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Lucida 3D Scanner

Assembly guide

P. P. Rubens, The Triumph of Eucharist over Idolatry, 1625, oil on panel, 65 x 91 cm (detail). 3D scanned in 2011 in the Museo del Prado, Madrid.
Standard configuration
For assembling the scanner in its standard configuration, that is, for recording a surface perpendicular to the floor (i.e. a wall or a painting on an easel) use a solid plane like a table to help you in attaching the parts during the process. Always work at a distance of at least 2 m from the object. Only when the scanner has been assembled should you bring it into position and closer to the object.

The steps for assembling the standard configuration of Lucida are:

Rails
01. Turn the rails frame sideways so you can reach the bottom.
02. Screw in the four feet in their correspondent threaded sockets.
03. Place the rails frame on the feet and bring the carriages in parallel.

Tray
04. Place the tray on top of the carriages in the correct orientation.
05. Use 16x M6 screws to attach the tray to the carriages.

Beams
06. Insert the plastic part in inside the front beam, facing backwards.
07. Fix it using 3x M5 screws.
08. Place each beam on top of two carriages, parallel to each other.
09. Make sure the beams are fully in touch with the carriages’ top.
10. Fix the beams to the carriages with 16x M5 screws.
11. Make sure that the beams are put exactly on top of the carriages.
12. Notice that the plastic piece is in the front beam facing backwards.

Plate
13. The aluminum plate will join the mast with the beams.
14. Use 4x M12 long screws to attach the mast with the plate.
15. Turn the mast upside down and place the plate on top of the edge.
16. Notice the orientation of the plate and insert the screws firmly.
17. Place the mast with the plate attached on top of the beams.
18. Use 8x M12 short screws to attach the plate to the beams.
19. Make sure the beams are parallel before inserting the screws.
20. Thread the screws evenly, tightening them when they are all in.

Z-axis
21. The longer edge of the leadscrew will be positioned at the rear.
22. Insert the leadscrew through the beams’ holes as indicated.
23. Thread the leadscrew in through the plastic part of the front beam.
24. Place one of the bearing mounts in the front socket of the tray.
25. Insert the leadscrew in the bearing mount and attach it to the tray.
26. Thread/unthread the top screw to tighten/release the bearing.
27. Place the other bearing mount on the socket at the tray’s rear.
28. Fix the mount to the tray with the correspondent screws and nuts.
29. Thread/unthread the top screw to tighten/release the bearing.
30. Insert the handwheel: notice the flat top of the leadscrew edge.
31. Tighten the screw to fix the handwheel.
32. Check that the Z-axis movement works fine by operating the wheel.

Backing frame
33. The componentes to connect the backing frame to the mast are:
   - 4 carriages
   - plate
   - break piece with handle
   - screws
34. Put the backing frame facing downwards on a horizontal surface (it is recommended to put some foam to protect the linear guides). Place each pair of carriages in opposite sides with the wheel facing inwards. Each carriage will be attached to the backing frame through two threaded holes. The standard position of the carriages is on the central area of the backing frame, as indicated in the image.
35. Attach a pair of carriages to the backing frame using 4 short screws. Attach the break piece with the handle to the plate and put on the other pair of carriages. Use 4 long screws to fix it to the frame.
36. Tighten the screws evenly to guarantee a correct attachment.
37. The break piece can be put in either pair of carriages, left or right.
38. Now the backing frame is ready to be attached to the mast.
39. Hold the backing frame with both hands and insert the first pair of carriages on the mast, sliding it from the top edge. Notice that the wheels should be placed exactly on the mast’s side channels. The break piece should slide in its correspondent socket of the mast.
40. Keep sliding the backing frame down the mast until the second pair of carriages are also sliding down the channels.
41. Once the four carriages are attached to the mast, try to move the backing frame sideways to check if the wheels are too loose. The four wheels should be touching the channels evenly. If there is no play, you are ready to tighten the brake through the handle (image 42). If the wheels are still loose, you will have to adjust the pressure of the wheels (image 45).
42. Rotate the handle clockwise to tighten the break. As it is not possible to make a full turn of the handle, use the button to release it and bring the handle back to its position, in order to keep tightening it. Be patient with this as the break might be too loose at the beginning.
43. Once the break is tightened the backing frame will stay in position at the desired height on the mast. Turn the handle every time you need to move the backing frame up or down.
44. If you need to release the break handle for any operation, slide the backing frame down the mast until the vertical linear guides touch the plate (make all movements gently).
45. If the wheels of the carriages need to be adjusted to change the pressure on the mast, unthread the side allen screw to rotate the wheel outside or inside.
46. It will be necessary to use a screwdriver to loosen the frontal screw, in order to allow for the allen screw to move.
47. The scanner should look like this after assembly. The next steps will be assembling the scanning head and connecting the wires between it and the control unit.
The Lucida 3D Scanner can also be assembled in a desktop configuration in order to record objects (such as manuscripts, fragile materials, etc.) that for conservation reasons cannot be mounted vertically on an easel and instead must be positioned horizontally and facing upwards.

It is possible to assemble the scanner in a desktop configuration with the same components and tools that are needed for the standard mode. The scanner needs to be placed on a solid horizontal surface (like a table) with recommended minimum dimensions of 100 x 50 cm.

Once the scanner has been assembled, the object must be placed on top of the table facing upwards. In order to achieve the correct scanning distance, it might be necessary to use additional supporting elements (for example, a box) to lift the object closer to the scanner. The maximum area that can be scanned is around 75 x 50 cm.

The steps (see images on pp.26-33) for assembling the scanner on a desktop configuration are:

01. Place the parts on a table, with the mast's front side facing up.
02. Fix the first leg to the mast near the edge with a spanner.
03. Fix the second leg parallel to the first leg.
04. Make sure the squares are properly fixed to the mast.
05. Slide the backing frame onto the middle of the mast before fixing the second pair of legs.
06. Lean the structure to access the break handle with your hand.
07. Tighten the break in such a way that the handle stays parallel to the table surface when tightened.
08. Now fix the second pair of legs.
09. Make sure the legs are mounted parallel to each other...
10. ...and all screws are tightened.
11. If necessary, adjust the height of the four feet so they are even.
12. Keep the structure upside down, do not turn it over yet.
13. Use the two shorter screws to fix the chain to the horizontal rail.
14. Use one of the included allen keys to tighten these screws.
15. Pull the three wires down, between the channel and the backing frame as usual.
16. Now fix the scanning head onto the slide with another allen key.
17. Use two more small screws to fix the chain to the scanning head.
18. Do the calibration now (don’t connect the vertical motors yet).
19. Turn the scanner on its legs - two people should perform this step.
20. It is easier to turn the scanner if you roll the wires around the slide.
21. This is the recommended position of the scanner, laptop and control unit on the table.
22. Make sure the three wires (trigger and USB cables) are pulled down like this, so they don’t interfere with the scanner’s movement.
23. Use any support (boxes, etc.) to bring the object up to the correct scanning distance.
24. Watch the hanging cables at all times during scanning.
The various tasks involving the assembly of the Scanning head must be carried out in this order:

- Laser diode plate
- Laser module
- Cameras
- Full scanning head
- Adjusting laser beam
- Cameras setup

Scanning head cross cut A, B (scale 1:1)
The following components and tools are required to assemble the Laser diode plate:

- PCB board
- Temperature sensor
- Laser diode
- Copper laser diode plate
- Plain white paper
- Tin (0.5 mm)
- 6 pin male header strip
- M1.6x3 screws (4x)
- Solder
- Allen keys

Start by mounting the laser diode and temperature sensor onto the copper plate. Make sure that the pins of both components correspond to the positions of the holes on the PCB board.

There is a specific arrangement for the temperature sensor. Before placing the temp. sensor onto the copper plate, cut three thin, short strips of plain white paper (approximately 2 mm wide). Then add glue to one edge of each strip and glue the strips to the bottom of the temperature sensor groove. The paper forms a basket-like structure which insulates the temperature sensor from the copper plate. Now you are ready to attach the temperature sensor. Once it has been attached, cut off the extra paper.
(Check: Step-by-step tutorial, Fig. 01)

The copper plate can now be joined to the PCB board. Place the PCB board onto the copper plate and pass the three laser diode pins and three temperature sensor pins through their corresponding holes on the PCB board. Once they are in place, solder them onto the PCB board using tin (0.5 mm) and a solder.
(Check: Appendix A, Fig. 02)

To secure the PCB board onto the copper plate use four (M1.6x3) screws to attach its four corners.
(Check: Step-by-step tutorial, Fig. 03)

Now, take the 6-pin male header strip and press the plastic part onto one side of the pins. This lengthens the pins, allowing them to be correctly attached to the trigger board.
(Check: Step-by-step tutorial, Fig. 04)

Finally, attach the 6-pin male header strip to the top of the PCB board through its six holds and solder it to the board.
(Check: Step-by-step tutorial, Fig. 05)
Laser module

The following components and tools are required to assemble the laser bore:

- Laser bore
- Cylindrical lens & Holder
- Aspherical lens & Holder
- Polarising plate
- M2x5 screws (2x)
- Allen keys
- Cutter
- Plastic tube
- Araldite glue
- Air pump

Place both the aspherical and convex lenses each into their corresponding lens holder. Note that the curved part of the convex lens must have an upward orientation. To secure both lenses in place, carefully apply Araldite glue on to the edges of the lenses using a thin tool – for example, a pin. For the aspherical lens, the glue is applied onto the sides through two holes on the lens holder; but for the convex lens the glue is added from the top in the area between the edges of the lens and the edges of the lens holder.

(Check: Step-by-step tutorial, Fig. 06)

Once the glue is dry, position the polarising plate on top of the convex lens holder.

(Check: Step-by-step tutorial, Fig. 07)

Note: it is very important to check the diagram before placing the lens holders into the laser bore.

(Check: Next page)

Now the lens holders can be joined onto the laser structure. Start by positioning the convex lens holder in place, while maintaining a vertical orientation for the polarising plate – the same orientation through which the laser beam will be projected onto the surface of the scanned object. Push the lens holder into the hole of the laser module using a plastic tube of the same size as the lens holder.

(Check: Step-by-step tutorial, Fig. 08)

Scrape off any extra dry glue from the aspherical lens-holder – so that it can fit easily – then push it behind the cylindrical lens-holder.

(Check: Step-by-step tutorial, Fig. 09)
**Laser bore cross cut A (dimensions in mm)**

**Laser bore cross cut B (dimensions in mm)**
Cameras

The following components and tools are required for the cameras:

- Camera board
- Camera holder
- Isolator film (2x)
- Camera (2x)
- Lens & Holder (2x)
- M3x16 screws (2x)
- M1.6x6 screws (4x)
- M2x3 plastic washers (4x)
- Hexagonal star screwdriver
- Lens handling tool
- Air pump
- Allen keys

Make sure that the two lens-holders are facing one another as they are symmetrical. Positioning them correctly before assembly prevents errors such as inserting the cameras in the wrong orientation. Then, screw the lenses onto the lens-holders. The image shows the camera lens fastened onto the lens holder. 

(Check: Step-by-step tutorial, Fig. 10)

Place the lens holder in a well-supported position. On top of it place the Isolator film, in order to avoid contact between the metal body of the lens Holder and the Camera board.

(Check: Step-by-step tutorial, Fig. 11-12)

Use the hexagonal-star screwdriver to unscrew the four interior screws from the camera board that attach it to its protection.

(Check: Step-by-step tutorial, Fig. 13)

Quickly and carefully remove the plastic cover from the camera board and place it on the isolator film. This procedure should happen quickly because leaving the camera exposed to light, air and dust weakens its sensors and could damage it. Prepare four M1.6x6 screws and M2x3 washers. Place the washer in the correct position onto the board. Start adding the screws in a diagonal order for stability purposes. Finally, fix the camera holders to the camera bar using three Mx16 screws.

(Check: Step-by-step tutorial, Fig. 14)

Note: the plastic washers are longer than their screws. It is thus necessary to cut the extra material in order to shorten them.

Note: it is important to be extremely careful while moving the camera board from its protection case to the camera holder.

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Full scanning head

The following components and tools are required for the full scanning head assembly:

- Camera bar
- Connection plate
- Laser module
- Cable-tray Bracket
- Internal clip
- Protection plate
- M2 washers (6x)
- M2x10 screws (6x)
- M3x5 screws (2x)
- M1.6x3 screws (2x)
- M2x5 screw
- M2x5 grub screws (2x)
- Allen keys

To begin, attach the camera bar to the connection plate using a set of four M4x12 screws and two dowel pins.

(Check: Step-by-step tutorial, Fig. 15, 16)

Now fix the laser module onto the connection plate using 6 (M2x10) screws and 6 M2 washers. Then, attach the cable-tray bracket to the side of the laser module using 2 (M3x5) screws. At this point, the scanner-head assembly is almost complete. Attach the internal clip to the connection plate using an (M2x5) screw.

Now you can mount to scanning head onto the horizontal slide carriage using four M3x10 screws. Then connect the scanning head onto the Arduino using a flat ribbon cable and mount the scanner head onto its stand.

The scanner head is now ready for testing and laser alignment. The laser beam must first be adjusted to ensure that it can project in a vertical, centered line. Attach the scanning head onto a horizontal backing frame – this will house the polycarbonate laser adjustment tool that will assist in laser beam rotation (LBR). Place the LBR tool onto the horizontal guide beneath the scanning head and tighten it. Now, using the same plastic tube that was used to insert the lens-holders, adjust the orientation of the cylindrical lens-holder, making the slit on the polarising plate completely vertical.

(Check: Next page)

After adjusting the laser beam, position the protection plate onto the laser module and fix it with two M1.6x3 screws

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Adjusting laser beam

The following components and tools are required for adjusting the laser beam:

- M2x5 grub screws (2x)
- Allen keys
- Laser adjustment tool
- Lense adjustment plastic tube

To start, loosen the two grub screws at the side of the laser structure and place the laser adjustment tool on the horizontal guide. This tool is made of transparent polycarbonate; it has a grid of vertical engravings onto which the laser is projected.

Look at the laser on this grid: the laser lens adjusting plastic tube should be used to slightly rotate the cylindrical lens holder until it reaches a completely vertical position. Now tighten the two grub screws.

The second step involves centering the laser beam projection onto the laser adjustment tool. In order to centre the laser beam, un-tighten the two M2x5 screws at the back of the laser control board. Shift the board slightly, until the laser beam projection reaches the centre of the laser-adjustment tool.
Cameras setup

The following components and tools are required for aligning cameras:
- M2x5 grub screws (2x)
- Allen key

Configuring the cameras

Access the IDS Camera Manager software. This software enables the user to change the ID number corresponding to the camera and allows the scanning software to read it. On IDS Camera Manager software, open the Camera Information tab and change the Camera ID to the necessary port number, ie. Cam1 - Port 1 and Cam2 - Port 2. To check the port number unplug one of the cameras and see which one remains on display.

Adjusting the cameras

After mounting the scanner head onto the horizontal guide and checking the necessary connections, open the Lucida Application. In the settings tab, check the camera window: start by identifying Camera A and Camera B. Once identified, carry out the following steps with both Cameras A and B:

01. Adjust the focus of the lens by screwing it in/out: loosen the grub screw at the side of each Camera holder. Remember to re-tighten the grub screws once the focus is adjusted.
02. Adjust the rotation angle by rotating the lens holder.
03. Adjust the view-window by unscrewing the four screws at the back of the camera board (just enough to allow free motion). Shifting the camera board horizontally will appear on the live view window as vertical motion.
At the end of the alignment process, the camera profile seen in the calibration window should look something like this for both cameras:

Components

The following components are required for assembling the scanning head (see next pages for reference pictures):

A  Laser bore  
B  Camera holder (2x)  
C  Camera bar  
D  Connection plate  
E  Cable tray bracket  
F  Laser diode plate  
G  Laser diode  
H  Aespherical lens holder  
I  Cylindrical lens holder  
J  Aespherical lens  
K  Cylindrical lens  
L  Polarising plate  
M  Bore protection plate  
N  Camera (2x)  

The following screws, grub screws and washers are required:

(2x) M1.6x3 screw  
(4x) M1.6x6 screw  
(1x) M2x5 screw  
(6x) M2x10 screw  
(4x) M3x5 screw  
(2x) M3x16 screw  
(4x) M4x12 screw  
(4x) M2x5 grub screw  
(4x) M2x3 plastic washer  
(6x) M2 metal washer
Step-by-step tutorial

Summary of the necessary steps for assembling the Scanning head:

01. Using strips of plain white paper, prepare the copper plate that will house the temperature sensor. Note, the laser diode is already in.
02. Solder the temperature sensor onto the PCB board.
03. The PCB board is attached to the copper plate with four screws.
04. Adjust the 6 male pin header in place before soldering.
05. Solder the 6 male pin header to the PCB board.

06. Carefully place the cylindrical lens in its holder, with the curved side facing upwards.
07. Stick the lens onto its holder using Araldite glue. Then place the polarising plate on top.
08. Once the glue is dry, remove the extra projecting layer of glue.
09. Place the lens holder in the laser bore using the plastic tube.

10. Position the camera holders into the correct orientation.
11. Insert the threaded camera lens into the camera holder.
12. Use two surfaces to support the camera holder (facing downward) for easy access while putting the Camera boards in place.
13. Use the hexagonal-star head screwdriver to unscrew the four screws holding the camera protection.
14. Place the camera board on the camera holder.

15. Use two dowel pins to position the connecting plate to the camera bar before attaching it with screws.
16. Fix the laser module to the plate using six M2x10 screws.

17. Image of the assembled control unit, showing the position of the three microcontrollers, the Arduino board and the other components.
Control unit

As with the previous tutorial on assembling the Lucida head, this tutorial is only designed as a reminder for someone who has already assembled several control units with the help of one of Factum’s operators. It takes the user through the steps required with the aid of diagrams.

Components and tools:
Microcontrollers (3x); Arduino Board; M3x8 Screws (10x); Acrylic base; Power supply cable (200 cm); Flat ribbon cable (15 cm); Conductor cable (600 cm) (4x); Ferrite for Power supply cable; Ferrite for Flat ribbon cable; Ferrites for Flat ribbon cable divisions (2x); Motor connectors (3x); Solder; Tin; Allen keys; Flat head screw driver

01. Place the three controllers and Arduino board in their corresponding locations on the acrylic base, then attach them using the 10 M3x8 screws. Tighten the screws. Make sure that the Acrylic Base is placed on the right before positioning the screws.
02. Prepare 15 cm of flat ribbon cable.
03. On one end of the cable place a Ferrite and fix a connector, placing the red cable on the right side while connected to the PBC board. The flat ribbon cable will have 10 wire divisions, but only the first seven will be needed.
04. Separate the first seven wires, starting with the red edge as N. 1 and place them in the sockets at the head of the 3 Controllers in the order shown in the previous diagram.
05. Once each wire is placed in its location tighten the screw. For wire N. 5 and wire N. 6 fit on them a small Ferrite to reduce signal noise before placing them each in the corresponding socket.
06. Now prepare two 2.5 cm sections of the power supply cable.
07. The power supply cable is made of two divisions, one black and the other red. The black one will be used as the ground cable and the red one as the voltage cable. Separate the voltage and ground wires that you have prepared then place them in their sockets, as shown on the diagram above.
08. Then prepare 2-meter-long power supply cable. Place one end of the cable in the sockets on the third controller where the arrows are located on the diagram. Then solder the other end to the round connector.
09. Prepare 3 sections of a conductor cable each 1.5m – 2m long (the length is dependent on the job that the set will be used for).
10. When the 3 wires are ready remove from each side 3cm – 4cm of the plastic coat, exposing the four inner wires on each side.
11. Then remove a section of the coat around 0.5 mm long to expose the copper wire. Solder the wires onto the connectors in the following order:

<table>
<thead>
<tr>
<th>Color</th>
<th>Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Red</td>
</tr>
<tr>
<td>Red + White</td>
<td>Yellow</td>
</tr>
<tr>
<td>Green</td>
<td>Blue</td>
</tr>
<tr>
<td>Green + White</td>
<td>White</td>
</tr>
</tbody>
</table>

Note: if the colours are different try coming up with the best fit combination and remember to note it down

12. For the other end, place each conductor cable in a controller following the order previously shown.

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Troubleshooting

What if the scanner head is connected to the computer but the laser beam is not appearing?
There could be two problems: either the ribbon-cable connecting the trigger board to the Arduino or the USB cable connecting the Arduino to the computer are malfunctioning. Start by checking the connection of the two cables. If they are well connected and do not show any problems then check the trigger board and Arduino board connection through the shielded flat ribbon cable.

What if the laser beam is not projecting as a clean line?
This problem is very common once a scanner head has been finished and is and ready to go on the horizontal guide. The first step towards solving it is to unscrew the laser control unit and take out the laser lenses. Start by checking whether the glue has touched any part of the lens (the aspherical lens or the convex lens) edges. If the glue has found its way onto the surface of a lens, then this lens must be replaced. Otherwise clean both lenses thoroughly. The laser line should be clean again. For changing the laser lenses please refer to the section: Mounting the Laser Module.

What if the laser intensity is lower than it should be?
This kind of problem can only be spotted once all the preparation steps are done and the scanner head is ready for calibration. At this point the laser intensity must be lowered to its minimum value which is ‘1’ (this is why the calibration plate has a shiny metallic surface – the intensity value of ‘1’ should be enough). The laser should appear as a clearly defined white line in the camera window. There is a problem if the line is dim or dark grey. However, it is best to carry on with the calibration and make sure that there is really a problem. When there is an evident problem no response will occur on the screen after pressing the “Pulse” button and the software will crash. Now you are sure there is a problem with the laser diode. A weak laser will later affect the scanning of dark surfaces and lead to data loss in the darker shades of the spectrum. The only solution is to change the laser diode. It is not necessary to change the entire copper plate or PCB board and this would rather be considered a waste.

What if the scanner head was perfectly assembled but during calibration or scanning the software crashed or the scanner head moved without any information showing on the screen?
In this situation, the problem is probably related to the video wires connecting the two cameras to the trigger board. To ensure that the problem is coming from the video wires, test another scanner head with the wires from the malfunctioning head. If the problem persists then the video wires must be replaced. If you test the wires using the voltmeter, they might show positive results but if they are not functioning properly with the head, then they must be changed.

What if the camera view in the settings tab detects the signal more slowly than it should?
In this situation check the USB port that is used for the slow Camera(s), as the problem could be that the USB ports used for both cameras are sharing the same power supply on the computer and this will show a failure in detecting the signal. In this case, the cameras start performing poorly. You can solve this problem by plugging the camera USB in a different port.
Contact us

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If you ever need help with your Lucida, email the address above. To help us understand the problem it is very helpful to include pictures or a video as attachments with your email.

You can also telephone us: +34 915 500 978

Feedback
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For general questions or for your comments and ideas send an email to the address above.

For more information
www.factum-arte.com
www.factumfoundation.org

Resources
Lucida user’s manuals can be downloaded from Factum Arte’s website:

Assembly Instructions
factum-arte.com/lib/kcfinder/upload/files/Lucida/manuals/2015_Lucida_A5_Assembly_Final.pdf
https://vimeo.com/8261186 (password: factum53)

Operator’s manual
factum-arte.com/lib/kcfinder/upload/files/Lucida/manuals/2015_Lucida_A5_Operator_Final.pdf

Processing applications
factum-arte.com/lib/kcfinder/upload/files/Lucida/manuals/2017_Lucida_A5_processing_Final.pdf