CHAPTER I INTRODUCTION

1.1 Research Background

The logistics and distribution industry is experiencing rapid development along with the increasing volume of goods that must be processed every day. One important aspect of the distribution system is the sorting process, which groups goods by size, weight, or other characteristics before they are shipped to their final destination. Effective sortation enables faster and more efficient distribution of goods, making it essential in modern supply chains. Under ideal conditions, sortation systems should be able to perform with high speed, high accuracy, and optimal space efficiency, especially in distribution centres that handle thousands to millions of items per day. However, the reality on the ground shows that many industries still rely on manual sortation methods, where workers visually sort items and place them in the appropriate categories. Krishnan et al. (2024) mentioned that this manual method is no longer able to fulfil the increasingly complex and dynamic needs of modern logistics.

Manual sortation methods have many limitations, such as inaccuracies in sorting, delays in delivery, and increased operational costs due to dependence on human labour. In addition, manual sortation cannot optimise the use of space in warehouses, as goods are often arranged without an efficient system, leading to lower storage capacity and the potential for uncontrolled accumulation. From a social perspective, manual sortation does create jobs, but workers often experience fatigue due to monotonous and repetitive tasks, which results in decreased efficiency and increased potential for errors.

As a solution to this limitation, many companies are turning to technology-based automated sortation systems such as robotics, smart sensors, and computer vision. These technologies allow sorting of goods to be done without human intervention, thereby reducing errors and improving operational efficiency. One of the most effective approaches in automated sortation systems is You Only Look Once (YOLO), a deep learning algorithm designed for real-time object detection. Compared to traditional methods such as colour segmentation or edge detection, YOLO has advantages in speed, accuracy, and computational efficiency, allowing the system to work more optimally in dynamic environments.

Research by Amna et al. (2023) showed that a computer vision and deep learning-based fruit grading system can improve accuracy in automatically detecting fruit quality. Another study by Duan et al. (2024) developed a YOLO-based sorting system for fresh cut flowers, which showed improved efficiency with real-time detection up to 98% accuracy. In addition, the study by Pham et al. (2024) proved that YOLOv8 can identify objects with high speed and better precision than methods based on colour segmentation or edge detection. However, although previous studies have proven the effectiveness of YOLO in various applications, its application in size-based automated sortation systems for space optimisation in warehouses and distribution centres still needs to be further developed. Therefore, this research aims to develop a YOLO-based automated sortation system that is capable of sorting items by size and ensuring that items are optimally placed in storage space.

To overcome the problem of slow and inaccurate manual sorting, this research develops a computer vision-based automatic sorting system using YOLO, which allows items to be classified by size automatically. The system consists of several main components, ESP32-CAM camera to capture images of goods on the conveyor, YOLO as an object detection algorithm capable of recognising and measuring the size of goods in real-time. NodeMCU ESP8266 as a microcontroller in charge of controlling the entire system. Servo motor to direct the goods to the appropriate path based on YOLO detection results. The advantages of this system lie not only in speed and accuracy, but also in more efficient use of space. By automatically sorting goods by size and placing them in the appropriate categories, storage space can be optimised, so that the warehouse or distribution centre can handle a larger volume of goods with the same capacity.

Several previous studies have discussed the application of technology in automated sortation systems. Wijaya (2010) used RGB colour segmentation to sort objects based on weight, but this method is less stable against lighting changes, Tri Yunardi (2015) applied OpenCV-based contour detection for package sorting, but could not measure object size directly, Pratama (2022) developed a Raspberry Pi-based sorting system, which works well for objects with high contrast colours, but less effective for objects with complex colour patterns. Amna et al. (2023) developed a deep learning-based fruit grading system with CNN, which achieved high accuracy in detecting defective fruits, but still has limitations in processing speed. Pham et al. (2024) developed a cashew nut grading system based on YOLOv8 and Transformer, which showed better results in terms of speed and accuracy than previous methods.

Based on previous research, it can be seen that edge detection and color segmentation-based methods still have limitations in accuracy and sensitivity to the environment. Therefore, this research adopts YOLO as the main solution, as this model has the advantage of deep learning-based object detection, which is more accurate and faster than previous methods.

Based on the problems that have been described, it can be concluded that manual sorting methods have many limitations, such as low speed, inaccuracy, and inefficiency in the use of storage space. Along with the development of technology, a computer vision-based automatic sorting system with YOLO is a potential solution to improve accuracy, speed, and space optimization in the distribution of goods. Therefore, this research develops a YOLO-based automated sortation system that can sort goods by size accurately and efficiently, and ensure that goods can be optimally placed in storage space. With this approach, the system is expected to speed up the distribution process, increase warehouse storage capacity, and reduce dependence on manual labor.

1.2 Research Purpose and Benefits

This research aims to create a prototype of an automatic sorting device that can sort boxes by size (big or small) using computer vision and YOLOv8. The benefits of this research include improving classification accuracy in the sorting process.

1.3 Research Scope and Limitations

This research focuses on developing a YOLO-based automated sorting system, with the following scope and limitations:

1. Items are sorted by size, with the classification of large if greater than or equal to 5×5×5 cm and small if less than 5×5×5 cm.
2. The conveyor used in this system has a dimension of 50 × 10 cm.
3. The system consists of ESP32-CAM as a visual sensor, NodeMCU ESP8266 as a microcontroller, and servo motor for the mechanism of separating goods.
4. Using YOLOv8 as the main method to recognize and classify the size of goods in real-time in an automated sorting environment.
5. The system is only capable of sorting goods with a maximum weight of 700 grams, so goods with a load greater than this limit cannot be optimally processed.
6. The front camera is installed at a distance of 30 cm from the system to capture the initial image of the goods, while the top camera is installed at a distance of 65 cm for size analysis and classification of goods.
7. The system was tested under controlled conditions with fixed lighting, so it has not been tested against the effects of lighting variations and external mechanical disturbances.
8. The tests were carried out on a conveyor with a voltage of 1.27 Volts and did not cover high-speed variations or industrial conditions with greater workloads.
9. The YOLO model used is still based on a box dataset which is divided into large boxes and small boxes.