"Robotics is an area where a number of scientific fields meet" [6]

Urban Search and Rescue Robotics

| Tele-Operated Robot

Warwick Mobile Robotics

www.mobilerobotics.warwick.ac.uk | twitter @WMRobotics

The Competition | RoboRescue League

Location | Magdeburg, Germany

Date | 28th March to 1st April 2012

- Robots demonstrate their capabilities in a number of fields such as mobility, sensory perception, mapping, and practical operator interfaces in a simulated earthquake disaster zone [1]

| 2011 RoboRescue Competition

- It aims to increase subject awareness and promote collaboration between researchers from across Europe, to develop more successful robotic applications in the future

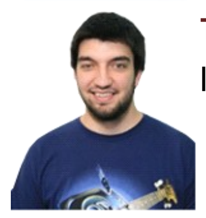
The Team

Kyle Blanch | Project Manager

Ethan Fowler | Systems Lead

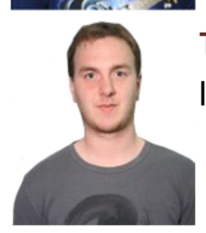
Joe Tomita | CAD Lead

Sam Johnston | Finance Officer

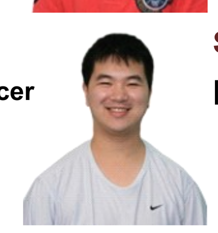


Tobias Burgess | Secretary

Anirudh Vijay | Publicity Officer



Tim Bradley | Sponsorship Officer



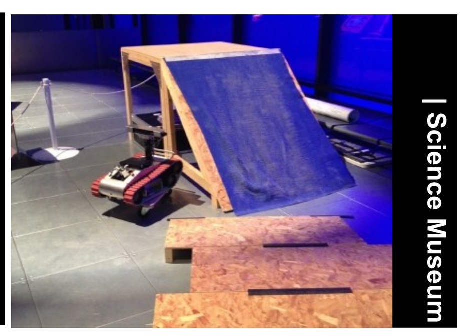
Simon Yeung | H&S Officer

Outreach

Visits | Local Schools & Science Museum, London

- Our work has been showcased to school children of multiple ages, highlighting the application of career paths in Engineering

| School Visit



| Science Museum

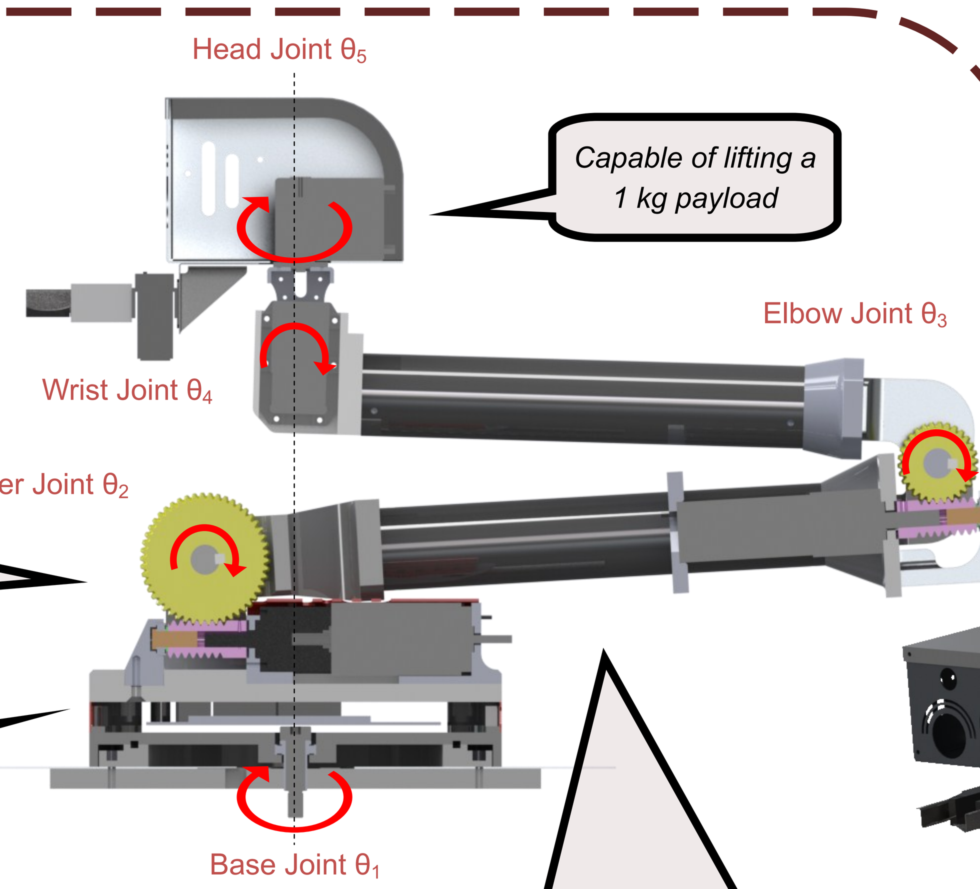
- The 2012 WMR Outreach programme has seen us visit numerous schools within the local area and partake in the Science Museum's Antenna Live Exhibition during the half term school holiday

Aims and Objectives

- To successfully compete in the 2012 German RoboCup Rescue competition
- Core 'Objectives' were identified by carrying out a SWOT analysis of the previous WMR robot
- To re-engineer the current system to deliver a greater level of performance in terms of functionality and reliability
- Design and build a new Mechanical Robotic Arm
- Integrate the system to be fully Tele-Operational
- Resolve the issues causing Flipper slack

Mechanical Arm

- Functionality and reliability increased by improving weight distribution and reducing backlash in the joints
- 5 revolute joints (as shown) move the sensory elements and gripper into positions that will allow victims to be identified and supported



Capable of lifting a 1 kg payload

Supported Ball Bearing and Thrust Spigot Housing

- Full support at both ends of the worm gear prevents bending of the motor shaft [2]

Modular Design

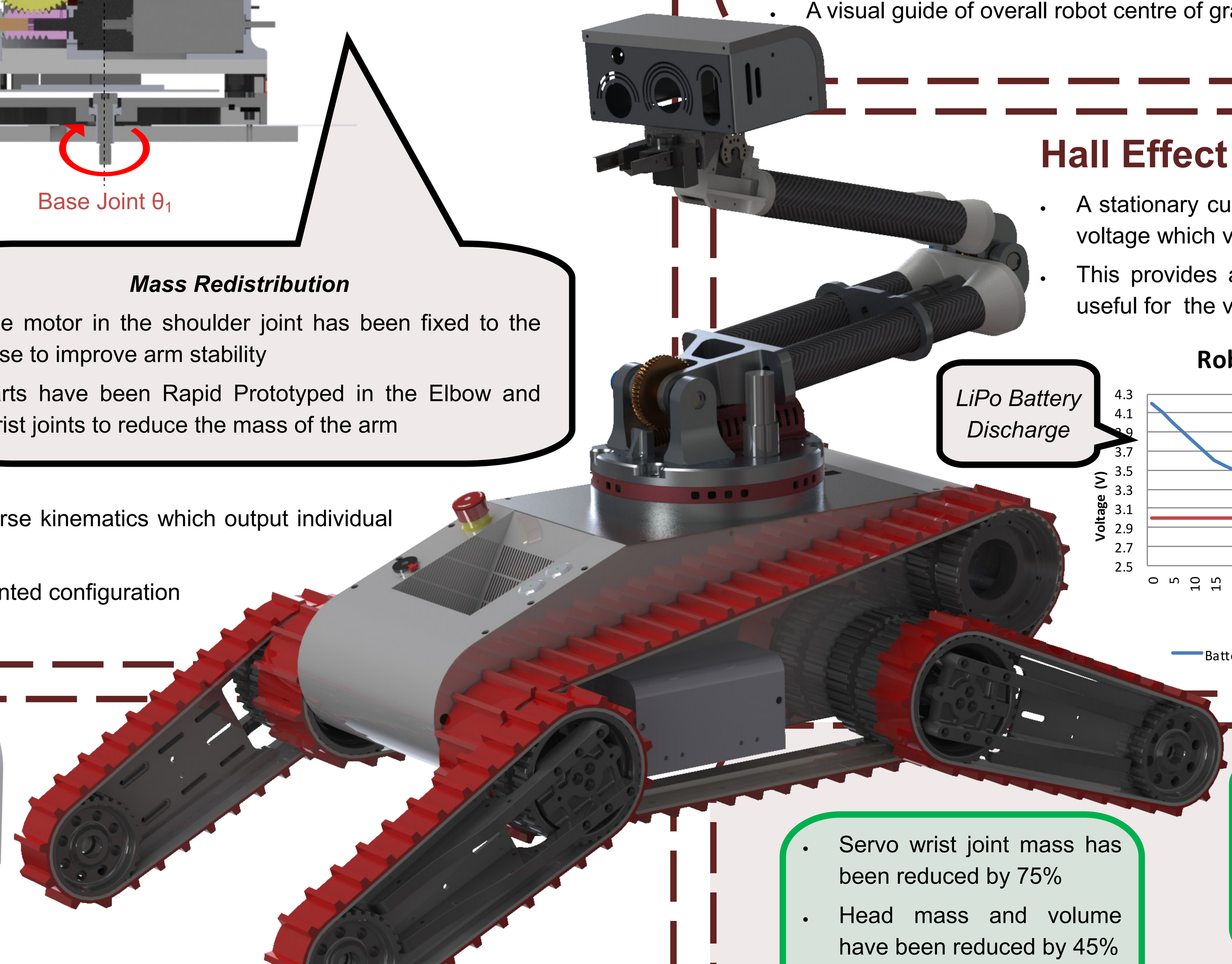
- Shims control the centre distance between the worm and worm wheel gears for accurate meshing [3]
- Modular design allows parts to be changed with ease
- 3-axis machining from Aluminium 60-68 T6 billet and plate has been used for the majority of parts

Mass Redistribution

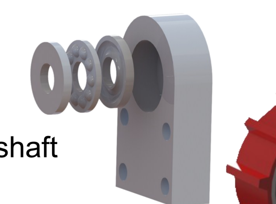
- The motor in the shoulder joint has been fixed to the base to improve arm stability
- Parts have been Rapid Prototyped in the Elbow and Wrist joints to reduce the mass of the arm

Inverse Kinematics

- The position of the end effector can be controlled directly through inverse kinematics which output individual joint angles to satisfy the complete motion of the arm
- For flexibility, independent joint control is also possible with the implemented configuration



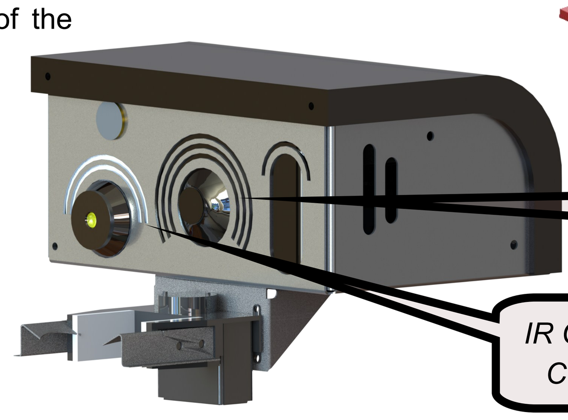
Flippers



- Chain slack has been reduced by re-pinning the internal shaft to the outer shaft
- A bearing system (as shown) has been devised to transfer most of the force from the motor shaft to the chassis
- Constraining the motor at both ends prevents bending of the motor shaft and housing caused by cyclical loading

Head

- The head contains sensors used for victim identification
- Redesigned to reduce overall size and weight
- The base frame consists of laser cut Aluminium sheet and the hood cover has been rapid prototyped



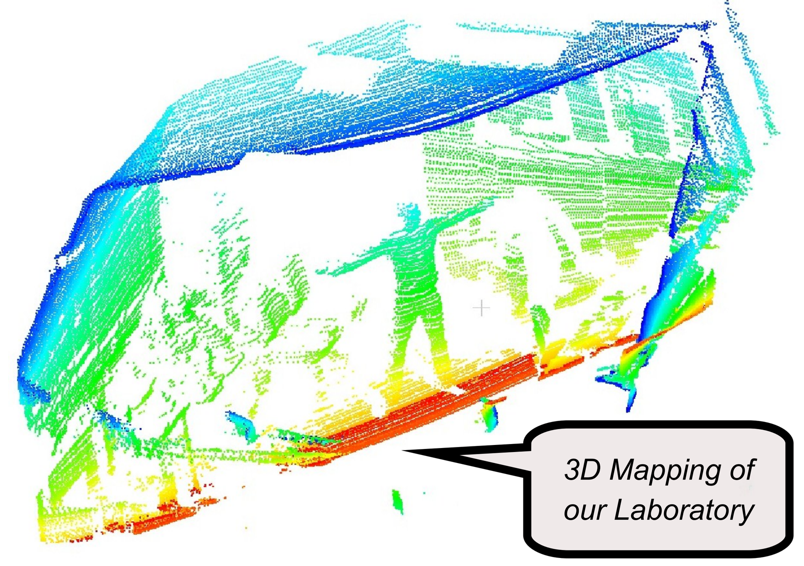
Web Camera, integrated LED, and Audio

IR Camera and CO_2 Sensor

QR Codes

- Finding, identifying and reading Quick Response Codes is a new requirement for the competition
- Live feed from the Web Camera outputs decoded results in real time using Java programming code

WMR QR Code



3D Mapping of our Laboratory

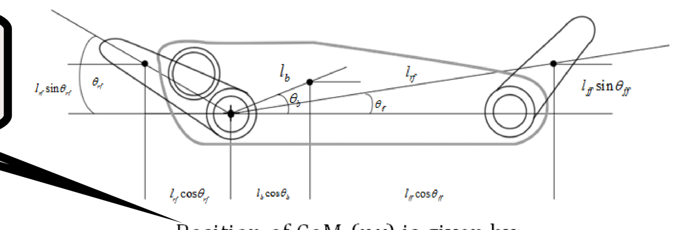
3D Mapping

- Tilting of the LiDAR (rotating distance-gauging laser) accounts for angles and simple trigonometry can be used to produce a 3D set of points
- The SLAM (Simultaneous Localisation and Mapping) technique estimates robot movement by comparing each LiDAR scan to its predecessor [4]
- Real time 2D representation can also be displayed to aid navigation
- Mapped information, victim identification and QR code data can all be stored as a point-cloud of the arena

Robot Representation | Interface

- The Arm and Flippers are visually displayed in 3D using absolute positional data obtained from encoders
- Limb centre of gravity and joint angles combine with accelerometer and gyrometer data to calculate robot tilt
- A visual guide of overall robot centre of gravity warns the operator of the robot toppling

Centre of Gravity Model for 3D Rep.



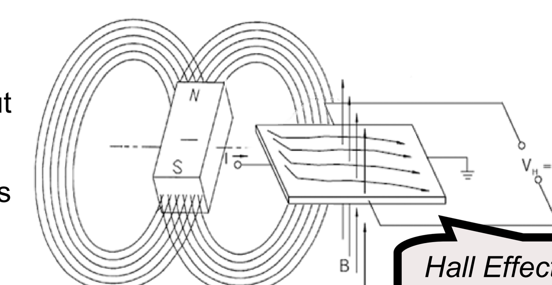
Position of CoM (x,y) is given by:

$$x=\frac{m_b l_b\cos\theta_b+m_{rf}l_{rf}\cos\theta_{rf}+m_{ff}l_{ff}\cos\theta_{ff}}{m_b+m_{rf}+m_{ff}}$$

$$y=\frac{m_b l_b\sin\theta_b+m_{rf}l_{rf}\sin\theta_{rf}+m_{ff}l_{ff}\sin\theta_{ff}}{m_b+m_{rf}+m_{ff}}$$

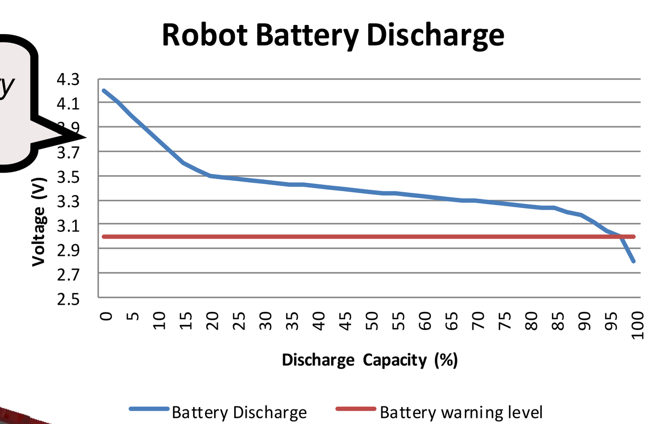
Hall Effect Encoders

- A stationary current-carrying conductor generates an output voltage which varies in response to a rotating magnetic field
- This provides an absolute position of the flippers which is useful for the visual interface



Hall Effect Encoder concept [5]

LiPo Battery Discharge



Battery Warning Sensor

- The device is connected to each individual cell
- The buzzer will sound when any cell drops below the pre-determined level, even though other cells may have higher voltages
- This prevents over-discharging which permanently damages the battery

Conclusions

- Servo wrist joint mass has been reduced by 75%
- Head mass and volume have been reduced by 45%
- Benefits include overall arm mass reduction and a lower centre of gravity

Appropriate manufacturing techniques and capabilities have been considered throughout the design process

Information from mapping and encoders now allows the operator to be fully aware of the robots own position and environment

All of our design changes were developed within our financial budget of £10,000

As part of our Outreach programme we demonstrated our robot to over 2000 people at the London Science Museum

Our changes to improve functionality and reliability can only be fully evaluated from our participation in the RoboCup competition

The torque requirements for the shoulder joint motor have been halved by reducing overall weight and using a larger diameter worm wheel gear

References

[1] Nardi D. RoboCup Robot League [online]. 2012 [cited 2012 March 06]. Available from: http://wiki.robocup.org/wiki/Robot_League

[2] Mott R.L. Machine Elements in Mechanical Design. 3rd Ed. Columbus, Ohio: Prentice Hall; 1999. p.296

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[4] Milstein A, McGill M, Wiley T, Salleh R, Sammut C. A Method for Fast Encoder-Free Mapping in Unstructured Environments. Jr. of Field Robotics. 2011. 28(6). 817-831

[5] EEWeb. Electrical Engineering Community: Hall Effect Sensors. 2011 [cited 2012 March 06]. Available from: http://www.eeweb.com/electronics-quiz/hall-effect-sensors

[6] Schweitzer G. Robotics - Chances and Challenges of a Key Science. 17th Int. Congress of Mech. Eng. 2003.

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