WASTE MANAGEMENT SYSTEM USING DEEP LEARNING MODEL

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honors

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DEDICATION

I dedicate my work to my family, supervisor, and my friends. A special feeling of gratitude to my supervisor, Prof. Madya Dr. Abdul Majid whose words of encouragement and push for tenacity ring in my ears. I also dedicate this dissertation to my friends and family who have supported me throughout the process. I will always appreciate all they have done, helping me develop my technology skills.

ABSTRACT

Waste collection is an important part of city management. Garbage bins are the initial component of any waste management system. To develop a superior waste management system, it is necessary to do research and analysis on the architecture of the deep learning model. This title provides a way in which waste management can open the trash bin depending on the garbage it observes via the raspberry pi camera. The suggested system would open the appropriate trash bin based on the waste type determined by the trained model using real-time object identification and classifications performed with deep learning. The suggested system is comprised of a Pi Camera, Servo Motors, and a Raspberry Pi 4 that controls the functioning of the device. The anticipated goal of this project is to determine the optimal deep learning architecture for waste identification and to improve the accuracy of the deep learning model.

ABSTRAK

Pengumpulan sisa adalah bahagian penting dalam pengurusan bandar. Tong sampah adalah komponen awal mana-mana sistem pengurusan sisa. Untuk membangunkan sistem pengurusan sisa yang unggul, adalah perlu untuk melakukan penyelidikan dan analisis mengenai seni bina model pembelajaran mendalam. Tajuk ini menyediakan cara pengurusan sisa boleh membuka tong sampah bergantung pada sampah yang diperhatikan melalui kamera raspberry pi. Sistem yang dicadangkan akan membuka tong sampah yang sesuai berdasarkan jenis sisa yang ditentukan oleh model terlatih menggunakan pengenalpastian objek masa nyata dan klasifikasi yang dilakukan dengan pembelajaran mendalam. Sistem yang dicadangkan terdiri daripada Kamera Pi, Servo Motors dan Raspberry Pi 4 yang mengawal fungsi peranti. Matlamat jangkaan projek ini adalah untuk menentukan seni bina pembelajaran mendalam yang optimum untuk pengecaman sisa dan untuk meningkatkan ketepatan model pembelajaran mendalam.

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LIST OF SYMBOLS AND ABBREVIATIONS

CNN	:	Convolutional neural network
GPU	:	Graphics processing unit
USB	:	Universal Series Bus
ML	:	Machine Learning
MNIST	:	Modified National Institute of Standards and Technology dataset
GPS	:	Global Positioning System
RFID	:	Radio Frequency Identification
TTN	:	The Thing Network
BiFPN	:	Bi-directional Feature Pyramid Network

CHAPTER 1

INTRODUCTION

1.1 Project Background

The authors in [1] proposes a smart garbage bin with integrated volume and weight sensors to measure the volume and weight of the bins. Various writers have presented waste management systems in their study [2]; these works propose the use of ultrasonic sensor modules to identify full garbage bins. Smart Waste Bins utilize ultrasound sensors as one of the primary components to accomplish their primary purpose. A garbage bin's overfilling is detected by the amplification of high-frequency sound that contacts the things in the bin and echoes back to the sensor's receiving port [2]. The usage of Internet of Things (IoT) in a Wi-Fi, Bluetooth, and Zigbee-equipped smart trash can to transmit data via cloud services [3]. The author of [4] suggests a system for trash management by separating wet and dry rubbish using sensors and a motorized conveyor belt.

Deep learning methodologies for data categorization with TensorFlow and deep learning are gaining popularity daily. Deep learning delivers quick and efficient solutions, particularly for the study of large data sets. This work performed a classification challenge on the MNIST data set, which is commonly utilized in deep learning applications. TensorFlow was utilized for this [5]. Using a CNN in deep learning, a model class that enables strong and often accurate assumptions may be generated by modifying various parameters [5]. Several libraries are utilized in deep learning research. Using the TensorFlow library, classification was performed in this investigation. Google's TensorFlow is an open-source software library for numerical calculation that is currently widely utilized by many major organizations. TensorFlow offers an interface for specifying machine learning algorithms and an application for executing them [5].

Some researchers additionally incorporated a GPS module to their smart bins for real-time position monitoring and an RFID module for personnel identity management. A Raspberry Pi is equipped with an RFID module to identify authorized individuals with access cards. RFID module activates Arduino Uno to open the electronic enclosure after authorized personnel are detected [6].

1.2 Problem Statement

The main problem is the country's waste system does not priorities the separation of rubbish based on the sort of garbage disposed by individuals. Too much garbage mixed complicates the recycling procedure. Need to use deep learning model to develop a better waste management system that according to the passage of The Fourth Industrial Revolution (IR 4.0)

1.3 Objectives

1. To develop the dustbin circuit with object detection.

2. To recognize and classify the waste object using deep learning technique.

3. To analyze the accuracy and capability of related deep learning model.

1.4 Scope of work

This project will study on ways to integrate deep learning technique into waste classification. This project will involve both hardware and software development where one is required to create the deep learning model so that the camera will detect the waste and open the dustbin based on the waste type. In software development, the object detection and waste classification using TensorFlow framework with different architecture such as EfficientDet and Inception. Meanwhile, in hardware development, to make the circuit connected with servo motors to allow the dustbin to be open. A Raspberry Pi version that suitable for each purpose based on input and output of the project, Module camera can detect object clearly and Servo motor works according to program output from the Raspberry Pi with the help of PCA9685 servo motor module.

1.5 Thesis Outline

This thesis consists of five chapters. The introduction describes the project summary, problem description, objectives, and task scope. The second chapter contains information regarding the project that may be obtained in reference books, on the Internet, in periodicals, and in other sources. The third chapter will examine hardware and software implementation as well as any project limitations. Chapter 4 will elaborate on the results and discussion, while Chapter 5 will conclude the project and provide suggestions for future work.

CHAPTER 2

BACKGROUND STUDY

2.1 Introduction

In this chapter, a review will be conducted to seek out and locate additional relevant material and data. Several research papers, magazines, and internet resources, such as E-books, will be utilized to conduct a comprehensive analysis of numerous additional ideas and background studies. The study will primarily build the garbage bin and will require some prior research on the various deep learning models designed for waste. Aside from that, this chapter may address how the project will contribute to the enhancement of user performance.

2.2 Deep Learning

Many published efforts on image identification and classification have implemented artificial neural networks to get the best results. These networks serve as the basis for models of deep learning. Deep learning is a subset of machine learning

techniques utilizing numerous layers of processing units and capable of solving nonlinear problems [7]. Each level layer abstracts and combines the supplied data somewhat. In many pattern recognition and classification domains, deep neural networks have overtaken conventional machine learning techniques in terms of accuracy. In the realm of image recognition, deep neural networks, specifically convolutional neural networks (CNN), have been shown to achieve exceptional results [8].

2.2.1 Bi-directional Feature Pyramid Network (BiFPN)

BiFPN is one of the main contributions for EfficientDet. To create an Efficient object detector, multi-scale feature fusion is one of the key. There are various variations that involve in excellent image on Feature network design [9].

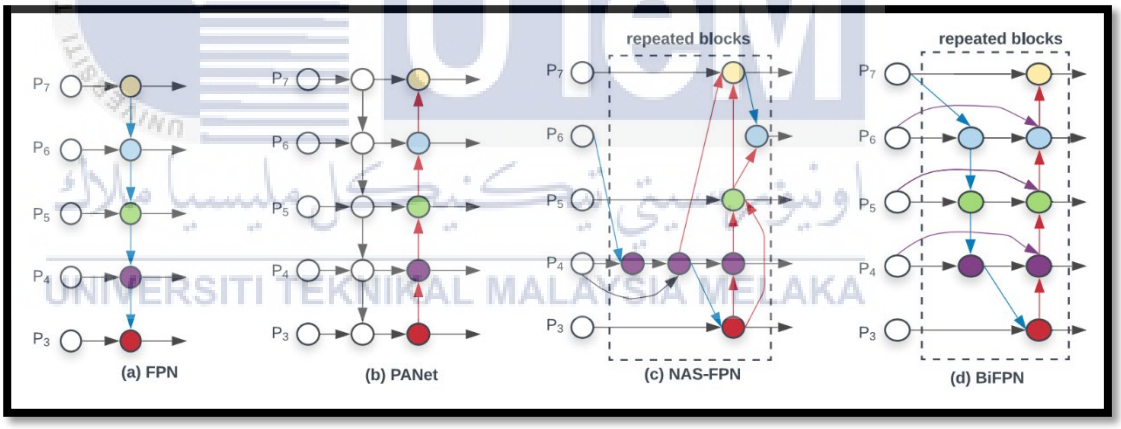

Figure 2.1: Feature Network Design for cross-scale feature fusion after the introduction of FPN

FPN combines top-down and lateral connections to integrate multiscale characteristics [10]. Notable is the fact that, despite combining distinct characteristics, FPNs merely summarize them without distinction. By looking at the Figure 2.1 above, the P7out and additional output characteristics are calculable.

$$P_7^{out} = Conv\left(P_7^{in}\right) \quad (1)$$

$$P_6^{out} = Conv\left(P_6^{in} + Resize(P_7^{out})\right) \quad (2)$$

$$P_3^{out} = Conv\left(P_3^{in} + Resize(P_4^{out})\right) \quad (3)$$

Resize is often a downsampling or upsampling operation for resolution matching, while Conv is typically a convolution operation for feature processing [11].

In BiFPN, the optimizations that got introduced is Weighted Feature Fusion. This feature will choose different resolutions and resize them to sum up all the input features equally. Take note that the weights are trained by network using the backward propagation [9].

2.2.2 EfficientDet

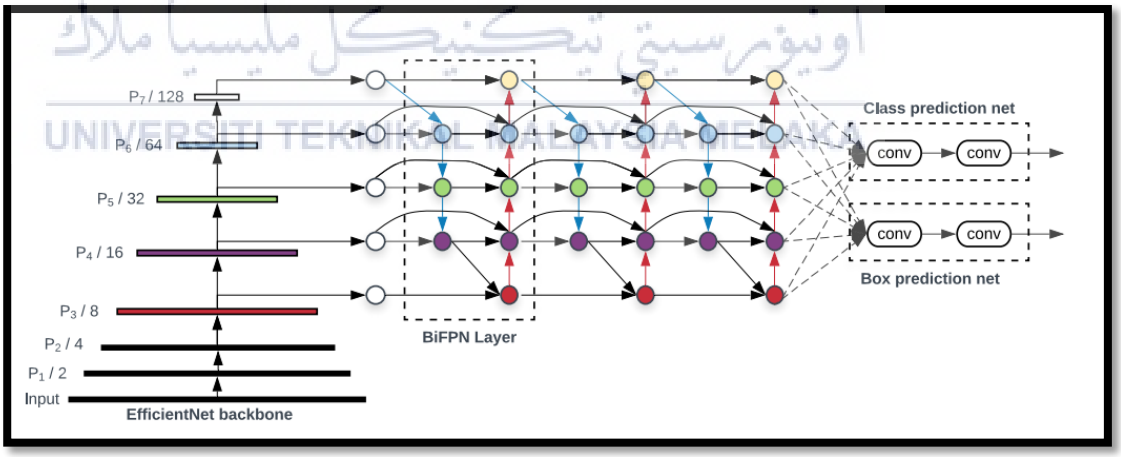

Figure 2.2: : EfficientDet Architecture

EfficientDet is an architectural and scaling strategy for convolutional neural networks that scales all parameters of depth/width/resolution uniformly using a compound coefficient. In contrast to current practice, which arbitrarily scales these