MEMS Based Haptic Assistive System for Physical Impairments

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Abstract— Computer-assisted therapy is one of the most promising new techniques for those suffering from physical and neurological dysfunction. Yet, impairments to physical movement arising from a central nervous system dysfunction or from muscle spasms generated through other neurological damage or dysfunction can often make it difficult or impossible for individuals to interact with computer-generated environments using a conventional mouse interface. Here we are going to give a assistive system based on gesture control which is convenient for disable person to access the PC very easily.
***Index Terms*— Assistive, Ataxia, Haptic, Impedance.**

I. INTRODUCTION

Our gesture input system can be conveniently used by anyone who wishes not to be tied down to a desk when using a computer, making it perfect for giving presentations or web surfing from the couch. The intuitive hand motion controls also allow it to serve as an alternative video game controller. Additionally, since our input system does not exert pressure on the median nerve at the wrist while in use, it may prevent the development of carpal tunnel syndrome and other repetitive stress injuries.

In recent years, as part of computer-assisted therapy, there has been a considerable body of work directed toward the development of rehabilitation and power/motion coordination systems based on assistive robotic devices. As a result, a wide and diverse range of interface systems have been developed, or used ranging from manipulandums to simple power orthoses and even exoskeletal systems. These devices aim to assist in all areas of physical therapy, for instance, to recover from different injuries, to compensate for various disabilities, or to provide motion coordination/assistance and performance evaluation. Some of these pathological conditions such as Parkinson’s disease, muscular dystrophy, muscle ataxia, and cerebral palsy have symptoms such as reduced strength, restricted or irregular (jerky) movements, poor motion coordination, and a continuum of impairments involving spasms and tremors. Often these physical impairments can make it difficult or impossible for sufferers to interact with computer- generated environments using conventional mouse type interfaces limiting their scope to take advantage of developments in computer technology for work, educational, entertainment, and social purposes. This has a significant impact on life and work opportunities. Assistive robotic devices may help to ameliorate these difficulties for this group. For interactions with a computer-generated environment, the efficacy of various human–machine interfaces such as force feedback mouse have been evaluated in GUI interaction tasks. Velocity-dependent force feedback has been evaluated in a number of other studies to damp erratic motions. It has been shown that increasing the viscous damping helps reduce the level of sudden motions but at the same time resistance to voluntary movement may occur.

Following the same trend, this paper aims to improve the capability and efficiency of people with motion impairments arising from the pathological disorder muscle “Ataxia,” while interacting with computer-generated environments using a conventional mouse interface. Ataxia (from Greek ataxia, meaning failure to put in order) is unsteady and clumsy motion of the limbs or trunk due to a failure of the gross coordination of muscle movements. It is a relatively rare disorder with about 20000 cases in Europe and North America (1/50000). While the term ataxia is primarily used to describe this set of symptoms, it is sometimes also used to refer to a family of disorders. It is not, however, a specific diagnosis. Symptoms usually appear between the ages of 5 and 15 and involve poor muscle tone and weak muscles, difficulty making rapid changes in muscle tension, and undershooting or overshooting of a target trajectory. The third symptom is not only due to the failure of the gross motion coordination and control, but is also a physical consequence of the first two symptoms. Weak muscle tone or inability to rapidly change the muscle tension prevents the subjects from perceiving the expected motion effect of their effort, leading to overshooting of the target trajectory. Subjects, consequently, apply greater effort to generate satisfactory motions which often results in overshooting trajectories. These symptoms can make the use of computer keyboard and mouse devices difficult or even impossible.

II. EXISTING METHOD:

A planar two-degree-of-freedom (DOF) haptic device and an assistive control scheme are proposed for improving 2-D cursor-based motions of ataxia impaired individuals when interacting with a computer-generated environment. The reduction in the undershooting is achieved by assisting the execution of movement to compensate for the poor muscle tone.

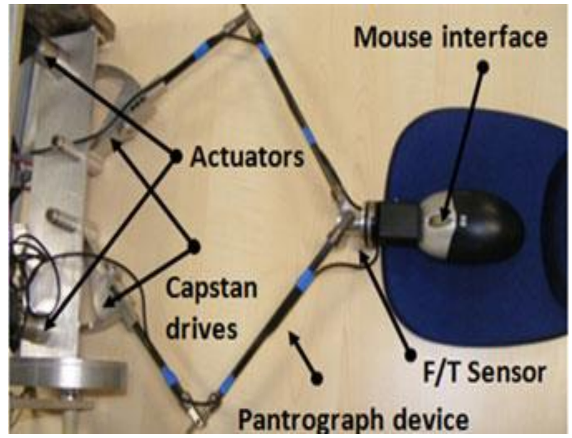

Fig. 1. Planar pantograph haptic system integrated with a mouse.

This allows the impaired subjects to generate motions with less effort which in consequence reduces the possibility of overshooting. The end-tip of the device has been attached to a traditional mouse interface to form the complete mouse motion assistive interface. The paper is organized as follows. It presents the assistive haptic device. Next it introduces the operational principles of the assistive control scheme, while Section IV presents the extension of the controller to the full system.

III. HAPTIC ASSITIVE SYSTEM BLOCK DIAGRAM:

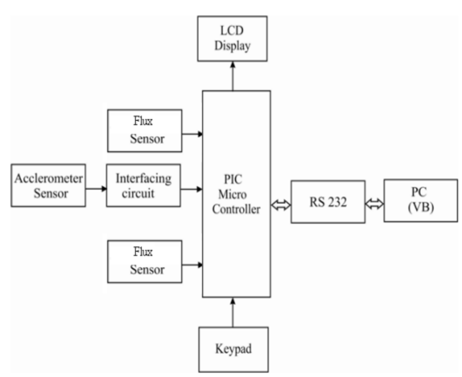

Fig 2 Block Diagram of haptic assistive system

Micro controller is a standalone unit ,which can perform functions on its own without any requirement for additional hardware like i/o ports and external memory. The heart of the microcontroller is the CPU core. In the past, this has traditionally been based on a 8-bit microprocessor unit. For example Motorola uses a basic 6800 microprocessor core in their 6805/6808 microcontroller devices. In the recent years, microcontrollers have been developed around specifically designed CPU cores, for example the microchip PIC range of microcontrollers.

Accelerometer is mainly used for cursor movement. When the accelerometer experiences an acceleration, the mass is displaced to the point that the spring is able to accelerate the mass at the same rate as the casing. The microcontroller that has been used for this project is from PIC series. PIC microcontroller is the first RISC based microcontroller fabricated in CMOS (complementary metal oxide semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory. The main advantage of CMOS and RISC combination is low power consumption resulting in a very small chip size with a small pin count. The main advantage of CMOS is that it has immunity to noise than other fabrication techniques.

The haptic device and its control scheme aims to aid a subject with motion coordination difficulties to interact with GUIs using a mouse by assisting the movements in the trajectory regions where motion is weak. We introduce the assistive control for the haptic device by initially considering the 1-DOF linear mechanical system shown in The extension of the concept to the full system will be discussed in the next section.

In resemble the mass and damping properties of the human forearm and hand segments (mouse motions are primary generated by the movement of the elbow, wrist, and finger joints). The user mass/damper block is fixed to the device end-tip through a force sensor which monitors the forces exchanged between the user and the haptic device. The device itself is represented by the mass/damper network denoted by Md and . The spring/damper arrangement indicated by is a virtual spring/damper group which is attached to the device tip at its one end point and represents the assistive control network. The remaining notations introduced as follows: is the force applied by the user, the force provided by the device, Fs the force measured by the sensor, the force generated by the actuator A, the current device end- tip position, and Xe the assistive network grounding position which is dynamically updated according to the user effort and intended motion.

IV. EXPERIMENTAL EVALUATION AND DISCUSSION

A number of experiments were conducted to evaluate the performance of the impedance assistive control scheme.

A. Assisting the Execution of Free-Path Trajectories

The first experiments aimed to validate the functionality of the assistive control scheme and evaluate its ability to provide different assistive force levels. During these trials, one healthy subject manipulated the device without any constraints, and executed a number of free-path trajectories.

The execution of these trajectories under the assistive mode of operation required the tuning of the assistive control scheme. The inertial matrix of the desired impedance was set ac- cording to to maintain the Cartesian inertia of the haptic system at the original level.

Both simulations studies and experimental manual tuning procedures. As a starting point, we consider a bandwidth of rad/s) and a damping ratio off or the assistive response of the 2-DOF system presented. Fine tuning of the stiffness and damping matrixes was performed by a series of trials where adjustments of the (**K**a , **B**a **)** were made while the healthy subject manipulated the device in the *XY* plane to reach randomly indicated target locations. Overshooting of the trajectories was measured at the target locations but it was not visually shown to the subjects (overshooting of the cursor was visually removed by attracting the cursor image to the target location despite the fact that the real-measured trajectory may overshoot the target location). The tuning of the assistive net- work was then performed manually based on the amplitude of the overshooting at the two target point locations and the level of the assistive forces applied during the motion from one target.

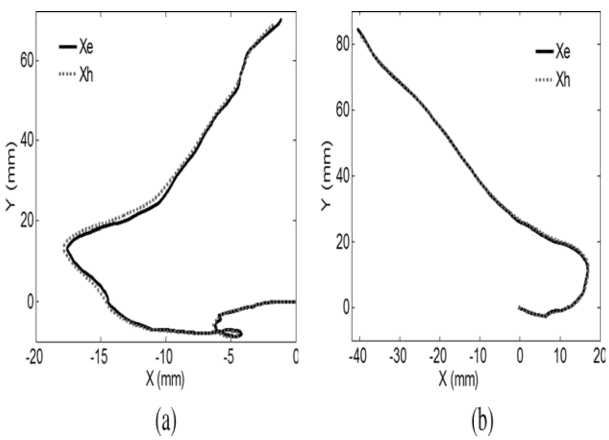

Fig 3. Unconstraint trajectories executed under the assistive mode

The computation of the user forces was achieved using and through the monitoring of force applied to the force sensor and the force generated by the device which was computed from the measurement of the device state. The individual *X* and *Y* components of the assistive impedance equilibrium trajectory **x**e as well as the user hand trajectory **x**h are presented in the middle row. The assistive functionality of the sys- tem and its control scheme can be observed in the last row of which shows the forces applied by the user and the forces generated by the device. The ratio between the forces generated by the device and those applied by the user can be regulated by tuning the matrix **K***f* . presents a second trajectory performed with *k*f = 2.

The corresponding user and device forces generated and the resulting trajectory components. In this second case, as can be seen in the bottom row the ratio between the device forces generated in response to the user applied forces is higher, indicating greater assistance. For both levels of *kf* , the resultant trajectories are smooth, as predicted in the simulations used for the tuning of (**K**a **,** **B**a) with no evidence of forced oscillations.

B. Improving the Tracking Performance

The second set of trials involved a subject suffering from muscle ataxia. The purpose of these experiments was to evaluate if the assistive functionality demonstrated in the first (able bodied) experiment can aid the ataxia impaired subject to interact better with a computer-generated environment by reducing the effect of undershooting/overshooting behavior. The test subject was a regular computer user and possessed the ability to manipulate the mouse in a somewhat good manner but with difficulties in the accurate target tracking, e.g., moving a vertical or horizontal slider or selecting an item from a drop- down menu.

During this experiment, the subject, sitting in front of a computer display, manipulated the mouse attached to the tip of the haptic device and performed a number of tracking experiments with and without the use of the assistive control scheme.. A target tracking task required the subject to follow an on- screen target pattern with a cursor which was controlled by manipulating the mouse at the tip of the haptic device in a manner similar to computer mouse input. In the first phase of this experiment, no haptic assistance was provided.

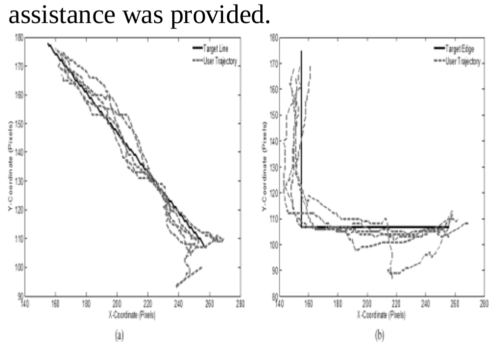

Fig. 4. Line and edge tracking performance of the muscle ataxia impaired subject.

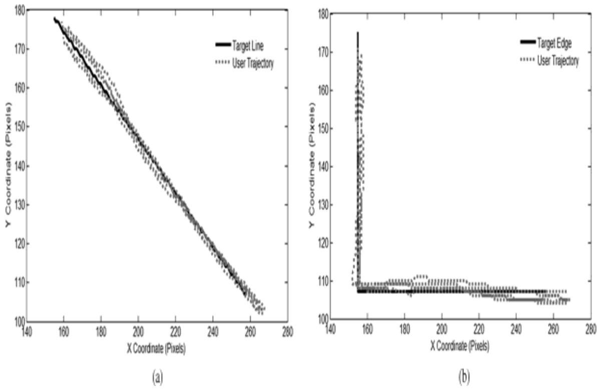

Fig. 5. Line and edge tracking performance of a typical healthy subject.

To demonstrate the tracking difficulties of the muscle ataxia subject, the same experiment was also repeated with the healthy subject. Both the impaired subject and healthy subject were asked to track the line and edge patterns several times as quickly as they could.

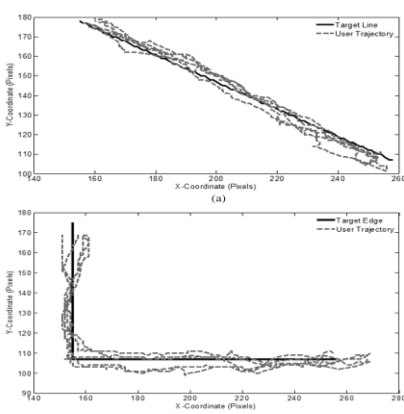

Fig. 6. Line and edge tracking performance of the impaired subject with assistive control.

In terms of execution time, the impaired subject was, in addition, able to complete the task in less time (19% reduction) compared with the time needed in the case of the unsupported trajectory, *t*(W/WO) = 14.72/18.13 s. In the case of the line target similar trends were observed. The overall trajectory is also smoother and more regular with fewer and smaller jerks or spasms.

V. CONCLUSION

Our proposed device was developed to assist the impaired subjects with poor muscle tone and weak muscles to interact with a computer-generated environment using a mouse interface. The device control scheme was designed to assist the impaired subject to complete a tracking task with higher accuracy and in less time. The overall system was evaluated with experimental trials performed by a healthy and an impaired subject suffering from muscle ataxia. Following the previous promising output the current work focuses on improving the system hardware optimizing, size, portability, and cost. Further trials are also foreseen for the near future to assess the application of the system in other pathological conditions including Parkinson's disease, muscular dystrophy, and cerebral palsy. These disabilities are typically associated with symptoms such as reduced strength, restricted or irregular jerky movements, poor motion coordination, and a continuum of impairments involving spasms and tremors. Further extensions of the assistive controller may include the use of electromyography signal to intrinsically monitor and extract the user intention/ direction of motion which will drive the device assistance effort.

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