Minos 2012

Laser Cut Schools Robots

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Contents

- Involvement with STEM and 2 schools
- Robot design & cost criteria
- Wall follower design
- How the wall follower developed
  -Pictures, circuits and stages of development
- Birmingham City University Line follower
- Experience with building it
- Lessons learnt
- Next time and the Future

Involvement with STEM and 2 schools

www.stemnet.org.uk STEMNET creates opportunities to inspire young people in Science, Technology, Engineering and Mathematics (STEM).

I was recruited as a STEM ambassador and volunteered to help at 2 schools:

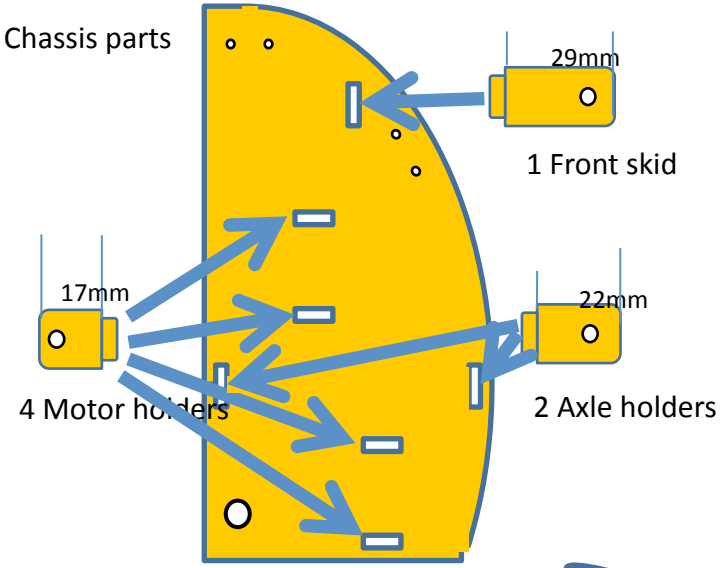
- King Edwards Grammar School, Stratford-Upon-Avon who wanted an after school electronics club.
- Holyhead Academy, Handsworth who wanted an after school robotics club.

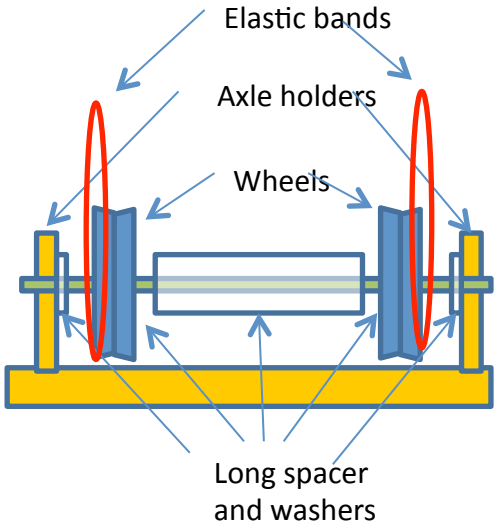
Both ran for an hour after school once a week during term time from October 2011 to April 2012

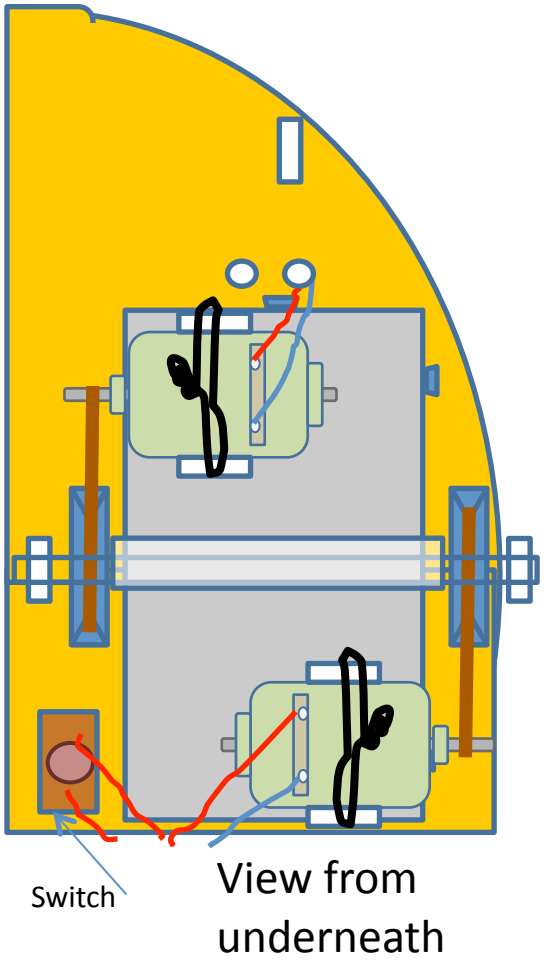
Robot design & cost criteria

- Able to be built by students from age 11 to 15
- No prior electronics knowledge presumed
- No soldering, basic assembly skills only required
- Incremental project with a result every Unit
- Less than £10 per student total cost all in
- No time to develop and test it beforehand so Unitly increments designed “just in time”
- Needing to be supported by activity worksheets

Wall follower design

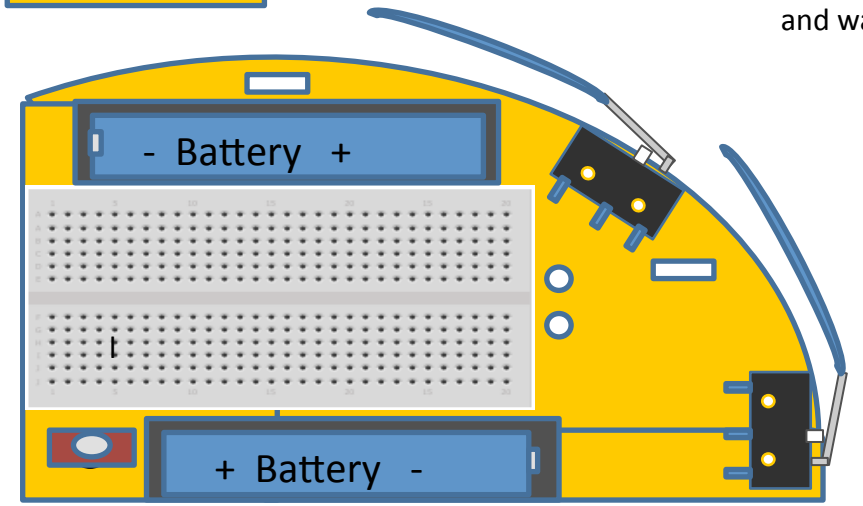






View from underneath

Top View



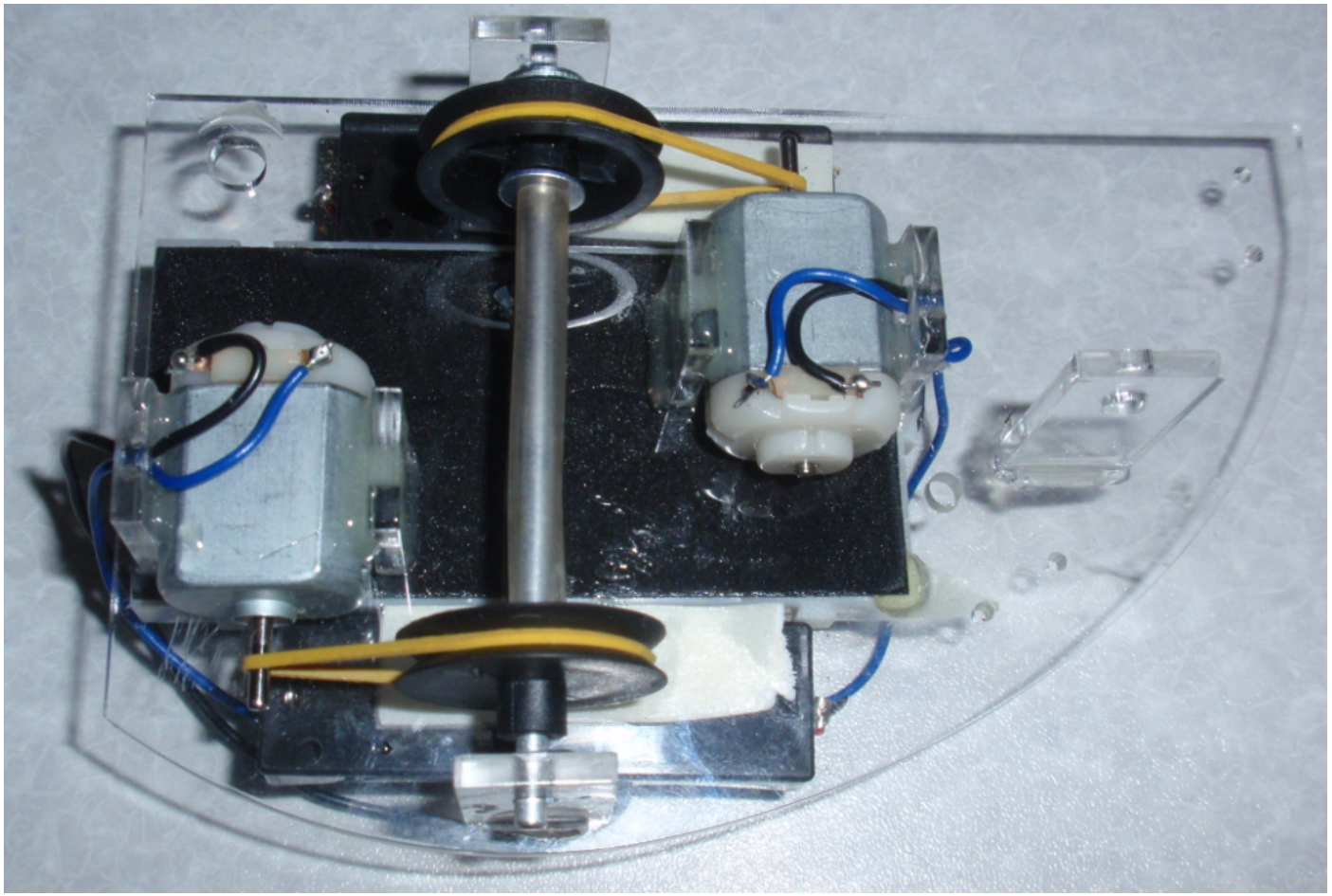
Note: All the motors, battery holders and switches had solid core wires pre-soldered onto them, so they could be immediately plugged into the breadboard by the pupils.

How the wall follower developed

Unit 1) Talked about Robots + sensors process and actuators
Unit 2) Glued parts into chassis & built axle assembly
Unit 3) Added breadboard & battery box. Talked about circuits.
Unit 4) Connected motors in various ways to make it move & spin
Unit 5) Added 1 micro-switch, to make simple left wall follower
Unit 6) Added second micro-switch to turn right at wall ahead
Unit 7) Added 2nd battery, switch and LED. More on circuits & components
Unit 8) Added 2 LDRs & Transistor array to make a light seeker
Unit 9) Added a pre-programmed PIC to do a sequence of moves
Unit 10) Added an IR decoder to make it be remote controlled

Note: Every week I brought along a different robot to show them

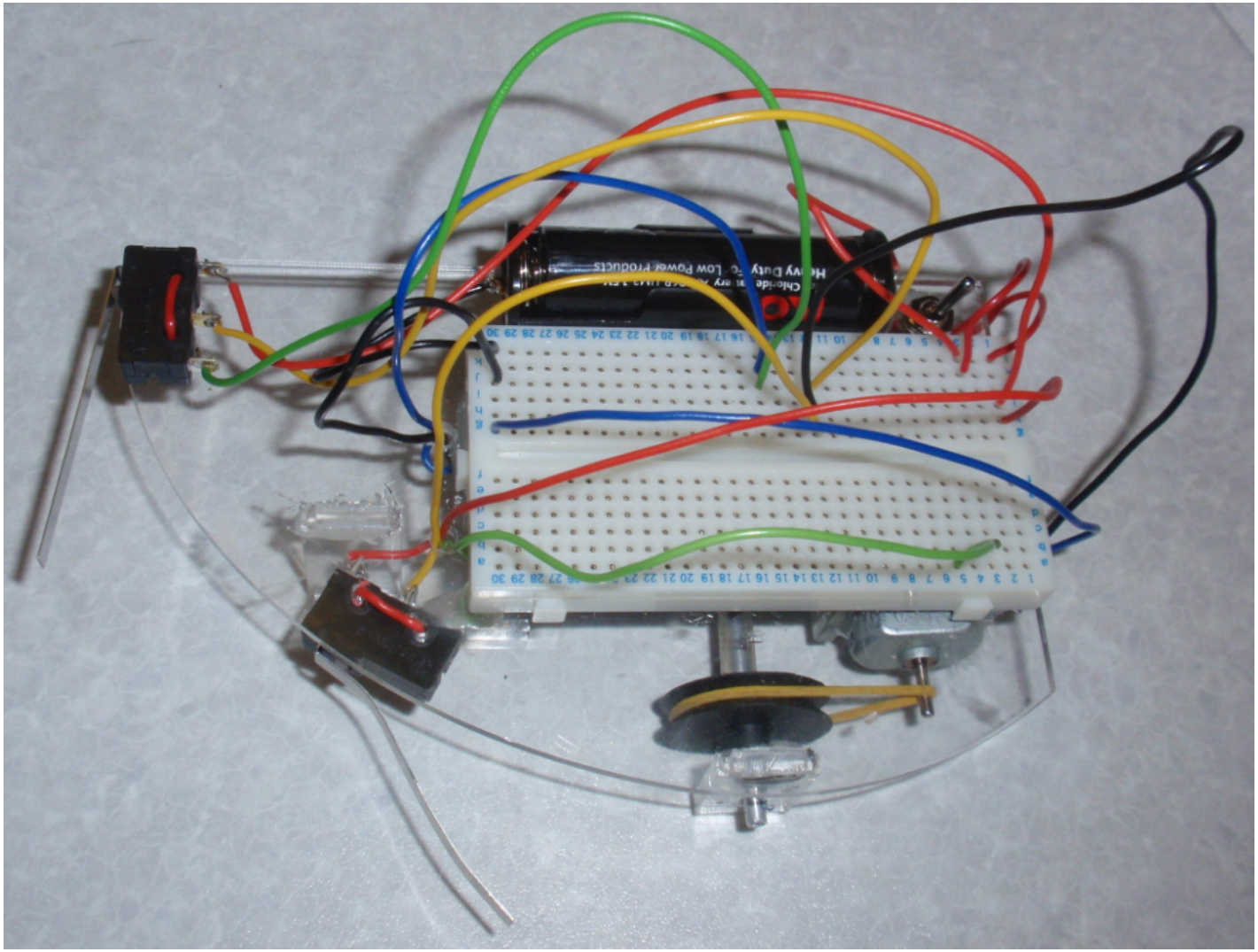
Drive system underneath chassis



Motors held firmly by plug in parts and easy to line up with wheels. Held in place by double sided tape

25mm pulley wheels give 12.5 : 1 ratio for suitable speed & power

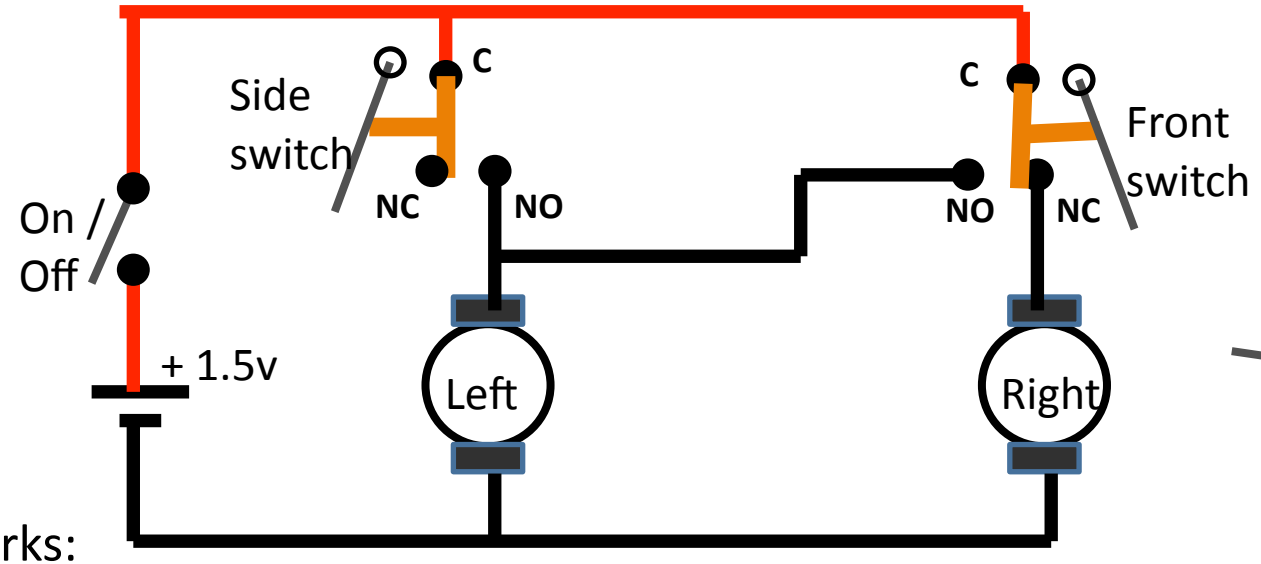
Top view of assembled robot

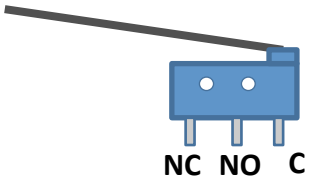


Initial version has just 1 AA battery. Second battery added for later projects that needed 3 volts.

All wires colour coded in standard way to simplify assembly instructions and make fault diagnosis easier

Contact Wall follower robot circuit



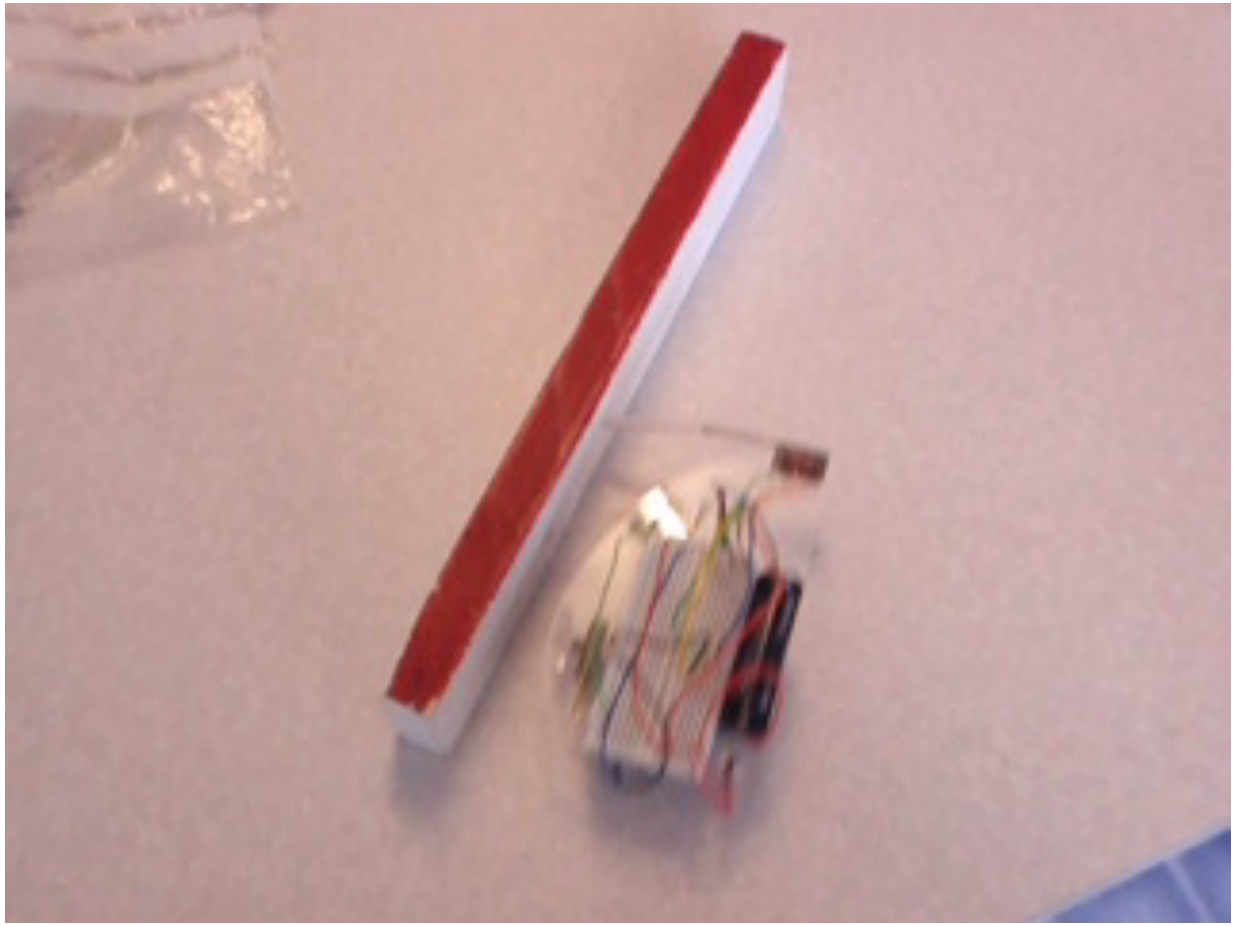


Micro-switch
contacts

How it works:

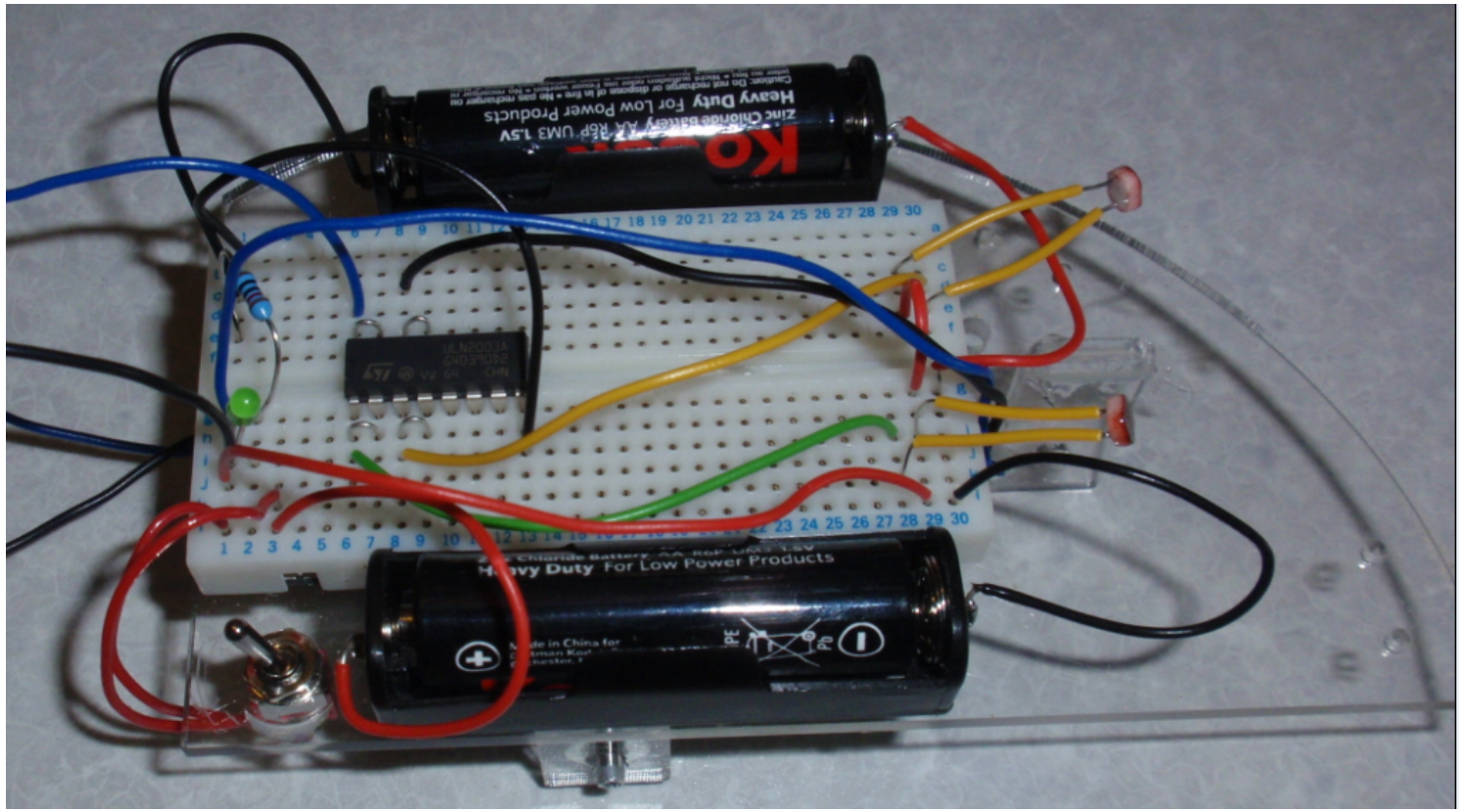
- When front switch is not pressed power goes to right motor
- When robot is against the wall the side switch is pressed and so power goes to the left motor
- With left and right motors getting power the robot goes straight ahead along the wall
- When robot comes off the wall the side switch takes power off the left motor so robot turns left
- When robot hits wall ahead the front switch diverts power from right to left motor so robot turns right

How it performed



General drive system works well and reliably even with just one 1.5V battery
Wall following generally OK but not perfect, scope for improvement by tweaking position of micro-switches and length of levers.

Light seeker robot

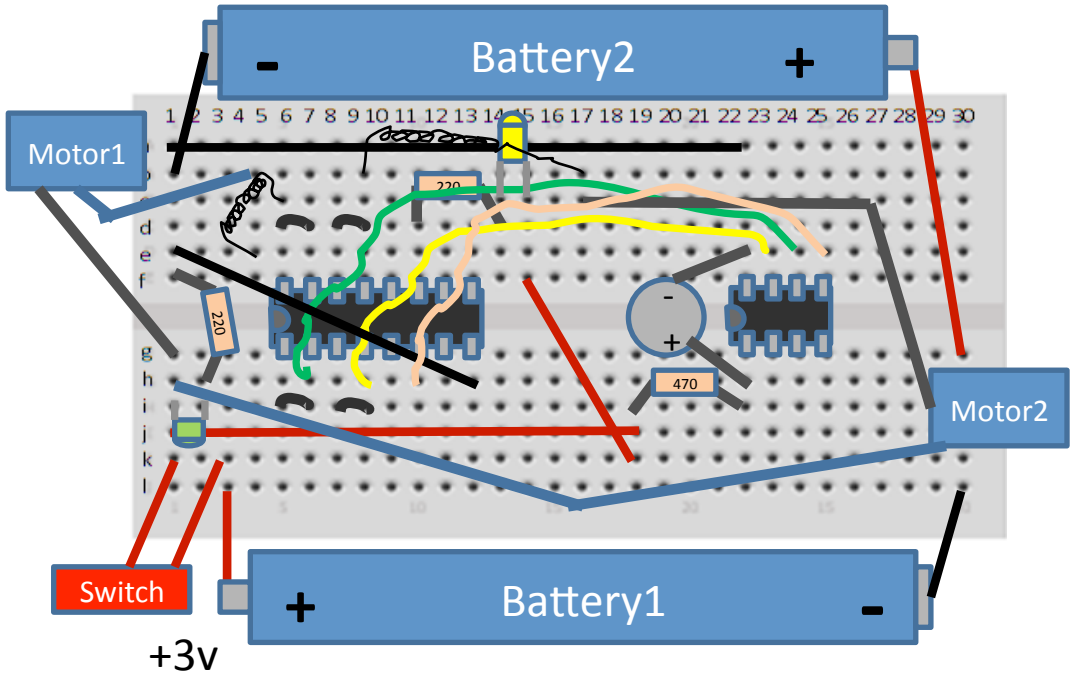


ULN2003A transistor array used to switch on motors based on light from the 2 LDRs.

Two transistors in array used for each motor to handle current

PIC based motor move sequencer

PIC motor sequencer breadboard layout



PIC12F675 used to drive the motors via ULN2003A transistor array previously used.

Low value resistance wire used to make small resistors to reduce motor current, to help stop PIC being reset by voltage drop when motors start up.

How did it go?

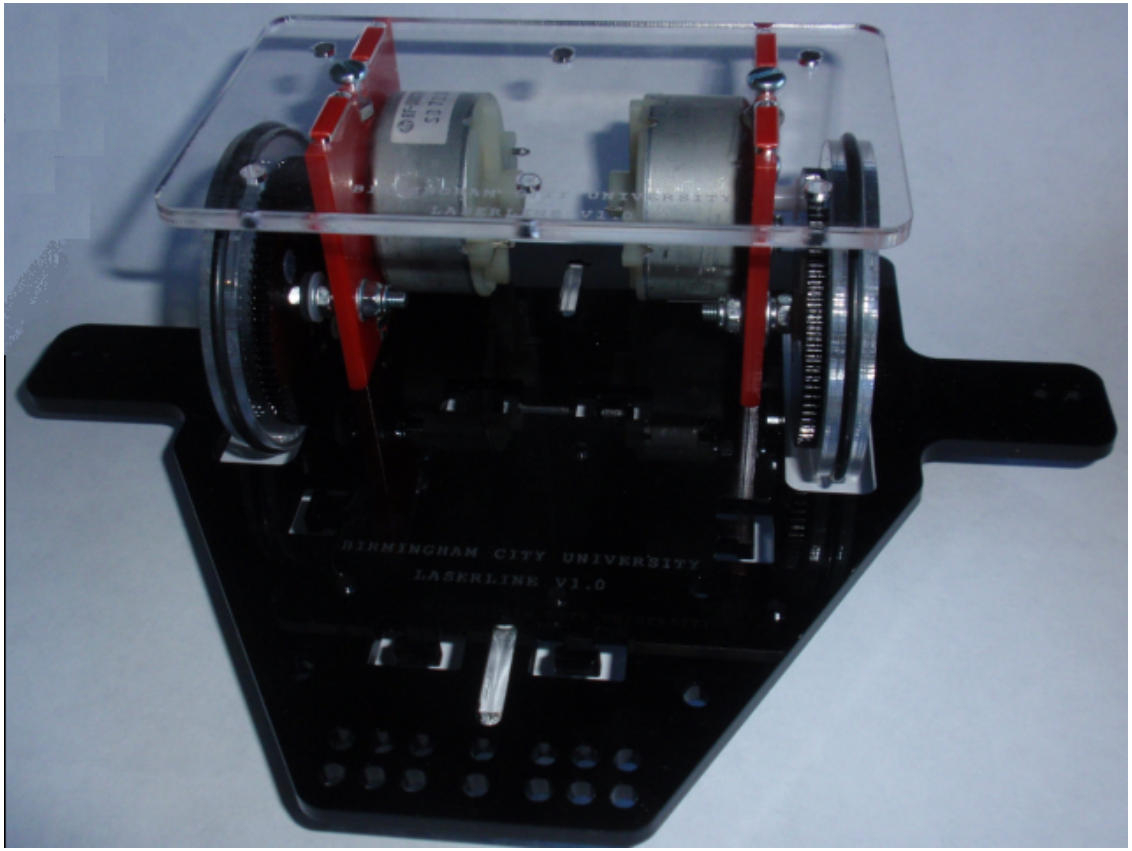
- Pupils were absorbed with the project and all said that they enjoyed it.
- Several pupils really took to it and I expect they will follow up with more experiments themselves

Parts list & costs

Chassis Perspex -The plastic shop	£1
Axle 3mm aluminium tube - Albion	28p
Wheels - Rapid 37-0481 pulleys	50p
Axle spacer – air tubing - Pet shop	7p
4mm washers - Screwfix 100 pack	3p
Drive belts Elastic bands – Staples	2p
Fixings – Blutack & dbl sided tape	5p
Wire 5 colours – Rapid 0.6mm	12p
Motors 3volt - Rapid 37-0140	74p
Micro-switches – Rapid 78-2408	£1.16
Switch single pole – Rapid 75-0130	53p
Breadboard – Maplins AD100	£1.90
Battery Holders - Rapid 18-0150	18p
AA Batteries – Poundland	20p
Total for basic line follower	£5.64

Extra for Lightseeker	
LDR low resistance – Rapid 58-0134	66p
ULN2003A – Rapid 82-0618	24p
Extra for PIC sequencer	
PIC 12f675 – Rapid 73-3284	92p
Extra for IR control	
IR receiver 38khz – rapid 55-0902	65p
Total extras	£2.47
Project Total cost per robot	£8.11p

Birmingham City University Line follower



All parts laser cut – including the gears

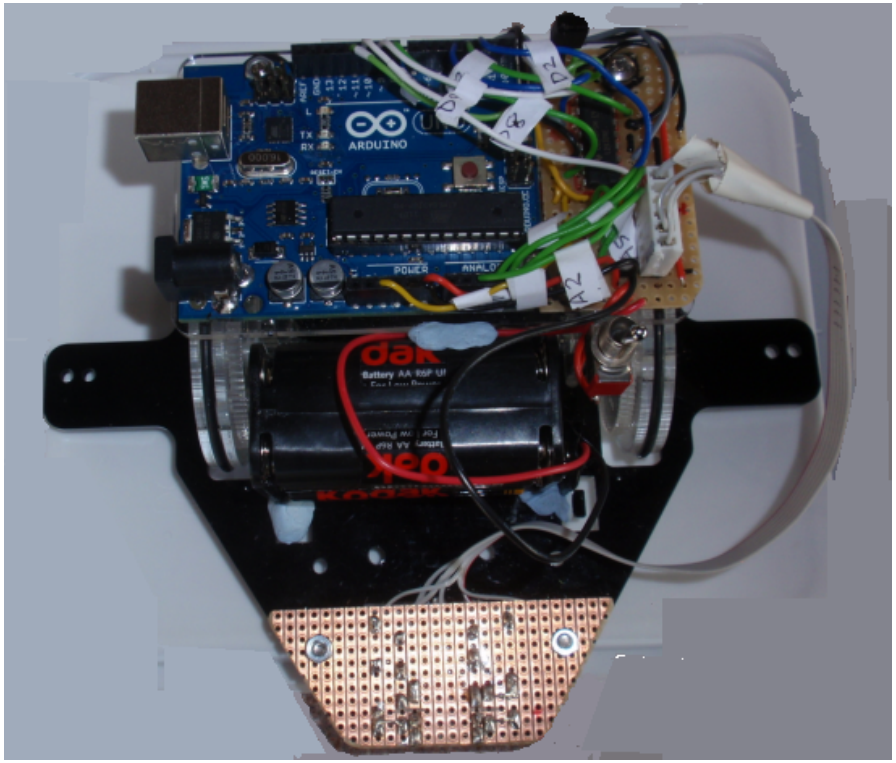
Held together with screws so able to be taken apart

Space for electronics on top, with batteries between the wheels and cut outs for LEDs and phototransistors

A much better engineered and more robust chassis than the wall follower, also capable of bring used for multiple projects

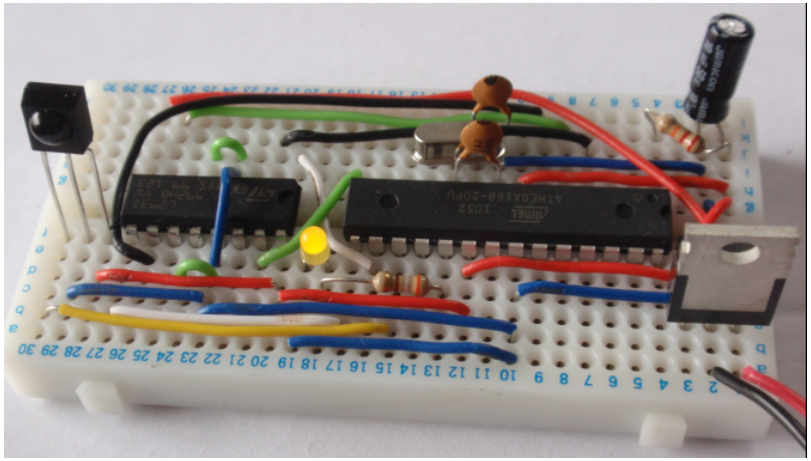
Experience with building it

- Only a few built so far, but main parts go together pretty easily
- Younger students have trouble doing up the locking nuts that hold the wheels on and sorting out which washers should go where
- 1st trial used a commercial Arduino Uno and separate L293 H bridge board
- 2nd design puts Atmega 168, L293D, regulator and an IR receiver onto a breadboard to reduce cost
- Both versions programmed with Arduino Sketch environment (like a simplified C+)



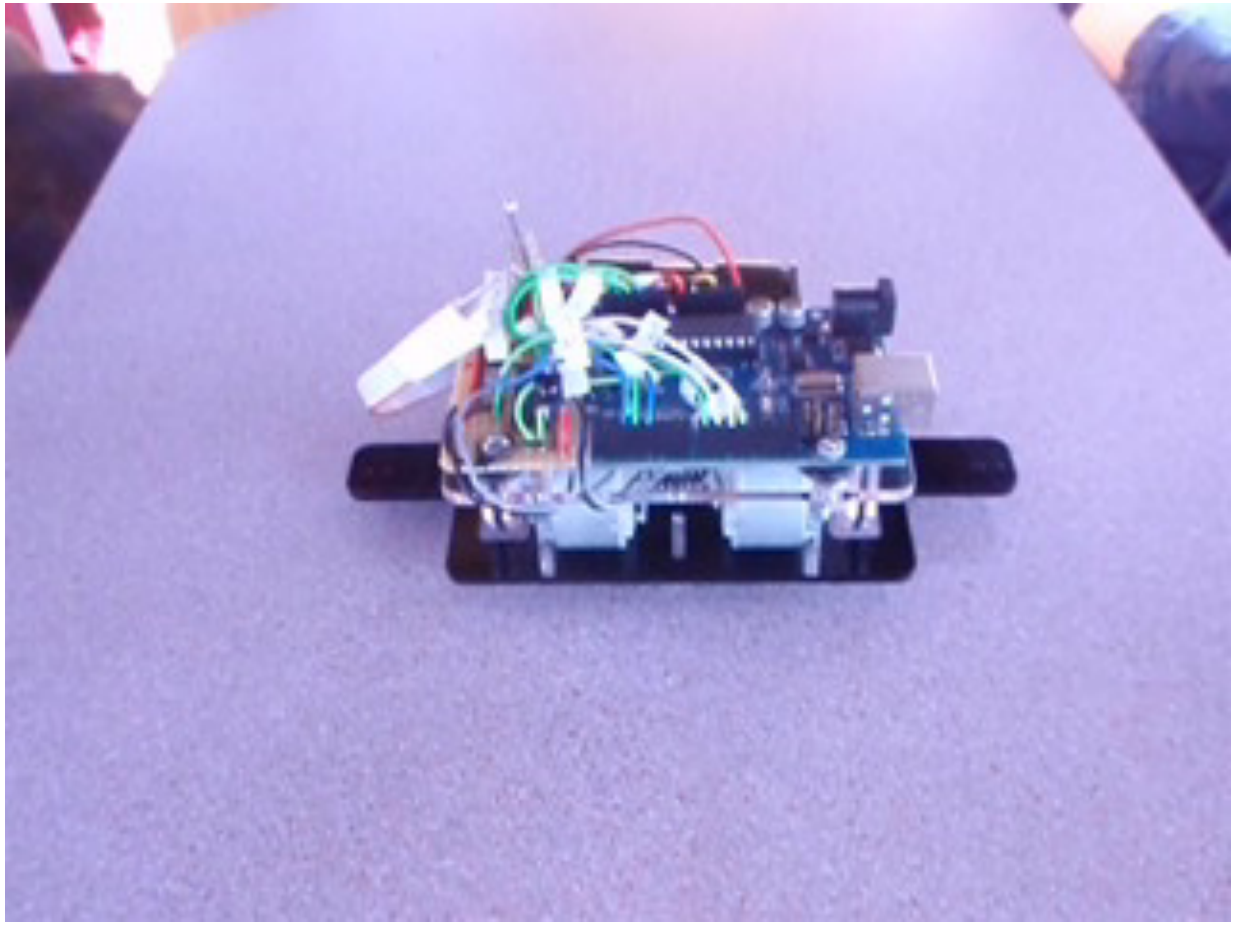
A few pictures

Chassis with Arduino Uno, motor board and some line sensors



Atmega 168, L293D, regulator and an IR receiver on breadboard

How it runs



Being manoeuvred under remote IR control

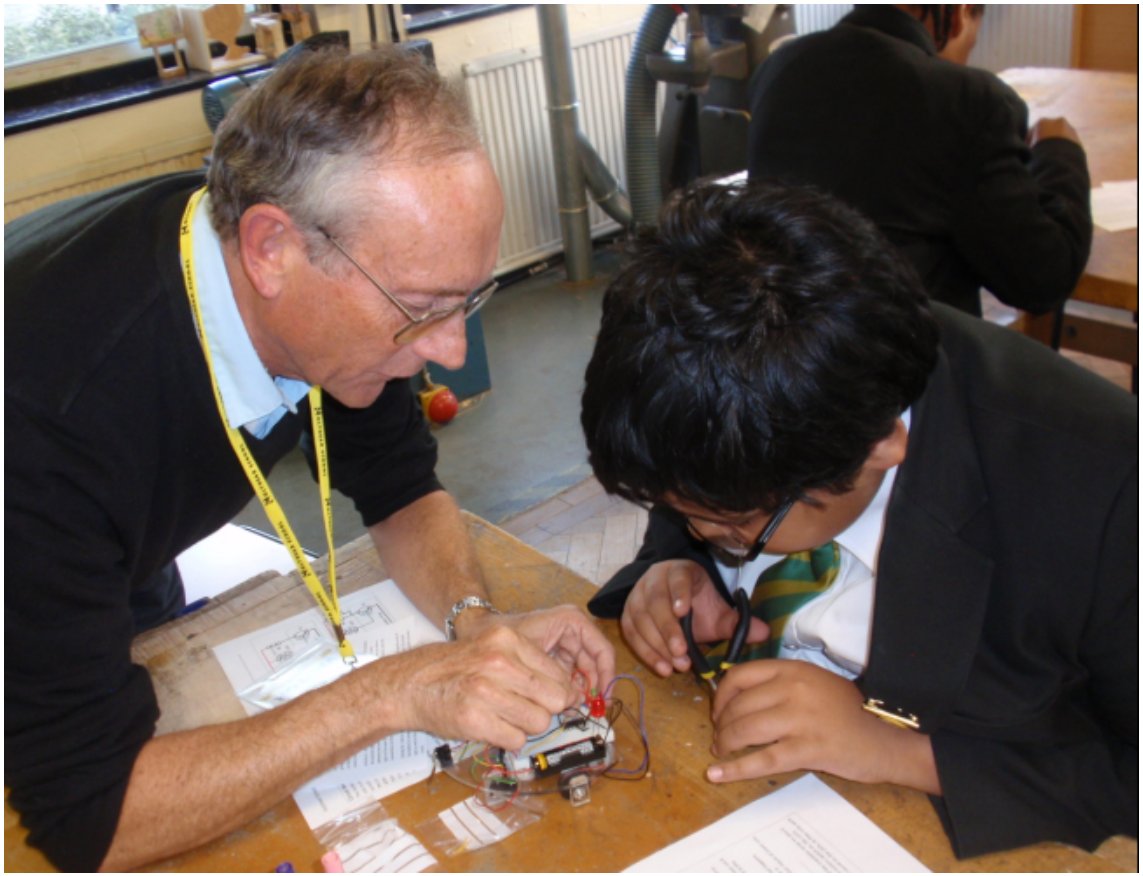
Parts list & costs

For breadboarduino IR controlled robot using B'ham Chassis

Chassis wheels & gears Perspex -The plastic shop	£1.50
Screws, locknuts and washers – Screwfix	about 20p
Atmega168 20pu Rapid 73-4276	£2.88
16Mhz crystal – Rapid 90-0370	28p
Two 22pf capacitors for crystal & resistors	about 20p
L293D H bridge – Rapid 82-0192	£2.88
5v regulator LM7805ACZX - Farnell 1467367	18p
Wire 5 colours – Rapid 0.6mm	12p
2Motors	about £1.20p
Switch single pole – Rapid 75-0130	53p
Breadboard – Maplins AD100	£1.90
Battery Holders for 6xAA- Maplins	£1.36
AA Batteries – Poundland	60p
4 High brightness LEDs & phototransistors	about £4.00
SFH309FA (Farnell122744)/ SFH409 for IR or TLDR4900 and TEPT4400 or Vishay BPV11 for visible light	
IR receiver 38khz – rapid 55-0902	65p
Universal remote control – Poundland	£1.00
Total	**about £16.95**

Use of a programmer or another Arduino

Lessons learnt



Activities and tasks have to be very well documented, especially for younger pupils because if you are helping one pupil and someone one else is stuck they will get frustrated (and probably mischievous)

Good soldering is tricky for 11 year olds, so is worth avoiding. It is easier with 13/14 year olds but still need a lot of supervision.

Very glad we went for breadboards and prewired components for most pupils.

Next time and the Future

I have been asked to help both schools again later in the year

Holyhead hope to get someone from Aston University to do some sessions on coding for their after school club. Taking their projects to schools fairs etc.

KES have re-activated their GCSE electronics option and have 20+ pupils wanting to do it