AIoT POTHOLE DETECTION SYSTEM USING YOLOV5

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JUDUL: AIoT POTHOLE DETECTION SYSTEM USING YOLOV5

SESI PENGAJIAN: 2022 / 2023

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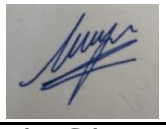

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AIoT POTHOLE DETECTION SYSTEM USING YOLOV5

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This report is submitted in partial fulfillment of the requirements for the Bachelor of Computer Science (Artificial Intelligence) with Honours.

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

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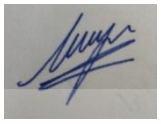

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DEDICATION

My FYP supervisor, DR. Nur Zareen Zulkarnain deserves special thanks for her unwavering support throughout the project's completion, her patience in guiding me through every phase of the project and for inspiring and encouraging me while I worked on this project. I am grateful for the assistance my supervisor provided. I would like to dedicate to my cherished parents and siblings, who have continuously given me the willpower, support, and motivation to complete my project during my university years. Finally, I want to thank my friends for their unwavering support and assistance over the past years of my university life. Lastly, I would like to thank The Almighty God who has given me the strength and willpower to complete this project.

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ABSTRACT

The AIoT Pothole Detection System using YOLOv5 is an innovation that is made to help the society. The elements implemented in the project are artificial intelligence primarily focusing on object detection, IoT device integration and YOLOv5 algorithm. The objectives of this innovation is to implement object detection to detect potholes present on the road, measure the performance of two different YOLO models detection accuracy for pothole detection and evaluate the performance of the chosen YOLO model. The problems that can be solved from this innovation are plenty and they are to improve road safety of drivers and riders providing them enhanced driving experience, reducing damage to vehicles and provides efficient road maintenance helping reduce infrastructure damage. In addition to that, this project is a way to embody the state-of-the-art potentials like IoT (Internet of Things) and AI (Artificial Intelligence) technologies, especially incorporating them and producing futuristic innovations. Pothole detection system using YOLOv5 deployed to a Raspberry Pi 4 offers a holistic solution to a common urban infrastructure challenge and has a lot to contribute to the overall well-being and safety of communities.

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ABSTRAK

"AIoT Pothole Detection System" menggunakan YOLOv5 adalah satu inovasi yang dibuat untuk membantu masyarakat. Elemen yang dilaksanakan dalam projek ini ialah kecerdasan buatan yang memfokuskan terutamanya pada pengesanan objek, penyepaduan peranti IoT dan algoritma YOLOv5. Objektif inovasi ini adalah untuk melaksanakan pengesanan objek untuk mengesan jalan berlubang, mengukur prestasi dua model YOLO yang berbeza ketepatan pengesanan untuk pengesanan lubang dan menilai prestasi model YOLO yang dipilih. Masalah yang boleh diselesaikan daripada inovasi ini adalah banyak dan ia adalah untuk meningkatkan keselamatan jalan raya pemandu dan penunggang memberikan mereka pengalaman memandu yang lebih baik, mengurangkan kerosakan kenderaan dan menyediakan penyelenggaraan jalan yang cekap membantu mengurangkan kerosakan infrastruktur. Di samping itu, projek ini adalah satu cara untuk menjelmakan potensi terkini seperti teknologi IoT (Internet of Things) dan AI (Kecerdasan Buatan), terutamanya menggabungkannya dan menghasilkan inovasi futuristik. Sistem pengesanan berlubang menggunakan YOLOv5 yang digunakan pada Raspberry Pi 4 menawarkan penyelesaian holistik kepada cabaran infrastruktur bandar yang sama dan mempunyai banyak perkara untuk menyumbang kepada kesejahteraan dan keselamatan keseluruhan komuniti.

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LIST OF ABBREVIATIONS

FYP	**-**	**Final Year Project**
AI	**-**	**Artificial Intelligence**
IoT	**-**	**Internet of Things**
AIoT	**-**	**Artificial Intelligence Internet of Things**
CNN	**-**	**Convolutional Neural Network**
RPI 4	**-**	**Raspberry Pi 4**

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Potholes are areas of road surface that have cracked, worn away, and eventually formed a hole. They start out as tiny cracks. If they're not fixed right away, they can grow. Potholes may be anywhere from a few inches wide and deep to a few feet wide and several inches deep.

Vehicles depend on a flat, smooth surface to move across city streets and highways. They can move swiftly, pleasantly, and safely as a result. A ride over a pothole will be unsteady and maybe dangerous. They might potentially mess with a car's wheel alignment in addition to harming the tyres.

Potholes can cause a variety of damages, both to vehicles and to the infrastructure of roads. Some of the potential damages that can result from hitting a pothole is damage to vehicle tires where the potholes can cause punctures, flats, or blowouts in tires. The impact can also cause tire alignment issues or damage to the suspension system.

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Besides that, the wheels and rims can result in bent or cracked rims that need to be repaired or replaced due to hitting the potholes. A major damage happens mainly to the suspension system including the shocks, struts, and springs which can lead to expensive repairs and reduced driving comfort.

The undercarriage of a vehicle, including the exhaust system, oil pan, or transmission can also be damaged due to hitting a pothole and lastly potholes can also cause damage to the roads themselves, which can lead to costly repairs for municipalities and governments. The damage can include cracking, crumbling, and erosion of the road surface, as well as damage to underground utilities' and infrastructure.

Due to all this safety threatening reasons, a pothole detection system has been proposed to overcome the issues faced by drivers or riders on the road. This system is believed to detect pothole while they are driving on the road and gives the driver a warning like sign to avoid the potholes on the road.

1.2 Problem Statement(s)

The roads in Malaysia as we all know has many dreaded potholes and it is one of the many annoyances that many drivers experience. No matter how shallow or deep they are, driving over them is extremely unpleasant. These tiny cracks in the pavement can disrupt commuter traffic and are a significant factor in axle and suspension failure in automobiles. They may develop as a result of poor road construction and design, inclement weather, and inadequate drainage.

Potholes in the road can cause a great deal of damage to cars and other vehicles. They can puncture tyres and ruin vehicles' suspension and steering alignment. They can also cause scratched paintwork and marked bumpers from the impact of the car hitting the broken road. Driving into a pothole can also cause loss of control over the car, which can lead to accidents involving more than one vehicle.

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1.3 Objective(s)

The project's main objective is to overcome the menacing pothole issues faced by drivers or motorists on the road by developing the pothole detections system (PDS) using image recognition. The main objectives of the system are as such:

1. To detect the potholes present on the road using computer vision (object detection).

2. To measure the performance of two different YOLO models detection accuracy for pothole detection.

3. To evaluate the performance of the chosen YOLO model.

1.4 Scope

The targeted users for this project is car drivers and bike riders including an vehicle drivers since vehicles nowadays can have its own dash camera fixed in it. Part of the scope is the modules to be developed and they are as such:

1. AI object detection for detecting the potholes on the road.

2. A system that can display alerts to drivers or riders.

3. Creating a beep alert sound using sensors.

1.5 Project Significance

The significance of having a pothole detection system can be important in many ways and one of it is improved safety. Potholes can pose a significant safety risk for drivers, particularly if they are not visible or if they are located in areas where drivers are not expecting them. PDS can help identify and locate potholes in real-time, allowing drivers to take appropriate action to avoid them.

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Besides that, PDS is believed to reduce vehicle damage as potholes can cause significant damage to vehicles, including punctured tires, bent rims, and damage to the suspension system. By detecting and avoiding potholes, drivers can reduce the likelihood of incurring these types of costly repairs.

In addition to the project's significance, PDS can be cost saving by identifying and repairing potholes early where these costs can be minimized since potholes can cause significant damage to roads, resulting in costly repairs for municipalities and governments. With that being said, we can also have improved road maintenance where PDS can help municipalities and governments identify areas that require maintenance and repair more quickly and accurately. This can help prioritize maintenance efforts and ensure that resources are used more efficiently.

Overall, this pothole detection system (PDS) can help improve road safety, reduce vehicle damage, save costs, and improve road maintenance efforts. As such, it is an important tool for both drivers and municipalities alike.

1.6 Expected Output

The expected output of this project is as follows:

- The AI model correctly detects and recognizes the potholes present on the road.
- The system then alerts the driver or rider beforehand they can pass by the pothole from far (example 100m away).
- A beep sound to let the driver or rider avoid the pothole on the road.
- Implement PDS in real-time vehicles by default manufacturing and improvise vehicles safety on road.

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1.7 Conclusion

In conclusion, we have discussed what and how potholes form and how it leaves a menacing impact on people who use the road such as drivers, riders and pedestrians even. Besides that, we analyzed all the safety threatening problems of the potholes and how pothole detection system (PDS) can overcome all such problems in a simple way. Some of the expected outputs of PDS and how it functions were also discussed in this chapter.

CHAPTER 2: LITERATURE REVIEW AND PROJECT METHODOLOGY

2.1 Introduction

In chapter 2, relevant project journals and research papers will be stated and discussed as they are used as citation in this project. This is a crucial step and it is done so that the objective of this project can be accomplished by first comprehending the necessary fundamental ideas, methods and techniques to be used.

The purpose of all these literature reviews are to collect relevant, timely research on my project topic, and synthesize it into a cohesive summary of existing knowledge in the field. From doing so, this project can come up with its own argument on this topic by conducting my own original research.

There are numerous research papers and journals that are related to this project's objective(s), specifically the various techniques used to create a pothole detection system, machine learning algorithms comparisons on pothole detection and the different results and outcome using varying deep learning methods.

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2.2 Facts and Findings

According to The Federal road accidents caused by potholes have resulted in more than 5,000 deaths in India in the three years between 2018 and 2020, according to official data. As per the Ministry of Road Transport and Highways (MoRTH) data, the total number of road accident deaths due to potholes in 2018, 2019, and 2020 stood at 2,015, 2,140, and 1,471, respectively, totalling to 5,626 deaths. As many as 4,775 and 3,564 accidents have occurred in 2019 and 2020, respectively, due to potholes.

As for the statistics in Malaysia, in a study conducted by (Yusria Darma *et al*, 2017) revealed that uneven roads are amongst the many factors leading to road traffic fatalities, with 11.25% of which being associated with this, and potholes constituting 11.2% in Malaysia.

Accident cases due to potholes or bad roads are rising and as many as 223 accidents caused by poor road conditions especially potholes in Selangor were recorded between 2018 and 2020. According to the Selangor Traffic and Investigation Department, Chief Superintendent Azman Shari'at, 148 cases resulted in death. Out of these fatalities, 116 cases involved motorcyclists. In this article, some major accidents that took place caused by potholes were stated as well.

According to an article from The Vibes.com, a total of 285 deaths or an average of 57 fatalities annually due to pothole incidents were recorded over a period of five years from 2014 to 2018. (Tamrin, 2021) stated in the article that data obtained from the annual statistical report by the Royal Malaysia Police has shown that deaths due to potholes in 2018 added up to a mere 0.88% of overall road fatalities nationwide. Figure 1 shows the statistical bar graph of accidents involving potholes in Malaysia and in 2018, there were 55 deaths, with 16 suffering serious injuries and 40 minor injuries and the highest death count due to pothole incidents was 101 (in 2015), or 1.5% of overall road deaths.

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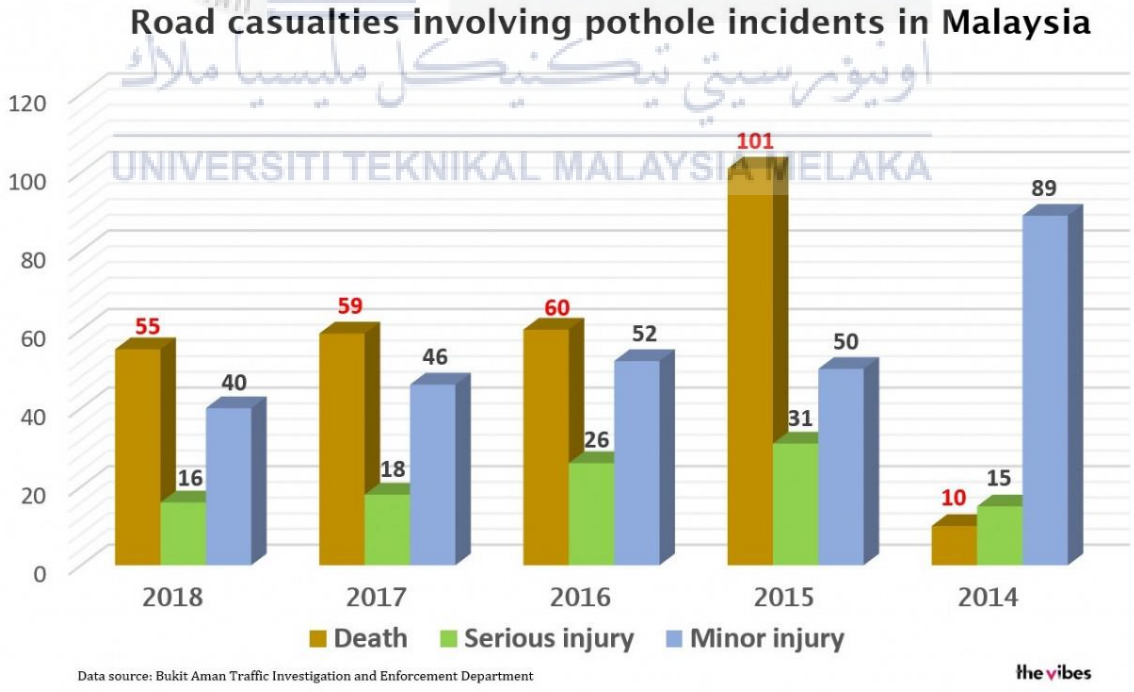

Figure 1: Statistics of accidents involving potholes in Malaysia.

2.2.1 Domain

One of the many domains of the pothole detection system, the very crucial one is computer vision which involves the development and implementation of algorithms and techniques to analyse visual data, such as images or videos, captured by cameras or sensors. Computer vision is mainly for object detection, image segmentation, feature extraction, and anomaly detection to identify and locate potholes.

Besides that, machine learning and deep learning domains are fundamental to pothole detection systems. These domains involve training models to recognize patterns in data and make predictions. Techniques like convolutional neural networks (CNNs), transfer learning, and data augmentation can be employed to train models for pothole detection. These domains are used for feature extraction, classification, and decision-making in pothole detection systems.

Pothole detection systems can utilize sensor networks embedded on vehicles to gather data related to pothole or road conditions. These sensors can capture information such as vibrations, accelerations, or changes in road surface characteristics, which can help in detecting and predicting the presence of potholes.

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Internet of Things (IoT) technologies enable the integration of various devices and sensors within the pothole detection system. This domain involves collecting data from connected devices, transmitting data wirelessly, and enabling communication between different components of the system.