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REVIEW ON INTELLIGENT ACTIVE SOFT ORTHOTICS-ANKLE FOOT

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Abstract: Active soft orthotics is a specialty within the medical field concerned with the design, manufacture and application of active soft orthoses. Active soft orthotics includes neck braces, lumbosacral supports, knee braces, wrist supports and ankle foot. An orthotic device means a support, brace, or splint used to support, align, prevent, or correct the function of movable parts of the body. Over the past few decades, highly sophisticated human assistive devices, including orthotics has begun to emerge. Orthotic treatment is the most common method for the foot-drop cases. Orthotic device has the potential not only for preventing the development of abnormal gaits over time but also for providing immediate assistance in walking. More recently, active soft orthotic devices have been developed, utilizing pneumatics and soft sensors. The soft nature of these devices increases user mobility and limits muscle atrophy in non- actuated degrees of freedom relative to rigid orthotics, allowing greater comfort for extended use and inclusion in a wearer's daily life. Acceptance and community acceptance become especially important for devices to be used by children. The prototype is composed of three physical layers: base, actuation, and sensing.

In Intelligent Active soft orthotics- ankle foot (IASOAF), we are using sensors, dc gear motor, ADC, switching unit, microcontroller, communication protocol and monitor. At the input side, sensors are connected and according to the value of sensors, the actuation process is happening

Keywords—*Intelligent Active soft orthotics- Ankle foot (IASOAF), sensor, microcontroller, communication protocol*

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I INTRODUCTION

We have surveyed that around 21 million people i.e., 16 percent of populations in INDIA are handicapped and they are not able to do their daily routine or work as normal people do. So we decided to help them to conquer this deformity. So we are presenting our paper on the concept of Intelligent Active Soft Orthotic-Ankle Foot device. The objective of IASOAF is to provide motion to the deformed part of handicapped people. Sometime people get filled with inferiority complex because of their deformities and they also think that they can never compete with the world. And this is the device which will help them to do so and make them so worthy that they can walk, run with the world and also conquer over their inferiority complex. And they can live their life normally forever. The intelligent active soft orthotic ankle foot (IASOAF) is intended to support the ankle with correct deformities, and the prevention of future injuries. It also holds ankle and foot in proper alignment with the right foot drop. IASOAF 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] IASOAF 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 IASOAF which gives adequate stability and flexibility.

The primary goal of this paper is to review on set of design tools for developing orthotics that mimic the force, velocity, moment, range, and power characteristics of natural human actions while allowing unrestricted user movement in other, non-actuated degrees of freedom. Intelligent Active soft orthotic ankle foot may be used to:

• Control, guide, limit and/or immobilize an extremity, joint or body segment for a particular reason

• To restrict movement in a given direction

• To assist movement generally

• To reduce weight bearing forces for a particular purpose

• To aid rehabilitation from fractures after the removal of a cast

• To otherwise correct the shape and/or function of the body, to provide easier movement capability or reduce pain.

II.LITERATURE REVIEW

Exhaustive literatures were collected from various journal and conference. Few of them which are closely related and they are critically analysed.

Pieter Beyl, Joris Naudet, Ronald Van Ham and Dirk Lefeber, Associate Member, IEEE have been carried out research on topic,” Mechanical Design of an Active Knee Orthosis for Gait Rehabilitation”, Proceedings of the 2007 IEEE 10th International Conference on Rehabilitation Robotics, June 12-15, Noordwijk, The Netherland.

The salient features of the research are given below:

a) The control strategies and the assessment of mechanical concepts actuated by the pleated pneumatic artificial muscles is the proof for the active knee rehabilitation.

b) Special attention is made towards the Assembly and the concept of adjustment.

c) The proposed experimental set-up was used for young adults and persons of advanced age.

d) Electromyography signals were used to measure the muscles physiological changes.

The Study on “Analysis of the Assistance Characteristics for the Plantarflexion Torque in Elderly Adults Wearing the Powered Ankle Exoskeleton “was presented by Kyung Kim, Jae-Jun Kim, Seung-Rok Kang, Gu-Young Jeong and Tae- Kyu Kwon4 in International Conference on Control, Automation and Systems 2010 Oct. 27-30, 2010 in KINTEX Gyeonggi-do, Korea.

The salient features of the research are as follows:

a) An ankle-foot orthosis is to restore the rehabilitation function of the amputated knee and ankle joints.

b) It reduces back and hip pain and improves mobility to afford the patient a healthier life.

Kurtulus Erinc Akdogan, Atila Yılmaz, EmreTileylioglu and okkes Tolga Altınoz were carried out research on the topic, “Microcontroller based realization of gait speed estimation for electronic above knee prostheses” 2011 IEEE 19th Signal Processing and Communications Applications Conference (SIU).

The objectives of the paper are

a) Knee prostheses are easy to use and have low cost.

b) In knee prostheses, a gyroscope and accelerometer between the standard sensors were selected.

c)For these two sensors the speed estimation algorithms are develops and they uses in microcontroller based control unit of artificial knee

The Study on “Powered Ankle–Foot Prosthesis Improves Walking Metabolic Economy” proposed by Samuel K. Au, Jeff Weber, and Hugh Herr, Member, IEEE

The salient features of the research are as follows:

a)The powered ankle–foot prosthesis is capable of providing human-like ankle work and power during stance, can decrease the metabolic cost of transport (COT) compared to a conventional passive-elastic prosthesis.

b)The clinical importance of prosthetic interventions that closely mimic the mass distribution, kinetics, and kinematics of the missing limb.

Samuel K. Au, Jeff Weber, and Hugh Herr were carried out research on topic ” Biomechanical Design of a Powered Ankle-Foot Prosthesis”

The goals of the paper are as follows:

a)In this paper, a novel, powered ankle-foot prosthesis is proposed.

b)The prosthesis comprises a unidirectional spring in parallel with a high performance, force-controllable actuator with series elasticity.

c)By exploiting parallel and series elasticity, the design is shown to be capable of satisfying the restrictive design specifications dictated by normal human ankle walking biomechanics.

"Active Soft Orthotic Ankle Foot (ASOAF) for Gate Pathologies: a Designing Approach "was proposed by Ganesh Yenurkar, Rajesh Nasare and Chandrashekhar Gode. The salient features of the research are given below:

a)The development of system which is more comfortable without restricting angle while sitting.

b)The prototype of this design will be flexible and awareness with the gait pathologies disorders by using different types of sensors.

"Bio-inspired Active Soft Orthotic Device for Ankle Foot Pathologies" was presented by Yong-Lae Park, Bor-rong Chen, Diana Young, Leia Stirling, Robert J. Wood, Eugene Goldfield, and Radhika Nagpal

The salient features of the research are given below:

a)A bio-inspired active soft orthotic device was designed and prototyped using soft actuators and sensors.

b) The prototype showed the capability of 12degree and 20 degree of dorsiflexions from a resting foot position and from a forced plantarflexion position, respectively.

c)The prototype also demonstrated repeatability of feed forward-control and capability of feedback control for the ankle joint angle.

„„Powered Ankle-Foot Prosthesis"" was presented by Samuel K. Au and Hugh M. Herr.

The salient features of research are given below:

a)The minimum level of series compliance that adequately protects the transmission from damage during foot collision fails to satisfy bandwidth requirements.

b)To minimize prosthesis COT and motor or transmission size, we select a parallel stiffness that supplies the necessary ankle stiffness during early stance period dorsiflexion, eliminating the need for SEA during that gait phase.

Drawbacks of previous research:

The main contribution of all these previous papers is to design and implementation of a soft active orthotic device that mimics the biological muscle-tendon architecture only. It does not contain the wireless sender and receiver of signals. And it is totally dependent system which does not contain decision making tool.

III.PROBLEM IDENTIFICATIONS

Prominently two problems are identified during the working of IASOAF. a) 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. b) When any type of obstacle will find between the paths of journey of IASOAF, then the model of IASOAF will damage due to accident of obstacle and IASOAF. To overcome this limitation, we have to incorporate a decision making tool. And, also the two experiments will be conducted for (i) In order to show the influence of the toes through the comparison of walking with and without IASOAF, and (ii) clarify the functions by correlating the activity of the main muscles that control the ankle and the toes to shoe sole pressure data during walking. These two experimental results will be analyzed the components and conditions of an ankle foot model for the development of an IASOAF. The functional performance of IASOAF will be quantified with the measures of time and distance, as length of step, stride length, speed, Cadence, and the cycle time. The performance of IASOAF will measure with the help of kinematics and kinetics of leg joint. The design requirements such as small size, light weight, high efficiency and low noise will make the creation of a daily user assistance challenging devices.

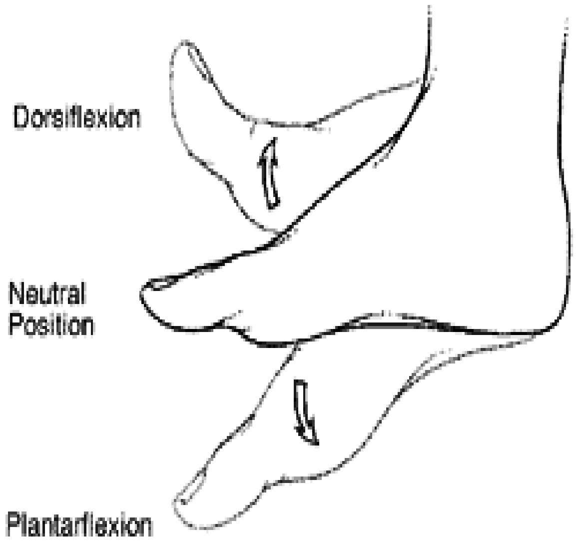

Figure.3.1: Dorsiflexion and plantarflexion of ankle joint

The device provides and assistance in three regions will be determined by the functional requirements of the walk:

(I) dorsiflexior to avoid foot slap during, loading response by foot motion controlling

(II) Plantar flexor torque, which is used to provide assistance to the propulsion for the support, and

(III) dorsiflexior torque to prevent the foot from falling by maintaining toe clearance while walking.

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.

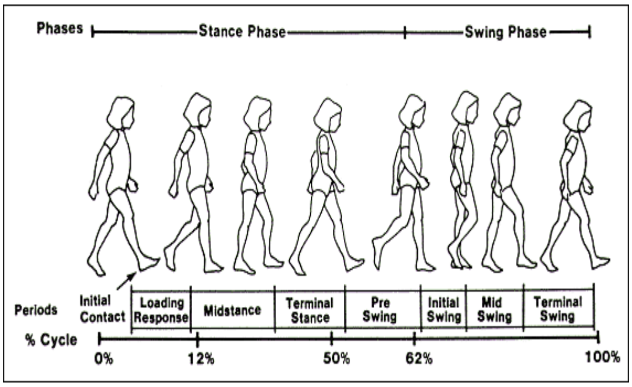

Figure 3.2: Walk cycle for stance and swing phases.

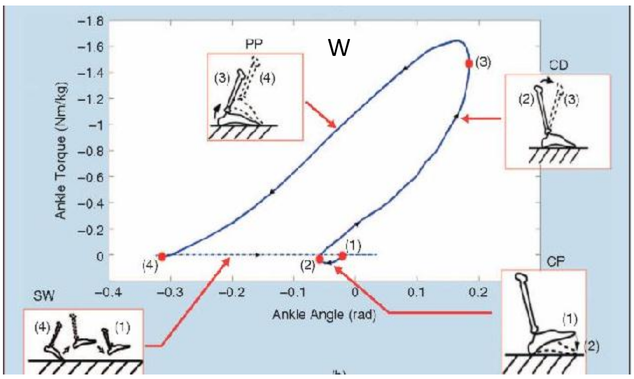

Figure 3.3: Graph between ankle torque and ankle angle

(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-Off 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 behaviour 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 behaviours during CP, CD, PP, and SW phases of gait, respectively.

Segments (1)–(2) and (2)–(3) reveal different spring behaviours 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.

IV.BASIC CONCEPT OF DESIGNING

Designing

The designing of IASOAF is carried out in AutoCAD software. 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

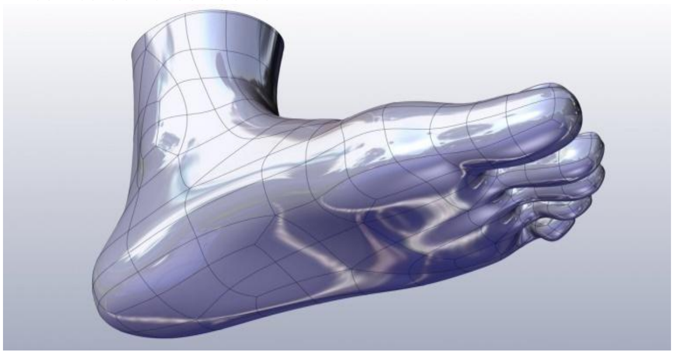

Figure 4.1: 3D model of the foot

System Block Diagram

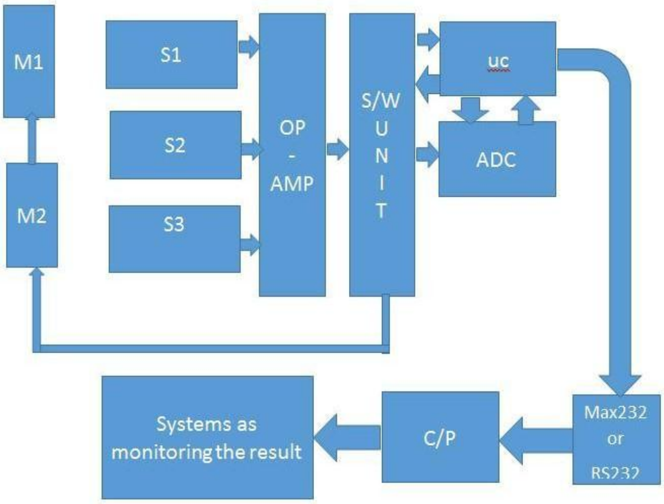

Figure 4.2: Block diagram of system.

Description

This block diagram consists of Sensors, OP-AMP, Microcontroller, Switching unit, Motor, ADC, Communication Protocol and Monitor unit. In input side we have connected sensors i.e. flex sensor, tilt sensor. The Output of these sensors is given to the op-amp which amplifies the weak signal of the sensors. Now the output of sensors is amplified and it is given to the switching unit. The basic function of switching unit is to provide data to different units. So now output of sensors gives to ADC 0809 via switching unit. The main function of ADC is to convert analog value into digital value. System always takes digital value and our sensors gives always analog value. That"s why we are required ADC and same here ADC is converting analog value into digital value. In ADC0809 has 8 input pin and for selecting any pin, it has three channels i.e. A, B, C. ADC 0809 require clock frequency for that timer IC555 used. For one clock frequency ADC transmit or receive one bit data. After receiving sensor value, ADC it gives to microcontroller, microcontroller gives command to switching unit to control output circuit according to sensor value. In Output side we are connected DC gear Motor and Monitor Unit. The use of DC gear Motor is to give the actuation or movement to the device and the use of monitoring unit is to give output in the form of waveform in laptop or pc via software. In that it shows how much amount of pressure created on the device and how much angle changes in between ankle foot and Knee joint and it also shows how many times the motor switches and changes the movement of it. The overall system consist of

a)Prototype of active soft orthotics ankle foot.

b)Hardware

c)Software

V.CONCLUSION

The main contribution of this paper is the design and implementation of a active soft orthotic device. The current design shows that such an orthotic device can provide active assistance. The main contributions of this work are the static and dynamic characterization of force and displacement for pneumatic actuators that are suitable for intelligent active soft orthotic designs. Orthotic designs can include a constant restoring force in addition to soft actuators allowing a full range of motion with reduced complexity and energy consumption. Though comfort, ease of use and acceptance is believed to be improved with soft Systems. In addition to the active assistance for walking, the device also has a significant meaning for physical therapy. Since the device is easily programmable not only for the ankle motions using the tilt sensor but also for replaying the recorded motions. For the long-term success of such orthotic devices, we are also investigating relevant clinical requirements and potential control strategies to provide a new level of mobility and active assistance.

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 have 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 IASOAF will be generated.

The intelligent designed IASOAF is fast responsive for target patient and patient will feel comfortable. The prototype of IASOAF is flexible and has awareness about walk disorders by the use of different types of sensors and data monitoring unit.

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