Faculty of Cognitive Sciences and Human Development

RESIDUAL ATTENTION NETWORK FOR BRAIN TUMOUR DETECTION

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Bachelor of Science with Honours
(Cognitive Science)
2019

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Grade: A

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Final Year Project Report ☒

Masters ☐

PhD ☐

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This declaration is made on the 28 day of May year 2019

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RESIDUAL ATTENTION NETWORK FOR BRAIN TUMOUR CLASSIFICATION

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This project is submitted

in partial fulfilment of the requirements for a

Bachelor of Science with Honours

(Cognitive Science)

Faculty of Cognitive Science and Human Development

UNIVERSITI MALAYSIA SARAWAK

(2019)

Dedicated to

My Amma, brothers, family and friends.

The project entitled "Residual Attention Network for Brain Tumour Classification" was prepared by Sashwini A/P S Thiagaraju and submitted to the Faculty of Cognitive Science and Human Development in partial fulfilment of the requirements for a Bachelor of Science with Honours (Cognitive Science)

Received for examination by:

(DR ABDULRAZAK YAHYA AL-HABABI)

Date:

28/May/2015

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A

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ABSTRACT

The main aim of this study is to design and produce an automated algorithm system using Residual Attention Network (RAN) model, which will classify brain tumour. In this project digitalised Magnetic Resonance Image (MRI) is used which is obtained from Malaysian hospitals. The MRI dataset consists of those of patients who are 20 years and above both male and female. The Residual Attention Network model is trained and tested using the MRI dataset. The performance of the algorithm is evaluated based on training accuracy, testing accuracy, validate accuracy and validate loss and comparative analysis with Residual Neural Network (ResNet) and Convolutional Neural Network (CNN). ResNet and CNN were tested using the same dataset. Results from this study certainly proved that RAN provided the best performance among the 3 algorithms. ResNet has good performance with its accuracy ranging from 66% to 90%. The normal CNN algorithm did not perform well with the accuracy being very inconsistent between 57% and 71%. RAN produced the highest and most consistent accuracy which is from 94% onwards. Further explanation is provided to prove the efficiency of Residual Attention Network for the classification of brain tumour.

ABSTRAK

Tujuan utama kajian ini adalah untuk merekabentuk dan menghasilkan sistem algoritma automatik menggunakan model *Residual Attention Network*, yang akan mengklasifikasikan tumor otak. Dalam projek ini, *Magnetic Resonance Image* yang telah ditukar kepada format digital digunakan yang diperoleh dari hospital Malaysia. Data MRI tersebut terdiri daripada pesakit yang berusia 20 tahun ke atas lelaki dan perempuan. Model *Residual Attention Network* dilatih dan diuji dengan menggunakan dataset MRI. Prestasi algoritma dinilai berdasarkan *training accuracy, testing accuracy, validate accuracy, validate loss* dan analisa perbandingan dengan *Residual Neural Network* (ResNet) dan *Convolutional Neural Network* (CNN). ResNet dan CNN diuji menggunakan dataset yang sama. Keputusan dari kajian ini membuktikan bahawa RAN menyediakan prestasi terbaik di antara 3 algoritma. ResNet mempunyai prestasi yang baik dengan ketepatannya antara 66% hingga 90%. Algoritma CNN biasa tidak berfungsi dengan baik dengan ketepatan yang sangat tidak konsisten antara 57% dan 71%. RAN menghasilkan ketepatan tertinggi dan konsisten yang meningkat dari 94% dan seterusnya. Penjelasan lanjut diberikan untuk membuktikan kecekapan *Residual Attention Network* untuk klasifikasi tumor otak.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Brain tumour classification has always been a challenging endeavour in the medical field. Through the centuries the medical field has undergone many advancements especially in the medical imaging sector. The human brain is the most crucial organ as it governs the processes that happens in the body. The human brain is also one of the most vulnerable organs as it is prone to diseases which can cause it to falter. One of the most prominent disease would be brain tumour.

Brain tumours are the growth of masses of cells that are cancerous or non-cancerous. Brain tumours can be classified into two categories- primary and secondary tumours. Primary tumour can either be malignant which is cancerous or benign which is non-cancerous. Malignant brain tumour is threatening to the human life force. Secondary tumour is metastatic tumour (National Cancer Institute, 2014). This type of tumour grows in other parts of the human body and travel to the brain via blood stream and grows in the brain. Brain tumours include those that grow in the cranium and also the spinal cord.

The level of danger posed by the tumour depends on the type, size, its location and its speed of development. In Malaysia, brain and nervous tumour has been occurring at 2.7 for male and 2.2 for female per 100000 population every year as recorded in the National Cancer Registry (Chye, Rampal and Yahaya , 2008). According to Goh et al. 3.7 incidents out 100000 population has been recorded in Sarawak during the year 2009. In Kelantan and Terengganu, 0.44 incidents per 100000 population is recorded per year (1998).

According to a study conducted by Nurul Balqis Md Dzali et al. (2017), 217 newly diagnosed cases of various types of brain tumours were recorded from the year 2011 to 2014 in Hospital

Universiti Sains Malaysia (HUSM). The pie chart of the results obtained from the study can be viewed below.

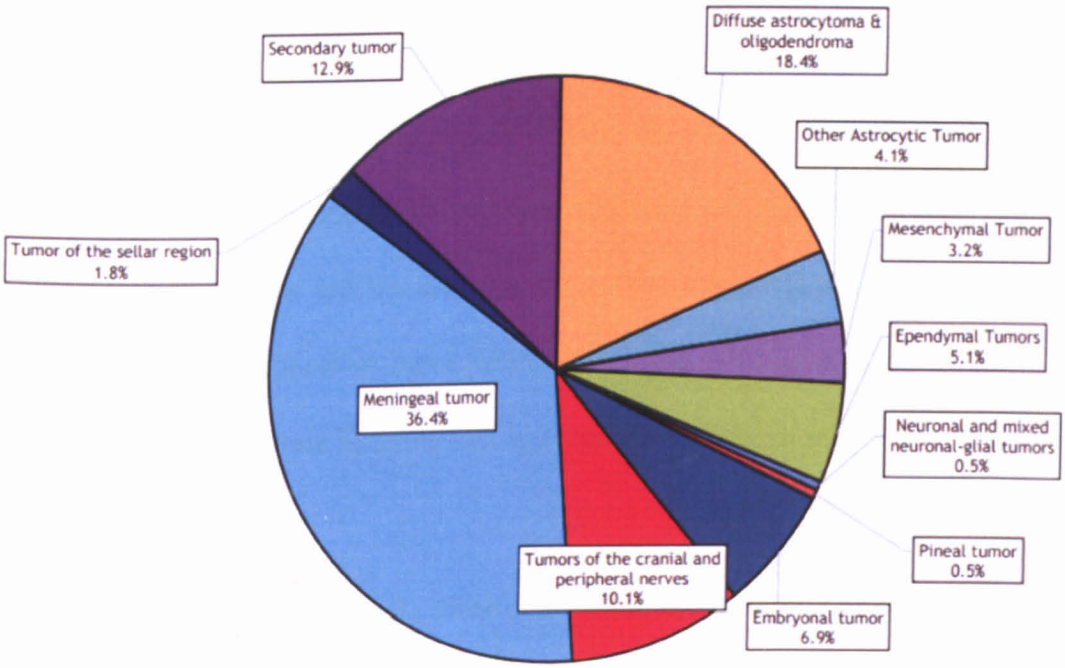

Figure 1.1. Distribution of brain tumours (Nurul Balqis Md Dzali et al., 2017)

The pie chart in figure 1.1 describes the distribution of brain tumour according to its categories. Meningeal tumours are the most common to occur as it has a record of 78 cases out of 217 cases (36.4 %). Grabbing the second place would be astrocytic and oligodendroglial tumours with 40 cases (18.4 %). Secondary tumours recorded 28 cases (12.9%) followed by cranial and peripheral nerve tumour (10.1%), embryonic tumour (6.9%), ependymal tumours (5.1%), other astrocytic tumour (4.1%), mesenchymal tumour (3.2%) and tumours in seller region (1.8%). Pineal tumours, neuronal and mixed neuronal are the most uncommon recorded cancer in the hospital. This study proposes a Residual Attention Network (RAN) model to classify and help in the diagnosis of brain tumour. The use of the RAN can increase the accuracy and efficiency of classification and diagnosis of brain tumour and at the same time reduce the time span involved.

1.2 Problem Statement

Brain tumour classification requires a very tedious process as it is very hard to distinguish between the different types of brain tumour there are. Early detection of brain tumour is crucial for the beginning stages of treatment (Bahadure, Ray & Thethi, 2017). After clinical detection, MRI detection is used to locate the tumour and predict its size and type. All these information is needed to diagnose and produce the accurate and effective therapy, surgery, radiation or chemotherapy. Studies have proven that the earlier the tumour is detected, the higher the chances of survival of the cancer-effected patient (Coatrieux, Huang, Shu, Luo & Roux, 2013). This shows how crucial is brain imaging and appropriate classification tools are to the medical world.

In a study conducted by Cheng et. al., three approaches are used to classify brain tumours – intensity histogram, grey level co-occurrence matrix (GLCM) and bag-of-words. However these methods are very specialized whereby the person who uses these methods must have knowledge about tumour. This is where neural networks comes to work as neural networks are highly generalizable and features can be extracted with image input (Paul, 2016). The flourishing growth of deep learning produced many methods to detect brain tumour. Over the years many deep learning methods were produced such as Back Propagation Neural Network (Zhang, Yudong, et al., 2011), Probabilistic Neural Network (Saritha & Paul, 2013), Deep Neural Network (Anbarasa Pandian & Balasubramaniam, 2015; Rajkumar & Justin, 2017). However these methods have their flaws. The methods done previously can be improved more in terms of accuracy and efficiency.

This study proposes a model which helps to show the impact of Residual Attention Network on the classification and diagnosis of brain tumour. Residual Attention Network (RAN) is very beneficial as it applies attention mechanism as well as it being a form of extensible Convolutional Neural Network (Wang et al., 2017). Residual Attention Network is relatively

new to the deep learning industry and has not been used to explore the medical field. The use of deep learning can increase the accuracy of the efficiency of classification and diagnosis of brain tumour and at the same time effectively reduce the time span involved.

1.3 Research Questions

1. How can the data of brain tumour be pre-processed?
2. Can we classify brain tumour using Residual Attention Network (RAN)?
3. Can we achieve high accuracy in brain tumour classification using RAN?

1.4 Research Aim

The main objective of this study is to design and produce an automated algorithm system that will detect brain tumour using artificial neural networks.

1.5 Research Objectives

1. To pre-process the MRI datasets for brain tumour classification.
2. To apply RAN algorithm for brain tumour classification.
3. To evaluate the performance of RAN based on the accuracy of performance.

1.6 Definition of Terms

Table 1.1

Definition of Terms

No	Term	Definition	Operational Definition
1	Tumour	Tumour is an anomalous mass of cells which exist in or on the brain (Tom, Rolf, Ole & Mark 1998).	Tumour is mass of cell growth in regions of brain that is life threatening.
2	Cancer	Cancer is a rapid and uncontrollable growth of abnormal cells that can damage healthy cells nearby (National Cancer Institute, 2018).	Cancer describes the growth of cells that is rapid, uncontrollable and spreading to the surrounding brain area.
3	Benign	Benign means something that doesn't possess cancerous characteristics (Pàez-Ribes, Marta, et al., 2009).	Benign refers something that is not dangerous, grows in one place and is static
4	Malignant	Malignant means something that possesses cancerous characteristics (Bégin, Michel E., et al., 1986).	Malignant tumour are the type of tumour that is rapidly growing and spreading.
5	Secondary tumour	Secondary tumours are tumours that originates from different parts of the body and travel to the brain via blood stream (Thompson et al., 1998).	Secondary tumour are tumour cells from different region of the body that travels and grows in the brain.
6	Medical Imaging techniques	Imaging technique that helps in the detection and diagnosis of medical problems (Min JK, Dunning A, Lin FY, et al, 2011).	Imaging tools that is used to capture the images of brain to help the classification and diagnosis of brain tumour.

1.7 Significance of Study

Brain tumours are one of the most life threatening diseases there is. Doctors and medical personals depend on decision support tools and medical imagery to help detect and diagnose brain tumours. Special automated tools such as the one being proposed in this study certainly helps to reduce human error that occur during the classification and diagnosis of brain tumour and at the same time reduce the time consumed in the process.

1.8 Scope of Study

The scope of this study is to produce a classification model using deep learning to classify brain tumour. This system should be able to classify brain tumour accurately for diagnosis and treatment. The study will be able to assist doctors in the diagnosis of brain tumour effectively and in a short time. The demographic of this study is the Malaysian people between the ages of 20 to 30.

This study was implemented using Jupyter Notebook which is an open source web application to produce the model needed to classify the brain tumour images – MRI images. The algorithm used for this model is Residual Attention Network. Residual Attention Network is an improved version of Convolutional Neural Network (CNN) that is integrated with residual connections (He, Ren and Sun, 2015). The model developed is evaluated for its performance based on the accuracy that it achieves once it is done processing the dataset.

1.9 Summary

In this chapter the concepts of brain tumour and terminologies are discussed thoroughly which provides the necessary understanding to the necessity of brain imaging and deep learning to the classification of brain tumour. Brain tumours require rapid classification and diagnosis to ensure efficient treatment where the reasons to this are discussed in the problem statement.

1.9 Outline of Chapters

Figure 1.2 below explains briefly the contents of each chapters in this study.

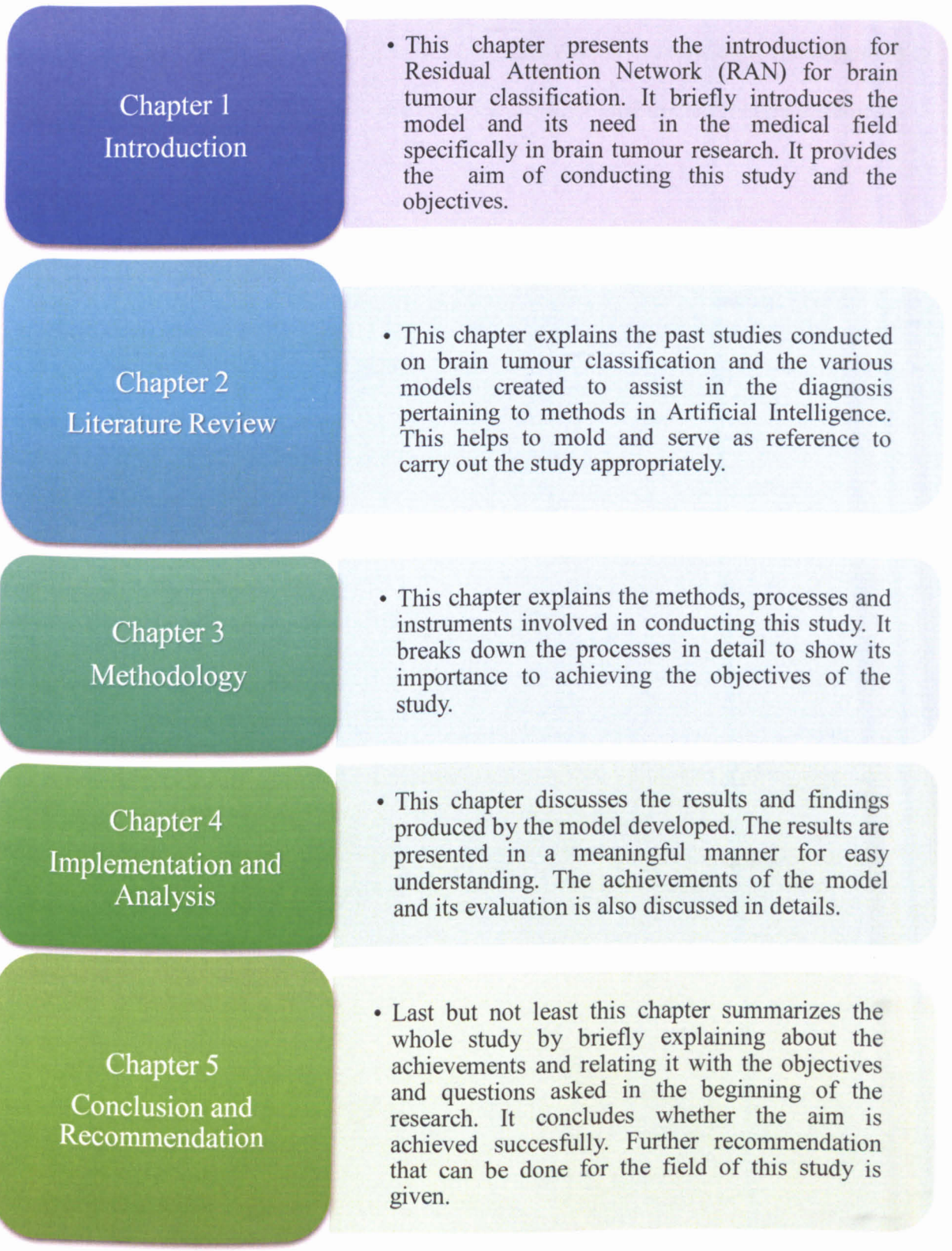

Figure 1.2. Outline of chapters

1.9 Summary

In this chapter the concepts of brain tumour and terminologies are discussed thoroughly which provides the necessary understanding to the necessity of brain imaging and deep learning to the classification of brain tumour. Brain tumours require rapid classification and diagnosis to ensure efficient treatment where the reasons to this are discussed in the problem statement.