Step Counter for Ankle Rehabilitation

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ABSTRACT – A new 3-DOF step counter for ankle rehabilitation system with servo motors was proposed in this study. The aim was to control and move ankle to the 3 step angles in order to execute ankle dorsiflexion/plantarflexion rotation (x-axis), internal/external rotation (y-axis) and inversion/eversion rotation (z-axis). The system was developed based on Arduino Uno microcontroller and the gyro meter module (MPU-6050) was used to show the ankle movement of patients. The results show that the servo motor was capable to provide enough power to move the ankle as it rotates to the position that needed controlled by the Android device.

1. INTRODUCTION

One of the most common acute injuries that athletes suffered is an ankle sprains [1,3] show in Figure 1. This injury happens when the ankle bends more than normal and affect or damage the ligament [2]. In the worst situation, the ligament can stretch or torn. Fong et al. [3] found that swelling, bruising, sudden pain and unable to walk as usual is the symptom of ankle sprain. Normally, the ligament needs six weeks to heal, although the rate of everyone to recover is different. In those six weeks, the patients need to do rehabilitation exercise such as inversion, eversion, dorsiflexion and plantarflexion [4]. The purpose of rehabilitation is to give the ability for the ankle to regain strength and flexibility.

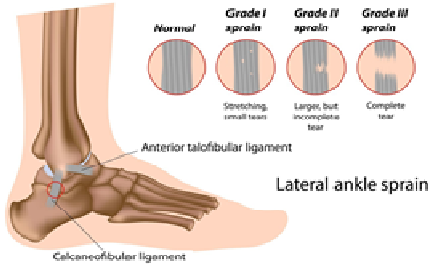

Figure 1 Ankle sprain level

Usually, rehabilitation exercise conducted by a nurse or doctor at a hospital or health centre. So, the patients need to go there, although too far from their house. To solve this problem, we want to design the product with specification that used in the exercise such as move in three dimensions and angle of foot platform. This angle must accurate and right, to make sure the ankle in good position and success in order to heal it.

Most rehabilitation devices such as actuator use to move or control the system do not operate smoothly and can cause discomfort to the patient. The study about the positions of the ankle about three orthogonal anatomical planes as plantarflexion/dorsiflexion rotation, internal/external rotation and inversion/eversion rotation was set based on the research that have done accordingly in Table 1 [5,6] and Figure 2.

Table 1 Angle of rotation for each servo

Servo motor	Joints motion	Angle range of motion (°)
1 (x-axis)	Internal/Abduction	0° ~(25°-30°)
	External/Adduction	(25°-30°)~0°
2 (y-axis)	Dorsiflexion	0° ~(25°-30°)
	Plantarflexion	(40°-50°)~0°
3 (z-axis)	Inversion	0° ~(40°-50°)
	Eversion	(25°-30°)~0°

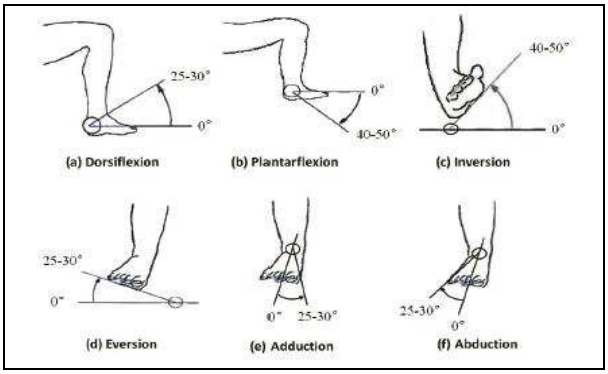

Figure 2 Movement of ankle joint into the step angle

This design controlled by smartphone (Android) with Arduino as a medium of interaction. The apps in smartphone will control the speed of servomotor at hardware. Therefore, the patients can do the rehabilitation everywhere their want, without help from nurse or doctor.

2. METHODOLOGY

The material used for this project include the Arduino Uno, Bluetooth (HC-05), gyro meter (MPU6050), servo motor (MG995), acrylic footplate and surrounding aluminium beams that are connected to the system ground. To move the platform, the patient's will push the button in android phone, thus transmitting

the data strings to the microcontroller that is connected via Bluetooth.

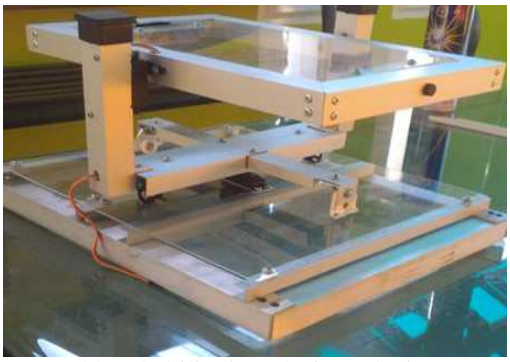

Figure 3 Ankle rehabilitation platform devices

The data received is processed and move the servo motor that is connected to the microcontroller. The feature buttons has 3 in total where it is classified as 'SLOW', 'MEDIUM' and 'FAST' so the patient able to choose the speed of motor.

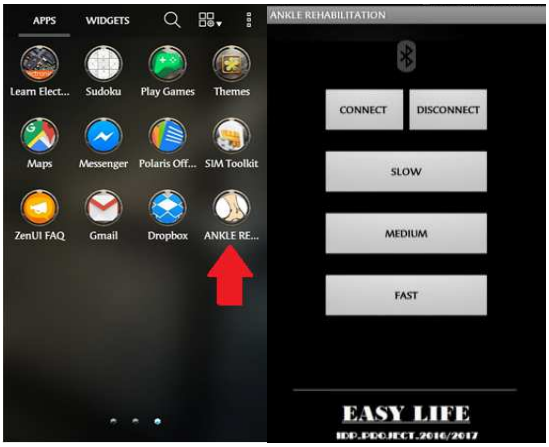

Figure 4 Easy Life applications

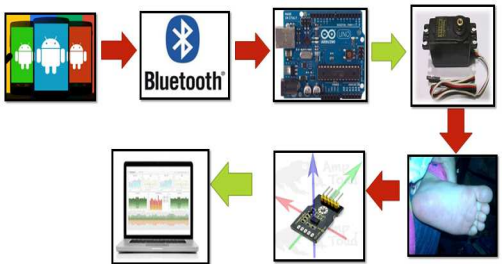

Figure 5 The overall of ankle rehabilitation system

3. RESULTS AND DISCUSSION

Since our project output mainly can be seen directly through the rotation of the platform when the ankle of patient is placed, 3 dimensional images are obtained through the function gyro meter which converts the movement of patient into 3 dimensional images that can be seen through personal computer or desktop. In order to produce the 3 dimensional images, processing software is used which interacts with gyro meter to receive signal from the motor movement and send signal to the particular personal desktop that will displays the relevant images. Figure 6 represents the 3 dimensional images of each axis angle z, y and x axes.

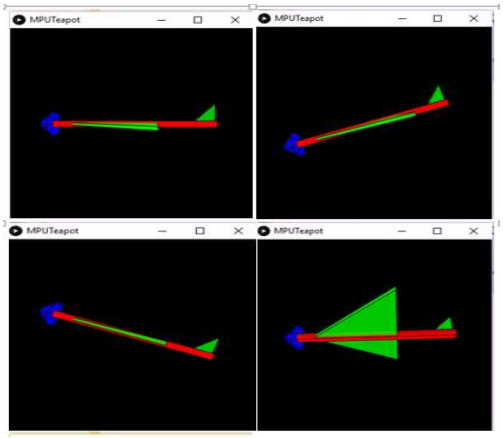

Figure 6 MPU Teapot using processing software

4. CONCLUSION

In conclusion, the present study achieved all the objectives that have been stated. The human body ankle was made of inferior tibia, inferior fibula and talus. Ankle joint's movement are divided into a several types which is Dorsiflexion and plantar flexion (main movement of ankle joint), Normal dorsiflexion (25°-30°), Plantar flexion (40°-50°), Adduction or abduction (25°-30°) Inversion and eversion (35°-40°) and normal valgus movement (0°-15°). Thus, our prototype of the project has ensured the ankle movement is in suitable angles that has been researched so that the ankle to be treated in a good way.

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