanced technology such as machine learning algorithms. The cost of a sorting machine will depend on several factors, including the complexity of the sorting process, the speed and accuracy required, the type and quality of sensors and cameras used, and the level of automation and customization needed. However, it's important to note that the initial investment in a sorting machine can often pay off in the long run in terms of increased efficiency, productivity, and cost savings. Furthermore, there are often options for leasing or financing equipment, as well as used and refurbished machines, which can help make the cost of a sorting machine more manageable for businesses and organizations with limited budgets.

Human error and inaccuracy are common in many industries, particularly in tasks that require a high level of attention to detail, such as sorting chips and chocolates. Humans are prone to making mistakes due to factors such as fatigue, distractions, and varying levels of skill and experience. These errors can have serious consequences, including increased costs, reduced efficiency, and decreased customer satisfaction. By automating the sorting process with a machine that uses machine learning algorithms, the risk of human error and inaccuracy can be greatly reduced. This can lead to more consistent and reliable results, as well as improved quality control and increased productivity.

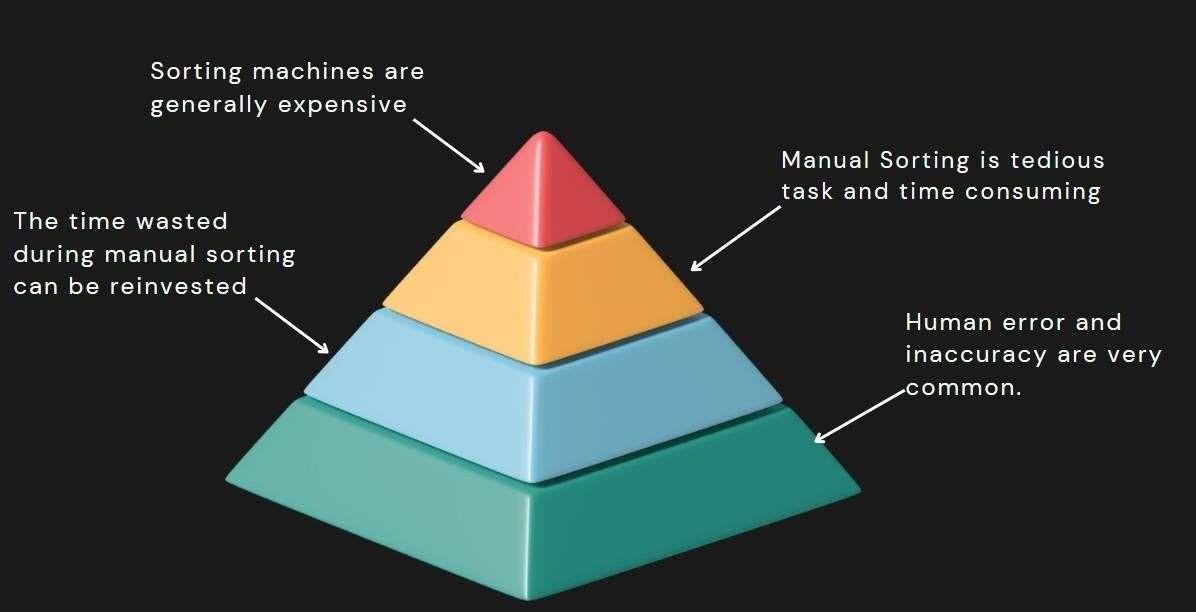


Figure 1.2 (a) (A pyramid diagram comparing manual sorting and machine sorting)

**4. Literature Survey**

The following section deals with the survey of the existing systems, tools, and technologies used for real-time vital monitoring of the underwater stream.

**The theory associated with Problem Area**

The sorting of chips and chocolates is a detailed and intricate operation. This process is governed by a sequence of systematic steps, including sizing, categorizing by thread type, quality check, cleaning, and packaging. The accuracy and consistency of the sorted chips and chocolates are vital for any business.

In today's sorting arena, automated detection of mismatched or defective chips and chocolates is essential for ensuring the quality. Traditionally, mismatch detection was done manually, which was not only time-consuming but also prone to errors. Consequently, automated detection systems are increasingly being adopted in the industry to minimize mistakes and enhance efficiency. Central to these systems are the detection algorithms. Over the past years, many experts in the field have been focused on developing precise and swift algorithms.

In comparison to manual sorting and detection methods, the automated systems have shown greater reliability and speed. As a result, the automation of nut and bolt sorting has become a focal point of research in both computer science and mechanical engineering disciplines. This documentation aims to offer insights into both the algorithms for researchers and practical application challenges for industry professionals

**Existing Systems and Solutions**

In the manufacturing sector, sorting chips and chocolates accurately is considered a pivotal task, as the quality and integrity of assembled products rely heavily on this crucial step. In the past, manual human intervention dominated the process of sorting and matching chips and chocolates. Issues like lack of consistency, human fatigue, and time inefficiencies plagued this manual method. However, applications based on Machine Learning (ML) and Deep Learning (DL) techniques present a promising solution. These technologies can overcome the limitations and inefficiencies associated with manual sorting, introducing a more accurate and streamlined process.

**Research Findings from Existing Literature**

* **Grading of Potato Chips According to Their Sensory Quality**

The paper presents that the potato chips were classified in quality categories according to their color after frying at oil temperatures (120, 140, 160, and 180±1 °C) and undergoing some pretreatments (control or unblanching, blanching, and blanching plus drying). For each oil temperature, six time intervals were considered since the beginning of the frying process until the corresponding time at which potato slices reached a moisture content of 2%. In order to define quality categories according to the surface color, we worked with 79 frequent consumers of potato chips who classified the color scores of the potato chip photographs located in a standard color chart in the following categories: (1) desirable color, (2) still acceptable color and (3) nondesirable color.

Potato chips with a pale color do not have the rich smell expected by the consumers. Indeed, more than 80% of panelists rejected the product. For more than 60% of consumers, potato chips must be a bit toasted with a color golden brown but not burned.

**Computer vision classification of potato chips by color.**

The research paper investigates the use of computer vision for the classification of commercial potato chips based on their color. The study aims to design a tool that can objectively categorize potato chips according to their color, correlating sensory measurements with objective measurements obtained through a computer vision system. The research utilized to classify potato chips in seven color categories, and simultaneously, the color of the same potato chips was objectively determined by a computer vision system in L\*, a\*, b\* units. The study found that a linear regression model was successful in predicting potato chip sensory color values from the corresponding instrumental measurements by computer vision, with an error of approximately 4% for smooth chips and 7% for chips with ruffles. The paper also highlights the potential practical applications of the automatic classification methodology in the food industry, emphasizing its ability to improve quality control and characterize foods more accurately.

The study demonstrates the successful correlation between sensory and objective color measurements of potato chips and the potential of computer vision systems for automatic classification of food products based on color, providing valuable insights into quality control.

**Computer vision based analysis of potato chips –A tool for rapid detection of acrylamide level**

The study "Computer vision based analysis of potato chips – A tool for rapid detection of acrylamide level" focuses on the development of a rapid tool for estimating acrylamide levels in fried potato chips. The research combines digital color image analysis with parallel LC-MS based analysis to establish a correlation between acrylamide levels and specific image features. A semi-automatic segmentation algorithm is used to classify pixels of fried potato images into three sets based on their color, and a new parameter called NA2 value is defined to correlate with the level of acrylamide. The study demonstrates a strong linear correlation between NA2 value and acrylamide level, enabling the prediction of acrylamide levels in test samples. The results confirm the efficacy of the computer vision system in providing explicit and meaningful descriptions for inspection and evaluation purposes, with only one failure out of 60 potato chips when using a provisional threshold limit of 1000 ng/g for acrylamide.

The research aims to address the public concern regarding high concentrations of acrylamide in fried and baked foods, given its classification as a probable human carcinogen. While various analytical methods for acrylamide analysis exist, they are laborious, costly, and not easily adaptable for process control purposes. In response, the study presents computer vision as a rapid, non-contact tool for the inspection and evaluation of food products, specifically for predicting acrylamide levels in potato chips. The study emphasizes the importance of improving the evaluation quality of food products to meet consumer expectations and regulatory demands.

The methodology involves the use of digital image processing and the extraction of a meaningful parameter (NA2 value) from the segmented images, which is then correlated with the acrylamide level. The results demonstrate the potential of computer vision as a powerful technique for safety evaluation and inspection purposes in the food industry. The study underlines the practical application of this approach, envisioning the installation of digital cameras in packaging lines for real-time analysis and inspection of potato chips. Overall, the research presents a promising computer vision approach for the prediction of acrylamide level, offering speed and accuracy in the evaluation of food products, as well as potential for future industry adoption and regulatory compliance.

**Computer Aided Inspection System For Food Products Using Machine Vision – A Review**

The paper titled "Computer Aided Inspection System for Food Products Using Machine Vision – A Review" presents a comprehensive overview of the Computer Aided Inspection (CAI) system for the detection of defects in food products. The aim of the review paper is to emphasize the importance of developing an inspection system that ensures high-quality and safe food products, given the potential health hazards associated with defects in food items. The CAI system is highlighted as an automated, non-destructive, and cost-effective technique based on image analysis and processing, which can be adopted in the food industry. The various stages of the CAI system, including preprocessing, enhancement, feature extraction, and classification, are outlined, with a focus on its potential application in inspecting and grading fruits, meat, vegetables, grain, bakery products, confectionary products, and processed food products. The paper also reviews recent developments and advances in CAI in the food industry, examining the fundamental elements of the system and technology.

The paper delves into the components of a computer vision system, detailing the hardware configuration, image acquisition, image pre-processing, segmentation, and feature extraction/selection. It also discusses the application of computer vision for grading and sorting of fruits and vegetables, emphasizing the challenges and potential tasks in the agriculture industry. The advantages of decision trees and classification rules over neural networks are highlighted, along with the potential of techniques for automated detection and classification of microorganisms in preventing outbreaks and maintaining food safety. Furthermore, the document addresses the recent developments in agricultural technology, emphasizing the demand for automated, noninvasive methods to enhance crop quality and yields in precision agriculture. The review also touches on the challenges and potential of computer vision systems in the inspection and quality evaluation of agricultural and food products, highlighting the need for a standardized method for assessing the quality of different types of food.

The paper provides a thorough review of the Computer Aided Inspection system for food products using machine vision, offering insights into its potential applications, technological components, challenges, and the need for further advancements in the field to meet modern manufacturing requirements and ensure food safety and quality.

**5. Novelty**

The literature survey shows that most of the systems have been built on pre-learned models just

for classifying spoiled chips/chocolates. But we have built a completely automated monitoring system that needs no human intervention in the identification and segregation process. From the chips and chocolates being placed on the conveyor belt till reaching the packaging stage, our system makes sure that no defective item is passed on, ensuring efficient and quality management service for the company all under one belt. The system keeps record of chips/chocolates items and thus further can be used to reassess and fix issues accordingly. This provides a platform for faster and more reliable channeling in the production line and thus increases profits in the long run.

**6. Objectives**

* Object Detection and Classification: To develop a deep learning model capable of accurately detecting and classifying chips and chocolates based on specified criteria.
* Quality Improvement: To improve the quality of chips and chocolates supplied to consumers by detecting and classifying defective products.
* Real-time Processing: To implement a real-time system that can process images, providing rapid and efficient quality control.
* The proposed project aims to achieve these objectives by using deep learning to create a sophisticated quality control system that can accurately detect and classify products and improve the quality of chips and chocolates supplied to the consumer.

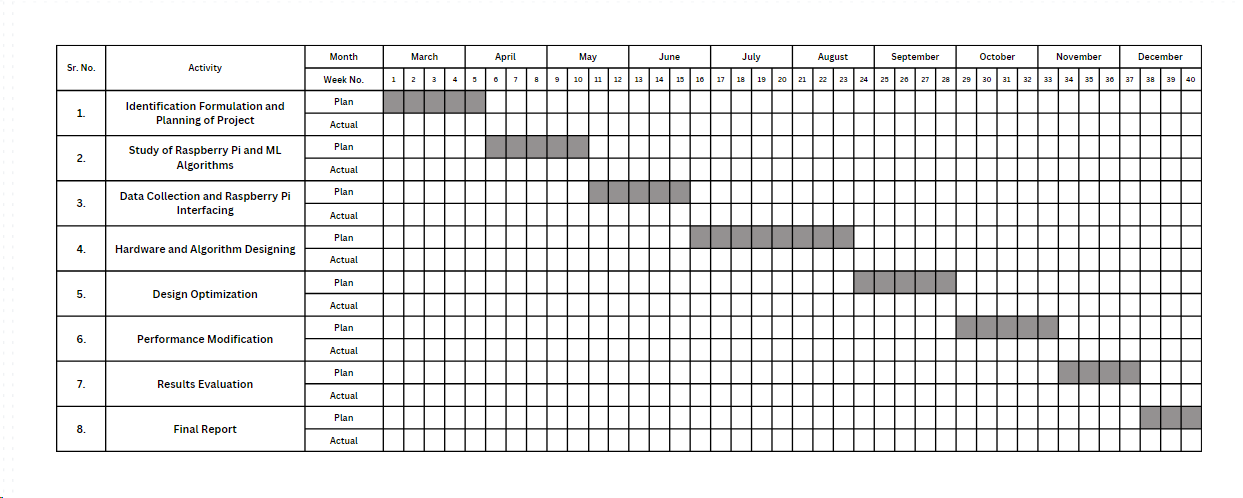
**7. Methodology**

The methodology for achieving the set objectives of the project includes the following steps:

We will be developing a prototype that can conduct continuous monitoring in the conveyor belt of the chips and chocolates production line. The camera tracks chips and chocolates on the conveyor belt and our onboard pc raspberry pi makes the rotating sorting bin decisions. This approach is based on learning from past experiences which had separate systems for inspecting defects and were less efficient.

We will accomplish this by separating it into three stages:

* Chips and chocolates are loaded onto the conveyor belt, aligning them for the next stage of the sorting procedure.
* Multiple photos are collected with a camera and delivered to the Raspberry Pi 4.
* Images are received and processed using OpenCV and our own Deep CNN, which returns a probability as output indicating whether or not the chips/chocolates are spoiled.

**8. Work Plan**

**9. Project Outcomes & Individual Roles**

Our project aims to control the quality of products supplied to the consumer. Our project can be majorly categorized into two parts. In this initial phase, the project aims to implement a robust product detection system utilizing the YOLOV5 algorithm. The focus is on training the deep learning model to accurately identify and locate chips and chocolates within images, laying the groundwork for subsequent classification. Product Classification: Building upon the successful detection in Phase 1, the project advances to product classification. This phase involves defining criteria for categorizing products based on quality, training an extended deep learning model, and integrating a seamless system for real-time classification of detected products, contributing to an enhanced and automated quality control process.

| Member | Role |
| --- | --- |
| Tanishq Dublish | Hardware Component Designing and Raspberry Pi Setup |
| Saneha Garg | Algorithm Designing and Overall coordination |
| Priyanka Bedi | Hardware Component Designing and Raspberry Pi Setup |
| Anshul Garg | Integrating ML with Hardware |
| Sushant Kumar | Algorithm Designing and Dataset collection |

**10. Course Subjects**

* Data Science Applications: NLP, Computer Vision and IoT (UCS672)
* Artificial Intelligence (UCS411)
* Electronic Engineering (UEC001)
* Foundations of Data Science (UCS548)
* Machine Learning (UML501)

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