Rml Glove An Exoskeleton Glove Mechanism With Haptic Feedback

Ms. Ayushi Sudhir Pethe[1], Prof. D. S. Bhosale[2]
Department of E& TC
[1, 2] JSPM's BSIOTR Wagholi,Pune,India

Abstract- *This paper presents the design, implementation, and experimental validation of a haptic glove mechanism: the RML glove (Robotics and Mechatronics Lab). The designed haptic in-terface is a lightweight, portable, and self-contained mechatronic system that fits on a bare hand and provides haptic force feedback to each finger of the hand without constraining their movement. In order to experimentally test the new design, teleportation with this glove for mobile robot navigation is also studied. By compar-ing teleportation experiments with and without force feedback, the results show that this new admittance (using force as input and position as output) glove with force feedback can provide effective force feedback to the user and augment telepresence.*

Keywords - *Exoskeleton, force feedback, haptic interface, teleoperation mapping*

I. INTRODUCTION

HAPTIC interfaces can measure one's body position and movement, while concurrently providing operators with touch, force or torque information generated from a remote or virtual environment . During the last decade, haptic devices have been utilized in many applications for medical training and rehabilitation, telesurgery telenavigation , as well as micromanipulation .Of remote robots, as opposed to other haptic devices such as joy-sticks and PHANTOM . 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.

Turner et al. completed tests for a commercial haptic glove known as the CyberGrasp . The CyberGrasp is a haptic device with one-direction active force feedback, which fits on the. As one type of haptic devices, haptic gloves expand the ca-pabilities of force feedback by allowing the user to feel virtual hand, and provides force feedback to each finger. In order to reduce the weight and size of the mechanism, the glove joints were activated by a cable-driven mechanism which transmits the force between the fingers and a distant Actuator Unit. With this design the load of the haptic device was reduced on the hand, but the outside Actuator Unit still restricted the natural motion of the hand to 1 m spherical radius from the Actuator Unit due to limited cable objects in a much more natural way. This ability is required in many applications . The high dexterity of haptic gloves also makes them applicable to the control of complex movements of remote robots, as opposed to other haptic devices such as joy-sticks and PHANTOM . 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.

II. PROBLEM STATEMENT

The designed haptic in-terface is a lightweight, portable, and self-contained mechatronic system that fits on a bare hand and provides haptic force feedback to each finger of the hand without constraining their movement. In order to experimentally test the new design, teleportation with this glove for mobile robot navigation is also studied. By compar-ing teleportation experiments with and without force feedback, the results show that this new admittance (using force as input and position as output) glove with force feedback can provide effective force feedback to the user and augment telepresence.

III. BACKGROUND

Employed magneto-rheological brakes (MR brakes) to develop a haptic glove referred to as the MR glove, with a wearable size placed on the back of the fingers [16]. Passive force was transmitted through small MR brakes con-nected directly to the exoskeleton links instead of using cables. MR brakes can apply passive torque up to 899 Nm•m on three fingers in both flexion and extension directions. However, the entire glove weighed 640 g; the load concentrated on the fingers and creates a discomfort to the operator when using the glove for an extended period of time. Besides, an MR brake requires high current drivers and high capacity batteries, which are bulky and heavy. Moreover, the MR glove which employs controllable brakes belongs to the category of passive haptic devices [1] that cannot provide active force feedback to the operator.

.IV. SYSTEM DEVELOPMENT

A. System Block Diagram

The haptic system is composed of a glove skeleton and a control interface. The overall Design shown in figure.

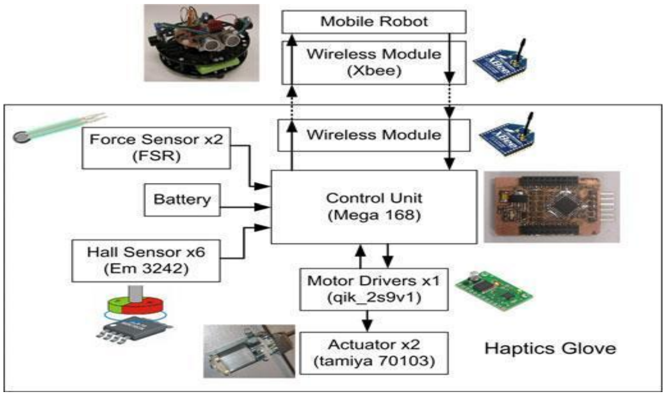

Fig.1.Block Diagram

B. Hardware Selection

1. Microcontroller
LPC2138 microcontrollers are based on a 16-bit/32- bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontroller with embedded high speed flash memory ranging from 32kB to 512kB. A 128-bit wide memory interface and a unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30% with minimal performance penalty. Due to their tiny size and low power consumption, LPC2138 is ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, SPI, SSP to I2C-bus and on-chip SRAM of 8kB up to 40Kb.

2. Control Systems
The teleoperation control system consists of the glove mech-anism and a mobile robot as shown in Fig. 7. When the operator wears and operates the glove, the rotation angle and the status of the mechanism links are measured and each finger position is calculated via inverse kinematics solution of the mechanism.

3. Actuation Systems
In order to lighten and simplify the whole glove, the movements of the Distal Inter-phalangeal (DIP), Metacarpophalangeal (MCP), and Proximal Interphalangeal (PIP) joints of each finger are coupled together with one actuator module. The actuator unit consists of a brushed dc-motor (Mabuchi FA-130, [25]) geared to a pulley through nonbackdrivable worm gears. The maximum speed of the actu-ator module is 150 r/min when powered with 9-V battery. At this speed, the time of the hand's maneuver, from fully open to close, then back to open again, is about 1 s.

4. Glove Sensor
Through the glove, hand gesture of the user is measured, mapped, and transmitted to the mobile robot in the form of velocity commands through a wireless network. Conversely, distance information of the ob-jects around the robot is collected, processed, and sent back to the glove to generate a virtual interaction force to the user. Based on the feedback of this virtual force, 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 [24].

C. Implementation and Results

Experiments were set up to evaluate the performance improvement provided by the haptic glove in HRI mode. The trial area (approximately 1 × 1.4 m) was surrounded by four large white boards . Two boxes (rectangular: L37 × W17 × H28 cm, cylinder: D25 × H37 cm) were located inside the enclosure. The operator's goal was to navigate the robot (D13 × H10 cm) to follow the wall and return to its start point, while avoiding collision with the objects and completing the task as quickly as possible. Initially, the robot was located inside the starting area and the angle between its translation axis and the right wall was arbitrary selected from -30° to 30°. Direct view of the trial area was obscured during the teleoperation, but the wireless camera mounted on the robot provided a real-time active view on a monitor directly in front of the glove user . Once the robot returned to the home position, the trial timing was terminated.

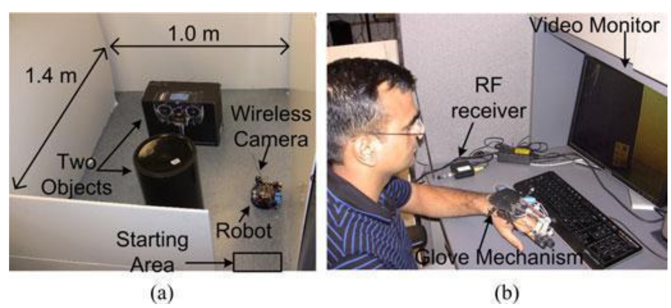

Fig.2. Example Hardware Implementation

V. DISSCUSSION AND FUTURE WORK

The performance of the haptic glove was evaluated on a mo-bile robot in a master–slave control experiment with force feed-back. Because of the integrated force feedback, the operator can "feel" what the robot senses (e.g., distance to an obstacle), which enables a smoother and safer human-in-the-loop control of the robot. By comparing the two kinds of teleoperation with and without force feedback, the experimental results show that this new admittance glove with force feedback can augment telepresence.

IV. CONCLUSION

The proposed glove mech-anism has the following advantages:Since fingers are far more dexterous than the wrist data gloves provide accurate motion capture [37]. Since the human hand has large information capacity in gesture-based communication [38], the glove mechanism can provide. Since wireless glove apparatus is a valuable communication method, it makes controlling robots during covert or hazardous missions possible. In the future, the two-finger design will be further devel-oped into a five-finger design.

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