

This document describes the details of the system that I designed to automatically control the microtome/camera setup. If you have questions, I can be reached at:

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Hardware

There are 4 key hardware components in the system:

1. 1x Arduino (we are using an arduino uno r3, but any modern arduino should work)
2. 1x Dual Channel Relay module (we are currently using the [SunFounder 4 Channel 5v Relay Shield Module](#))
 - a. A relay is needed because the linear actuator needs 12v of power, while the arduino can only supply 5v of power.
 - b. The system only needs a dual channel relay (one channel drives the actuator forward and the other channel drives it backwards), but using a 4 channel module allows us to easily repair the system if one of the relay modules wears out-- just switch modules
3. [1x Flora TCS34725 Color Sensor](#). This sensor is placed directly over the red indicator light on the microtome and is used to check whether or not the microtome is ready to make a cut
 - a. We use a color sensor so that we can specifically detect a red light turning on, so the sensor doesn't trip if the overhead light is turned on or something like that.
 - b. Any color sensor should work, but if using a different sensor, the bracket that attaches the sensor and linear actuator to the control panel will need to be re-printed to hold the new sensor instead.
 - c. This product may have been discontinued by adafruit, but we ordered a few replacements and as of 07/17/2023, it can still be purchased at the Houston microcenter.
4. 1x Linear Actuator, we are currently using a [DC House Mini Electric Linear Actuator 0.4in](#), but any small + fast linear actuator should do.
 - a. The linear actuator is used to press the start/stop button on the microtome control panel. We do not need a strong linear actuator, we need a small, fast one.

Other Hardware

Besides the key electrical components, there are a few other hardware components for this system. Dr. Mayerich should have the STL files for the 3D-printed components, and the STLs are also on Github

1. Control_panel_holder_bottom: This 3D-printed bracket holds the color sensor and linear actuator in place over the microtome control panel.
2. Control_panel_holder_top: This small piece goes over the flora color sensor to keep it in place

3. Automated_system_rack: This is a 3D-printed rack to hold the arduino and relay module. Not necessary, but keeps everything nicely contained.
4. 12v power source: The current design uses a 12v wall charger with the end cut off and its power and ground wires soldered to pins that plug into the relay module. This power is used to drive the linear actuator.

Software

There are two pieces of software necessary to run this system:

1. MUVitome: This is the custom, in-lab C++ application that controls the camera. I changed the program to allow for automatic control, and my changes should be commented throughout the code.
2. Muvitome_control_program. This is the arduino IDE code that controls the color sensor and linear actuator. Its primary functions are to read the status of the microtome indicator light using the color sensor and send that status to MUVitome. When MUVitome is ready to take another slice, it sends a signal to muvitome_control_program, which then activates the linear actuator. NOTE: THE ARDUINO IDE CANNOT BE OPEN WHEN MUVITOME IS RUNNING! If the ide is open, then the serial communication with MUVitome will not work. If you want to change muvitome_control_program, open the ide, do your changes, upload the program to the arduino (you just have to run it from the arduino IDE), then close the ide.

General Usage

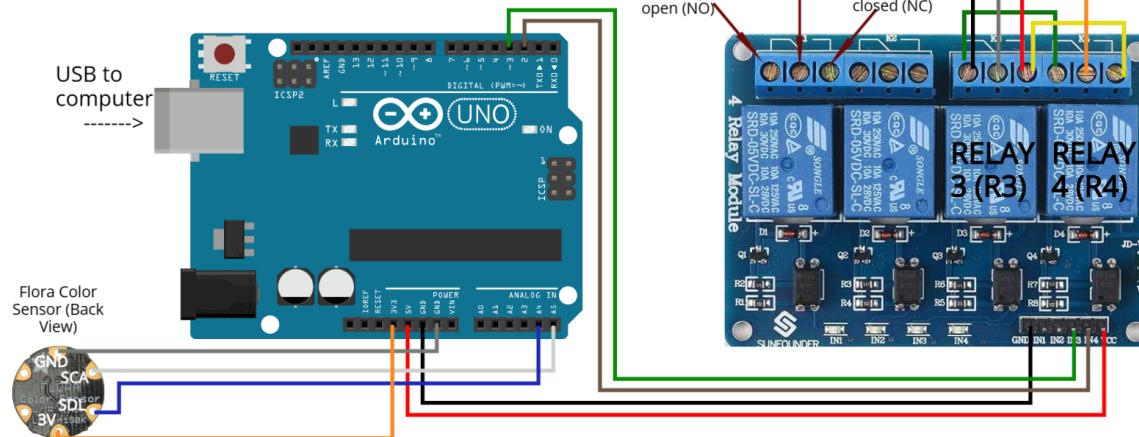
1. Plug USB into Arduino and plug the relay into the 12v power source (2 connections: black wire to black wire and red wire to red wire).
 - a. Make sure everything else is plugged in, refer to wiring diagram
2. Start muvitome.exe, make sure the message “Successful connection to COM[x]” is printed to the console, where x is the number corresponding to the COM port the arduino is plugged into.
 - a. The port number can be checked in the arduino IDE or the device manager
3. Home and Center the camera, set other settings as needed.
4. Enter the maximum number of images you want to take in the “Maximum # of Images” box. If you don’t have a limit, just enter an arbitrarily large number like “9999999”
5. Click the “Auto START” checkbox. A mosaic should begin. As soon as the mosaic finishes, the relay should activate, causing the microtome to cut. As soon as the cut is done, another mosaic should begin. At this point, you can walk away and do something else! Check the system every hour or so.
 - a. You can also press the “single slice” button to make a slice without taking an image, or the “single press” button to press the start/stop button once (a double press causes the microtome to make a cut, a single press does not)
6. To stop the system, click the “STOP” button.

- When done, unplug the USB from the arduino and unplug the relay from the 12v power source.

Wiring

Please note that I am not an electrical engineer (I learned basic electrical engineering for this project), so this may not be the most efficient way to do things. However, it does work. See the last page for a full-page diagram

- Green: NO R3 ↔ NO R4
- Yellow: NC R3 ↔ NC R4
- NO R3 → 12v pwr GND (black to black)
- NC R3 → 12v pwr hot (red to red)
- Common R3 → Lin. Actuator GND (grey to black)
- Common R4 → Lin. Actuator pwr (orange to red)
- Arduino 3V → Flora 3V (orange)
- Arduino GND → Flora GND (grey)
- Arduino Analogue Pin 4 → Flora SDA (blue)
- Arduino Analogue Pin 5 → Flora SCL (white)
- Arduino 5v → Relay VCC (red)
- Arduino GND → Relay GND (black)
- Arduino Digital Pin 2 → Relay IN4 (brown)
- Arduino Digital Pin 3 → Relay IN3 (green)



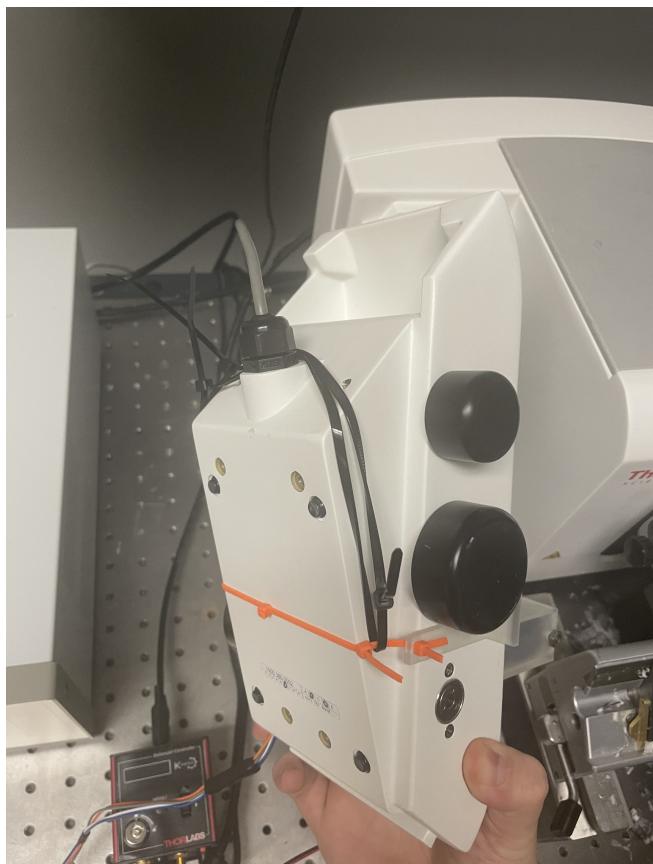
What to do if the system isn't working: common issues and fixes

- Make sure everything is plugged in, refer to the wiring diagram.
- Make sure the arduino IDE with muvitome_control_program is not open while MUVitome is open, as this will "clog" the serial port and cause MUVitome to be unable to read from the arduino. **SOLUTION:** close the arduino IDE and restart MUVitome
- When you start MUVitome, make sure the message "Successful Connection to COM[x]" is printed. If this message isn't printed, then MUVitome is not connected to the arduino.
- Are the "Auto START" and "Maximum # of Images" buttons grayed out on the MUVitome GUI? If so, make sure to home and center the camera before starting automatic mode.

5. Make sure that the wire on the back of the control panel is plugged in-- it can come unseated when trying to attach the control panel holder to the control panel. It's kind of annoying to plug back in, but possible.

Attaching the Control Panel Holder to the Control Panel:

Currently, we just zip-tie the holder to the control panel, but there is definitely a better way long term. For the short-term, refer to the images below:



- Green: NO R3 ↔ NO R4
- Yellow: NC R3 ↔ NC R4

- Arduino 3V → Flora 3V (orange)
- Arduino GND → Flora GND (grey)
- Arduino Analogue Pin 4 → Flora SDA (blue)
- Arduino Analogue Pin 5 → Flora SCL (white)

- NO R3 → 12v pwr GND (black to black)
- NC R3 → 12v pwr hot (red to red)
- Common R3 → Lin. Actuator GND (grey to black)
- Common R4 → Lin. Actuator pwr (orange to red)

- Arduino 5V → Relay VCC (red)
- Arduino GND → Relay GND (black)
- Arduino Digital Pin 2 → Relay IN4 (brown)
- Arduino Digital Pin 3 → Relay IN3 (green)

