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DESIGN OF WALKWAY RIG SYSTEM FOR GAIT MOTION TRACKING OF CHILDREN WITH CEREBRAL PALSY

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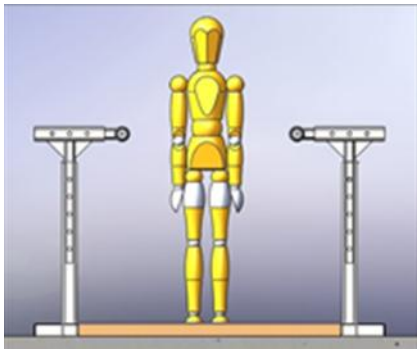
Graphical abstract



Abstract

This paper reports the design of walkway rig system for gait motion tracking of children with cerebral palsy (CP) at Universiti Tenaga Nasional (UNITEN), Malaysia. The walkway rig consists of a modular walkway platform, adjustable parallel bar, and overhead gantry with body support harness system. The rig has been designed to support different modes of walking assistance depending on a subject's walking capability. The modes of walking assistance are body weight support system, parallel bars along walkway, usage of walker, and human assisted. The key feature of this system lies in the flexibility of it to enable more options during gait motion tracking for CP children. System design and stress analysis were done using CAD software. The design is evaluated using virtual mannequins to check the functions and suitability for CP children. The evaluation shows that the proposed system is feasible to be implemented for CP children gait motion tracking.

Keywords: Cerebral palsy, walkway system, gait tracking

1.0 INTRODUCTION

Cerebral palsy (CP) is the leading cause of developmental disability in children [1]. CP is a movement and postural disorder resulting from a non-progressive lesion or injury to the immature brain [2]. Children with CP show wide spectrum of symptoms which generally affect walking capability of these children to some degree depending on CP severity. Both Snyder and Sharan [3, 4] suggested that clinical gait analysis can be used as a tool for treatment planning and management of CP. This implies that the availability of quantitative gait parameters obtained from gait analysis will allow therapist and researchers to better understand CP children gait pathology. Furthermore the data could be utilized for development of assistive and rehabilitative devices.

Gait analysis can be defined as systematic study of human walking. Gait analysis has long been used as a diagnostic tool, in physical therapy, and sport science [5-11]. It is an important component towards treatment and management of diseases which affect human locomotion. The analysis would enable researchers to determine specific group of muscles that are having problems in terms of strength, flexibility, range of motion, and coordination. Diagnosis will be made and therapy regime will be tailored to suit a patient according to findings through gait analysis.

Most CP children will be having limited ambulation capability. This requires modification to equipment set up for assistance during gait analysis. There is lack of research which specifically addresses gait analysis system specialized for CP children. Gait analysis systems utilized by Pringle et al. and Chen et al. [10, 12] would only cater to limited number of CP children with good walking capability.

Providing walking assistance for CP children during gait analysis is not as straight forward it may look. Different modes of assistance need good accessibility

and modularity of the system. In addition, many of the equipment parameters such as length, height, and width must be adjustable as well. By considering the aforementioned requirements, the proposed system is expected to enable more CP children to participate in the study.

2.0 THE WALKWAY RIG SYSTEM

The walkway rig is intended as a part of the gait motion tracking system used to study walking gait of children with cerebral palsy.

2.1 Design Requirements.

A study has been conducted to establish the design requirements based on two aspects which are the engineering requirements and user requirements. Important engineering requirements are:

- Adjustability to adapt to four different modes of assistance in walking
- Modular in design, such that it is easy to be assembled
- Low production cost

User requirements are important to ensure stress-free environment for the CP children to use the walkway rig. The essential requirements are:

- Child-friendly aesthetics
- Provide safe support and stability during standing and walking

2.2 Overview of The Rig Design.

The gait tracking system comprises of the walkway rig, optical motion tracking system, and wearable sensor system. The walkway rig comprises of a 3-meter walking platform with adjustable and removeable parallel bars and an overhead gantry.

The walkway shown in Figure 1 is designed in UNITEN which has features that suit the sizes and special needs of children with CP. Anthropometric measurement data of CP children is used to determine the walkway rig dimensions. The approaches to address CP children special needs include structure design of walkway, a body-weight support system, and the methodology that will be used to conduct gait analysis. These approaches would make the system suitable to wider population of CP children.

The walkway is designed to cater for the methodology used for gait analysis which will incorporate walking assistance for children with CP. The subjects will be assisted in walking by means of a harness, the walkway parallel bars, a walker, and/or human assisted walking such as shown in Figure 2. The methods of assistance needed by children with CP may provide further details pertaining development of assistive and rehabilitative devices for the CP affected children.

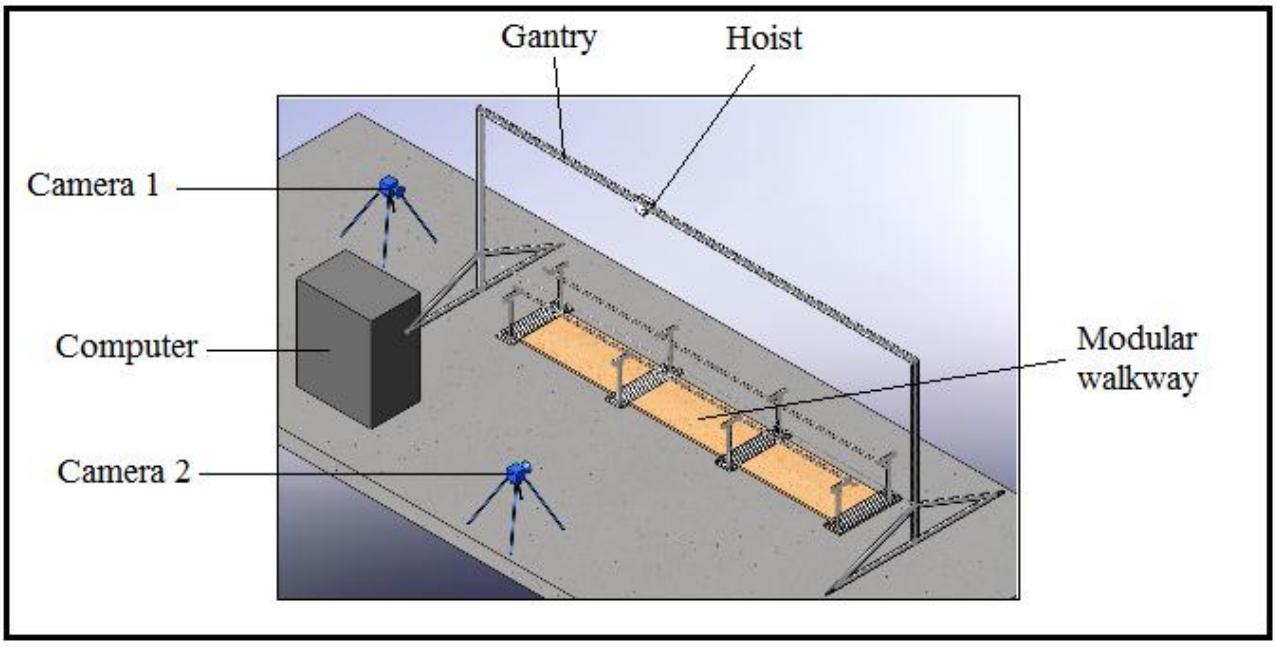


Figure 1 Overall design of the walkway rig

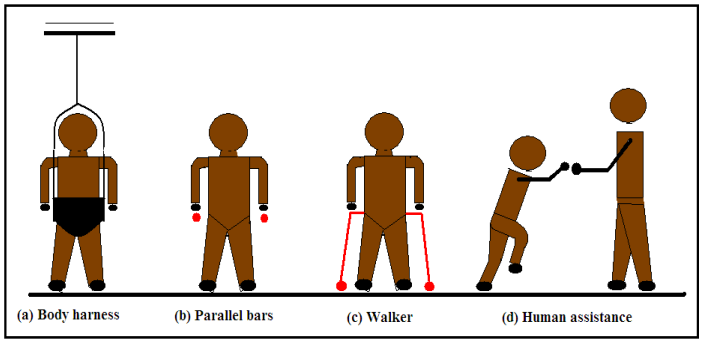


Figure 2 Mode of walking assistance

Mode (a): Body harness – body weight is supported by body harness attached to a hoist
Mode (b): Parallel bars – walking assistance using subject's upper limbs and walking bars
Mode (c): Walker – walking assistance using assistive device such as a walker
Mode (d): Human assistance – walking assistance provided by a human

2.3 The Walkway Platform

The structure is modular which gives convenience to gait analysis operator to adjust the length of walkway by increments of 1500mm. Each platform module has dimensions of 750mm (width) x 1500mm (length) and the weight of 26.5kg. The minimum length of walkway is 1500mm and can be extended to the maximum value of 4500mm depending on a subject's ability to walk. It has detachable stainless steel parallel bars mounted on stanchions attached to the base of the platform. The surface of walkway is lined with anti-slip material (rubber) for safety. Figure 3 shows the walkway platform.

2.4 The Parallel Bar.

This detachable parallel bars is adjustable within the height range of 550-800mm and adjustable width range of 300-500mm. The diameter of the bar is 33.7mm with length of 4750mm. Figure 4 shows the close up view of the mounting/support for the parallel bar.

Upon investigation using manual calculation, parallel bar and stanchion components were detected to be the critical parts of the walkway. Stress analysis was done using CAD software with maximum load of 120kg. The result of analysis done showed a factor of safety of 1.55.

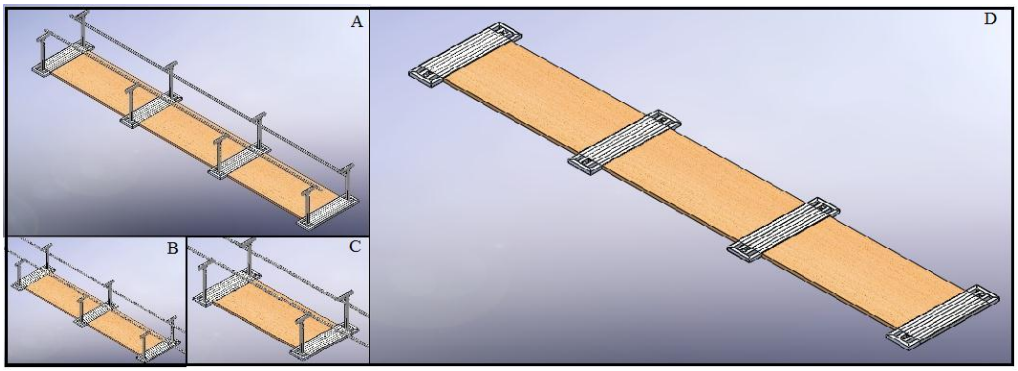


Figure 3 Modular walkway platform with available configurations

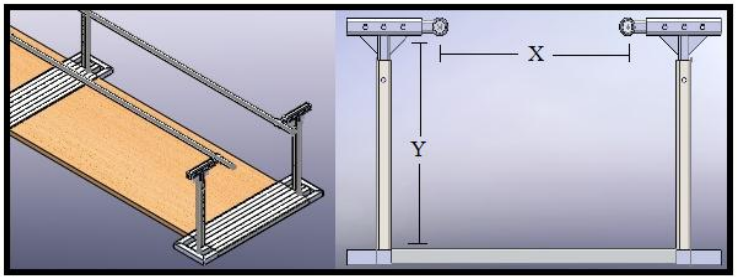


Figure 4 Parallel bars with adjustable height (y) and witdth (x)

2.5 The Overhead Gantry

A gantry crane support, as shown in Figure 5, complete with smooth operating trolley is also incorporated into the walkway system which acts as a body-weight support for CP children. Height of the gantry crane support is 2500mm and length is 5000mm while the maximum allowable load is 250kg. The CP children which are having difficulty in ambulation will be attached to the sliding trolley via a body harness and fiber sling. Clearance height of the subject can be adjusted by varying the fiber sling length or by adjusting height of gantry beam

3.0 EVALUATION

Virtual mannequin is used to evaluate the walkway rig design to ensure the conformity with the required measurements and functions. The virtual mannequin was obtained from the internet [13] and modified to suit the user age group. Figure 6 shows evaluation process within 3D CAD software using mannequin.

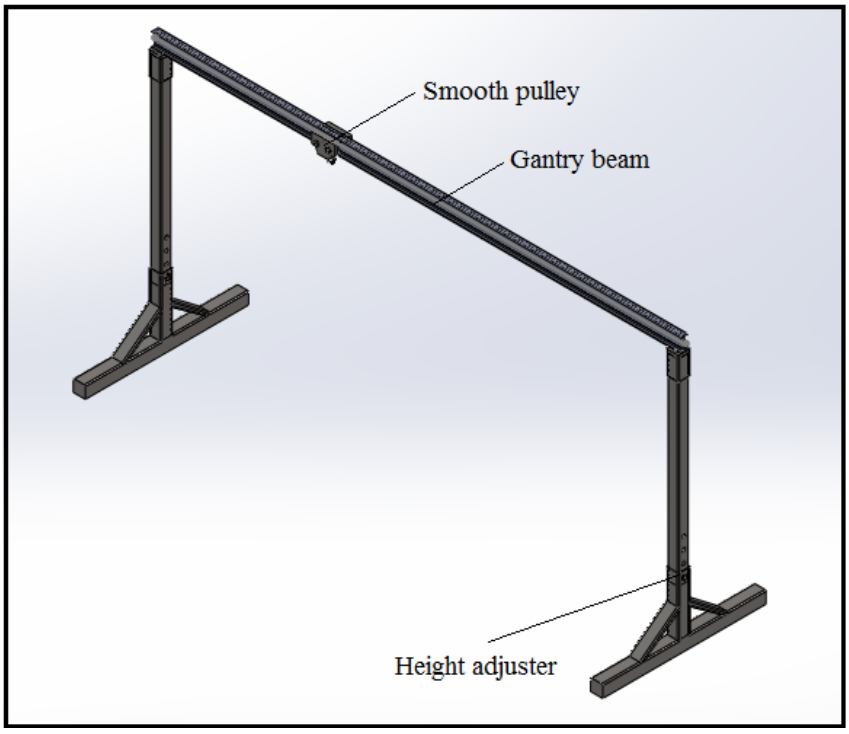


Figure 5 Gantry crane support

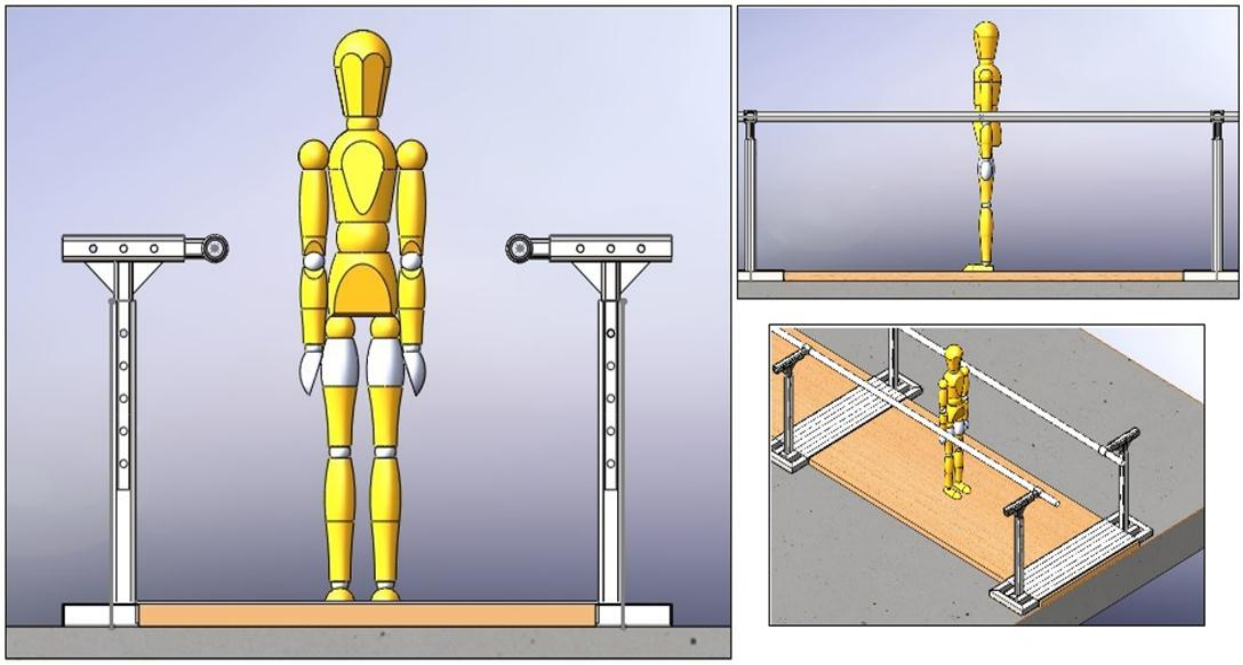


Figure 6 Evaluation using mannequin within 3D CAD software environment

4.0 CONCLUSION

The design of walkway rig system for gait motion tracking of CP children is presented in this paper. The walkway design complete with body-weight support system will enable gait analysis to be done on more population of CP children. The gait data obtained will represent CP children better when more subjects can participate in this study.

Acknowledgement

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