



2D AFFECTIVE SPACE MODEL FOR DETECTING  
AUTISTIC CHILDREN MOTOR IMITATION  
DEVELOPMENT DISORDER

BY

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the degree of Master of Computer Science

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## **ABSTRACT**

Autism Spectrum Disorder (ASD) is a complex developmental disorder that represents abnormality development of brain and its function. Few studies had seen the impact of early detection and intervention, and how it gives positive effect for the children to improve their life as good as other normal children. There are three major impairments of the autistic children namely: social interaction with others, communication and fine motor movements. A simple case of fine motor movements could be finger tapping, imitating other action and also managing their fingers towards objects. Many psychologists and psychiatrists diagnosed these autistic children as early as three years old. In Functional Magnetic Resonance Imaging (fMRI) studies, finding shows the brain region such as prefrontal cortex (especially in the pre-motor cortex), occipital and etc, did involve in motor impairment in autistic children. Thus, it is possible to differentiate between normal and autistic children using motor imitation skills but all these process require the psychologists, psychiatrist or expert to monitor and make decision on their observations. However, fMRI is an expensive process and could not be automated and be used for masses. In this research, it aims to look at motor imitation skills for autistic children using electroencephalogram (EEG) approach. Preliminary result has shown great potential in identifying motor imitation skills impairment in autistic children. EEG device will be used to capture the brain signals, and two methods for analysis such as Gaussian Mixture Model (GMM) and Kernel Density Estimation (KDE). The Multilayer Perceptron (MLP) will be adopted as the classifier. Although the MLP was used as classifier the end results shows great potential of using the EEG model approach based on the 2D affective space model (ASM) for early detection of motor imitation skills development disorder among autistic children.

## خلاصة البحث

طيف التوحد للأطفال عبارة عن الاضطرابات التنموية المعقدة، والتي تشير الى خلل في تطوير الدماغ الطبيعي ووظيفته. وقد يوجد بعض الدراسات غير كثيرة التي تمت فيها التشخيص المبكر لهذا الاضطراب والخلل، وكذلك شهدت هذه الدراسات مدى تأثير إيجابي للأطفال لتحسين حياتهم كالأطفال الآخرين الطبيعيين. وهناك ثلاثة مضرات رئيسية للأطفال المصابين بالتوحد وهي (1): عدم القدرة على الاندماج في الحياة الاجتماعية، (2) وعدم القدرة على التواصل مع الآخرين، (3) و صعوبة في تقليد الحركات البسيطة، مثل الإشارة بالإصبع لشي معين أو تقليد حركة معينة أو عمل بصمة الإبهام. و حسب دراسات الأطباء النفسيين وأطباء الجهاز العصبي يمكن تشخيص هذه الأعراض في السنة الثالثة للطفل. ومما أشارت إليه دراسات التصوير بالرنين المغناطيسي الوظيفي أن هناك مناطق عديدة في الدماغ، تشمل في الإعاقات الحركية لدى الأطفال المصابين من التوحد كمثل قشرة مقدم الفص الجبهي (وخاصة في القشرة أمام الحركية)، ومؤخر الرأس وغيرها، لذلك يمكن التمييز بين الطفل العادي و الطفل المصاب التوحد اعتمادا على عملية تقليد الحركة، لكن الصعوبة تكمن في العملية التي تحتاج إلى علماء النفس، وطبيب نفساني خبير، للنظر والمراقبة، بالإضافة إلى استخدام الصور الطبية مكلفة وصعوبة استخدامها. هذه الدراسة تهدف استخدام جهاز EEG للنظر في المهارات الحركية التقليدية للأطفال المصابين بالتوحد. وقد بينت النتائج الأولية الإمكانيات الكبيرة على كفاءة استخدام جهاز EEG لتحديد المهارات الحركية التقليدية في الأطفال المصابين بالتوحد. وسوف يتم استخدام هذا الجهاز لالتقاط إشارات الدماغ. و للتحليل واستخراج المعلومات منها طريقتان، هما : Gaussian Mixture Model (GMM) and Kernel Density Estimation (KDE). ولعملية التصنيف تم استخدام طريقة Multilayer Perceptron (MLP). بينت النتائج النهائية إمكانيات كبيرة لاستخدام نهج EEG استنادًا على نموذج فضاء ذو بعدين (2D) (ASM)

للكشف المبكر عن اضطراب حركي تقليدي لتنمية المهارات لدى الأطفال  
المصابين للتوحد.

## APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it confirms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Information Technology.

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and Communication Technology

## DECLARATION

I hereby declare that this thesis is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Najwani Razali

Signature .....

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MOTOR IMITATION DEVELOPMENT DISORDER**

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## LIST OF ABBREVIATIONS

fMRI	Functional magnetic resonance imaging	CHAT	Checklist for autism toddlers
ASD	Autism spectrum disorder	DSM-IV	Diagnostic and statistical manual of mental disorder 4 <sup>th</sup> edition
PDD	Pervasive developmental disorder	KDE	Kernel density estimation
NASOM	National autism society of Malaysia	GMM	Gaussian mixture model
CNS	Central nervous system	MLP	Multilayer perceptron
EEG	Electroencephalogram	ASM	Affective space model
ADHD	Attention-deficit hyperactive disorder	PET	Positron emission tomography
FFA	Fusiform face area	DCDQ	Developmental coordination disorder questionnaire
WISC-III	Wechsler intelligence scale for children	M-ABC	Movement assessment battery for children
MEG	Magnetoencephalography	SAM	Self-assessment manikin
BIMEC	Biometrischcentrum	BEBF	Basic emotion as basis function
STFT	Short time fourier transform	AMISE	Asymptotic mean integrated square error



# **CHAPTER ONE**

## **INTRODUCTION**

### **1.1 OVERVIEW**

Autism is a lifelong developmental disability with three main areas of difficulties namely; impairment in social interaction, impairment in communication and restricted/repetitive behaviors, activities and interest (American Psychiatric Association, 2000). Autism is a spectrum disorder and each child disorder may vary from one to the other. The autistic spectrum disorder (ASD) includes Pervasive Developmental Disorder (PDD), Asperger's syndrome and autistic disorder (also called 'classic' autism). Some of PDD children had high intelligence but face other challenges relating to mental disorder. Children with autism are sensitive to its surrounding and avoiding the unfamiliar faces. Although some psychologist claimed that autism is not a genetic disorder, it normally happens due to the narrow calcium channels that affects the communication between the neurons in the brain itself (National Institute of Mental Health, 2011). Such narrow calcium channel can be widened if it intervention is carried out at a very early stage of the child life. Today's technology allows detection of autism only as early as 3 years-old of the child age and can only be carried out by expert in the field. Current intervention process carried out by autism centers had shown tremendous improvement for these children and in some cases have these children to be able to fit into a normal primary school. The National Autism Society of Malaysia (NASOM) has been very well supported both by the community and government to provide such intervention for the ASD children.

Parents suspecting their child of such abnormality can send them to this center for necessary action. This center will provide an assessment and diagnosis thus early intervention and also vocational training can help improve the situation. Thus, it is expensive and would require tremendous amount of time and patience on both the experts and the child to produce meaningful and accurate results. In addition parents may be tabooed by the fact that in most countries autism is not something you want others to know about your child.

One can see that autism not only affects an individual but also affect others, especially the immediate family members. As the child grow it will also affect the way he/she react to the environment thus the child education environment, working environment and his/her own personal life. Worst, such disorder can be temperamental and reactionary on certain situation. The community at large tries to avoid having to handle such disorder and avoid people with autism. Autistic children need people especially family members to be with them all the time before they can learn doing things on their own. Furthermore, parents also need to spend a lot of money and time since teaching and caring these autistic children require special skills and patience. Parents also need help from psychologists to train their children in order to speed up the process of improving the child behavior and communication skills so that they can lead a normal life.

## **1.2 AUTISM**

The term ‘Autism’ for the past 100 years has been used and it comes from the Greek word “autos” which means “self”. It is used to describe a person who removed himself from social interaction. In 1911, Eugen Bleuler, a Swiss psychiatrist, is the first person to use this term in order to describe a group of people with symptoms of

schizophrenia. In the 1940s, some other researcher from United States begins to use this term to portray children with emotional and social problem.

Based on Neurological Disorders and Stroke, National Institute of Health, autism spectrum disorder (ASD) is a range of complex neurodevelopment disorders, characterized by social impairments, communication difficulties, and restricted/repetitive/ stereotyped patterns of behavior. Among the three characteristics, social interaction impairment is the earliest develop symptom in the autistic children. A baby that does not react when people called their name, shows very little facial expression and expresses an extreme emotion like angry, sad or happy is one of the criteria of autistic child. Besides, fine and gross movement also one of the characteristics of these children. Some finding, refer to the theory of mind, shows that children with autism learn few actions differently compared to control children. As mentioned, autistic children rely more on their own internal sense of body position (proprioception) rather than visual information coming from external world in order to learn new pattern of movement. Proprioception is an automatic sensitivity mechanism in the body that sends messages through the central nervous system (CNS) and then it will send information to the rest of the body on how to react and with what amount of tension (Suzanne Nottingham, 2008). This problem turns to be an interesting issue which had been discussed by other researchers in Kennedy Krieger Institute at USA. They conducted a study about movement issue and their finding suggested new light of details discussion towards this problem which is the potential analysis and research can be done using neuro-imaging. It investigates whether or not proprioceptive versus visual feedback is actually associated with abnormal patterns of structural and functional connectivity of the brain of children with autism. Their study attempts to find out whether patterns of motor learning can be altered to increase visual

connections in specific region of the brain. Imitation also became an issue which was discussed in many study related to motor movement. Imitation plays an important role in early infant development in order to learn new behavior or actions.

Autism is divided into three major types which are (Renee, A.A., 2012; Walker, D. et. al., 2004; Willemsen, S.S., 2002; National Institute of Mental Health, n.d.):

- Autism Disorder
  - It is the most common and normally referred to autistic children with problem in social communication, interactions and also imaginative play in children below than 3 years.
- Asperger's Syndrome
  - This group of children has similarity with autistic disorder but they are different in term of intelligence level. They tend to score average or more than average level in any IQ tests.
- Pervasive Developmental Disorder
  - Children in this range seem to have some characteristic of autism children but they do not fit into other categories.

### **1.3 MOTOR FUNCTION AND MOTOR IMPAIRMENT**

Recently many researchers dealing with autistic children show lots of interest findings on relationship between motor function, cognition, language development and social communication disorder (Joni et al. 2002; Prizant et al. 2003; Zelaznik & Goffman, 2010; Rommelse et al. 2007; Marton et al. 2005). Daichman, Cueli Dutil and Tucman (2010) had presented a brief report about autism and impairment of motor function. The authors discussed in detail the sensorimotor system and some other clinical findings in children with autism. In the late 19<sup>th</sup> century, studies by Marco Davare et

al. (2005) and Stewart et al. (2007), explaining the location of the brain which related to motor function. Their finding proved that the movement abnormalities occurred if there is removal of cortex in the frontal region. Initial study by Sherrington on non-human subjects found that movement of different body part was evoked by the stimulation of different points along the precentral gyrus.

The development of motor function and the fine and gross motor movements requires skills of learning. Such skills need to be developed, where by experience and knowledge gain from very young becomes critical and important. According to Susan, (2009), Andry et al. (2000), Acosta-Calderon and Hu (2003a, 2003b) and Thorn (2008), imitation is the way for infant to learn throughout their early stage development. Thus basic learning skills especially in imitation are important to attain proper and correct learning to ensure the brain function properly.

#### **1.4 LEARNING**

One of the basic learning skills for success is the ability to learn and succeed in any aspect of human life. With the ever-increasing rapid technological change in work place and home, societal needs also changes in the context of globalization. People must learn and continue to learn in order to maintain their usefulness in the society. Thus to learn is a quintessential tool for lifelong learning. Education and training are needed to provide the learning environment for the development of these competencies, including those with fewer opportunities (with special needs and school dropouts), throughout the whole lifespan (including pre-school and adult learners) and through different learning environments (formal, non-formal and informal) (Fredriksson and Hoskins, 2007). Learning is a process to gain new knowledge, understanding and apply it in our day-to-day life. Kids in schools are required to study

many different subjects from languages to mathematics for analysis. Such need for a vast learning methodology requires different learning skills and adaptation. Learning mathematics require both memory and analytical skills to be successful.

Over the past century, mathematics had become one of the most important subjects that have been discussed and study in detail. Students' ability, cognitive strategies and understanding in solving mathematics questions become an important aspect in order to improve the understanding or misunderstanding for that matter in this subject. According to some researchers, solving mathematical problem is one of the most difficult areas for student to handle throughout the process of learning (e.g., Santos, 2007; National Council of Teachers of Mathematics, 2009). Mathematics is an intellectual process that involves a variety of cognitive functions, including visuo-spatial skills, memory, attention and semantic representation (Campbell et al. 2009; Roi Cohen & Vincent, 2009; Vinod Venkatraman, 2006). Ganor et al. (2008) explained theoretically the neurocognitive modeling of the brain when performing mental calculations. Dehaene proposed the "triple-code-model" which explained how different brain regions are responsible for the processing of spoken numbers, recalling numerical knowledge, calculation and comparing magnitudes.

## **1.5 LEARNING AND EMOTION FOR AUTISM AND CONTROL CHILDREN**

Brain researchers have demonstrated that the effectiveness of learning depends on emotions, thus the process of learning cannot be separated physiologically from the processes of the brain and body that are responsible for emotions. Cubed (2010) and Priscilla (n.d.), a teacher for over a quarter of century, shared her experience and finding towards learning and emotion. Learning required memory, attention, understanding and reasoning which is needed during lecture, tutorial or even

examination. Smart students may not perform well when their emotions are affected during the learning process. When student are disturbed by their emotion, they cannot stay focus and easy problems become difficult and complicated. I would refer this scenario as the on/off switch for learning. Neurologist are beginning to understand this issue and substantiate their ideas and reasoning. It is found that the limbic system has the power to open or close the access to learning, memory and the ability to make novel connection. In the case of autistic children they normally have problem in interpreting and processing the in-coming information due to their brain's ability in accepting the information and keeping it in memory. Autistic children also use the input information in a significantly different way compared to that of a neuro-typically developing children (Alice et al. 2012; Lisa, 2007).

## **1.6 EMOTION AND AUTISM**

Unable to express emotion is one of the most outstanding characteristics of an autism people such that they do not show their feeling, do not interact with others and have no interest to have social interaction. The difficulties in socializing and communicating by those diagnosed as ASD resulted in they not being able to control their emotions. Poor understanding of facial expression (Grossman et. al., 2000) and complex emotions (Begeer et. al., 2008) may lead to inaccurate appraisal of a given event, for example, seeing a stranger's approach to shake hands as some kind of a threat. The negative actions will make those diagnosed with ASD to be isolated, with no friends and difficult to be in a group. Early intervention is needed to help these ASD children to be able to lead a normal life. Neurologists found that emotion and social respond can be detected easily as it is an autistic case. Uta & Chris (2010) first proposed the use of neural basis social intelligence which amygdale, orbito-frontal

cortex and superior temporal gyrus constituted to the social brain. According to the hypothesis, the child diagnosed with autism is biologically incapable of ‘reading’ the emotions of others. Autistic children normally faced fear and anxiety towards stranger and they fail to express normal expression towards new faces. Moreover, autistic children often show signs of emotional instability, such as unprovoked crying, temper tantrums and dramatic mood swings. These outbursts may be caused by the confusion of social situations or by sensory stimuli overwhelming the brain. Frequently, people with ASDs experience frustration with their inability to express feelings and desires, which may lead to meltdowns and unprovoked outbursts. Unfortunately most of the work in understanding the brain behavior and the activation of the neurons is carried out using the functional magnetic imaging resonance (fMRI) which is expensive and cumbersome.

### **1.7 ELECTROENCEPHALOGRAM AND BRAIN**

Electroencephalogram is medical equipment that is used to record brain signals and was initially recorded on paper strips also known as electroencephalograph. Any changes in the brain activity due to diseases like epilepsy, autism can be observed by comparing to a normal patient’s brain signals. Thus, it can be useful tool in order to do diagnostic about certain diseases. EEG uses wires and electrodes to be placed on the scalp to make connection from the brain to the equipment and record it to the computer. Table 1.1 (Binnie, C.D, 2003) below showed the types of EEG bands with its role and pathology.