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# INTELLIGENT ACTIVE SOFT ORTHOTICS-ANKLE FOOT

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**Abstract:** The human that has neuromuskuloskeletal disorders used Ankle-foot orthoses (AFOs) to maintain safe and accurate foot step, in order to maintaining a normal walk pattern. Todays designed with AFOs gives sufficient support during walking, but having stability issues such as degree of freedom at ankle joint, pronation , the lack of dorsiflexion , Insufficient hip mobility, which cause imbalances and pain in other joints of human ankle during walking and running. The paper suggest the prototype for redesign of AFOs using a microcontrollers based system .This system provide human walk assistance focuses on ankle foot joints. The different sensors will sense the signal from respective ankle joint and gives information to microcontroller so as to operate the respective motor for the displacement. The paper also suggested ASOAF manufactured with using soft and flexible aluminium material. This material provides high strength, high elasticity, light weight, high durability, high malleability, high machinability, easy joining, excellent corrosion protection, Zero toxicity, Non-magnetic material which provides the stability and mobility during the normal walk. The designed intelligent controller is fast responsive for the target patient and patient will feel comfortable.

**Keywords:** Active soft orthotic (Ankle foot) (ASOAF), Dorsiflexion, intelligent controller, pronation

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## INTRODUCTION

The active soft orthotic ankle foot are intended to support the ankle with correct deformities, and the prevention of future injuries. Since the beginning of 1980's, the basic idea of active powered orthotic device has been explored by using hydraulic and pneumatic device. Rehabilitation of patients that has neuromuscular disorders create the compensatory walk pattern in patients, and interventions such as physiotherapy and reinforcement with active soft orthotic ankle-foot (ASOAF) helps normalize the walking pattern.[1][2] An example :drop foot. Due to the damage of long nerves of the brain or spinal cord, the lower leg anterior muscles become weaker while posterior muscles become stiffer. Thus, the foot down in oscillation phase causes toe strikes instead of the heel strikes, which sometimes gives rise to stumble and fall. ASOAF has the potential to prevent the development of abnormal Aires in time and providing immediate assistance to walk. It also holds ankle and foot in proper alignment with the right foot drop. ASOAF is rigid has hinge support at the joint angle depending on the ankle mobility. They are used by children , young as well as adults who have medical problem.[3] ASOAF allows little dorsa -flexion or planting, which in turn makes running and walking over changes in elevation, such as a very difficult to curb. Often, people have to significantly change their patterns of walking, which causes increase the stress on other joints, such as knees, hips and back, pain and discomfort. [4]A growing interest in develops an inexpensive ASOAF which gives adequate stability and flexibility.

The specific objectives of the paper are

I) Determination of the design specifications for ASOAF for adults with sclerosis multiple or hemiplegia
II) Redesign the existing AFO
III) The construction of a prototype of the ASOAF

## 2. MATERIALS AND METHODS

The designing of ASOAF is carried out in AutoCAD software as shown in figure1. The 3D model of ankle foot in the standard triangular language (stl) format was imported. The model was then converted into a solid ankle foot model using a mesh to solid converter.

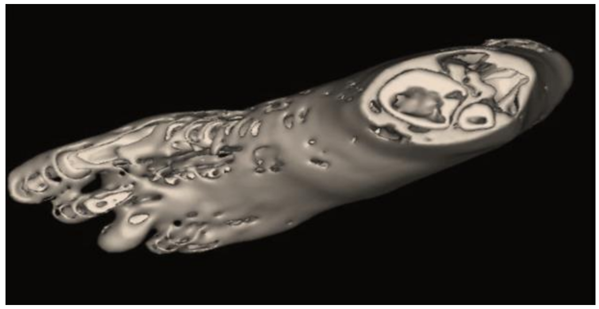

**Figure1. 3D model of the foot (Source [8])**

The intelligent system consists of four primary detection components-sensing, data acquisition, wireless communicator and friendly oriented software for the interpretation of the data. The prototype of design is depends upon the microcontroller based system. The different sensors will sense the signal from respective ankle joint and gives information to microcontroller so as to operate the respective motor for the displacement. It also has decision making tool for decision making. The control system has contains sensor, control circuit and data monitoring unit.

**i) Sensors:**

The basic idea of this project is the development of active soft orthotics ankle foot. It is necessary to measure accurate signals for walk and walk cycle in order to operate the system effectively. And it is also necessary to choose most suitable sensors, which can measure all cases the walk cycle. There are several options available for sensor such as force sensors, distance sensors, pressure sensors.

**ii) Sensor used in ASOAF:**

Force sensors: As its name implies, force sensors are used to measure force. Depending on your application, it can also be used for measuring weight or mass. Force sensors can be integrated into ASOAF to measure ankle / wrist forces, moments and loads. It can also be used in walk analysis to measure the ground reaction forces and loads exerted by a belt or pad.

**ii (a). Distance sensor:**

The distance sensor has ability to detect the presence of nearby objects without any physical contact. The object being sensed is referred to as the sensor’s target. The maximum distance that this sensor can detect is defined “normal range” Distance sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object. In ASOAF, the distance sensors are use for detecting distance of ankle foot from reference floor.

**ii(b). Pressure sensors:**

For pressure measurement, an electrical signal must generate in response to a pressure input. The pressure is measured either by deflection or strain.

The limitation of pressure sensors are as follows*:* I)It is small in size, just as force sensors*.* II) It needed a little signal analysis before it is inserted in the control system. III)The measuring reading which measured by pressure sensor of some points below the foot which measured by pressure sensor, maybe changed from one foot to another.

**ii(c). Strain Gauge sensors:**

These sensors normally used to measure the stress or strain in materials depends on its amount of bending due to the applied force. So this bending is proportional to the change in the resistance of the sensor, and the value of applied voltage.

**iii) Sensor selection:**

The general selection criteria for choosing any type of sensor are as follows:

Range: the sensor must be capable of measuring the full range of the event. Sufficient margin must remain at the top end of the range so the measured event must not exceed the range of the sensor and cause damage.

Frequency response: the frequency response of the sensor is the range of frequencies over which the sensor gives a precise response. It must be capable of measuring the full range of expected frequencies of the experiment.

Sensitivity: The sensitivity of the sensor is defined as ratio of the change in sensor output to a change in the input to be measured.

Accuracy: The accuracy refers to how close the output of sensor is to the actual event. Environmental conditions; such as temperature, moisture, water and other should be considered while choosing a sensor.

Cost: The cost of a sensor is an important factor and depends on the standard of the project.

**iv) Control circuit:**

The signals of the sensors will be transferred to the control kit which consists of a microcontroller, analog and digital input / output ports, power supply. The structure of active soft orthotic ankle foot consist of all of circuits, amplify and filter circuits, microcontrollers and power supplies for electronic circuits and MR damper kit. The patient must carry the ankle foot and be able to walk with him in any place.

**v) Data monitoring unit:**

It receives the data from the sensors and provide signal for the necessary action that was passed.

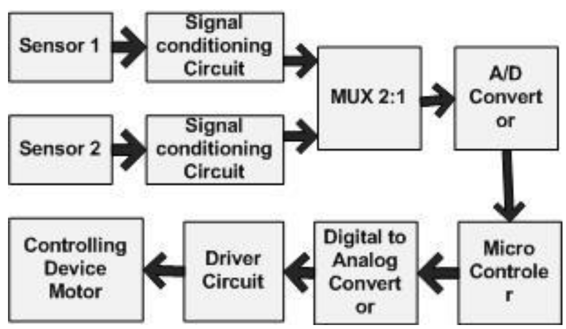


**Figure 2.Intelligent control system of ASO-Ankle foot**

The design specifications are depends upon the following parameters

**Table 1**

| S.No | PARAMETERS OF DESIGN SPECIFICATIONS |
|---|---|
| 1 | Weight (kg) |
| 2 | Max. Allowable Dorsiflexion (deg) |
| 3 | Max. Allowable Plantarflexion (deg) |
| 4 | Peak Torque (Nm) |
| 5 | Peak Velocity (rad/s) |
| 6 | Peak Power (W) |
| 7 | Torque Bandwidth (Hz) |
| 8 | Net Work Done (J) |
| 9 | Offset Stiffness (Nm/rad) |

The objectives of the design specification of active soft orthotics ankle foot are as follows:

* The ASOAF must be at a weight and height similar to the intact limb.

* The system must offer a great instant output power and torque during push-off.

* The system must be capable of changing its stiffness as dictated by the quasi-static stiffness of intact ankle.

* The system must be able to control the position of the joint during the swing phase.

* ASOAF must provide enough shock tolerance to prevent damage to the mechanism during the heel strike.

Previous orthotics has shown that one has better walking efficiency but is cosmetically less acceptable to the patient. And also the brittle nature of materials causes the ductile failure mode. Aluminium structure of ASOAF is used for overcoming these limitations which provide better stability, mobility, light weight, various stiffness setting, significant energy storage and return capabilities.

**3. RESULTS AND DISCUSSION**

The main contribution of this work is the design and the implementation of active soft orthotic ankle foot that mimics biological architecture of the tendon. To understand the strategies of neuromuscular control participating in the walk and run, is necessary to understand walk cycle. In fundamental gear unit walk cycle, two distinct phases can be identified: a) stance phase, and b) swing phase. Stance phase begins when the foot contacts reference floor (from heel contact) and ends when the reference foot lift floor (toe off). The stance phase is typically 60% of the normal adult walk cycle. Swing phase begins when the reference foot lifts off the ground and ends when the foot comes into contact with reference floor. This phase normally occupies 40% of the normal adult walk cycle. The mechanical design of the device foot was motivated mainly by foot drop condition. The stance phase of walking can be divided into three sub-phases: Plantar Flexion, Dorsiflexion, and neutral.

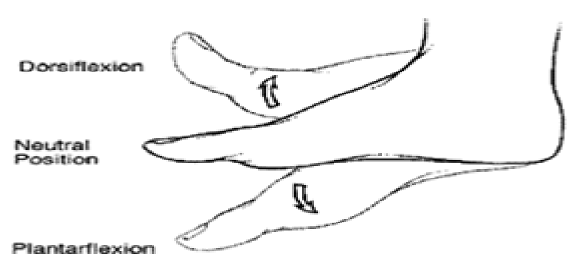


**Figure 3. Dorsiflexion and plantar flexion of ankle joint**

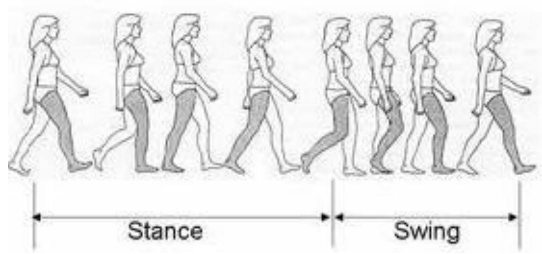


**Figure 4. Walk Cycle for Stance and Swing Phases**

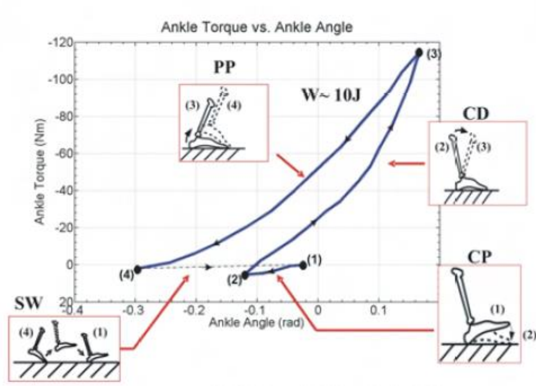


**Figure 5.**

(1) Heel Strike

(2) Foot Flat

(3) -Max. Dorsfl

(4) Toe Off

(1)-(2)- Controlled Plantarflexion (CP)

(2)-(3): Controlled Dorsiflexion (CD)

(3)-(4) Powered Plantarflexsioon Push-Cff Phase (PP)

(4)-(1): Swing Phase (SP)

W = Work Done at the Ankle Joint

Average ankle torque is plotted versus ankle angle for N = 10 individuals with intact limbs walking at a moderate gait speed (1.25 m/s). Data are from [9], replotted in the manner of [9].

The solid line shows the ankle torque–angle behavior during stance while the dash line shows the ankle behaviour during the SW. The points (1), (2), (3), and (4) represent the conditions of the foot at heel-strike, foot-flat, maximum dorsiflexion, and toe-off, respectively.

The segments (1)–(2), (2)–(3), (3)–(4), and (4)–(1) represent the ankle torque–angle behaviors during CP, CD, PP, and SW phases of gait, respectively.

Segments (1)–(2) and (2)–(3) reveal different spring behaviors of the human ankle during CP and CD, respectively. The area W enclosed by points (1), (2), (3), and (4) is the net work done at the joint per unit body mass during the stance period.

The measure two problems are identified during the working of ASOAF. i) If the system gets any power flex then their communication will be restricted to that time. To overcome this issue we have to provide constant power supply. ii) When any type of obstacle will find between the path of journey of ASOAF, then the model of ASOAF will damage due to accident of obstacle and ASOAF. To overcome this limitation, we have to provide a decision making tool.

For the long-term success of such active soft orthotic ankle foot device, we are also investigating relevant clinical requirements and potential control strategies that would work seamlessly with the user’s motion. Our goal is to achieve a fully untethered wearable system to provide a new level of mobility and active assistance.

**4. CONCLUSION**

In this paper, we studied the different systems approaches to provide human walk assistance focuses on the ankle foot joints. Various techniques were used to increased mobility, stability and energy return during normal walk and run. Some of the existing models that has stability issues, expensive, insufficient energy return, insufficient energy storage, lack of wireless sender and receiver and also not contain decision making tool. To overcome this limitation, the design concepts of ASOAF were generated.

The intelligent designed ASOAF is fast responsive for target patient and patient will feel comfortable. The prototype of ASOAF is flexible and has awareness about walk disorders by the use of different types of sensors and data monitoring unit. The results of the system is in the process, here we just placed the design approach for the ASOAF system.

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