

Dissertation

by Amgad AbuKwider

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**A Study of Mind Control Robot Vehicle
Using Lego ROV**

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Project submitted as part of the requirements for the award of BSc (Hons) Software
Engineering

April 2016

DECLARATION

I, ...(FULL NAME)..... declare that I am the sole author of this Project; that all references cited have been consulted; that I have conducted all work of which this is a record, and that the finished work lies within the prescribed word limits.

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Abstract

The following project will be aimed at having Mind control robotic vehicle. This will look at how it is possible to use the human mind to move objects. This project is unlike many project currently undergoing which uses rather than the thought that occurs in the mind and focuses on neuroscience area which involves the nerve system.

In the project the methods that will be undergoing will begin with approach being deductive where it will test the logic behind this idea. This will be followed by the main part which are Experiments, software development and Document review. This will begin with the document review being all based on research so that when coming to software development there will be an idea of what is expected to happen and how it will occur. With the software development being completed the experiment will occur testing what has been worked and developed in the previous section.

The methodology that will be used during the development will be focused on Feature-Driven Development. It was chosen as there will be contact with the supervisor over the progress and the fact of not being able to move onto the next stage without the current working on stage being complete. This will also contain the list of most required task known as the MoSCoW list. This will show the Must have, Should have, Could have and won't have.

With the currently most known about existing projects and experiments with the ROV are NASA where they have worked on space rovers and communicating with it through the large scale of space. The mind control has not had many developments occurring and rather very little interest have occurred in this area as it is rather a complex area to touch.

This will finish with the conclusion and recommendation of the project which will look at the overall result and how it could have been effected it different approach could have occurred being written under the recommendation.

"The number one benefit of information technology is that it empowers people to do what they want to do. It lets people be creative. It lets people be productive. It lets people learn things they didn't think they could learn before, and so in a sense it is all about potential."

- Steve Ballmer

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Introduction

The following project will focus on investigating the brain use for controlling ROV. This will be done using Electroencephalography (EEG) and using Lego Robot. This will look at what currently exists, any experiments currently undergoing and who are working with this sort of idea. There will also look at similar methods that are being used by other people such as the use of Neuroscience.

Aims & Objectives

The overall aim for the project has not changed after the research and remains to be; being able to use EEG waves via the Melon® headband to control a built remote-controlled vehicle.

Objectives:

- ❖ A deeply research to occur with any written work relating the brain-machine interfaces.
- ❖ Read Brainwaves. In order to successfully read the brainwave, monitoring program will be introduced to interface with the Melon® headband. Bluetooth communication will be used in order to talk to the Melon® headband.
- ❖ There will be transmission between the monitoring program and the remote-controlled system. The use of either Wi-Fi or Bluetooth to succeed the transmission.
- ❖ Translation of the brainwave to understood signal. For the remote-controlled system to understand; the signal of the brainwave will be converted to an understandable signal. This will need to be a very accurate and consistent translation.
- ❖ Remote-controlled system. In order to have the success of this project, building a suitable system to respond to the translated data of the brain and create variety type of testing.

Brief Description

The following research topics that will be discussed are the following; ROV which will look at what is the difference between ROV and Robot; it will continue into the different operations that ROV is being used in which will include who uses these sort of operations.

Followed by the next topic which will look into Brain Control looking at what current exists that uses the brain to control objects. This will look that the brain computer interfaces which is responsible of different types of ways; such as surgical implants, EEG, non-implants, artificial limbs it will also contain the Melon headband™.

The topic will finish with the recent development of biofeedback and how it is currently been used in gaming. Working will be topic to follow which looks into military usability and civilian usability which will take into the next topic known as hobbies.

In the topic hobbies it will look at how people took time to work on their interest in this field where they developed Camera Drones and Remote control toys.

The final part of the research topic will focus on the ROV that will be used developed by Lego Mindstorms. This will look at any current or completed experiments that people have used Lego Mindstorms product and have anyone attempt to use Brain Controlled Lego. It will also contain information at the language that it can currently be developed on and what the hardware that is needed.

This will be followed by the non-researched topics and more of experiments and software development.

It will begin with the topic about research and development methodology where it will explain what research method will be done in order to get the information needed and the development methodology will look at what approach will be taken in the development method.

This will lead into the next topics which is the design and implementation where any coding and test plans will occur. This will also contain any diagrams design with the case documents.

The project will be completed with the remaining topics which are evaluation of how the topic has work and how the experience of the project went. It will be followed by the conclusion and recommendation of the project, talking more about project rather than how it was felt working on this sort of project and it will finish with the reflection on the overall of this project.

ROV

The following is information will be about ROV - Remote Operating Vehicle

What is the difference between ROVs and Robots?

ROVs (remote-operated vehicle) are used for vehicles to be operated without any human being inside the vehicle. There are three main types of ROV such as RCV (Remote-Controlled Vehicle), ROUV (Remote-operated underwater vehicle) and UAV (Unmanned aerial Vehicle). Each of the types goes in specific operations ROUV for underwater, RCV mainly for land, UAV for drones/Aerial and RCV joint with UAV for space missions which is one of the difficult operations for humans.

The use of ROV is mainly focused at underwater experiment which is due to many experiments being developed for it, in order to provide a better understanding of underwater. Pranesh *et al* [1] state the use of suitable materials for ROV frame is important for the extreme environment and the pressure of hydrostatic and the variety of temperature.

The current robotic developed is focused on making the robot to operate without the human control. Robots that are being developed are hard coded making them only operate on the given tasks and do not know how to create other tasks for itself. An example of hard coded robot is for a robot to only have one purpose such as open and closing doors, while it is capable of doing that it cannot change doors, or move to a different location to operate on a different door. Some organisation have already attempted to make a breakthrough in humanoid and the most successful organisation is HONDA™, developing a Robot called ASIMO. One of the most famous robots created is Hondas' Asimo. Chestnutt *et al* [2] acknowledge the level of control that has been provided to Asimo, the direct location of the foot cannot be specified. This provides the solution of specifying the desire of displacement of the body. The footstep that gets taken varies based on the state of the robot.

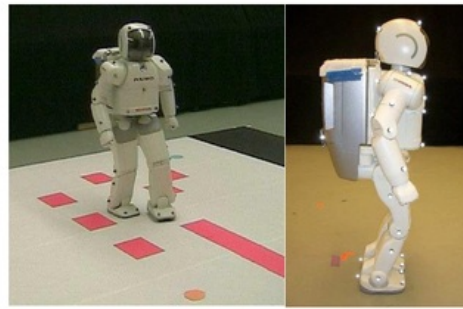


Figure 1 the Honda ASIMO Humanoid robot

Types of Operations

Underwater

In the science world, the use of remote controlled vehicles (RCVs) and robots is ideal for investigating anything from space to underwater. Places that human beings cannot reach due to limitation. When Remote robot is used for underwater it improves the understanding of the ocean deeply and widely. Doniec *et al* [3, para 1] state that current underwater robots are limited in the distance they can travel and by their need for real-time communication with their operators.

They continue to say [3, para 2] that land-based ROVs are much easier to communicate with, and making them real-time controlled is easier due to wireless communication and ability to have it travel distance with it still being connected unlike water which requires a long cable, making communication difficult and needs time, also water absorb the electromagnetic sent by the radio.

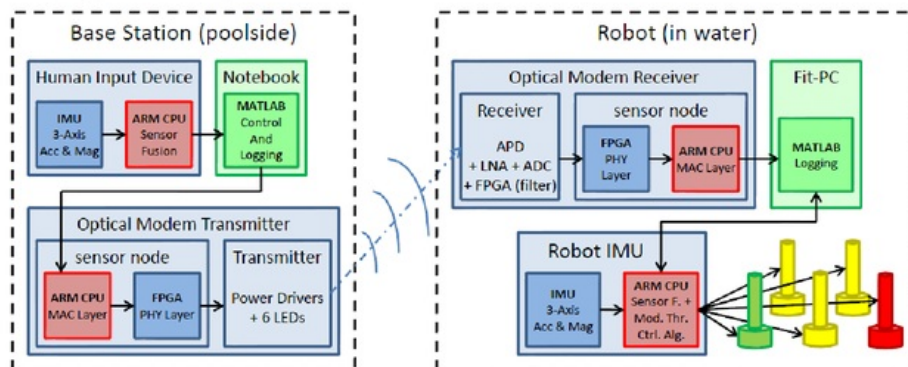


Figure 2 System overview showing the data path through all modules.

Robots that are used for underwater investigation are not capable of surviving long underwater without getting damaged, or connection breaking. This is caused by the robot being tangled or jammed also thickening the cable would cause it to be less flexible. Alternatives to cable-based communication are being investigated to get around this, for example using acoustic waves as described by Hung & Na [4].



Figure 3 Underwater Robot

When the robot is being created it gets given a set of tasks for it to execute on its operation "Investigating Underwater". The state of the robot would be monitored for any necessary implements or intervention. A group of the underwater robots would need to communicate in order to monitor oil spills, this would need to pass back motion coordination and formation control. Wang *et al* [5] investigated this in their study of shoals of remotely-operated fish.

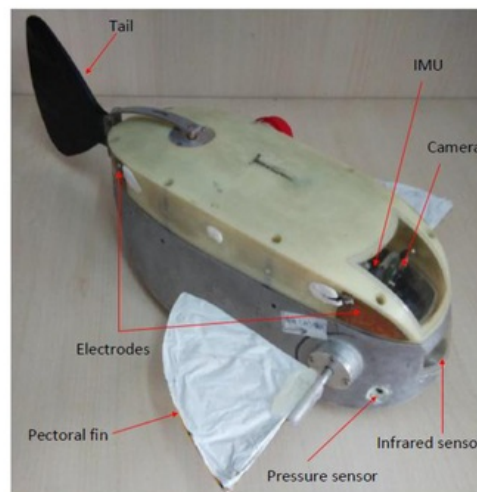


Figure 4 Mechanical and electrical configurations of the boxfish-like robot.

Land

The robot that gets designed for the industrial environment they make sure that it is capable of going from point one to another point as quickly and efficiently possible. Chinnaiah *et al* [6] state the solutions to this requires the use of complex algorithms, the use of shortest path algorithms allow it to find the point quicker.

The robot developed is advancing quickly and many people are starting to experiment with different ways to use the robot. Some of the robots that have been developed are controlled through a handheld device such as smartphones. It will communicate with the robot and give it operations and tasks for it to complete. Wu and Chen [7] strong base

solution is for the robot communication to be done via the internet and wireless communication.

The main problem when robots are being developed for field investigation is the transmission time due to the delay making data such as image arrive late than anticipated. This would cause the robot to be controlled from a delayed image and operate using previous time, and not a real time operation. Reducing the delay would improve the robot operating remarkably due to the images being up to date. Tominaga *et al* [8] investigated this in their study of Image Sequence Prediction for Remote Robot Control.

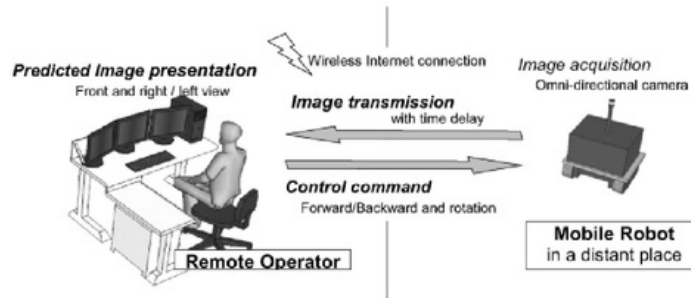


Figure 5 System concept of the remote-controlled robot.

Aerial

When developing aerial mobile robots for flight use, it is critical to make sure the designed mechanism allows the advanced navigation system to be safe and tested. The design is purposely designed for manipulator manoeuvring aerial mobile robot without having any limitation to fly. It also needs to make sure while it is flying any problems that occur in the flight of the robot, does not lose balance and is capable of hanging up without crashing or any failure to the robot as stated by Lee *et al* [9].

With the technology advancing the development of quad-rotor helicopter can be put to the test by remotely experimenting the flight duration and how it handles attitude. Quad-rotor helicopter flight control system automatically stabilises augmentation. Zou and Tseng [10] state developed quad-rotor contains multi-sensors which are used to automatically adjust the flight attitude.

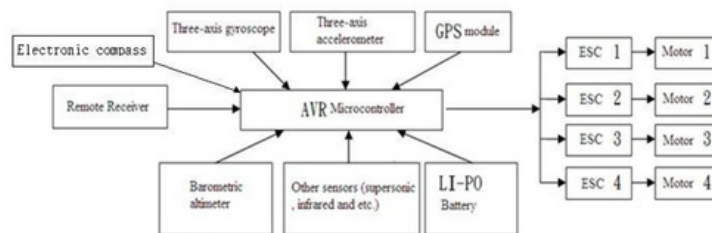


Figure 6 Hardware system architecture of quad-rotor aerial robot

The development of UAV (Unmanned Aerial Vehicle) makes it reliable for many different usages. The UAV being controlled through devices and sending messages could be suitable for investigation such as ocean investigation, fire, war, etc. It is also safer to use and it does not put any human in danger no matter what the UAV is investigating. The UAV is usually used by the military from infantry to marines/navy, which provides protection from above

of any danger ahead. The use of UAV with a submarine is a big advantage as it stops the submarine to have to go to surface now and again to communicate, as it can be used to communicate with multi users Pake and Anvar [11] investigated this in the study for Design and Development of Submersible Tube Launched UAV-Robot.

Space

The possibility of working in space from the earth under remote control gives a new anticipation in space exploration. When trying to figure out the way of doing this, the most known problem that needs to be overcome is the transmission signal time delay. Kulakov *et al* [12] state the feedback signal complicates the solution of control problem, especially if the robot is to remove objects using mechanical constraint.

The control known methods are mostly about one space robot, have some kind of manipulator. Some of the tasks that are need to be complete, require cooperative motion of some space robots, Chang'an *et al* [13] states handling of an object, assembling of flexible structure and so on. The operation ability depends on the size and scale of space robot which are restricted to being small due to the rocket launching the robot into space.

Who makes them?

NASA

NASA launched its first every long distance robot mission in mid-2000, where it sent two mobile exploration platforms to Mars for different science targets. The project name was 'The Mars Exploration Rover (MER)'. The two vehicles that were sent are named Spirit and Opportunity, they are identical with the same payload and engineering subsystems, as mentioned by Lindermann *et al* [14].

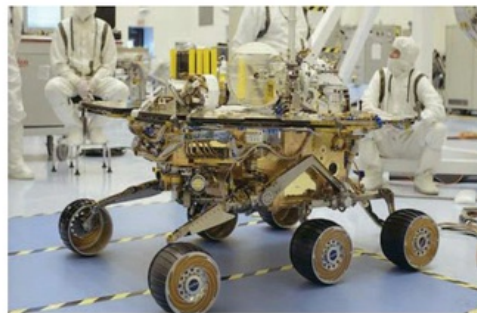


Figure 7 Flight rover Spirit in the JPL spacecraft assembly facility.

Katz and Some [15] states in the development of space robotic exploration in the early stage of development NASA experience some problems for the missions. The tools that were being used for the robotic where being damaged causing it to have malfunction problems, this was mainly caused in early stages of development when camera was the first tools used. Since these problems occurred it made them aware of the problem early in the stage making them able to tackle and stop the problem from occurring so often. They also went on to develop a robot which is able to climb mountains without having to damage it wheels or the equipment.

Time Taken

While NASA are continuous communication with Mars Rover, the data they receive is very limited. This is due to the distance of the rover from Mars to Earth, the available hardware, and the size it can send per second. The Rover is only capable to send 60 Megabits to orbiter which then takes from 1.5 to 5 hours to send the transition to Earth. The rover is small and does not have large solar panel and antenna. With the limited resource that is available to send robots out into space NASA did not want to put on any extra weight so it can successfully manage to reach Mars in shortest time possible, as stated by NASA [16].

Distance

NASA [17] have state that the rovers which they have sent to Mars, have travelled approximately 42 Kilometres since it's arrive. The rover does not travel fast and makes it movement more difficult as it need to take in information while it is moving, if it moves to fast it would have broken data. This slows it down and does not cover a lot and it also has to stop at the certain distance in order to communicate with the two orbiters that orbit Mars.

BAe

The British Aerospace (BAe) have been working on developing new technology that can be used for the security of the Military and Citizens. They have stated [18] the development of TRT Tactical Remote Turret which allows a single gunner to use it for protection and the use for light armoured vehicles. This increases the survive chances of an infantry and the safety of one. It can also be used by the gunner for cover in which it helps the infantry team retreat without losing anyone. They have also developed Remote guardian system in which they state [19] it is developed specifically for the V-22 Osprey. The development of this allows them to remotely control it, and it is also the first accurate remote weaponised system allowing it to be accurate during operation.

Brain Control

The following information is about the different ways of control the brain and ways of reading the brain

Brain Computer Interface

With the development and attempt to understand the brain more the use of electrocorticography (ECoG) has made it become the recognisable as promising signal platform for a Brain Computer Interface (BCI) research and application. The reading ECoG occurs by placing the electrodes underneath the human skull either above (epidural) or below (subdural) the dura mater. The recording result of ECoG is compared to the signals acquired from Electroencephalography (EEG) and intraparenchymal single neuronal recordings (The electrodes intraparenchymal allows the control of robotic limbs. The result provided show that people fitted with these are able to control three-dimensional movements explained by Leurthardt *et al* [20], the word intraparenchymal means within the bulk of the brain.). The ECoG recording provides characteristics which makes it

especially suited for the neuroscience research and result translation opportunities mention by Schalk and Leuthardt [21].

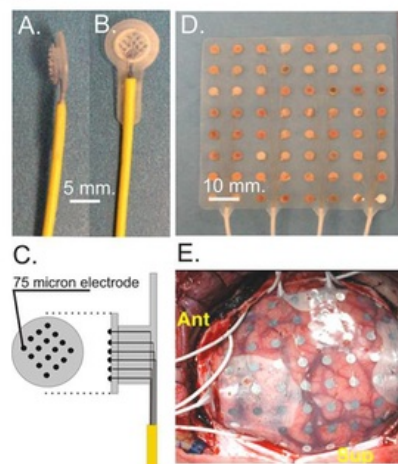


Figure 8 Micro and macro ECoG arrays. A-B: Microgrid arrays. C: Schematic of microgrid array. D: Standard clinical macrogrid. E: Surgical placement of macrogrid.

Surgical Implants

There have been many research and investigating the use of Brain-Computer interface (BCI) with implantable devices. The sophisticated electrodes and implantable chips have been able to perform such conversion which been investigated and many prototype have been demonstrated using these devices as investigated by Sun *et al* [22].

Senay *et al* [23] state having high performance brain implants is ideal tool to be able and detect any early physiologic state activity from accurately localising epileptogenic zone (Is the area where it provokes epileptic seizure) for subsequent surgical treatment. They can also be used to give warning signals to patients when it detects an incoming seizure.

EEG

How it works?

Electroencephalography (EEG) is used to read the brain activity. EEG allows the user to know more about the brain than before. With the ability to read the brain it takes a big step forward to understand how it does it, and how it know where to send the brain activity to which area of the body of if it is needed to be sent.

How it is used?

This is done through a device that is placed on a person's head. When the brain makes an activity the EEG device would pick it up and create a wave on a graph to show how the brain is responding the activity that is being processed. The brain waves that are read are not consistent as it relies on the person's emotions, thought, health, and level of tiredness.

Hirai and Yoshida [24] state EEG has been extensively used over the years to evaluate the brain process related to information processing. In the event of neural excitation or synaptic transmission in the brain electrical signals are increased. The biological signal are

then able to be recorded by the use of electrode placed on the scalp, when the recording is made it is designated as an electroencephalogram.

Non-Implants

The use of electroencephalographic signals to control the system of non-invasive brain computer interface (BCIs) without having to go over the pathways in the motor output. Pires *et al* [25] explains The BCI software that have been developed to today are communication system which is used on people who have suffered from severe motor impairments such as amyotrophic lateral sclerosis, muscular dystrophy, spinal cord injuries and cerebral palsy.

There have been many BCI non-invasive application developed since the introduction to people that have suffered problems, from control robot arm, assist mobility by controlling a wheelchair, and people with severe motor disability due to stroke. They have now the ability to communicate and interact using of computer and EEG as investigate by Ubeda *et al* [26].



Figure 9 Emotiv EPOC BCI Non-invasive

In figure 9 it shows one of the most popular EEG device, it is known as Emotiv EPOC developed by Emotiv System™. The Emotiv EPOC is a great wireless BCI device with the price being a low, you can get a standard Neuro-headset for \$299 while you can get the developer edition for \$500, while being shorter preparation time to be used as stated by Liu *et al* [27]

Artificial Limbs

The use of artificial limbs provides the ability for many people that have lost an arm/leg to be able to have a second chance. This does not mean they have the same functionality as they did previously do to the fact humans are unique biologically and have the capability of writing, reading and hold heavy objects without any problem. In artificial limbs this process is not the same as it does not have a responsive nerve system which carries the electrical impulse.

Melon Head band™

The Melon headband is a BCI device that uses EEG to interact with the brain. The use of this device allows the user to be able to read the brain activity, such as what their current status is. The headband works by installing a mobile application which allows it to communicate

with the headband on Bluetooth. The melon headband uses the alpha, beta, theta and delta to measure focus level of the user.

Brainwave	Freq (Hz)	Amp (μ V)	Description
Beta	>13	lowest	Awake
Alpha	8-13	Low	Relaxed
Theta	4-8	High	Tired
Delta	0.5-4	highest	Deep sleep

Figure 10 BRAINWAVE CLASSIFICATION

The Brainwaves is defined into these four classification, Beta, Alpha, Theta and Delta. The human brain acts open the human status, such as when the human is awake they spend most of time in Beta this also involves communication when they move interact, Alpha is mostly spent when humans are relaxing.

In delta the brain is spent when the person is mostly spent when the mind is unconscious which is presented in deep sleep while also being part of relaxing, so they spent the time moving between alpha and delta. Theta is the part of the brain spending the time in subconscious being awake but deep dreaming, this also where the brain would be during thinking of things such as memories or things to do in future. This can also occur during experiencing strong sensation and emotions as investigated by Bin Yahya and Murat [28].

Biofeedback

Afzal *et al* [29, para 2] With the body being moved sway the brain receives feedback, depending on the sensed feedback the brain would decide what it should do next. This is occurs during movement such as walking, running, cycling etc.

He continues [29, para 5] to investigate that there are different types of Biofeedback, they are used depending on what the user wants to train, and there are visual biofeedback, auditory biofeedback and haptic biofeedback. The haptic and auditory biofeedback are wearable balance assisting system which is task oriented exercises allowing the improvement of upright standing balance. The visual biofeedback is visually based reducing the sway of the body which is found in older population and found in the patients that have balance issues as investigated.

Biofeedback is used as part of stress management system. Biofeedback is used in training techniques which allows the improvement in health and performance in human brain activity. The term 'Bio' comes from the Greek origin which means 'Life' and 'Feedback' is to return information as stated by Maricic *et al* [30, para 6].

Games

Maricic *et al* [30, para 8] discusses that the modern day, the use of games would be the most effect way to improve people brain activity and respond. Introducing Biofeedback into games would have a positive impact with many people being capable of playing games. The Biofeedback gaming best would consist of hardware, software and methodology which always the user to learn different skills like relaxation and self-regulation when they are stressed.

Lairokapis *et al* [31] discusses the developed of Tetris Game using BCI control. In order for them to successfully develop an all-round operation system game they coded the game using Java. When coding the game they also had to make sure that the coding cooperates with the headset EEG input. The EEG devices that was used for the communication between the application, is ThinkGear created by NeuroSky™.



Figure 11 ThinkGear NeuroSky

The game was developed to teach the users how to control their state of mind during times where there is stressful demands situations to their own benefits. The more they become meditative they become capable to slow each of the shapes that fall in the terms of level's speed.

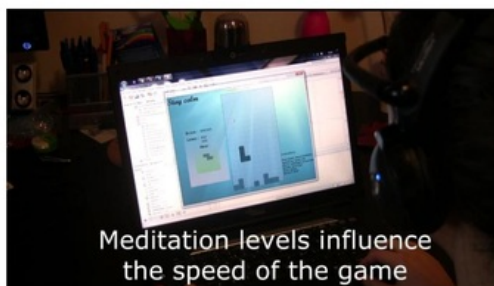


Figure 12 Tetris Game in action

Bos *et al* [32] explains during their research they decided to use one of the popular game known as World of Warcraft® which is developed by Blizzard Entertainment™. In order to test the use of BCI with the game they created AlphaWoW (Alpha-World of Warcraft) making it a BCI version of World of Warcraft. The user would play as elf druid and the character of the game will be controlled using the brain. The brain activity will be analysed for any alpha activities in which it will be related to the relaxation. The character is capable to transform from elf into a bear which is more of an aggressive character. The user will be transformed if the any stress occur in the brain activity while be relaxed it will change them back into elf shape.



Figure 13 a user playing World of Warcraft® with both conventional controls and mental states to control the character in the game. World of Warcraft® is a registered trademark of Blizzard Entertainment.

Working

The following information is about the different ways of this is used in field of work, from army to broadcasting

Military

Surveillance

In Karthigeyan *et al* [33] study, they explain that robots purpose is to be capable of flying in order to collect data and patrol. The military uses the patrol to be able detect any enemies that threat to some area, they also use the robot to provide guard for military. The collecting data is usually used for spying camera which is used with the robot. This allows them to get vital information on many things, from terrorist attacks to military threat. The camera would be able to take pictures and record videos, it can also work as real time monitor but it would be difficult to make it real time due to distance and difficulty of communicating.

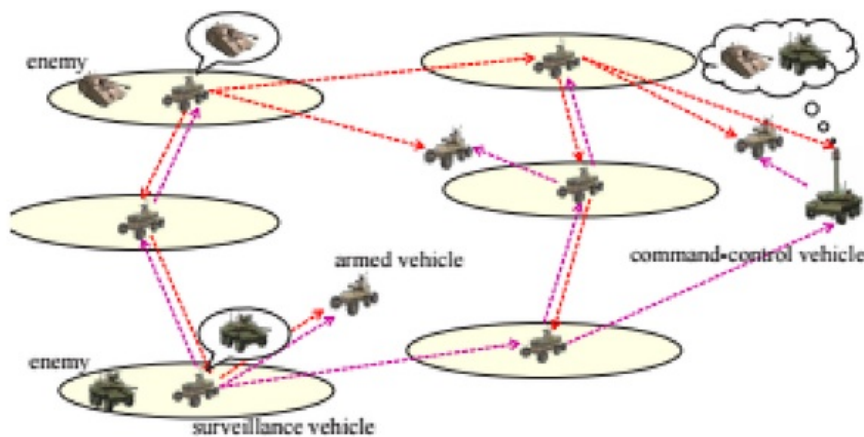


Figure 14 Autonomous military robots

In the journal written by Lee *et al* [34] states the surveillance vehicle in the military would have to patrol the area, checking for any incoming enemy vehicles. If the surveillance encounters an enemy it would report back the command-control vehicle which would allow the armed vehicle to would go to deal with the enemy. The surveillance vehicle would continue following the armed vehicle in order to give the exact location to the command-control vehicle. Once the enemy vehicle has been dealt with both surveillance vehicle and armed vehicle would resume their duties.

Combat

Dastur [35] explains the robot design in which he will be taking to develop. The robot will be a semi-autonomous with the ability to roam freely, and capable to have dual control of the mechanism for autonomous operation and the ability for remote control. The developed robot is going to be able to act in various tasks for tasks in which involves being a surveillance and tasks in which it is going to be a combat warrior. The robot operates on the module it is given, if the robot receives a new module it would start operating on it. With the development of a self-control robot, teaching to about the tasks it is given and routines it is going to perform while it is unmanaged and unguided is key part, it will also know the fail-safe in which it goes into once a problem occurs this would mean it gives its full control to the control centre operator which is then responsible for the completion of the task it was operating on.



Figure 15 A snapshot of the real robot

In figure 16 the image shows the robot vehicle in which Kim *et al* [36] developed, the left-hand side of the image shows the actual system operating and the unmanned military robot vehicle. Aerial target system known as EOTS (Electric Optical Tracking System) is placed on top of the robot vehicle. On the other side of the image (right side) it displays the indoor remote operating system which consists of an operator console with a projector the dome screen. There is also the real time system which is responsible for the 6 x 6 unmanned military robot. In the operation system there is a 3-axis camera stabilizer attached to a 6-axis motion simulator while a beam project in order to display the computer graphic virtual environments.



Figure 16 Concept of the indoor remote operating system

Civil

Science

The biggest science achievement in recent years was being able to send two unmanned self-control robot to Mars. The robots are able to move, take pictures and communicate with nearby Orbiter. The control centre in NASA HQ would send daily tasks to the robot using the orbiter and de-code message orbiter has sent in which the robot has gathered. Mak and Walton [37] have explained about the mission and state NASA scientist and research are working at JPL and its partner institutions to be able to analyse the data that they have download and images while also planning the next mission for the rovers that are on Mars for the next day.



Figure 17 Artist's depiction of a rover working on Mars.

Liu *et al* [38] states about how mobile robots are adopted to realise position-position transportation tasks. They explain how desk robots are operating and utilise to dispense of experiment plates in which the scientist work in. This provides the time consuming and increase the speed of results as the robot is capable of moving the plates between instruments. The other type of robot known as mobile robot is much different to desk robot. The mobile robot is main care is technical issues before being able to work including the following, Indoor Localisation, Path Planning, collision avoidance and distributing communication etc.

In research carried out by Wagner *et al* [39] explains why the Nomad Robot was created and The Science Autonomy System was developed. The creation of the Nomad robot was to search for Antarctic meteorites project making the autonomous meteorite search possible as the technologies and strategies where developed. Science Autonomy System was the control architecture to explore and *in situ* science that was able to integrate sensing, navigation, classification and mission planning. This allowed the Nomad robot to be able to search for meteorites autonomously being able to find and study surface samples while being able to perform full comprehensive patterned search.

Emergency Services

In article written by Jarvis and Marzouqi [40] they state on how the application context of the robot vehicle support to bush-fire fighting missions working under the supervision of humans. Three type of robot missions are been thought in the first instance. The first mission of the robot is to be able to forward scout and to report on the fire front condition in which can be a risk factor involving the human from entering. The second mission is for the robot to be able to have water in order to actually help with putting the fire out. The final mission is the crucial one due to the robot being required to escort any human in danger out, and rescue anyone that have collapsed and also any fire fighters that got injured.

For missions that are almost impossible for human to attempt, Arif and Samani [41] discuss how rescue robots are used in order to reduce the risk of human danger. The main object of a rescue robot is being able to handle hazardous situations that dangers for mankind. These situations can be falling buildings, rainstorms, obstructions and dangerous substance. The robots that get developed for this sort of missions are required to be fairly small and to be

lightweight in order for it be able to move between small places quickly and easily. This also makes it being able to enter small gaps in which humans and trained dogs impossible to do.

Hobbies

Camera Drone

Drones are increasing in popular and experiments are becoming more common as time goes on. Drones are capable of taking stereoscopic images with the capability of using two drones with camera it enhances the impression of depth within the images and makes the calculation of distance more accurate. To have a successfully production of the images the drone are required to have multiple cameras. This is not a great thing for drones as it increases the size and weight of it makes it have limited stability and not as much flight time as it would, this is crucial if the user is going to create a stereoscopic videos as investigated by Schurig *et al* [42].

Remote Control Toys

In the article written by Cai *et al* [43] they talk about how the use of android development would benefit them in development of remote controlled car to travel through maze. They connect the car with the mobile devices using Bluetooth®. The application will have arrows pointing in the four main directions; Left, Right, Forward and Back. These are the paths in which the car will operate, one the user click on the selected arrow it respond by moving that direction e.g. Clicking Left arrow makes car move left.

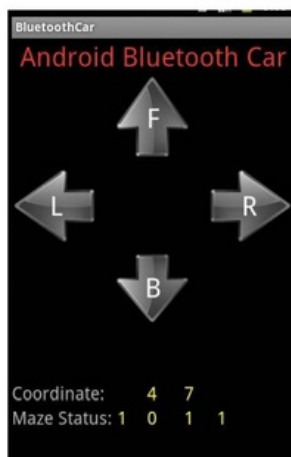


Figure 18 Software Interface

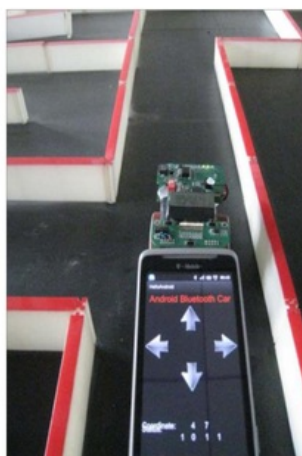


Figure 19 Experimenting in a maze

Thaller and Nussbaum [44] states that some of the toys are remote controlled. These can be cars, boats, helicopters and airplanes. The remote control toys radio transmitters are not accessible and use 2.4 GHz bands. The main advantage for the remote controlled toys is that the control unit e.g. controller is replaceable without having to modify the original product which removes warranty.

Lego Mindstorms

Who has done Lego ROVs?

There have been many development recently with Lego and ROVs. These are usually lifting stuff, underwater ROV made of Lego etc. Lego is not a very difficult tool to use and it is easy to understand. When developing systems using Lego the weight limited needs to be considered and speed in which it operates.



Figure 20 Lego ROV system

Figure 20 shows how the underwater ROV is being transported using ROV system made of Lego [45]. In the ROV system it shows how it uses rope in order to lift up the underwater ROV. This is one way to deal with weight but yet need to consider what strength is needed for the towers to hold the rope.

Brain Controlled Lego

With the use of mindstorm it makes it easier for the user to code information into the system that operates the Lego created robot. The use of EEG (refer to Brain Control heading) understanding the concept brain waves is vital and how the user needs to focus on the thought in order to be able to process the information. The Lego would be coded to respond to messages that were decoded from the brain wave.

Programming Language

The NXT-G programming is what is used by Lego mindstorm in order to be capable of code the Lego to do what the user request it to do. The layout of the Programming language is simple to understand and it is like most drag and drop with little coding wise. This makes it suitable for many different less skilled people to use.

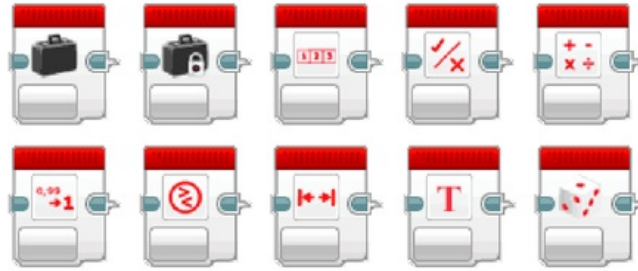


Figure 21 Data Operation Block from Programming Language

Hardware

There is not much needed for hardware wise. The system would require an operation system such as Windows 7, 8 or 10. There is also MAC software available. The software does not require much heavy duty CPU or RAM and 1 GB is suitable [46].

Research and Development Methodology

Aims & Objectives

The overall aim for the project has not changed after the research and remains to be; being able to use EEG waves via the Melon® headband to control a built remote-controlled vehicle.

Objectives:

- ❖ A deeply research to occur with any written work relating the brain-machine interfaces.
- ❖ Read Brainwaves. In order to successfully read the brainwave, monitoring program will be introduced to interface with the Melon® headband. Bluetooth communication will be used in order to talk to the Melon® headband.
- ❖ There will be transmission between the monitoring program and the remote-controlled system. The use of either Wi-Fi or Bluetooth to succeed the transmission.
- ❖ Translation of the brainwave to understood signal. For the remote-controlled system to understand; the signal of the brainwave will be converted to an understandable signal. This will need to be a very accurate and consistent translation.
- ❖ Remote-controlled system. In order to have the success of this project, building a suitable system to respond to the translated data of the brain and create variety type of testing.

Research Methodology

What research method will be use

It also contains the different philosophies, approaches, strategies, time horizons and techniques and procedures. The philosophy of the project is Positivism.

The approach that will be taken for the project is Deductive in which the creation of theories and hypothesis; the creation of research strategy which will test the hypothesis.

Following deductive approach the strategies are Experiments, Software development and document review. The document review is completed before coming to software development and experiment. Software development will be going into development methodology which is on how the project development plan will go and how it will be successful. The experiment is another way to test how successful the project is; this would usually look at what resources is needed for the experiment which this project requires humans. Basic training might be required to try and see if they can control their focus level so that they can operate the project.

Why is this the right ones

Do to the project being more focused on theory and hypothesis to develop the best and new technology positivism is the most appropriate choice. The deductive will usually follow what has been chosen in the philosophy. Deductive gives the project the opportunity to state what theories or hypothesis is needed for development of project.

The philosophy and approach will means that the following strategies that fit them will be software development, experiment and document review. Software development is used

for the development of the program that is needed for the project. With the program being completed experiments will be made to see how well it works.

Overcoming disadvantages

In the experiments as it requires the focus to be controlled it will be disadvantage with human emotions playing part. This will mean making sure the emotions doesn't play effect when attempting to focus.

Using advantages

Document review will give some advantages due to the ability of researching on similar sort of project, this would give an idea of what is required and also will give examples of what people used ROV and Brain control in different project.

Development Methodology

The development for the project will be done using the Feature Driven Development (FDD). FDD was best suited for this sort of project over the many others. Using the FDD will mean there are four steps that are needed to be taken before the completion of the project. The four steps that will be taken are the following:

- ❖ Development of the overall model – this will contain the system model as the first thing to be created
- ❖ Feature list – what the system needs to provide
- ❖ Building feature – all the features that get listed will have to be completed
- ❖ Updating features – all the features that get completed will then be crossed off the list

These stages will be repeated in till the completion of entire system.

Why Feature driven development will be used

Using feature driven development for this project has its advantages. One of the key things about feature driven development is being able to produce the MoSCoW list. Using MoSCoW provides of what features are required to be completed first and what features are not as much important.

MoSCoW stands for the following;

- ❖ Must have – what is required of the system to have
- ❖ Should have – extra benefits that the system will not fail if it didn't have
- ❖ Could have – feature that will be introduced if there is more time
- ❖ Won't have – these are features that will not be introduced at all time, these could be the could but won't features

This rule is vital in the development of software that have time limit to complete. Breaking them down into a list will show what is vital and what is not.

Why is this the right ones

The project has some complexity making it clear that some features will not be introduced at all. Using the feature driven development allows the understanding of what these feature are. The use of FDD also makes the communication between the developer and

customer more common allowing the almost a certainty that the system will not fail and the customer will always be satisfied with what has been produced at the end.

Having a list what features are more important makes the development easier due to being aware of what the developer should focus on. This can be a bad if the developer spends too much time on a single important feature and leaves the other important feature too late.

Overcoming disadvantages

Feature driven comes with disadvantages as it is another sort of agile method. Focusing on important feature can come a problem when there is time limited and the question of how much more you need to complete those important features.

Communication with customer can lead to confusing if the customer keeps changing their mind on previous features. Features that are important and get changed would mean that time has been wasted and limited time is shortened on other important features.

Using advantages

Having a MoSCoW list is vital and one the most important part of the feature driven development. Knowing what is required to be done before the extra features is important and not much time is wasted on extra features before important features.

Communication with the customer can lead to satisfaction of the development of the project. Understanding the customer is good for a developer because not many developers have regular contact with customer over a product they are creating them for meaning they won't be aware if they didn't like the feature they introduced or they have introduced the feature they wanted.

Tools/system that will be used

In the development phase the tools that are planned on using will be Java and Android Studio. There will be the use of SDK for the head device used. Coding Java can be done on many different platforms such as Linux, Windows and Mac.

Design & Implementation

Key:	Usability 	Performance 	Features 	Processing 
------	---	---	---	--

Functional Requirements

MUST	
	The application must give a tutorial on how it is used
	The application must have a 'Help' section
	The application must prompt Bluetooth connection
	The application must inform user to connect robot to Wi-Fi

Table 1 Must

SHOULD	
	The application should inform user of any update
	The application should log user activity
	The application should be user friendly and easy usable
	The application should run on android
	The application should teach the user how to focus
	The application should prompt an auto-update to the user

Table 2 Should

COULD	
	The application could show examples of usage
	The application could have game training

Table 3 Could

WON'T	
	The application will not have any personal information held
	The application will not use most of the device processor

Table 4 Won't

Non-functional Requirements

MUST	
	The application must be able to load required files
	The application must be able to update when new updates is released
	The application must connect to Bluetooth
	The robot must connect to Wi-Fi
	The application must be easy to use
	The application must connect to Head band device

Table 5 Must

SHOULD	
	The application should load fast
	The application should be consistent through-out
	The application should attempt to connect to Bluetooth on run time
	The robot should attempt to connect to Wi-Fi on run time

Table 6 Should

COULD	
	The application could connect to Bluetooth automatically
	The application could update automatically
	The robot could connect to Wi-Fi automatically
	The application could display battery life for head band device

Table 7 Could

WON'T	
	The application will not turn on automatically
	The robot will not work automatically
	The head band will not make user aware of its battery life

Table 8 Won't

7.4 Time box 1

Date – 4th April 2016

Duration – 10 Days

Completion Date – 14th April

7.4.1 Features

- Create a Front end interface
- Create Bluetooth connection
- Send messages

7.4.2 Design and Implementation

Use Case Description

Use Case Name: Connect headband to Application
Stakeholders & Interests: User
Brief description: When the application is turned on it searches for the Melon headband via Bluetooth and displays a list of available devices to the user. When the user selects the Melon headband the application connects to the headband
Pre-requisites: The headband has already been paired with the phone
Trigger: Application opened
Normal flow of events: 1. Detect paired Bluetooth devices 2. User selects the Melon headband 3. Application sends connect and returns confirmation string 4. Headband connects and returns confirmation string 5. Display confirmation to user that the connection has been made
Sub-flows: S-1 1. Application prompts user to turn on Bluetooth if required 2. Search for visible Bluetooth devices 3. Display list of paired devices
Alternative / Exceptional flow of events: S-1a: No confirmation string is returned 1. Display notice to user saying that the connection has failed

Table 9 creating the connection with the headband

Use Case Name: Get EEG Data
Stakeholders & Interests: User
Brief description: Once the connection with the headband succeeds. The data from the four sensors will be stored within the application.
Pre-requisites: Data from the sensor already exists
Trigger: Get data
Normal flow of events: 1. Detect sensors 2. Sensor gets the data 3. Sensor will send the data back to application
Sub-flows: S-3: 1. Sensor will make sure the headband is in contact with users head 2. Sensor will use the received data to send to application 3. Data will arrive on the device
Alternative / Exceptional flow of events: S-2a: No data available to collect 1. Display notice to user saying that device is not currently active or not placed correctly

Table 10 Getting the EEG use case document

Use Case Diagram

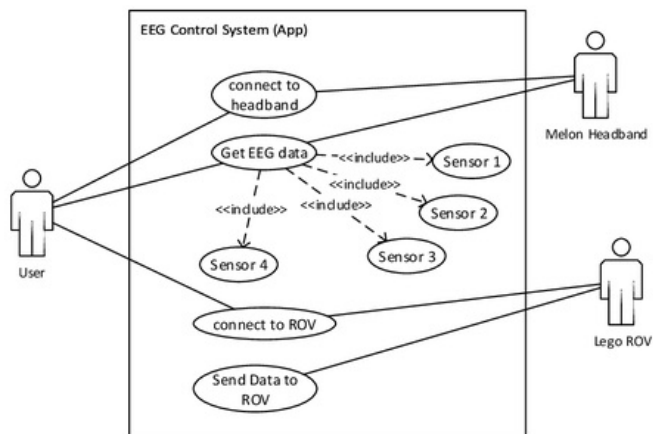


Figure 22 Use case for the whole system

In the creation of the system following the design. The display of the interface was successful by displaying the buttons and labels. The connection with the headband did not succeed and failed in repetitive attempt although the headband gets displayed.

7.4.3 Testing

Task ID	Task Name	Days expected	Actual Days	Planned Results	Actual Results	Problems	Comments
1	Design interface	1 days	1 days	Interface designed	Interface Displayed	N/A	Interface successfully displayed
2	Building program	3 days	3 days	Program successfully built	Program running	N/A	The program successfully runs on the device.
3	Successfully search	3 days	2 days	Find devices	Devices found	N/A	The list provided all available devices
4	Connect device	3 days	N/A	Communication occur between device and application	N/A	Connection could not be successful	The understanding of Bluetooth socket needs to be studied further.

Table 11 - Time box one test sheet

7.4.4 Evaluation

Due to the application on the most important part this meant a change was required and to attempt a different plan. The most success occurred in this was the application working and displaying Bluetooth when searching.

For ID 4 the problem that occurred was in the connection, it was capable of finding devices but failed to find connection with other devices. This needed the development of Bluetooth socket in order to have it connected. Attempts were made in order to try and fix it but it seemed that every solution was followed by a fail.

The Search for Devices

The code below represents what went into the application in order to being capable of search for devices through mobile.

```
public class MainActivity extends AppCompatActivity {
    private static final int REQUEST_ENABLE_BT = 1;
    ListView listDevicesFound;
    Button btnScanDevice;
    TextView stateBluetooth;
    BluetoothAdapter bluetoothAdapter;
    ArrayAdapter<String> btArrayAdapter;
    /** Called when the activity is first created. */
    @Override
    public void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_main);

        btnScanDevice = (Button)findViewById(R.id.scandevice);

        stateBluetooth = (TextView)findViewById(R.id.bluetoothstate);
        bluetoothAdapter = BluetoothAdapter.getDefaultAdapter();

        listDevicesFound = (ListView)findViewById(R.id.devicesfound);
        btArrayAdapter = new ArrayAdapter<String>(MainActivity.this,
        android.R.layout.simple_list_item_1);
        listDevicesFound.setAdapter(btArrayAdapter);

        CheckBlueToothState();

        btnScanDevice.setOnClickListener(btnScanDeviceOnClickListener);

        registerReceiver(ActionFoundReceiver,
            new IntentFilter(BluetoothDevice.ACTION_FOUND));
    }
    @Override
    protected void onDestroy() {
        // TODO Auto-generated method stub
        super.onDestroy();
        unregisterReceiver(ActionFoundReceiver);
    }
    private void CheckBlueToothState(){
        if (bluetoothAdapter == null){
            stateBluetooth.setText("Bluetooth NOT support");
        }else{
            if (bluetoothAdapter.isEnabled()){
                if (bluetoothAdapter.isDiscovering()){
                    stateBluetooth.setText("Bluetooth is currently in device
discovery process.");
                }else{
                    stateBluetooth.setText("Bluetooth is Enabled.");
                    btnScanDevice.setEnabled(true);
                }
            }else{
                stateBluetooth.setText("Bluetooth is NOT Enabled!");
            }
        }
    }
}
```

```

        Intent enableBtIntent = new
Intent(BluetoothAdapter.ACTION_REQUEST_ENABLE);
        startActivityForResult(enableBtIntent, REQUEST_ENABLE_BT);
    }
}

private Button.OnClickListener btnScanDeviceOnClickListener
= new Button.OnClickListener(){

    @Override
    public void onClick(View arg0) {
        // TODO Auto-generated method stub
        btArrayAdapter.clear();
        bluetoothAdapter.startDiscovery();
    };

    @Override
    protected void onActivityResult(int requestCode, int resultCode, Intent data) {
        // TODO Auto-generated method stub
        if(requestCode == REQUEST_ENABLE_BT){
            CheckBlueToothState();
        }
    }

    private final BroadcastReceiver ActionFoundReceiver = new BroadcastReceiver(){
        @Override
        public void onReceive(Context context, Intent intent) {
            // TODO Auto-generated method stub
            String action = intent.getAction();
            if(BluetoothDevice.ACTION_FOUND.equals(action)) {
                BluetoothDevice device =
intent.getParcelableExtra(BluetoothDevice.EXTRA_DEVICE);
                btArrayAdapter.add(device.getName() + "\n" + device.getAddress());
                btArrayAdapter.notifyDataSetChanged();
            }
        }
    };
}

```

The code above shows the functionality of what will be displayed on screen and what the project will do. It contains all the information that is needed to be able to scan for availability of devices.

The code also contains check Bluetooth state where it will check if the phone Bluetooth is enabled if not it will prompt to the user the requirement to enable it. Functionality that failed was when trying to click on the listed device in order to connect to it. It does not prompt anything.

The following screenshots are what the final result of searching for available devices.

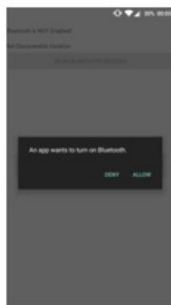


Figure 23 Requesting to active Bluetooth

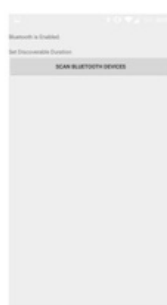


Figure 24 Displays Bluetooth is enabled and ability to search



Figure 25 Result of the scan

7.4 Time box 2

Date – 14th April 2016

Duration – 7 Days

Completion Date – 18th April

7.4.1 Features

- Create connection to ROV
- Simulate the EEG
- Send messages

7.4.2 Design and Implementation

Use Case Description

User Case Name: Connect to ROV
Stakeholders & Interests: User
Brief description: When the application is turned on it searches for the Robot Lego via Wi-Fi or Bluetooth and displays a list of the available devices to the user. When the user selects the robot Lego called Arthur application connects to the ROV
Pre-requisite: The ROV has already been paired with the phone.
Trigger: Application opened
Normal flow of events: 1. Detect paired Bluetooth devices 2. User selects the Robot Lego (Arthur) 3. Application sends connect string to ROV 4. ROV connects and returns confirmation string 5. Display confirmation to user that the connection has been made
Sub-flows: S-1 1. Application prompts user to turn on Bluetooth if required 2. Search for visible Bluetooth devices 3. Display list of paired devices
Alternative / Exceptional flow of events: S-4a: No connection string is returned 1. Display notice to user saying that the connection has failed

Table 12 creating the connection with the ROV

Use Case Name: Generate Simulated EEG data
Stakeholder & Interests: User
Brief description: User will attempt to act as the brain and move the required measurement to match the movement. This will allow the robot to move accordingly
Pre-requisite: Data has already set the measurement
Trigger: Movement of measurement
Normal flow of events: 1. Measurement exists in limited amount 2. Measurement modifiable by user 3. Data get set accordingly to each sensor 4. Sensor is then stored and ready to be sent to ROV
Sub-flows: S-3 1. Each sensor will be modified by the user 2. Each sensor will have its own range of measurements 3. Data will collect the sensors measurement
Alternative / Exceptional flow of events: S-2a: Measurements selected incorrect 1. Display notice to user saying the measurements is incorrect

Table 13 Simulating the EEG use case document

Use Case Name: Send data to ROV
Stakeholders & Interests: ROV
Brief description: When the data has been received on the application it will process it and send it to the ROV
Pre-Requisites: Sensor already sent the data
Trigger: Get data
Normal flow of events: 1. Check that data exists in application 2. Compare received data to movement required data 3. Data sent from application to ROV 4. ROV responds to received data
Sub-flows: S-4 1. ROV will use received data to move according to the data received 2. ROV will complete its movement
Alternative / Exceptional flow of events: S-1a: Data does not exist 1. Display to user that there is no data available to send to the ROV

Table 14 sending to the ROV

Use Case Diagram

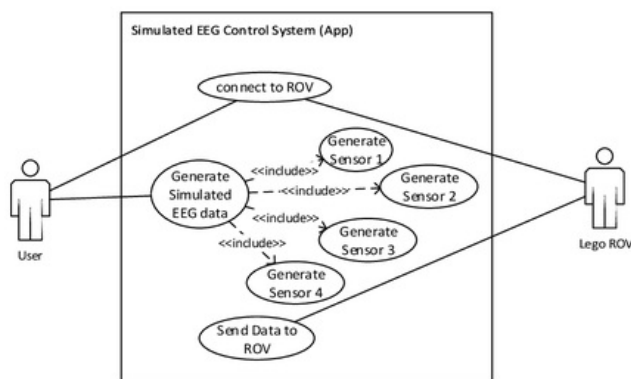


Figure 26 Use case for the new system

In the creation of the system following the design. The display of the interface was successful by displaying the buttons and labels. Connecting the ROV was success but do to the library are not available to code the sending messages to ROV it didn't allow a

successful sending. This meant that the only application can successfully work with the ROV is the one created by the developers.

7.4.3 Testing

Task ID	Task Name	Days expected	Actual Days	Planned Results	Actual Results	Problems	Comments
1	Connecting to ROV	3 days	2 days	Successfully connect to ROV	Connected to ROV	N/A	There was a success connecting to the ROV
2	Generate Simulation EEG	4 days	N/A	Successful have the application and ROV communicate using EEG simulation	Failed to connect both application with ROV	No library available to use other than the application which is only suitable for moving ROV as a controller	The ROV did not communicate successfully so the application was not successful

Table 15 - Time box one test sheet

7.4.4 Evaluation

After changing plans the problem didn't seem to want to give up. There was a success connecting the ROV but ROV would only work with its own application. The ROV library that can be used to succeed in coding the application which would communicate was not available and this limited the development. In the ID 2 the problem that occurred was the unavailability of EV3 library making coding anything to words the Lego robot much harder. This stopped any application being developed as the tools are not possible to access. There was many attempt of using the available tools that many people have tried in order to make it work but that continued in failing.

Evaluation

After the completion of the project this will explain how the project went and how it could be made better and which parts was the best.

With the final results coming in from the project the conclusion will be determined. This will come after the evaluating the progress of the project and how it was processed.

The final data in the end of project has a little difference to the research where the brain wave measurements is not as expected and the fact that they can be identical and the brain is only capable of interpreting. This would have mean that instead of using EEG rather focus on trying to use Neuroscience instead which is more reading the nerve system to interpreted the message. The other problem occurred that was not researched correctly is Bluetooth as it is rather a bigger required study in coding it. Bluetooth seemed like another language to study with it have many complexity to understand such as creating Bluetooth socket.

Some of the objectives were meet at the end of the project such as creating a Bluetooth search in order to find devices. There was many objects that were not achieved due to the complexity of the development.

The overall aim was not met at the end of the project, even though there was many attempts to find an alternative to achieve it. Some of the task were not possible due to the availability of the required areas.

Giving the completion of the project there were not many answers to what was expected. Some of the answers that was targeted was can human be interpreted without the nerve system. There was some information that needed clarification which was not given and therefore left unanswered.

If the project was to be redone, there would be many things that would have been different such as having the experience to code Bluetooth and java. Being able to understand the different ways to interpret the brain.

This project linked different modules together such as module like system analysis were many different areas of the project is required to be analysed. There was a link is software development were the need to be able to create software on different platforms and how it is done. The security was also linked to many different areas of modules were it is considered to be a vital part.

The was a similarity problem occurring in the project as it occurred to Tominaga *et al* [8] where the data was arriving late to the robot making it respond rather later than usual. This meant that there was in need of making sure nothing is holding up the connection and the speed of messaging.

Conclusion and Recommendation

After coming to an end to this project it proved to be tougher than expected. This meant that many alternatives had to be considered during the process making each stage take longer than required. This was not the aim at the started but adaption was required when necessary. To be able to use the mind to control object is yet an interesting area of study and would require a large number of people attempting this, due to the limitation of information and the low number of experiments that have occurred in that area. This project allowed the ability to learn many new things which would not be normally taught. There areas yet to exploited but with the time limit they were not exploited to its potential. The selected use of ROV was not a success due to no resources available to code it, this left and empty gap to what could have been a potential success in certain objectives.

This project still has many areas to be discovered and many different things will be learned during it. As the technology grows and better equipment get developed the experiments are yet to be done; also not to mention not many experiments have been done that are similar to this. This project will require enthusiasm, interest and ready to adapt to difficulties that can occur during the journey. This would mean for a future student/experimenter to pick up were the project has finished would require them to be ready to learn new things as they develop project. This will also need a large time scale available due to changes to different approach if one fails. Some of the areas that need to be tackled with large time scale is the brainwave understanding and how each brainwave is interpreted differently. This is due to brain having identical waves but sent to different parts of the human body and to manage to capture that and interpret it to human understanding would be a success itself.

Reflection

After going through the year working on the project there have been many things that have been learnt. To biggest thing that has been interested and possible best thing that have been learnt is being capable of reading the brain activity and that it is possible to interpret what the brain has sent to other part of the body.

In the course of learning that, it also proves that the brain process of information is greater and more power than any currently available technology and for technology to ever reach it seems improbable.

The process also taught the quickly expanding use of robotic technology in the world and how many different development have taken place. This included the understanding of technology going from space exploration to deep ocean exploration. It also showed how different work areas have used robotics to their advantages this included military and civilians.

This proved to be an important part for robotic technology and rather than the known country Japan working on it alone, many people across the world began exploring with them.

The ability to time manage was a challenge in the project and provided to be a vital part as well as time being limited. When time management is not being set and there is no actual schedule to what needs to be done by when, makes the entire process more complicated than it needs.

The requirement of learning a new language in short space of time was an experience that will be remembered for ever as it proved to be the project changer. This was due to not being able to code or find solutions to problems as there was no real experience to what the problem is and how it would be fixed.

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