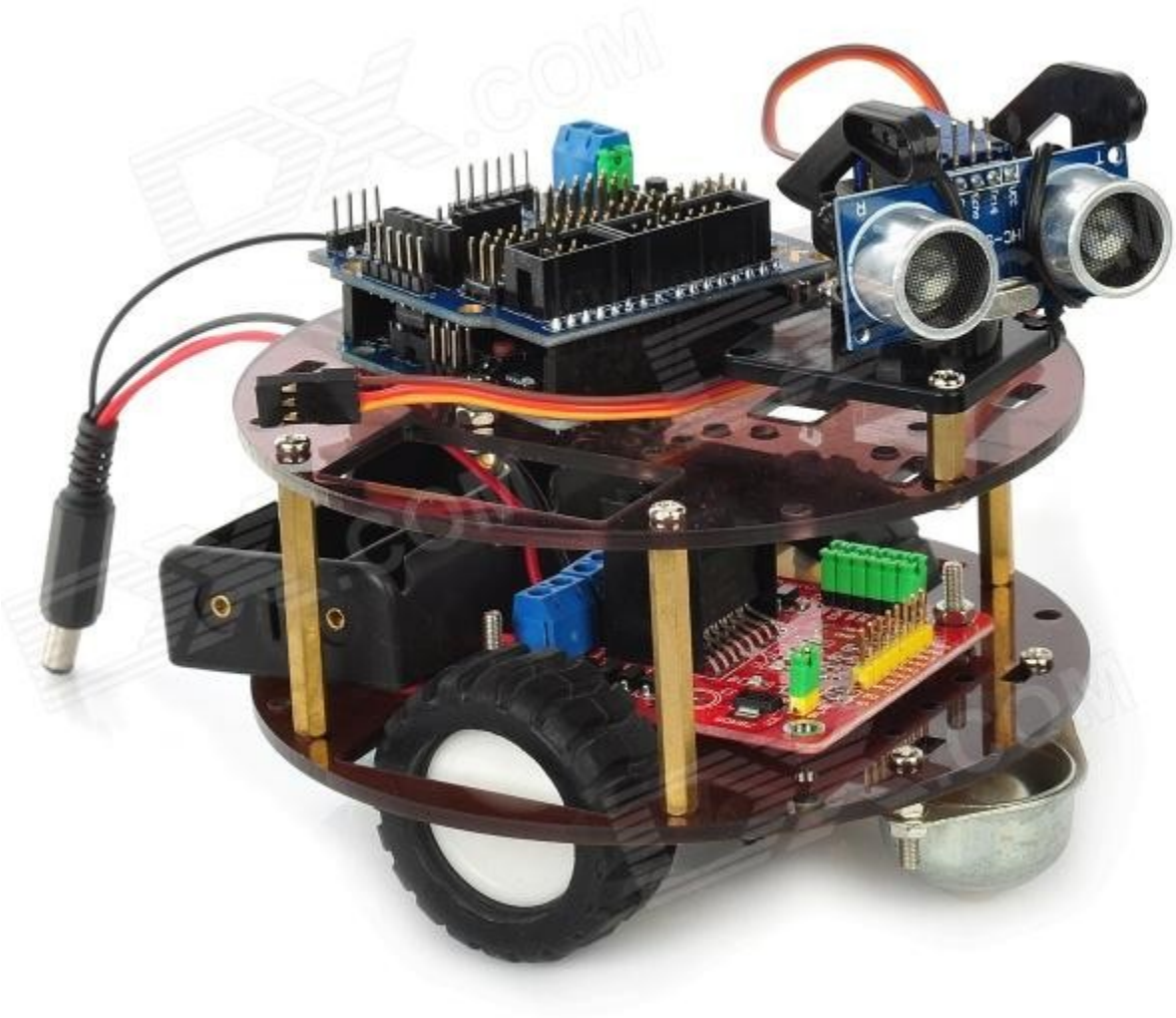
Let's Code Blacksburg!
Presents:



Learner Series: Building Autonomous Robots with Arduino, Robot Turtle Assembly HOWTO

Thomas Weeks 2014-04-19a
http://letscodeblacksburg.org/

Approximate Workshop Agenda:

10-10:20am – Arrival & Sign-Ins *[Cynthia]*

- -Attendees arrive
- -Sign in, receive kits,
- -Settle in, boot up

10:20-10:45am – Welcome & Orientation

- -LCBB Opening *[Cynthia / Tweeks]*
- -Volunteer Introductions *[Cynthia / Tweeks]*
- -Overview of class and milestones *[Tweeks]*
- -Quick Failure Talk, Build/Test/Sign-offs *[Monta]*

10:45 - 11:30am – Setup And Initial Testing:

- -Inventory & Parts Review *[Tweeks]*
- -RECIPE: Laptop Arduino Software setup (downloads & thumb drives) *[All Volunteers]*
- -RECIPE: Group "Blink" testing (wait for 100% working) *[Tweeks]*
- -Group Discussion of structure of Arduino programs (libs, setup, loop) *[Eddie]*

11:30 - 12:30pm – Start Building Bottom Motor Assembly: *[Eddie]*

- -Wire Motors and Test (just motors & bottom board, no arduino yet)
- -Wire motor board to sensor board (partial assemble) and Test

Noon - Pizza Arrives (start noshing while we work)

Noon - 1:30pm – Build & Testing of IR Line Following *[Monta]*

- -Wire up Simple IR Line Following circuit, program and Test
- -Integrate & Test IR Line Following + Motor Code

1:30-3pm – Build & Testing "Eyes" for Collision Avoidance *[Tweeks]*

- -Wire up Eyes (ultrasonic sensor)
- -Code and test
- -Integrate with motor and line following

3 - 5pm – Catch-Up || Refining || Stretch Time *[Instructors]*

- -Basic Level: T-shooting, Testing & Fixing Catch Up Time
- -Intermediate Level: Refining existing Setup (adv motor control, adv eye panning)
- -Advanced Level: Stretch goals of IR-Remote Control, Bluetooth, etc)

5-5:30pm – Wrap Up & Roboparade Registration: *[Tweeks]*

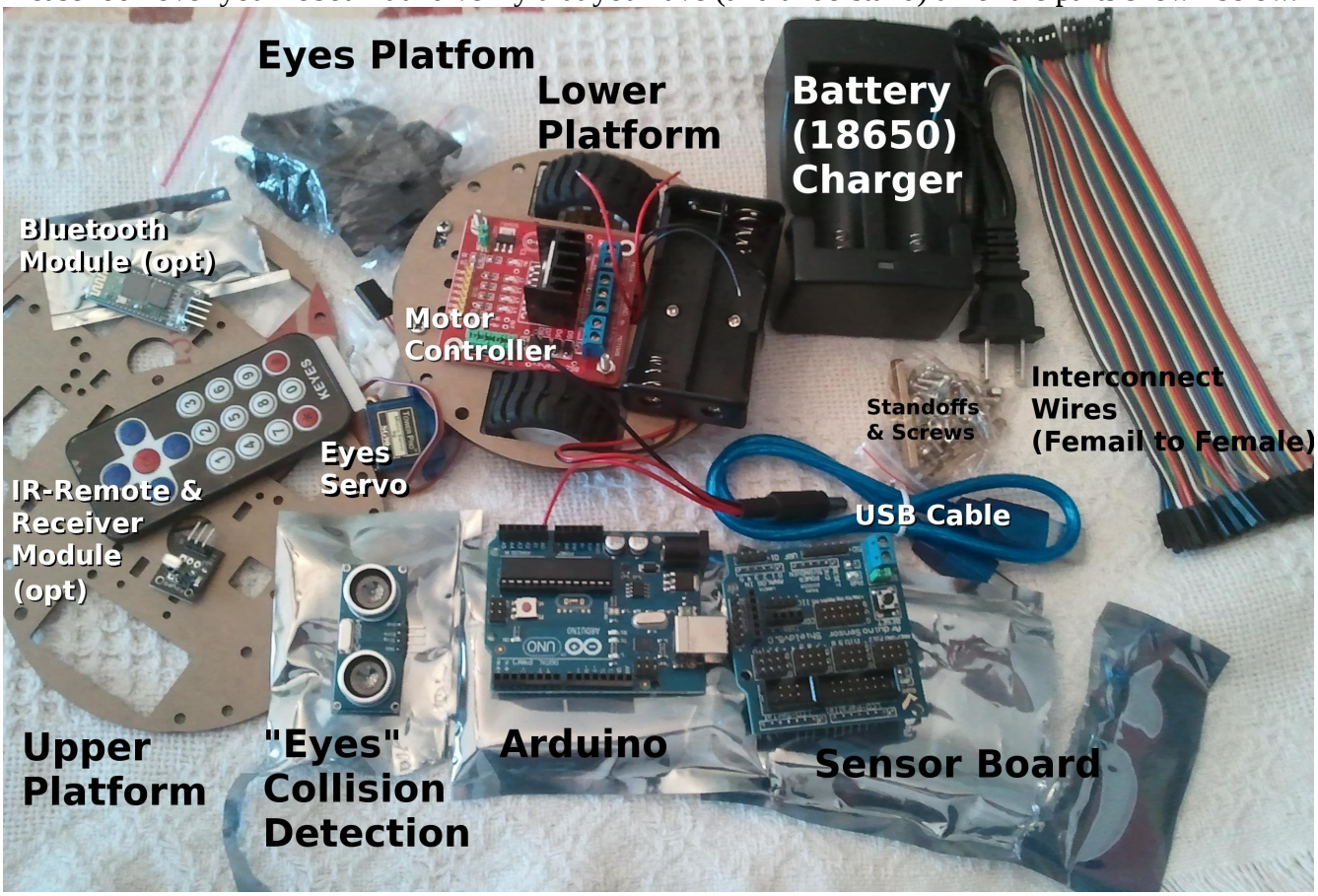
- -Wrapping up programming work (saving work, document remaining work, etc)
- -Register for the May 31st Roboparade
- -Decorating your bot for competition

5:30-6pm – Volunteer Clean Up *[Volunteers]*

- -Attendees can hang out, chit chat
- -Volunteers/TAs break down & clean up

Robot Turtle Kit Inventory & Parts:

Please look over your robot kit and verify that you have (and understand) all of the parts shown below.



Basic Parts Review: (clockwise)
-Lower Platform - The bottom of the robot that has the premounted wheels/motors, motor controller board, and IR line-follow detectors (underneath the platform).
-Battery Charger – Charges the special Li-ion 18650 batteries (not shown. look like over sized AAs).
-Interconnect Wires – Strip off and use these wired as directed by the build HOWTO (or instructor).
-Standoffs & Screws – For mounting platforms, boards and parts together.
-Sensor Board – This is the board that most of the electronic sensors, motor board and servo connect to.
-Arduino – The brain of the robot that we're going to program. Connects to laptop via the USB cable.
-Eyes – The ultrasonic ping echo locator that allows your bot to avoid colliding with obstacles.
-Eyes Servo* – The optional servo that mounts the eyes to the eyes platform for doing an “pan scanning”.
-Upper Platform – Where the Arduino, Sensor Board and Eyes platform all mount to (see cover photo).
-IR-Remote & Receiver* – Optional parts for ding remote control functionality.
-Bluetooth Module* – Optional wireless module for doing remote control from your smart phone.

The optional parts (opt) above are not required to complete this class, but are fun/useful “streatch goal” options that you can add on to your robot *after* you get the basic line-following kit completely working. For example, the IR-remote control + receiver are convenient for pausing, stopping, or remotely steering your robot (instead of chasing it down all the time). Likewise, the serial bluetooth module can let you remote control your robot from your smartphone! However, please do not waste time on optional features until you have completed the required base line follower project.

Robot Turtle Construction HOWTO Steps:

1) RECIPE: "Installing Arduino Sware & Drivers Recipe"
Follow this recipe from the LCBB Arduino Cookbook to ensure you have the proper software and drivers running on your laptop.

2) RECIPE: "TEST: LED (light) Blink Recipe" INSTRUCTOR:
Test compile and upload code to blink a built in LED. This tests is important as it verifies you can talk to your arduino.

3) Cleanup The Lower (wheel) Platform

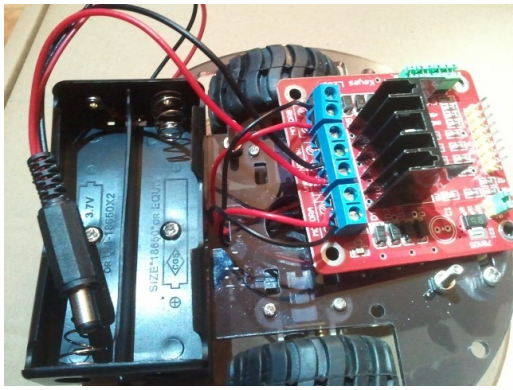
- Flip over pre-assembled bottom wheel platform and mark the "front/bottom" of the unit.
- If you prefer a shiny plexiglass look, then clean up the lower platform (optional)
  - Carefully remove all bottom section components, noting where each part & screw originated and the order in which the parts go back on.
  - Peel off all the plexiglass protective paper (except the "front/bottom" markings from above)
  - Carefully reassemble all parts back onto the bottom wheel platform as they originally were.

3) Wire Up Motors and Power:

- Test both wheel motors INSTRUCTOR:
  - With the motors still *not* wired into the motor controller board, touch the red and black wires for one of your wheel motors to the + and – terminals of one of your Li-ion 18650 batteries. If the motor smoothly turns, then that motor is good.
  - Repeat with other motor and get instructor to verify you've completed this step.

TESTING: Please perform all tests and get instructor/TA sign-off on all INSTRUCTOR testing write-offs. If you do not, the instructor may not assist you until these tests are complete.

- On the assembled wheel platform, remove the top mounting nuts holding the red "Keyes L298" motor control board so that you can more easily wire up the power and motor lines as seen to the right. With the battery holder mounted to the rear, the right side motor gets connected to the "Motor-A" terminals (blk outer, red inner), and the left motor connected to the "Motor-B" terminals (red inner, blk outer). Mount the motor control board back onto the wheel platform when done. And move on to the Motor Board/Sensor step after an instructor has examined your wiring.

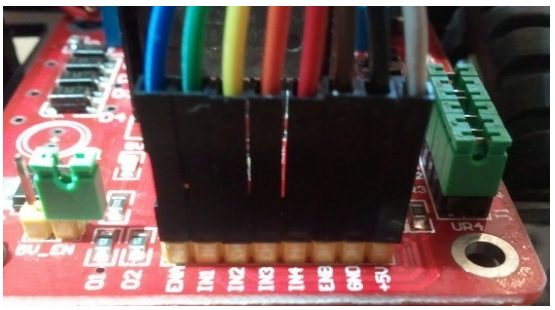

Connecting the motors and power (thick wires) to the motor controller.

CRITICAL DETAILS: Before putting batteries in your battery pack, have an instructor examine your wiring. Also, when screwing the motor and power wires into the blue terminal block, be sure not to insert the wires too far into the terminal block. The block should be holding the stripped wire and not the insulation. Putting the wire too far in can cause many robot motion and stability problems later.

- Examine your motor/power/wheel wiring. INSTRUCTOR:

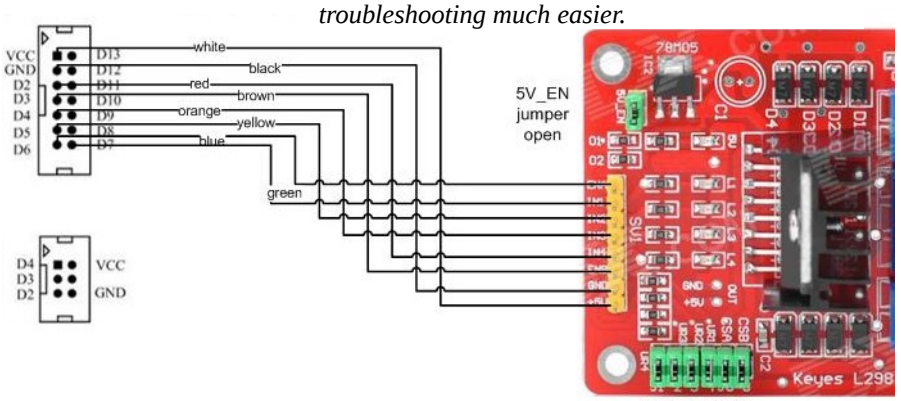
4) <u>Connect Motor Board to Sensor Board:</u>
This step connects the motor control board to the Arduino Sensorv5.0 board. (shown)

- Strip off eight color female-female patch wires from the pack (colors white, black, brown, red, orange, yellow, green and blue), keeping them all connected to each other (right)
- Wire up the yellow connector on the red motor controller board to the "LCD-Parallel" pins of the sensor board as listed below (from http://adhocnode.com/motor-control/)



When hooking the motor controller board to the sensor board, using the colors here makes troubleshooting much easier.

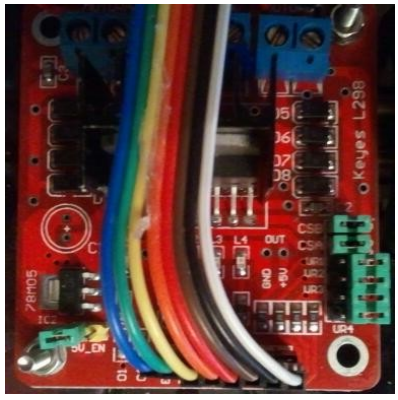
M.Board	Function	Wire	Sensor Shield
+5V	Logic V supply	white	VCC
GND	Ground	black	GND
ENB	motor-b enable	brown	D3
IN4	motor-b -	red	D2
IN3	motor-b +	orange	D4
IN2	motor-a -	yellow	D5
IN1	motor-a +	green	D7
ENA	motor-a enable	blue	D6



Wiring example from http://adhocnode.com/

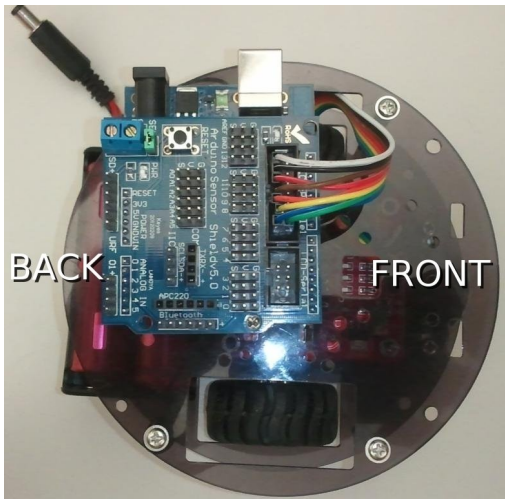
- Set the Keyes L298 motor board jumpers to the positions listed here:

Jumper	On/Off
CSB	ON
CSA	ON
UR1(pullup)	OFF
UR2(pullup)	OFF
UR3(pullup)	OFF
UR4(pullup)	OFF
5V_EN	OFF



This sets up the motor board to use motors A and B, and disables the four built in pull-up resistors. The 5V_EN tells the board to use the 5V logic supply that we are feeding it from the arduino/sensor board (white wire above).

- **Top/Bottom Platform Assembly:**
Collect the arduino, upper & lower platforms, the long brass standoffs, eight pan-head screws and two machine screws/nuts. The standoffs will hold the top and bottom platforms together and the two machine screws will mount the arduino to the top (photo).



ARDUINO MOUNTING: The Arduino is not mounted to the top platform using brass standoffs, but by simply putting the machine screws through the arduino board (from the top), through the top platform, attaching the nuts to the underside of the platform. It may be difficult as the screws are a little too short for this. If having problems, ask an instructor or TA for help. Don't stress the arduino board or torque down the screws or nuts too hard. Your arduino and your top platform should be flat and not warped from the stress of this mount.

MOTOR TESTING NOTE: Before verifying the motor control is working (next step), you must have first completed the cookbook "blink" recipe to verify that your laptop can talk to your arduino. Also, if anything is mis-wired, you will need to re-remove the top platform. Be sure that you can do so easily, and NEVER screw and unscrew things while the power is on! If you drop a screw into the live circuitry, you can easily blow your robots brains out!

- Inspection of your top/bottom/arduino assembly (power disconnected) INSTRUCTOR:_____

5) Program & Test the Motors INSTRUCTOR:_____

- **Program:** Follow the Arduino cookbook recipe for "**CONTROL: Robot DC Motor Control**", run the programs, answer the questions and record them below. Get instructor sign-off (above) before continuing.

NOTE: Don't spend a ton of time on this. Get into the recipe, run the code record the answers below, SAVE your program(s) to some meaningful name such as LCBB-bot-motor-program1, LCBB-bot-motor-program2, etc.. and get out. We have a lot to do!

- **Q: Did your bot go in a solid straight line (with the first program)? A:_____**
- **Q: What was your minimum usable motor speed (for both motors under load?) A:_____**
- **Q: What was your best straight line speed setting? A:_____**

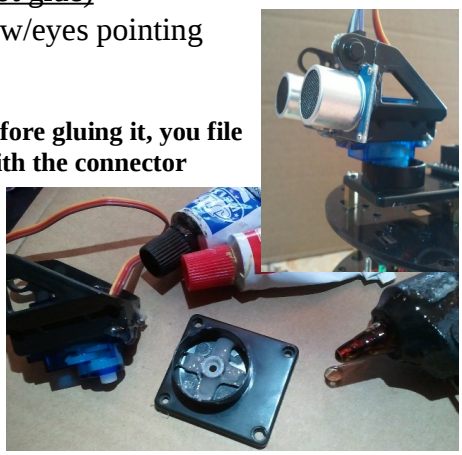
STRETCH GOAL:

Experimenting with much more fine grained, smooth turning motor control is possible. After you have your basic line follower code all working (and saved), and are looking to fine tune your robot's motor control, try checking out this code that tunes your motors to run at the same speed (at various speed settings), as well as varying turn rates for different speeds:

GitHub:
https://github.com/LetsCodeBlacksburg/arduino-robotics/blob/master/LCBB_motor_balance_diff_turn/LCBB_motor_balance_diff_turn.ino

6) <u>Assemble The Ultrasonic "Eyes" Platform:</u> <u>(need glue and/or hot glue)</u>

- **Assemble:** the triangular "eyes assembly" around the servo, w/eyes pointing forward:



NOTE: The eyes board can more easily be held in place if, before gluing it, you file a notch in the upper plastic arms. With the eye's mounted with the connector pointing upward, apply hot glue to the top arm edges where they meet the board, and behind the bottom of the board where the silver crystal (oval) is located. Then slide the eyes into place and hold until the hot glue sets.

- **Mount to Platform:** The bottom rectangular eyes platform receives the white, plastic, "servo horn". However, your white plastic horn may first need to be trimmed so that it fits in the base correctly (right). The white plastic horn should now be glued into place (hot glue or epoxy) and secured with the tiny, wedge shaped screws from the underside before sitting aside to set.

WARNING: Do not over-tighten the tiny little wedge shaped, self tapping screws from the underside of the base into the white plastic servo horn. If you strip the white servo horn, it may cease to provide a good firm hold. If you do mess this part up, you can always go back later and epoxy the horn to the base using JB-Weld epoxy (shown above) and not worry about the tiny screws.

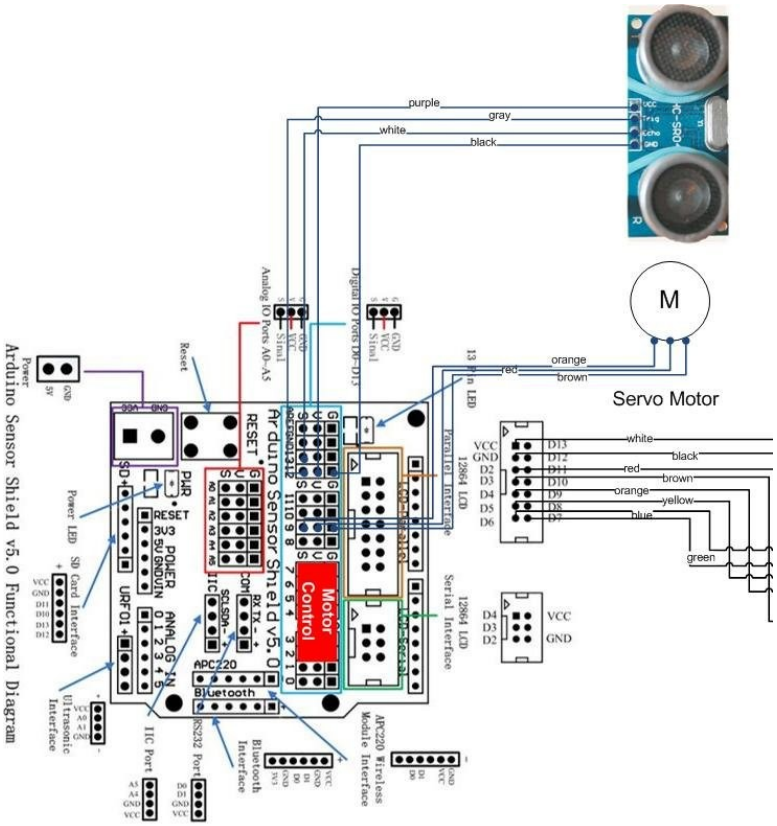
- **Soft Eye-Servo Mounting:** Mount the the assembled upper (triangular) eye/servo assembly to the bottom (rectangle) base by pushing the top servo's gear-shaft down into the white horn receiver (see above). <u>DO NOT GLUE OR SCREW SERVO SHAFT INTO THE HORN YET</u>. Feel free to mount the servo base plate to the robot body using the two brass standoffs to prepare to test it before gluing permanently.

EYES-BASE MOUTING: The wide, pan head screws screw into the two short brass standoffs from underneath the top platform, while regular, long shafted screws are used from the top of the rectangular eyes-base. The rectangular base's holes may need to be slightly enlarged with a blade to get the top screws through. Be careful when doing this or ask for instructor assistance.

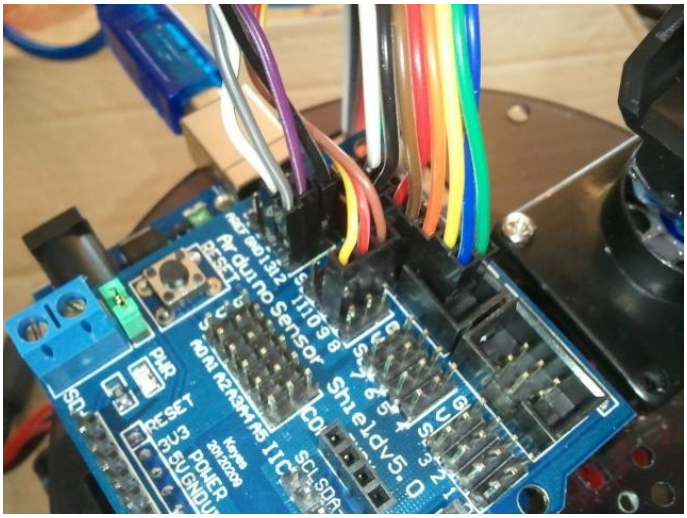
7) <u>Wire Up Eyes & Servo To The Sensor Board:</u> (connecting the eyes, and servo)

The sensor shield sits on top of the Arduino brain which controls everything. The diagram here shows how it is wires, and the photo below of what it should look like when done.

Wiring diagram of the ultrasonic "eyes" and the "neck servo" that moves them to the Arduino's Sensor Shield.



WARNING: Have an instructor or TA check your wiring <u>before hooking up the battery</u> or laptop to your arduino! It would be a shame to let the magic smoke out. ;^)



What it should look like all wired up to the Sensor Shield.

- <u>Inspection of your eyes and eyes-servo connections</u> INSTRUCTOR:

- **Eyes/Servo Orientation:** To test that the eyes servo's 90° mid-point is facing straight forward, first test the servo control by loading the arduino code for Examples > Servo > Sweep. Compile and upload it to the arduino to verify the servo can sweep from 0 though 180°. Next, set the **`myservo.write(pos)`** to value **`myservo.write(90)`** to center the servo. Then remove power, pull the servo/eyes assembly from the glued horn-gear, preposition it for 90° and screw the horn into the servo shaft from underneath, ensuring 90° is straight forward.

- **Gluing The Servo Into Servo Horn:** Now you may glue the servo shaft (top/eyes section) to the base (white horn) section, re-screw in the tiny wedge shaped screws into the base (from underneath), and the longer self tapping shaft screw from underneath the horn up into the servo shaft hole. Just be sure that you don't turn the servo when removing it, and that you reinsert to facing perfectly forward 90°. Let the glue set. Rerun the servo test from 0 – 180° again if you like.

EYE SERVO PANNING: The optimal eye-scan pan range for this robot is approximately 35 – 145°, if you're trying to detect possible collisions while moving forward.

8) Program & Test the Eyes (no servo movement at this time) INSTRUCTOR:_____

- **Follow the recipe for the "INPUT: Ultrasonic 'Eyes' Range Sensor"**
- **SAVE your program with a meaningful name like LCBB_bot-eyes**
- **Have an instructor or TA look at your restuls and sign-off above.**

STRETCH GOAL:

Come back to this goal after you have completed the full line following bot. Once you have the basic line following bot complete, you can experiment with more complex coding of the eyes that include:

- panning back and forth with the servo "neck" on the eyes (recommend 35° - 145°)
- make the ping scans more reliable by averaging multiple quick back to back pings
- interleaving the scanning code in with the other motor and line-following code
- collision warning and critical thresholds (for medium and fast turning)

See our advanced GitHub example code here:
https://github.com/LetsCodeBlacksburg/arduino-robotics/tree/master/LCBB_ping_trigger_echo_sensor_advanced

Other advanced/alternative examples here: http://adhocnode.com/range-sensor/

NOTE: Don't start playing with these more advanced code examples until you have the basic line-following and simple collision detection code all working.

9) Wire Up The Line Follower

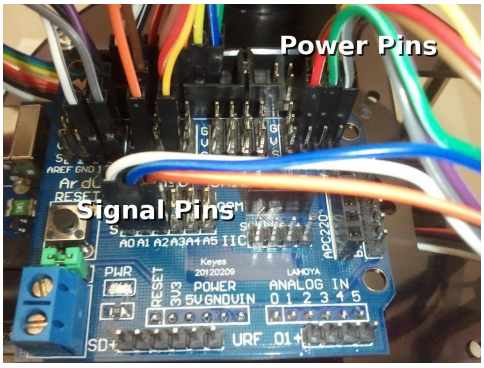
- Separate nine jumper wires (white,grey,purble,blue,green.yellow,orange,red,brown)
- Feed them through the small hole in the bottom platform of the bot
- Plug them into the IR line sensors according to this diagram:

Sensor Towards Left Wheel

Wire	Signal	Pin
white	S	(A0)
grey	V	any V
purple	G	any G

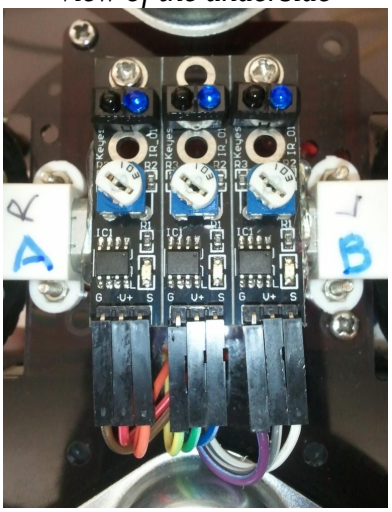
Sensor Middle

Wire	Signal	Pin
blue	S	(A1)
green	V	any V
yellow	G	any G



white(A0), blue(A1), orange(A2)

View of the underside



Sensor Towards Right Wheel

Wire	Signal	Pin
orange	S	(A2)
red	V	any V
brown	G	any G

NOTE: If you find it too difficult to get the wires through the small lower platform hole between the battery holder and motor controller board, you can either disassemble the robot and feed the wires through, or peel all the wires down to single strands and feed them through one by one.

- We recommend (but do not require) having an instructor or TA check your wiring.

10) Program & Test the Line Follower INSTRUCTOR:

- Follow the programming and testing in the recipe "INPUT: Line Following IR Sensor"
- Show an instructor or TA your serial output of this sensor board and get sign-off above.

Other examples: http://adhocnode.com/line-following/

11) Combine the Motor, Ultrasonic Eyes and Line following code and fine tune it to:

- follow electrical tape lines on white surfaces
- use ultrasonics to stop the bot until the coast is clear

STRETCH GOALS:

- Look at the previous Ultrasonic and Motor stretch goals
- Look into using the IR-remote control (and IR receiver module) for controlling your bot.
  NOTE: The IR remote control and IR receiver (#include <Irremote.h>) from here: https://github.com/shirriff/Arduino-IRremote
- Look into using the bluetooth module to control your bot from a smart phone: http://adhocnode.com/bluetooth-remote-control/