SMBE 4513 Project Report

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School of Biomedical Engineering and Health Sciences

Faculty of Engineering

Topic	: ANKLE FOOT ORTHOSIS WITH DISTANCE DETECTION
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1. ABSTRACT

A Malaysian university student named Mira suffering from brain injury due to a car accident has faced some problems in continuing daily life. Her vision became unable to accurately predict depth and distance, both of her leg muscles are weaker hence she relies on using a stick to assist her walking, navigating the direction, and also to coordinate her leg movement while walking. Beside that, she has to struggle in recalling the short term memories which means she will quickly forget what people just said and miss any instructions that have been told to her. Likewise, she is not strong enough in handling things if she only has to use one of her hands, thus she needs to get both of her hands to support. Not only did she get some physical impairments, yet there are also some changes on her facial features, such as her mouth became asymmetry while smiling which might be affected by nervous injury.

The purpose of this rehab engineering project is to assist Mira and other patients with similar disabilities especially in walking, so that they can return to their previous levels of activity associated with the duration of using the orthotics and the patient's compliance.

This study also discusses the cost-effectively (FES) functional electrical stimulation and sensors applied in the orthotics foot to show the correct direction and warning due to some obstacles the patients face while walking. The sensor pads processor may further be configured to receive environmental data associated with the surrounding of the user and adjust the signal parameters for the stimulation signal based on the environmental data. Furthermore, in at least one embodiment, the sensor of inertial measurement unit (IMU) may comprise a gyroscope to provide foot angular velocity data and an ultrasound-driven Human Machine Interface (HMI), for dexterous motion recognition due to its characteristic of detecting morphological changes of deep muscles and tendons. The semirigid material used in this study was made of polypropylene.

2. INTRODUCTION

Road traffic accidents are the leading cause of fatal injuries, such as Traumatic Brain Injury. TBI commonly causes life-long impairments in physical, cognitive, behavioural, and social function. The cognitive, behavioural, and personality deficits are usually more disabling than the residual physical deficits. Recovery from brain injury can continue for at least 5 years after injury.

One of the first symptoms to appear is a weakness in the extremities. The side of the brain injured will determine which limbs are impacted. Typically, if one side of the brain is damaged, the opposite side of the body will experience weakness. Sometimes, just the lower limbs will be impacted, other times both upper and lower extremities will be adversely affected. When someone has extremity weakness in the legs, it can be difficult to have good balance and even walk. Besides, the muscles can also become weak which may result in stiff joints.

Rehabilitation is effective using an interdisciplinary approach, and close liaison with the patient, family and carers. The focus is on issues such as retraining in activities of daily living, pain management, cognitive and behavioural therapies, and pharmacological management. General practitioners play an important role in providing ongoing support in the community, monitoring for medical complications, behavioural and personality issues, social reintegration, carers coping skills and return-to-work issues.

In the correction of lower extremity alignment and mechanical dysfunction, foot orthotics are recognized as an important consideration designed to correct an abnormal or irregular walking pattern by reducing stress forces that could potentially cause foot deformity and pain. By subtly altering the angles at which the foot hits a surface, orthotics serve functions that make standing, walking and running more comfortable and efficient.

3. LITERATURE REVIEW

3.1 Muscle Weakness

Arthrogenous muscle weakness is weakness of muscles acting about injured or inflamed joints. The weakness may be due to loss of muscle or to inability to activate the muscle. Weakness of the high muscles, and of the quadriceps in particular, is a common and important consequence of knee trauma, surgery or arthritis. Muscle weakness contributes significantly to disability and probably also renders the joint vulnerable to further damage. This review starts with a brief discussion of the contribution of atrophy to weakness. It concentrates, however, on inhibition of quadriceps activation and suggests some therapeutic implications. It does not deal with the reduced oxidative capacity and increased fatigability of disused muscle since, although important, these have not been part of our programme of work (Stokes, M. & Young, A., 1984).

3.2 Types of Orthosis

a) AFO (Ankle Foot Orthosis)

AFO also known as lower leg orthosis or ankle foot orthosis. In AFO, the joint in orthosis assumes the function of the ankle joint or those functions the foot is not able to perform anymore. AFO is used to support and align the ankle and foot by Suppressing Spastic and overpowering ankle and foot muscles, assisting weak and paralyzed muscles of the ankle and foot, and preventing or correcting ankle and foot deformities. An ankle-foot orthosis is particularly useful in assisting the functions of the ankle and foot when a person has a gait condition commonly known as “drop foot.” Drop foot is a neuro-muscular condition resulting in the inability of a person to Sufficiently lift one of their feet during a walking Stride. (Ingimundarson et al, 2005)

b) KAFO (Knee Ankle Foot Orthosis)

KAFO extends over the knee, the focus joint used at knee height. They are divided into free moving, locked, automatic system knee joints. KAFO locks the knee during stance and allows free-knee motion during the swing phase of gait, KAFO should provide stability in stance phase and unrestricted knee movements in swing phase (Raufman et al, 1996)

c) KO (Knee Orthosis)

Knee orthosis only covers the knee and provides medial, lateral, and rotational knee joints. The novel knee orthosis device stabilizes an injured or surgically repaired (Richard. A Nace, 2012).

3.3 Material of Orthosis

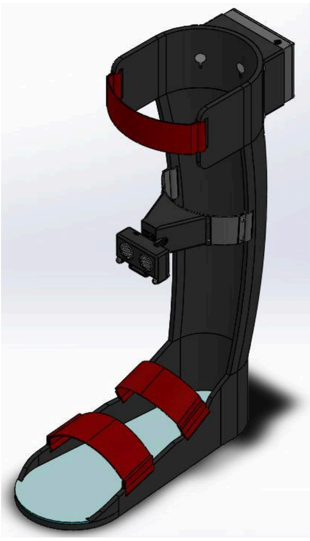
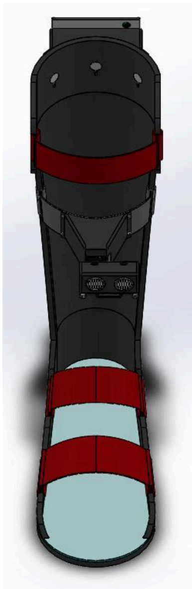
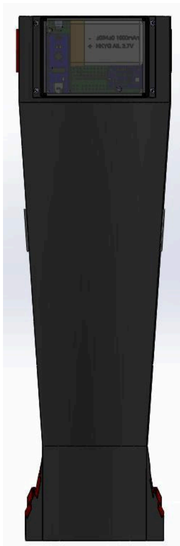
Polypropylene (PP) was introduced into ICRC projects in 1988 for the manufacture of prosthetic sockets. The first polypropylene knee-joint was produced in Cambodia in 1991; other components such as various alignment systems were first developed in Colombia and gradually improved. In parallel, a durable foot, made initially of polypropylene and EthylVinylAcetate (EVA), and now of polypropylene and polyurethane, replaced the traditional wooden/rubber foot (International Committee of the Red Cross, 2006).

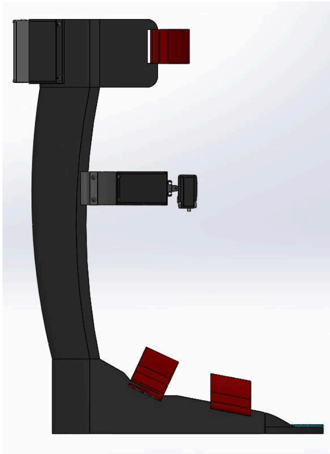
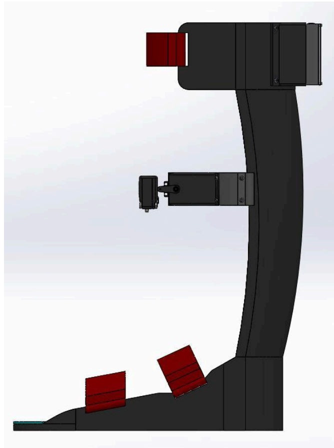
4. SOLUTION

4.1 Design and Engineering Drawing

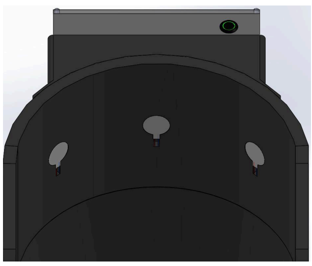
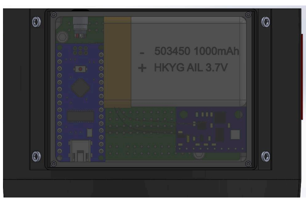
- **3D Design**

The design consists of 34 parts and components , By using SOLIDWORKS we made an orthosis with actual dimensions. The electric components include Arduino nano , PCB , lipo battery , micro usb module , gyro module , servo motor and ultrasonic sensor.

Isometric View	Front View	Back View
		

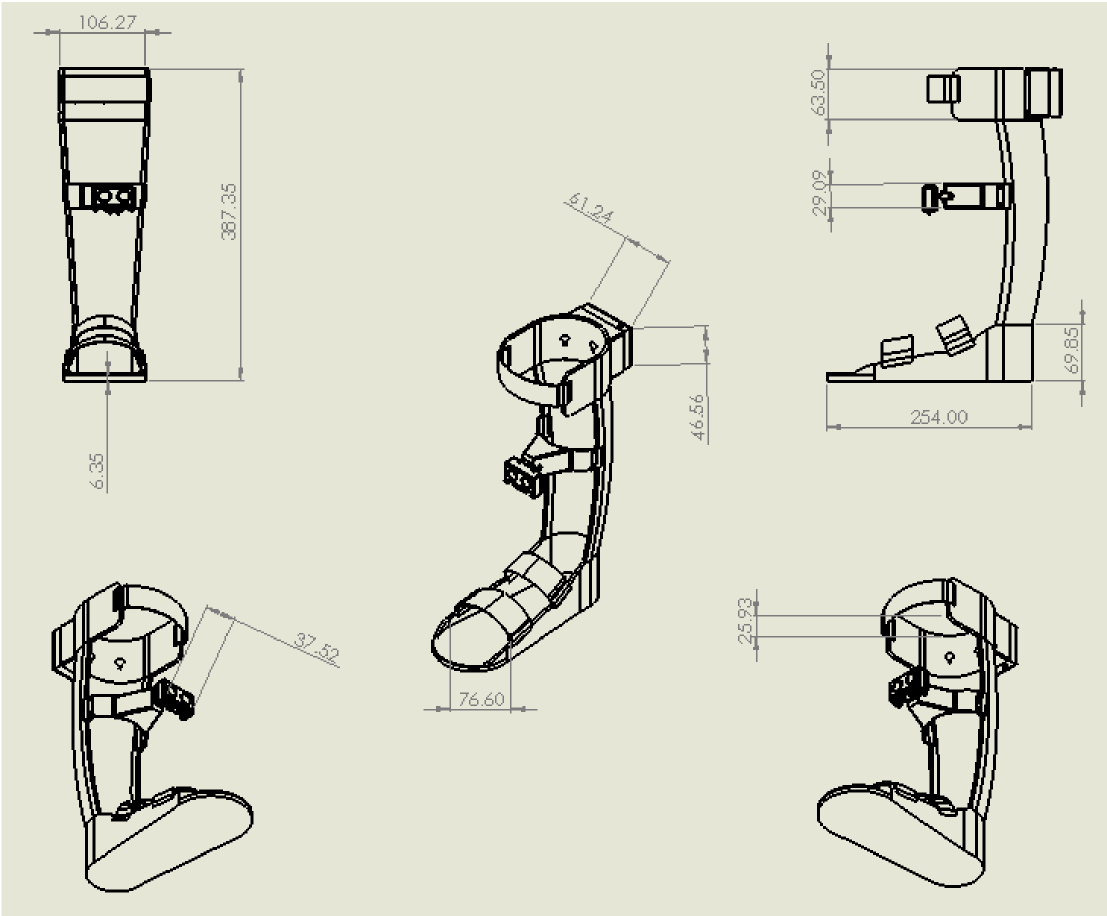
Right View	Left View
	

Features :

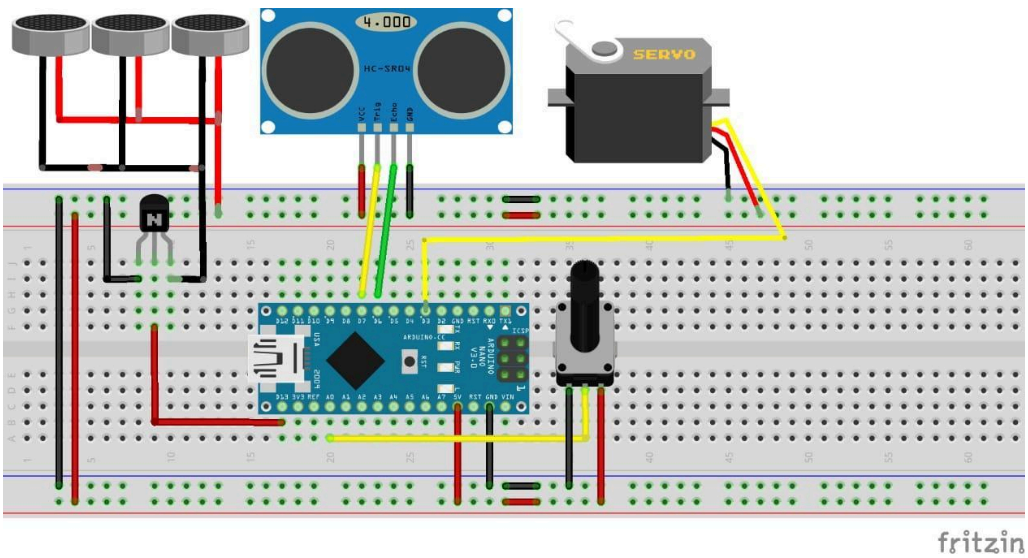
Output	Battery and other component	Sensor
		

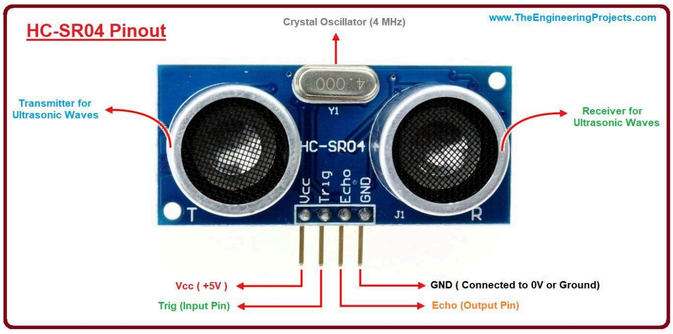
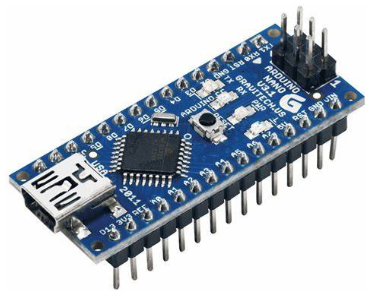
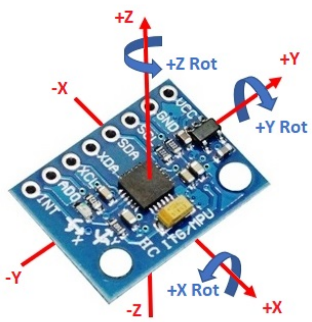
- **Engineering Drawing**

  The detailed dimension as figure below :



4.2 Circuit



Components	Pictures
Ultrasonic Sensor	
Arduino nano	
Gyro module	
Servo Motor	

4.3 Estimated Cost

The average cost based on market price in malaysia as follows :

Components	Price
Polypropylene (1.3kgs)	RM 145.5
Arduino nano	RM 14
Gyro module	RM 15.5
1000mAh Lipo battery	RM 20
Haptic motor (3pcs)	RM 15
TOTAL	**RM 210**

5. DISCUSSION

Foot Orthoses are recognized as an important consideration designed to correct an abnormal or irregular walking pattern. Also to correct deformity, improve function, or relieve symptoms of a disease. By subtly altering the angles at which the foot hits a surface, orthotics serve functions that make standing, walking and running more comfortable and efficient. In this project we made a foot orthosis with distance detection features to help mira standing and walking also improve her foot posture. With an ultrasonic sensor and gyroscope module ,The gyroscope used to follow mira's steps and give an output to the servo motor to hold the sensor at 0 y-axis. The haptic motor will vibrate when the sensor detects the obstacles within 2 meters.

Ankle foot orthosis is a complex and challenging application of rehabilitation engineering. Many variables must be considered when deciding upon the materials and fabrication technique used that is most suited for the end application of the orthosis. The materials chosen for the Orthosis must be biocompatible and biodegradable. such as polypropylene are commonly used rigid orthosis due to their biocompatibility, biodegradability and non-cytotoxicity.

6. CONCLUSION

Mobility and vision are important aspects in doing activities of daily living (ADL) and when it become disabled, it will disturb much of our daily routines. In order to regain their function and able to conduct daily activities, an assistive technology need to be created to help with the limitations. We come up with an ankle foot orthosis with ultrasonic sensor to overcome Mira’s limitations in mobility due to weak lower extremity and visual limitations where she have difficulties in predicting depth dan distance.

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APPENDIX

Code :

```
#include <Servo.h>

Servo myservo;

int potpin = A0;
int val;
const int pingPin = 7;
const int echoPin = 6;

void setup() {
  Serial.begin(9600);
  pinMode(13,OUTPUT);
  myservo.attach(3);
}

void loop() {

  val = analogRead(potpin);
  val = map(val, 0, 1023, 0, 180);
  myservo.write(val);
  delay(15);

 long duration, inches, cm;
  pinMode(pingPin, OUTPUT);
  digitalWrite(pingPin, LOW);
  delayMicroseconds(2);
  digitalWrite(pingPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(pingPin, LOW);
  pinMode(echoPin, INPUT);
  duration = pulseIn(echoPin, HIGH);
  inches = microsecondsToInches(duration);
  cm = microsecondsToCentimeters(duration);


  Serial.print(inches);
  Serial.print("in, ");
  Serial.print(cm);
  Serial.print("cm");
  Serial.println();

  if(cm < 200)
  {
```

```
    digitalWrite(13,HIGH);
    delay(350-cm);
    digitalWrite(13,LOW);
    delay(50+cm);
   }
   else
   {
    digitalWrite(13,LOW);
    delay(100);
   }
}

long microsecondsToInches(long microseconds) {
   return microseconds / 74 / 2;
}

long microsecondsToCentimeters(long microseconds) {
   return microseconds / 29 / 2;
}
```