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Forefinger Direction Based Haptic Robot Control for Physically Challenged Using MEMS Sensor

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***Abstract*-The ability to feel the world through the tools we hold is Haptic Touch. The sensory element that will transform information into experience by remotely interacting with things is challenging. This paper deals with design and implementation of fore finger direction based robot for physically challenged people. The design of the system includes microcontroller, MEMS sensor and RF technology. The robot system receives the command from the MEMS sensor which is placed on the fore finger at the transmitter section. Robot will follow the direction in which we show our Forefinger. The path way of the robot may be either point- to-point or continuous. This sensor can be able to detect the direction of Forefinger and the output is transmitted via RF transmitter. In the receiver section RF receiver which receives corresponding signal will command microcontroller to move robot in that particular direction. Therefore the simple control mechanism of the robot is shown. Experimental results for fore finger based directional robot are enumerated.**

Keywords- robotic body, wireless technology, MEMS sensor, Haptics.

I. INTRODUCTION

Haptics is a recent enhancement to virtual environments allowing users to “touch” and “feel” the simulated objects with which they interact. Haptics is the science of touch. The word is derived from the Greekword haptikos which means “being able to come into contact with”. The study of haptics emerged from advances in virtual reality. Virtual reality is a form of human-computer interaction (as opposed to keyboard, mouse and monitor) providing a virtual environment that one can explore through direct interaction with our senses. To be able to interact with an environment, there must be feedback. For example, the user should be able to touch a virtual object and feel a response from it. This type of feedback is called haptic feedback. In human-computer interaction haptic feedback means both tactile and force feedback[1].

Haptics are applied on a wide range of devices. In the extreme with respect to precision, surgical simulators use haptics to provide realistic forces that emulate the feel of a real medical procedure. In the extreme with respect to the magnitude of the force feedback, computer gamers can experience added realism to their favourite games with haptic enabled joysticks that allow them to feel every bump, explosion, rumble, burst of gunfire and other vibration-based activity. Haptics is also emerging into cell phone design. The simple act of the phone vibrating when a call is received is the most recognizable and rudimentary form of the technology. The clinical skills of medical professionals rely strongly on the sense of touch, combined with anatomical and diagnostic knowledge [1].

Haptic environment properties and human haptic perception as relevant to medical examinations and procedures: Characterization of the nature of haptic information, and how it is perceived, is necessary to understand how medical professionals use haptics to enable learning and achieve high levels of performance. Papers that explore haptic models of the patient, as well as perceptual or behavioural aspects of the haptic modality relevant to medical examinations and procedures, are solicited. Haptic systems and the role of haptics in training and evaluating clinical skills: Haptic simulators address a growing need for effective training and evaluation of clinical skills [3].

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Such simulators can be applied in a wide variety of medical professions and disciplines, including surgery, interventional radiology, anaesthesiology, dentistry, veterinary medicine and the allied health professions. These simulators rely on both technology development (devices, software, and systems) and an understanding of how humans use haptic feedback to perform established clinical skills or learn novel skills. Papers that address simulator development and/or evaluation from these perspectives are solicited [1] [3].

Motivation: The need to develop a simple yet effective module with low cost and user effectiveness for the need of physically challenged people.

Contribution: The proposed model is aimed at providing the basis for developing devices which are aimed at physically challenged people and people with less mobility.

Organization: The paper is organized is follows: Section II reviews the related work of the fore finger based ,Section III explains the Basic Design and Requirements, Section IV gives the hardware essentials, Section V deals with Implementation details and Section VI includes the snapshots of the kit and Section VII concludes the paper with Future enhancement discussion.

Applications: Haptic exploration has applications in many areas including planetary exploration, undersea operations and operations in remote and hazardous conditions. Applications of the human haptic interaction, multi-sensory perception, action and multimodal feedback can be applied in the fields of education, rehabilitation, medicine, computer aided design, skill training, computer games, driver controls, simulation and visualization.

II. RELATED WORK

MEMS are made up of components between 1 to 100 micrometres in size (i.e. 0.001 to 0.1 mm), and MEMS devices generally range in size from 20 micrometres (20 millionths of a metre) to a millimetre (i.e. 0.02 to 1.0 mm). They usually consist of a central unit that processes data (the microprocessor) and several components that interact with the surroundings such as micro sensors. At these size scales, the standard constructs of classical physics are not always useful [14]. Fore finger direction based robot is a machine that is controlled by MEMS sensor through Radio frequency technology.

The sensor which is placed on our fore finger operates when the direction of the finger changes. Finite element analyses using human finger model during dynamic touch showed that spatial information of the textured surface are related to temporal frequency changes at the position of tactile receptors [2]-[6]. In touch activities, if humans have the ability to estimate somehow the relative hand velocity *v* between the textured surface and the exploring finger, the spatial period Δp of the surface can be perceived by detecting the temporal frequency of the vibration [7], such that:

$$f = v / \Delta p \quad (1)$$

In artificial touch, when considering technological approaches in which mechanical sensing elements are embedded in skin-like elastomeric matrices that mimic human skin, such vibrations should be elicited by stimulus skin interface, by motion dynamics and by contact mechanics, and then gathered by the sensing units located under the covering material [8]-[10].Stimuli when applied in the horizontal direction against the surface of the skin-like tactile arrays may result in a more effective deformation of the sensor element with a fingerprint-type surface than that with a smooth surface [11].

A. MEMS Sensor

Micro electro mechanical systems (MEMS) (also written as micro-electro-mechanical, Micro Electro Mechanical or microelectronic and micro electro mechanical systems) is the technology of very small devices; it merges at the nano-scale into nano electro mechanical systems (NEMS) and nanotechnology. MEMS are also referred to as micro machines (in Japan), or micro systems technology – MST (in Europe) [14].

It has been shown that MEMS based tactile sensors can be designed and built with a 3D structure that can adequately be packaged with skin like polymeric materials so that the sensor and soft packaging become a new tactile sensible element like the Soft and Compliant Tactile Micro sensor reported in [12].MEMS sensor array and electronics for integration in a robotic finger is as shown in Figure 1. The Sensor has been mounted on a forefinger. A close up view of the MEMS Sensor is also shown in Figure 2.

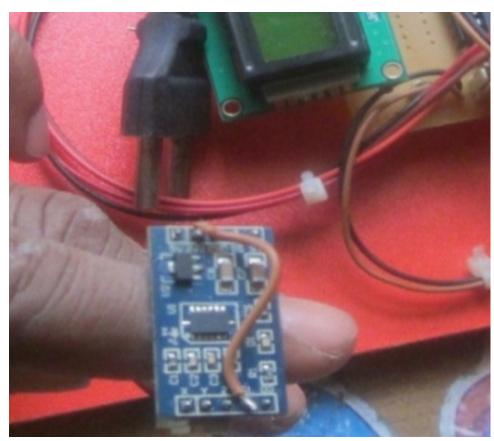

Figure 1. The MEMS sensor mounted on Forefinger.

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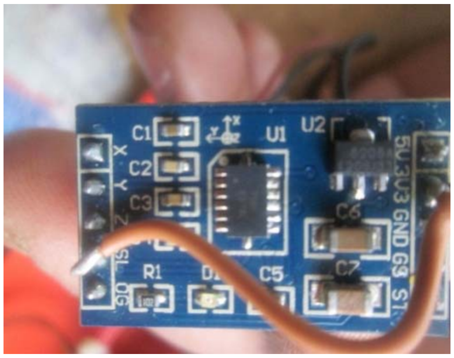

Figure 2. Close up view of the MEMS sensor

III.BASIC DESIGN AND REQUIREMENTS

The design of the robot consists of AT83S52 microcontroller,L293D driver circuit, RF transmitter and receiver, platform of the robot consisting a metal chassis and 2 DC motors which are used to control the wheels . The body is interfaced with RF receiver section and microcontroller. It receives the signals from the RF Transmitter section and operates the wheels of the robot where it can move in all the four directions i.e. (forward, reverse, right and left). The transmitter section consists of MEMS sensor (Figure 2) which is placed on fore finger, operates by changing the directions of the finger (i.e. lower 90- forward, upper 90-reverse, clock wise 60-right, anti clock wise 60-left). These directional changes will be transmitted to RF receiver at receiver section which is placed on robot platform.

IV.HARDWAREDESIGN

The Hardware design consists of robot, microcontroller unit, MEMS sensor, LCD unit, and RF transmitter and receiver unit. Robot platform is built up with metal chassis, 2 wheels attached to 2 DC motors, a load balancer and L293D driver circuit as shown in Figs. 3(a)-(b). The DC motor of +12v, 60rpm isused for robot movements. The motors are driven by motor Drivers based on the signal generated by microcontroller. L293D driver circuit is based on H-bridge concept, which is an electronic circuit, enables a voltage to be applied across a load or motor in either direction. The H-bridge concept is generally used to reverse the polarity of DC motor, or causes a break where the terminals of the motor are shorted or to let the motor free run to stop. Table 1 summarizes the operation of H-bridge with H-L corresponding to Figure3 (b).

Figure 3(a). Dc motor of 12V.60 rpm

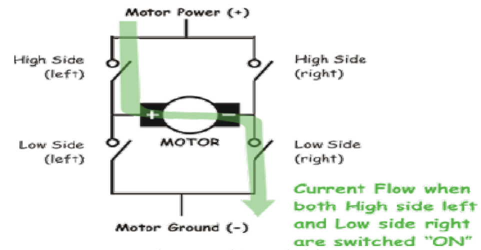

Figure 3(b). H-bridge

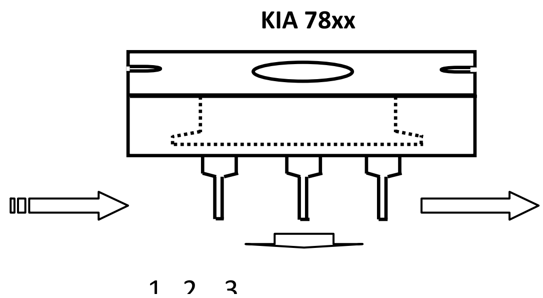

Figure 4. Voltage Regulator IC KIA 78xx

A. Pin Diagram of L293D

Both enable 1 and enable 2 of Micro Controller are shorted to V_{cc}(+5v) as the output of micro controller is too low to drive the DC motor. However this problem can be overcome by the use of driver circuit L293D as in Table 1 as it provides the current which is sufficient to drive the DC motor.

Table 1 L293DTruth Table

Input		Functions
V_{en}=High	C=High D=Low	Forward
	C=Low D=High	Reverse
	C=Don't Care	Fast Motor Stop
V_{en}=Low	C=D=Don't Care	Free Running Motor Stop

AT89S52 is a low-power, high-performance 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM). The on-chip Flash allows the program memory to be reprogrammed in-system or by a Conventional non-volatile memory programmer.

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B. *Features*

- Compatible with MCS-51™ Products
- 8K Bytes of In-System Reprogrammable Flash Memory
- Endurance: 1,000 Write/Erase Cycles
- 256 x 8-bit Internal RAM
- 32 Programmable I/O Lines
- Three 16-bit Timer/Counters
- Fully Static Operation: 0 Hz to 24 MHz
- Three-level Program Memory Lock
- Eight Interrupt Sources
- Full Duplex Serial port.
- On chip oscillator and clock circuitry.

C. *Power Supply Unit*

The circuit needs two different voltages, +5V & +12V to work. These dual voltages are supplied by this specially designed power supply. The stabilization of DC output is achieved by using the three terminal voltage regulators IC. This regulator IC comes in two flavours, As shown in Figure 4, 78xx for positive voltage output and 79xx for negative voltage output. For example 7812 gives +12V (Figure5) output and 7912 gives -12V stabilized output. These regulator ICs have in-built short-circuit protection and auto-thermal cut out provisions. If the load current is very high the IC needs ‘heat sink’ to dissipate the internally generate power.

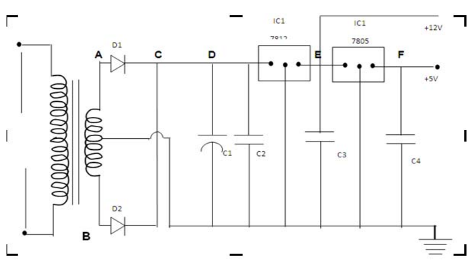

Figure 5. Circuit Diagram of +5V & +12V Regulated Power Supply

V.IMPLEMENTATION OF THE PROJECT

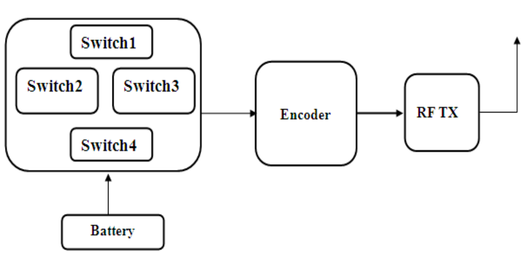

Figure 6. Transmitter Section

A. *Algorithm on the Senders side*

1) Whole Module is initialized
2) LCD on the transmitter kit will display the status of the module
3) The MEMs sensor which operates between 0 to 3.3V will transmit the information according to the variations done, which is analog value and it is given to ADC.
4) From ADC, input is given to Microcontroller which transmits the information through RF transmitter to remote location
5) RF receiver, receives the information and decodes it and sends to Microcontroller through which L293D driver circuits H-Bridge is controlled
6) The information from the H-Bridge will control the DC motor of the Robot.

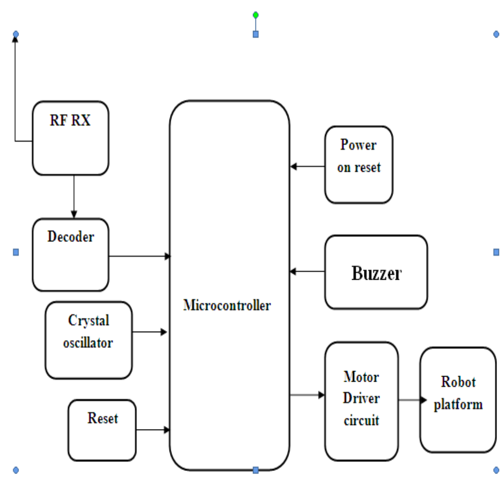

Figure 7. Receiver Section

B. *Algorithm on the Receivers side*

1) MEMs operate under a minimum value of 0V and maximum of 3.3V.
2) When MEMs is 60^{o} degree towards right, it will be operated from 0V to 1V.(The Robot moves in RIGHT Direction)
3) When MEMs is 60^{o} degree towards the left, the voltage varies from 1V to 1.5V. (The Robot moves in LEFT Direction)
4) When MEMs is 90^{o} upwards, it will be operated in 1.5V to 2.5V. (The Robot moves in FRONT Direction)
5) When MEMs is 90^{o} downwards, the voltage varies from 2.5V to 3.3V. (The Robot moves in BACKWARD Direction)
6) When MEMs is at 0^{o}.(The Robot is in STOP position)
7) The varied analog value from the MEMs sensor is given to ADC which will be converted to Digital Value

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VI.SNAPSHOTS OF THE ROBOT

Figure 8. Snapshot of the Receiver Section

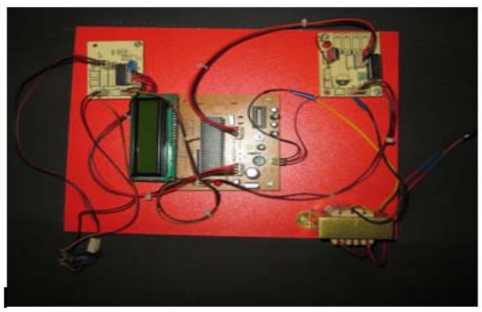

Figure9.Snapshot of the Transmitter Section

VII. CONCLUSIONS

In this paper we have implemented a robot which can be used by patients and people with less mobility to move the wheel chair by using gyro sensors- MEMS Sensors in particular. The design of the system includes microcontroller, MEMS sensor and RF technology. The MEMS sensor is placed on the fore finger at the transmitter section which moves the Robot in the direction of the Forefinger.

This sensor detects the direction of Forefinger and the output is transmitted via RF transmitter. In the receiver section RF receiver receives corresponding signal and will command microcontroller to move the robot in that particular direction. Experimental results for fore finger based directional robot are enumerated.

A. Future Enhancements

Design and implement a few haptic related projects for the benefit of physically challenged people. This proposal develops an approach for haptic exploration of unknown objects by robotic fingers. Because haptic exploration is coupled with manipulation and exploration using a sequence of phases is presented. With specialized fingers and sensors and appropriate planning and control robots can also be enabled to explore the worlds through touch.

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