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DEVELOPMENT OF RULE-BASED MOBILE DIAGNOSTICS SYSTEM

LEONG LEE HUA

This project is submitted
in partial fulfilment of the requirements for a
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The project entitled 'Development of Rule-Based Mobile Diagnostics System was prepared by Leong Lee Hua and submitted to the Faculty of Cognitive Sciences and Human Development in partial fulfillment of the requirements for a Bachelor of Science with Honours (Cognitive Science)

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ABSTRACT

Mobile technologies are nowadays widely been used in many fields of professions due to its highly-efficient multitasking function and it is no exceptional to the psychology field. There are many mobile apps available in Google Play Store and Apple Store but those existing apps are only diagnosed for one particular cognitive disease. This project is intended to develop a mobile rule-based diagnosis system for several cognitive diseases for instance Post-traumatic stress disorder, autism spectrum disorder, bipolar disorder, obsessive compulsive disorder and social anxiety disorder. Reason for choosing these 5 cognitive diseases is because of these cognitive diseases are more common among the citizens in Malaysia. The purpose of this project is to gather the symptoms of these diseases and hence provide preliminary diagnosis to users through mobile application and yet raise the awareness of public towards these five cognitive diseases. Knowledge-based system framework is applied in developing the rule-based diagnosis mobile application and apparently, mobile application had developed by using Corona SDK. VisiRule software was used in generating valid and semantical rule-based system for this mobile application.

Keywords: cognitive diseases, rule-based diagnosis system, mobile application

ABSTRAK

Teknologi telefon pintar masa kini telah digunakan dalam pelbagai bidang profesion disebabkan fungsi yang sangat cekap multitasking dan ia tidak biasa dengan bidang psikologi. Terdapat banyak aplikasi telefon pintar yang terdapat di Google Play Store dan Apple Store tetapi orang-aplikasi sedia ada hanya didiagnosis untuk satu penyakit kognitif tertentu. Projek ini bertujuan untuk membangunkan berasaskan peraturan sistem diagnosis mudah alih untuk beberapa penyakit kognitif, sebagai contohnya, Post-traumatic stress, gangguan spektrum autisme, gangguan bipolar, gangguan kompulsif keterlaluan dan gangguan kebimbangan sosial. Faktor untuk memilih 5 penyakit kognitif tersebut adalah kerana penyakit-penyakit kognitif tersebut adalah penyakit kognitif yang biasa di kalangan rakyat di Malaysia. Tujuan projek ini adalah untuk mengumpul gejala penyakit-penyakit ini dan menyediakan diagnosis awal kepada pengguna melalui aplikasi telefon pintar. Namun begitu, aplikasi telefon pintar juga dapat meningkatkan kesedaran orang ramai terhadap kelima-lima penyakit kognitif. Rangka kerja sistem berasaskan pengetahuan diaplikasikan dalam membangunkan diagnosis aplikasi mudah alih yang berasaskan peraturan dan nampaknya, aplikasi mudah alih telah dibangunkan dengan menggunakan Corona SDK. Perisian VisiRule digunakan dalam menjana sistem berasaskan peraturan yang sah untuk membina aplikasi telefon pintar ini.

Kata kunci: penyakit kognitif, sistem diagnosis berasaskan peraturan, aplikasi telefon pintar

CHAPTER ONE

INTRODUCTION

This chapter discusses about the background of the study, problem statement, research objective, research questions, significance and scope of the study. The general research topic for this study is developing a mobile application that can provide preliminary self-diagnosis for those who are suspected to have cognitive disorders such as Post-traumatic Stress Disorder (PTSD), Autism Spectrum Disorder (ASD), Obsessive Compulsive Disorder (OCD), Bipolar Disorder (BD) and Social Anxiety Disorder.

In this new era of technology, computing devices, especially smartphone have become one of the necessities in our daily life and the statistical data claimed that the demand for smartphones, tablets and notebooks reached to 2 million by year 2010 and they predict the numbers of user of those computing devices can reached to 10 billion by the end of 2020 (Stanley, 2011). According to BBC news (2006), a survey showing 90% of the statistics were children who owns a mobile phone uses it as frequent as their parents. Computing devices and computerized system do makes life easier hence; these are broadly used by individuals from all walks of life. In fact, people from all walks of lives are increasingly utilizing smartphones and tablets for their extreme multitasking abilities and their high efficient. For example, restaurant waiters use tablets to take orders instead of traditional way of taking order, i.e: writing down orders, registration procedure in hospital are replaced with a computerized system, self-training monitor system used by athlete and many more. The psychology field bears no exception from it. Computing devices especially mobile technologies is now getting more and more dominant in daily lives. Information are capable of being delivered anywhere at any time and this advantages clearly made mobile technology network more than just a mere computing device. Nonetheless, according to the 2011 National Health and Morbidity Survey, there are 12% of Malaysians suffering from mental

illness as 2% of them are suffer from depression, 1% psychosis, worrying occupied 1.8% from the 12% while the remaining involved anxiety disorder (The Sun Daily, 2012). High living expenses and the hectic lifestyle could be the factors that contribute to the statistics above. Therefore, mobile application that uses for self-diagnostics cognitive diseases is needed as it is a very good opportunity for them to know if there is any hidden mental illness in them. Moreover, the preliminary detection of cognitive diseases can raise the awareness of the public towards their mental health so that people who need it can seek for treatment before the conditions deteriorate. This can be beneficial for psychologists and their clients, as well as the families of the clients.

Background of the Study

“No health without mental health” This meaningful phrase endorsed by The World Health Organization (WHO) sends a clear message to everyone regarding the importance of mental health. According to the statistical data collected by WHO in 14 countries, the prevalence of rates for mental health disorders is in the range of 4.3% to 24.4% (Mohit, 2006). Mental health conditions, such as bipolar disorder, phobias, depression and etc are associated with high possibility of cognitive disability and may lead to commit suicide too (Mohit, 2006). In addition, mental health conditions will affect an individual’s thoughts, feeling, mood, cognitive ability to relate to others and daily functioning (D. Bloom et. al., 2011) and there is a surprising statistics data showing that approximately 450 million of people around the world are being affected by mental diseases (Kohn, S. Saxena, I. Levav, B. Saraceno, 2004). However, knowledge in mental health is still minimal due to lack of awareness in public and discrimination surrounding mental diseases issues or even the patients. An urgent need of raising public awareness with regards to mental health issues is required. Appropriate solutions are also required to further alleviate the sprouting numbers of mental disorders from all around the world.

Indeed, there are many clinical assessments for diagnosis of cognitive disorders and those assessments can only be conducted by licensed clinical practitioners, psychiatrists or psychologists. Many data need to be recorded such as the individual's current situation, past behaviors or signs and symptoms, family history and etc during the first consultation. Nonetheless, the workloads of psychologists are massive but the ratio between psychiatrists and psychologists and service users have not reached to an optimal level yet as the ratio of clinical psychologists in the Ministry of Health (MOH) to Malaysia population is 1:980 000 while the ratio of psychiatrists to population is roughly 1:125 500. (Boon, 2012). However, due to the problem of severely lacking in experts for mental health diagnosis, the aids of technology is much needed and fortunately, the rapid growing of mobile technologies able to deliver services directly to the patients with or without the assistance of a person. Furthermore, delivering of mental health information and care can be done in a more efficient way due to the highly accessible characteristics of mobile network. Mobile applications that are related to cognitive diseases such as PTSD Coach able to provide brief information regarding the symptoms of the diseases and other informative details, self-assessment, guideline treatment for users and etc. Experts (psychologists and psychiatrists) transformed their knowledge into the particular mobile application and there are a few similar mobile applications that related to other cognitive diseases too. Nonetheless, mobile application used for differentiating between the various types of cognitive diseases had not been developed yet at the moment.

Moreover, misdiagnosed of cognitive diseases is quite common even for the most experienced psychologists. The reason for the misdiagnosed is that many cognitive diseases sharing some particular symptoms in common whereby they can only be diagnosed through several different clinical assessments and being diagnosed repetitively. Apparently, this answered why a good mental health professional or even an experienced psychologist always

give his or her client a thorough evaluation based on a broad range of information (family history, sign and symptoms, occurrence of the symptoms and etc.) before coming up with a diagnosis. It is crucial to understand the background of the client's abnormal behavior because, just as in medicine, the diagnosis of one's receives can make a drastically change for that individual.

The expeditious growth of technology enables experts to store their knowledge in a system and let the system to do the diagnosis on behalf of the experts. This kind of system is known as expert system (ES). In fact, there are various functions of ES while rule-based diagnosis expert system named Pathfinder is one of them. It widely been used to assist pathologists with the diagnosis of lymph-node pathology (Heckerman & Nathwani, 1991). It contains more than 30 features that reflecting information that are relevant to the diagnosis of lymph-node disease (Heckerman & Nathwani, 1991). Besides that, implementation of automatic diagnosis systems saved time as it can cut down the time that needed to make appointment with psychologists since it can provide preliminary diagnosis that enable users to have some self-tested before they really go consult psychologists. Sometimes people are over diagnosis of their own behavior and misinterpret those syndromes as cognitive diseases. Nonetheless, rule-based diagnosis system can only give diagnose to certainty but not be able to provide 100% accurate results.

Problem Statement/ Motivation of the Study

Some of the cognitive diseases may share some particular symptoms in common and whenever the symptoms have multiple causes, people around that particular individual (for example their family members) will tend to misinterpret it and take him/her to examine diagnosis. Diagnosis of cognitive diseases are usually based on reports that stated by people around that individual and this will definitely lead to misdiagnosis since those people are not aware of the alternate causes for what that behaviour might be. False positive or false

negative diagnoses of impairment will occur when multiple test scores and results are interpreted wrongly (Grant, 2010). Besides that, the procedure of making appointment with psychologists is time-consuming and psychologists are not available in every cities especially those rural area. Other than that, charge for each psychology session is costly for those individuals from a lower-income family. According to Australian Psychological Society (2014), the initial consultation for 16-30 minutes is \$125, subsequent consultation for the same period of time, psychological assessment, clinical psychological assessment, neuropsychological assessment, report preparation, case conference, telephone consultation are \$125 respectively.

Objectives

General Objectives. This study intends to develop a mobile application that able to provide self-diagnose cognitive diseases such as Post-traumatic stress disease (PTSD), Obsessive Compulsive Disorder (OCD), Bipolar Disorder (BD), Social Anxiety Disorder and Autism Spectrum Disorder (ASD). This app caters to help the users to have preliminary test for themselves so that they know which cognitive disorder that they might be suffering at the moment.

Specific Objectives. First specific objective is to develop a rule-based diagnosis system for Post-traumatic stress disease (PTSD), Obsessive Compulsive Disorder (OCD), Bipolar Disorder (BD), Social Anxiety Disorder and Autism Spectrum Disorder (ASD). While the second specific objective is to identify the common symptoms of the cognitive disorders and diagnose them through mobile application. Other than that, the existing application for cognitive diseases diagnosis that available in Google PlayStore and App Store will be analysed and a brief review of the apps will be recorded in this project.

Research Questions

1. Can cognitive diseases be diagnosed using mobile application?

2. To what extent rule-based system in the mobile application can provide early detection of those 5 cognitive diseases?
3. Is there any existing diagnostics mobile application for cognitive diseases?

Significance of the Study

Prospect of this research study is for raising public awareness with regards to mental health issue. In addition, the mobile applications that will be developed at the end of project capable to provide preliminary detection of the 5 cognitive diseases. As a result, individual who had used this mobile application and unfortunately being informed that he or she has the probability of getting one of the cognitive diseases, he or she can immediately consult mental health professions and receive appropriate treatment before the condition deteriorate.

Scope of the Study

This research study is generally for everyone who is having abnormal behavior in their daily routine and suspected to have cognitive diseases such as Post-traumatic stress disease (PTSD), Obsessive Compulsive Disorder (OCD), Bipolar Disorder (BD), Social Anxiety Disorder and Autism Spectrum Disorder (ASD).

CHAPTER TWO

LITERATURE REVIEW

Diagnostic expert system on mobile phone

According to Hynes (2013), self-diagnosis test is becoming easier than ever as more self-test kits appear on websites and also smartphone. Those self-diagnose kits claim to diagnose everything that required by the users. According to Abdelhamid and El-Helly (2013), building an expert system (rule-base) application on mobiles requires steps as below:

- The first stage is to representing the knowledge from expert in a light weight and generic format and suitable for the limited device storage and processing capabilities of mobile phones. Extractions of knowledge are usually done from one or more experts by identifying the cognitive inferences, symptoms, concepts and meaning within a decision-making situation (Brazilian Journal of Medical and Biological Research, 2006).
- Experts will be asked to report the most significant or common symptoms of those cognitive diseases.
- Next, a suitable and appropriate user interface design needs to be designed for the limited capabilities of mobile phones. There are a few criteria that need to consider in designing the user interface such as the size of the screen and the way of data entry.
- The third step is to transferring clinical model to computational representation which is known as knowledge modeling. The technological approach implemented in this decision support system is based on the theory of parsimonious cover (Mitchell, 1997). The parsimonious cover concept is a formal mode of diagnostics reasoning as it defines a diagnosis as the smaller set of diseases and explains all the symptoms known to be present. For example, if disorder D1 can cause symptoms S1, S2, and S3, and D2 can cause S3 and S5, then if a patient is known to have symptoms S2 and S3,

the two plausible diagnoses are (D1) and (D2), that is to say, there are two competing diagnoses, one that states that the patient has only disease D1 and one that states that the patient has only disease D2. Both diagnoses "cover" or "explain away" all symptoms known to be present. In essence, the system represents the potential causal connections between diseases and symptoms, and different reasoning algorithms operate on such knowledge.

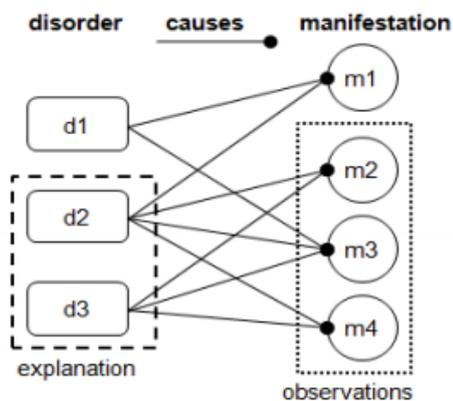


Figure 1. Background knowledge modeled with an example set of observations and explanations.

It builds a customized inference engine which enables limited processing capabilities of the mobile phones by using the knowledge representation that had fixed.

- The last step will be the deployment of the expert system application. In fact, most of the traditional approach of diagnosis problem solving models only using a single-fault assumption, where can have only one disorder approach and reveal the only causal model that related to the symptoms of the diseases. In addition, the goal of the diagnosis problem solver is to differentiate which are the disorders that contribute to those specific symptoms in users. Hence, the discrimination of diseases become very hard and requires more detailed knowledge to be acquired from the expert of those particular fields to verify the certain disorder and excluded other suspected disorders.

Language for knowledge representation

LISP program. It is a formal knowledge representation language that uses to represent the LISP Processing language as it allows programmers to create their new domain-specific languages. The name LISP derived from “LISt processing” and it is the second-oldest high-level programming language that still widely been use until now.

CLISP program. CLISP is a dynamic programming language. Premises are “conditions” whereas actions are “conditions” in CLISP programming language. It is written in C and Common LISP and it is multi-paradigm programming language which enables to supports more combination of programming languages. Normally, premises need to match vectors in working memory while actions will modify the working memory for instance:

```
(assert
  (organism
    (name organism-1)
    (identity e-coli)
    (confidence 0.8))
```

Figure 2: Example code for rule base system

Cognitive Diseases

Post-traumatic stress disorder (PTSD). Individual who have been exposed to extreme stressor or traumatic events that is life-threatening and provokes a deep sorrow, hopeless, fear and horror feelings to them are prone to be patients of PTSD (Yehuda, 2001). According to American Psychiatric Association, PTSD is a psychiatric disorder that can occur in individual who had experienced life-threatening incidents or witnessed those traumatic events such as sudden death of parents in accident, natural disaster, terrorist incidents, and violent personal assault like rape or sexual abuse. There are two types of traumatic events which is events that had passed and also events that is happening. Diagnosis of PTSD for children is usually dependent on the parents’ report and family history. Hence,

parents themselves who have PTSD may neglect some important issues in their children and this will lead to misdiagnosis. Common symptoms for PTSD are:

- Mental such as anxiety or depression
- Behaviour such as irritability, avoidance, anger or non-compliance, self-risk behaviour, threatening or aggressive behaviour.
- Re-experiencing such as intrusive memories, images or perceptions
- Nightmares
- Exaggerated emotions and physical reactions
- Avoidance or emotional numbing such as avoids activity, loss of interest, detached, restricted emotion
- Difficulty in sleeping
- Irritability or outbursts of anger
- Difficulty in concentrating
- Hyper observance
- Exaggerated startle response

(VA/DoD Clinical Practice Guideline for the Management of Post-Traumatic Stress, 2010)

Autism Spectrum Disorder (ASD). According to Pennington, Cullinan and Southern (2014), Autism spectrum disorder (ASD) refers to a group of pervasive neurodevelopmental disorders that involve moderately to severely disrupting functioning in regard to social skills and socialization, expressive and receptive communication, and repetitive or stereotyped behaviors and interests. Common symptoms are:

Communication Concerns

- Does not respond to his/her name

- Cannot tell me what (s)he wants
- Language is delayed
- Doesn't follow directions
- Appears deaf at times
- Seems to hear sometimes but not others
- Doesn't point or wave bye-bye
- Used to say a few words, but now he doesn't

Social Concerns

- Doesn't smile socially
- Seems to prefer to play alone
- Gets things for himself
- Is very independent
- Does things "early"
- Has poor eye contact
- Is in his own world
- Tunes us out
- Is not interested in other children

Behavioral Concerns

- Is hyperactive/uncooperative or oppositional
- Doesn't know how to play with toys
- Gets stuck on things over and over
- Toe walks
- Has unusual attachments to toys (e.g., always holding a certain object in hand)

- Lines things up
- Is oversensitive to certain textures or sounds
- Has odd movement patterns
- Absolute indications for immediate further evaluation
- No babbling by 12 months
- No gesturing (pointing, waving bye-bye, etc) by 12 months
- No single words by 16 months
- No 2-words spontaneous

(Filipek et. al., 1999. Journal of Autism and Developmental Disorder vol 29(6)).

Obsessive compulsive disorder (OCD). According to (Summerfeldt & Antony, 2002), bad parenting or other environmental factors are not the causes for Obsessive compulsive disorder (OCD). OCD is an anxiety disorder that related with obsessions and compulsions (Summerfeldt & Antony, 2002). Mental components of OCD comprises obsession thoughts, images or impulses that repeatedly come across one's mind and totally feel out of one's control. They will easily get anxiety and disgust. Common symptoms for OCD are:

- Contamination (e.g., Fears of germs, dirtiness, chemicals, AIDS, cancer)
- Symmetry or exactness (e.g. Belongings, spoken or written words, the way one moves or completes actions)
- Doubting (e.g., whether appliances are turned off, doors are locked; written work is accurate, etc.)
- Aggressive impulses (e.g., thoughts of stabbing one's children, pushing loved ones into traffic, etc.)
- Accidental harm to others (e.g., fears of contaminating or poisoning a loved one)

- Religion (e.g., Sexual thoughts about a holy person, dirty thoughts, distressing thoughts regarding morality)
- Sexual (e.g., Thoughts about personally distressing sexual acts)
- Other miscellaneous obsessions having to with themes such as lucky or unlucky colors or numbers, or with the need to know "trivial" details (e.g., House numbers, license plates).

(Summerfeldt & Antony, 2002, from <http://www.anxietytreatment.ca/obsessive.html>)

Bipolar Disorder (BD). Based on American Academy of Child and Adolescent Psychiatry (n.d), it will never be an easy task for diagnosing and treating bipolar disorder in children and adolescents, even for the most experienced psychiatrist. According to research, many of the symptoms of adult bipolar disorder had begun in their childhood stage but they did not realize it and continue to have the disorder as they came into adult stage (American Academy of Child and Adolescent Psychiatry, n.d.). More importantly, the number of children and adolescents diagnosed with bipolar bipolar disorder has increased significantly from the last decades (American Academy of Child and Adolescent Psychiatry, n.d). Some common symptoms of BD are:

Depressive Episode

- Depressed mood
- Loss of interest
- Weight gain/ loss
- Insomnia or hypersomnia
- Psychomotor agitation or retardation
- Fatigue or loss of energy
- Feelings of worthlessness or inappropriate guilt
- Diminished ability to think or concentrate

- Recurrent thoughts of suicide

Manic Episode

- Elevated or expansive mood
- Irritable mood
- Inflated self-esteem
- Decreased need for sleep
- More talkative than usual
- Flight of ideas/ racing thought
- Distractibility
- Psychomotor agitation/ increased in goal directed activity
- Excessive involvement in pleasurable activities that have high potential for painful consequences due to their poor judgment

(Grier, Wilkins, & Pender (2007), Retrieved from:

<http://www.nasponline.org/resources/principals/bipolar.pdf>)

Social Anxiety Disorder. Individual who had been diagnosed for Social Anxiety Disorder will fear that they will say or do something that they think will be humiliating or embarrassing themselves. Hence, they will tend to have some unusual behavior such as blushing, sweating a lot, appearing stupid in front of public and etc. Social anxiety disorder can have a great impact on a person's functioning, disrupting normal life, interfering with social relationships and quality of life and impairing performance at work or school.

Individual who suffer from this disorder may show their anxiety in diverse ways: as well as withdrawing themselves from social interactions, they may be more likely to cry and nervous when they are surrounded by people. They may also be less likely to acknowledge that their fears are irrational when they are away from a social situation. Particular situations that can