Space Robotic Interaction with Virtual Reality and Haptic Feedback

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Abstract

Our paper goes for making a Virtual Interface between a robot conveyed in space and a human eyewitness with haptic criticism. This is made conceivable by utilizing Micro electro mechanical Sensors (MEMS).The constant live feed is gotten utilizing a RF Transceiver with the assistance of visual aids.The utilization of augmented reality strategies will be of extraordinary advantage for the individual working starting from the earliest stage it permits the execution of implies that assistance the administrator in spatial introduction, route and control.

Introduction

Telepresence causes the human administrator to effectively intercede and control in a remote domain. The human administrator can, in a perfect telepresence framework, never again individualize between a cooperation with a genuine situation and an in fact interceded one. This is accomplished by theuse of computer generated reality and haptic input innovations. The client on Earth is given a constant criticism through Virtual Reality, which influences the client to collaborate in a 360 degree vision with the remote area. The haptic input gives the human operatora high-loyalty sensor criticism from the remote workspace.

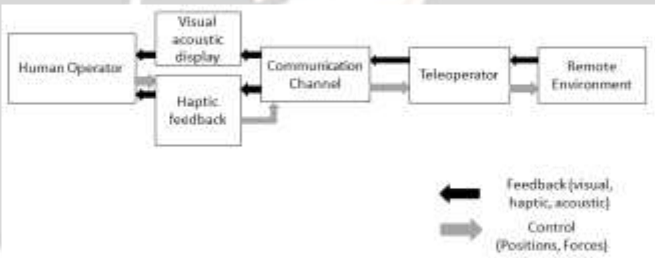


Figure1: Block Diagram of Multi Modal Telepresence

The innovation has been stirred by applications in atomic power plants so as to empower a protected treatment of unsafe material. When all is said in done, earthbound applications can be differentiated by the kind of the hindrance among administrator and the teleoperator. The treatment of hazardous material as of now referenced requests matter as the boundary. On the off chance that scale is the hindrance, as it is the situation in negligible principal surgery,[1] the telepresence framework approves the human administrator to do full scale measured techniques on the administrator side, by decreasing them down to miniaturized scale estimated developments on the teleoperator side.

Teleoperations in space are shackled by the processing power accessible on shuttle and the roundtrip time postponements of the long correspondence chains and research is still in a sprouting stage, with the greater part of the automated missions being demonstrator of innovations. Essentially there are two recognized kinds of mechanical missions in space: free flyers and automated controllers. The job of the free flyer is for the most part worried about juxtaposition, for example, meeting and docking with the objective satellite. It is likewise bound to be utilized for supposed assessing missions, in which the objective satellite is observed or on-circle overhauling (OOS) moves are reinforced. The goals of automated controllers are to interface with the objective and execute controls requested from administrator's side. This can either be executed self-rulingly with the human administrator just definitely viewing and just giving abnormal state directions or teleoperated, with the human administrator having a functioning job [1]. This paper goes for underscoring the benefits of computer generated reality procedures for human aided space mechanical get together. It underlines the abilities of telepresently controlled servicer satellites notwithstanding self-sufficient control.

I. TRANSMITTING PART

The transmitting part is available in the Earth from which the client will almost certainly send in directions to the test present in the remote workspace. The human administrator on Earth can cooperate with the remote area in a constant domain and will likewise have the capacity to feel the tactile encounters, for example, sight, contact and acoustics. The transmitting part includes the top of the line sensors, criticism gadget and hardware and the computer generated experience arrangement.

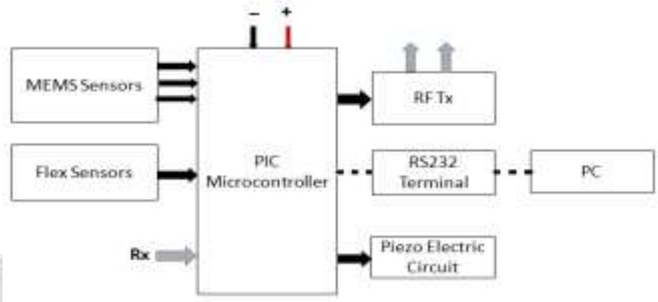


Figure 2: Circuitry on the operator site

Flex sensors

It measures the amount of deflection caused by bending the sensor. There are various ways of sensing deviations, from strain-gauges to hall-effect sensors. The three most common types of flexion sensors are:

- Conductive ink-based
- fibre-optic
- conductive fabric/thread/polymer-based

A property of bend sensors worth noting is that bending the sensor at one point to a recommended angle is not the most effective use of the sensor. As well, bending the sensor at one point to more than 90˚ may lastingly mutilate the sensor. Instead, bend the sensor around a radius of curvature [4,5,7]. The petite the radius of curvature and the farther the whole length of the sensor is involved in the deflection, the better the resistance will be (which will be much greater than the resistance achieved if the sensor is fixed at one end and bent acutely to a high degree). In fact, Infusion Systems define the sensing parameter as “flex angle multiplied by radius”.

Specifications:

A typical bend sensor has the following basic specifications:

- range of deflection
- uni- vs. bi-directional sensing
- uni- vs. bi-polar sensing
- range of resistance (nominal to full-deflection)

Range of deflection: Determines the maximum angle of aberration that can be measured (as opposed to the maximum angle the sensor can be bent).

Range of resistance: Bend sensors can vary largely (even the same product) in terms of their range of resistance, measured as the difference from nominal resistance to resistance at full deviation.

Conductive Fabric/Thread/Polymer-based:

Conductive fabric-, thread- or polymer-based flexion sensors generally consist of two layers of conductive palpable material with a layer of an impervious material (e.g. Velostat) in between. It is mostly sandwiched in between layers of more intemperate material, e.g. Neoprene. As pressure is enforced (directly or by bending) the two layers of conductive material get pushed closer together and the resistance of the sensor decreases. This sensing mechanism is congruent to force-sensitive resistors. Basically, these types of sensors are pressure sensors which also sense deviation (pressure as a function of deviation): bending the palpable material across an angle of a rigid structure results in stretch of the sensor material which put pressure onto the sensor. It is this pressure that is measured. Foam/Polymer-based sensors decrease their nominal resistance as the material is flattened. These sensors are known to have poor accuracy, repeatability and hysteresis.

Properties

- quasi-linear behaviour for pressure-sensing
- slow response, due to physical deformation (internal energy)
- high hysteresis, poor accuracy & repeatability
- high temperature and humidity-tolerance
- highly modifiable
- economic

MEMS Sensor

Micro-Electro-Mechanical Systems, or MEMS, is a technology that in its most general form can be defined as miniaturized mechanical and electro-mechanical elements (i.e., devices and structures) that are made using the techniques of micro fabrication. The critical physical dimensions of MEMS devices can vary from well below one micron on the lower end of the dimensional spectrum, all the way to several millimetres. Likewise, the types of MEMS devices can vary from relatively simple structures having no moving elements, to extremely complex electromechanical systems with multiple moving elements under the control of integrated microelectronics [6]. The one main criterion of MEMS is that there are at least some elements having some sort of mechanical functionality whether or not these elements can move.

MEMS are separate and distinct from the hypothetical vision of molecular nanotechnology or molecular electronics. 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 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. Because of the large surface area to volume ratio of MEMS, surface effects such as electrostatics and wetting dominate over volume effects such as inertia or thermal mass.

While the functional elements of MEMS are miniaturized structures, sensors, actuators, and microelectronics, the most notable (and perhaps most interesting) elements are the micro sensors and micro actuators. Micro sensors and micro actuators are appropriately categorized as “transducers”, which are defined as devices that convert energy from one form to another [1,3,6]. In the case of micro sensors, the device typically converts a measured mechanical signal into an electrical signal.

The real potential of MEMS starts to become fulfilled when these miniaturized sensors, actuators, and structures can all be merged onto a common silicon substrate along with integrated circuits (i.e., microelectronics). While the electronics are fabricated using integrated circuit (IC) process sequences (e.g., CMOS, Bipolar, or BICMOS processes), the micromechanical components are fabricated using compatible "micromachining" processes that selectively etch away parts of the silicon wafer or add new structural layers to form the mechanical and electromechanical devices. It is even more interesting if MEMS can be merged not only with microelectronics, but with other technologies such as photonics, nanotechnology, etc. This is sometimes called “heterogeneous integration.” Clearly, these technologies are filled with numerous commercial market opportunities.

While more complex levels of integration are the future trend of MEMS technology, the present state-of-the-art is more modest and usually involves a single discrete micro sensor, a single discrete micro actuator, a single micro sensor integrated with electronics, a multiplicity of essentially identical micro sensors integrated with electronics, a single micro actuator integrated with electronics, or a multiplicity of essentially identical micro actuators integrated with electronics. Nevertheless, as MEMS fabrication methods advance, the promise is an enormous design freedom wherein any type of micro sensor and any type of micro actuator can be merged with microelectronics as well as photonics, nanotechnology, etc., onto a single substrate [3,6].

II. FEEDBACK DEVICE AND CIRCUITRY

In a robot, some of the devices are used as the constituents of a robot's control system for providing feedback and control actions in order to control the manipulator. Such devices are:

Feedback devices:

- Position Sensors
- Velocity Sensors

Piezoelectric sensors:

A piezoelectric sensor is a physical device that uses the piezoelectric effect, to calibrate changes in pressure, movement, temperature, acceleration, strain or force by transforming them to an electrical charge [2]. These sensors are versatile tools for the calculation of various mechanisms. They have been successfully used in variety of applications, such as medical, aerospace, nuclear instrumentation, and as a tilt sensor in consumption electronics or a pressure sensor in the touch pads of mobile phones. In the automotive manufacturing industry, piezoelectric elements are used to monitor combustion when developing internal combustion engines.

These sensors are either fixed directly into extra spaces into the cylinder head or the spark/glow plug is decked with a built-in miniature piezoelectric sensor. The rapid growth of piezoelectric technology is directly related to a set of distinctive advantages. The high modulus of elasticity of all piezoelectric materials is commensurable to that of many metals and goes up to 111 N/m^2. Even though piezoelectric sensors are electromechanical mechanism that reacts to compression, the sensing element shows almost zero deflection. This gives piezoelectric sensors ruggedness, an extremely high natural frequency and an exquisite linearity over a broad amplitude range [2,3]. Moreover, piezoelectric technology is insensitive to electromagnetic fields and radiation, allowing measurements under harsh conditions. Some materials used (especially gallium phosphate or tourmaline) are highly stable at high temperatures, allowing sensors to have a working range of up to 1000 °C.

III. VIRTUAL REALITY

Virtual reality is an artificial atmosphere that is created with software and presented to the operator in such a way that the operator suspends belief, thinks and accepts it as a real environmental setting. The definition of virtual reality comes, candidly, from the definitions for both 'virtual' and 'reality'. The definition of 'virtual' is constructive and reality is what we experience as human beings. So the term 'virtual reality' basically means 'constructive-reality'. This could, of course, mean anything but it generally refers to a specific type of reality impersonation. Virtual reality is the term used to describe a three-dimensional, computer generated environment which can be explored and interacted with and by a person. That person becomes part of this virtual world or is immersed within this reality and whilst there, is able to manipulate objects or result in a series of actions.

On a system, virtual reality is mainly experienced through two of the five senses: sight and sound. The basic form of virtual reality is a 3-D image that can be explored collaboratively at a personal computer, consistently by manipulating keys or the mouse so that the content of the image moves in some direction or zooms in or out. More convoluted efforts involve such approaches as wrap around image display screens, actual rooms augmented with wearable computers, and haptic devices that let you feel the displayed perception.

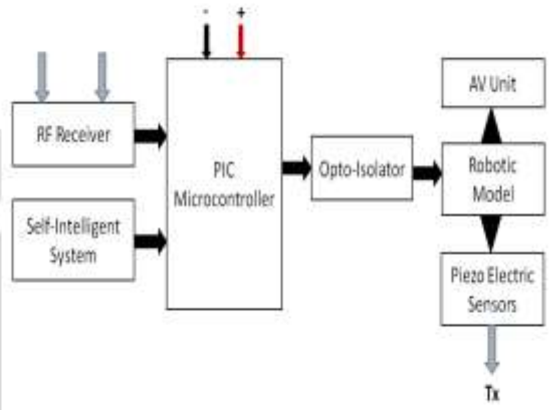
Virtual reality has been widely accepted by the military – this includes all three services (army, navy and air force) – where it is used for training the comrades in a virtual environment. This is particularly useful for training soldiers for combat situations or other hostile settings where they have to learn how to react in a germane manner. A virtual reality simulation allows them to do so but without the risk of fatality or a serious injury [5,8]. They can re-enact to a particular sketch, for example engagement with an enemy in an environment in which they experience this but without the real world risks. This has proven to be safer and less costly than traditional training methods.

A celebrated use of this technology is in robotic surgery. This is where surgery is done by means of a robotic device – operated by a human surgeon, which saves time and risk of complications involved. Virtual reality is being used for educating purposes in the field of remote telesurgery where surgery is performed by the surgeon at a faraway location to the patient[8]. The main feature of this system is force feedback as the surgeon or the operator needs to be able to gauge the amount of pressure to use when performing a delicate procedure.

Virtual Reality so far has been employed to simulate real life conditions which are mostly graphically generated. But the idea of using it in real time has not been employed. This concept of real time live feed Virtual Reality can be done.

IV. RECEIVING PART

The receiving part is present in a remote workspace to which the user on Earth will be able to send in commands and control the receiving bot. The human operator on Earth can interact with the remote location in a real-time environment and will also be able to feel the sensory experiences such as sight, touch and acoustics. The receiving part encompasses the high-end sensors, haptic feedback circuitry, virtual reality AV real-time input and the robot.



Robotic Model

The robotic model is designed to be the most durable product since it needs to move over a tough terrain. This series of moves require skills and very importantly an intelligent system within itself. The self-intelligent system is pre-programmed to face tough challenges by the bot over an alien location. Say for example when the bot encounters a pit or if it is about to crash on a rock, within a minimum threshold the bot can make its own decision. This decision will prevent the bot from damaging its peripherals and causing a failure in the system.

This model is attached with an arm model for picking up samples and analysing the terrain. The arm model is supported by a lead screw mechanism which helps the robotic arm to have a flexible up and down motion. The robotic arm is controlled by the flex sensors input transmitted from the operator's end. The movement of the bot and the lead screw is controlled by the user using MEMs sensor. At the tip of the robotic arm a piezoelectric sensor is used which sends its feedback to the operator.

V. RESULT AND CONCLUSION

This system can enable the human operator on the ground to actively intervene in the remote environment and provides the possibility of instantaneous contingency operations.

Haptic feedback has also been included for enhanced user interface with the telepresence system. Virtual reality will be added to the receiver end so that the user can feel the sensory experiences such as sight, touch and acoustics.The theoretical advantages of virtual reality will be tested in a depictive hardware environment and evaluated in detail in the future.

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