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ScienceDirect

Procedia Computer Science 76 (2015) 388 – 393

Procedia Computer Science

2015 IEEE International Symposium on Robotics and Intelligent Sensors (IRIS 2015)

Human-Robot Interaction for Children with Cerebral Palsy: Reflection and Suggestion for Interactive Scenario Design

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Abstract

This paper explains how a humanoid robot NAO can be used as an assistive technology in specific therapy for children with cerebral palsy (CP). The role of the robot is to motivate the children as to keep them engaged in therapy. To achieve this, the robot must have appropriate appearance to be able to establish affective engagement between child and robot. In addition, the robot should exhibit the right therapeutic approach of managing children with CP. How the humanoid robot NAO acts as a tool to assist in improving the outcome of conventional therapy especially by imitation learning will also be explained. Four interactive scenarios in human-robot interaction (HRI) were designed based on the measurement items in Gross Motor Functional Measure (GMFM). The scenarios will then be constructed based on suitability that will be executed by the robot. As a result from the discussions between clinicians, therapists and engineers, four interactive scenarios consists of introductory rapport, sit to stand, body balancing and ball kicking activity have been formulated. The study has been performed in collaboration between the Faculty of Medicine and the Faculty of Mechanical Engineering at the Medical Specialist Centre, Discipline of Rehabilitation Medicine, Faculty of Medicine, UiTM Sungai Buloh, Selangor, Malaysia.

Peer-review under responsibility of organizing committee of the 2015 IEEE International Symposium on Robotics and Intelligent Sensors (IRIS 2015)

Keywords: Human-robot interaction, humanoid robot ; cerebral palsy; rehabilitation

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1. Introduction

Cerebral Palsy (CP) is an umbrella term that encompasses a group of non-progressive and non-contagious motor conditions that causes physical disability, chiefly in the various areas of body movement[1] which is the most common physical disabilities in children[2]. Over the last decade, an unchanged of the prevalence of CP in the world population has been noted. Generally, worldwide statistics showed that approximately 2-4 in every 1000 children has CP[3, 4].

Robotic assistive technology nowadays has been widely used in rehabilitation[5]. It is an approach that must be able to demonstrate requested exercises, have an appearance that is attractive to children, and should be able to communicate (verbal and non-verbal) with patients and therapists[6]. One of the expected benefits of the robot is to assist the therapist to conduct specific

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doi:10.1016/j.procs.2015.12.315

therapeutic exercises. It can also establish affective engagement between the child, therapist and robot[7]. Rehabilitative therapy for children with CP has started to see some advantages due the increasing of the feasibility and applicability of the robotic solution to physical problems[5]. Because of attention span of a child is shorter than that of an adult, difficulties maybe faced by therapist in getting the child to comply with required exercise. A way to manage this is to combine therapy with play. Many researchers have focused on child rehabilitation with play to engage the children in performing action that aid their rehabilitation process. At the moment, intervention therapy involves Social Assistive Robotics (SAR) is still a few. SAR is one of the robotic technologies that assists its' user mainly through social interaction[8]. For example, previous study from G.Keren[9] introduced Kindergarten Assistive Robotics (KAR) as a learning development tool for typically developing children in preschool education. Motivation and communication of the children has increased during the interactions. Apart from that, robotic toys have been shown to aid in early intervention for children with developmental delays and to engage children in imitation based play[10]. A study from M. Fridin from Ariel University Center in Israel had used a humanoid robot called "Robotics Agent Coacher" to help children with CP to improve their motor function and daily living skills. It has resulted in positive interactions between the child and the robot[11]. Studies conducted using SAR has shown positive impacts in many aspects especially in increasing the children's social interaction. Thus, this study aimed to observe the therapeutic exercises in children with CP with involvement of the therapist.

In this study, two children with CP were exposed to the humanoid robot NAO once a week for eight weeks. Approval by UiTM Medical Ethics Committee was granted for the purpose of this research project. The study has been conducted in collaboration with Medical Specialist Centre, Discipline of Rehabilitation Medicine, Faculty of Medicine, UiTM Sungai Buloh and Faculty of Mechanical Engineering, UiTM, Shah Alam, Malaysia.

1.1. Humanoid robot NAO

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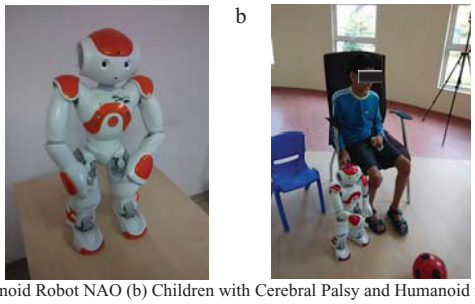

Fig. 1. (a) Humanoid Robot NAO (b) Children with Cerebral Palsy and Humanoid robot NAO

Figures above show a humanoid robot called NAO that is produced by the French company Aldebaran-Robotics. It comes with its height of 0.57 meter and weighing 4.5 kg. The main advantages of NAO are the light weight and affordable cost compared to other available robots of same performance[12]. As most children prefer robots, a humanoid robot NAO has the potential to be used as a tool in rehabilitation therapy for children with CP. Furthermore, the size of the humanoid robot NAO is like a 2 years old toddler draws the attention of the chils. In this study, humanoid robot NAO will execute interactive scenarios focusing on repetitive motion training with an aim to improve truncal balance, coordination and lower limb gross function of children with CP. The robot needs to produce repetitive actions and maintain its stability. With the potential to increase children's motivation, this robot will be able to help the children to be more active and motivated during the interactive sessions.

2. Conventional Therapy vs Robot-assisted Therapy for Children with CP

Conventional treatment includes physical, occupational and speech therapies, medical procedures, surgeries, and medications. Nevertheless, treatment plans are variable because each condition of the child with CP is different. The treatments are tailored to a child's physical, developmental, mental, and emotional needs. Physical exercise is one of the conventional therapies to improve motor skills. It is used to manage spasticity and to improve the pattern of motor function. However, conventional physical therapy conducted by therapists may have its limitations in term of repetitive movement. The robot can assist the therapists in producing high number of repetitive movement with more precision.A humanoid robot is very attractive to the child who can interact with it depending on how the robot has been programmed. The human-like shape and simple design can capture the interest and attention of the children interacting with the robot. Previous study shows that children have good respond towards the robot[6]. Some children showed the increment of duration in attention, smiles more frequent and spontaneous, vocalizations and verbalization while using robots[9]. It is important to stress that the use of robot in rehabilitation is not to replace the function of the therapist. Physical therapy aimed at imitation learning will be more effective compared to conventional therapy by using the humanoid robot which is physically shaped like a human being that can produce controlled and repeatable movements.