Robot-arm Control System using LEAP Motion Controller

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***Abstract*— The objective of this research was to design and construction of the system for control robot arm using LEAP Motion Controller. This research has adapted the principle of LEAP Motion Controller and servo motor control. The designed and constructed the project was composed of 3 main parts: 1) detector part, 2) signal control and processing part using microcontroller ATMEL 328 on board (Arduino UNO R3) and 3) display part consists of a robotic arm with a handle two inches. The results of functional testing shown that the system can handle and control the movement of the robot arm to the objectives of the project.**

Keywords*— *Leap Motion Controller; robot arm; servomotor;

I. INTRODUCTION

Technology to track the movement of the body especially The movement of the hands and fingers are likely to grow in the field of research, the more recent Microsoft Research or MSR is a laboratory of the Microsoft company has offered devices to detect motion of the hands and fingers in real time. The device is called Digits. The Digit uses seventeen sensor, which is a prototype developed and relatively expensive, despite the use of Digits must wear wristbands, Which now has a large device as a result, controlling troublesome. Or wearable electronic device called Myo Gesture Control Armband or called Myo armband that can command a computer. Smart phone operating system, Windows, Mac, iOS, Android or other device. Using the principles of sensing Electromyography (EMG). Present, there are devices called LEAP Motion Controller, a device for detecting the movement of the hand and finger by using LED Infrared Sensor third position takes up a third dimension covers 140-150 degrees and a small digital two camera. to detect the movement of the two hands and ten fingers. The maximum resolution of the image capture 200 frames per second, users do not need to wear any make control more convenient.

Material outside of the LEAP Motion Controller device constructed of aluminum the device dimensions are 80 x 30 x 11.25mm (Fig. 1.) on a black glass to reduce noise exposure in the workplace because the LEAP Motion Controller uses infrared light to detect movement of the palm and fingers its inside (Fig1.) is a small digital camera to track the hand or object in range detection device, infrared shooting out a model of the X-axis, Y-axis and Z-axis. X-axis is the length, Y-axis is height, Z-axis is depth. LEAP Motion Controller includs CPU and USB Controller within which they must work together to find the location of the object. Fig2. show a position of coordinates that represents all modules of the Leap Motion. The X, Y and Z-axis is the Effective range the coordinates are not equal. The X axis is the axis width. It is a axis value that has both a positive and a negative value. The coordinates of the distance that is 117.5 - (-117.5) mm, Y axis is 82.5 – 317.5 mm and Z axis is 73.5 – (-73.5) mm respectively. Because the Leap Motion Controller use infrared light can not shine through the object, it can not detection if the overlap of the hand and fingers. Leap motion controller supports the popular 3 Series main software : Window, Mac and Linux, software will connect LEAP Motion Controller via USB bus we are able to read the data of hands movement and fingers from the device by Application Programming Interface (API) to access the data. The main language is suitable for applications including C ++, Java, C #, Python and JavaScript API, which makes it possible to develop applications from a variety of sources.

Conclude: Attribute of Leap Motion Controller

- Motion Sensor that is designed to control the computer with both hands and finger.
- Leap Motion Controller can control the images or objects on a computer software with ease.
- There are discrepancies between the controller and point-to-point millimeter high accuracy.
- We can simulate a 3D object on a computer and can magnify images with a fingertip.
- Time response is very high.
- The device LEAP Motion Controller will remember the location of objects by reference to the X axis, Y, and Z axis, with the Origin in the center mirror surface of the device, which X-axis is the length, Y-axis is height, Z-axis is depth.

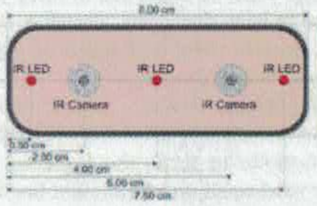

Fig. 1. Visualization of a Schematic View of Leap Motion Controller.

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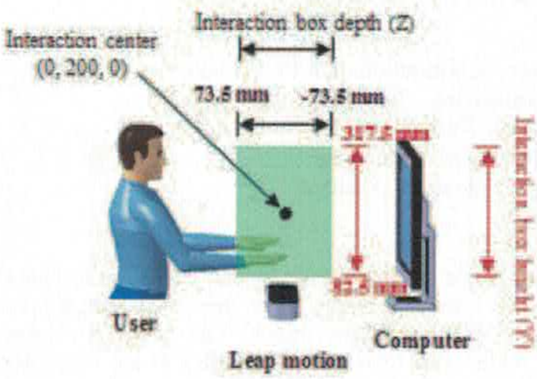
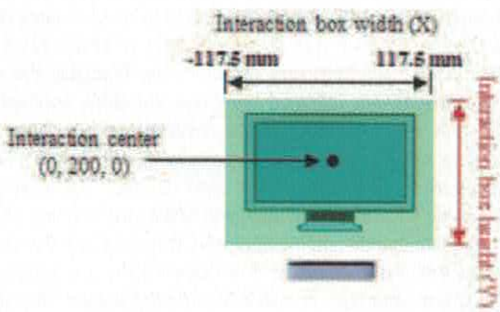


(a)



(b)

Fig. 2. Interaction box (a) side view (b) front view

II. MAPPING LEAP COORDINATES TO WORLD 3D COORDINATES

LEAP Motion Controller will provide information in the form of a set of data called Frame by Frame (Frames) will provide a list of all the elements of movement, posture and motion detectors at all. Information will include :

- Hands : all data of hands includes the location data is measured in millimeters. Speed of movement is measured in millimeters per second, and so on.
- Pointables : the fingers were classified by the width of the pointer. The store is in the same position, direction, speed, width, length, and palm-owned Pointable that (according to resident ID).
- Gestures : can be classified in three forms: a circular motion to keep the speed, direction, center value,start point, present point and speed of the swipe it save the location and direction.

The coordinates of frame (hand and Pointable) in millimeter unit we must convert the coordinates is the angle to bring the servo motor to rotate the angle we want. Mapping coordinates we used equation of a straight line in Eq. 1.

$$X_{NEW} = \left[(X_{LEAP} - START_{LEAP}) \times \frac{RANGE_{LEAP}}{RANGE_{NEW}} \right] + START_{NEW} \quad (1)$$

$$RANGE_{LEAP} = LEAP_{END} - LEAP_{START}$$

$$RANGE_{NEW} = NEW_{END} - NEW_{START}$$

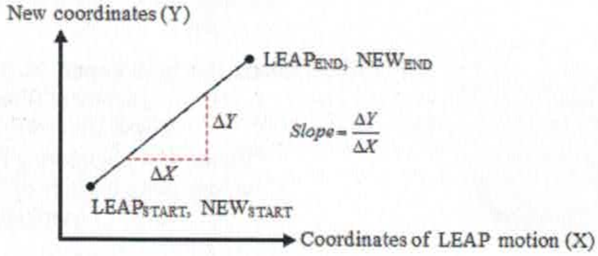


Fig. 3. Equation of a straight line

III. SYSTEM ARCHITECTURE

Controlling system shows in Fig. 4. This system consists of 4 main pasts:

- The signal detection consists of a leap motion controller
- The signal processing part using JavaScript and Node.js
- Microcontroller
- The robotic arm

In the first part: LEAP Motion Controller's internal components is a two camera digital to detect the motion of the hands and fingers and a three LEDs infrared for detect the distance between the user's hand with the Leap Motion Controller. To detect the distance for control the robot arm, CPU inside the LEAP Motion Controller is processing visual information. It then sends the data to the movement of the hands and fingers into a computer, The data will be formatted data on the distance and the position coordinates of the hand and fingers after that sent to the microcontroller for signal processing and send control commands to drive the servo motors to control the robotic arm

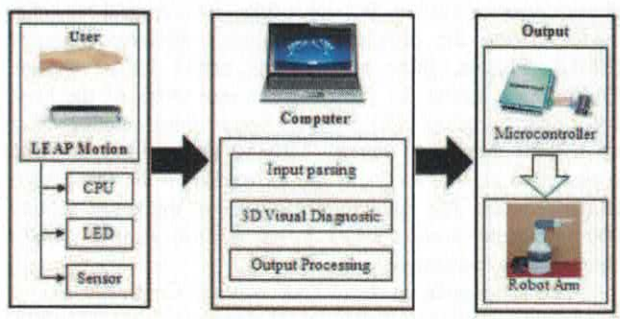


Fig. 4. Block diagram of control system.

IV. CONNECTION BETWEEN THE LEAP MOTION CONTROLLER AND ROBOTIC ARM

This research used node.js. Node.js, which is working on a Server-side structure and form of the language used to write JavaScript language is a language that is designed to work with Event-Driven. We also need to install the package is the leapjs and johnny-five packages to get data from the Leap

Motion device and send it to the microcontroller. The javascript library for Leap, called leapjs, works by waiting for a Leap 'frame' to be emitted to the listener, which then calls an anonymous function. We use this function to set our variables for later use with johnny-five. Here's the basic form of it:

```
var controller = new Leap.Controller();
controller.on('frame', function(frame) {
  <get our Leap Motion data here>
});
```

The johnny-five package basically requires we to initialize a board and whatever else we are going to use inside that.

```
board = new five.Board();
board.on('ready', function() {
 servoBase = new five.Servo(3);
 servoShoulder = new five.Servo(9);
 servoElbow = new five.Servo(10);
 servoClaw = new five.Servo(6);
 ...
```

There are four servos in the arm, and three separate main controls. The base rotation is controlled by the x position of the hand. The end effector is controlled by the distance between two fingers. Finally, the shoulder and elbow joint angles are calculated by the inverse kinematics equation with inputs of the y and z coordinates.

```
function calculateBaseAngle(x) {
  var n = 100*normalize;
  x = 1.5+2*x/n;
  var angle = 90+Math.cos(x)*90;
  return angle;
}
```

Fig. 5. shows the directional control the robot arm. X-axis of Leap motion device to control the motor1 (θ1), Y-axis of Leap motion device to control the motor2 (ϕ1), Z-axis of Leap motion device to control the motor2 (ϕ2)

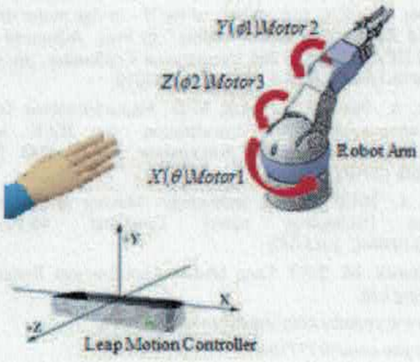


Fig. 5. Directional control the Robot Arm by Leap Motion device

V. Robotic Arm Prototype

This research uses the process of Rapid Prototyping by using 3D printer, and the prototype is designed in CAT software. Fig 6. shows the robot arm prototype. The designed robot arm has four degree of freedoms (DOF) which consisted of waist, shoulder, elbow, and fingers. The structure of the gripper showed the number of fingers, means the position of the two fingers determined the position of the clamps of the gripper. By developing 4 DOF, the robotic arm able to mimic the motion of a human arm while the operator controlling the robotic arm for pick and place objects task. Based on the formulation of the inverse kinematics equations that are modeled, the underwater robotic arm is developed.

Fig. 6. Robot arm prototype

VI. Experimental Results

Fig. 7. shows the experiment setup consisting : Leap Motion Controller, Computer, Robot Arm and Power Supply. Figure 8 shows test distance of Leap Motion Controller in X, Y and Z axit compared to the angle of servo motor in the Robot Arm. Finaly Performance testing of the totle system.

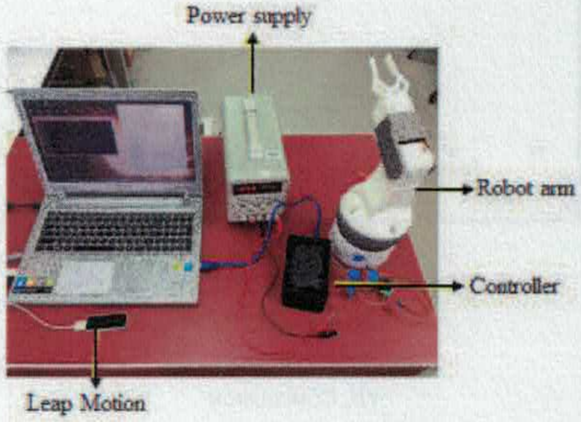
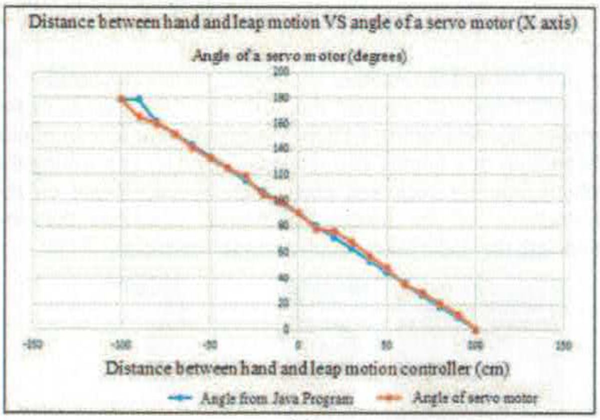


Fig. 7. Experiment setup



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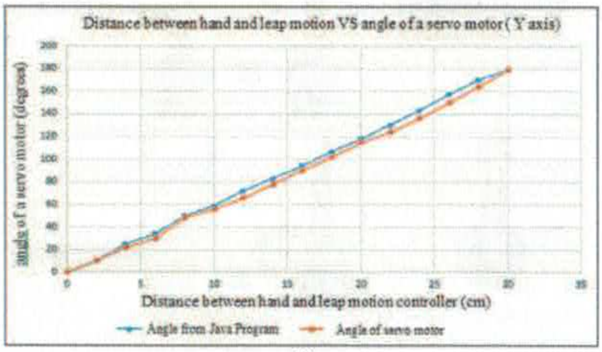

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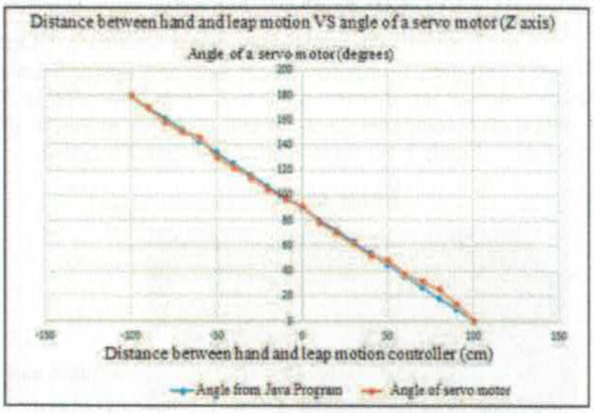

(c)

Fig. 8. Test the functionality of LEAP Motion Controller compare angle of servo motors.

VII. CONCLUSION

Objectives this research is use LEAP Motion Controller to detect the movement of the hands and fingers to control the robotic arm. The leap motion controller has sensitivity to light, it may cause a crash.This research can be controlled precisely. The results are satisfactory. You can use the LEAP Motion

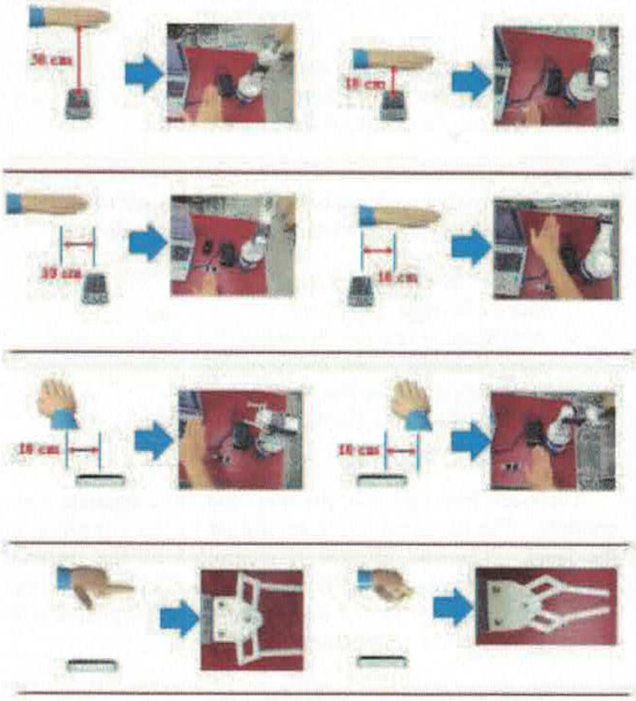

Fig. 9. The results of direction control.

Controller device with high accuracy for precision in detection check of 0.01 millimeters per second.

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