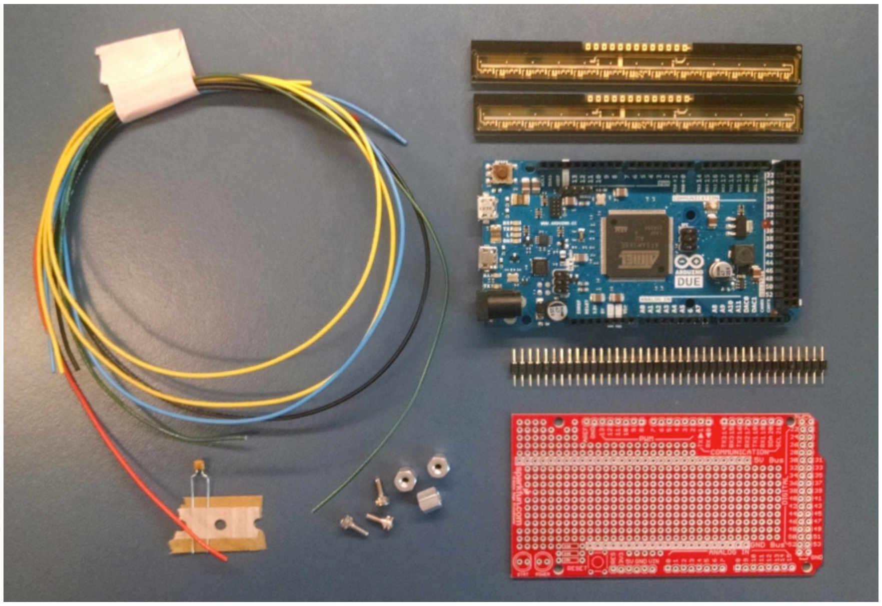
Supplementary Protocol

Building plans for laser angle calibration device.

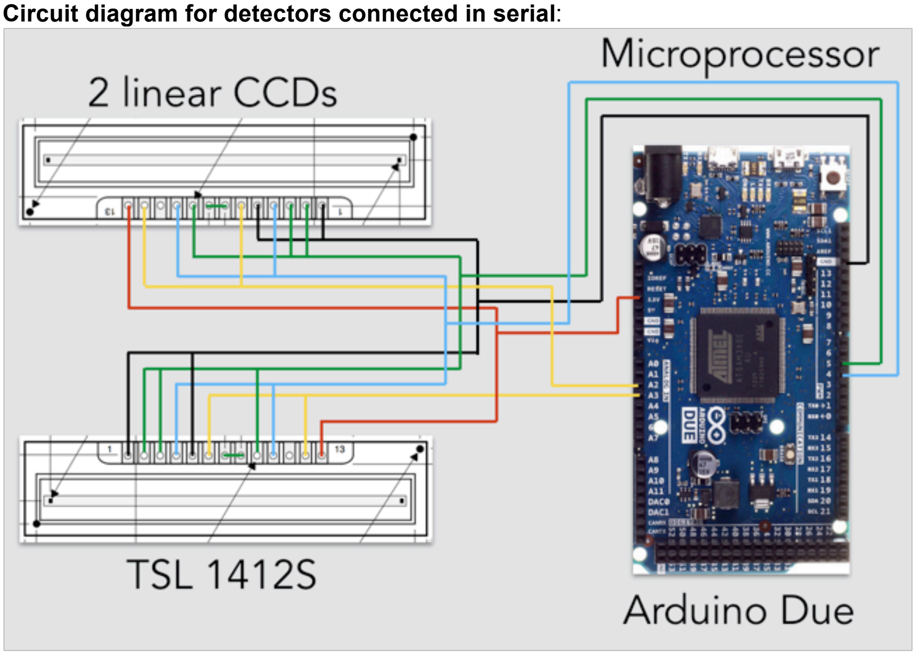
We designed a simple apparatus that consists of a clear, brightly colored acrylic front plate, and two linear CCDs detecting fluorescence emerging from the front plate. Using an automated procedure, this device defines the relation between motor position and angle within minutes and at much higher precision than possible using manual procedures. The building plans for this device and firmware are detailed here. Note that the precise pin used at each step is flexible as long as the physical arrangement of the detector matches the firmware code.

Parts needed:



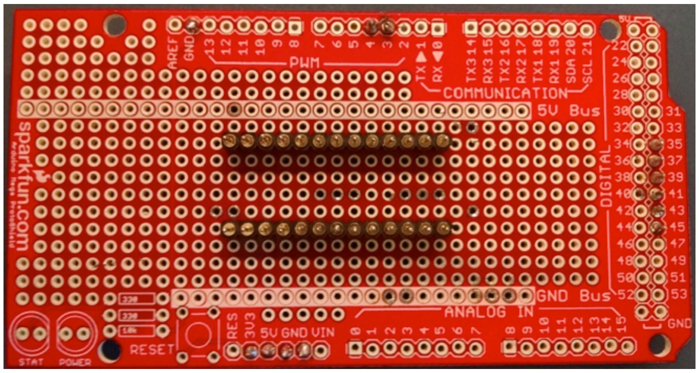
1 Arduino Due
2 TAOS Linear Sensor Array (TSL 1412S)
1 SparkFun MegaShield Kit (DEV-09346)
1 0.1 μF capacitor
3 0.25” hexagonal standoffs with screws
SparkFun Break Away Headers - Machine Pin (PRT-00117)
24-gauge solid core wire

Circuit diagram for detectors connected in serial:



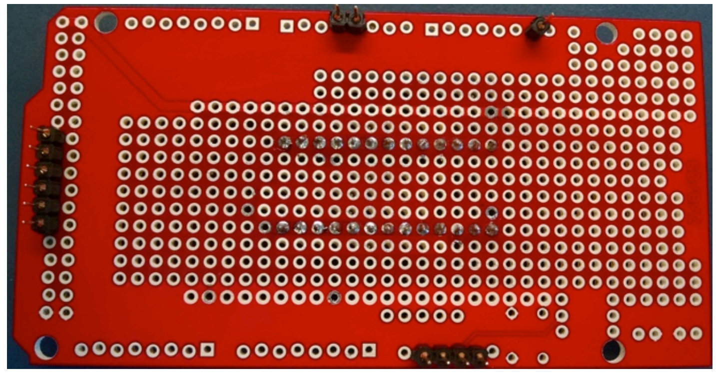
Step 1: Connect headers to MegaShield

Front:



Solder two rows of 13 pins onto the MegaShield to mount the two detectors. The acrylic housing is designed for the detectors to be mounted exactly as shown.

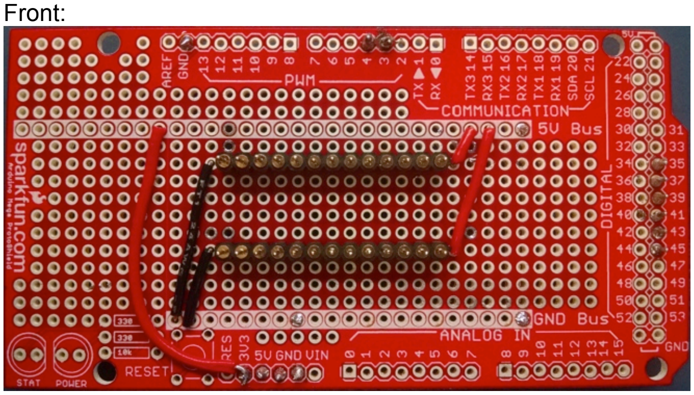
Back:



Solder pins into the power and ground. Do not solder pins into the pair of ground pins shown at the bottom right of this image or the hexagonal standoffs will not fit. Additional pins may be added for stability.

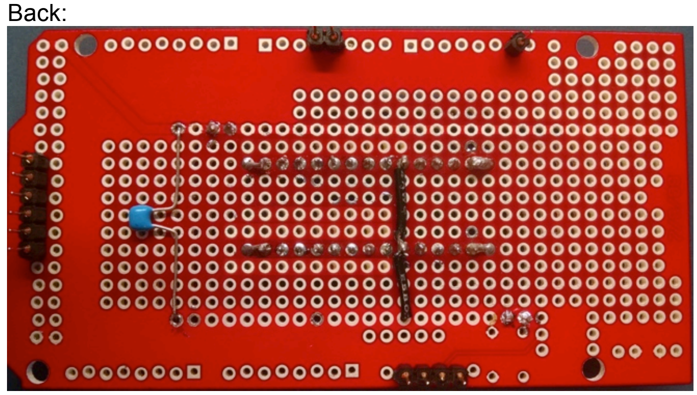
Step 2: Connect the power and ground

Front:



Solder the power to the V_{DD} pins and the ground to the V_{PP} pins of the detector as shown. Connect the 3.3V pin to the power bus.

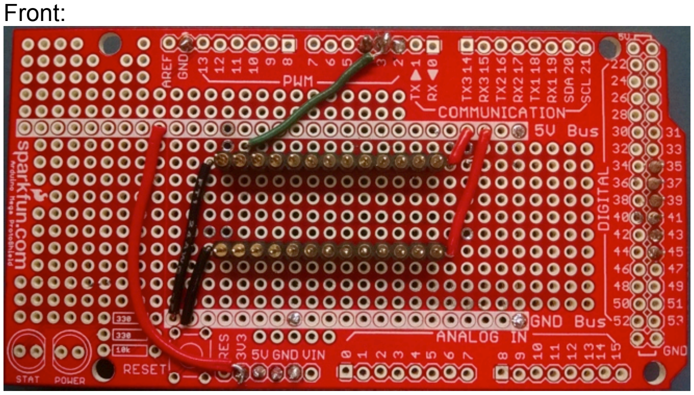
Back:



Solder the ground to the GND pins of the two detectors. Solder the 0.1 μF bypass capacitor between the power and ground.

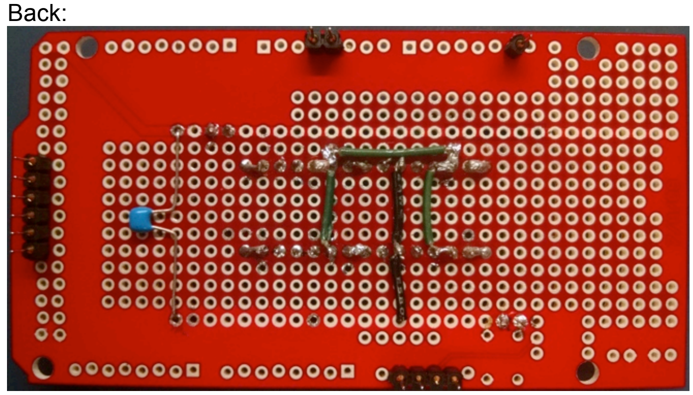
Step 3: Connect the serial input and hold

Front:



Solder a connector from Arduino PWM pin 3 to the SI1 pin of detector 1.

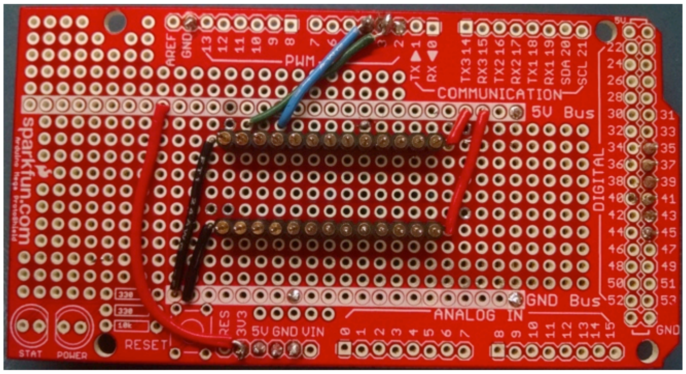
Back:



Solder connectors from SI1 of detector 1 to SI1 of detector 2. Solder a connector from the SI1 to SI2. Solder a connector from SI2 of detector 1 to SI2 of detector 2. Solder SI pins to neighboring HOLD pins

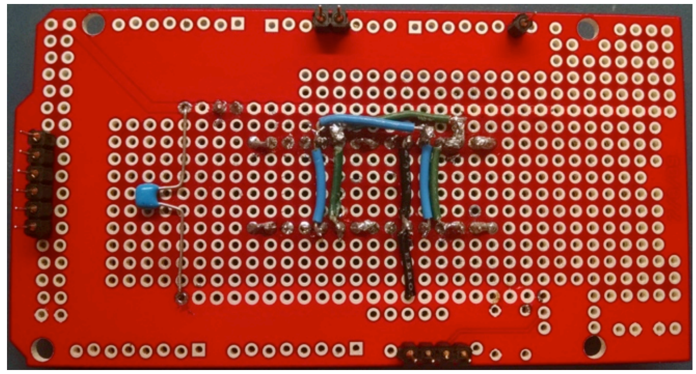
Step 4: Connect the clock

Front:



Solder a connector from Arduino PWM pin 4 to the CLK1 pin of detector 1.

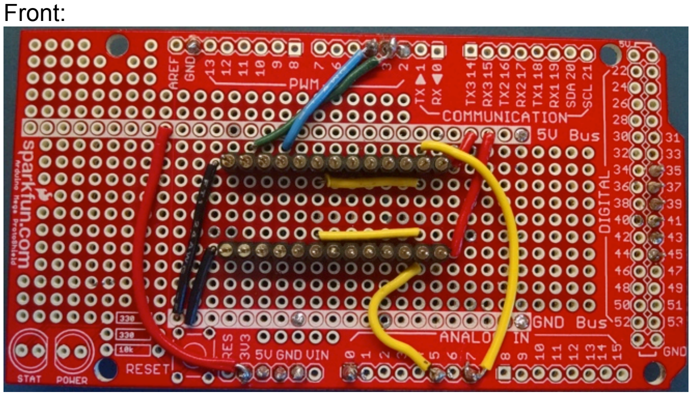
Back:



Solder connectors from CLK1 of detector 1 to CLK1 of detector 2. Solder a connector from the CLK1 to CLK2. Solder a connector from CLK2 of detector 1 to CLK2 of detector 2.

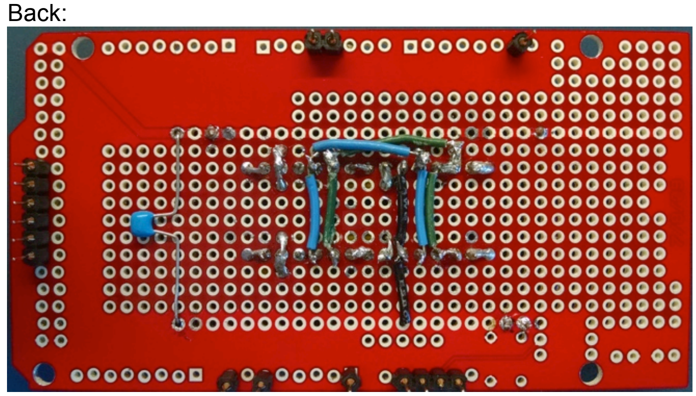
Step 5: Connect the analog outputs

Front:



Solder a connector from AO1 to AO2 for each detector. Solder a connector from detector 1 AO2 to Arduino Analog In pin 7. Solder a connector from detector 2 AO2 to Arduino Analog In pin 5.

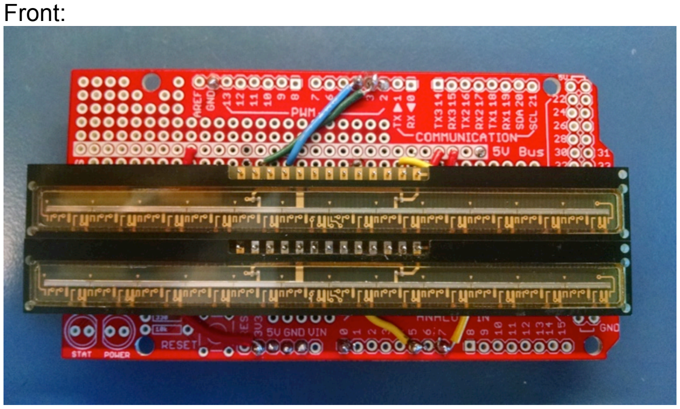
Back:



Solder analog output wires to detector pins.

Step 6: Attach detectors and arduino board

Front:



Connect detectors to pin headers. Soldering not required as heat may damage detectors. Plug in shield with detectors to Arduino Due board.

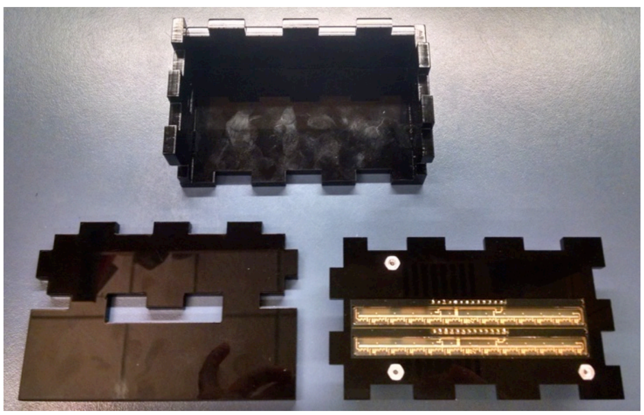
Step 7: Load firmware code

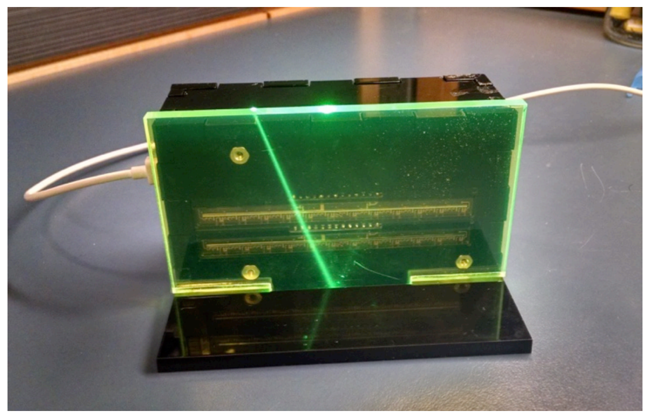
Connect Arduino to computer using the microUSB programming port.
Download firmware code, open in Arduino software, and upload sketch to device.
Firmware for detectors in serial (https://github.com/kcarbone/SAIM_calibration/tree/master/SAIM_arduino_serial)
Firmware for detectors in parallel (https://github.com/kcarbone/SAIM_calibration/tree/master/SAIM_arduino_parallel)

Step 8: Laser cut acrylic housing

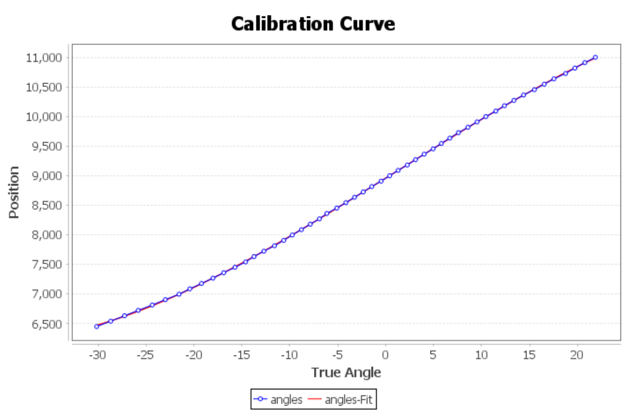
96-well plate sized Arduino case (https://valelab.ucsf.edu/~kcarbone/20151202_calibrator.ai)
Perspex front plate (https://valelab.ucsf.edu/~kcarbone/20151204_calibrator_front.ai)
These files are intended for use with 0.25" cast acrylic. For the acrylic front plate, we recommend:
405 nm laser: Red fluorescent acrylic from Tap Plastics
488 nm laser: Blue or green fluorescent acrylic from Delvies
561 nm laser: Blue fluorescent acrylic from Delvies

Step 9: Assemble device





Step 10: Run laser angle calibration using μManager plugin



μManager plugin development hosted at:
https://github.com/kcarbone/SAIM_calibration

Example calibration curve used for SAIM data acquisition plotted as motor position (A.U., y-axis) versus refractive index corrected angle (degrees, x-axis). Real data shown as blue circles, cubic polynomial fit ("calibration curve") shown as red line.