1.0) Name:

2.0) Project Title: Design and Development of a Speech-Activated Bionic Joint

3.0) Background:

Stroke is a leading cause of permanent disability in the united states. According to the national stroke association, each year, about 730,300 people suffer a stroke, and approximately two third of these individuals survive and require rehabilitation [1]. Quadriceps muscle weakness (QMW) limits an individual's ability to provide knee-extension moments, and thus increases the risk of leg collapse while the affected leg is weight bearing [2]. Individuals with paralysis of a leg are often prescribed leg orthotics in order to maintain the capacity to ambulate. Knee ankle-foot orthoses (KAFO's also know as long-leg braces) are generally designed with knee joint locking mechanisms as drop ring locks or bail locks, which fix the brace in full extension providing unyielding support [3]. Knee bracing gained interest as the financial investment and risk in the professional athlete escalated. The goal of knee bracing was to preserve natural function without restricting performance [4]. Assistive knee braces are a kind of wearable lower extremity exoskeleton that can enhance people's strength and provide desired locomotion. It is possible to use knee braces to assist elderly or disabled people on improving their mobility to solve many daily life problems. Studies have been conducted in the development of exoskeletons such as Robo knee developed by Pratt et al, and the wearable walking helper by Kalamata and sakai [5]. Some of the designs allow the torsion to be adjusted; giving some variety and further improvement in efficiency over a simple passive device. However, their shortcoming is in their inability to be adjusted in real time. This introduces a second class of device beyond the passive orthotics. It is comprised of active or powered devices, and although more complicated in design, they are definitely the most versatile [1]. E.g., Figure 1 shows the brace designed by a previous team on this project.

Figure 1: Knee brace developed by the previous team

4.0 Literature Review:

Knee braces are supports to be worn when you have pain in your knee. Some people use them to prevent knee injuries during sports [1]. Braces are made from combinations of metal, foam, plastic, or elastic material and straps. They come in many sizes and designs [12]. There are different kinds of knee braces. Each one is used for different reasons [1]. Research on exoskeleton device to augment or support a human user is not a new idea. Human imagination and science fiction have made popular the notion, that a wearable mechanical device could allow the human operator to push physical boundaries. Dollar et al. state that focused research on exoskeletons only began in the late 1960s in both United states of America and the Yugoslavia. Whilst research in the USA was mainly driven by the military, the goal of the latter was to help patients with defects in the locomotor system to regain mobility. The work carried out by professor Miomir Vukobratovic and his colleague at the Mihajlo Pupin Institute is the most extensive, published exoskeleton research to date. One substantial outcome would be the discovery of the zero-moment-point (ZMP) concept, which has since revolutionized robotic biped motion [2]. Since those early years, exoskeleton research has grown to encompass a much larger filed of application. Exoskeletons are also currently developed to assist in rehabilitation, to increase the mobility of the elderly and even for purely entertainment purposes. A quick survey of these notable lower limb devices indicates that there has been an explosive increase in the exoskeleton research in the past 10 to 15 years, for all the applications [3]. Out of these devices, only those that are specially related to the current work, or those that have influenced it directly are reviewed in this project. Therefore, only actively actuated lower limb exoskeleton will be considered [4]. The devices are selected based on their relevance, similarity in application, and the availability of sufficient technical data. Reviews by Dollar and Herr provided more details on the other exoskeleton system such as Robo knee, MIT knee exo and Rex bionic legs. Another review by Jimnez-Fabin and Verlinden explores the various control algorithms (user intention estimation methods) implemented in the lower limb exoskeletons. A large portion of the lower-limb rehabilitation exoskeletons are treadmill based wearable robotic device for a gait training and assessment of motor function in stroke patient and are used mainly to reduce both labor intensity and the cost of rehabilitation. Though not directly related to the current work, these devices give a deeper understanding of the biomechanics of the lower-limb and the ideal joint trajectories [11].

The Honda bodyweight support assist and stride management assist are also fascinating devices with similar construction and purpose to KAFOs. However, very little is known about the devices ‘human-machine interaction’ and intent estimation system. As robots move from isolated work cells to unstructured and interactive environments, they will need to become better at acquiring and interpreting information about their environment. In particular, in cases where robot-human interaction is planned, human monitoring provides valuable information, which can enhance the safety of the interaction by providing a feedback signal to robot planning and control system actions [5]. An intelligent programmable actuated knee orthodox could be used as an alternative to currently available mechanically-passive braces existing option for control of pathologic knee movement during gait include use of long leg brace (KAFO’S). The device supplies assistive torque at the knee joint to alleviate the loading at the knee, and thus reduce the muscular effort required to perform activities of daily living. The hypothesis is that the added torque would facilitate the execution of these movements by people who previously had limited mobility. A single rotational degree of freedom at the knee joints was placed to ensure that the exoskeleton had a high kinematic compliance with the human leg [9]. The Voice Activated Intelligent System (VAIS) primarily comprises of a Voice Recognition and Processing system and Wireless Communication. Speech recognition and processing technology gives a natural interaction method for many computing tasks. It allows users to communicate with electronic devices using natural language. Due to the increase in computing power of PCs, this method can be easily implemented. The basic design consists of 2 processing units: Speech processor and a microcontroller unit. We set up the wireless communication between the two processing units by two transceivers. One of them connects with Speech processor working at the transmitter to transmit the signal; another one is connected with microcontroller unit to be the receiver [13].

5.0) Objectives:

1) To develop a knee brace which will be providing 20-30% support to partial paralytic human.

2) Incorporate a voice activated controller module to operate the knee brace without any physical effort.

3) To gather experimental data for the kinematic and kinetic performance that will be determined during the course of the research for the developed system using a mechanical test set up.

6.0) Methodology:

In this study, computer simulation will be used to design the knee brace followed by the fabrication of the brace.

Research will be conducted for the existing available products followed by studying pros and cons and scope for improvement. This procedure involves performing background research of product requirement such as materials, product design and validation.

I) Design of knee brace

The CAD model of knee brace will be designed on Solidworks. Many average-sized adult fit in size Medium knee braces. So, a standard Medium size knee brace available in the market with a dimension of 15.5cm above knee and 14cm calf (below knee) will be consider for initial designing. There are 3 things which we will be considering while designing Brace.1) Scaling Dimension (first step to be considered prior to modeling the brace) 2) Modeling 3) Simulation and shape optimization (once the modeling process is completed we would run simulations to check whether the design is durable enough and if yes, the design could be optimize further or not).

II) Design of Control System

The control input for this New brace design must be derived from naturally occurring movement of the leg. Pressure sensors will be used to monitor the forces exerted by the leg during extension or flexion movement. There will be two pressure sensors fixed to knee brace one will be at the upper part of knee brace and other will be at the lower end of the brace. A new program and function will be developed in MATLAB to automate the algorithm on a computer. Initial research suggests that MATLAB can be the programming tool for use for this project, due to its applicability to the engineering profession and its ease of use.

III) Design and development of prototype.

After the initial design been drafted the knee brace will be subjected to Finite element analysis (FEA) using Solidwork tool. There will be two main types of FEA analysis 1) Linear static stress analysis 2) Thermal stress analysis of parts and assemblies. The main reason to perform this analysis is to check for maximum displacement and contact stress. Structural analysis is also important because it can evaluate whether this structural design will be able to withstand external and internal stresses and forces. Different components of knee brace will be developed using 3D material printing process and then assembly will be carried out. Electrical components such as sensors, battery and microcontroller are then attached to knee brace for giving live feedback which will be connected directly to computer for generating results.

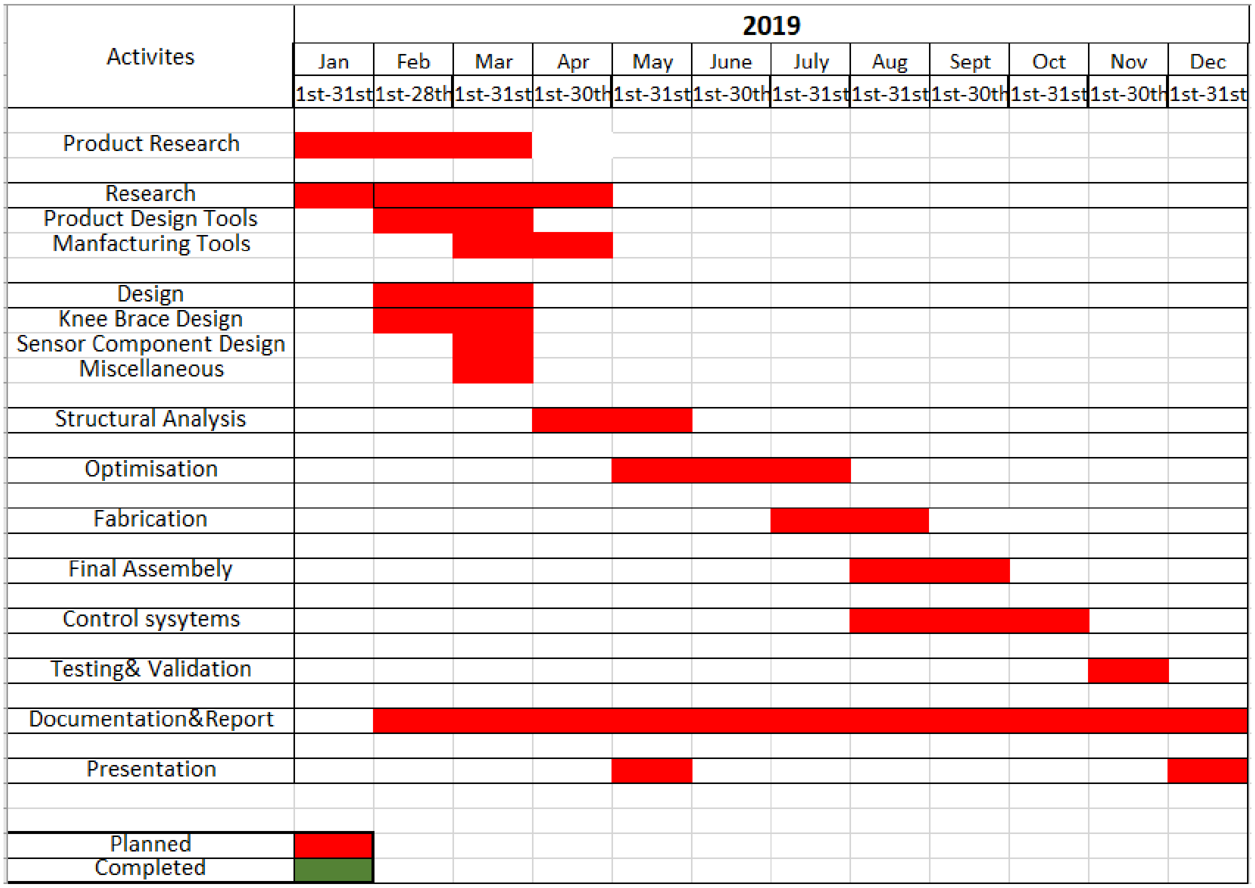
IV) Experimental setup results

Thus, after fabrication the product will be able to use for test however it will be not tested directly to human. The reason is the regulations that prevents us testing on unhealthy individuals without extensive reviews by a committee. When testing on a healthy individual, their actual muscle activity might bias the test result As So, we will develop an experimental setup which would give us more accurate result which then can be compared to the theoretical result.

7.0) Deliverables:

A working prototype of speech activated bionic joint along with the data to prove that it will work well to assist a human in need.

8.0) Timeline:



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