International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 06 | June - 2021 ISSN: 2582-3930

Industrial Emergency Robotic Vehicle using Leap Motion Technology

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Abstract - The exponential growth rates that we have observed over the last decades seem to promise more exciting technological advances in the future, and today we all are witnessing events that were conceptualized in movies and computer gaming a few years ago. From humanoid robots to virtual reality, the possibilities are just endless. Leap Motion is an example of spearheading technology that has the aptitude to change the way we control machines and therefore, how we control our world! Leap Motion is a sensor that is operated through a personal computer with hand gestures. We are using this technology to have control over the physical robot arm. This paper discusses the use of Leap Motion controlled robotic vehicle in industries under any kind of emergency and the working of leap motion controlled robotic vehicle.

Key Words: technological advances, humanoid robots, virtual reality, leap motion, hand gestures, robotic vehicle

1. INTRODUCTION

Robots are designed for the next generation of creating a full human-like robotic system with human skeletal and muscular systems. The whole idea behind this is to develop a robotic arm which is the same as the human arm and to reduce the burden of humans and not to limit the robot to one set of a particular task. Leap Motion technology is one such device that implements many possible ways, which is very simple and effective. The main aim of developing a human hand tracking system is to create a communication between the human hand and the robotic arm, with the most detailed and kinematically accurate human characteristic robotic arm, with the ultimate goal of replacing the human hand completely. We are using a 'leap motion sensor' to control the robotic arm based on spatial augmented reality, which is more efficient, and has less delay. The Operating characteristics of the robotic arm are, the hand should have three movable fingers and the entire system must have at least 4 degrees of freedom. Thus, man power is reduced as we are using an automated robot. Automatic monitoring has been advancing to minimize human efforts.

The Leap Motion Controller uses an infrared scanner and sensor to map and track the human hand. This information is used to create, in real time, a digital version of the hand that can manipulate digital objects. The robotic arm moves in accordance with the movement of the human hand above the leap motion sensor. The captured data is sent to the controller and interfaced with the motors and other devices connected to it for the robotic arm for movements. Below shows the basic block diagram of the leap motion controlled robotic arm.

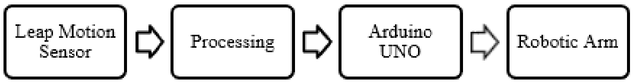

Fig -1: Leap Motion Controlled Robotic Arm Block Diagram

This robot can be used virtually for any application, including research or service in the medical field and military fields as well as industrial applications. In this paper we are mainly focusing on industrial applications. Nowadays, in industries forklifts are incredibly useful machines to lift and move heavy pallets, boxes etc. But according to the statistics an estimation of 85 deaths per year is due to forklift accidents and the forklift drivers have so far been lucky to escape the clutches of automation , but now that could be about to change. Robotic arm can make a huge difference in the industries as well as save human lives.

2. LEAP MOTION TECHNOLOGY

The leap motion is one of the latest tracking software and a hardware prototype in the industry. From a hardware perspective, it is quite simple. The device consists of three infrared LEDs and two cameras. The infrared led lights have a tracking capacity up to 850 nanometers.

In this device, wide-angle lenses are used and have a large interaction space of eight cubic feet, which later takes the shape of an inverted pyramid – the intersection of the binocular cameras' fields of view. Earlier, the Leap Motion Controller's viewing range was limited to roughly 60 cm (2 feet) above the device. With the latest Orion beta software, this range has been expanded to (2.6 feet) 80 cm. The LED light propagation limits this range through space. This becomes harder to infer our hand's position after a certain distance. Hence LED light intensity is only limited by the maximum current that can be drawn over the USB connection.

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At this point, to make necessary resolution adjustments in the sensor the USB controller reads the sensor data in its local memory. This data in the leap motion software is streamed via USB. Grayscale stereo image is formed by taking the data of the near-infrared light spectrum. This is later divided into the right camera and left camera. Typically, these are the only objects that you'll see which are directly illuminated by the Leap Motion sensor Controller's LEDs. However, halogens, incandescent light bulbs, and daylight will also light up the scene in infrared waves.

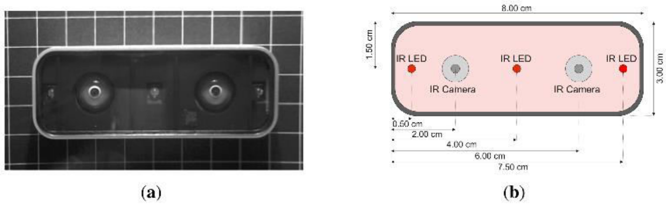

Fig -2: Leap Motion Controller

3. 4-DOF ROBOTIC ARM

A 4-degree robotic arm consists of 4 servo motors that allow 4- degrees of freedom, as pointed out by each arrow. Motor 1 rotates the entire robotic arm and is controlled by a panning hand motion in the x-direction. Motor 2 lifts and lowers and when the operator moves their arm along the y-axis, the robotic arm moves directly above the sensor. Motor 3 also raises and lowers the arm for more precise movement when the operator moves its hand in the Z direction. Lastly, motor 4 opens and closes the robotic gripper when the operator forms a pinching gesture with his/her thumb and index finger.

Three-fingers were chosen for the hand design because they are able to fully utilize the features of Leap Motion. A Three-finger design is much more stable and precise for picking up and gripping objects. Also, in the case of search and rescue, a human would more readily accept a robot due to the human-like appearance. Thus, our robotic arm is suitable for many applications such as pick and place, bomb defuse, spot welding, industrial automation etc., thus not restricting it to one set of tasks. It is cheaper than the robots that are commercially available in the market.

The microcontroller controls each motor through PWM wires. The motor receives each command from the computer program via a microcontroller. The microcontroller is powered by 5 volts, taken from the computer using a serial cable, and receives commands that manipulate the physical arm. Alternatively, the microcontroller is powered by an external power supply, which provides both 12 and 5 volts to the terminal block on the board. The power supply receives 220 volts from the wall outlet.

` **Fig -3**: 4- DOF Robotic Arm

4. BIOMECHANICS OF HUMAN HAND

The human hand is one of the most complex and dexterous motor systems in the human body for communication and interaction and there are different ways to actuate a hand model. Tendon-driven robots are robots whose limbs mimic biological musculoskeletal systems. The typical human hand is equipped with five fingers. They aid in everyday functions. The study of mechanical principles of all living organisms is referred to as Biomechanics. Organic movements and the organic structure of any organism are directly related to biomechanics. Biomechanics uses orthodox engineering sciences and engineering mechanics to analyze organic movements. When speaking about human body movements, biomechanics refers to the internal bone structure and the connections that bones and joints have along with the relation of bone movements. To have a fully functional and efficient humanoid robotic hand and arm, it is imperative to fully research the biological design and functionality of the human hand. Studying the fingers, the palm, and the immediate relation of arches due to the movements show the functionality and the usefulness of the hand.

Fig -4: Bone Structure of Human Hand

5. PROPOSED CONCEPT

We know that almost all the industries adopt automation, but when there is a failure in the automation system the production stops. During this the emergency robotic vehicle comes into picture. The vehicle with a robotic arm moves to the failure spot, helps in moving, picks (kgs to tons) and clears the area in which these tasks cannot be done by humans. The arm is mounted on a 360 degree rotatable vehicle in which both the vehicle and the arm is manually controlled by an operator. Surveillance camera can be used for monitoring purposes with infrared night vision for monitoring purposes in case of emergency in the industrial area.

Leap motion sensor is a kind of sensor which captures the visuals of the human hand in 3D Cartesian with its infrared camera. The captured visual is then converted into frames which in later is compared with the predefined algorithm developed by the software developers. Corresponding signals are generated and visuals of motion can be seen on the laptop screen. Finally the received signals are sent to the arduino board which is the control signal generator. The signal is sent to servo motors for movements of the robotic arm.

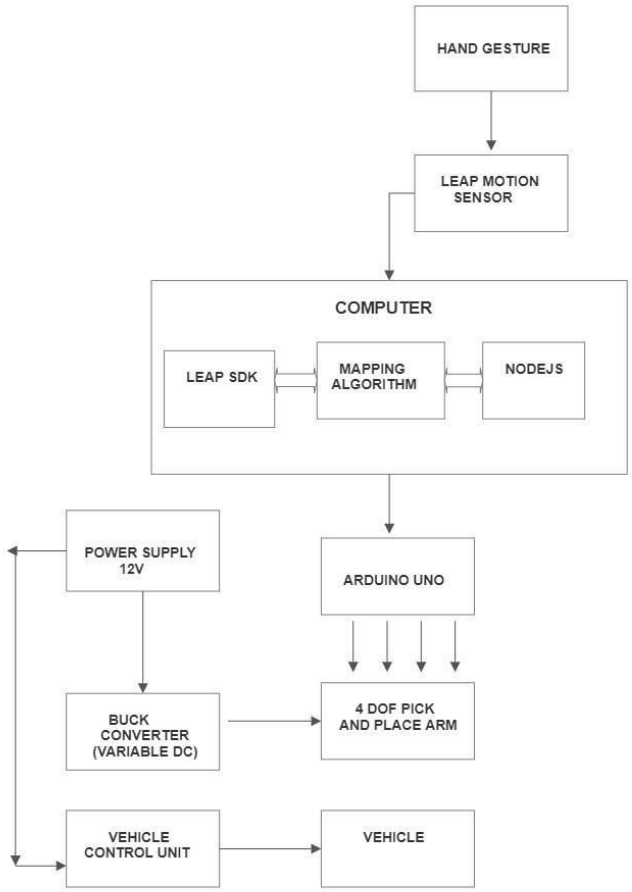

Fig -5: Methodology of leap motion controlled robotic arm

6. IMPLEMENTATION

The leap motion controlled robotic arm is implemented in two ways: hardware design and software design.

6.1 Hardware Design

The motors consist of four servo motors connected to the robotic arm with the respected required torque. The hand gesture is acquired by the leap motion then transmitted to the mechanical arm and mimics the gesture position. The equipment comprises a straightforward open equipment plan for the Arduino board.

In the proposed system we used the servo MG995 that is popular for its performance and low price. The motor is used in many applications, mainly Robotics. The key features of MG995 servo motors are:

- Metal geared servo
- Stable and shockproof
- Weight is of 55g
- Operating voltage range: 4.8 V to 7.2 V
- Operating temperature range: 0°C to +55°C
- Fast control response
- Dimension: 40.7×19.7×42.9mm
- Stall torque: 9.4kg/cm (4.8v); 11kg/cm (6v)

6.2 Software Design

API (Application Program Interface) is a semblance of different programming languages that are used by the developers to access the processes. The API of leap motion provides us all the possible opportunities to interact with the controller and sensor for retrieving the input values by hand for processing inverse kinematics. Many languages are used for controlling leap motion such C#, JAVA, python etc., Using C# as API we created interactive communication between sensor and robotic arm, Using a C# program which tracks the manipulator's hand movement by means of mapping through leap motion. The code used to control the manipulator gets the three-dimensional hand position of the manipulator and sends it ahead for the controller to convert it into degrees. The code repeatedly gets the values and calculates forward kinematics. This approach can be targeted with different robots with any Degree of Freedom. It justifies that this is the most obvious, smooth and simple way to handle a robotic arm in real time.

7. CONCLUSION

By reaching the conclusion, Gesture control commenced to be one of the simplest and easy ways by which a complex robot could be controlled easily, with the help of different sensors and among them is the leap motion sensor. With the ability for developers to design their own software for the Leap Motion Controller its creative potential is incredible. The creators of Leap Motion have put the tools into the hands of others to experiment with and modify.

This is already leading to the development of new, unique, software and uses for this technology. Focusing on the project, the first step is control of the robotic arm through human gestures. Thus the ongoing research suggests that it is very much possible to make a robot mimic human movements in the near future.

Our paper gives an early study of this technology and how leap motion controllers can be used in industrial application. Because Leap Motion Controllers allow users to manipulate 3D objects in an instinctual way they can be used to familiarize students with complex structures. Currently anatomy students with Leap can use software like Cyber Science 3D to dissect a body and chemistry students can examine molecules from the RCSB protein bank using the Molecules program. Both are just a few examples of the educational benefits of gesture based computing. Thus results conclude that the system can detect hand gestures efficiently in real time and execute accordingly.

ACKNOWLEDGEMENT

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mention of the people who made it possible, whose constant guidance and encouragement crowned the efforts with success.

I would like to profoundly thank **Management** of Jyothy Institute of Technology for providing such a healthy environment for the successful completion of the work.

I would like to express my thanks to the Principal **Dr. K. Gopalakrishna** for their encouragement that motivated me for the successful completion of the work.

Also, I would like to express my deepest sense of gratitude to **Dr. K. Chandrasekhar**, Professor and Head of Department for his constant support and guidance throughout the completion of the work.

I would also like to thank the Project Coordinator **Dr. Chethana K** and **Rajesh Sudi,** Department of Electronics and Communication Engineering and all other teaching and non-teaching staff of Electronics and Communication Engineering Department who have directly or indirectly helped me in the completion of the work.

Last, but not the least, I would hereby acknowledge and thank my Parents who have been a source of inspiration and also instrumental in the successful completion of the work.

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