

UNIVERSITI TEKNOLOGI MARA

**IDENTIFICATION OF AUTISM
SPECTRUM DISORDER GAIT
PATTERNS BASED ON THREE-
DIMENSIONAL GAIT ANALYSIS**

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ABSTRACT

Autism spectrum disorder (ASD) is a complex and lifelong neurodevelopmental disorder that affects the brain growth, functional capabilities, and quality of life of an individual. The existence of movement and gait abnormalities particularly in children with ASD are presently regarded as additional evidence that supports the diagnosis of ASD. In clinical practice, most of the assessment of gait abnormalities are primarily grounded on subjective judgements made by experienced clinicians which are usually manually interpreted, time-consuming, burdensome, and often include subjective and inaccurate evaluations. Hence, automated identification of abnormalities in ASD gait patterns is important for early intervention and post-treatment monitoring. So far, however, there has been little discussion dealing specifically with automated identification of ASD gait patterns. Thus, this study endeavours to propose an automated machine learning-based approach for accurate identification of ASD and normal gait patterns on the basis of dominant gait features acquired from three dimensional (3D) gait analysis. The proposed approach consisted of five sequential stages of data acquisition, data processing, features extraction, features selection, and model classification. The gait data of 30 children with ASD and 30 healthy typically developing (TD) children were acquired using a state-of-the-art 3D motion capture system and two force plates during the self-selected speed of barefoot walking. Time-series parameterisation techniques were applied to the kinematic and kinetic waveforms to extract useful gait features. Two statistical feature selection techniques, namely the statistical hypothesis tests and the stepwise method of discriminant analysis were utilised to select dominant gait features that would best differentiate between ASD and TD gait patterns. Four different machine learning classifiers which include linear discriminant analysis (LDA), k-nearest neighbour (KNN), kernel-based support vector machines (SVMs), and artificial neural networks (ANN) were employed to perform the classification tasks. The superior classification performance was achieved using the ANN classifier with six dominant gait features. The 10-fold cross-validation test results showed that the proposed classification model was able to produce the optimum classification performance with 98.3% accuracy, 96.7% sensitivity, and 100.0% specificity. These findings suggest the potential use of the proposed methods as an aided tool that may be beneficial for clinicians to perform an automated and accurate diagnosis of ASD gait patterns as well as for evaluation purposes of the treatment programmes.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter provides a brief introduction of the research work and describes the overall structure of the thesis. It explains the general background and motivation towards the research work and includes the problem statements of the study, research objectives, research questions and research scopes. A list of the contributions of this research work are addressed in this chapter.

1.2 Background and Motivation

Autism spectrum disorder (ASD) refers to a group of complex neurodevelopmental or neurological disorders that affects brain growth, functional capabilities and quality of life of an individual [1]. ASD is a severe and lifelong impairments which account for substantial health loss across the lifespan [2]. These days, ASD has been one of the most prevalent neurological disorders worldwide [3]–[5]. ASD has recently received a considerable critical attention and has been the focus of developmental disabilities research topics [6], largely as a result of multinational reports of its rapidly increasing prevalence [7]–[13].

According to the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), ASD is characterised by persistent deficits in social communication and social interaction, and by the presence of restricted and repetitive patterns of behaviour, interests, or activities [1]. Additionally, several related characteristics that support the diagnosis of ASD are the existence of motor and movement disturbances such as irregular motor signs, clumsiness, as well as abnormalities during normal walking [1]. These symptoms can be clinically evident in the first few years of individuals' childhood [1]. It has been suggested that movement disturbances are considered as one of the early indicators that can be used to support the diagnosis of ASD as it will usually or probably precede social or linguistic deficits [14]. Researchers across disciplines have recognised movement and walking disturbances as the focus symptoms related to the disorder [6].