Post Stroke Flexion-Extension Rehabilitation: Design of Low Cost Lower Limb Exoskeleton

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Abstract- *With the huge development and the latest technological advancement in mechatronics, prosthetic devices have acquired interest in many different fields such as medical and industrial fields. A prosthetic device can be an external wearable machine that covers the body or part of it. It is generated by electric motors. It can be installed on and elbow, wrist & finger. Moreover, it can be used for different purposes such as rehabilitation, power assistance, diagnostics, monitoring, ergonomics, etc. Most of the existing wearable devices face different problems in terms of size, cost and weight; they are huge, expensive and heavy. Therefore, the goal of this project is to design a portable, lightweight and low-cost rehabilitation system for people with a fracture/paralysed based on accelerometer sensor. In this project, we are using PIC microcontroller to monitor and control the knee&ankle. The wearable device allows a user to perform specific movements and exercises to train the patient's fracture/impaired led using IoT communication. Thus, the user gradually starts to restore the functionality of his leg and also alert the care takers/doctor though IoT module based on the leg gesture movement.*

Keywords- Knee &Ankle , Pic Micro controller, IOT Module, Prosthetic Device, Accelerometer Sensor.

I. INTRODUCTION

Amputation of a person's body part influences the life of affected psychologically as well as physically. Currently, rehabilitation of such people is mostly done with the help of dummy limbs made of wood, plastic and/or other light materials. Researchers believe it could offer hope to people who have suffered spinal cord injuries, strokes and other conditions where they will need to regain strength, mobility and independence. Transfemoral amputation is a major disabling condition and early rehabilitation intervention is essential for regaining adequate level of mobility, thus independence in daily life.

In recent years, research in wearable robotics fostered the development of innovative active mechatronic lower-limb prostheses designed with the goal to reduce the cognitive and physical effort of lower-limb amputees in rehabilitation and daily life activities. These devices also enable execution of those tasks requiring active power delivery at the level of the knee joint. Lower extremity amputees suffer from mobility limitations which will result in a degradation of their quality of life. Wearable sensors are frequently used to assess spatiotemporal, kinematic and kinetic parameters providing the means to establish an interactive **control of the amputee-prosthesis environment system. Gait events and the** gait phase detection of an amputee's locomotion are vital for controlling lower limb prosthetic devices. The paper presents an approach to real-time gait event detection for lower limb amputees using a wireless gyroscope attached to the shank when performing level ground and ramp activities. The results were validated using both healthy and amputee subjects and showed that the time differences in identifying Initial Contact (IC) and Toe Off (TO) events were larger in a transfemoral amputee when compared to the control subjects and a transtibial amputee (TTA). Restoring locomotion functionality of transfemoral amputees is essential for early rehabilitation treatment and for preserving mobility and independence in daily life. Research in wearable robotics fostered the development of innovative active mechatronic lower-limb prostheses designed with the goal to reduce the cognitive and physical effort of lower-limb amputees in rehabilitation and daily life activities. To ensure benefits to the users, active mechatronic prostheses are expected to be aware of the user intention and properly interact in a closed human-in-the-loop paradigm. In the state of the art various cognitive interfaces have been proposed to online decode the user's intention.

II. IDENTIFY, RESEARCH AND COLLECT IDEA

Existing System

The existing work presented in this paper is the first step in the development of a prosthetic leg based on Electromyography (EMG) signals, for above knee amputees. The surface EMG signals picked up from the calf muscles of a healthy leg during the muscle activity are interfaced with a microcontroller using EMG acquisition system. These signals are processed, analysed and used to actuate the knee joint of the prosthetic leg. During the course of the present work, it was possible to control the rotation of a motor of prosthetic knee joint using EMG signals from the healthy leg. The completely designed prosthesis will allow users to walk with a better gait.

The human history has been accompanied by accidental trauma, war and congenital anomalies. Consequently, amputation and deformity have been dealt with one way or the other throughout these ages. Our motivation behind this project is the fact that in India, there are nearly 80 lakh people living with limb loss and around 6 lakh people require prosthetic leg every year. Around 70 percent of these are from rural areas. Being engineers, it is our responsibility to develop technology that can improve the life of such people. Our project aims to provide prostheses for above-knee amputees in which the important part is to acquire EMG signals from the calf muscles of the healthy leg and analyse them to provide the control signals to actuate the knee joint of the prosthetic leg using a microcontroller. We intend to design a prosthetic leg which is inexpensive, water resistant and easy to fit.

Proposed System

- Microelectronics and high level integration provide in combination with simulation and modeling of embedded systems new approaches in biotechnology and medical therapy.
- The integration of intelligent systems as well as sensors and actors in an adaptive hardware/software-platform increases flexibility and provides a scalable measurement and identification platform.
- Based on modeling and simulation methods, different applications, like biosignal identification, prosthesis control and rehabilitation monitoring, offer completely new treatment and therapy options.
- In this paper we focus on the platform extensions of the modular gesture movement acquisition and identification platform by using Internet-of-Things modules and introduce new applications for rehabilitation monitoring and evaluation of motion sequences.
- The proposed system allows the user/doctor/physiotherist to control the prosthetic leg anytime from anywhere by using smart mobile phones or PC.
- The user/doctor can control the lower limp via internet by using mobile application and monitor parameters The data is received by IoT module is collected by the microcontroller which is PIC (16F877A) Microcontroller.

HARDWARE SUMMARY

1. POWER SUPPLY

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others.

Power supplies for electronic devices can be broadly divided into linear and switching power supplies. The linear supply is a relatively simple design that becomes increasingly bulky and heavy for high current devices; voltage regulation in a linear supply can result in low efficiency. A switched-mode supply of the same rating as a linear supply will be smaller, is usually more efficient, but will be more complex.

2. TRANSFORMER:

Transformers convert AC electricity from one voltage to another with little loss of power. Transformers work only with AC and this is one of the reasons why mains electricity is AC.Step-up transformers increase voltage, step-down transformers reduce voltage. Most power supplies use a step-down transformer to reduce the dangerously high mains voltage (230V in UK) to a safer low voltage.

3. BRIDGE RECTIFIER:

A bridge rectifier can be made using four individual diodes, but it is also available in special packages containing the four diodes required. It is called a full-wave rectifier because it uses the entire AC wave (both positive and negative sections). 1.4V is used up in the bridge rectifier because each diode uses 0.7V when conducting and there are always two diodes conducting, as shown in the diagram below. Bridge rectifiers are rated by the maximum current they can pass and the maximum reverse voltage they can withstand (this must be at least three times the supply RMS voltage so the rectifier can withstand the peak voltages). Please see the Diodes page for more details, including pictures of ridge rectifiers.

4. REGULATOR:

Voltage regulator ICs are available with fixed (typically 5, 12 and 15V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current ('overload protection') and overheating ('thermal protection').

5. BATTERY CELLS

Battery Cells are the most basic individual component of a battery. They consist of a container in which the electrolyte and the lead plates can interact. Each lead-acid cell fluctuates in voltage from about 2.12 Volts when full to about 1.75 volts when empty. Note the small voltage difference between a full and an empty cell (another advantage of lead-acid batteries over rival chemistries).

III. WRITE DOWN YOUR STUDIES AND FINDINGS

IMPLEMENTATION

INTERNET OF THINGS (IOT)

The **Internet of things** (**IoT**) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these objects to connect and exchange data. Each thing is uniquely identifiable through its embedded computing system but is able to inter-operate within the existing Internet infrastructure.

The figure of online capable devices increased 31% from 2016 to 8.4 billion in 2017. Experts estimate that the IoT will consist of about 30 billion objects by 2020. It is also estimated that the global market value of IoT will reach $7.1 trillion by 2020.

The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, virtual power plants, smart homes, intelligent transportation and smart cities.

"Things", in the IoT sense, can refer to a wide variety of devices such as heart monitoring implants, biochip transponders on farm animals, cameras streaming live feeds of wild animals in coastal waters, automobiles with built-in sensors, DNA analysis devices for environmental/food/pathogen monitoring, or field operation devices that assist firefighters in search and rescue operations. Legal scholars suggest regarding "things" as an "inextricable mixture of hardware, software, data and service".

1) CONSUMER APPLICATION

A growing portion of IoT devices are created for consumer use. Examples of consumer applications include connected car, entertainment, home automation (also known as smart home devices), wearable technology, quantified self, connected health, and appliances such as washer/dryers, robotic vacuums, air purifiers, ovens, or refrigerators/freezers that use Wi-Fi for remote monitoring. Consumer IoT provides new opportunities for user experience and interfaces.

2) SMART HOME

IoT devices are a part of the larger concept of home automation, also known as domotics. Large smart home systems utilize a main hub or controller to provide users with a central control for all of their devices. These devices can include lighting, heating and air conditioning, media and security systems. Ease of usability is the most immediate benefit to connecting these functionalities. Long term benefits can include the ability to create a more environmentally friendly home by automating some functions such as ensuring lights and electronics are turned off. One of the major obstacles to obtaining smart home technology is the high initial cost.

IV. RELATED WORK

INSTRUCTION SET

A PIC's instructions vary from about 35 instructions for the low-end PICs to over 80 instructions for the high-end PICs. The instruction set includes instructions to perform a variety of operations on registers directly, the accumulator and a literal constant or the accumulator and a register, as well as for conditional execution, and program branching.

Some operations, such as bit setting and testing, can be performed on any numbered register, but bi-operand arithmetic operations always involve W (the accumulator) ; writing the result back to either W or the other operand register. To load a constant, it is necessary to load it into W before it can be moved into another register. On the older cores, all register moves needed to pass through W, but this changed on the "high end" cores.

PIC cores have skip instructions which are used for conditional execution and branching. The skip instructions are: 'skip if bit set', and, 'skip if bit not set'. Because cores before PIC18 had only unconditional branch instructions, conditional jumps are implemented by a conditional skip (with the opposite condition) followed by an unconditional branch.

Skips are also of utility for conditional execution of any immediate single following instruction.

The PIC architecture has no (or very meager) hardware support for automatically saving processor state when servicing interrupts. The 18 series improved this situation by implementing shadow registers which save several important registers during an interrupt.

V. OBSERVATION

CORE FEATURES:

- High performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC- 20MHz clock input
- DC- 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory,
- Up to 368 x 8 bytes of Data Memory (RAM)
- Up to 256 x 8 bytes of EEPROM data memory
- Pin out compatible to the PIC 16c73/74/76/77
- Interrupt capability (up to 14 external/internal)
- Eight level deep hardware stack
- Direct, indirect and relative dressing modes
- Power –On Reset
- Power – Up Timer (PWRT) and Oscillator Start – Up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code operation
- Power saving SLEEP mode
- Selectable oscillator options
- Low-power, high speed CMOS EPROM/EEPROM technology
- Fully static design
- In-circuit Serial Programming (ISCP) via two pins
- Only single 5V source needed for programming capability
- In-circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.5v - 5.5v
- High sink source current: 25mA

VI. CONCLUSION

The proposed arm hosts state-of-the art technological advancement, communication protocols, control systems, and human interfacing. Technological advancements have led to the development of numerous wearable robotic devices for the physical assistance and restoration of human locomotion using internet of things. While many challenges remain with respect to the mechanical design of such devices, it is at least equally challenging and important to develop strategies to control them in concert with the intentions of the user. This work reviews the state-of-the-art techniques for controlling portable active lower limb prosthetic and orthotic (P/O) devices in the context of locomotive activities of daily living (ADL) through cloud communication. Orthopedic physical therapy treats injuries to the muscles, bones and other tissues in the body. Patients might have been injured from accidents or playing sports, or they might have difficulties resulting from surgery or a chronic disease. Orthopedic physical therapy treats many types of musculoskeletal injuries, including knee and hip injuries, which result in restrictions in mobility for 20 million patients. In this research, a technology probe is presented for wearable physical therapy support systems, which was deployed into 10 patient homes for three days. Patients wear the device when they exercise and remove it when they finish. The data are visualized on amobile phone/PCcayenne Dashboard to assist PT decision-making during clinical sessions. This gives it great potential in many applications related to the health care field as well as other fields. As long as health care is considered, the idea could be expanded to other body parts as well as to patients having other dysfunctions as nerve damage. On the other hand, many industrial and commercial applications can utilize many features of the proposed lower limp. This is also useful for elderly people, people under rehabilitation, and people with limited mobility, etc. The proposed lower limp amputees may be interfaced to a robotic structure and function as a helper or caregiver to this group of people. It can be programmed to do various functions according to specific patient needs. One potential limitation of this study was the relatively small sample size and the within-group variations in the severity of lower-limb loss injuries. However, this diversity may be considered beneficial as the range of functional abilities improves the external validity of the regression equations, making them more suitable for the wider amputee population. We have developed accurate prediction of physical activity energy expenditure in lower-limb amputee’s population specific prediction models in lower-limb amputees using IoT.

REFERENCES

[1] F. Sup, A. Bohara, and M. Goldfarb, “Design and control of a powered transfemoral prosthesis,” Int. J. Robot. Res., vol. 27, no. 2, pp. 263– 273, 2008.

[2] F. Sup, H. Varol, and M. Goldfarb, “Upslope walking with a powered knee and ankle prosthesis: Initial results with an amputee subject,” IEEE Trans Neural Sys Rehab Eng, vol. 19, no. 1, pp. 71–78, 2011.

[3] M. R. Tucker, J. Olivier, A. Pagel, H. Bleuler, M. Bouri, O. Lambercy, J. del R Millan, R. Riener, H. Vallery, and R. Gassert, "Control ´ strategies for active lower extremity prosthetics and orthotics: a review," J. Neuroengineering and Rehabilitation, vol. 12, no. 1, 2015.

[4] A. Nanjangud and R. D. Gregg, "Simultaneous control of an anklefoot prosthesis model using a virtual constraint," in ASME Dynamic Systems Control Conf., San Antonio, TX, 2014.

[5] K. A. Hamed and R. D. Gregg, "Decentralized feedback controllers for exponential stabilization of hybrid periodic orbits: Application to robotic walking," in American Control Conference, 2016.