OPTIMIZATION OF INTRUDER DETECTION ALGORITHM USING RASPBERRY PI PLATFORM

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

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DEDICATION

I dedicate this work to my family, especially my beloved parents whom always been there for me and been a source of my inspiration to study and work and also provide moral, spiritual, emotional and financial support. I also dedicate this work to my brothers and sisters, friends and teachers who shared their guidance and moral support throughout my life.

ABSTRAK

Projek ini melibatkan penggunaan senibina Rangkaian Neural Konvolusi (CNN) untuk membangunkan algoritma pengesan penceroboh. Pada asasnya, algoritma pengesan penceroboh melibatkan tugas klasifikasi imej untuk mengklasifikasikan imej input ke penceroboh dan bukan penceroboh. Baru-baru ini, CNN telah menunjukkan mempunyai ketepatan yang besar pada aplikasi klasifikasi imej. Oleh itu, projek ini berdasarkan model LeNet dan MobileNet, di mana kedua-dua model dilatih untuk mengklasifikasikan imej penceroboh dan bukan penceroboh. Selepas pelbagai model DNN telah dilatih, model terbaik dari segi prestasi telah dipindahkan dari Komputer Peribadi (PC) ke Raspberry Pi 3 Model B+. MobileNet telah menunjukkan mempunyai ketepatan yang tinggi di samping mengekalkan kerumitan model yang rendah. MobileNet v3 telah dipilih untuk dipindahkan ke Raspberry Pi kerana ia telah terbukti mempunyai ketepatan tertinggi apabila diuji dengan imej penguji. Apabila fasa port selesai, prestasi dari segi ketepatan dan kelajuan MobileNet v3 di Raspberry Pi dan PC telah dibandingkan dan dinilai. Kelajuan MobileNet di Raspberry Pi adalah sebanyak 2.855 fps manakala di PC sebanyak 6.263 fps secara purata. Kelajuan dari segi fps MobileNet v3 apabila dilaksanakan pada Raspberry Pi adalah 54.41% lebih perlahan dibandingkan dengan PC. Ini menyimpulkan bahawa

model DNN berjalan lebih lambat pada Raspberry Pi berbanding apabila dilaksanakan pada PC.

ABSTRACT

This project involves the use of Convolutional Neural Network (CNN) architecture to develop an intruder detection algorithm. Basically, the intruder detection algorithm involves image classification task to classify input image into intruder and non-intruder. Recently, CNN have shown to have great accuracy on image classification application. Thus, this project is based on LeNet and MobileNet models, where both of the models were trained to classify intruder and non-intruder images. After various DNN models have been trained, the best model in terms of performance were ported from Personal Computer (PC) to Raspberry Pi 3 Model B+ in the deployment phase. MobileNet have shown to have high accuracy while maintaining low model complexity or number of operations. MobileNet v3 was chosen to be ported to Raspberry Pi because it has proven to have highest accuracy when tested with testing images of intruder and non-intruder. When the porting is complete, the performance in terms of accuracy and speed of MobileNet v3 in Raspberry Pi and PC was compared and evaluated. The average speed of MobileNet v3 when running on Raspberry Pi is 2.855 fps while on PC is 6.263 fps. The speed in terms of frames per second (fps) of MobileNet v3 when executed on Raspberry Pi was 54.41% slower compare to PC. This conclude that DNN model runs slower on Raspberry Pi compared to when executed on PC.

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LIST OF SYMBOLS AND ABBREVIATIONS

CNN	:	Convolutional Neural Network
PC	:	Personal Computer
GPU	:	Graphical Processing Units
DNN	:	Deep Neural Network
CNN	:	Convolutional Neural Network
ANN	:	Artificial Neural Network
MLP	:	Multi-layer perceptron
ReLU	:	Rectified Linear Unit
COCO	:	Common Object in Context
MACs	:	Multiply-Accumulates
ILSVRC	:	ImageNet Large Scale Visual Recognition Competition
Wnid	:	WordNet Identification
ONNX	:	Open Neural Network Exchange
API	:	Application Programming Interface
FTP	:	File Transfer Protocol
RAM	:	Random Access Memory
VPU	:	Vision Processing Unit
ASIC	:	Application-specific Integrated Circuits
TPU	:	Tensor Processing Unit

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

Convolutional neural network (CNN) is a class of deep neural network that is commonly used to analyze visual images. CNN architecture consists of weights and biases that are learnable in deep learning. There are many applications of CNN such as face detection and recognition, gender recognition, object detection, and other common computer vision tasks.

1.1 Background of project

This project involves the use of CNN architecture to develop an intruder detection algorithm. Basically, the intruder detection algorithm involves image classification task to classify input image into intruder and non-intruder. Recently, CNN have shown to have great accuracy on image classification application. Thus, this project is based on LeNet and MobileNet models, where both of the models were trained to classify intruder and non-intruder images. After both models have been trained, they were ported from Personal Computer (PC) to Raspberry Pi in the deployment phase. When the porting is complete, the accuracy and losses of both of the networks were evaluated.

1.2 Problem Statement

The main problem is that CNN model requires high complexity in terms of number of operations, thus computationally expensive. To efficiently process the high complexity of CNN models, a very powerful Graphical Processing Units (GPU) is required. In order to implement the CNN model on an embedded and resource constrained system like Raspberry Pi, the CNN model must be optimized so that it will operate using lesser number of operation or complexity while maintaining high accuracy on the Raspberry Pi. More importantly, Raspberry Pi has limited computing power and memory storage to store and run the CNN model. Thus, the CNN model can be optimized experimentally by reducing the computations in the neural network experimentally so that it can fit into Raspberry Pi platform.

1.3 Objectives

The following statements are the objectives of this project:

- To train LeNet and MobileNet models for image classification.
- To implement optimized deep neural network (DNN) on Raspberry Pi.

- To evaluate the performance of deep neural networks on Raspberry Pi in terms of accuracy and speed (frames per second)

1.4 Scope of Project

The scope of this project is to classify input images into intruder and non-intruder using two existing CNN models; LeNet and MobileNet. Both of the CNN models were written in Python language and uses TensorFlow 1.9 and Keras 2.2 framework. The version of Python is 3.5.2. Various versions of LeNet and MobileNet were trained and all of the networks' accuracy were evaluated. Training phase was assisted by using two GPUs; NVIDIA GeForce GTX 970 and Tesla K70c. The best optimized CNN model was selected and then ported to Raspberry Pi 3 Model B+. The accuracy and speed (frames per second) of the CNN model on Raspberry Pi was evaluated.

1.5 Thesis Outline

This thesis consists of five chapters that includes Chapter 1: Introduction, Chapter 2: Theory and Background Study, Chapter 3: Methodology, Chapter 4: Results and Discussion and Chapter 5: Conclusion and Future works. Chapter 1 briefly states the background of project, problem, objectives, and scope of the project. Chapter 2 discusses theories related to Neural Network, recent CNN architecture and several background studies. Chapter 3 shows the method of this project while Chapter 4 depicts the result and analysis. Chapter 5 concludes the project and states the future works.

CHAPTER 2

THEORY AND BACKGROUND STUDY

This chapter covers the theories that are used to understand and train a CNN model. Large deep neural networks like VGGNet, GoogleNet, ResNet, DenseNet and MobileNet were also described briefly. Several background studies were conducted to study a few applications of CNN and the optimization of the DNN models into Raspberry Pi platform.

2.1 Neural network

Neural network or Artificial Neural Networks (ANN) is a computational brain-like model inspired from the way of how humans learn. A neural network has interconnected artificial neurons that transmit data among each other called nodes. The neural network consists of three layers: Input layer, hidden layer and output layer. Figure 2.1 shows the layers in neural network.