Implementation of User Interface for Real Time Control for Wearable Orthotic Device

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ABSTRACT
Man machine interface is one of the crucial feature of any developed system. A powered lower-limb orthotic device used for rehabilitation ofparaplegics provides agraphical user interface for the subject which can be implemented on the real time control of thewearable orthotic device. The rapid development of modern technology does not pace up with current interfaces since they are obsolete and do not meet the user requirements. The real challenge is to develop a user friendly, low cost and intuitive graphic interface which could be easily availed by the user. The work has been focused on developing a smart user interface using compact touch screen display for easy system up-gradation with minimal changes using simple programmable environment such as LabVIEW. An additional feature of the developed system is the interface between GUI touch display and real time controller which makes thesystem even simpler. NI-SbRIO has been used for control implementation and data acquisition, it has built in FPGA feature that ensures the accuracy of acquired data and high synchronization. The developed interface is very useful in real time operation.

Keywords
orthosis, graphical user interface, rehabilitation, touch display, realtime control, exoskeleton

1. INTRODUCTION
Spinal cord injurypatients suffer physical disabilities causes the prevention in the control over movement, making the walking difficult or even impossible. A proper rehabilitation for these patients is given byorthosis, an external device is to be fitted to the body to improve the functionality of human body. Generally named as exoskeleton which is the combination of sensing, control and information.Exoskeletonis an active external mechanical structure attached to a part of human body to augment power or increase themobility of that body part[1].Over the past few decades, many sophisticated robotic lower limb exoskeletons have been developed by the scientific and engineering community.Robotic lower limb exoskeleton has been built for augmenting performance with better human gait pattern [8, 9], assisting with disables, studying human physiology, and retraining motor deficiencies. The recent developments on human robot interaction [2, 3, 4, 5, 6, 7] implement various user interfaces for the control strategies. The user interface is the decisive factor in the acceptance of an orthosis aid system. Several designers have developed various user interfaces such as computer display screens[2]. Here the command is given through Tablet PC display of thecomputer to control the robotic arm. It is based on graphical user interface but theaddition of PC system makes the system bulky and expensive, another method uses voice commands [3, 7].In this, the user specifies a set of commands to perform a task,

record them as a macro, and then replay that macro as a high-level action that is seventeenmotions designed for health exercise[7]. It is prone to noise and needs linguistic accuracy. Wrist pad communicator is the user interface which is implemented on Rewalk Powered Exoskeleton [4]. The patient wears the wrist watch which act as a controller to select particular mode of operation. The system is very costly effective.Another version is joystick based control [5]. Here an external trainer is required and system is not reconfigurable.Finger-mounted walk controller [6] implements complex algorithm which is cumbersome to remember the patterns that makes thesystem lessuser friendly. This paper is focused to develop a user interface that is more intuitive with less complexity and easy accessibility. Graphical user interfaces is one of the most effective command strategy for environmental control [10, 11, 12, 13]. These have been designed for tablet computers. In contrast to the above mentioned methods, implementing stand-alone touch display is more effective. It provides the commands signals as well as manipulate and control the exoskeleton with a single touch.

In the following sections, hardware and software architectures with user interface control strategy have been described, summarize key experimental results on human gait loco motor adaptation in neurologically intact subjects, and present real time experimental data from a subject with incomplete spinal cord injury undergoing motor retraining with lower limb exoskeleton.

2. HARDWARE AND SOFTWARE COMPONENTS
2.1 Hardware Components
2.1.1 SbRIO
Single-Board RIO controller is a highly reliable embedded device for intelligent stand-alone operation. It integrates a real-time processor, reconfigurable field-programmable gate array (FPGA), and analog and digital I/O on a single PCB. SbRIO supports multiple programming environment, including LabVIEW. It allows to focus on the unique features (extendable memory using SD Card, serial ports, 96 additional FPGA DIO lines, and high frequency) for a particular application.

2.1.2 Capacitive/Resistive Touch Display:
Touch display module incorporates monochrome, resistive, capacitive gem modules. The simple programming interface assist developers in designing desired man-machine interface which enables easy one touch access.They are easily programmed with GUI programming in a minimal time and can be easily modified and updated with less efforts.

2.2 Software Components

The system is developed around two software platforms namely *labVIEW* and *GEMstudio*. LabVIEW is graphical programming environment consisting of two windows. The Front Panel and Block Diagram. FrontPanel is the place where theuser interface is developed. After program development cycle is done, the final executable file shows this particular interface virtual instrument. The block diagram is where the actual control program is written. GEMStudio is a software design environment for the implementation of user interface for touch display and is easily programmed by GEMscript with less complexity and minimum time span .Here the modifications and updation can be done easily.It includes an emulator that allows the developed user interface to be simulated on the development computer in order to test the application. After this development stage and test, the user interface can be deployed through GEM studio or through a display file via an API in Lab VIEW by installing specific drivers available in VI package manager toolkit.

3. SYSTEM ARCHITECTURE
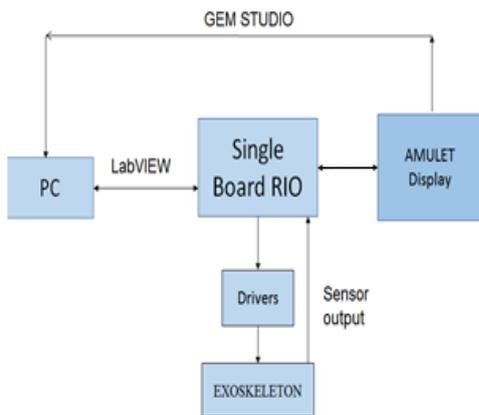
Fig 1. Block Diagram of Real Time Control Architecture

It consist of four main components: *Single Board RIO, Motor drivers, Touch display module and exoskeleton* set up**.** SbRIO sits at the heart of the entire system. Motor drivers will provide the PWM anddirectioninputto control the actuators which are attached to joints of lower limb *exoskeleton***. T**he data frompotentiometer sensors due to exoskeleton movement (feedback data) is taken by the SbRIO and send to PC through Ethernet communication. Touch Display Module can either be turned on through RIO system or Tablet PC having related drivers. The connection protocol is made through VISA. The sensors values were displayed in angular form on the computer screen. In the subsequent stage, data from touch display was fed directly to SbRIOcontroller for mode selection which consists of many display screen coded after each mode selection using GEM script programming.

4. PROGRAM FLOW

Mainly three custom control buttons have been designedfor displaythrough programming for selecting various modes of operations. Initially, thedisplay is powered on and it verifies for the ideal position of theexoskeleton. In case, the ideal (stand) mode, is not selected user will select this mode by tapping stand mode button then select the particular mode according to patient's body requirement via buttons for each mode as sit, walk, and exercise. Touchdisplay has the different modes in subsequent display screens and the

feedback data from sensors will be shown on the computer display.
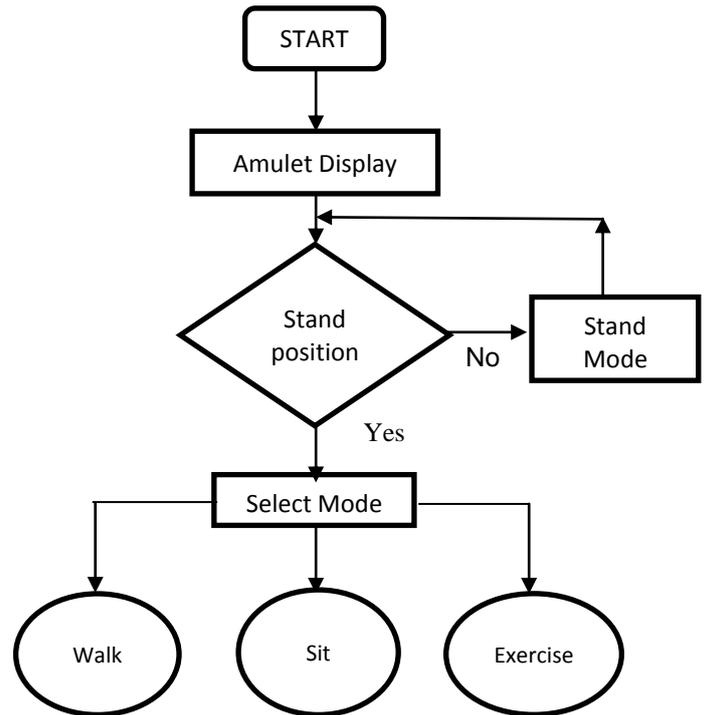
Fig2. Program Flow for Real Time Algorithm

5. REAL TIME TESTING

Rigorous real time trials were made to ensure workability of the system. The exoskeleton is placed on a subject and touch display module is handed to him. The subject asked to change the mode of exoskeleton position such as stand, walk, exercise, sit, when to start and when to stop, under the supervision of atrainer.

Fig 3. Real Time Controlled Algorithm Testing with a Subject

This minimal training ensures patient adaptability to the system. In figure3,the subject is controlling the exoskeleton modes with touch screen display by navigating various pages through GEM Studio. Each time subject selects the mode, anew page will open with astart and stop option.

Fig 4. GUI Display

Fig 5. Shows the page for sit mode selection. It monitors the angle values during sit. Further, programming for other modes is done to monitor and control the position of EXOD which works in synchronization with wearer.
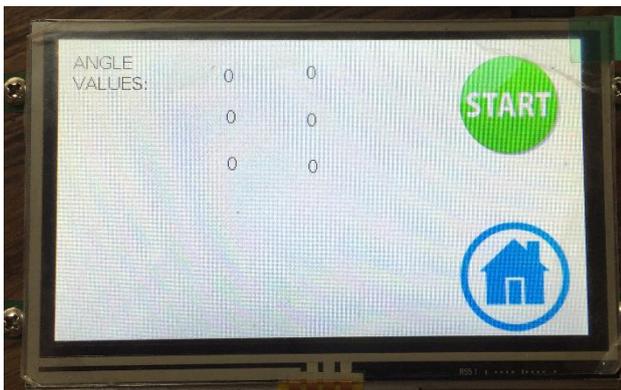
Fig. 5 Designed Page 2 for Sit Mode
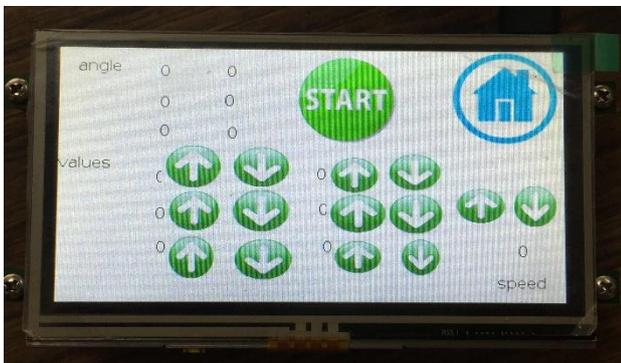
Fig. 6 Designed Page 3 for Exercise Mode

Fig. 6 shows the page for exercise mode selection. It monitors and control the angle values with the control of speed during exercise. Further, programming for other mode like walk is also done to monitor and control the position of EXOD which works in synchronization with wearer.

6. RESULTS

Wearer selects the particular mode as sit, walk or exercise. The data is taken in form of angle values from potentiometer sensors for six lower limb joints when EXOD move as shown below. Angle value taken with respect to time in LabVIEW for left and right hip, knee and ankle.
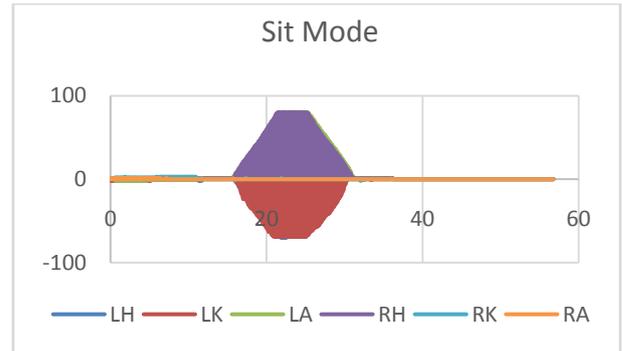
Fig 7. Hip and Knee Angle Trajectory in Sit-To-Stand Mode

In sit mode the hip and knee angle is achieved as 75 degree and -79 degree respectively as shown in Fig. 7
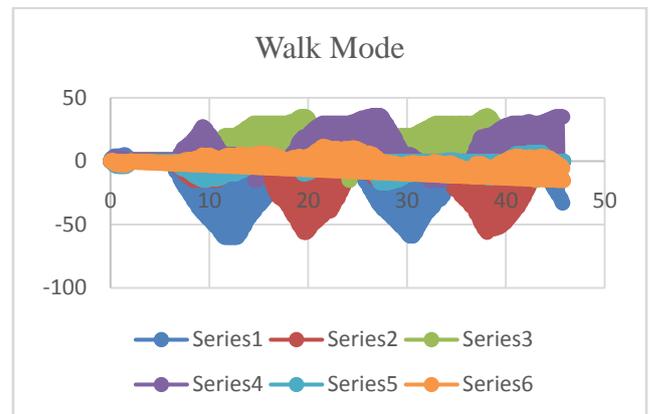
Fig 8. Joint Angle Trajectories in Walk Mode

The walk mode trajectories as shown in Fig 8. for all the joints. Here the series shows the hip, knee, and ankle for both left and right joints simultaneously.
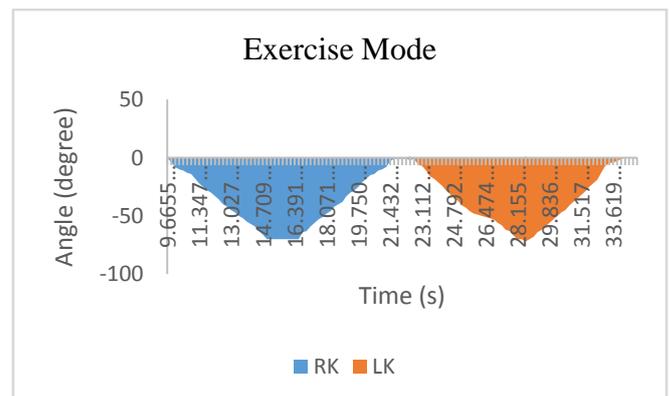
Fig 9. Knee Angle Trajectory In Exercise Mode

The knee joint movement angle trajectory for both the leg is shown in Fig 9.

7. CONCLUSION AND FUTURE WORK

A simple touch based user interface is developed on real time control by a capacitive/resistive display for an orthotic device. The patient has ease in control for providing inputs to the device with minimal training. The developed system uses a tablet PC for analyzing sensor data as well as the touch module inputs. This ensures a better control over the system. In addition to the above mentioned features, the software

platform makes system integration simple through graphical programming. The system will be further extended into a standalone system by replacing the PC with an embedded real time controller. This will assist in developing a wearable and portable device.

8. REFERENCES

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