CHAPTER 1 INTRODUCTION

1.1 Project Background

Sustainable industrialization is an essential component of sustainable development. In the development of resilient Infrastructure, sustainable industrialization and research and innovation are focused on SDG 9 (Halkos & Gkampoura, 2021). In line with this goal, the role of technology in addressing traffic difficulties is crucial. Countries may improve road safety, reduce congestion, and boost overall transportation network efficiency by investing in long-term infrastructure and fostering transportation system innovation. Furthermore, promoting inclusive and sustainable industry through technological advancements can lead to the development of environmentally friendly autos, smart transportation systems, and successful urban planning strategies. Adopting SDG 9 principles can help to alleviate traffic congestion while also ensuring the long-term sustainability and resilience of transportation networks around the world.

Traffic problems are one of the most complex and common issues in land transportation, especially in urban areas (Saputra & Savitri, 2021). The causes of traffic problems include red light violations, changing lanes without signaling vehicles, or driving in the wrong lane, which can cause accidents, disrupt traffic flow and congestion due to the unbalanced growth in the number of vehicles with the capacity of transportation infrastructure. In this case the role of technology is needed, to reduce this problem.

Basically, technology is created to facilitate human work. Technology is an inseparable part of human life in the current era and has become a primary need (Cholik, 2021). The development of technology and information presents opportunities as well as challenges that bring about changes in all aspects of life, from the smallest scope of individuals to the broadest scope of nations and even the world (Makbull Rizki, 2022). The rapid development of technology is not limited to just one field, but spans various areas such as education, healthcare and medicine, agriculture, livestock farming, environment and energy, industry and

manufacturing, and security. The development of technology in the field of security aims to enhance public safety, such as the use of artificial intelligence for security surveillance, IoT-based security networks, and object detection and tracking.

Object detection and tracking play a crucial role in the field of security as they provide the ability to identify specific objects or entities in various contexts and situations. Object detection involves detecting objects from one or multiple classes in an image. The goal of object detection is to detect all instances of objects from a set of known classes, such as people, faces, or cars, in an image. Typically, only a small number of objects are visible in an image, but there are a large number of possible locations where the objects could appear and need to be explored. In each object detection, various forms of information are displayed, such as the object itself, its location and scale, segmentation masks, and bounding boxes (Amit et al., 2020). Object detection is one of the most fundamental and challenging problems in computer vision. It aims to find the locations of objects from a large number of predefined categories in natural and real-time images (L. Liu et al., 2020).

In object detection, there are two applied methods: Single Object Tracking (SOT) and Multi-Object Tracking (MOT). Compared to SOT, Multi-Object Tracking has two tasks: determining and detecting multiple objects simultaneously and maintaining the identity of the objects across frames. In Multi-Object Tracking, there are two processing modes, there are online tracking and offline tracking. Online tracking relies on information from the past up to the current frame, while offline tracking uses observations from both the past and the future, for real-time tracking requires online tracking (Rhodes, 2018). Multi-Object Tracking is a task in computer vision that involves detecting and tracking multiple objects in a video sequence. The goal of MOT is to identify and locate the desired objects in each frame and then associate them across frames to track their movements over time. Object detection in MOT presents various challenges in factors such as occlusion, motion blur, scale variations, and changes in object

appearance and is typically addressed using algorithms that integrate object detection and data association techniques (Zou, 2019).

Object tracking is a crucial component in various computer vision applications, such as surveillance, autonomous vehicles, and robotics. In this project taking specifications on vehicle surveillance such as cars and motorcycles. Accurate and robust object tracking is essential to ensure the reliability and effectiveness of these systems. This project aims to improve the accuracy of object tracking using Box-MOT (Bounding Box Multi-Object Tracking), a novel approach that combines object detection and tracking to enhance tracking performance.

1.2 Problem Statement

Object tracking algorithms often face limitations in handling occlusion, scale variation, and changes in object appearance. Object tracking algorithms frequently struggle with occlusion, which occurs when detected objects are obscured by background changes or lens deviations, resulting in tracking errors and potentially losing object tracking. A further obstacle is scale variation, which makes object detection difficult when objects move in relation to the camera or change in size as a result of perspective, viewing angle, or distance factors (Oksuz et al., 2021). Changes in object appearance, such as rotation, lighting changes, color variations, and changes in shape or structure, complicate object detection accuracy.

Multiple Object Tracking (MOT) has become increasingly popular due to its academic and commercial potential. Although various solutions have been proposed to address this problem, it remains difficult due to factors such as abrupt appearance changes and severe object occlusions (Luo et al., 2021). The problems it raises for researchers, developers, and practitioners working in computer vision and object tracking algorithms.

Object tracking problems such as occlusion, scale variation, and object appearance changes arise in various fields such as surveillance systems, autonomous vehicles, and robotics where accurate object tracking is essential (Oksuz et al., 2021).

Object detection, one of the most fundamental and difficult problems in computer vision, seeks to locate object instances from a large number of predefined categories in natural images (L. Liu et al., 2020).These challenges in object tracking will persist as algorithms for object tracking are developed and implemented in a wide range of applications that require precise object tracking capabilities.

Many scholars have continuously improved existing methods for increasing efficiency and tracking performance in some areas (S. Liu et al., 2021). Understanding and addressing these object tracking issues will improve the tracking application or system's accuracy, functionality, and performance in challenging scenarios such as occlusion, scale variations, and changes in object appearance, reducing real-time tracking failures and increasing object detection robustness.

1.3 Objectives of the Project

The project's objectives are outlined follows:

a) **Design and Implementation of Bounding Box Multi-Object Tracking (Box-MOT)** : The project aims to designing and implementing an object tracking accuracy enhancing system using Bounding Box Multi-Object Tracking (Box-MOT) technology. Through the implementation of this method, the project aims to develop tracking system that tackles certain things tracking problems and advances tracking technology.

b) **Implement Bounding Box Multi-Object Tracking (Box-MOT) for object tracking using YOLOv8 models :** Through the use of Box-MOT, the project aims to investigate and propose methods with YOLOv8 to improve object tracking accuracy. The study aims to close the identified gap in object tracking accuracy and make a positive impact on the field by investigating this novel approach. The project intends to provide useful contributions that solve the existing limitations in object detection and tracking by focusing on enhancing tracking accuracy.

c) **Performance Evaluation of Bounding Box Multi-Object Tracking (Box-MOT)** : Thoroughly assessing the created object tracking system using Box-MOT, performance system is a crucial component of the project. Important criteria including accuracy, efficiency and resilience are evaluated in this assessment across a range of scenarios. The project intends to advance object tracking systems by offering insights into the system strengths, limits and opportunities for improvement through systematic testing under various scenarios.

1.4 Significance of the Project

Object tracking has emerged as a valuable tool with significant implications in various fields, each of which benefits from its use. One prominent application of object tracking is in security surveillance. Enhanced object tracking in this field allows systems to identify and prevent criminal activities. By simultaneously identifying and tracking suspicious objects, it helps law enforcement agencies improve surveillance effectiveness in public areas, critical infrastructure, and transportation hubs. It also helps mitigate increasing threats that significantly impact public safety. Another potential application is real-time identification and tracking of multiple vehicles, aiding in traffic management and road safety by detecting violations and accidents more quickly. Supporting intelligent mobility and smart transportation systems is crucial as it enables vehicles and road infrastructure to detect surrounding objects such as pedestrians and vehicles.

In addition to the security field, object tracking plays a crucial role in ensuring physical and data security. Monitoring the movement of people and objects in a specific area allows security systems to detect suspicious access and trigger security alarms. Identifying users based on behavior by studying the movement patterns of employees and visitors enables automatic identification-based access to specific areas.

In the world of trade, object tracking plays a crucial role in business and retail efficiency. By improving accuracy in detecting objects on shelves and store areas, it can help optimize inventory, prevent theft, and enhance the shopping

experience for customers. In other cases, object tracking also plays a role in detecting components or products in industrial environments, aiding in process monitoring and reducing manufacturing errors. Additionally, it assists in real-time monitoring of business vehicle fleets for efficient route planning, timely vehicle maintenance, and speedy delivery of goods. With the advancements in technology, object tracking in these areas optimizes business operations and presents exciting opportunities for new growth.

In the field of robotics and automation, accurate and efficient object detection is crucial for robot interaction and manipulation. By enhancing a robot's ability to detect and interact with objects in its surroundings, it can be used in applications such as object picking, autonomous navigation, and human-robot collaboration.

There is a significant potential for ethical implications in object tracking to address ethical concerns and ensure responsible use of this technology, which is of utmost importance. Privacy and data security must be ensured to prevent misuse and protect individual privacy. In the development of this technology, it is crucial to ensure that the system is used for legitimate purposes and to avoid misuse or legal violations.

In conclusion, object tracking offers transformative potential in various fields. Its capacity to enhance security, support intelligent mobility, improve access control, drive business and retail development, enable human-robot collaboration, and engage in ethical considerations makes it a wise governance for progress and sustainable integration into modern society.

This project holds significant importance in various domains:

a) Security and Surveillance: Improving object detection accuracy can enhance security measures, identify and prevent criminal activities, and protect critical infrastructure.

b) Access Control and Authentication: Simplifying access control based on individual movement patterns to secure access to areas, objects, or data.

c) Retail and Marketing: Object tracking drives business and retail development by optimizing inventory, preventing theft, and enhancing the shopping experience for customers.

d) Robotics and Automation: Improving object detection accuracy can enhance a robot's ability to detect and interact with other objects in its surroundings.

e) Ethical Considerations: The importance of object tracking lies in its role in the development of technology that is wise and responsible in addressing ethical concerns.

1.5 Scope of the Project

The project scope encompasses the following areas:

- **Data Collection**: Collecting diverse datasets of object images to be detected for training and testing the system.
- **Algorithm Selection and Development**: Developing the Box-MOT algorithm to integrate object detection and tracking. This involves creating a model with Box-MOT algorithm for accurate and robust object detection and improving object tracking accuracy.
- **System Development**: Creating a real-time object detection and tracking application using the Box-MOT algorithm.
- **Enhancing Tracking Performance in Real-World Scenarios**: Improving the tracking performance on objects to address challenges that may arise in real-world object detection scenarios.
- **Performance Evaluation**: Evaluating the effectiveness of the algorithm through extensive experiments and metrics. Algorithm evaluation is conducted to assess and measure the system's practicality and effectiveness, including tracking accuracy, execution speed, and robustness to occlusion and scale variations.
- **Comparing the Proposed Approach with Existing State-of-the-Art Object Tracking Methods**: In this stage, comparing the Box-MOT algorithm with other well-established tracking methods to understand how

much improvement the Box-MOT algorithm provides to the system's performance.

- **Ethical and Privacy Considerations**: Investigating and addressing ethical issues related to object detection and tracking, including data privacy and security.

1.6 Assumption and Limitations

In the context of the "Enhancing Object Tracking Accuracy using Bounding Box Multi-Object Tracking (Box-MOT)" project, several key assumptions and limitations are recognized, which frame the project's scope and potential constraints:

1.6.1 Assumption

- **Hardware resources**: It is assumed that object tracking and detection require adequate hardware resources, particularly Graphics Processing Units (GPUs), storage capacity, Ethernet and USB connections, to facilitate efficient model training and accurate object detection.
- **Data availability**: It is assumed that a large amount of high-quality training data is available to train the object detection and tracking models. This dataset should include diverse objects, backgrounds, lighting conditions, and occlusion scenarios to ensure the models can generalize well in various real-world situations.
- **Object detection and tracking algorithms**: It is assumed that the algorithms used for object detection and tracking are reliable, thoroughly validated, and tested. The chosen algorithms should be capable of accurately detecting and tracking objects in various scenarios, such as occlusion, scale variations, and changes in object appearance.
- **Real-Time tracking performance**: It is assumed that the chosen algorithms are capable of real-time tracking and provide fast and accurate results for applications that require real-time object monitoring and analysis.

- **Consistent and high-quality video or image input**: It is assumed that the input data, whether images or videos, used for object detection and tracking is consistent and of high quality.

1.6.2 Limitations

- **Training Data**: The availability of diverse and high-quality training data is crucial for accurately training object detection and tracking models. However, limitations in the quantity or quality of training data can affect the system's ability to generalize well across various scenarios and objects.
- **Complexity of Real-World Scenarios**: Real-world scenarios cannot be predicted and can be complex in terms of object tracking and detection, such as occlusion, scale variation, and changes in object appearance. These factors can pose challenges in accurately tracking and detecting objects and impose limitations on the system's performance.
- **Environmental Variability**: Changes in environmental conditions such as lighting, weather conditions, or camera perspective can affect the accuracy of object detection and tracking. This factor can impose limitations and challenges in achieving high accuracy in various situations.
- **Trade-off between Accuracy and Speed**: In object tracking and detection systems, there is often a trade-off between accuracy and detection speed. Increasing accuracy in the system requires more computational resources and slower processing speed, while prioritizing real-time tracking can result in less accurate object detection.
- **Ethical and Privacy Concerns**: Object tracking and detection systems can raise ethical and privacy concerns, especially when used in sensitive environments. It is important to ensure responsible and ethical use of this technology regarding privacy issues.