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Development of Imitation Learning Through Physical Therapy Using a Humanoid Robot

Norjasween Abdul Malik^{*a}, Hanafiah Yussof^a, Fazah Akhtar Hanapiah^b

^a*Faculty of Mechanical Engineering, Universiti Teknologi MARA, Shah Alam, 40450, Selangor, Malaysia*

^b*Faculty of Medicine, Sungai Buloh Campus Universiti Teknologi MARA, UiTM, Sungai Buloh, 47000, Selangor, Malaysia*

Abstract

Humanoids have increasingly become the focus of attention in robotic research, especially in rehabilitation robotics. In the past few years, the prevalence of Cerebral Palsy (CP) in the world population has remained unchanged. CP is one of the most common disorders affecting muscle control and coordination in children, resulting in movement disorders. There are assistive technologies that are used for increasing, maintaining or improving the functional abilities of CP children. However, there is still a lack of interventional therapy which involves Social Assistive Robotics (SAR). Socially assistive technologies have great potential in education & learning for children, especially for children with disabilities. Problems faced by children with CP may not be confined to physical impairment but may in addition have impairments of cognition, visual, language and communication. Therefore, combining physical, speech and language and occupational therapy with cognitive and social development is very important. This paper aims to describe the architecture of using humanoid robot NAO as a tool to augment physical learning for CP children. This work is mainly based on qualitative study, which is aimed to analyze how the HRI impacts the motor gross function and attention. This paper will describe the aim, objectives, methodology, and experiment layout. Experiment with CP children will be done in the near future after obtaining ethical approval from UiTM Ethics Committee. The outcome of the study may exhibit positive utilization of the humanoid robot NAO as a new intervention tool to augment therapy for children with CP.

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* Corresponding author. Tel.: +603-5543 6455 ; fax: +603-5543 5160.

E-mail address: norjasweenabdulmaik@gmail.com

1. Introduction

Cerebral palsy (CP) is a group of permanent disorders involving the development of movement and posture causing activity limitation that are attributed to non-progressive disturbance that occurred in the developing fetal or infant brain^{1,2}. Types of CP can be classified into spastic, dyskinetic and mixed³. In the mid-1800s, Dr. William John Little Osler⁴ and Dr. Sigmund Freud⁵, a neurologists, pioneered the study of CP and knowledge regarding CP has been increasing since then. CP is the most common physical disabilities in childhood⁶. Over the last decade, an unchanged of the prevalence of CP in the world population has been noted. Generally, worldwide statistics show that approximately 2-4 in every 1000 children born today has CP^{3,7}.

Physical therapy addresses gross motor function and skills. Considered one of the mainstay therapies of CP, it is used to decrease spasticity, strengthen underlying muscles, and teach proper or functional motor patterns. Physiotherapist will also teach the family or caregivers how to help the child with CP to help themselves. Since most children are attracted to technology, robots can be used to elicit cooperation in physical rehabilitation. In this paper, it will describe the use of a humanoid robot as an augmented tool in the physical therapy of CP children. For this study, 4 modules will be programmed to generate the robot behavior in the interaction session.

1.1. Human Robot Interaction(HRI) for CP children

Human robot interaction (HRI) has widened their wing to be applied in rehabilitation. Interest in social robots is growing as one of the upcoming field of next generation robots especially as assistive tools in rehabilitation². It is believed that HRI promises better experience for CP children to learn motor skills⁸.

Previous studies involving CP children investigated robotic exoskeletons and electrically powered wheelchair⁹ to replace function. In previous years, there is still lacking of intervention therapy which involves Social Assistive Robotics (SAR). SAR is one of the robotic technologies that assist user primarily through social rather than physical interaction¹⁰. For example, previous study from¹¹ has introducing Kindergarten Assistive Robotics (KAR) as a tool for learning development for normal children in preschool education. SAR has increase children's motivation and communication during the interaction.

Play has been successfully introduced into physical therapy and rehabilitation of children with disabilities^{12,13}. Thus, SAR is suggested to move to be applied for CP children. One of the study involve SAR is Robotics Agent Coacher for CP motor Function (RAC CP FUN)¹⁴ which is designed to improve their motor function and activities of daily living. Besides that, study from¹⁵ which using a mobile robot named "Neptune" and¹² using a toy robot named "Cosmobot" results that robot can become a social mediator for learning. While study from¹⁶ and¹⁷ used Lego Mindstorms robots¹⁸ for CP children's play activities and resulted that the children reacted positively toward the robots where some children increased their attention span, and keep engaged while they used the robots. However, most explored robotic systems before are mainly in the form of toys, not in humanoid form. Thus, this study proposed to use a humanoid robot as adjunct in physical therapy session with CP children. It has good potentials to be used as a therapeutic tool because the movement of the robot can be controlled and reprogrammed to suite the children's ability. The robot may have the potential to influence the physical therapy imitation learning, helping the child to be more responsive and kept engagement during the therapy session.

1.2. Motivation

Conventional physical therapy conducted by humans will have some issues especially in imitation learning. Therapists have the tendency to get tired, hence resulting with less accuracy. From a study done by¹⁰, they had observed that the children responded positively towards the robot. Some children showed increased attention duration, spontaneity and frequency of their smiles vocalizations and verbalization while using robots¹¹. With the potential to increase children's motivation, robots will be able to help the children to be more active and motivated during the learning sessions. Two objectives of the study are to develop a physical therapy algorithm for physical therapy imitation learning between a robot and CP children, through interactive motor exercise and to develop and implement the modules for human robot interaction.

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