System Integration and Control of Dynamic Ankle Foot Orthosis for Lower Limb Rehabilitation

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Abstract—Gait disorder is the inability of a person to assume upright position, maintain neither balance nor the aptitude to initiate and sustain rhythmic stepping. This form of disability may originate from cerebellar disease, stroke, spinal injury, cardiac disease or other general conditions that may bring about such disorder. Studies have shown that one’s mobility may be improved with continuous locomotor activity. Traditional rehabilitation therapy is deemed labour as well as cost intensive. Rehabilitation robotics has been explored to address the drawbacks of conventional rehabilitation therapy and the increasing demand for gait rehabilitation. This paper presents a simple yet decent technique in the control and actuation of a new Dynamic Ankle-Foot Orthosis (DAFO) designed to rehabilitate the dorsiflexion and plantarflexion motion of the ankle. The DAFO is equipped with two force sensitive resistors (FSR), which act as a limit switch controlling the actuation of the DC motor to a certain dorsiflexion/plantarflexion motion according to the gait phases detected. The results show that the two FSR sensors are sufficient to detect gait phases and act as limit switches to control the actuation of the ankle DC motors, and thus proving the potential of the current system and design for future application.

Keywords—Gait analysis; plantarflexion; dorsiflexion; Dynamic Ankle-Foot-Orthosis (DAFO); rehabilitation

I. INTRODUCTION

World Health Organisation’s (WHO) 2013 World Health Statistics reported that 8% of Malaysia’s population is well above 60 years old [1-2]. Whilst, about 11% and 7.2% of children aged between 0 to 18 years are discovered with physical and cerebral palsy disabilities, respectively was reported in the Malaysian Ministry of Health’s annual report 2011 [2-3]. The report also suggests that there is an average increase of 300% of stroke patients on top of 1.2 million new diabetic cases reported annually. It is not uncommon that gait abnormalities affect the aforesaid percentile [4]. Gait, in essence is one’s ability in maintaining balance and assume the upright position as well as one’s capability in initiating and sustaining rhythmic stepping [5]. Gait disorders may originate from cerebellar disease, neuromuscular disease, cardiac disease, cognitive impairment, stroke, brain or spinal injury or even other general circumstances that may cause this condition [6-8].

We have been developing a new Dynamic Ankle-Foot-Orthosis (DAFO) to facilitate lower limb rehabilitative initiatives in Malaysia [13-16]. The DAFO is designed to rehabilitate the dorsiflexion and plantarflexion motion viz. upward and downward motion of the ankle. This paper describes a simple yet decent technique in the control and actuation of the DAFO. The objectives of the present study is to investigate the effectiveness of a simple control algorithm triggered by the force sensors that defines the motion of the DAFO which replicates the gait cycle of a healthy person.

II. METHODOLOGY

A. Design of the DAFO

The material used in the fabrication of the DAFO is primarily Polypropylene. Acrylonitrile Butadiene Styrene (ABS) is also used in some parts along with Ethylene Propylene Diene Monomer (EPDM) rubber as well as stainless steel. It is equipped with two force sensitive resistors (FSRs)