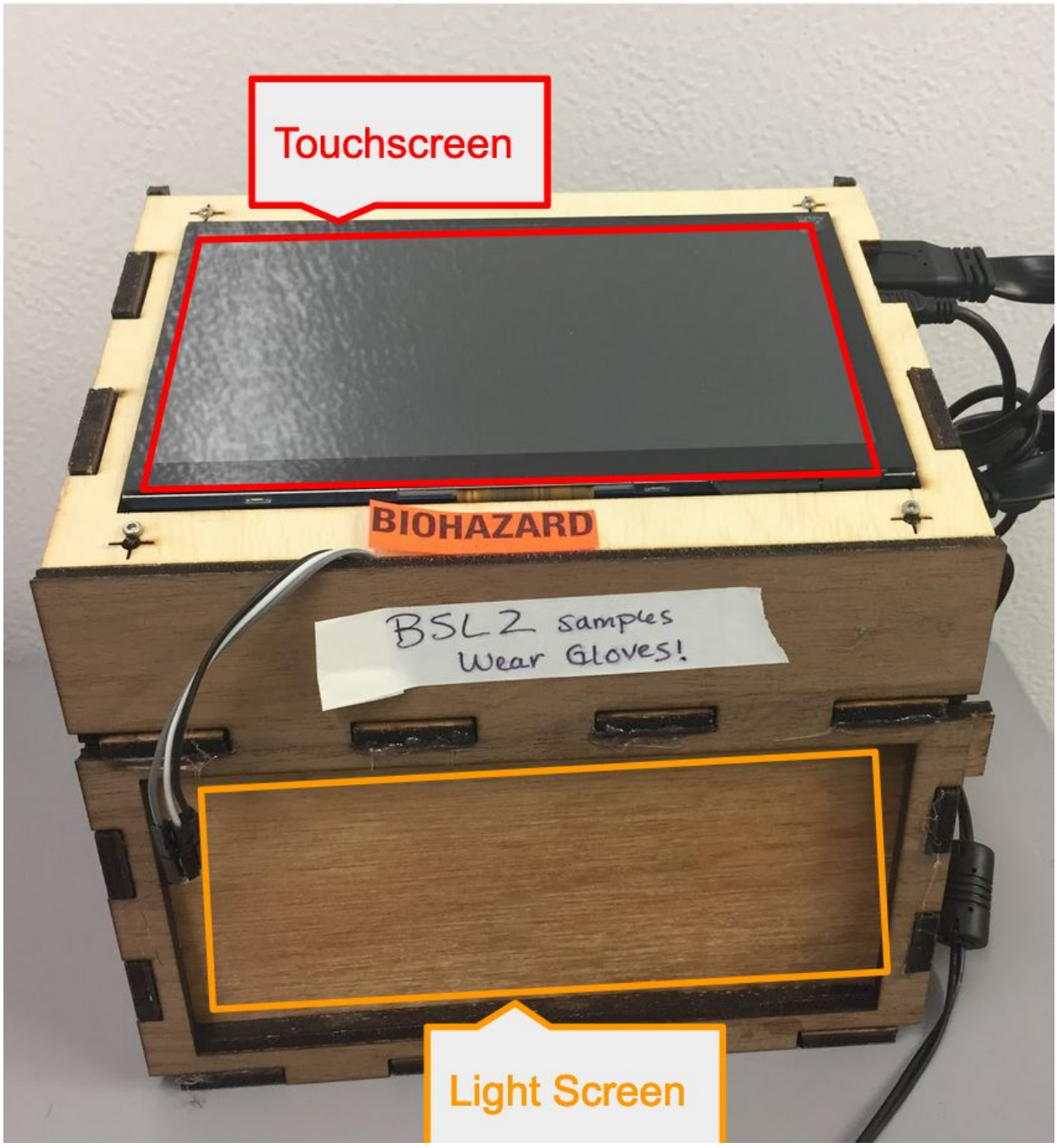
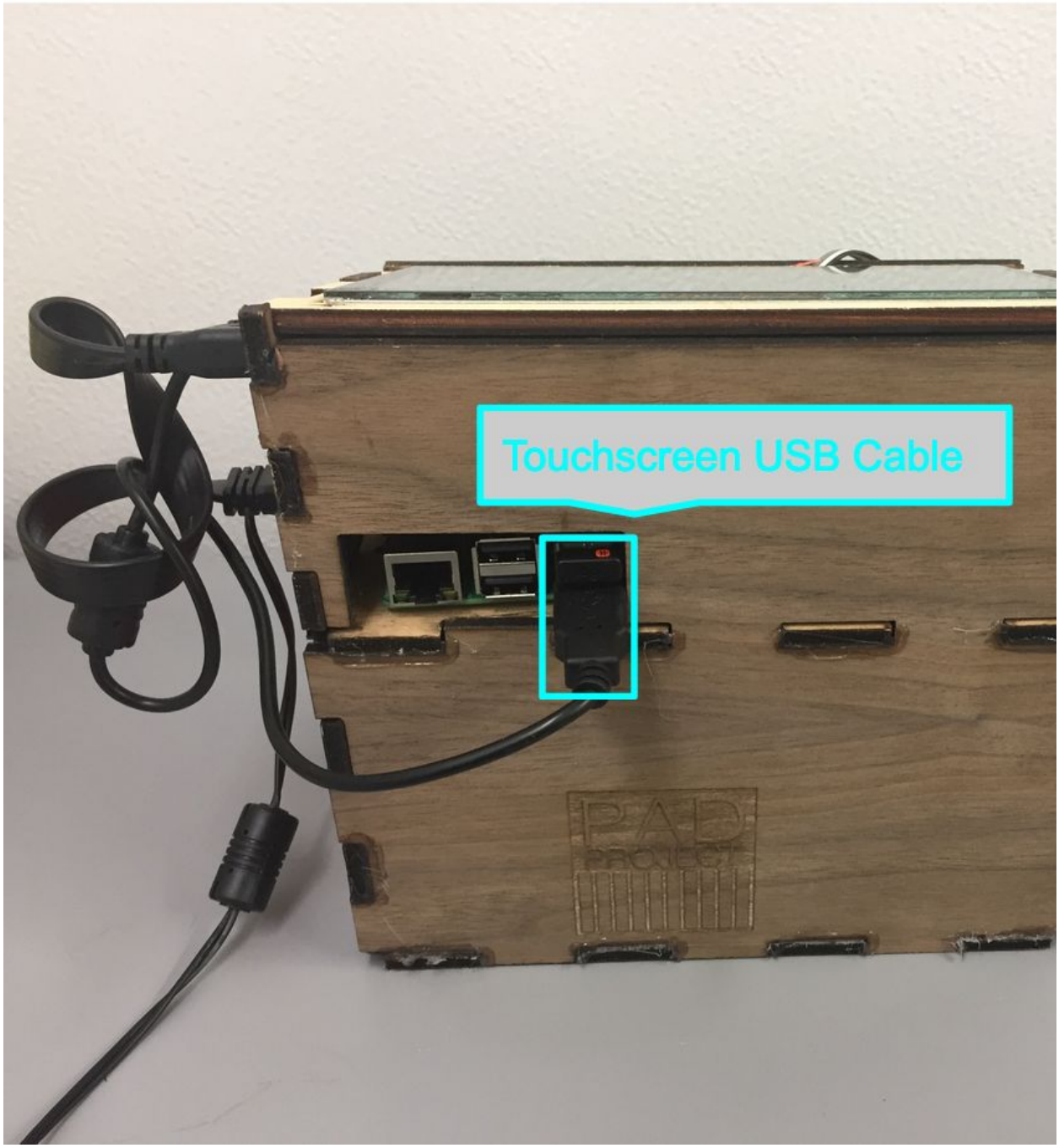
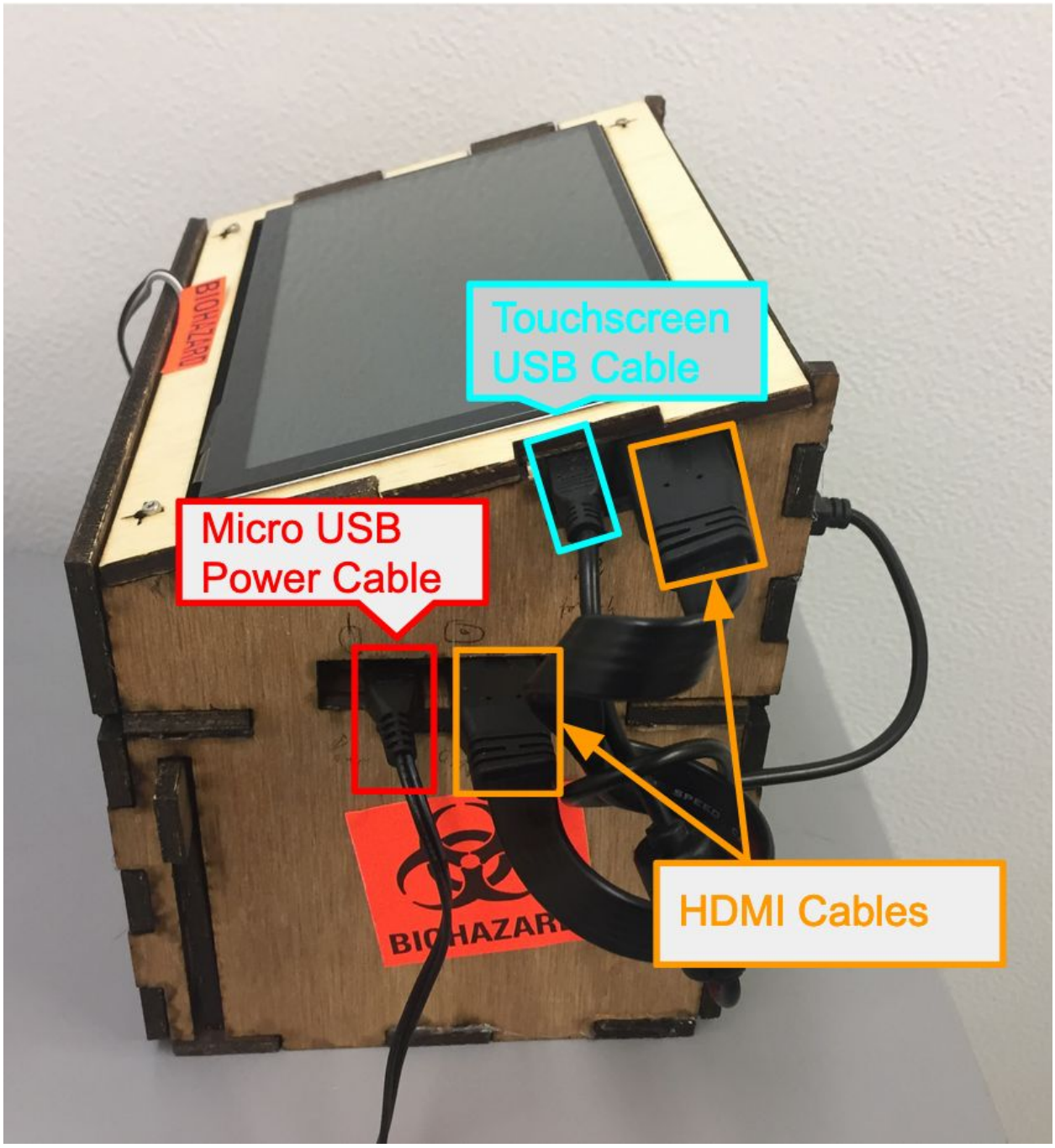
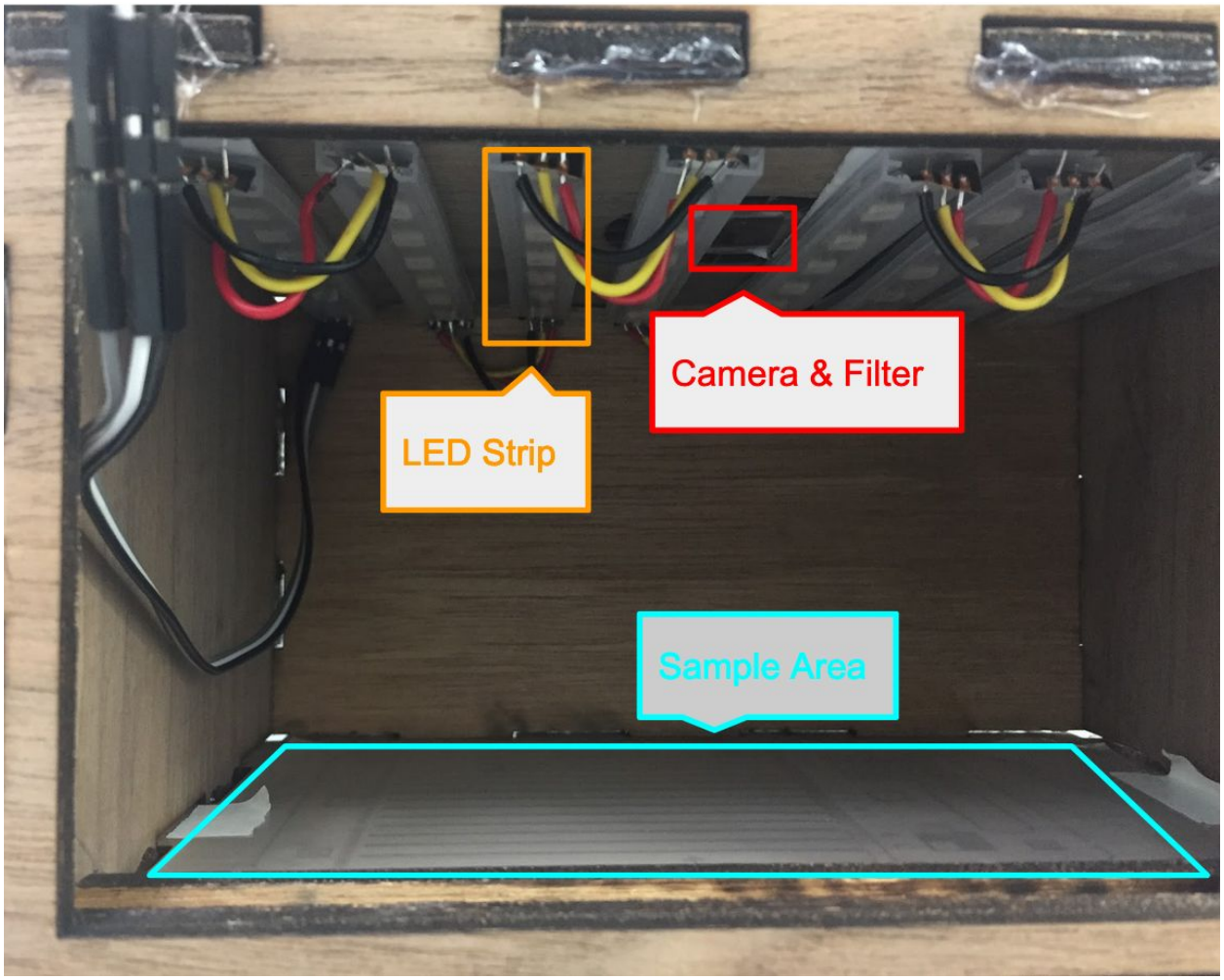
Electronic Supplementary Material (ESI) for Analytical Methods.
This journal is © The Royal Society of Chemistry 2020

Lightbox Summary




Touchscreen USB Cable


Touchscreen
USB Cable
Micro USB
Power Cable
HDMI Cables


Camera & Filter
LED Strip
Sample Area

Lightbox Assembly

Finished Lightbox:

Figure 1. Fluorescent Lightbox
Sample completed lightbox, showing connections for HDMI, USB, and micro USB cables. Detailed instructions for the hardware assembly and software configuration are outlined below.

Hardware

Parts:

- ⅛'' Plywood, roughly 60cm by 60cm
- M/F Breadboard wire
- Raspberry Pi 3 B
- Raspberry Pi camera
- 5V, 2.5A micro USB wall power adapter
- Neopixel 16 LED ring OR Neopixel LED strips
- gel filter sheet, cut into 3, 1 cm squares, Roscolux #25 is used for imaging red fluorescent protein

Equipment:

- Soldering iron
- Laser cutter
- Hot glue gun
- Wire strippers

Parts Assembly:

The Lightbox is made of laser cut plywood, which electronics are screwed or hot glued to. First, the main body of the lightbox is assembled, but the top and bottom are left unattached. Next, the electronics are added and the camera is calibrated. Finally, the bottom is attached and the top placed over the Raspberry Pi so it is protected but can still be accessed to make changes or repairs.

Orientations are given from the perspective of someone looking at the Figure 2, as follows: **left** and **right** are the left and right of the viewer, **top** and **bottom** are towards the top of the page or away from it, **up** is the side facing the viewer, **down** the side facing away from them. Thus, when looking at plate [TOP_BASE], the **up** side is visible, the four screw holes are to the **left** of the LED ring slot, and very slightly skewed to the **top**. The **up** side of pieces will have scorch marks from the laser cutting, and so should be oriented towards the inside of the box whenever possible. Assembly directions are given as though the pieces are oriented exactly as shown in "Lightbox.pdf"- if they should be re-oriented, it will be explicitly said.

"Text in quotes" is exact, verbatim text from printed hardware labels. [Text_in_brackets] are exact names of the laser cut plates, outlined in Figure 2.

Steps:

1) Acquire parts listed above
2) Laser cut from ⅛" plywood the "Lightbox.svg" file.

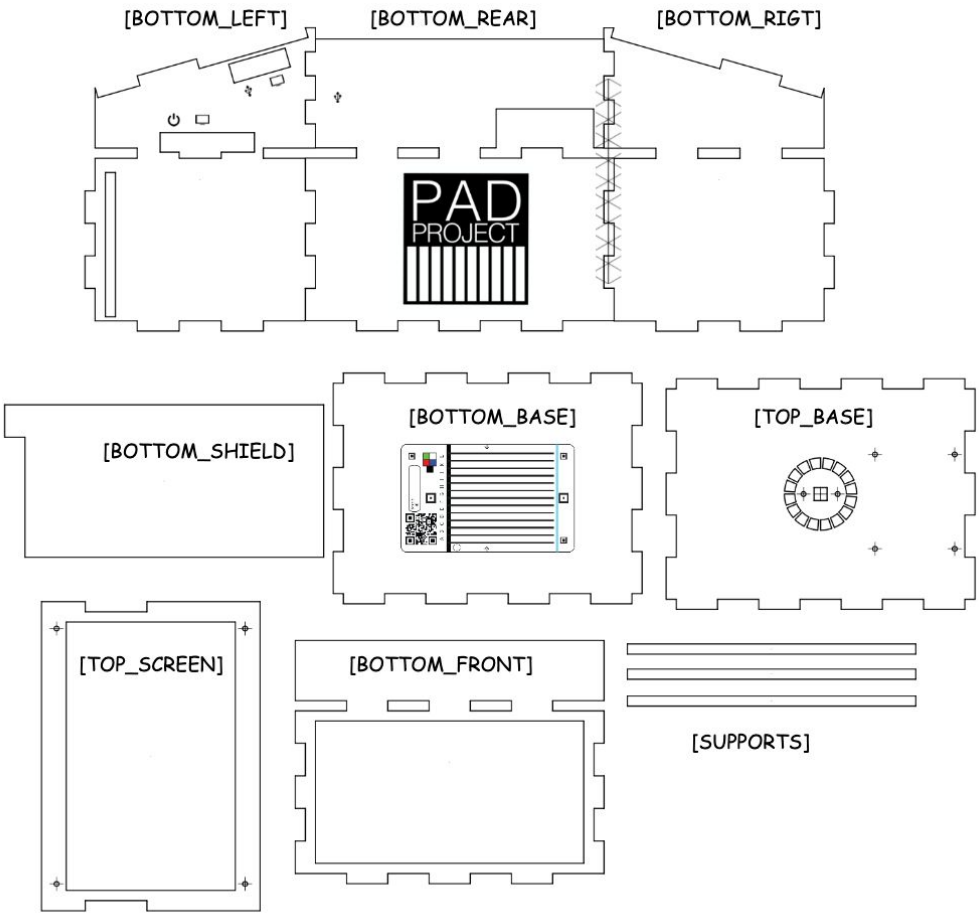


Fig 2. Diagram of plywood casing pieces
The contents of Lightbox.pdf from the github page, each piece labeled with its name.

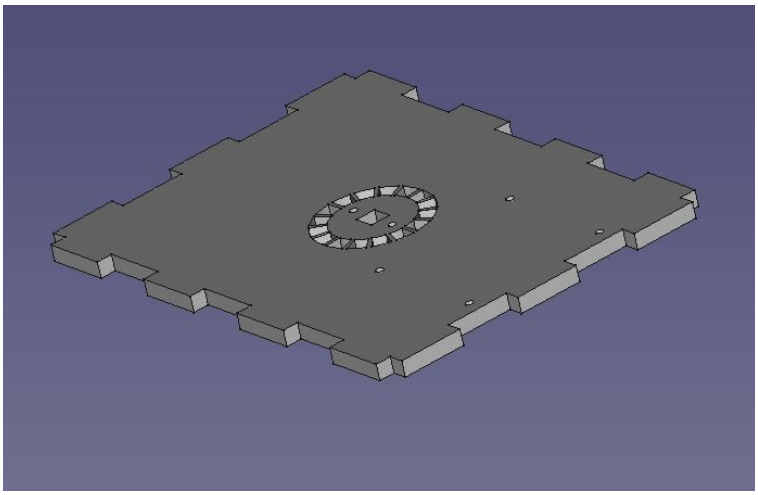
LED Setup

3) LED ring- (standard lightbox):
    a) Place the ring so that the LEDs face down. Solder the male side of a breadboard wire to each of the following connections, leaving the female side exposed: one to “Power 5V DC”, one to “Power Signal Ground”, and one to “Data Input”. Do not solder anything to the “Data Out” connection.
4) LED strip- (fluorescent lightbox):
    a) Cut the strip into 8 strips of 7 LEDs each. Lay [TOP_BASE] **down** and evenly space the strips along it, so that the long axis of each strip is parallel to the **top/bottom** axis of the [TOP_BASE].
    b) Solder connecting wires between the exposed connections of the strip.
    c) Connect the first segment of the strip to the Raspberry Pi as with the LED ring.

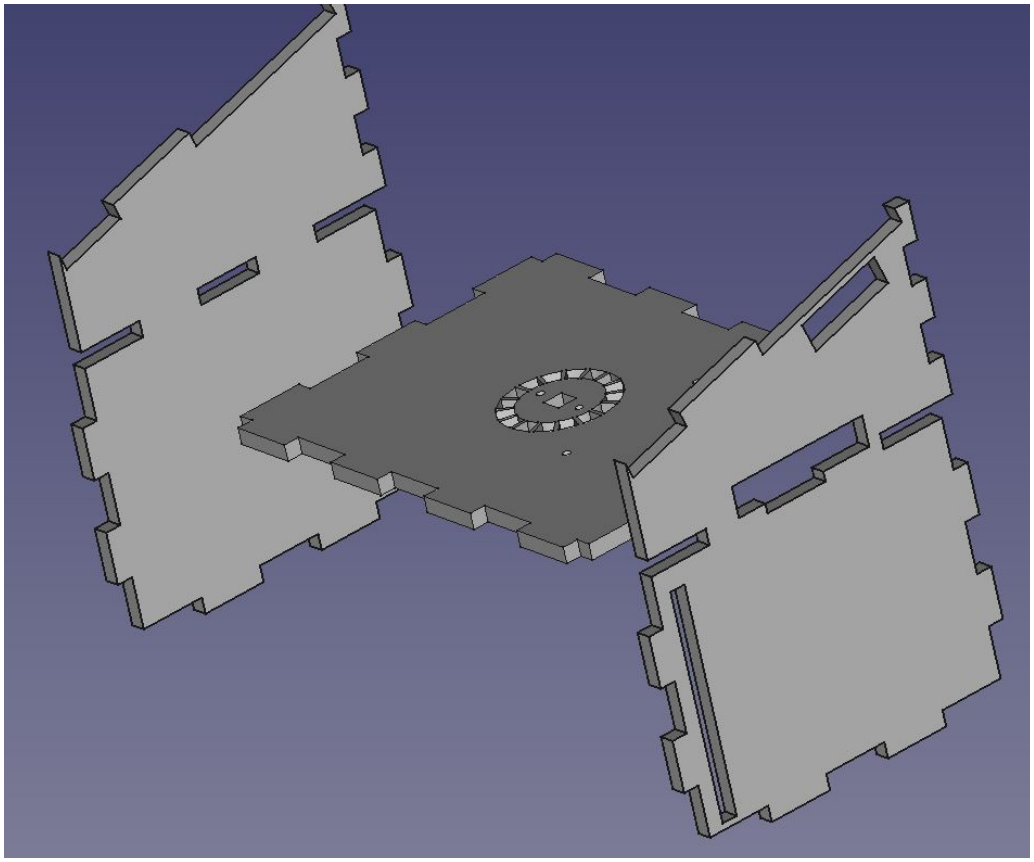
Electronics Assembly

5) Place the raspberry Pi on plate [TOP_BASE] so that its screw holes line up with the screw holes laser cut in the plate. Check that the four USB connections at the back of the raspberry Pi align with the **bottom** edge of the plate: if they do not, flip the plate over.
6) Connect the raspberry Pi to the plate using 4 M2*8 screws, secured with M2 nuts and washers.
7) Connect the LED ring to the GPIO pins of the raspberry Pi. GPIO labels are described here. "Power 5V DC" should connect to a 3.3 volt pin, "Power Signal Ground" to a ground pin, and "Data Input" to pin #18.
8) Connect the touch screen to the raspberry Pi. First, connect the HDMI ports on the screen to the raspberry Pi using the HDMI cable. Next, connect one of the USB ports on the raspberry Pi to the micro USB port farthest from the HDMI port on the screen. Finally, make sure the switch on the screen labeled "backlight" is set to "ON"
9) Connect the camera's ribbon cable to the raspberry Pi's camera slot. Pull up on the plastic bar above the slot and insert the ribbon cable, taking care that the metal contacts of the ribbon cable are on the same side as the metal contacts in the slot. Gently press down on the plastic bar until it clicks. WARNING- the raspberry Pi has a display slot of the same size- connecting the camera to this while the raspberry Pi has power can permanently damage the camera. The correct slot will be labeled "CAMERA".
10) Insert the SD-reader extender into the raspberry Pi's SD card slot. Prepare a SD card, following the instructions in Software, and insert it into the SD-reader extender's read slot.

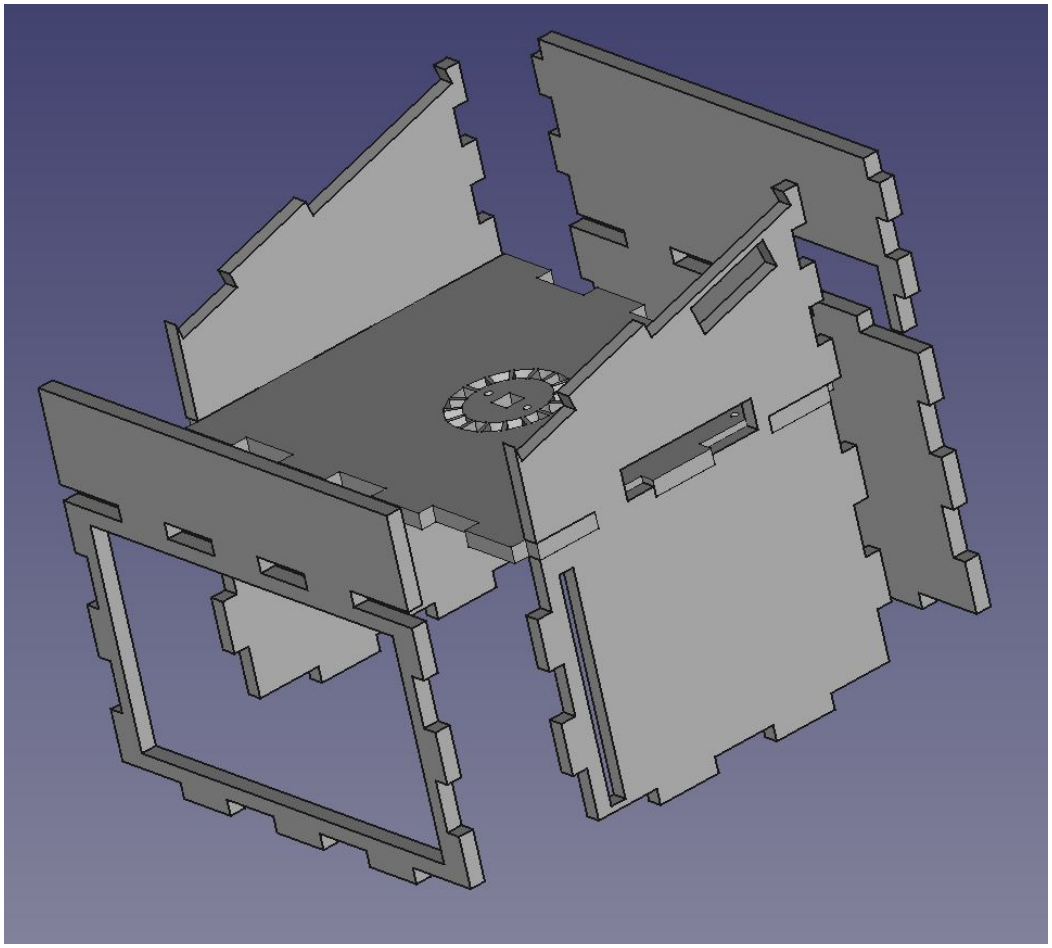
Plate Assembly Part I



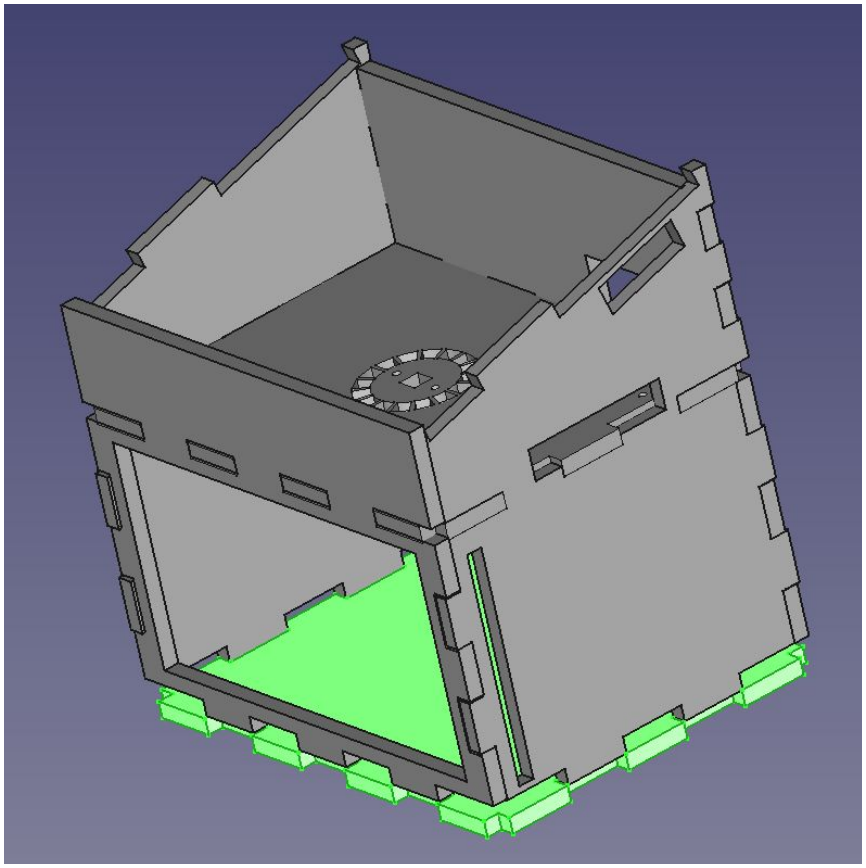
11) Place the [BOTTOM_REAR] plate so its **down** side faces you. Hot glue the [BOTTOM_LEFT] and [BOTTOM_RIGHT] plates to it so that the holes in the [BOTTOM_LEFT] align with the raspberry pi.



12) Hot glue the [BOTTOM_REAR] and [BOTTOM_FRONT] plates so that the holes in the [BOTTOM_REAR] plate align with the raspberry pi.



13) Lay the whole assembly over the [BOTTOM_BASE].



Camera Calibration

1) Using a light colored permanent marker, make a reference mark on the circle of plastic surrounding the camera lens, taking care not to mark the lens itself.
2) Using a pair of pliers, very gently grip the circle of plastic surrounding the camera lens and turn it 90 degrees counterclockwise.
    a) The rectangular connector above the camera may come undone. If this happens, pause, and gently push it back into its socket.
3) Gently push the camera into the square hole in [TOP_BASE]. Connect the Raspberry Pi to power.
4) Open terminal, and type **raspistill**
5) A preview window will open. Check that the bottom of the box is in focus.
6) If the bottom is out of focus, adjust the focus by turning the circle around the camera lens in 10 degree increments, counterclockwise to bring the focus closer, clockwise to move the focus away.

Plate Assembly Part II

1) Hot glue the [BOTTOM_BASE] to the rest of the box.
2) Screw the touch screen to [TOP_SCREEN].

3) Place [TOP_SCREEN] over the top of the box. Do not glue it down- you may need to access the parts under it to make repairs.

Software

The Raspberry Pi software relies on a number of external libraries, which must be correctly downloaded and installed for the provided scripts to work. **Bold text** indicates lines of code to be executed verbatim, including capitalization and punctuation. The different sections described below are broken up by subject. It is strongly recommended to run Basic Setup first, after which the sections can be run in any order the user desires. Estimated times for completion are included next to each section for ease of planning.

Basic Setup- estimated time: 20 minutes

1) Flash Raspbian Buster with desktop onto a 16+ GB micro SD card
    a) Software Source- https://www.raspberrypi.org/downloads/raspbian/
    b) Installation Guide- https://www.raspberrypi.org/documentation/installation/installing-images/README.md
2) Insert the micro SD card into the slot in the lightbox and connect the lightbox to a 5V, 2.5A micro USB power source.
3) The lightbox will boot up. Follow the set up prompts to set language, timezone, etc…
4) Open terminal.
5) **sudo apt-get install matchbox-keyboard**
6) **sudo apt-get update**
7) **sudo apt-get upgrade**
8) **sudo raspi-config**
    a) Enable Camera
    b) Enable SSH
    c) reboot

OpenCV- estimated time: 6 hours

1) Open terminal
2) **sudo apt-get install build-essential cmake pkg-config**
3) **sudo apt-get install libjpeg-dev libtiff5-dev libjasper-dev libpng12-dev**
4) **sudo apt-get install libavcodec-dev libavformat-dev libswscale-dev libv4l-dev**
5) **sudo apt-get install libxvidcore-dev libx264-dev**
6) **sudo apt-get install libgtk2.0-dev**
7) **sudo apt-get install libatlas-base-dev gfortran**
8) **sudo apt-get install python2.7-dev python3-dev**
9) **wget -O opencv.zip https://github.com/Itseez/opencv/archive/3.4.3.zip**
10) **unzip opencv.zip**

11) **wget -O opencv_contrib.zip**
    https://github.com/Itseez/opencv_contrib/archive/3.4.3.zip
12) **unzip opencv_contrib.zip**
13) **wget https://bootstrap.pypa.io/get-pip.py**
14) **sudo python get-pip.py**
15) **sudo pip install virtualenv virtualenvwrapper**
16) **echo -e "\n# virtualenv and virtualenvwrapper" >> ~/.profile**
17) **echo "export WORKON_HOME=$HOME/.virtualenvs" >> ~/.profile**
18) **echo "source /usr/local/bin/virtualenvwrapper.sh" >> ~/.profile**
19) **source ~/.profile**
20) **mkvirtualenv cv**
21) **pip install numpy**
22) **cd ~/opencv-3.4.3/**
23) **mkdir build; cd build**
24) **cmake -D CMAKE_BUILD_TYPE=RELEASE **
    **-D CMAKE_INSTALL_PREFIX=/usr/local **
    **-D INSTALL_PYTHON_EXAMPLES=ON **
    **-D OPENCV_EXTRA_MODULES_PATH=~/opencv_contrib-3.4.3/modules **
    -D BUILD_EXAMPLES=ON ..
25) **make**
    a) This will take several hours and requires no input
26) **sudo make install**
27) **sudo ldconfig**
28) **cd ~/.virtualenvs/cv/lib/python2.7/site-packages/**
29) **ln -s /usr/local/lib/python2.7/site-packages/cv2.so cv2.so**
30) Close terminal

GUI & Image Handling- estimated time: 5 minutes

1) Open terminal
2) **source ~/.profile**
3) **workon cv**
4) **sudo apt-get install qt5-default**
5) **sudo apt-get install python-pyqt5**
6) **sudo apt-get install pyqt5-dev**
7) **sudo apt-get install pyqt5-dev-tools**
8) **sudo apt-get install libzbar-dev**
9) **ln -s /usr/lib/python2.7/dist-packages/PyQt5**
   $VIRTUAL_ENV/lib/python2.7/site-packages
10) **ln -s /usr/lib/python2.7/dist-packages/sip***
    $VIRTUAL_ENV/lib/python2.7/site-packages
11) **pip install enum**

12) **pip install zbar-py**
13) **pip install pillow**
14) **pip install picamera**
15) Close terminal

Behind the Scenes- estimated time: 5 minutes

1) Open terminal
2) **source ~/.profile**
3) **workon cv**
4) **cd Documents**
5) **git clone -b yeast https://github.com/PaperAnalyticalDeviceND/Litebox.git ./**
6) Provide git credentials
7) **pip install requests2**
8) **sudo apt-get install libhdf5-dev**
9) **sudo pip install h5py==2.9.0**
10) **pip install tensorflow**
11) Close terminal

LED Control- estimated time: 10 minutes

1) Open terminal
2) **source ~/.profile**
3) **workon cv**
4) **sudo apt-get install build-essential python-dev git scons swig**
5) **cd ~/**
6) **git clone https://github.com/jgarff/rpi_ws281x.git**
7) **cd rpi_ws281x/**
8) **scons**
9) **cd python**
10) **python setup.py install**
11) **sudo python setup.py install**
12) **sudo apt-get install python-dev swig**
13) **python ./setup.py build**
14) **sudo python ./setup.py build**
15) Close terminal