Robotic Arm Simulation using Leap Motion Controller

Viraj Shukla, Gourav Singh, Sagar Kamble, Pallavi S. Bangare

***Abstract:** As we all know with the invention of robots various complex human tasks have been easier and can be done simply. Robot can help in industries to achieve faster production by replacing human efforts and also robots can go to places where human life can be in danger. Although no robot can match ingenuity of human hand. Using controllers to simulate mobile robotic arm was a tedious task for humans as it had numerous keys and it was not easy to calculate joint angles manually. So to overcome this drawback Leap motion controller is very accurate, fast and robust device which can calculate joint angles precisely. Leap motion sensor can track human hand 300 times a second within a 1 meter hemisphere. Functions Leap Motion can perform are far more impressive than one might imagine. The impressive performance of the leap is because of the two monochromatic IR sensors and infrared LED's. In this paper we present implementation of leap motion to control the Mobile Robotic Arm via gestures of human hand. Here we are using leap as a motion controller to simulate the robotic arm which is connected through serially (232) via USB port. This serial communication is supervised through AVR microcontroller that is mounted on Arduino UNO. The coordinates that come from leap are compiled in JAVA and given as input to Arduino UNO. We have written Arduino code that interprets the input from JAVA and transmit them in order to control the motion of the Mobile Robotic Arm and four wheel buggy. Practical implementation has also been explained.*

***Index Terms:** Arduino UNO, Leap Motion, Robotic Arm*

I. INTRODUCTION

Image Processing is widely used in many of the applications such as abundant object detection, face recognition, digital image processing. Image processing is not just limited to adjust the spatial resolution of the images captured by cameras. It can also be used in the gesture recognition. The topic we are concerned includes gesture recognition to control mobile robotic arm. Gesture refers to any bodily movement. In this paper we are going to discuss about the robotic arm which is mounted on a four wheel buggy. The robotic arm we have used is 2 axis robotic arm which moves upwards and downwards and open close. The whole robotic arm is driven by motors inside which is operated by the controller. The buggy is also driven through 2 motors. The controller we are going to use is leap motion controller.

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The leap motion is a very accurate and robust. It has 2 monochromatic infrared cameras which are used to track hand movement. It also has 3 infrared LED's which calculates the joint angles. It can track any movement within 1 meter hemisphere range.

Here we have explained the system that we have implemented using Leap Motion and Robotic Arm. The working of the system is also explained in further part with a practical implementation scenario. Research papers based on the Concepts of Image processing and Software Engineering were studied for this work [7] [8] [9] [10] [11]. For the design purpose other authors work was studied [12] [13] [14] [15] [16] [17] [18]. Few Machine Learning and Security related papers were also studied [19] [20] [21] [22] [23] [24] [25].
Procedure for Paper Submission

II. PROPOSED SYSTEM CONCEPTS

A. Leap Motion

The new approaches of human-computer interfaces will facilitate a more natural, intuitive communication between people and all kinds of sensor-based input devices, thus more closely mimicking the human-human communication [2]. The Leap Motion Sensor is a small USB peripheral device, designed to place on a physical desktop, facing upward.

Using two monochromatic IR cameras and three infrared LEDs, the device observes a roughly hemispherical area to a distance of about 1 meter [1]. The data that is obtained from the Leap Motion Sensor contains various details of handssuch as position, orientation, and frame ids, finger bone information [2].Leap Motion Sensor can track a human hand 300 times a second with millimetre accuracy. The two monochromatic IR sensors used in the device detect the heat signature from the hand while other infrared LED's detect the shape structure of the hand. Together they provide us the data of positions of each joint in hand including bone of fingers. The two monochromatic IR cameras keep track of the movement of the hand whereas remaining three IR LED's concentrate on the joints of hand. It is the screen shot of the leap motion visualizer tool that is used to monitor the hand movements as detected by the sensor [2]. The sensor provides the position of our hand and fingers represented in 3D coordinates i.e. (X, Y, and Z) is by using gestures of human hand and this is done by using leap motion [1].

In figure1 the leap motion controller has 5 components including two monochromatic cameras and 3 Infrared LED's, in which two cameras are used to detect the signature of the hands and LED's are used to detect the shape of hand or object [1].

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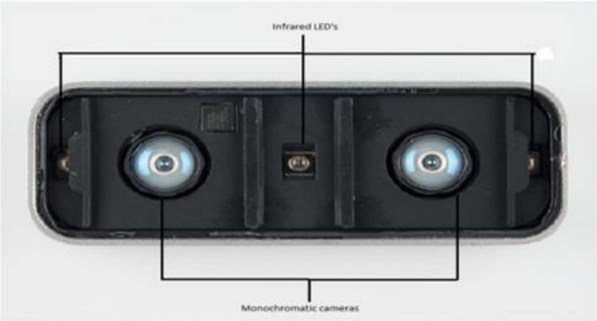

Fig. 1 Leap Motion Controller

In figure 2 the leap motion visualizer has been shown, therefore we can see how hand coordinates has been tracked by leap motion controller.

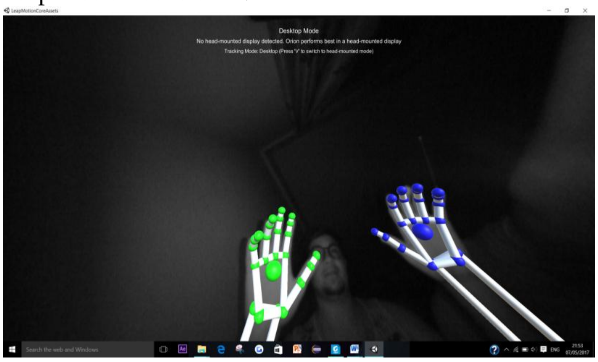

Fig.2 Leap Motion Visualizer

B. Robotic Arm

A Robotic Arm is a type of mechanical arm, usually programmable, with similar functions to a human arm, the arm may be the sum total of the mechanism or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing either rotational motion or translational (linear) displacement [3]. The links of the manipulator can be considered to form a kinematic chain. The terminus of the kinematic chain of the manipulator is called the end effector and it is analogous to the human hand.The end effector, or robotic hand, can be designed to perform any desired task such as welding, gripping, spinning etc., depending on the application [4]. For example, robot arms in automotive assembly lines perform a variety of tasks such as welding and parts rotation and placement during assembly [3].

In some circumstances, close emulation of the human hand is desired, as in robots designed to conduct bomb disarmament and disposal. Also robots can go to places where there is a threat to human life or it is impossible for a human to survive in such places.It can be controlled manually using commands from the computer for each joint. We have created a java program that sends commands to the two axes robotic arm. This is done using a technique called timed angle turn [3].

Robotic arm is commanded using the Motor driven IC's and Arduino UNO which is eventually connected to leap motion. The below figure shows the robotic arm prototype that we have designed for the system [4]. Movements that are performed by the following robotic arm are open, close, upward, and downward.

Following figure shows two axes Robotic Arm:

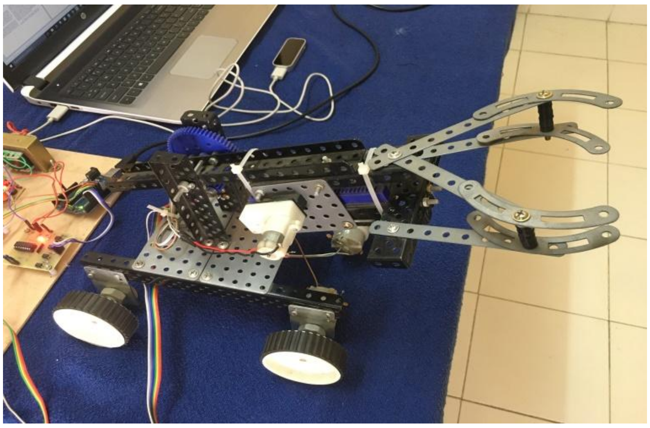

Fig. 3 Robotic Arm

C. Arduino UNO

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) [2] that runs on your computer, used to write and upload computer code to the physical board. The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board – you can simply use a USB cable [2]. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package. The Uno is one of the more popular boards in the Arduino family and a great choice for beginners.

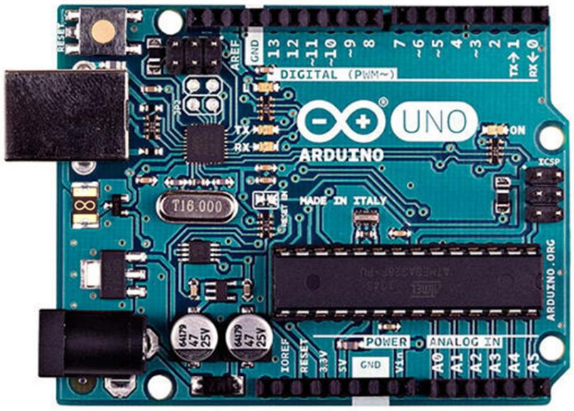

Fig. 4 Arduino UNO

III. SYSTEM ARCHITECTURE

The figure shows how the simulation of robotic arm [3] actually works which has been implanted on the four wheel buggy. The main components of the architecture are Robotic buggy, Leap Motion, Robotic Arm, Arduino UNO, Motor Driven IC's etc. Basic and important components of the architecture have been explained in the proposed system concepts.

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The 3D hand coordinates are extracted [7] by leap motion can be in the form pitch, roll and yaw [3]. Distance formula are used to define specific or custom kind of motion for the object (here Robotic Arm) that is to be controlled by Leap Motion. These coordinate which have been obtained by Leap are then given to Microcontroller [2], which then controls the Motor driven IC's. Robotic Arm and Buggy are commanded by the IC's. The interfacing between Microcontroller and Computer is done via Max232.

The system architecture shows the schematic flow of how the system worked:

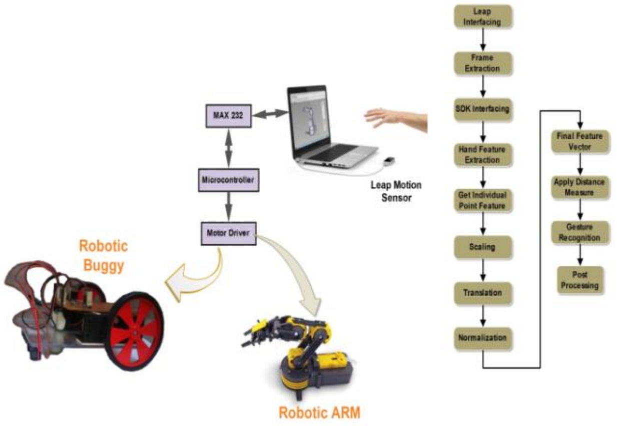

Fig. 5 System Architecture

In the above figure the right hand side explains the system flow of gesture coordinate recognition [7]. It basically starts with the Interfacing phase, where interfacing of leap and system is done. It also performs some functions on features extracted from leap these functions are Scaling, Translation, and Normalization. Finally Distance Measure formula is used to obtain gesture recognition [7].

A. Mathematical Model

Set Theory:
Let S (be a main set of) ≡ {I, F, G, A, LeapInterface() , FeatureExtraction()}
Where,
I = {I1, I2, I3, I4, In}
Where I is infinite set of input frames.
F = {F1, F2, F3, F4,………….. , Fm}
Where F is infinite set of features.
G = {G1, G2, G3,…., Gi}
Where G is infinite set of gestures.
A = {A1, A2, A3,….., Ai}
Where A is infinite set of actions associated with each gesture.
Functionalities:
I = leapInterface();
F= Featureextraction(I);
Fn = Normalization(F);
G = Gesturerecognition(Fn);
A=Takeaction(G);

TABLE I Mathematical Model

Action	Buggy	Arm	Action Name
A1	Forward	Up	Pitch down
A2	Reverse	Down	Pitch up
A3	Left	N/A	Roll left
A4	Right	N/A	Roll Right
A5	N/A	close	Fingers closed
A6	N/A	open	Fingers open
A7	Buggy mode change	Arm mode change	Roll

B. Algorithm

I) Buggy Test

Step: 1 Start leap camera interfacing

Step: 2 for each frame
If (hand == right hand)
For each fingure
Extaxtframe()
Extact movement()
Extract fingurepoint()

Step: 3 Calculate
1. Yaw
2. Pitch
3. Roll

Step: 4 Compare distance
If (pitch > 60)
Forward()
if (pitch < -60)
Reverse()
Step: 5 Send commands to microcontroller for buggy control

II) Arm Test

Step: 1 Start leap camera interfacing

Step: 2 for (left hand && right hand)
Calculate distance between pitch of both hands
Step: 3 compare distance
If (distance < 2500)
Close the hands
Else if (distance > 2500)
Open the hands

C. Experiment Performed

The figure below specifies the implementation of the system. We have used Leap motion, Robotic Arm and Arduino UNO in the implementation [5]. Hand coordinate are tracked from Leap and given to the computer system [3]. These coordinate are then synchronized with java to form two parameter function i.e. data and command. These parameters are passed on to the Adruino UNO [6] which is then compiled to command two motor driven IC's. Motor driven IC's are placed in the system to control the Robotic Arm Moment and Buggy Movement. The movements that are performed by the buggy is forward, reverse, right, left that is controlled using IC's and Arduino UNO [2].

Robotic Arm is two axes arm its movements are open, close, upward, downward which are again controlled by same. Quality metrics were also studied [26] [27] [28] [29].

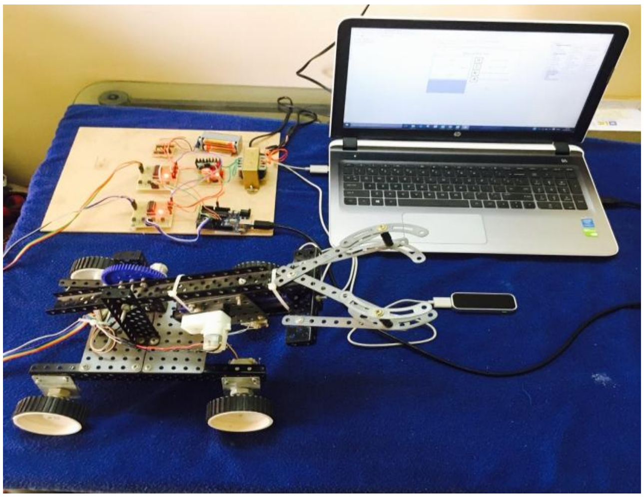

Fig. 6 Practical Implementation

IV. CONCLUSION

With the help of a sensor such as leap motion and gesture control we are able to achieve seamless synchronization with human hand and robotic arm. We have seen in the Gesture Control of Drone Using a Motion Controller ayanava sarkar and team were able to move the AR Drone with help of motion controller through the hand gestures. They also were able to make the Drone flip and they have mentioned that the Leap can teach to recognize more hand gestures and movements by altering the python scripts and adding more functionality.

From Real-Time Robot Control Using Leap Motion A Concept of Human-Robot Interaction we can conclude that with help of sensors such as leap motion and few mathematical equations (Inverse Kinematics, integration) we are able to achieve seamless synchronization between human hand and robotic arm. By studying these papers we were able to design the system i.e. robotic arm simulation using leap motion controller. It allows better control ability and it facilitates its use. Thus, we have developed aprototype of robotic arm, which can be operated in three dimensions (3D) with the degrees of freedom (DOF) of the human forearm. Thus the prototype designed has much better accuracy with low cost. It can we the revolution in the future.

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