Building a mobile robot with ROS

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Department: Design Engineering & Mathematics

Course: BEng Design Engineering

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Contents

Introduction

Mobile robotics is an exponentially growing field in the Robotic community. Up to date, there are various companies that are working to implement the philosophy into cars to give them the capability of moving around autonomously, as they recognize that after its establishment it will have a good economic and social impact. One of the main reasons engineers are pursuing autonomous navigation is because autonomous vehicles would cause less accidents on the roads, as a result of a more controlled environment (Bertoncello).

ROS (Robot Operating System), is one of the main platforms where the automation of mobile robots from their navigation to tasks like, the pick and place problem, are studied to build fundamental algorithms for generic robots. This project aims to replicate and build a mobile robot with ROS and its currently available packages. Furthermore, a robot manipulator will be added to the mobile robot, to study the combined interaction of a mobile and fixed robot to the world.

Differential drive(fig.1) will be the footprint of the design of the mobile robot, as the kinematics involved are less articulated compared to other configurations of wheel drive (the Ackermann drive in fig. 1.1 for example). The robot will have two casters, which will move the centre of mass at the centre of the robot (like shown in figure 1.2); this will influence the positioning of the circuitry and other components on the robot. Figure 1.3 illustrates a draft of the layout of the circuitry.

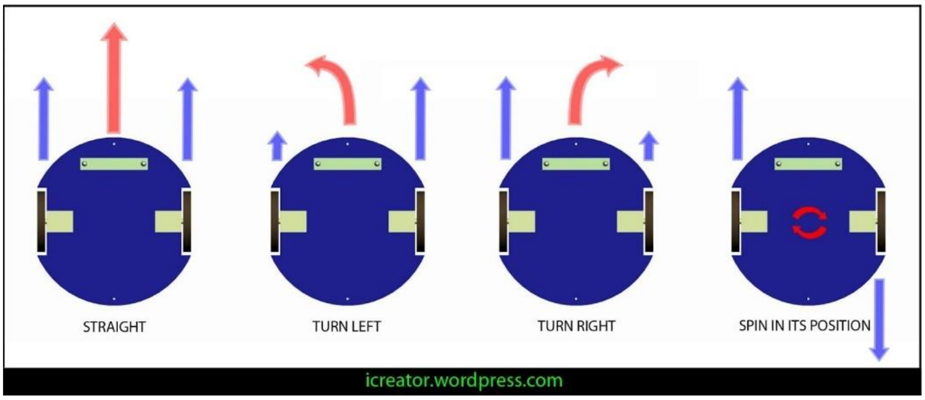


Figure 1: Differential drive

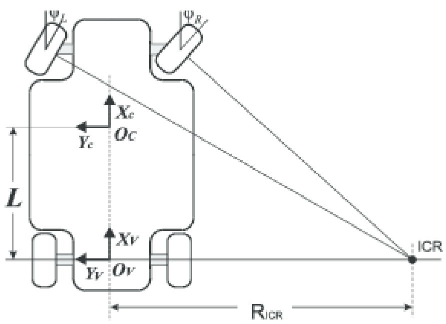


Figure 1.1: Ackermann drive

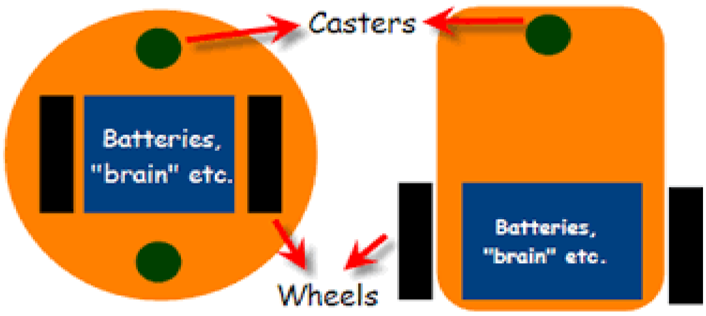


Figure 1.2: types of differential steering configurations

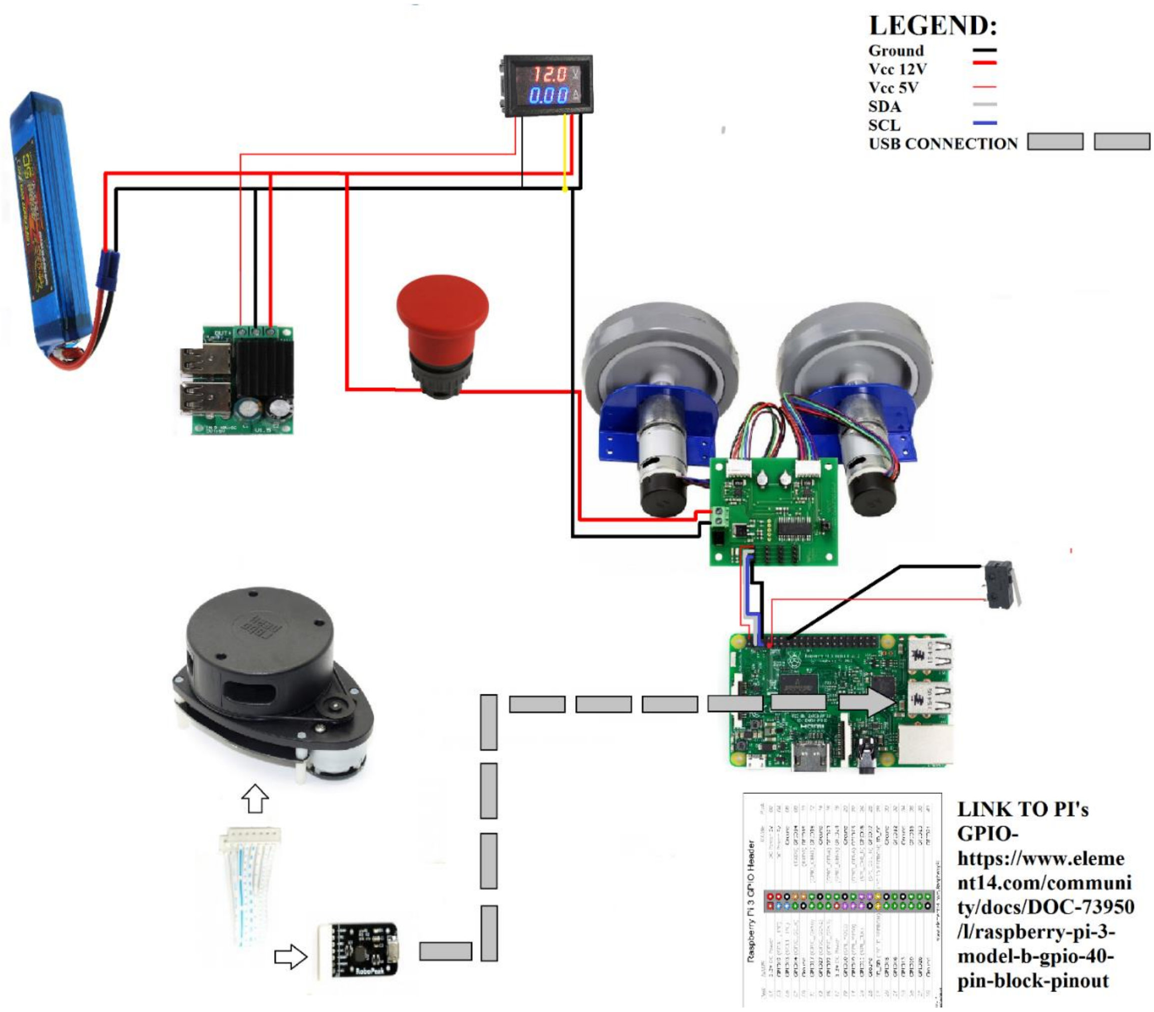


Figure 1.3: draft of the circuitry

Automated machines are slowly becoming, more and more, part of our everyday life; as such, the need to teach about Robotics is increasing. The goal of this project is to educate young people who might have an interest in the world of robot autonomation. Thus, a pc or mobile software application will be built to enhance the robot with features that will be user friendly, allowing the user to have an idea of the basic functions of the mobile robot.

Literature review

Mobile robots

After the advent of robot manipulators in industries, there came the need for robots to be able to move around, without being fixed to a physical location that is where mobile robots came to be. Mobile robots, are machines capable of mobility and are mainly classified by two branches which are:

- *The environment they travel in*
  Robots are referred with different names depending on where they are deployed. An example could be the UGVs (Unmanned Ground Vehicles) which are known to be land or home robots.
- *The mechanism they use to move*
  Mainly wheeled robots, human-like or animal like robots, robots with tracks are under this classification.

How does a mobile robot navigate? There are many types of mobile robot navigations. Hereafter a study of the types of mobility will be carried out to be able to understand the differences between the types of navigation which will consequently give more insight on what autonomous navigation is. Below are the main types of robot navigation systems:

Tele-op

The robot is remotely controlled usually with a joystick but also with other devices.

Guarded tele-op

Mobile robots that are guarded tele-operated are normally driven by an operator but can also move around by detecting and avoiding obstacles.

Line-following robot

The line-following robot is one of the first Automated Guided Vehicles (AGVs). These robots could follow a visual path created on the floor and could only detect obstacle, hence they did not have the skill to circumnavigate an obstruction to their path.

Autonomously randomized robot

These types of robots detect obstacle by colliding with them, after which they correct their orientation to ultimately avoid the obstacle.

Autonomously guided robot

An autonomous guided robot has an idea of its location and can reach various goal within the known environment. It can localize itself with the aid of sensors such as encoders lasers and global positioning systems which are often controlled by algorithms like the Monte-Carlo localization.

Sliding autonomy

These robots incorporate various types of mobile navigation. The helpMate hospital robot is an example of a sliding autonomy robot which can switch from manual mode to autonomous guided robot.

The ROS frameworks

Software developers still come across notable challenges whilst building programmes for robots. The **Robot Operating System** (ROS) platform sets up the stage to ease some of these hardships. What is ROS?

ROS is an open-source, meta-operating system for your robot. It provides the services you would expect from an operating system, including hardware abstraction, low-level device control, implementation of commonly-used functionality, message-passing between processes, and package management. It also provides tools and libraries for obtaining, building, writing, and running code across multiple computers (http://wiki.ros.org/, n.d.).

Commercially available mobile robots

Mobile robots available in the market, are mostly built for industrial settings. Hence the range of customers is quite narrow. However, there are robots like the Cosmo which price and features make it so that is it available for a wider range of customers. Autonomous navigation in vehicles, is still a topic of research thus it is not in the market yet. Competitions over the years, like the DARPA (Defence Advanced Research Projects Agency) Grand Challenge, have incited the creation of new ideas and technologies to make the dream of self-driving cars come closer

to reality. Companies like Waymo (under Google) have encountered some milestones in the subject. Today their self-driving car is in the testing phase and is being tested in public roads.

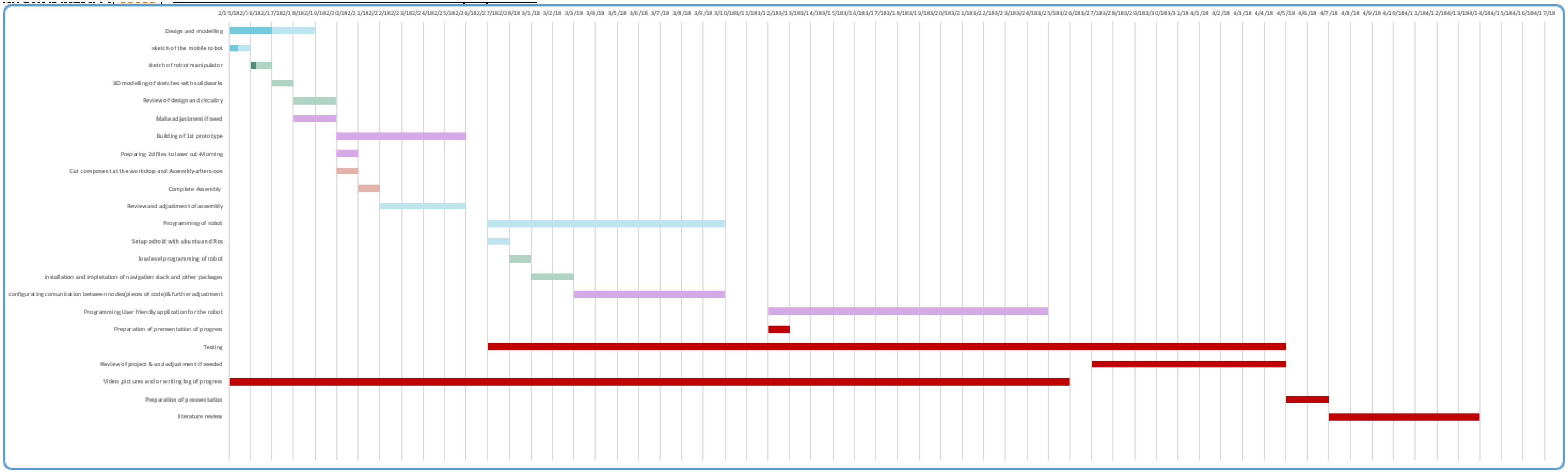
Robots for educational purposes

Robots will have a great impact in the future our society and as such the need to educate the upcoming professionals in the subject is growing even more. There are various tools available that allow the study of technology with user friendly interaction. The Mirto robot is an example (Raimondi, n.d.), where students learn to build and program a mobile robot.

One of the robots in the market that educates the user in programming and gives insight in robotics is Anki Cosmo the robot. It has algorithms that gives it a behaviour making it fun for the user to interact with. Another robot used for educational purposes is the Bee-Bot and which has an easy to use software Scratch that allows faster and easy to learn programming.

This project will attempt to educate the user in ROS showing the basics of the platform in a simpler way. An idea that hasn’t been implemented yet, is to programme from the rqt graph making connection between already made nodes by clicking on them which would generate topics automatically and so looking at the communication interface of ROS in a visually.

Project Planning



Task Name	Start Date	End Date	Duration (Days)	Days Complete	Days Remaining	Percent Complete
Design and modelling	15/02/2018	19/02/2018	4	2.00	2.00	50%
sketch of the mobile robot	15/02/2018	16/02/2018	1	0.45	0.55	45%
sketch of robot manipulator	16/02/2018	17/02/2018	1	0.25	0.75	25%
3D modelling of sketches with solidworks	17/02/2018	18/02/2018	1	0.00	1.00	0%
Review of design and circuitry	18/02/2018	20/02/2018	2	0.00	2.00	0%
Make adjustment if need	18/02/2018	20/02/2018	2	0.00	2.00	0%
Building of 1st prototype	20/02/2018	26/02/2018	6	0.00	6.00	0%
Preparing 2d files to laser cut-Morning	20/02/2018	21/02/2018	1	0.00	1.00	0%
Cut component at the workshop and Assem	20/02/2018	21/02/2018	1	0.00	1.00	0%
Complete Assembly	21/02/2018	22/02/2018	1	0.00	1.00	0%
Review and adjustment of assembly	22/02/2018	26/02/2018	4	0.00	4.00	0%
Programming of robot	27/02/2018	10/03/2018	11	0.00	11.00	0%
Setup odroid with ubuntu and Ros	27/02/2018	28/02/2018	1	0.00	1.00	0%
low level programming of robot	28/02/2018	01/03/2018	1	0.00	1.00	0%
installation and impletation of navigation	01/03/2018	03/03/2018	2	0.00	2.00	0%
configurating comunication between nodes	03/03/2018	10/03/2018	7	0.00	7.00	0%
Programming User friendly application for t	12/03/2018	25/03/2018	13	0.00	13.00	0%
Preparation of prensentation of progress	12/03/2018	13/03/2018	1	0.00	1.00	0%
Testing	27/02/2018	05/04/2018	37	0.00	37.00	0%
Review of project & and adjustment if need	27/03/2018	05/04/2018	9	0.00	9.00	0%
Video ,pictures and or writing log of progres	15/02/2018	26/03/2018	39	0.00	39.00	0%
Preparation of prensentation	05/04/2018	07/04/2018	2	0.00	2.00	0%
literature review	07/04/2018	14/04/2018	7	0.00	7.00	0%

Budget

Student Name:	Marlon Gwira
Student Number:	M00539673
Project Title:	Building a mobile robot with ROS
Supervisor:	Dr Zhijun Yang

Checklist of university resources required (delete rows if not applicable)

	Comments
Workshop (inc. waterjet & laser cutters)	machine tools will be used to build and assemble the robot
3D printing	where traditional methods of machining won't work in buiding components, 3D printin will be required
Solidworks	this resource will allow for 3d modelling of components
Arduino	will be required to do some low level programming
Bolts and nuts	no charges applied
Washers	no charges applied
Odroid C2	this arm board's computation is more powerful than the raspberry pi, which will reduce compiling time and overall time spent in the programming and testing phase

Estimated Budget

Name	link	Quantity	unit cost (ex VAT)	unit cost (inc VAT)	cost	Comments
0droid C2	https://www.amazon.co.uk/Odroid-C2-Einplatinen-Workstation-1-5GHz-Quad/dp/B01CY4V5LC/ref=sr_1_1?ie=UTF8&qid=1518437278&sr=8-1&keywords=odroid+c2	1		65.00	65.00	
Robot Eletronic RD02 12V complete Robot Drive System	https://www.ebay.co.uk/itm/Robot-Electronics-RD02-12V-Complete-Robot-Drive-System/122036524463?epid=1977840311&hash=item1c69f195af:g:sHcAAOSw-KFXe2zd	1		120.97	120.97	The kit comes with 2 motors, the H-bridge, 2 wheels and 2 supports for the motors
Emergency stop button	https://www.ebay.co.uk/itm/ABB-Bouton-darret-durgence-diametre-30mm-Rouge-NO-NF-Type-Champignon-NEUF/182641967433?hash=item2a864f4149:g:iiQAAOSwN2VZU93J	1		14.99	14.99	
Power Switch					0.00	
12v Lipo battery	https://www.amazon.co.uk/Turnigy-2200-mAh-11-1-25-%C2%B0C-Battery/dp/B00GK61Z98/ref=sr_1_8?s=electronics&ie=UTF8&qid=1518582462&sr=1-8&keywords=lipo+battery+11.1v	2		29.60	59.20	
Usb step down module	https://www.amazon.co.uk/Adjustable-4-USB-Step-down-Power-Module/dp/B00MLTWK9C/ref=sr_1_10?s=electronics&ie=UTF8&qid=1518582701&sr=1-10&keywords=usb+step+down+module	1		5.24	5.24	
Lidar	https://www.robotshop.com/uk/rplidar-a1m8-360-degree-laser-scanner-development-kit.html	1	147.40	176.88	176.88	
Voltmeter and Ammeter gauge	https://www.amazon.co.uk/Yeeco-DC0-100V-Voltmeter-Multimeter-Motorcycle/dp/B015O6CEA8/ref=sr_1_2?s=electronics&ie=UTF8&qid=1518583565&sr=1-2&keywords=digital+voltmeter+and+ammeter	1		7.99	7.99	
Black acrylic sheets-5 mm thick	/	2		29.72	59.44	
Acrylic tube 10mm-1 meter long	/	1		2.16	2.16	
Threaded rod M6-1 metre long	/	1		0.52	0.52	
15g Servos x4		1			22.99	
9g Micro Servos x6	https://www.amazon.co.uk/Top-Spring-Servos-Helicopter-Airplane-controls/dp/B01KNWN8LW/ref=sr_1_4?s=kids&ie=UTF8&qid=1518615469&sr=1-4&keywords=servo+motor	1		11.99	11.99	
Robber band	/	/			0.00	
PLA	https://www.ebay.co.uk/itm/3D-Printer-Filament-PLA-1-75mm-1Kg-15-Colours-Makerbot-Up-Leapfrog/122033441977?_trkparms=aid%3D555019%26algo%3DPL.BANDIT%26ao%3D1%26asc%3D20151005190705%26meid%3D5d5811fff80f468a9d200cc43d520495%26pid%3D100506%26rk%3D1%26rkt%3D1%26%26itm%3D122033441977&_trksid	1		10.99	10.99	
mini wifi router	https://www.amazon.co.uk/WiFi-Router-150Mbps-Hotspot-Wireless/dp/B01N63NJFA/ref=sr_1_23?s=electronics&ie=UTF8&qid=1518613983&sr=1-23&keywords=mini+wifi+router	1		7.99	7.99	
casters	https://www.amazon.co.uk/Ball-Caster-Metal-3-8-Black/dp/B0054JDI0G/ref=sr_1_6?s=electronics&ie=UTF8&qid=1518615025&sr=1-6&keywords=casters	2		5.30	10.60	
				TOTAL	576.95	80-100£ to be added to the total to compensate for any losses or in case of redesign

MIDDLESEX UNIVERSITY SCHOOL OF DESIGN ENGINEERING AND MATHMATICS

RISK ASSESSMENT

Department/School	Science & Technology, Design Engineering and Mathematics
Project	New Boat Propulsion system
Location/s	The Ritterman Building Hendon
Date or period this Risk Assessment covers	8^{th} February 2018, 23^{rd} May 2018
Persons Involved	Programme leader – Dr Vaibhav Gandhi Technical Supervisor- Neil Melton Supervisor – Dr Zhijun Yang Student – Marlon Gwira
Principal Location address and Contact No.	Middlesex University, Hendon central, London, NW4 4BT Tel: +44 2084115000

HAZARD - Pre-Vetted Contractors - attach specific assessment		HAZARD		HAZARD	
Aircraft / "special" flying *	[ ]	Access/egress	[ ]	Machinery	[x]
Armourers *	[ ]	Animals	[ ]	Manual handling (attach specific assessment)	[ ]
Costume/Make-Up Vehicle	[ ]	Audience/Public		Mines/excavations/caves/tunnels/quarries	[ ]
Diving Operations *	[ ]	Communication Failure	[x]	Noise (attach specific assessment)	[ ]
Explosives/Pyrotechnics/ Fire effects *	[ ]	Compressed gas/cryogenics	[ ]	Person with special needs	[ ]
Flying Ballet *	[ ]	Confined spaces	[ ]	Physical exertion	[ ]
Hydraulic Hoists (Cherry Pickers) *	[ ]	Derelict Buildings/dangerous structures	[ ]	Radiation ionising/non-ionising	[ ]
Lasers *	[ ]	Electricity or gas	[x]	Speed	[ ]
Location Catering	[ ]	Fire/Flammable material	[x]	Tropical Diseases (e.g. Malaria - attach details of medical arrangements e.g. prophylactics, local hospitals and evacuation plan)	[ ]

Location Lighting Services *	☐	Fight sequence	☐	Vehicles/off road driving	☐
Hire of Lighting Equipment	☐	Glass	☐	Violence/ Public disorder	☐
Scaffolds *	☐	Hazardous substances/ chemicals/ drugs micro-organisms (attach specific - assessment)	☐	Water	☒
Smoke Effects *	☐	Heat/cold	☐	Weather	☐
Stunts *	☐	Hostile Environment: (attach confirmation of clearances from Senior Management)	☐	Working patterns/working hours	☒
Physical Effects	☐	Inexperienced performer or children **N.B.** for children, risk assessment must be provided to parents or guardian.	☐	Working at heights	☐
		Lifting appliances/ machinery	☐	Other	☐

Experts Engaged

List experts used, including pre-vetted contractors. Each pre-vetted contractor should be required to provide the significant findings of their risk assessment in writing. This information should then be included in or appended to this form and reviewed with other activities and arrangements to check effective co-ordination.

Details of Activity

Briefly Describe what is intended. For clarity, this may include sketches/story board/diagrams/checklists

The activity will consist in building a mobile robot. The robot will have a differential drive and it will be electrically powered with a lithium battery. The battery is the main cause of concern as it is highly inflammable. It has 12V and 9 Ah and will be used and charged in a fire bag.

Hazards Identified and Risks Arising	**Risk Assessment and Proposed Precautions**
Identify and list what could reasonably cause harm. Against each identify who is at risk, i.e. who could be harmed and how. Ignore the trivial, concentrate only on those hazards that could result in serious harm or affect several people.	*For each of the above, evaluate the risks and decide whether existing precautions are adequate or more needs to be done. Take into account information from contractors, premises management, resource providers, and others about the risks and controls. List the proposed controls for each significant hazard and identify any contingency plans in place for emergencies or failures of safety critical arrangements, e.g. miss fire of explosive effect or stunt; car going off road; member of public being door stepped, turning violent.* ***Include fire and first aid and welfare arrangements.***
Communication failure(H)	Communication between the robot and the laptop will be via laptop through WIFI. In case of communication failure, the robot will carry the last command sent. An emergency stop button has been fixed on top of the robot to seize the robot's movement to avoid the possibility

	of it causing harm to other people or whiles running or damaging itself.
Electricity or Gas (L)	The robot will go through a thorough supervision to ensure wiring to the battery and to the circuit boards are properly connected, before each use. All wiring will be organised and made visible to be able to easily detect any malfunctions and avoid short circuits.
Locations (L)	The activity will take part in the following locations: - The Ritterman building in Middlesex University, Hendon Campus. - In the student's house 2 minutes from university.
Machinery (M)	Most of the testing will be done in the Ritterman building which has safe and healthy measures to contain, in the worst-case scenario, a fire outbreak that may be caused by any device related to the robot.

First Aid	A first aid kit will be in the vicinity just in case the likelihood of an injury may occur.

N.B. THIS MUST BE SIGNED BEFORE THE EVENT CAN GO AHEAD

I have read the above and am satisfied that:

- It constitutes a proper and adequate risk assessment in respect of the programme activity and that the precautions identified above are sufficient to control the risks.
- Adequate arrangements are in place to communicate the risk assessment findings and to co-ordinate the safety arrangements of all those affected, e.g. site owners, engineers, contractors, freelances, resources, etc.

Signature of Head of Department/Project Leader ………………………………………………………**Name Dr Vaibhav Gandhi**

Date: 7 May 2013

Details of Safety Training received ☒ Interactive ☐ Other (give details below)

Signature of person conducting this assessment

……………..……………………………………………**Name Mr Nick Weldin**

Date: 8th February 2018

Signature of person with designated responsibility for safety co-ordination

……………………………………………**Name Neil Melton**

Date: 8th February 2018

Review Date; Two-time event

References

Bertoncello, M. (n.d.). Ten ways autonomous driving could redefine the automative world. *https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/ten-ways-autonomous-driving-could-redefine-the-automotive-world*.

http://wiki.ros.org/. (n.d.).

Raimondi, F. (n.d.). *http://www.rmnd.net/middlesex-robotic-platformo-mirto/*.