REACTIVE DIGITAL SYSTEMS

TOPOBOX

educator edition assembly guide

→ **Assembly Time: 3-4 hrs with 2 people**

PART
one

[Assembly of wooden sandbox and legs.]

1. Lay out the leg beams and spreader boards. To screw the boards to the leg beams, you will use the included screwdriver and T25 bit.

2. Begin screwing the boards to the legs with the countersunk pre-drilled holes facing outwards. Leave the wood screws loose.

3. When you have a few boards attached to the beams, you may find it easiest to place the assembly upside down (with the casters upwards) and have a partner hold the beams upright while you attach the remaining spreader boards. Attach all spreader boards.

4. Tighten the screws evenly, working your way around the structure and tightening each screw a little bit at a time to avoid warping or skewing the box.

5. Flip the assembled structure so the wheels are on the ground, and lock the wheels so the table stays in place while you complete the rest of the assembly.

6. Rest the shelf on the lower spreaders. The two “feet” attached to the shelf should be facing the floor.

7. With help from a partner, lift the empty sandbox and rest it on top of the assembled leg structure. It should fit in place without any screws or fasteners.

PART
two

[Attaching metal mast to wooden sandbox.]

1. One of the long sides of the sandbox will have four sets of two screw holes (two at each end). Attach a 6-hole flat bracket using four silver wood screws (shown in image). You will use the included 10mm socket bit to attach the screws.

NOTE: Two holes on each bracket should extend over the side of sandbox. Tighten the screws so that they are snug.

2. Attach a T-nuts to each set of overhanging bracket holes with two 1/2" ¼x20 screws. The T-nut should face toward the inside of the box. Loosely tighten the screws until they just begin to thread. The raised side of the T-nut should face away from the bracket.

PART
two | continued

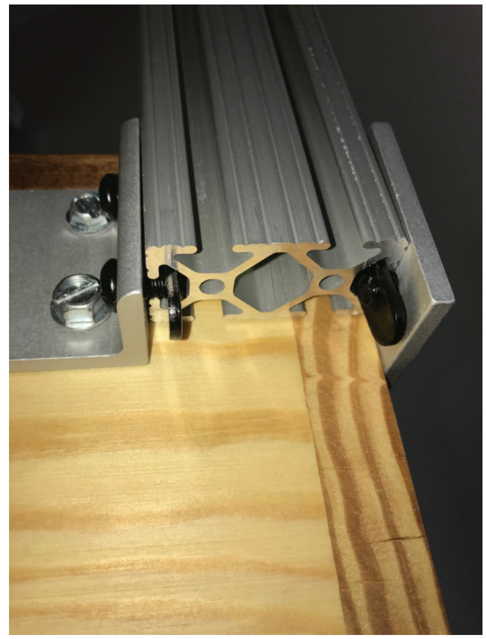
3. Grab four L-brackets. Attach a T-nut to the short side of each bracket (what would be the bottom of the L) with 2 1/2" ¼x20 screws. Again, the raised side of T-nut should face away from bracket and the screws should go through the bracket first. Tighten the screws until they just begin to thread.

4. Bring the four L-bracket/T-nut assemblies to the box structure. On the short sides of the sandbox, there will be two sets of two screw holes adjacent to the flat brackets you already installed. Attach the long side of each L-bracket to the set of screw holes using more silver 10mm screws, tightening gradually. The short side of the L-brackets should stick out away from the box, and the T-nuts attached to the 6-hole brackets and L-brackets should face each other.

NOTE: You will not tighten wood screws completely until Step 5.

PART

two continued



5. Take each 48” upright (the longest beams in the package) and slide them between the L-bracket and flat bracket, making sure the T-nuts slide into the grooves on the narrower, single-grooved sides of the upright.

NOTE: The beam will have two circular holes at one end. Make sure the holes are 1) at the top of the beam and 2) facing the interior of the sandbox.

(ANOTHER) NOTE: The beam should be flush with the bottom of the lower brackets. If necessary, loosen the bracket screws to make it easier to slide the uprights through.

Tighten the bracket screws with included T-handled Allen wrench. Tighten into the metal uprights fully before tightening the rest of the wood screws into the box.

PART
two | continued

6. To have a better angle for the rest of the assembly process, lift the box (with help from a partner) with the uprights attached and set it down on the floor.

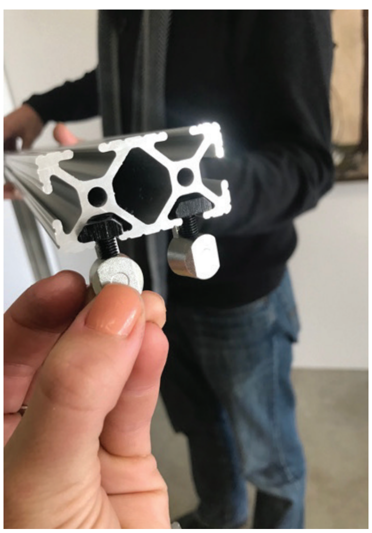
7. Take the 43” metal beam and rest it with the wide side down on top of the uprights. Make sure the ends of each piece are flush with each other.

PART

two | continued

8. Grab four anchors (pictured below). Loosen them with the yellow-handled Allen wrench. Fit the black component of each anchor into each groove on the bottom of the 43” uprights. The silver component of each anchor should slide in to the two holes in each 48” beam and be flush with back of the anchor and the sides of the metal beams.

NOTE: The text will be facing the interior of the box on both sides. Do not tighten anchors.



PART
two | continued

9. Repeat for other side. The flat back of the anchors should face each other. Tighten all anchors through the grooves of the 48” uprights with the Allen wrench.

10. Place the 2”x2”x4” projector mount base on top of the beam. Use an anchor to connect the 2”x2”x4” to the 43” crossbeam. The anchored side of the mount should face the back of the box, as shown in photo. Slide the mount stand to the center of the beam and tighten the anchors down through the grooves of the mount base.

PART

two | continued

11. Assemble two more L-brackets with T-nuts attached to each hole with 1/2” ¼x20 screws. All T-nuts should be attached to the outside of the “L” with the screw heads on the inside.

12. Slide the parallel T-nuts on the four-holed side of each assembled L-bracket into the grooves on top of the beam. Slide both brackets in on the right side of the projector mount base (as you stand facing the front of the box) with the short side of each “L” facing the other.

PART

two | continued

13. Slide the 15” metal beam between L-brackets with the exposed T-nuts while fitting into the beam’s groove. The back of 15” beam should be flush with the edge of the 43” beam, and the round anchor hole on the beam should face the right side of the box.

Tighten the T-nut screws into the 15” beam but do not tighten the L-brackets down into the 43” beam. You should still be able to slide the 15” beam and L-bracket set-up from side to side in the tracks of the 43” beam.

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PART

two | continued

14. Attach T-nuts to perpendicular sides of the triangle brace with 1/2” ¼x20 screws. The T-nuts should be outside the triangle and the screw heads should be on the inside.

PART

two | continued

15. Slide the T-nuts in the triangle brace in the left side of the groove of the 15” beam. The perpendicular side of the brace should be flush with the end of the beam, and the T-nut should extend slightly over the end. Tighten the T-nut screws into the 15” beam.

PART

two | continued

16. Get the 11” beam and slide it on to the exposed T-nut on the triangle brace so the back of the 11” beam is flush with the outside edge of the 15” beam. The two beams should create an “L” shape.

17. Slide an anchor into back of this “L” with the round component fitting into the screw hole on the edge of the 15” beam and the flat part sliding into the groove on the 11” beam. Tighten the anchor through the grooves of the 15” beam so it is flush with the edge of the beam. Tighten the T-nut screws in the triangle brace and the 11” beam.

PART
two | continued

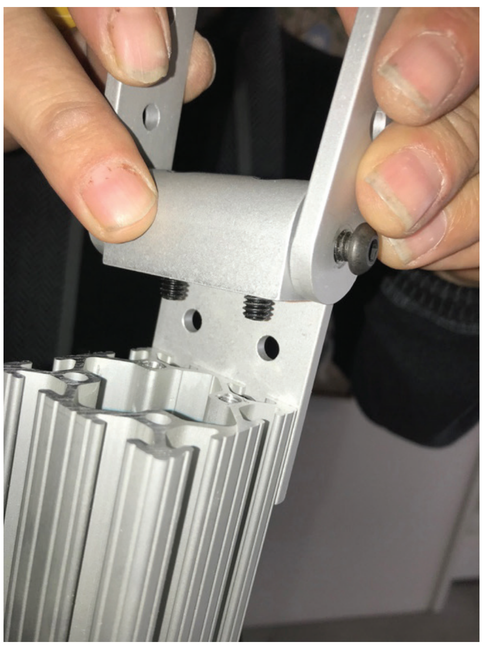
18. Use 1/2" ¼x20 screws to assemble one 6-holed flat bracket with 2 T-nuts, one in each hole at the bottom of the bracket. As usual, the screws should go through the flat bracket before the T-nuts, and the raised side of the T-nut should face away from the bracket.

19. Slide the T-nuts into the grooves on the backside of the projector mount base. Tighten the screws so the bracket extends above the top of the projector mount base and the top two holes of the bracket are open and exposed.

PART

two | continued

20. Mount the hinge into the two threaded holes in the 2”x2”x4”, with the curved side forward. Tighten the screws into the 2”x2”x4”. Load the four holes.

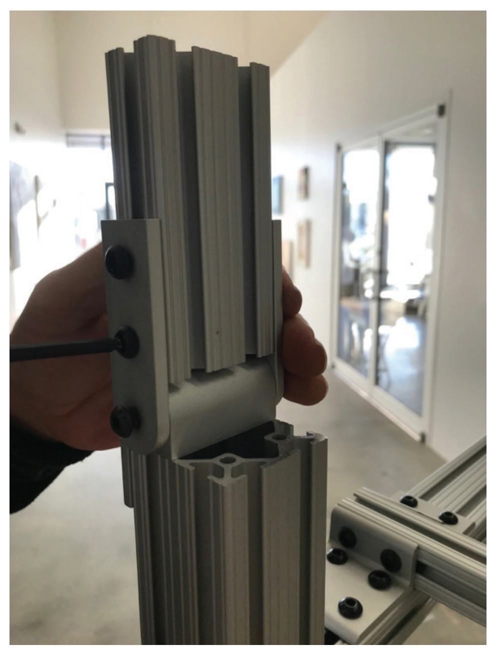


PART

two | continued

21. Load the four holes in the hinge with T-nuts and screws.

22. Slide the 1”x2”x4” projector mount into the T-nuts attached to hinge. With the 1”x2”x4” pointing upwards, press it downwards while tightening the T-nuts.



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PART
two | continued

23. Grab the safety collar and slide it over the 1”x2”x4” projector mount, ensuring it covers the flat bracket. This will secure the mount in a vertical position.

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PART
two | continued

24. Insert two 1/4x20 screws, washers, and lock washers into the spider mount, using the two curved slots just above the empty hole on the perimeter. Attach a single T-nut to each screw so the T-nuts are on the opposite side of the disc. Slide the T-nuts into the front grooves of projector mount beam so the arms face the inside of the box. Tighten the projector mount once it is in place.

PART

two | continued

25. Unwrap the projector. Loosen the arms of the spider mount and then rotate arms to line up with brass screw holes on back of projector. Attach the projector to the spider mount with the lens pointed downward. Fetch M4 screws and washers from the kit (in a separate plastic bag). Start with top arm and use the M4 screws and washers to fasten the mount arms to the projector. Tighten the screws with the included H3 Phillips head.

PART

two | continued

25. Using four zip ties, attach the Kinect sensor to the 11” metal beam so the sensor points downwards. The base of the sensor should point toward the back of the box. Tighten the ties so the sensor is snug against the beam. Make sure you do not cover up any of the sensors with the zip ties.

PART
three

1. Now it's time to start plugging in the electronic components.
2. Plug power cord into computer tower and plug the other end into a power outlet. Use the shorter cord provided.
3. Plug power cord into projector and plug the other end of cord into a power outlet. Use the longer cord provided.
4. Plug the HDMI cord into the corresponding port on the back of the computer. Plug it into the lower, horizontally oriented port, which feeds into the computer's video card.

NOTE: Do not plug the cord into the upper, vertical HDMI port.

5. Plug the other end of the HDMI cord from the computer into the HDMI port on the projector.
6. Plug orange tipped Kinect cord into adapter. Plug the adapter into the computer via a USB port. Plug the Kinect sensor's power cord into the power source.
7. Turn on both the computer and projector.
8. Unwrap keyboard. Plug included dongle into USB port on computer tower.

NOTE: Be sure you do not discard the dongle. You will find it in the keyboard package.

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PART

three | continued

8. At this point, you should darken your room to align the projector. An image should now be projected on the bottom of the box.

9. Set the projector's zoom on to its widest setting by using the upper toggle (labeled with a "T") on the front of projector above the lens. Leave the zoom on this setting.

10. Use the projector remote to open the settings menu for the projector. Press "Menu," then select "settings," and from there select "keystone". Select "H/V Keystone and set both the H and V keystone to 0. Turn Auto V-Keystone off.

11. Exit out of "Settings" by pressing "Menu." The projected image should fill the box up to top edges and be square within the frame of the box. If needed, tweak the position of projector by unscrewing the top arm from back of projector and gently bending it back to move picture forward. If you need to move the image back, add more washers between the screw and the projector arm. These adjustments will require trial and error.

12. Once the picture is adjusted properly, press "menu" on the remote, select "extended," then "projection," and choose "set to front." Exit out of the menu.

13. You now have a functional TopoBox! You can quickly test the software by placing an object inside the box and seeing how the projection changes. At this point, the image is likely misaligned. In the final step, you will make final adjustments to the image.

PART
four

1. Make sure the projector is fully zoomed out using the dial near the lens.
2. Grab the wireless keyboard and open the Sandtable Tools folder on the desktop, double click the icon 2-RawKinectViewer.sh and click on “Run in Terminal”. This will open theRawKinectViewer window, and you should see two images projected side by side. One image shows a video feed, the other shows a depth image.
3. Look at the depth image and slide the camera arm in the grooves of the 43” support beam to adjust the image. Center the image so it is square within the frame. The walls of the box should be obvious in the depth image. If you need to move the image forward or backward, you can adjust the screws that go into the camera arm. Once camera image is in the desired position, tighten the screws that go down into the 43” beam. The image may move slightly, so adjust the screws as necessary to get the image back in place.
4. Re-focus image if necessary. The focus toggle is located above the zoom toggle.
5. With a partner, lift and re-mount table on top of wheeled stand. Mount the computer tower on shelf below table. Unplug cords if necessary. ALWAYS WAIT FOR THE ELECTRONICS TO POWER DOWN BEFORE UNPLUGGING CORDS.

PART
four | continued

7. Rout the wires by running the sensor cord through top tracks of camera arm. Run the projector cord through top tracks of horizontal beam. Run all the cords down the 48” beam down toward the bottom of box. You can secure the cords by pressing them into the grooves of the metal beams or tie them down with extra zip ties.

PART
five

1. CONNECT AND CONFIGURE THE 3D CAMERA

Turn the computer and projector back on and stop the program by hitting the escape key. Double click the Sandbox Tools folder on the desktop. Then double click the icon labeled 1-GetCalib.sh. In the dialog box that will appear select “Run in Terminal”

You will be prompted for a password, which is Sandtable 1 Leave the Sandbox Tools folder open for the next steps.

The next steps are covered in the video : https://youtu.be/ClUaOcrXriw You should open it and follow along.

PART
five | continued

2. ALIGN THE 3D CAMERA

Ignore the color video stream on the right side of RawKinectViewer's display window and focus on the depth image stream on the left (the AR Sandbox does not use the color video stream). You can hold down the "z" key and move the mouse to help center the depth image in your display. The mouse scroll wheel will zoom in. You can close the RawKinectViewer by pressing the "esc" key.

3. MEASURE SANDBOX'S BASE PLANE EQUATION

You will need the RawKinectViewer again so start it by double click the icon 2-RawKinectViewer.sh and click on "Run in Terminal". You need to enter the base plane equation (and the 3D sand surface extents in the next step) into the BoxLayout.txt file in etc/SARndbox-2.5 inside the SARndboxsource directory. To edit the file double click the 3-Link to BoxLayout.txt icon

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PART
five | continued

Now enter the base plane equation as described in the video. To copy text from a terminal window, highlight the desired text with the mouse, and then either right-click into the terminal window and select “Copy” from the pop-up menu that appears, or press Shift-Ctrl-c. To paste into the text editor, use the “Edit” menu, or press Ctrl-v. Or, highlight the desired text in the terminal window with the mouse, and then move the mouse into the desired position in the text editor window and press the middle mouse button to copy and paste.

RawKinectViewer prints two plane equations when a depth plane is extracted: the first in depth space, the second in camera space. The AR Sandbox needs the second, camera-space, plane equation. After copying it, the equation has to be reformatted slightly. RawKinectViewer will print:

Camera-space plane equation: x * <some vector> = <some offset>

where <some vector> is a three-component direction vector defining the “up” direction in camera coordinates, typically close to (0.0, 0.0, 1.0), and <some offset> is the vertical position of the measured plane underneath the camera, which is in centimeters and negative. BoxLayout.txt needs that plane equation in the following format:

<some vector>, <some offset>

where the direction vector and the offset are separated by a comma.

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PART

five | continued

NOTE: For some reason, the depth plane equation reported by second-generation Kinect cameras (Kinect-for-Xbox-One) may be inverted. Before continuing, check that the fourth component (offset) of the camera-space plane equation is in fact negative. If it is not, flip the signs of all four components of the plane equation in BoxLayout.txt, e.g., (-0.01, 0.04, -0.9991), 105.3 becomes (0.01, -0.04, 0.9991), -105.3.

4. MEASURE SANDBOX'S 3D BOX CORNER POSITIONS

Measure the 3D extents of the sand surface. As of version 3.2 of the Kinect package, this can be done inside RawKinectViewer as well by following the instructions in the video on page . Make sure to measure the box corners in the order lower-left, lower-right, upper-left, upper-right. After you have copied the box corner positions into the text editor as described in the video, save the file (via the "File" menu or by pressing Ctrl-s), and quit from the text editor (via the "File" menu or by pressing Ctrl-q or by closing the window).

PART

five | continued

5. ALIGN THE PROJECTOR

Align your projector such that its image fills the interior of your sandbox. You can use the calibration grid drawn by Vrui's XBackground utility as a guide. Double click 4-XBackground.

After the window showing the calibration grid appears, press F11 to toggle it into full-screen mode. Ensure that the window really covers the entire screen, i.e., that there are no title bar, desktop panel, or other decorations left. Press the "Esc" key to close XBackground's window when you're done.

Ensure to disable all digital image distortion features of your projector before alignment, and only use optical features, i.e., optical focus adjustment and optical zoom. Specifically, disable any kind of digital keystone correction, and check that the projector maps the incoming video signal 1:1 to its display pixels. The best way to check for 1:1 matching is to look at the central horizontal bar in XBackground's test image. It should be a clear pattern of alternating white and black one-pixel-wide vertical lines with no smearing or stair steps.

Slight over-projection outside of the sandbox, and any remaining keystone distortion of the projected image, will be taken care of by the following projector calibration step.

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PART
five | continued

6. PROJECTOR/CAMERA CALIBRATION

Calibrate the Kinect camera and the projector with respect to each other by running the CalibrateProjector utility. To start it double click 5-CalibrateProjector and select Run in terminal.

The calibration program expects a disk of diameter 120mm (4.7"), which is a standard CD, CD-ROM, or DVD. The easiest way to create a calibration disk is to glue a sheet of white paper to the data side of a CD/DVD/…, carefully cut around the edge of the CD, and draw a cross onto the paper that intersects exactly in the center of the CD's hole.

NOTE: Do not worry if the projected calibration image (yellow background, yellow or green disk) does not line up with the physical sandbox. This calibration step will make the image line up after it's done.

RUNNING THE AUGMENTED REALITY SANDBOX

At this point, the Augmented Reality Sandbox is configured, calibrated, and ready to run.

SAND!

Your TopoBox is now ready to use. Add your preferred substrate and have some fun. We recommend white play sand. The resolution will be higher on brighter, whiter sand.

You'll need 200 lbs.

Add a little water to the sand for cohesion.