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Hand Gestures Recognized Haptic Glove in Medical Training

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ABSTRACT: Aiming at realization of direct and intuitive cooperation between human and robot, the project is to develop an interface system for a mobile robot that can communicate with its user via hand-to-hand force interaction.The objective of this project is to represent an approach for controlling a mobile robot with hand gestures.A foremost goal of this project is to provide basis for understanding glove system technology and how it can be applied. Development of novel design of a haptic glove mechanism that is a lightweight, portable and self-constrained mechatronics system that fits on a bare hand and provides haptic force feedback to the finger of the hand without contraining their movement.The whole Haptic System is composed of a glove skeleton and a control interface.This interface uses microcontroller.This proposed system can be implemented by using appropriate embedded system.

KEYWORDS: Exoskeleton; haptic interface ;Force Feedback; mobile robot;telesurgery

I. INTRODUCTION

Haptics is an enhancement to virtual environment that allow users to touch and feel the simulated objects with which they interact. The paper focuses on design and implement a mobile robot and control it using a human gestures by means of haptics technology. The several enhancements should be required to the typical VR simulation. Firstly the system requires a appropriate haptic synchronization which transmits the feedback to the user's hand. Mostly, joysticks or small robotic arms are used for interfaces. Second, rendering tools has to be introduced, which contains a library of functions to calculate contact forces. Haptic rendering tools were usually designed for specific interface devices. Haptic gloves are the more complex category of haptic interfaces.

Haptic gloves has the capabilities of force feedback by allowing the user to feel virtual objects in a much more natural way. Although many research activities have been performed on haptic glove designs, they either restrict the natural motion and maximum output force of the hand or are bulky and heavy. The design issue related in haptic sensations is that the user hand movement should be unrestricted in case of absent of the. Haptic devices must allow the user to make desired motions, thus requiring sufficient degrees of freedom of motion. The proposed haptic device will be designed in such a way that it will solve all the design issues.

The glove designed in this paper provides haptic feedback during human machine communication. Haptic interfaces will recognize the user's hand gestures and simultaneously send the force information to the user. Past many years, haptic devices have been used in many applications of medical training and rehabilitation ,tele-surgery ,tele-manipulation, tele-navigation, as well as micromanipulation. The goal of this project is to introduce a haptic glove that satisfies following objectives,So that additional benefits were achieved with the Glove:

- Amount of Actuators needed is reduced: The whole mechanism can be done by using one single actuation unit.
- Amplification of workspace: The Actuator unit is placed at the back of the hand. So that motion of the user's finger would be unrestricted. It also increases the workspace of the proposed glove.

Our project is devoted to developing the principles and tools needed to realize advanced haptic glove and human-machine systems capable of haptic interaction.

In this paper, the design and implementation of the haptic glove are described. The paper is organized in certain sections. Section II describes the mechanical design and of the glove. Section III shows the electrical design of the

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system. Section IV defines the control system of the glove mechanism and Section V summarizes the paper and describes future work.

II. RELATED WORK

The hand gestures of the user are measured, mapped and send to the mobile robot via RF module. Simultaneously, object information around the mobile robot is collected, processed and send back to the glove. So that virtual interaction force can be generate to the user. Based on the feedback, the user can “feel” the approach to an obstacle and hence control the robot more smoothly and safely in an intuitive way with natural motions of the finger.

As shown in the figure, The designed glove prototype fits on a bare hand f the user. The system, contained battery ,control unit, actuator unit and mechanical hand skeleton. Described all components are light in weight and embedded inside the glove, So that user can make a hand movement very freely without being restricted.

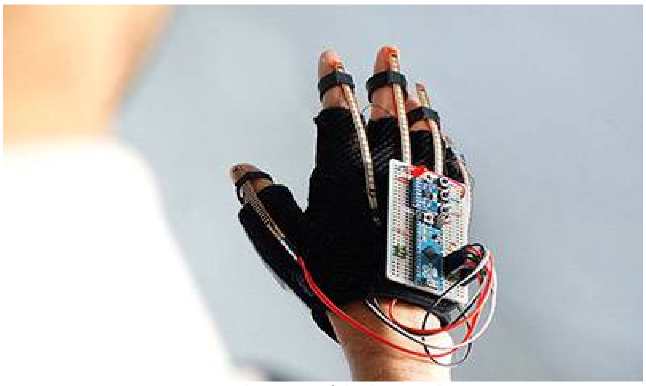

Fig.1. Schematic of the haptic glove

A. **Actuation Unit**

Fig.1 shows the proposed haptic glove.Which gives the realistic feel of touching or holding any object.The designed glove also satisfies the requirements regarding design issues which are mentioned in the introduction.The user can freely make a movement with his hand as all components are embedded inside the glove.So,the without being restricted;user can easily make a hand gestures.

The glove is further designed to fit onto the back of the hand , so the operator can feel the motion of the fingers in a more realistic way .Three primary components define the proposed design: a support pad, servo motors, and the actuator unit.Electronic components including the control system and batteries are attached to the support pad. The actuator unit, connected to the support pad, consists of a brushed DC-motor.

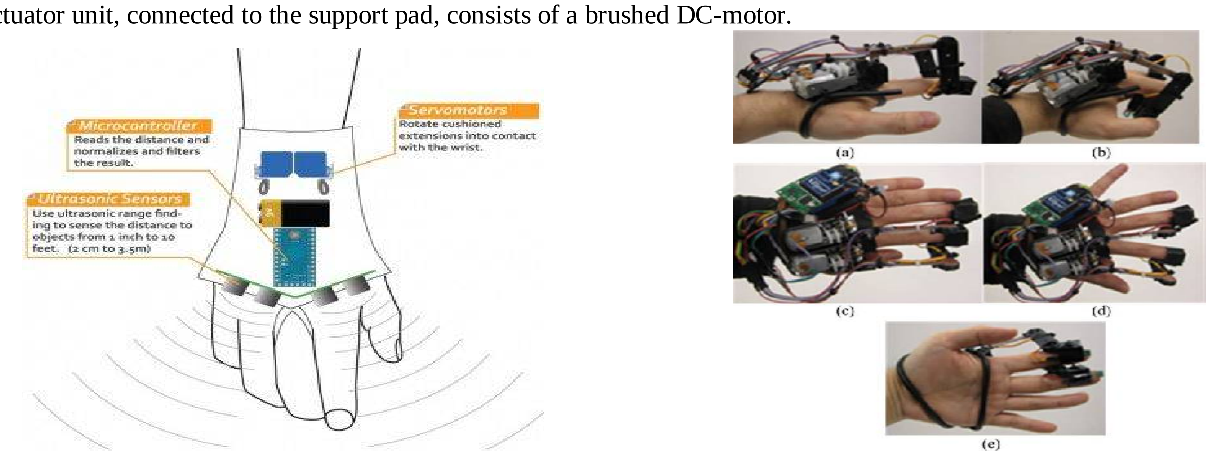

Fig.2. Different views of the glove mechanism in stretched, bent and abduction position

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Fig. 3(a) and (b) shows the side view of a user hand with the glove in stretched and bent positions. In Fig. 3(c) and (d), The top view in normal and abduction position can be seen. The bottom view is shown in Fig. 3(e).
In case of static equilibrium, if there is an external force
f_e=[f_{ex} + f_{ey}]^T applied on the tip of the finger mechanism, by virtue of the principle of virtual work, the actuator's forces f_{ai}, = 1, 2 (for two fingers)should be,

$$fa = -J^T fe \quad (1)$$

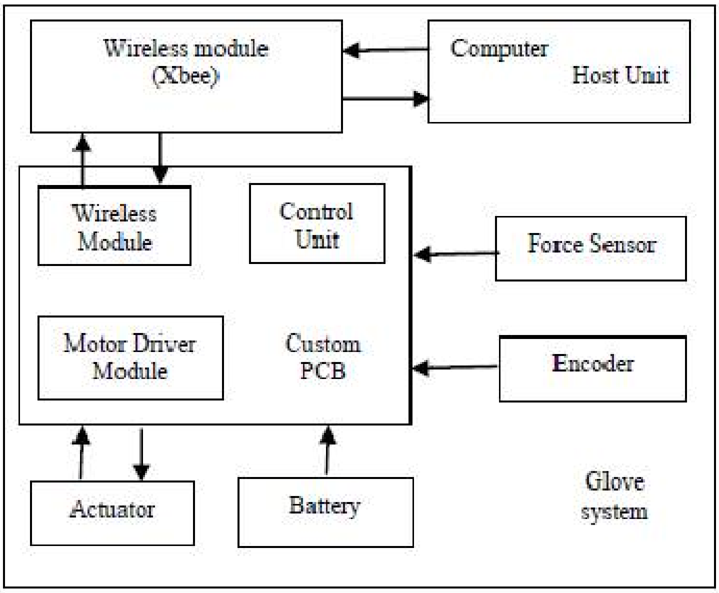
where J denotes the Jacobian matrix of the haptic device. According to, the normal force on the finger pad is more important for haptic devices. Therefore, the primary force that will be sensed by each finger in the glove will be the normal force applied to the surface of the fingertip. The accuracy of the magnitude of this normal force f_{ey} , is a key factor in haptic glove and precision teleoperation grasping tasks applications. Thus, the contact force component in the other direction (i.e.,f_{ex}) is ignored.

III. ELECTRICAL DESIGN

The whole system is about the glove skeleton and control interface. The figure shows the electrical design. The system uses MEGA168 microcontroller to read force sensor datas. It also controls the force applied at the user's fingers. Microcontroller communicates with the mobile robot. Here different sensors are used, including Flex sensors and Forse sensitive sensors. These sensors are used to measure a normal force at the fingertips. Servo motor's current is measured through the shunt circuit. Here, force measurement is essential for force feedback and data collection.

A customized PCB is mounted to reduce the complexity of the design and also to reduce ht thickness of the mechanical construction. Here, encoders are used directly onto the PCB board. It is used as carrier of the electrical components and signals. This functions make the glove mechanism lighter.

Human-machine synchronization can be achieved via RF module. This RF module make the glove lighter, portable and self-contained. The data which haptic glove transmits contain contact force. And the data that haptic glove receives contain the information about mobile robot speed and forces applied to the user's fingers.



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IV. CONTROL SYSTEM

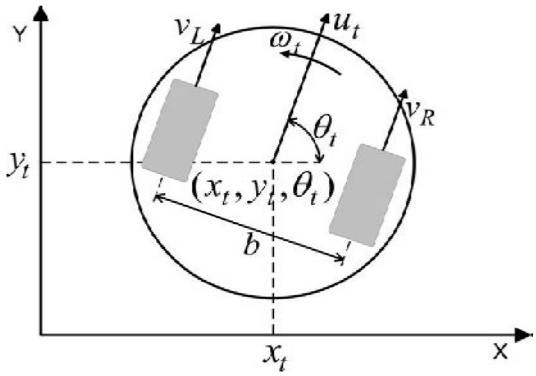
A. Teleoperated Control

Mechanism of the glove and the mobile robot is included in this control system. The contact force and position of the fingers can be measured and calculated via kinematic mechanism. The velocity commands are calculated and send to the mobile robot via RF module. Accordingly ,the mobile robot controls the speed of the wheels. Meanwhile, The obstacle distance information is converted into a virtual force through robot and again sends it back to the haptic glove. This will generate force feedback to represent the proximity to obstacles.

when the glove is in active mode force feedback can be provided based on the proportion of the velocity between the finger's motion. The controller works on the principle of conversion of the obstacle distance information from the mobile robot into an equivalent force applies at the fingertips of the user. When the robot is moving fast or it is getting close to an obstacle, The glove will provide a large force feedback. In that case, The controller will help to reduce the speed to avoid the collision.

B. Model of the Mobile Robot

The Fig, the position of the mobile robot can be denoted as $p = [x, y, \theta]^T$,The kinematic motion of the mobile robot can be defined as,



$u = (vR + vL)/2$ (2)

$\omega = (vR - vL)/2$ (3)

$$\begin{bmatrix} x \\ y \\ \Theta \end{bmatrix} = \begin{bmatrix} cos\Theta & 0 \\ sin\Theta & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} u \\ w \end{bmatrix} \quad (4)$$

$$\begin{bmatrix} x \\ y \\ \Theta \end{bmatrix} = \begin{bmatrix} x_0 + \frac{u}{w}[\sin(\theta_0 + w\Delta t) - \sin(\theta_0)] \\ y_0 - \frac{u}{w}[\cos(\theta_0 + w\Delta t) - \cos(\theta_0)] \\ \theta_0 + w\Delta t \end{bmatrix} \quad (5)$$

Here, u and ω are linear velocity and angular velocity of the mobile robot , respectively;
vL, vR are the velocity of the left and right wheels;
$[x_0, y_0, \theta_0]^T$ are the position and orientation in the previous time step.

C. Mapping of the teleoperation

In this paper, the use's hand gesture was measured through the glove and received information is converted into velocity commands. These commands are sent back to the mobile robot. The mapping between the robot velocity commands and the user's finger position is defined by ,

$$v_R = \begin{cases} 0, & if\ 30° \geq \theta_{1middle} \geq 0° \\ -K_m\theta_{1middle}, & Otherwise \end{cases} \quad (6)$$

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$$v_L = \begin{cases} 0, & if\ 30° \geq \theta_{1index} \geq 0° \\ -K_m \theta_{1index}, & Otherwise \end{cases} \quad (7)$$

Table: Robot movement according to the Hand Gestures

Finger position(I:Index,M:Middle)	Locomotion of the robot
Both[-90,-30]	Move forward
Both[-30,0]	Stop
Both[0,30]	Move Backward
I:[-30,30],M:[-90,-30]	Turn Left
I:[-90,-30],M:[-30,30]	Turn Right

The wheels of the mobile robot is controlled through the user's index and middle fingers. Index finger is set to control left wheel of the mobile robot. And right wheel of the mobile robot is control through the middle finger.

V. Conclusion and Future Work

In this paper, Sensor-based haptic gloves is presented in detail. Designing of haptic glove and mobile robot is described in this paper. Simultaneously, related calculations has also done.

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BIOGRAPHY

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