NORTHERN ARIZONA UNIVERSITY
College of Engineering, Forestry & Natural Sciences

To: Professor Razi

From: EOD ROBOT #1, Fahad Al Maraghi, Chaoju Wang, Yuting Zhang, Hanxiao Lu, Qiyuan Huang

Date: 10/13, 2017

Subject: Client Status Report

We would like to thank professor Abolfazl Razi for kindly sponsoring our project EOD Robot. Professor Razi is not only the sponsor, but also the mentor of EOD robot. We truly appreciate his support and patient guidance of this project. Our team is highly motivated and determined to successfully complete this project in a timely manner. Any project relating to robotics and automation is considered by us to be a pleasure to work with. Robotics is quickly becoming a booming field. The infinite Flexibility and uses that we can get out of robotics with modern technology allows us to achieve complicated functions. Furthering this field is an objective of ours. We believe that Robotics and Mankind have only just started to walk hand in hand, and the future seems filled with endless possibilities. Enjoyability and experience gained is also a major factor in our choice. If the project wasn't as enjoyable or interesting as it is we wouldn't have picked it.

Current Uses:

Robots that operate using mimicry of the user is prominently used in the field of Machine learning, where the machine would extract information based on the user's movements in which motion capture systems are used. This method is used to teach robots how to walk or how to lift an object for example. Another form of this technology lies in facial mimicry, a good example of this would be a hanson Robotics, they used mimicry to teach “Sophie” (a social robot) facial expressions.

This report will explain what our project is in detail, what method we used to realize the solution, and will provide the reader with information pertaining to the control of the robot.

EOD ROBOT #1

Contact Information:

Team Member	E-Mail	Phone Number
Chaoju Wang	cw892@nau.edu	928-221-1942
Fahad Almaraghi	fa256@nau.edu	928-637-3198
Hanxiao Lu	hl443@nau.edu	928-225-0439
Qiyuan Huang	qh33@nau.edu	928-255-9257
Yuting Zhang	yz292@nau.edu	928-225-0773

Table of Contents:

Problem Definition/Description:

This project deals with design and implementation of a specific type of robots called-Body control explosive ordnance disposal (EOD). The idea is to use robots to perform tasks that may cause hazard to people and hence is not safe to be done by ordinary people. An example would be moving a suspicious box that may include explosive material in an Airport. An important challenge and feature in remote-controlled robots is to design a user-friendly and low-cost man-machine interface. In this project, we are proposing to use body-controlled robots, where the robot will try to imitate a person’s actions. In particular, the robot will include a remote-controlled arm, which will follow the motion of the hand of the instructor. This is the easiest way to guide a robot. You pretend to do something, and the robot just follows you. EOD robot can be used to perform tasks under dangerous circumstance by imitating the movement of human arms. It can carry boxes, catch things, push buttons, and so on. Totally there are two control center based on Raspberry Pi. One is located in human arms to gather signals from sensors, another is located in the robot to control the march and movement of the robot. In addition, a communication system is needed to exchange signals between human and robot. When sensors on human’s hands capture the movement, the electrical signals will be send to robot as wireless signals. Then the control center will catch the signals and control the movement of robot to imitate human.

Research Survey Results Section

- Chaoju Wang

My research includes:

- Some solutions of capturing the movement of the hand.
- Microcontroller
- Programming language

Our project is called the Body Control Explosive Ordnance Disposal (EOD) Robot. The basic idea is to build a robot controlled by wearable device like a glove to move or disarm an explosive object. After several meetings with my teammates, I have been assigned some problems to research.

Solutions that using sensors

We find that the most difficult thing is capture the movement of human's hand. We looked over the Internet, trying to find some sensors to solve this problem. After discussing about what we find with teammates, we choose several kinds of sensors to react with hand moving. I'm going to introduce the 3 most reliable. The first one is pressure sensor which resistor will be changed if we push it. It is very cheap, but it's may a little low accuracy. The second one is capacitive touch sensor. It just like the touch pad on smart phone and it is easy to use. The last one is angle sensor. It can capture the rotation of the wrist, but it is very expensive. We plan to test these options this or next week.

Microcontroller: Raspberry PI

After do some research about the robot, we plan to use some modules to achieve our objective. First, we are going to use Raspberry PI as the micro-controller of robot and the glove, because Raspberry PI 3 model B has built-in WIFI function, and it's easy to develop the communication system between devices. Maybe we need two Raspberry Pies because we have a lot of in and out signal to deal with but there are only 14 GPIO (General Purpose Input/Output) on one Raspberry Pi [1]. Besides, we will use the metal platform with tank track. The metal platform can hold heavier thing and tank track is suitable for almost all the terrain [2]. For the robot arm, we decide to use a 6-axis arm. We can control the movement of the arm easily by the servo motors. We can add some tool on the robot arm such as screwdriver and wrench to upgrade the robot. So, the robot not only can move the object, but also can do some complex operation on the target.

Programming Language: Based on Python

Since we are going to use Raspberry Pi as the microcontroller of the project, we use Python as the main programming language. Python is doing good on Raspberry Pi and it is easy to learn. Cause we need to display the video on both computer and phone, website are the most convenience options. So, we need to use HTML to develop a web function and we don't need design to different applications for computers and smartphones. The requirement says that we need to design a visualization application to observe the move of the robot. We are going to program it on computer by using Java or Python [3]. As we may be going to use Java, Python, and HTML, I suggest that we use Eclipse as the IDE. This software is good at compatibility and maintainability with the language we used. And we can use Git to do the version control of our code.

[1]Raspberry Pi. (2017). Raspberry Pi 3 Model B - Raspberry Pi. [online] Available at: https://www.raspberrypi.org/products/raspberry-pi-3-model-b/ [Accessed 14 Oct. 2017].
[2]Kookye.com. (2017). How to use phone app to control robot smart car with ESP8266 wifi module and expansion board – kookye.com. [online] Available at: http://kookye.com/2016/11/23/how-to-use-phone-app-to-control-robot-smart-car-with-esp8266-wifi-module-and-espansion-board/?preview=true [Accessed 14 Oct. 2017].
[3]Raspberrypi.org. (2017). Python - Raspberry Pi Documentation. [online] Available at: https://www.raspberrypi.org/documentation/usage/python/ [Accessed 14 Oct. 2017].

● Yuting Zhang

My research includes:

- Sensors
- Part of control system
- Visualization

Sensors

I have assigned to research on sensors of the EOD robots. The sensors are distributed on human's hands to control the movement of the robot. The important thing here is that the robot's whole arms should be controlled just by human's hand, the goal of this is to reduce the number of sensors. Just use hands can avoid the situation that human's arms are all covered by sensors. Thus, the sensors on human's wrists should be able to catch the movement of wrists or catch the angle change of wrists.

For that, I found some angle sensors [1] and some pressure sensors to achieve the goal. If we use angle sensors, the rotate angle will control the movement of the robot. That means the robot's arm will turn left when human rotate the hand to left and turn right when human rotate the hand to the right. Totally around 8 sensors will be put on one of the human's hands. Three sensors on three separate fingers, one sensor on palm and four sensors on the wrist. Maybe we will use gloves to fix sensors.

Part of control system

In addition, I am assigned to a part of the control system work. The movement of human's arms will be the control signal of the EOD robot. This process includes transfer from hand movement to the electrical signal and transfer between the electrical signal and wireless signal. Two control centers are needed to achieve the goal. One in human hand to collect the sensors' signal, transfer them to the wireless signal and send the signal to the robot. Another control center is located on the main body of the robot to receive the wireless signal and transfer them to the electrical signal.

Then use the signal to control the movement of robot arms, also use the signal to control the match direction and speed. To complete these two parts of the communication system, our group decided to use Raspberry Pi 3 to build it [3]. We will use Python to develop programs. The main reason to use Raspberry Pi 3 is that it has the wireless model, so we can control the robot at a distance. Wireless is necessary since the robot may work in the dangerous environment, so people must control it at a distance.

Visualization

The last part of the job I am assigned is to realize the visualization of the robot movement. Virtualization will be next semester's work since we should build the robot first. This part is totally software work about writing the program to present the robot motions on a computer screen. The first step is to capture the motions of the robot. Sensors may be used to capture the motions of the robot. But if we use sensors, sensors will be covered all over the robot. Sensors are easily affected by environment especially in some dangerous places the robot may be used. Thus, sensors may be impractical.

My group found that Xbox may be working to capture the movement of the robot, that still in discussions. After motions capture, I will use Python to realize the visualization. There are some useful plotting libraries in Python like Matplotlib [2]. That will help to do the virtualization part.

Reference:

[1] Standard SWS66 angle sensor. (n.d.). CaRID. [Online]. Available: https://www.carid.com/standard/intermotor-steering-angle-sensor-mpn-sws66. Accessed Oct. 10, 2017.

[2] Matplotlib. (n.d.). The Matplotlib development team. [Online]. Available: https://matplotlib.org/. Accessed Oct.10, 2017.

[3] RASPBERRY PI BLOG. (n.d.). Raspberry Pi fundation. [Online]. Available: https://www.raspberrypi.org/
. Accessed Oct.10, 2017.

- # Qiyuan Huang

My research included:

- The best workspace for the robotic arm
- Suitable material for the main structure of robotic arm
- Bluetooth: a kind of wireless method

I was assigned to research the robotic arm that is suitable for our project, as well as the Bluetooth wireless control. The requirements of my research is to find out the best workspace for the arm, and use what kind of material to make its structure strong enough. I have done research of robotic arm and Bluetooth. In this essay, and I will give a brief summary of my research and solutions.

Workspace:

First of all, workspace of the robot arm is an important factor to consider, we have to ensure the arm has enough workspace to implement a variety of functions. I need to figure out what exactly workspace we choose for our robot arm without affecting the volume and stability of the whole robot. The robot workspace (sometimes known as reachable space) is all places that the end effector (gripper) can reach. The workspace is dependent on the DOF angle/translation limitations, the arm link lengths, the angle at which something must be picked up at, etc. The workspace is highly dependent on the robot configuration. [1] I found that the main joint of the robot arm rotates a maximum of 180 degrees because most servo motors cannot exceed that amount, so when we build our robot arm, I would like to choose 180 degrees as the rotate angle of the main joint in order to get the maximum workspace. Then, we only need to adjust the parameters of the other parts of the robotic arm to accommodate it. The problem of the current solution is to buy a finished robot arm is just little more expensive than to build a robot arm. Obverse, the more efficient way is to buy a finished robot arm from Amazon compare with we DIY our robot arm.

Material:

I also need to find a suitable material for our robotic arm. I think the robotic arm must be strong enough considering the possibility of doing a high strength work, as well as we plan to add many tools on the arm. Robots are mostly built of common materials. Some specialized robots for clean room applications, the space program, or other "high tech" projects may use titanium metal and structural composites of carbon fibers. The operating environment and strength required are major factors in material selection. Steel, cast iron, and aluminum are most often used for the arms and bases of robots. If the robot is mobile, they usually equip them with rubber tires for quiet operation and a positive grip on the floor. Robots contain a significant amount of electronics and wiring, and some are radio or laser controlled. The cylinders and other motion-generating mechanisms contain hydraulic oil or pressurized air. Hoses of silicone, rubber, and braided stainless steel connect these mechanisms to their control valves. To protect the robot from the environment, some exposed areas are covered with flexible neoprene shields and collapsible bellows. [2] I was considering using engineering plastics as main material to ensure the strength while reducing the overall weight, but the joint and the skeleton parts of the robot arm are made of stainless steel. Using these common materials to build up the robot arm not only can satisfy our requirement, but also cost-saving.

Bluetooth:

Bluetooth and Wi-Fi (the brand name for products using IEEE 802.11 standards) have some similar applications: setting up networks, printing, or transferring files. Wi-Fi is intended as a replacement for high-speed cabling for general local area network access in work areas or home. This category of applications is sometimes called wireless local area networks. Bluetooth is a standard wire-replacement communications protocol primarily designed for low-power consumption, with a short range based on low-cost transceiver microchips in each device. Because the devices use a radio (broadcast) communications system, they do not have to be in visual line of sight of each other; however, a quasi-optical wireless path must be viable. Range is power-class-dependent, but effective ranges vary in practice. See the table on the right. Officially Class 3 radios have a range of up to 1 meter (3 ft.), Class 2, most commonly found in mobile devices, 10 meters (33 ft.), and Class 1, primarily for industrial use cases,100 meters (300 ft.). Bluetooth Marketing qualifies that Class 1 range is in most cases 20–30 meters (66–98 ft.), and Class 2 range 5–10 meters (16–33 ft.). [3]

Generally, the more detailed the earlier investigation, the more helpful to the later work. Therefore, I will continue doing research if it is necessary

Reference:

[1] Society of Robots, (copyright 2005-2014). “On the Japanese concept of punctuality”. [online]. Available: http://www.societyofrobots.com/robot_arm_tutorial.shtml. pp. 4-5.

[2] Edelson, et al. "Robo Surgeons." *Popular Science*, April 1995, pp. 62-65, 90.

[3] Wikipedia, “Bluetooth”. [online]. Available: https://en.wikipedia.org/wiki/Bluetooth. pp. 4-6.

● Fahad Al Maraghi

My research included:

- Xbox Kinect viability as motion capture system for robot to mimic user movements
- Electroencephalography (EEG) to capture brain patterns and translate to robot as movements
- Gyroscope + Accelerometer
- Pressure activated sensors on glove to realize robot movement
- Making the robot semi/full autonomous using:
    - Image Processing
    - Ultra-sound
    - Photosensors

Kinect:

The Xbox Kinect is a highly accurate motion capture system that has been used in machine learning. Scientists are using Xbox Kinect to capture the motion of the user in order to translate those movements to the robot which mimics the user's movements. By finding a way to translate movements to numbers that the robot can understand, we could achieve this.[1]

EEG :

EEG is a method in which we can record and visually see the electrical activity of the brain. The idea here is; when the user lifts his/her arm for example, neurons fire in a specific pattern. We can read this pattern using an EEG headset, use the data to create a for a system of movement the computer understands. It's been done before, a 16 year old High school student in India that created a robotic arm that moves in the same way (to a degree of accuracy) when the user wearing an EEG headset is moving using brain pattern recognition. [2]

Pressure Activated sensors:

Using pressure sensors (Force Sensitive Resistors) placed in specific areas of the glove we embody mimicry between the user and robot. For example, if the user does a clamping motion with his/her hand, the robot would do the same. This would happen due to a force sensitive resistor being placed between the thumb and index finger (aka forefinger). Extensive brainstorming is required in order to create a valid system of mimicry, but it is possible to achieve. It's the simpler cheaper alternative.

Image Processing:

Image processing is a commonly used technique. If we attach a camera to the robot and develop an image processing system using image segmentation the robot would be able to understand its surroundings to a degree. This could be used as an assist function for the user or to make the robot autonomous if developed further. [3]

Photosensors:

Photosensors can be used to calculate distances. We can use several photosensors working in unison as a detection system. The Bot could know if it is about to collide with an obstruction using photosensors.

Gyroscope & Accelerometer:

An accelerometer is an electromechanical device that is sensitive to acceleration forces and is dynamic to movement or vibrations, while a gyroscope is a device that is used to sense orientation. Using a combination of the two, a system of defining movement for the robot could be achieved. With this system we would translate the user's movement into numbers the robot can understand and mimic. I've had experience with gyroscopes and accelerometers before.

Force sensitive Resistors:

Over the course of the next week and a half we've done enough research to decide on a method, and after discussing our findings with Prof. Razi the force sensitive resistors were chosen. We found the perfect part to help us achieve this; Adafruit Round Force Sensitive Resistors.

The Force sensitive resistors show promise, but that does not mean it does not come with its own set of problems. The first problem is sensitivity control. Experimentation is required to figure out if we can control the sensitivity level of the sensor. The hypothesis is that by changing the value of the pull-up resistor we can control the sensitivity of the sensor.

Cost is not an issue with this solution, since the sensors themselves are cheap. Market conditions and patents that can potentially block our progress do not affect us, due to the relative simplicity of applying the FSR and no patents trademarking this solution. Since the FSR's are analog and our microcontroller (raspberry pi) does not have analog pins, an ADC extension board with at least 8 channels is required to support our 9+ sensors .

References:

[1] Yavşan, E. and Uçar, A. (2016). Gesture imitation and recognition using Kinect sensor and extreme learning machines. Measurement, 94, pp.852-861.

[2] Instructables.com. (2017). Mind Controlled Robotic Arm. [online] Available at: http://www.instructables.com/id/Mind-Controlled-Robotic-Arm/ [Accessed 13 Oct. 2017].

[3] non, (2017). [online] Available at: http://web.mit.edu/profit/PDFS/EdwardTolson.pdf [Accessed 14 Oct. 2017].

- HanXiao Lu

My research includes:

- The technology we might use
- communication system
- Sensors
- robot body
- All language we might use in the project

The technology we might use

Our team's Capstone is design and make a EOD (Explosive Ordnance Disposal) robot [3]. The problems we should solve include: sensors, robotic arm, power systems, communication system etc. Robotic arm, power system and sensors can be easy to solve because there are many developed technologies can be used in our robot.

Communication system

The real problem is communication system. We have many choices such as, Bluetooth, WIFI and radio connection. Finally, we choice the Raspberry Pi (The Raspberry Pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools and in developing countries [1]) which use WIFI communication system. Because Bluetooth is not good enough for long distance control and radio is not good enough if we want the robot have many functions. Technology of WIFI is already developed greatly. We can use Python to program the communication system. It is also can help us program more functions for the EOD robot.

Sensors

The technology we need include, robot body and sensors. As the sensors, our team have three choices: Force Sensitive Resistors, Capacitive Touch Sensing and Pressure Sensitive Conductive Sheet. Force Sensitive Resistors is the most efficient option and it is cheap, but it's accuracy is not very well and sometimes unreliable. Capacitive Touch Sensing is easy to use just like we use our smart phone, but when we use is on our hand, it can lead to miss touching because it has high sensitivity. Pressure Sensitive Conductive Sheet is also a little unreliable, but is can be shaped to any size we want. So, we might choose Pressure Sensitive Conductive Sheet in the end.

Robot body

As the robot body, we find that two technologies we could use: Devastator Tank Mobile and Robot Smart Car Platform. Devastator Tank Mobile is lighter than Robot Smart Car Platform, which means it do not need very powerful battery. But on the other said it also means it's Carrying Capacity not as good as Robot Smart Car Platform. The body we will use finally will depend on what situation will have when we use robot.

All language we might use in the project

Raspberry Pi IDE:

Use to program the communication system to control the robot.

HTML (camera): Hypertext Markup Language (HTML) is the standard markup language for web applications. We can use HTML program a application to control the camera on the robot. [2]

Python:

Python is a widely used high-level programming language for general-purpose programming. We will use Python as the main language to program the most part of robot.

JAVA:

Java is a general-purpose computer programming language that is concurrent, class-based, object-oriented, and specifically designed to have as few implementation dependencies as possible. We will use JAVA as the backup language.

Altium Designer:

Altium Designer is a PCB design software, an electronic design automation software package for printed circuit board, FPGA and embedded software design, and associated library and release management automation. We will use Altium Designer to build the PCB board of the circuit in the robot.

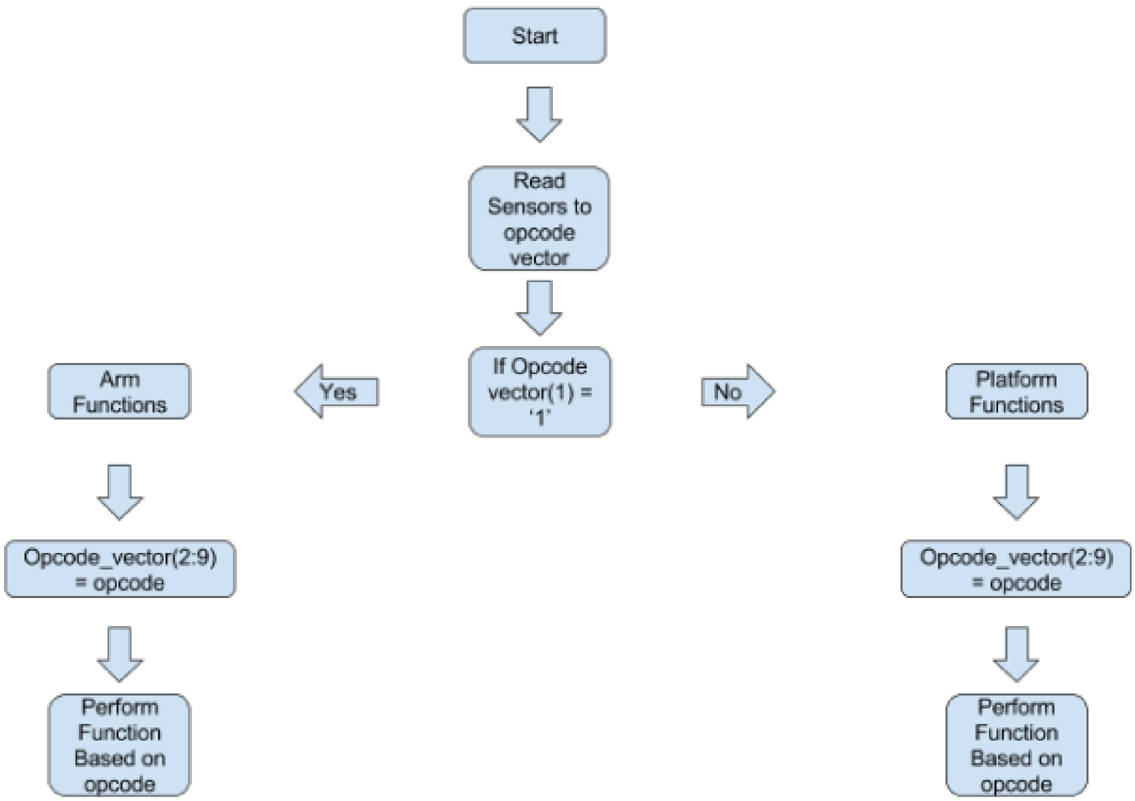
Reference:

[1]https://www.raspberrypi.org/

[2]https://en.wikipedia.org/wiki/HTML

[3]http://www.army-technology.com/projects/teodor-explosive-ordnance-eod-robot/

Flow chart Basic overview:



The basic structure of the code will be as shown (figure 1):

Based on the sensors that are activated on the glove a vector of a length of 9 bits approximately is sent to the robot. Based on the combination of ones and zeros from the opcode_vector sent, the robot reacts. The opcode vector represents a combination which is part of a function library. For example, a opcode vector of “100111001” represents activated sensors one four five six and nine which could represent the function move arm right. Using this method functions could be sent that resemble miming.

Marketing Requirements :

- **State of Technology**
  - **Problems and Constraints**

    Problems:

    There are several problems that should be explored;

    - Controlling the sensitivity of the Force Sensitive resistors
    - Accuracy and reliability of the system in regard to the sensors activating when they are supposed to.
    - Powering the system via external battery packs
    - Speed of system, how responsive is the system to commands?

    Constraints:

    - Distance between user and Robot must be at least 1.5 meters
    - Robot must mimic movements of user to some degree
    - Robot must be able to at least pick up item and place it somewhere else

  - **Alternative Solutions**

    Electroencephalogram (EEG):

    EEG is a method in which we can record and visually see the electrical activity of the brain. The idea here is; when the user lifts his/her arm for example, neurons fire in a specific pattern. We can read this pattern using an EEG headset, use the data to create a for a system of movement the a computer understands. It's been done before, a 16-year old High school student in India that created a robotic arm that moves in the same way (to a degree of accuracy) when the user wearing an EEG headset is moving.

Kinect:

The Xbox Kinect is a highly accurate motion capture system that has been used in machine learning. Scientists are using Xbox Kinect to capture the motion of the user in order to translate those movements to the robot which mimics the user's movements. By finding a way to translate movements to numbers that the robot can understand, we could achieve this.

Gyroscope & Accelerometer:

An accelerometer is an electromechanical device that is sensitive to acceleration forces and is dynamic to movement or vibrations, while a gyroscope is a device that is used to sense orientation. Using a combination of the two, a system of defining movement for the robot could be achieved. With this system we would translate the user's movement into numbers the robot can understand and mimic.

Image processing:

Image processing is a commonly used technique. If we attach a camera to the robot and develop an image processing system the robot would be able to understand its surroundings to a degree. This could be used as an assist function for the user or to make the robot autonomous if developed further.

Photosensors:

Photosensors can be used to calculate distances. We can use several photosensors working in unison as a detection system. The Bot could know if it is about to collide with an obstruction using photosensors.

Mechanical :

Basically, the mechanical specifications are depending on what kind of platform and robot arm we are going to use. According to our research, we choose a metal platform called "KOOKYE: Robot Smart car Platform" and a 6-axises called "SainSmart DIY Control Palletizing Robot Arm". We divided the hardware of our robot into several parts, the platform, the robot arm, microcontroller which is Raspberry Pi, sensors, power system, wire connection system, raw data processing system (like ADC), and some other peripheral equipment's

- Size:
  The size of the robot is about 11*10*10 inches, and the glove (remote control device) is a normal size of glove with a Raspberry Pi which is 3.37*2.22 inches.
- Weight
  The robot will be about 3 kg, and the control-glove will be less than 100 g.
- Interconnect
  The connection between two devices (the robot and the glove) is by WIFI. The inner device connection like communication between microcontroller and ADC is by physical wires and jumpers.
- Package
  The final product will come out in a plastic box or corrugated paper box with the air bag and foam plastic in it.
- Protection
  We are going to use the tank track as the motion system, and the metal platform as the robot body. So it will be strong and durable. We have the idea that adding a ultrasound sensor to avoid the obstacle in the way.

Electrical :

We choose lithium battery pack as the power of our robot. This section talks about some information of our power supply for robotic part. We need to choose a battery with high power endurance in order to achieve the work demand of our robot, as well as has a strong adaptability of high and low temperature.

- Power < 9V
  Lithium battery has a high-power endurance. This battery also has a high storage energy density, which has reached 460-600Wh/kg, it is about 6-7 times of lead-acid batteries.
  Service life: 6 years.
  Working temperature: -20℃--60℃.
- Accuracy
  Single cell: Using battery charger controller in order to guarantee the ±1% final battery working voltage specification accuracy.
  Battery pack: Working voltage is unstable.

- Values & Range
  Single cell: Power type battery: normal discharge current is 2C, the maximum discharge current of 15C~20C, discharge of 15~45 degrees Celsius, average charging current is 1C, the discharge voltage of 4.2V~3.0V (mainly used in electric vehicles, electric saws and other equipment).
- Interfacing
  The battery has three interfaces, they are anode, cathode and the output terminal of temperature sensing voltage.
- Aging
  Typically, the service live of lithium battery is more than 6 years. There are three main internal factors of lithium batteries:
  (1)The degradation of active substances.
  (2)The aging and deterioration of conductive agents, binders and current collector plates.
  (3)Electrolyte decomposition.

Environmental :

Our design allows for optimum efficiency at room temperature. Although the functionality of the robot would drastically increase if it were able to operate in extreme conditions, some parts are not able to function in these conditions. Our preferable operating range would be from -5 °C to 45 °C. Shielding from Vibration shock and humidity is a requirement; some form of shock absorbers would be applied in the final design. Water Proofing the robot is a good suggestion, however this would be difficult, making it water resistant is an achievable goal.

- Temperature
  The best temperature range for the EOD robot would be from -5 °C to 45 °C. If the temperature higher than 60 °C, the efficiency of CPU on Raspberry Pi will be reduced. If the temperature lower than -5 °C, the efficiency of power system on EOD robot will be reduce.
- Humidity
  The EOD robot can endure humidity under 90%. When the humidity higher than 90%, the circuit and battery might be broke.
- Vibration & Shock
  Because we will use caterpillar band, the EOD robot can be adapting most kind of grand, like grass or sand. But because the size of robot is not huge, so it cannot pass some big obstacle.
- Slope

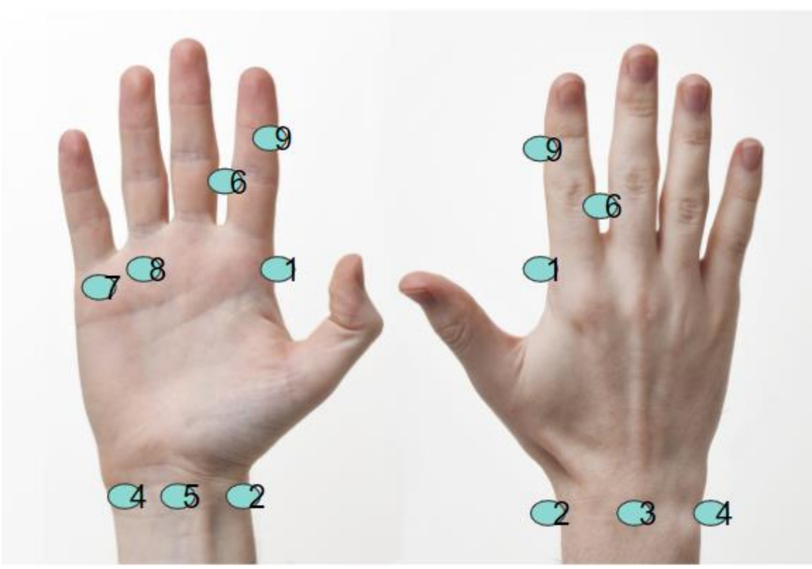
Consider about the power system and barycenter of robot. The best slope for robot is under the 30°. Because the robotic arm makes the barycenter higher than we thought and we just use low voltage battery as the power source.

Documentation :

From this section, the client or user would understand how to use the EOD Robot. Instructions on how to use the commands to control the robot and arm movements. In addition, the maintenance schedule is located here. Information regarding parts used, part numbers, schematic, and source code are placed in this section.

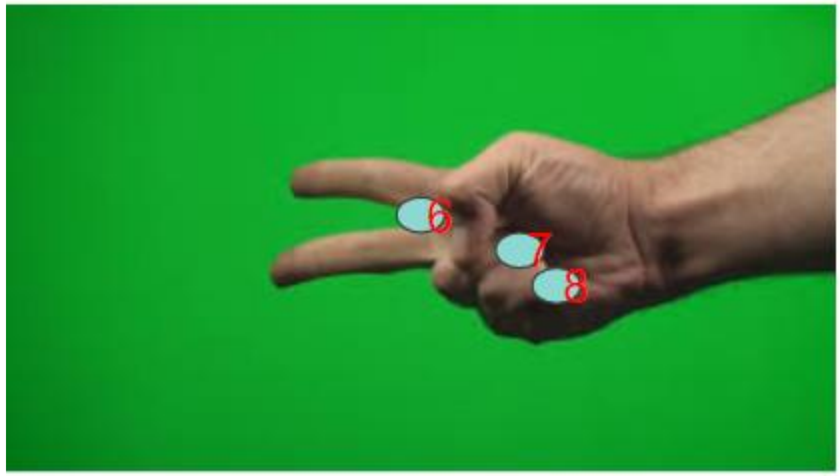
- Operator's Manual: Below
- Maintenance Manual: in development
- User's Guide: in development
- Platform: “KOOKYE: Robot Smart Car Platform”
- Code: in development

Operation manual & user guide



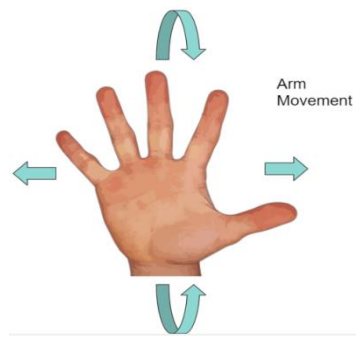
As shown above (figure 2), these are the Force Sensitive Resistors locations on the glove. Sensors four, five, two, and three control directional movement of either the robotic arm or the platform itself. For example, if the user were to tilt his/her hand to the left then sensor two would activate resulting in a left turn to the robotic arm or platform.

Sensor One determines whether the user is controlling the arm or platform. If the user's thumb were to apply pressure to Sensor one the arm would be the component receiving the instructions and if sensor one is not pressed, then the platform would receive instructions. This is a form of Multiplexer.



Sensors seven, eight, six and nine are used to perform function for the robotic arm. Every combination of the four performs an action based on the shape of the user's hand. For example, if the user were to make his/her hand into the scissor gesture (figure 3 to the right), sensors seven, eight would be activated, sensor six would be activated when the user closes the gap between his/her fingers and signals a cut motion to the robot.

When controlling the robotic arm, sensor one should be activated. To control the direction the arm is facing, simply tilt your wrist in the direction you intended the arm to head towards (figure 4). If you want the arm to go up or down, then simply tilt your wrist upwards or downwards and the arm would mimic. The sensors that deal with horizontal movement are sensors two and four, while vertical motion is determined by sensors five and three.



For Platform control we decided to model the controls after the traditional aircraft yoke (figure 6). To move the platform forward simply hold your fist vertically as shown to the right (figure 5) and tilt your wrist forward, and for backwards motion tilt backwards. Left and right motions are realized by tilting your wrist left at a 90-degree angle to the left and a 90 degree angle tilt to the right is required for a right movement of the platform.

<u>Software/GUI :</u>

Since a raspberry pi being used as the microprocessor, Python is us to go to language for this application. Our code is going to be structured as shown in the figure above with relative simplicity. Based on the FSR sensors the glove component will transmit data to the robot. The first Most significant bit (leftmost bit) of the Opcode Vector transmitted from the glove determines whether the user is controlling arm or platform. The other 8 bits determine which function the robot calls and executes. These functions are basically movement instructions.

- Code: in development (look at figure 1)
- Language: Python

Since our Microcontroller (control center/Robot brain) is a raspberry Pi, python should be used as the programming language. Python is considered to be the standard language for Raspberry Pi programming. Speed and efficiency are attributes of Python when used in conjunction with a Raspberry Pi

<u>General :</u>

Generally, this robot is strong enough to work on field environment since it has precise and well organized mechanical structure. In addition, it has basic movement like catch and push. It can be used to carry boxes and do basic field work like push buttons on dangerous objects under the control of human arms' movement. The way people use it is to move hands, and the robot will capture the motion and imitate the movement of human.

- **Reliability:**
  It has high reliability since it is built by strong metallic material. The structure of this robot is also well designed. It is constituted of platform, arms, and main body. The range of the temperature it can afford is also wide.

- **Self-Calibrating :**
  We applied communication system on it, so it can supervise the uniformity of the robot movement and human movement.

- **Vendor Preferences:**
  Vendors provide many alternative design that clients can make a choice. Accelerometer and Kinect are alternative parts can be added on the robot if clients want. Vendors are highly accuracy factories to produce robots. The factories should be well professional on control the production of the accurate communication system.

- **Client Preferences:**

Clients are more likely to be organizations who have to do dangerous work on field environment. To avoid the potential risk of this kind of works, robot can replace human to carry boxes and touch the uncertain objects.