PULSE TOPOLOGY

BY RAFAEL LOZANO-HEMMER

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GENERAL IMPORTANT INFORMATION

This short section must be read for proper operation.

PULSE TOPOLOGY (2021)

BY RAFAEL LOZANO-HEMMER

Technique

LED light bulbs, LED light dimmers, contactless heartbeat sensors, audio playback, computer.

Description

"Pulse Topology" is composed of thousands of light bulbs suspended at different heights that create a series of crests and valleys—an intimate landscape that visitors are invited to traverse. Each light bulb glimmers to the pulse of a different participant, which contributes to a connective arrangement. Custom-made pulse sensors record visitor heartbeats; when a new participant interacts with the installation, their pulse is added to the canopy of recordings above them, with the newest recording replacing the oldest.

Forming a platform for self-representation, in "Pulse Topology" individual heartbeats come together to form an immersive chorus of light and sound. Translating an interior force to an exterior form, the piece makes tangible the otherwise invisible register of the heartbeat, which glows and then fades in the spirit of a memento mori.

Operation

Please refer to Appendix I - Installation for detailed system information and wiring diagram.

1. Ensure all elements are connected to their AC power source.

2. If the computer(s) are set to a power ON/OFF schedule then the artwork will turn ON/OFF automatically at the set times. In theory, the secondary computer(s) will be turned On prior to the main one (labelled "A").

3. It is also possible to manually turn the computer(s) ON/OFF via their power button: starting with the secondary computer(s), then the main one.

4. Each of the computers will start a delay sequence to allow the heart rate sensor applications to be in sequence with the main control application on the main computer. This will appear as a window showing a camera feed of the sensors.

5. Once the PulseTopology app is running - it should be live within 5 minutes - all light bulbs should be flashing and the quiet rumbling of all the heart should be audible through the subwoofers.

6. Placing a hand under any of the Heart-rate sensors for 10 seconds and longer should start the population process. Check all installed sensors to confirm.

   If the sensor's LED spot (warm white) changes to the LED ring (cool white) and your heart beat displays on the topology above, the sensor is properly running.

7. If any sensor does not react, or if the piece didn't start properly: a power cycling of the control computer is recommended - the main computer if the issue is more general, a secondary computer if it is related to a specific sensor. If it still doesn't turn on, then hold the power button all the way down for 10 seconds. Then, wait at least three seconds, then press the power button all the way down for one second, and you should be up and running again.

General Artwork Behaviours

Each light bulb glimmers to the pulse of a different participant, which contributes to a connective arrangement. The pulse patterns or 'choreography' of them across the lightbulb installation can be finely adjusted in brightness, speed and sequence using the custom software on the computer. In most setups sound is added to the work, generally via subwoofers playing back the heartbeat.

Interacting With the Artwork

A participant interacts with the installation by placing its hand under one of the provided sensors. The sensor's camera reads the heartbeats by analyzing the changing skin tone of the hand placed in view. Then, a local set of bulbs are 'taken over' and will flash only this new heartbeat for a short time, then the software assigns the beat to one bulb while all others return to their previously displayed heartbeats.

NOTE: A proper distance to read the heart rate is between 0.5" and 5" away from the sensor bottom.

Maintenance

Please be very careful when cleaning the bulbs that you do not use hot water, and a poly-carbonate safe cleaner will do. If you clean the bulbs or cables, turn off all power to the piece, do not spray water, use a clean dry towel.

Never clean the dimmer bays beyond dusting. If you clean the floor please avoid any mopping near the troughs where the dimmers are held.

Placement Instructions

The ceiling height of the exhibition space should be at least 6m (20'). The floor is preferably waxed concrete or another reflective material. The light bulbs rest at different heights based on a 3D model which determines their cord lengths. It creates a 'rolling hills' or topological map feeling where each bulb is like a surface point on a curved plane. These 3D layouts are tailored to each space by the artist's studio and prepared by fastening the cables together in advance.

DETAILED TECHNICAL INFORMATION

Normal Software Operation
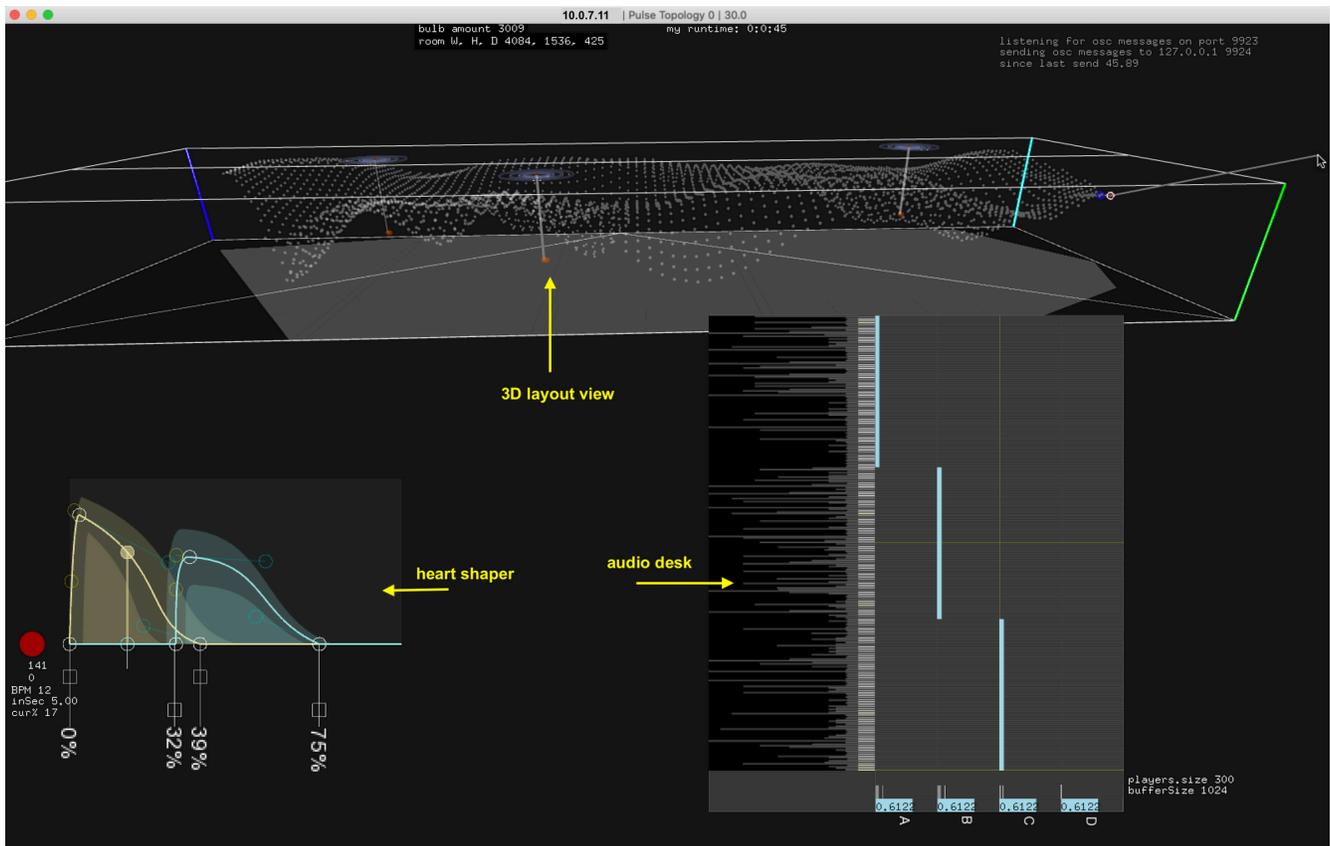
PulseTopology.app software

On all the computers, the rPPG.app is scheduled to start after the computer's boot process while only on the main computer, the PulseTopology.app is scheduled to start shortly after the rPPG.app. Once started, the app displays an array of white dots arranged in the same shape as the installed topology of light bulbs. Each dot represents one light bulb.

When no person is participating all 3000+ light bulbs pulse at the BPM of a past participant.

Each bulb has a unique x,y location and a z value defined by the predesigned topology, it is assigned to a row and column number, is assigned to a DMX universe and a specific DMX channel. When the app starts it loads data/layout/layout.csv and data/BPMs.csv file which sets up the above mentioned variables. When the app closes all BPM readings get written to BPMs.csv.

In the App you can see 1 or many circle patterns drawn inside the heart grid; each representing the location of one of the rPPG heart rate sensors.

Each light bulb has a predefined look-up-table (LUT), that gets generated when the app loads and when a new BPM is assigned to a heart. The brightness change follows the values in the LUT. Each LUT has 1000 values which get traversed sequentially, slow or fast depending on the BPM.

When a person places their hand under one of the sensors a hand touch signal is sent from the rPPG.app to the PulseTopology.app. As soon as this happens the physical sensor sculpture switches from LED spot light to LED ring.

This is the start of the "population" stage.

Shortly after that 4 or so light bulbs near the sensor stop pulsing and turn to a fixed/solid brightness. It takes about 10-15 seconds until a proper BPM is measured by the rPPG.app via the sensor's built-in USB camera. Once a good BPM is acquired it is sent from rPPG.app to PulseTopoloy.app. At that moment the 4 or so solid bulbs start pulsing to the new BPM reading. Those 4 or so bulbs will also stop playing their previous heart beat sound and instead the sound of the new BPM reading will become a bit louder. After a pre-defined duration more and more bulbs will start pulsing in unison. The amount of bulbs increases exponentially over time. Once a maximum size is reached all those bulbs (which might just be a subset of the 3000+ bulbs) pulse together until a hand is no longer detected by the sensor then the bulb amount decreases again. The decreasing animation does not have the sensor at its centre but a newly picked light bulb. The light bulb at the centre of this decreased animation will be the host for the new heart beat.

This is the end of the "population" stage.

It is possible for multiple participants to activate their own heart rate sensor. As a result multiple population moments can overlap and create a more nervous behaviour.

The reaction to an hand presented to the sensor is displayed in the rPPG.app to within 3 phases - noticeable via the label at top right of display and the exposed graph while reading: at first the software detects no hand, then detects a hand and after few seconds, finally displays the detected live heartbeat live.

rPPG.app - State of the app when no hand is under it.
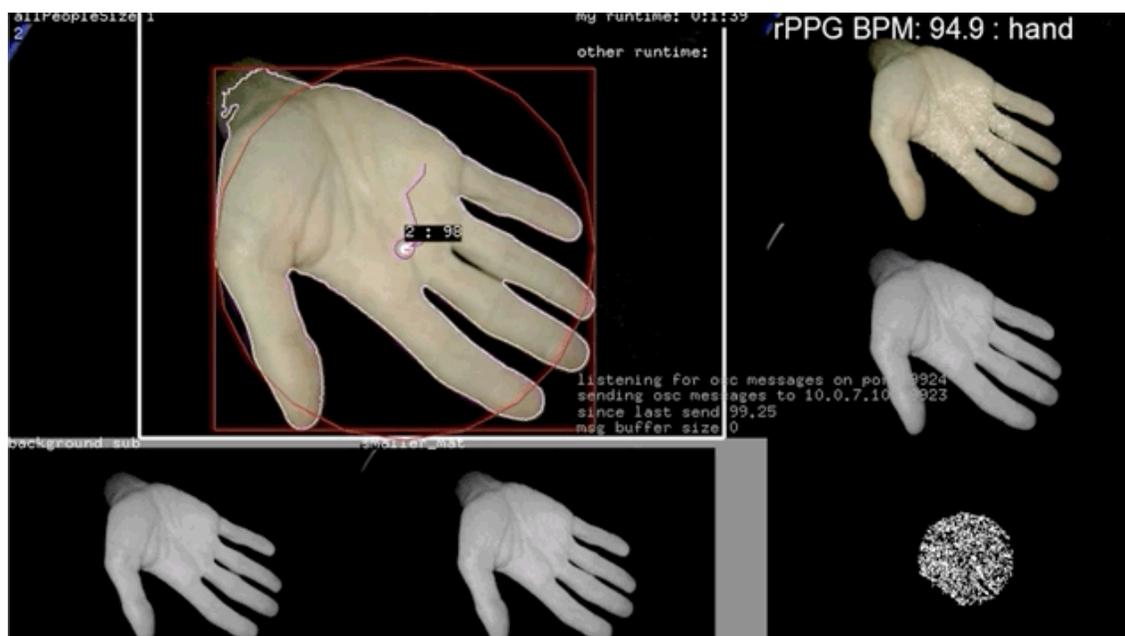
rPPG.app - State of the app when a new hand is placed under it.
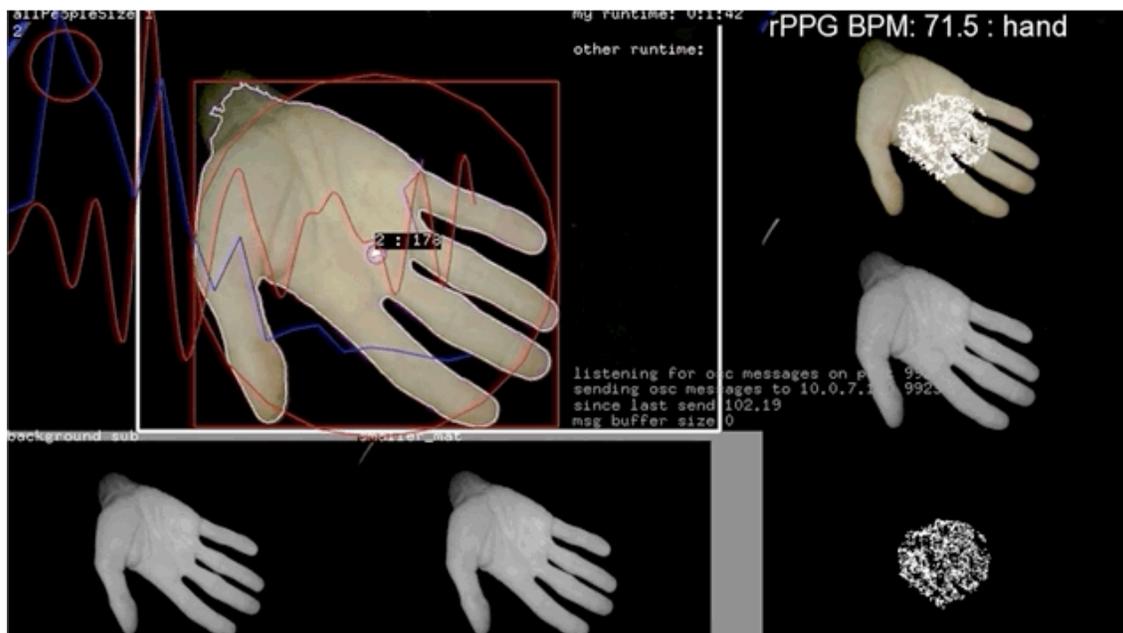
rPPG.app - State of the app when the hand's heartbeat is detected

Manual Software Calibration

pulseTopology.app

       The pulseToplogy.app has a GUI function that can be accessed by pressing in the G key on the keyboard. Be very careful when opening this option, it controls everything and if the GUI is shut it will save the changes made to it.
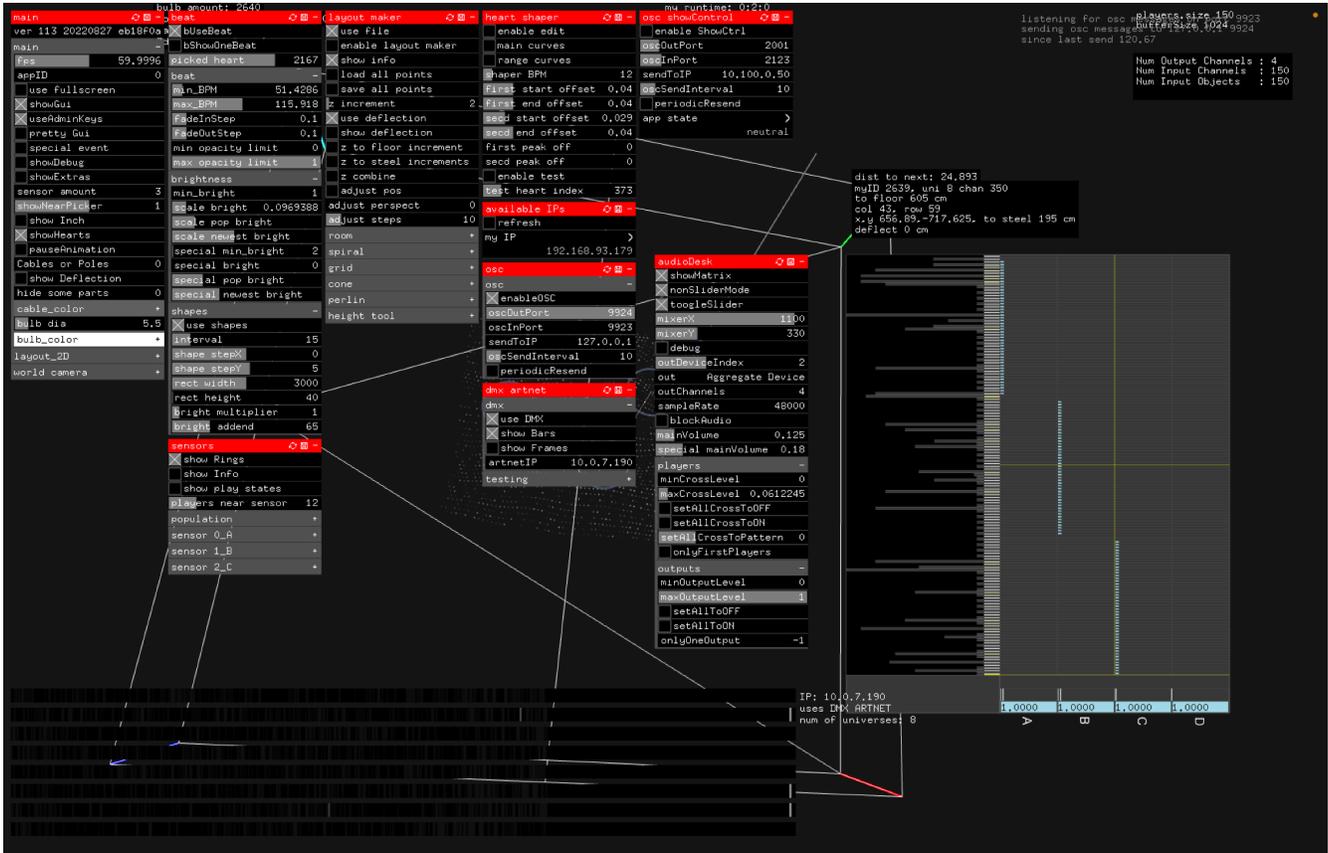
       The GUI is divided into subsections: a subsection name is labelled into a red or dark grey title bar and associated settings are listed under that title bar. Below, you will get information about different settings within each subsection.

Main
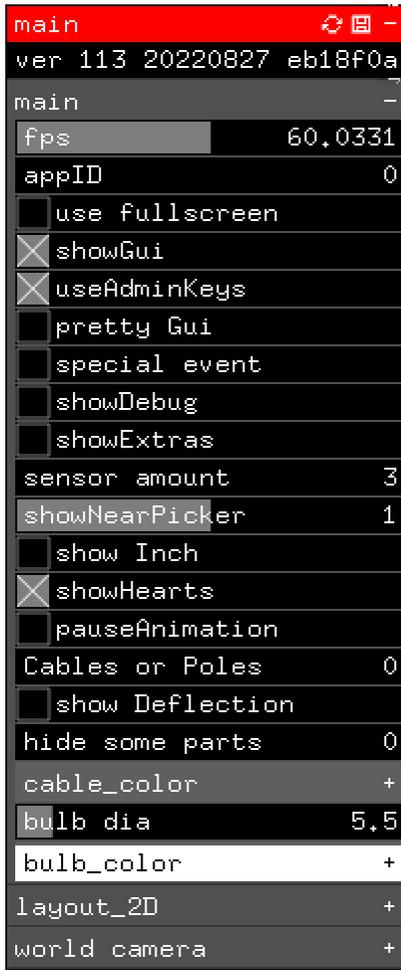
FPS: Should be 60. Will be lower if someone is remotely connected but it should not be so severe that you see a visible change in the artwork.

appID: Set to 0. This denotes computer A. The pulseTopology.app only runs on computer A.

special event: Should only be used when trained by Antimodular staff on how to run the piece for a special event. Can also be triggered by pressing the "s" key.

showDebug: Shows debug windows to help deduce a potential problem.

Sensor Amount: set the number of sensors you are using, if there are 3 sensors then set number to 3.

pauseAnimation: pauses the heartbeats. Use this feature only for professional photographs of the artwork.

Beat

bUseBeat: *should be selected*

min_BPM: minimum BPM that will be saved into the artwork

max_BPM: maximum BPM that will be saved into the artwork

Beat / Brightness

Setting the bulb brightness and visibility of heartbeats. Keep in mind when setting this that we never want the bulbs to be fully off or too bright that they hurt to look at.

min_bright: minimum bulb brightness, should never be 0.

scale_bright: how bright a bulb can go. Should never be too bright to look directly at. Setting this to 0 would mean that the bulbs never get a pulse or brightness value.

Scale pop bright: how bright the active bulbs get when someone is using the sensor.

Scale newest bright: how bright the bulb that stores the last detected heartbeat is: should be different from the other bulbs.

Special min_bright: min_brightness for special event mode.

Special bright: max brightness for special event mode.

Special pop bright: how bright the bulbs are when someone is using the sensor in special event mode.

Special newest bright: how bright the last saved heartbeat is for special event mode.

Beat / Shapes

There should be an occasional sweep that goes through the artwork, the direction, size, and speed is determined by the artist. This is unique to each space.

Use shapes: *should be selected*

Interval: How often the sweep happens.

Shape stepX: sets the x axis size

Shape stepY: sets the y axis size

Rect width: sets the width of bulbs covered by sweep

Rect height: sets the height of bulbs covered by sweep

Bright multiplier: increases the brightness of sweep

Bright addend: increases the brightness added to sweep

Sensors

For testing purposes buttons 1-6 on the keyboard can be pressed to simulate a sensor detection.

1 & 2 control sensor A.
3 & 4 control sensor B.
5 & 6 control sensor C.
Press 1, 3, or 5 once to select the corresponding sensor. Then press a second time to activate it.
Press 2, 4, or 6 once to deactivate the corresponding sensor.

Show rings: *should be selected*

Show info: select when programming sensors to see more information

show play states: select to see when sensors are being activated. Helpful for determining population region and that sensors are labelled correctly.
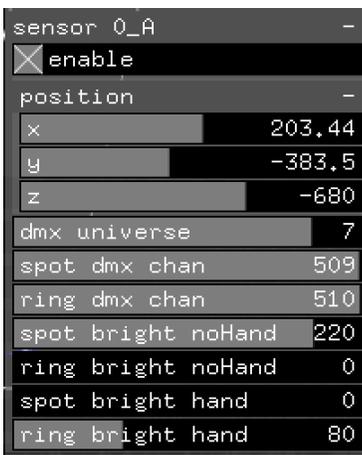
Sensors / Sensor 0_A + Sensor 1_B + Sensor 2_C, etc.
(each sensor is controlled independently)

Enable: *should always be selected*

X, Y, Z: All sensor locations replace a lightbulb. Find that lightbulb's X, Y, Z coordinates in the csv (pulseTopology → bin → data → layout → layout.csv) and input it into these fields so the sensor is in the right position. If this is not done, the piece will not populate from the correct spot when someone interacts with the sensor.

dmx universe: set this to the universe this sensor's LED ring and spotlight are plugged into

Spot dmx chan: set this to the dmx channel the spotlight has been plugged into (typically 509 or 510)

Ring dmx chan: set this to the dmx channel the LED ring has been plugged into (typically 509 or 510)

The proper sensor functionality is that when no hand is present only the spotlight is on. Then when a hand is detected the spotlight turns off and the LED ring turns on. The following settings are responsible for this behaviour.

Spot bright noHand: Turns the spotlight on when the RPPG.app does not detect a hand. Needs to be bright enough that it is visible when you walk into the space, so that people know where the interaction zones are but not so bright that it distracts from the artwork.

Ring bright noHand: Turns the ring light on when the RPPG.app does not detect a hand. should always be set to zero.

Spot bright hand: Turns the spotlight on when the RPPG.app detects a hand. should always be set to zero.

Right bright hand: Turns the ring light on when the RPPG.app detects a hand. Needs to be bright enough that the sensor gets reliable readings every time a hand is seen by the RPPG.app. This value should be adjusted and tested thoroughly during the programming stage of installation.

Sensor / Population
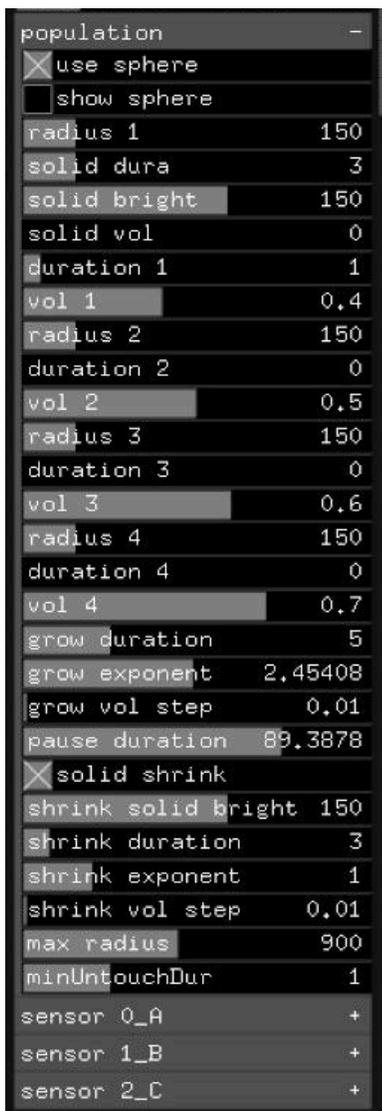
population	−
☒ use sphere	
☐ show sphere	
radius 1	150
solid dura	3
solid bright	150
solid vol	0
duration 1	1
vol 1	0.4
radius 2	150
duration 2	0
vol 2	0.5
radius 3	150
duration 3	0
vol 3	0.6
radius 4	150
duration 4	0
vol 4	0.7
grow duration	5
grow exponent	2.45408
grow vol step	0.01
pause duration	89.3878
☒ solid shrink	
shrink solid bright	150
shrink duration	3
shrink exponent	1
shrink vol step	0.01
max radius	900
minUntouchDur	1
sensor 0_A	+
sensor 1_B	+
sensor 2_C	+

The setting max_radius can be changed to adjust the size of the sensor radius: the area that gets populated with your heartbeat when you're using the sensor.

Layout maker
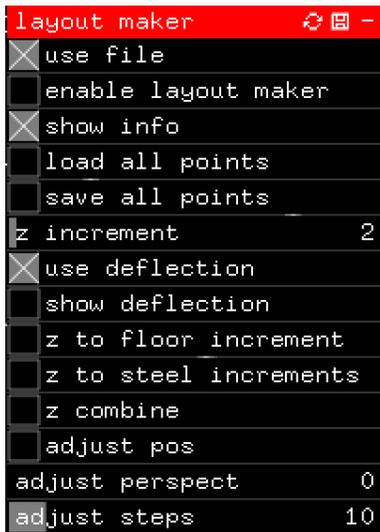
Use file: *should always be selected*

This allows the software to read the layout.csv file which determines the bulb locations and dmx addresses. If you ever need to make changes to the layout.csv make a copy of the original file then change the new updated file to the name "layout.csv and put it in the correct location (mentioned above). Restart the pulseTopology app and your new csv will be loaded in.

Available IPs

My IP: should be set to the IP labelled on the front of the computer. Usually in the range of 10.0.7.XXX

OSC
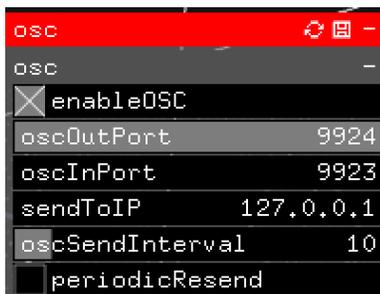
enableOSC: *should be selected*

oscOutPort: pulseTopology.app should be set to 9924 to communicate with the different instances of RPPG.app.

oscInPort: pulseTopology.app should be set to 9923 to communicate with the different instances of RPPG.app.

DMX Artnet
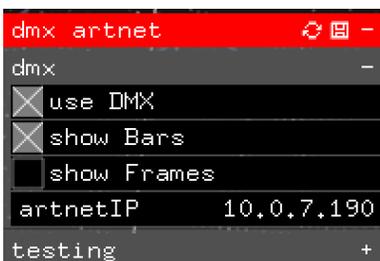
Use DMX: *Should always be selected*

artnetIP: Set to IP address of DMX device being used

audioDesk

showMatrix: *should always be selected*

Out: Aggregate device should be selected. **Note:** The app will not open if it does not detect an Aggregate Device.

outChannels: set to 4

sampleRate: should be set to 48000

mainVolume: controls general volume of the artwork

Special mainVolume: controls general volume of the artwork in Special mode

minCrossLevel: adjust this slider to increase the volume of the single heartbeat when someone is using a sensor

There aren't too many parameters that should be set in the rppg.app when programming Pulse Topology. Below are listed the main parameters to verify.

Setting	Description
rPPG detector / app id	each rppg.app needs its own app ID so the pulsetopology.app can differentiate them with their respective sensors. 0 = A, 1 = B, 2 = C
rPPG detector / use rPPG	*should always be selected*
rPPG detector / show rPPG	*should always be selected*
enable OSC	*should always be selected*
osc / oscOutPort	set to 9923
osc / oscInPort	set to 9924
osc / sendToIP	set to IP address of pulseTopology.app (mac mini A)
UVC / exposureValue	sets the exposure of the camera. If this is not set correctly the sensor will not be able to detect heartbeats properly. The exposure value should be close to 1 so that the camera is very dark and you can only see the spotlight, as shown in the image below

*** *The OSC In and Out ports, and the sendToIP ensure communication between the rPPG.app(s) and the pulseTopology.app. Once setting these, restart all apps and you should see the sensor's runtime in the top-middle of the pulseTopology.app.* ***
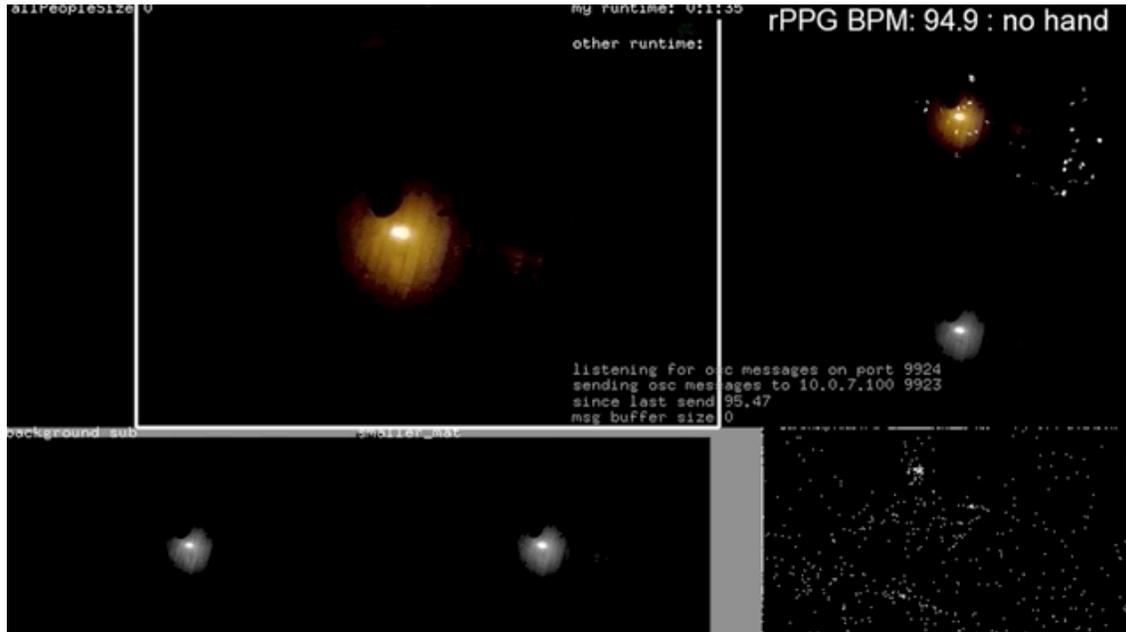
Example of a typical camera brightness

Network

All computers are connected to each other via a wired LAN (local area network) connection. Typically, their IPs are set to manual IP, with an IPv4 address under the 10.0.7.x pattern, and the network mask being 255.255.255.0.

The Ethernet to DMX controller is also connected to the same network. Its IP address is 10.0.7.190. No other device should have this IP address.

All computers can be connected to the museum's wifi network.

If there's a possibility of network conflict between the 2 network types, the artist's studio should be told in advance to prepare for a different IP pattern.

Only the main controller controls the artwork's audio. Sometimes, the artwork is set to use multiple Audio cards (like the Focusrite Scarlett 2i2): in such a case, the Audio MIDI setup application on the main computer needs to be used to create an "Aggregate Device" using all the provided USB audio interfaces.
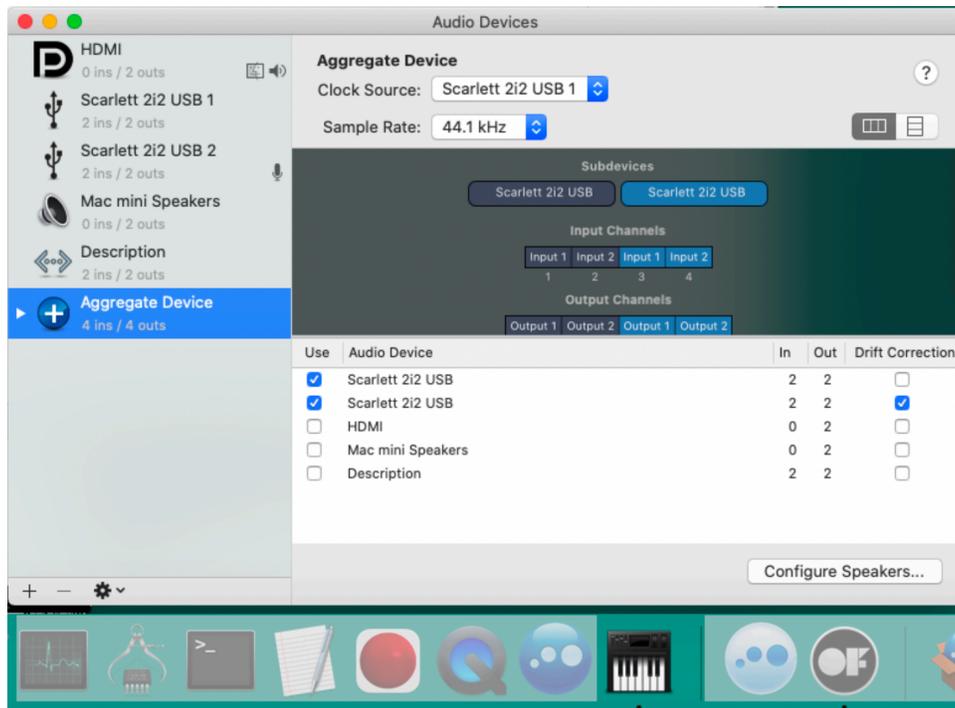
Some versions of this artwork use only one Scarlett 4i4 instead of 2 x Scarlett 2i2. In this case please match these settings in Audio MIDI Setup app and Focusrite Control app in order to gain access to all 4 line output ports.
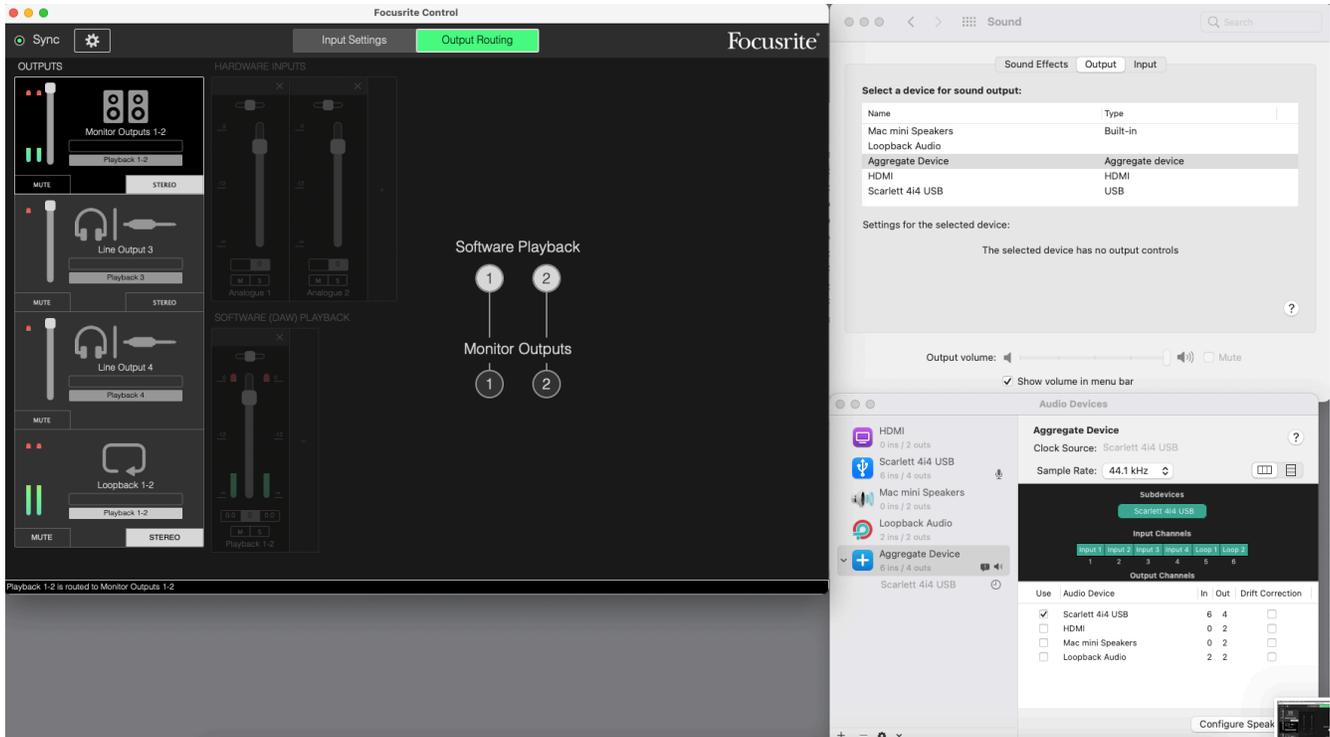
If you find that Line Outputs 3 & 4 are louder than Line Outputs 1 & 2 on the Scarlett 2i4:

If you're using the unbalanced (RCA) line outputs to send audio to an external mixer from your Scarlett 4i4 and you notice that outputs 3 & 4 are louder than outputs 1 & 2 then this may be due to the position of the monitor dial on the front of your Scarlett 4i4.

The volume for both balanced and unbalanced outputs 1 & 2 are controlled by the monitor dial on the front of your 2i4. Therefore if you're experiencing less signal from outputs 1 & 2 than 3 & 4, make sure that your monitor volume is set to maximum to ensure that both sets of unbalanced outputs are sending equal volume levels to the two channels on your external mixer.

Remote Access to Artwork's Computer

There is a software installed on the computer running this artwork that allows the studio to connect remotely to the artwork. This feature is helpful when you require assistance from the studio, as we can remotely connect to it, do a quick inspection, and do a debugging session of your components, if needed. In order to enable this feature, the computer has to be connected to the internet at all times. Depending on the computer's operating system (Windows 7/8/10/11, OSX), the procedure to set the computer online will vary. Please look online for tutorials, if necessary.

Preliminary Troubleshooting Steps

When placing a hand under the sensor the population stage does not occur

Is the LED light from the sensor switching from spot to ring? If it is not, the sensor computer is offline and needs to be booted up. If it is, and it's constantly changing instead of holding on to one, the hand placed is not close enough to get a proper reading or the exposure settings in the rPPG.app need to be adjusted. Follow the steps outlined in the Manual Software Calibration → rPPG app section.

A section of lights are off.

Ensure that all the LED displays of the dimmers are on, if they are not that means the dimmers are not receiving power and there has been something unplugged/disconnected.

If all displays are on, check for a dot '.' between the "A" and start of the address displayed - (For example, A.001) If the . is present that means the dimmers are receiving a DMX signal, if the . is not present, follow the DMX chain to where it last appears and check the connection or cable for that dimmer.

NOTE: A DMX cable shorting can cause the line to shut off in reaction, this is a rare case but if you have exhausted all other avenues, look at the red cables to ensure none are touching bare metal.

A single lightbulb is off

Is it fully screwed in? The light bulbs work best if they are fully screwed in then let off a quarter of a turn, add or release the thread while plugged in to find the sweet spot of that bulb.

Is the bulb working? Take a bulb next to it that is currently functioning, if the bulb is placed in the socket and works fine, then you need to replace the broken bulb.

If that did not work, check the button contact of the bulb, the levered metal might have been bent too far in and now does not make proper contact with the bulb. Using a wood implement or POWERING OFF and using your finger can raise the lever to contact.

If that did not work, check the red and black connections to the dimmer bay, tug on them to see if they were properly nested or not.

Finally, if all those steps did not work, you need to replace the affected socket with a socket that is proven to work.

There is no sound

Check that the main computer is on and its volume is on.

Check that the audio matrix is loading in the pulseTopology.app properly like the image below.
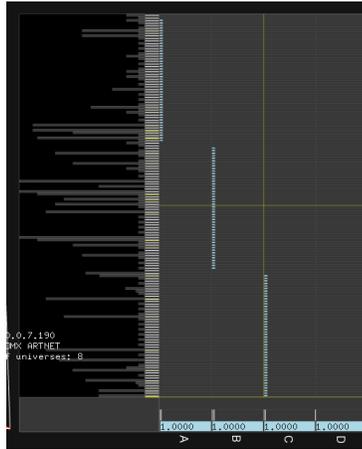
Check that the Scarlett is on and indicator lights are on,

Check that the subwoofer is on and its indicator lights are on.

If all those aspects are on and there is no sound, call the studio for support

There is a glitching flicker in one area.

This means that the DMX universe is too full and needs to be broken in two by an opto splitter or a booster needs to be added to the chain. Unplug the DMX ethernet chain in the middle of the addresses (150 range) and place in a DMX amplifier provided to you by the studio, this will need a separate power supply (also provided by the studio)

Everything is on but there's no sound and the lights are off

You may have accidentally entered "special event mode" . Ensure "special event" is not selected in the Main section of the GUI or press "s" to exit special event mode.

Troubleshooting Assistance

Prior to contacting the Antimodular Studio with a problem about your artwork, please ensure that you went through the preliminary troubleshooting steps outlined in the previous section.

The troubleshooting process will vary depending on the problem. In order to make the process easier, it is recommended that you collect and send the following information to the studio:

- Date and time when the problem first happened;
- Description of the problem;
- Actions taken so far and conclusions;
- Detailed photographs (or videos) displaying the problem;
- Detailed photographs (or videos) of the suspected faulty component;
- Detailed photographs (or videos) of the whole artwork and its surroundings;
- Personnel involved.

Support (Contact Us)

If you would like support for the piece, please feel free to call Lozano-Hemmer's studio in Canada:

Antimodular Research
4462 rue Saint-Denis
Montréal, Québec, Canada
H2J 2L1
Tel 1-514-597-0917
info@antimodular.com
www.antimodular.com

APPENDIX I - INSTALLATION

Description of Components

This artwork requires the following components:

Component	Description
Computer	Typically an Apple Mac Mini, the computers act as a receiver for the sensor's input, while one - labelled as main unit - also acts as the main control hub of the piece.
USB over Cat5 extender	Extends the USB signal over ethernet from the sensor to the computer. Has to be of good quality and at least USB 2.0.
Sensor	Reads the pulses from the hand of a user.
Ethernet Switch	Allows the computers and the DMX controller to interface together.
DMX controller	Converts the ARTNET signal from the main computer into a DMX signal to control the dimmers. Each port is numbered and that number corresponds to the universe number.
8-Pack Dimmer	Receives the DMX signal and dim their attached light bulbs accordingly.
Light Bulb Assembly	LED light and cabling reacting to heartbeat, forming the light topology.
Ethernet Cabling	Interconnects the computers, the network switch and the DMX controller together to carry network communication. Also used by the USB extender to carry USB signals. Should be at least CAT5e and shielded.
USB Cabling	Connects sensor, audio card or USB extender to the computer.
External Audio Card	Receives sound signals from the main computer and outputs it to the subwoofers.
Subwoofer	Outputs sound generated from the main computer.
Audio cabling	Most subwoofers use XLR 3 pin, the external Audio card might use the same connector. There might be a need for different cabling or adapter(s), based on the units in use.

Monitor	Used to control and display the softwares. Main monitor can be shown or hidden for the exhibition, the secondary monitors are of no use in that context. When no monitor is connected, we recommend a video fooler to have a display "connected" to the computer at all times.
Video cabling	Connects the main computer to the display, when exhibited. Typically using an HDMI cable.

Wiring Diagram
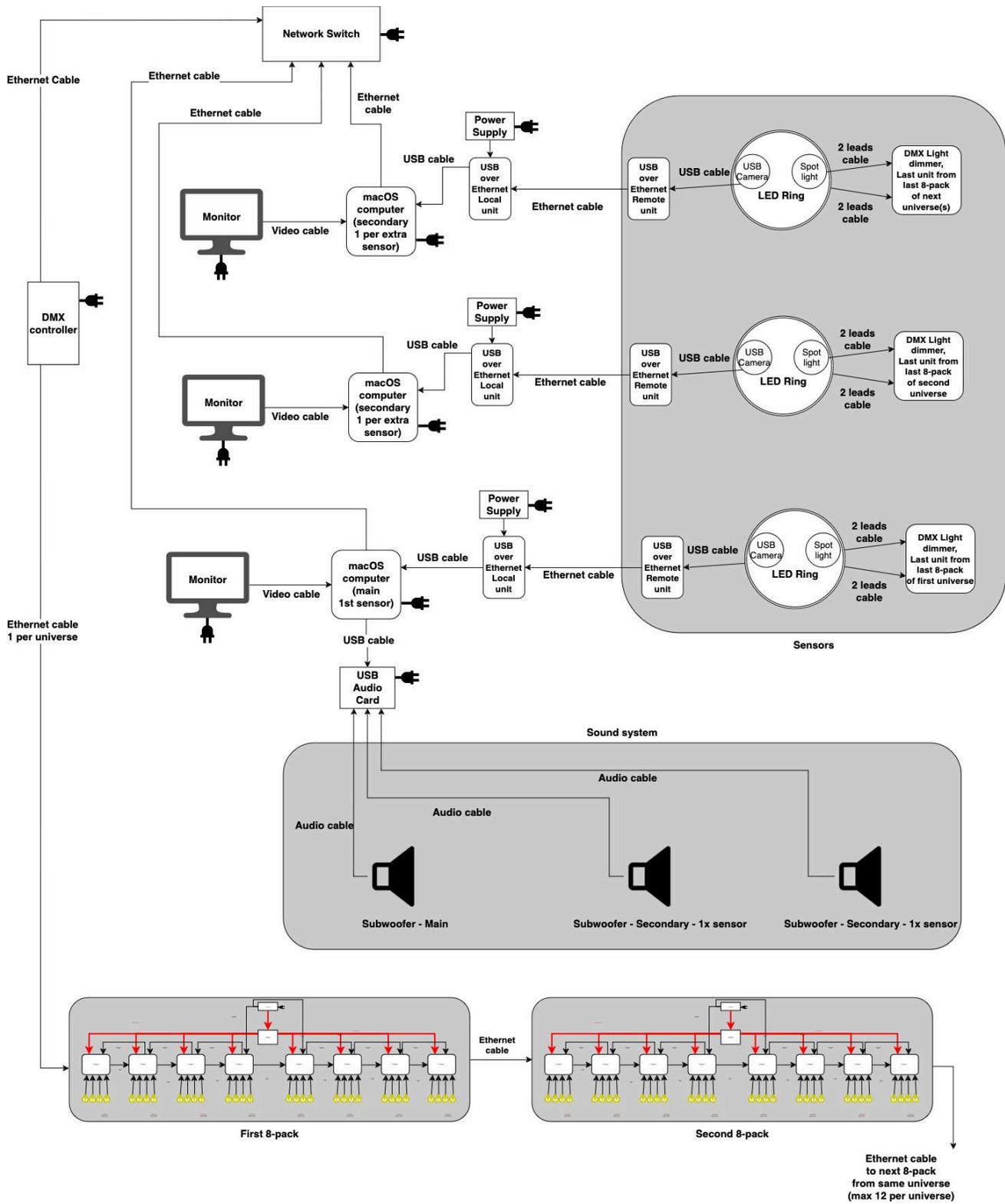
APPENDIX II - TECHNICAL DATA SHEETS

General Power Requirements

Power source feeding the artwork should always come from a consistent power source, not on a generator, a surge protection system or a dimmable system.

Each 8-pack dimmer's power supply unit uses 2.6 Amps on 115 Volt circuits **or** 1.7 Amp on 230 Volt circuits.

Additionally, the electronics driving the artwork (computers, network switch, USB extenders, etc., typically organised in a server rack) need 2 independant 15 Amps circuits (120V) or 2 independant 10 Amps circuits (230V).

A standard 3000 bulb installation will use 96 PSUs for a total of 280 Amps on 115 VAC or 184 Amps on 230 VAC. This being said, this is the maximal consumption, when all bulbs are at full brightness: the site's electrical architecture should handle such needs. However, considering the nature of the work, the real consumption should be around 25 and 60%, depending on the average brightness of the artwork.

The ratings stated above are separate from the power needs of the sound system which would be the venue's responsibility.

Rack Assembly of the Electronics

We typically provide the electronic components: computers, sound cards, DMX controller, ethernet switch, USB extenders, power supplies, power cables and power bars within a meshed rack assembly to ease the equipment management and handling. The following pictures display such a system.

Audio output C

Ethernet to computers

Ethernet to Strom 8

Audio output B

120/240VAC power

Audio output A

DMX via Cat5e to Dimmers

10.0.7.190

Front side of the rackmount

USB extension to Heart-rate sensors via Cat5e

USB port for wireless keyboard

HDMI foolers or display connection
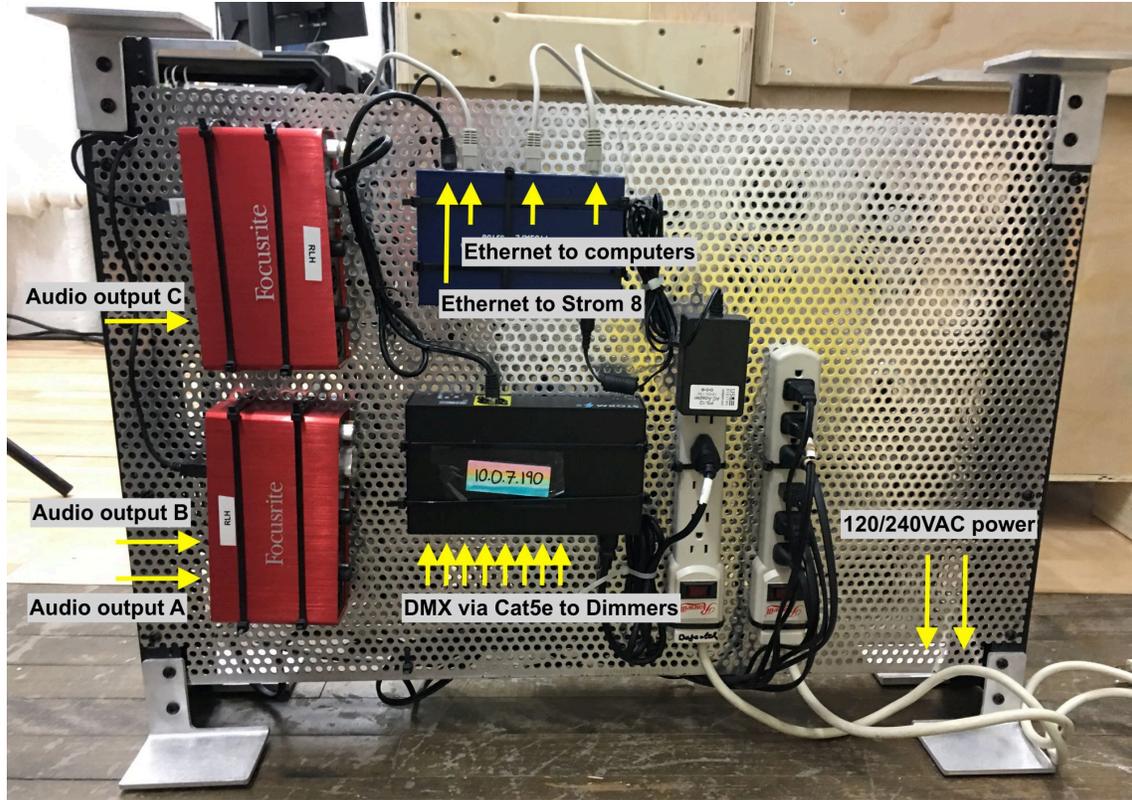
Back side of the rackmount

Computer and Software

At the time of writing this manual, the software operating on the computer is coded under openFrameworks' platform. Software version referred to in this manual are #113 20220827 for the PulseTopology.app and #31 20220512 for the rPPG app. Both apps run on an Apple computer on OSX 12.1. Such software was initially released and tested on an Apple MacMini with an M1 processor, 8GB of RAM and 512 GB of storage.

The softwares rPPG.app and PulseTopology.app are launched, in such an order, by the custom-made software delayOpen.app that, as the name implies, delays the software launch to allow all system resources to be loaded in priority.

Sensor

The sensor is conceived to be suspended from the ceiling, solely using its cabling as a suspension method. The 3 cables coming out the sensor are the camera's USB cable, and two 2-lead DC power cables coming from the lights and connecting to a dimmer unit from one specific DMX universe.

Component	Description
USB camera	Reads the pulses from the hand of a user, connected via USB that is extended by a USB extender. Typically using a Kurokesu C1 Micro M12 camera.
Camera lens	Allows a full field of view for the camera. Typically using a Back-bone M12 1.45mm 190° 10 megapixels fisheye lens.
LED Light	The LED ring light has a 76mm diameter. Used to give a flat and equal lighting of the hand under the sensor, it will turn on when an object is detected. Will be connected into address 509 of the nearest universe. Typically used an Adafruit 4433 light.
LED Spot	A mini 3000 Kelvin spot light used to indicate the sensor position on the ground, will be turned on by standard. Will be connected into address 510 of the nearest universe. Typically using an Osram Dragon Eye Led, IP65 mini spot, De1-w4f-830-g3.
WAGO connectors	Extends the LED ring and spot cables.
3D printed housing	2 parts printed (SLS) in white nylon, black stained. Assembled with the camera and lights screws and zip ties.

positive and ground power for LED Spot and Ring connecting to DMX LED dimmer
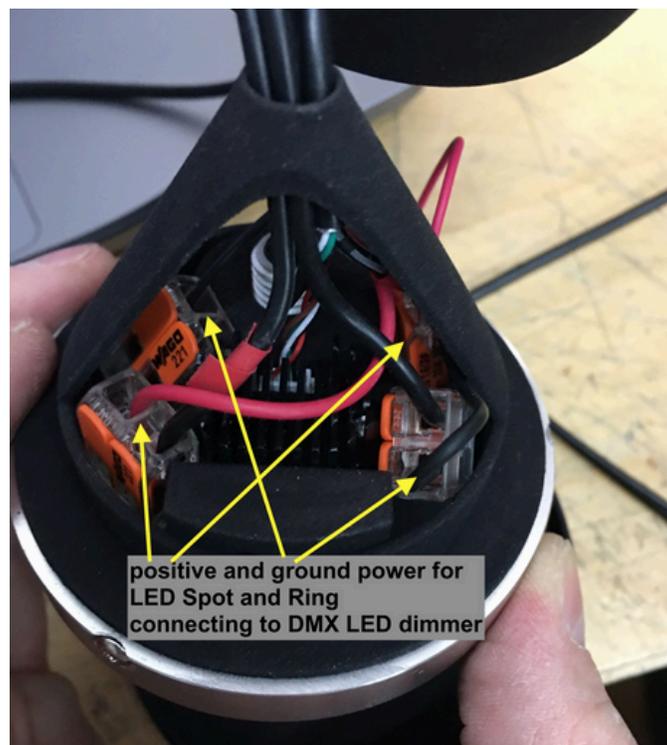
External Audio Card

The external audio card used in the system could differ from an installation to another. Up to now, we used pairs of Focusrite Scarlett 2i2 (aggregated in OSX) or single Focusrite Scarlett 4i4. Future setups could use a different card brand or model: to be discussed with the artist's studio.

Note: consider the need for audio adapters to interconnect the subwoofers and the audio card. Typically, there is a need for a ¼" to XLR adapter for every single subwoofer connected.

Ethernet Switch

The ethernet switch could be managed or not, the most important element is it should be a Gigabit switch to allow proper communication speeds between the different components of the work.

A managed switch or even a router could be of a good use if ever there is a need for merging Internet connection and the local network (computers, DMX controller, etc), like when WiFi is not a viable option for a stable and speedy Internet connection.

DMX controller

The DMX controller will carry over the playback commands from the computer to the controllers.

In the current version, an Artnet to DMX controller has been used. Controlled by the computer via ArtNet protocol, the device transfers the commands to the dimmers as DMX signals. Each port is numbered and that number corresponds to the universe number. Up to now, we used Enttec Storm 8, Enttec Storm 24. Future setups could use a different controller brand or model: to be discussed with the artist's studio.

8-Pack Dimmers

        The light bulbs are connected to DC dimmers arranged in groups of 8 units, called 8-packs. All the dimmers are powered by a single power supply: using terminal blocks for the DC positive lead.

        There is typically a maximum of twelve (12) 8-packs per DMX universe, limiting each universe to 384 active channels, including the sensor's lights. The 8-pack are generally installed staggered along the exhibition space, following the grid pattern: the DIN rails are usually screwed onto a wall in said space.
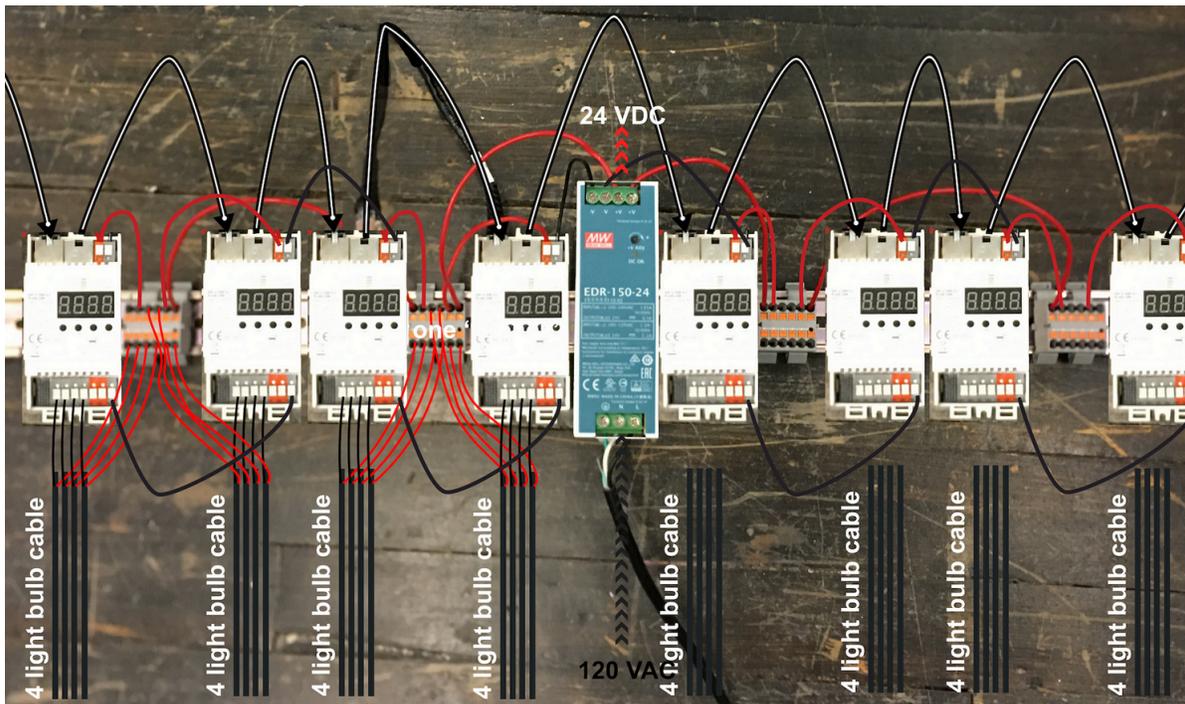
Visual reference image - Refer to the <u>wiring diagram</u> below for proper connections.

Component	Description
Din Rail	A metal backing, used for ease of management and installation. Typically using the TS35 type.
Power supply	Provides power to the dimmers and the light bulbs with 24V direct current.
Terminal blocks	Allow DC's positive lead distribution from power supply to all dimmers and light bulbs.

LED Dimmer	A 4 channel dimmer that reacts to the DMX signal from the system. Running on 24VDC, outputs constant current addresses to the lights plugged into it and sends data in a chain to other dimmers. Every dimmer of a single universe should be set to a different DMX address to avoid duplicate channels.
Jumper cables	Solid core 17 AWG cables connecting interconnecting the dimmers, the terminal blocks and the power supply. Red is used for positive leads, black for negative leads. Negative lead splits from the power supply and goes to the two closest dimmers then daisy chain to the next 3 dimmers on each side.
Ethernet Cables	Carries DMX signal between dimmers. A cable connects to the first dimmer on the left, then from a dimmer to another. The last dimmer on the right should jump to the next 8-pack in sequence.

The dimmers will have a universe denoted on them, from the DMX controller runs an ethernet to the first dimmer of each universe (address 001). The last dimmer on any universe will have a DMX terminator connected in the out port.

On the dimmer themselves, you might need to adjust their frequency setting to PF 16 to reduce the light flicker seen by camera.

NOTE: Dimmers use electrical power supplies considered "exposed" please refer to all electrical safety laws in your area to assess how to properly construct the troughs. PSUs will have plugs attached but all electrical power and wiring will need to be done on site and not by the artist team.

We can recommend the following unit for this artwork. That said, other units could be used, here are the most important specs for this unit:

Specification	Details
Input Voltage	24 VDC
Output Current	0.35A / channel
Output Power	8,4W / channel (34W total) at 24VDC
Output Type	Constant Current
Installation Method	TS35 DIN rail compatible
DMX channels	4 channels

Reference unit - Sunricher SR-2108FA3-RJ45-DIN

We can recommend the following unit for this artwork. That said, other units could be used, here are the most important specs for this unit:

Specification	Details
AC current	2.6A @ 115VAC / 1.7A @ 230VAC
DC Voltage	24V
DC Rated Current	5.2A @ 115VAC / 6.5A @ 230VAC
DC Rated Power	125W @ 115VAC / 156W @ 230VAC

Reference unit - Mean Well EDR-150-24
Datasheet:
https://www.meanwell-web.com/content/files/pdfs/productPdfs/MW/EDR-150/EDR-150-spec.pdf

8-pack's - Wiring diagram

8-pack (up to 12 per DMX universe)
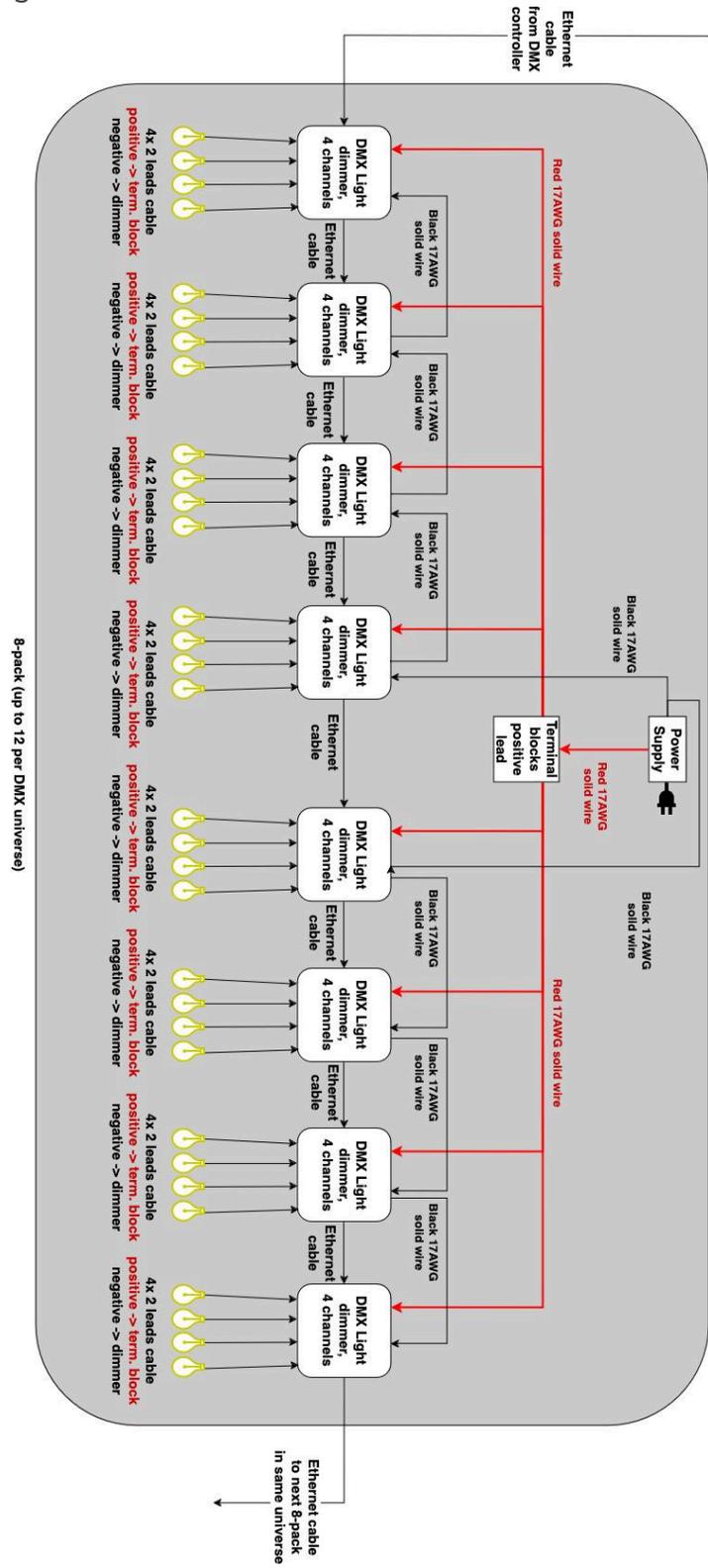
Light Bulb Assembly

Component	Description
Power cable	The wire carrying power to the light bulb. Should be 22AWG 2 leads SVT, have a matte black jacket without any printing on them and . In most installations, the length varies from 15 to 30 meters.
Plastic lamp holder, shrouded in a metal bell	The light socket, typically with an E26 thread. The metal bell covers the socket to make a cleaner assembly.
Light bulb	A LED light, with a clear polycarbonate bulb. The bulb has an A19 Edison shape (+/- 11mm long, 6mm of diameter), runs on 24VDC, is dimmable, produces at least 320 lumens (typically 4W) and has a 2700K color temperature. There's typically 4 filaments inside the bulb, about 38mm long.

Labeling of cabling

The lights power cables will all have a unique label on two parts of the installation: one label will be placed just past the attachment point of the light bulb on the aircraft cable, while a second will be placed near the plugging point of the dimmers.

The labels read as such:

(Universe) - (DMX Address) (Row) - (Column)
1 - 001 02 - 12

The Universe will always be one integer, the address will be three integers, and the row and columns will be two integers respectively.

APPENDIX III - ASSEMBLY OF THE WORK

Weights

The light bulb assembly weighs 77 grams without the cable. The 22 AWG cable weighs 5.7 grams per 30 cm, and cable lengths vary from 15m to 30m.

- a 15m cable is 285g added with 77g of socket, so 362g, rounded up to 390g or 0.39kg;
- a 20m cable is added with 77g of socket, so 457g, rounded up to 480g or 0.48kg;
- a 25m cable is added with 77g of socket, so 552g, rounded up to 580g or 0.58kg;
- a 30m cable is added with 77g of socket, so 647g, rounded up to 670g or 0.67kg.

Each point on a column is .53kg (averaging the length), so if you have for example 34 points of a column then that column weighs 34 x 0.53kg or 18.02kg in light bulb and wire.

⅛" galvanised steel 7x19 cores is the minimum steel cable gauge you may use at maximum of 60 points on line. Anything larger than ⅜" galvanised steel 7x19 is not recommended for aesthetic purposes.

Suspension of Light bulbs in the Exhibition Space

The rigging points for the piece should be placed at the correct height and spacing, rated and able to hold the minimum weight of 50KG per line. The weight of a line increases if force is placed on the line by way of a tightening device such as a turnbuckle.

NOTE: Rigging has inherent dangers associated with it, always use a certified professional when installing things above the heads of others.

Correct
U-Bolt of All Clamps
on Dead End of
Rope

Accepted rigging (NOTE: Always use thimbles to avoid damage)

Aircraft cables rated for 50 KG and above, preferable galvanized steel, crimped or saddled by a professional are to be hung from the rigging points by way of a shackle, to a turnbuckle, to a shackle on both sides. (IF using truss, then concurrently to a rated rigging strap)

Pre-measured lightbulb wires are then attached with black zip ties tightened and cut to the aircraft cables at the correct spacing and sequence denoted by the labels provided and the unique

topology map for the installation. At the end of the cable the wires should be able to fall or cascade along the wall freely in the space.

NOTE: All aircraft cables will have a "midpoint" in which the light bulb wires run to the left or right of, the middle is requested to be taped or painted to hide the shine of the metal cables.

The sensors will replace one lightbulb in the grid, denoted on the provided layout. The sensor will need two cables with two cores run to a dimmer bay, and one ethernet cable that runs directly to the corresponding control computer for that sensor.

The dimmers will sit on the bottom of the installation in a pre constructive "trough" or "cover" provided by the site. The labels on the wire will align with labels of the dimmers denoting the DMX address, plugging the red into the corresponding address terminal and the black into a free power terminal.

For Rigging, please consult the following image.

NOTE: Adding side force by way of turnbuckle or other device changes the weight calculations and should be done only by a certified professional