UNIVERSITI TEKNOLOGI MARA

REAL-TIME MEASUREMENT AND GAIT DETECTION ALGORITHM FOR MOTION CONTROL OF ACTIVE ANKLE FOOT ORTHOSIS

AMINUDDIN BIN HAMID

Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science

Faculty of Mechanical Engineering

May 2015

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Aminuddin Bin Hamid
Student I.D. No.	:	2010314251
Programme	:	Master of Science in Mechanical Engineering
Faculty	:	Mechanical Engineering
Thesis Title	:	Real-Time Measurement and Gait Detection Algorithm for Motion Control of Active Ankle Foot Orthosis
Signature of Student	:	.....
Date	:	May 2015

ABSTRACT

Human gaits are complicated motion that required synergy of muscle coordination, timing and balance. Normally, walking gait pattern is essentially a casual footstep, i.e. one foot moving forward and then followed by another foot stepping ahead of the first foot at the same distance. However, many people cannot walk with normal gait pattern due to neuromuscular disorder affecting the lower limbs leading to weakening of the dorsiflexor muscles of the foot and ankle. In order to support the weak muscle on Ankle Foot Orthosis (AFO) device is worn on the lower leg and foot to provide permanent assistance and control the motion of the foot from dragging during walking. But a typical AFO device is a passive one which tends to be rigid and fail to provide dorsi/plantar flexion motion during walking. The Active ankle foot orthosis (AAFO) has been developed to overcome this problem by assisting the motion of the ankle complex based on force controlled actuator. One of the challenges that researchers have to face with the development of AAFO is providing an efficient transmission and producing continuous and smooth gait cycle. This thesis proposes a real time gait phase detection system to control AAFO for rehabilitation and assist ankle motion. Therefore, the information of real-time human gait phase is important for active control of AFO motion. In this thesis, the real-time gait phase is obtained by measuring ground reaction force (GRF). The proposed system consists of an AFO equipped with ball screw actuator that provides direct assistance to control ankle joint during dorsiflexion and plantarflexion motion. The position of the ball screw actuators is controlled by using motion controller based on the inputs received from three force sensors embedded in the insole and an encoder attached at the ankle joint. The data acquired from force sensors during walking condition is transferred to the host computer powered by LabVIEW software for visualization and analysis. From the result analysis, the developed control algorithm shows that the real-time GRF measurement has the ability to enhance the AAFO functional performance and improve the patient gait.

ACKNOWLEDGEMENT

In the name of Allah, the most gracious, the most merciful, all praise due to Him, by His will and guide I was given strength and wisdom to complete this work. Peace and blessing upon His beloved prophet which by his virtue we choose the right path to our final abode.

My great appreciation to my former supervisor, Mr Mohd Nor Azmi Ab. Patar who contributed ideas, constant guidance, material assistance and warm friendship for the completion of this work. Also, great appreciation to my current supervisor Ir. Dr. Muhammad Azmi Ayub and co-supervisor Dr Sukarno for their relentless commitments to make sure that this work achieved its goals. Special thanks to my colleagues Mr. Abdul Halim Esa, Mr. Ahmad Zulhilmi Mohd Ziyadi and Mr Mohamad Sufian So'aib for sharing their knowledge and experience on laboratory works. Not to forget all laboratory staffs, especially Mr Elwan Salleh who provides technical assistance.

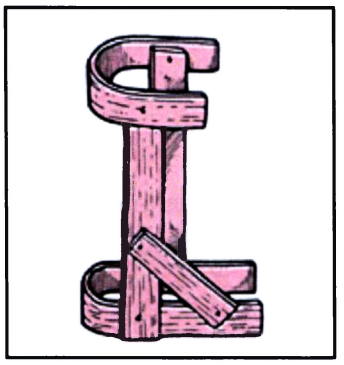
Special thanks dedicated to my wife and family members who were the source of inspiration and motivation at the time of ease and hardship. I gratefully acknowledge UiTM for providing excellent facility which allows this work to go smoothly and the Ministry of Science and Technology (MOSTI) for providing fund.

CHAPTER ONE
INTRODUCTION

1.1 INTRODUCTION TO ANKLE FOOT ORTHOSIS (AFO)

The word orthosis is derived from the Greek *ortho*, meaning straight, upright, or correct. Orthosis refers to a static or dynamic device and is preferable to splint or brace, which refer only to a static device. Perhaps the oldest of all devices to stabilize the knee joint was known as early as in the Fifty Dynasty (2730 – 2635 BC) of Pharaoh. Mummies were found with intact orthosis, used for fracture bracing. Hippocrates, around 370 BC, used splint on the leg, avoiding placement of pressure point over bony prominences. Galen (AD 130-201) used dynamic orthosis for scoliosis and kyphosis. In the 12th century, the medical school at Bologna considered orthotics as an important part of medical knowledge. They standardized, simplified and lightened orthosis by using wood and metal. Figure 1.1 below shows the early ankle foot orthosis designed by Arcaeo [1].

FIGURE 1.1
Early ankle foot orthosis [1]



Andre Pare (1509-1590) known for his pioneering work in prosthetics, also contributed to orthosis fabrication. Pare's book described spinal corsets, fracture orthosis, weight-relieving or those for hip disease and shoe modifications. He commissioned armor makers who became proficient in the use of metal, leather and wood to produce orthosis.