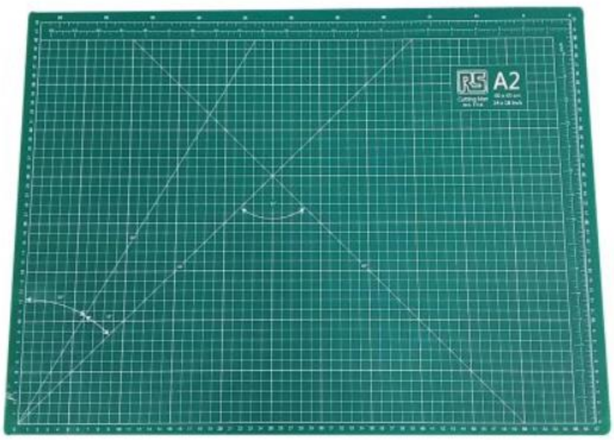
Arduino Hardware build (COMPASS)- L.A.Brown (dec18)

Gather all your components:

1. Shopping
    a. Circuit boards
    b. Cases (Arduino box (code
    c. General lab/workshop gubbins:
        i. Soldering iron - decent quality and range of tip sizes (fine/angled tip best for boards)


        ii. Pliers and Tin snips - for tidying up boards (*e.g.* RS cable cutters, 606-484 RS pro)
        iii. Self-healing mat - cutting and soldering safely



    d.
        i. Care and advice:
            1. Follow local lab/ safety rules
            2. Ask someone if unsure
            3. Test thoroughly and get components of slightly more sensors than you need, your failure rate will be above zero, especially if this is all new.

Build guide (individual PIRs):

Start by checking that you have all the components for building. In the case of the PIR sensors, each board will need 1x 1K Ohm resistor, 1x 10K Ohm resistor, 1 x RJ12 horizontal jack and 1x PIR sensor with integrated digital amplifier.

If you want the light-dependant resistor (LDR) to be mounted on this sensor board you will also need a 2-pin header, another 10k Ohm resistor and the LDR itself.

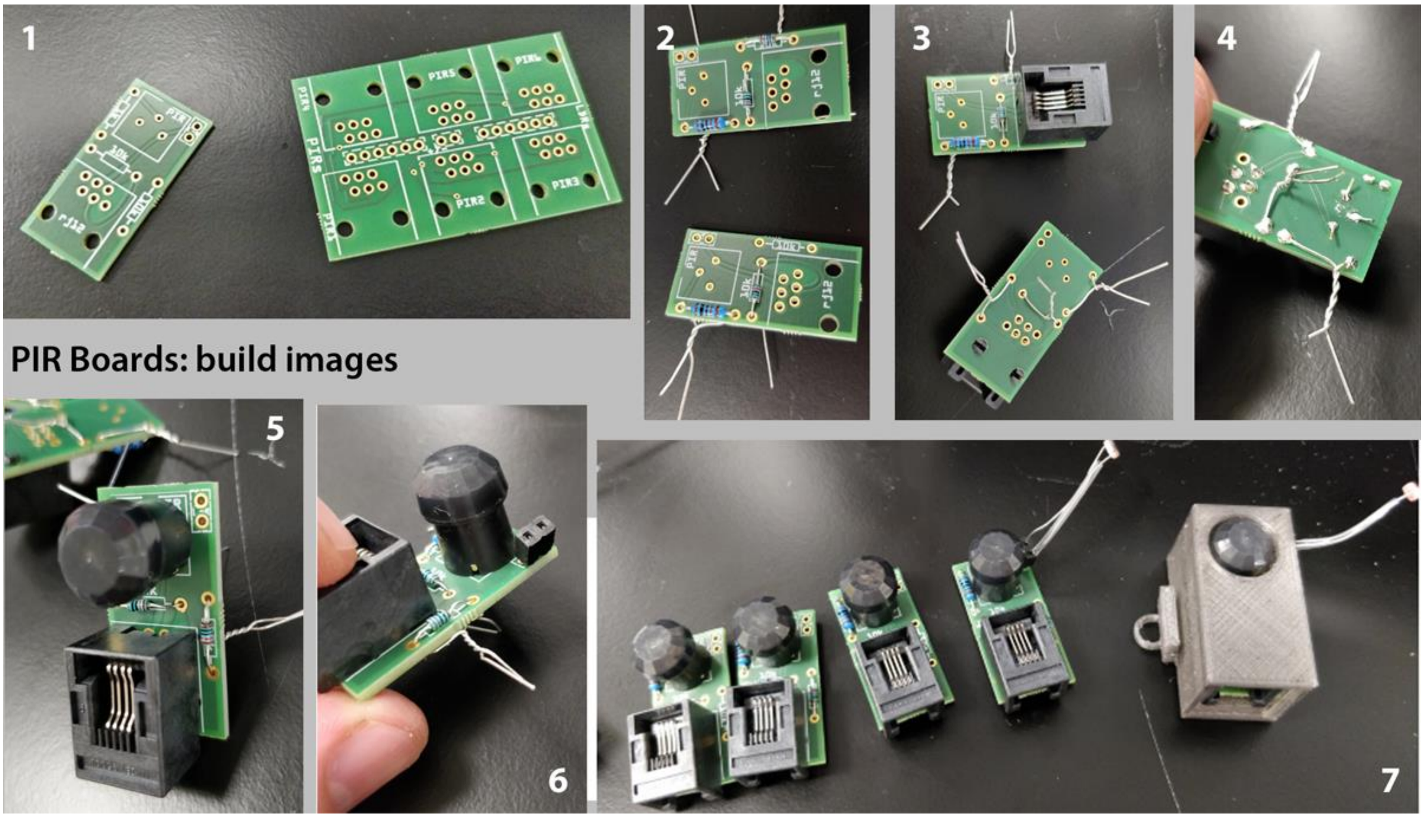
Every component sits on the same side of the board (the side with the markings, **1**).

Start by putting the resistors through the PIR board in the marked locations and pull these tight by twisting the wire ends (**2**). The RJ12 jack can then be pushed onto the board (again on the same side, **3**). Finally, the PIR module can be mounted on the same side of the board and held in place by bending the wire legs apart on the other side. Right-angled RJ12 connectors were used for the breakout boards for the PIRs, as this offers better options for positioning cables.

Careful soldering can now be carried out at all the holes where connections come through. As the only expensive component is the PIR module, this can be soldered after you are happy with all other connections. Then check there are no lose components or connections (check both sides of the board and fix with more solder if needed (**5**).

Then tidy by removing loose wires with tin snips, just beyond the soldered points. Add a resistor and 2-pin header to any board that will have and LDR mounted (**6**).

Run final checks for lose connections or missing components and add LDRs and cases if needed (**7**). Be careful to ensure 2 wire legs of the LDR do not cross (short out the LDR), either using heat-shrink tubing or tape).

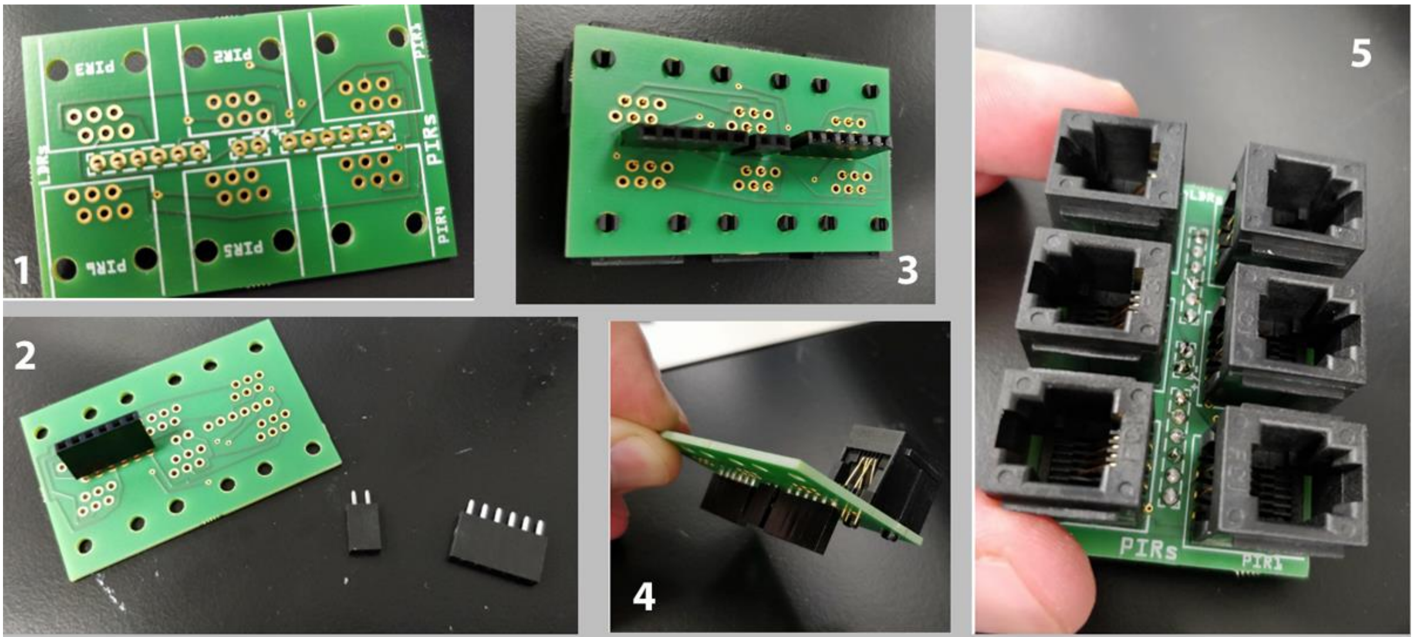


PIR Boards: build images

Build guide (main board)

Start by checking that you have all the components for building. In addition to the main board (**1**), you will need 1x 6-pin header (for 6 PIR inputs), 1x 2-pin header (for power), another header (6-pin possible, 2 will be enough in most cases) for the LDR signal inputs and 6x vertical RJ12 jacks (receptacles).
Vertical RJ12 connectors were used on the base unit for easier management of cables. Don't use right-angled RJ12 connectors, as these are for the PIR boards.

The headers are mounted to the underside of the board (**2**) and so it is easier to solder these in place first. Take care to balance the board with headers in place while soldering (or tape/bluetack away from the holes to hold the components in place for soldering). Once these are all soldered (**3**) you can mount the RJ12 connectors to the other side of the board (**4**) and then solder these in place to finish the board (**5**).

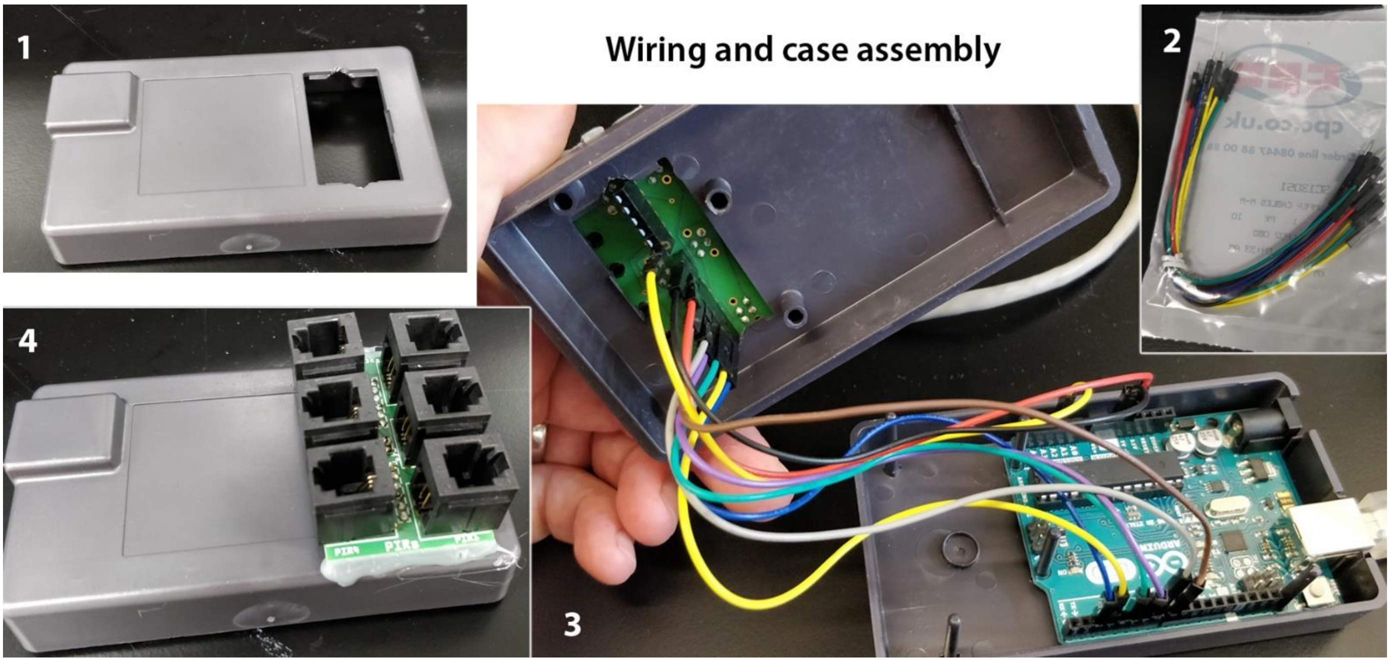


6-channel base board: build images

Build guide (case and Arduino unit)

This is based on using the Arduino case and a set of male-to-male jumper wires. First test if the main board fits through the existing hole in the top of the case. You may need to carefully remove a small section of the case either side of the hole (**1**) to mount the board flat to the case. Fit the Arduino Uno microcontroller into the lower half of the case and then insert the jumper cables (**2**) into the correct pins of the microcontroller. Start with GND (black) and 5V (red, **3**). The remaining jumper wires will need to match the settings in the Arduino sketch that upload to the board. This will normally be A2 for the LDR and digital pins 2,3,5,6,7, and 8 for the 6 PIR sensors. (check these positions match the sketch later).

The other ends of the jumper wires can then be run through the hole in the case and into the headers on the main board (use the writing on the other side of the circuit board to confirm (PIR 1-6 from one end, + and – for power in the middle, then LDR pins. LDR pin for PIR sensor 1 is closest to the power pins). Once finished you can close the case. The main board can be held in place easily with a little hot melt glue at the sides (**4**). If the case shown is not available (original 'box for Arduino'), any other case should work, but more cutting and fixing may be required.



Wiring considerations

For the current system we have used RJ12 cabling and connectors for joining the sensors back to the main board on the microcontroller. This provides a balance between cost, ease of use and performance.

Distance

RJ12 cables can be bought pre-made or made to length easily. Unnecessary long cables should be avoided as these increase the chances of these acting as antennas for inference.

No crossover

If you are following the reference design, it is important to note that the cables should not be a crossover type See below.

Order of coloured cores in cable should differ at each plug.

Good connections

Good crimp connections are essential for reliable recordings. Consider making a set of short cables for testing your sensors, and keep known working cables to compare to new cables

Cable tidy

Always tidy and fix cables once everything is in place

Tests of hardware

Careful testing of the sensors when built is essential. This can be done in several steps:

First test

Following loading the microcontroller with the relevant sketch, sensors can be plugged in and readings collected from the >Tools >Serial Monitor heading of the Arduino IDE. Decreasing the inter-loop delay in the sketch will give faster feedback on when the sensors are active.

Output to red LED

Alternatively, the additional sketch provided as part of the paper can be used to light and LED when the sensor is active. Using a visible-wavelength LED provides a simple circuit for checking sensors are working in the lab.

IR LEDs outside cage

Like above, an output to an LED can be used to show when the senor is active. Combining this with video (such as included with the Wellcome Open Research paper) can confirm the type and extent of movements detected. These approaches can be achieved using the other Arduino sketch included with the paper and Github repository.

Before each experiment

Following positioning of the system it is essential to record over empty cages to ensure all sensors are stable and consistently reading zero. Introducing animals to cages under every other PIR will ensure that recordings are being obtained while neighbouring sensors remain inactive. Move cages to confirm the same is true for the remaining sensors. This process should be repeated before all new experiments.

Repeat EEG correlation study

The final and most complete check would be a full replication of the EEG – PIR comparison in the original paper. This will be impossible and unwise for many labs, but where EEG surgery is regularly carried out it would be useful to confirm the level of agreement between methods in your lab. Please let us know if you do this.

Wiring and positioning of sensors

Stability

Fix sensors so that they are stable, as a moving sensor and astatic mouse will appear as active as a moving mouse and a stable sensor.

Protection

Although the final built sensor boards will be fairly solid, All possible efforts should be made to position the sensors and fix them such that they are not knocked or moved in the process of changing cages and cleaning.