

REQUIRED HARDWARE

This tutorial focuses on installing and calibrating the software, but doesn't cover the details of the hardware setup. *(Note: Do not plug the Kinect or projector unit until instructed by the tutorial.)*

For detailed information on the hardware setup, see the AR Sandbox hardware tutorial.
Diversified Woodcrafts' ARS Series includes:

A Our first generation Kinect
B: Our short-throw digital projector (BenQ MW632ST)
C: Our Linux-friendly computer
D: Our 40"w x 30"D x 8"H Sandbox
(Not Included) Roughly 200 pounds of white sand like Sandtastik White Sandbox Sand

INSTALL SOFTWARE

A: Turn the computer on; make sure internet is connected
B: Open a terminal and run these three commands *(Note: All commands must be typed exactly as shown; upper and lowercase will make a difference):*

sudo add-apt-repository -ys ppa:system76-dev/weekend-project
sudo apt-get update
sudo apt-get install arsandbox

C: Find out what your user-name is by running this command in the terminal:

whoami

D: Add yourself to the *vrui-grp* group with this command, replacing **USERNAME** with the user-name returned by the whoami command above:

sudo adduser USERNAME vrui-grp

E: **Reboot your computer** so all the above changes take effect.

CALIBRATE KINECT

A: Plug-in the Kinect to the laptop and to the power source

B: Open the terminal and run:

KinectUtil getCalib 0

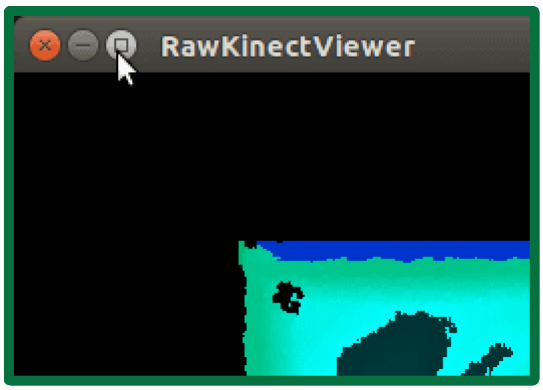
This will download the intrinsic calibration parameters directly from your Kinect's firmware and then write the result to a file in */etc/Vrui-3.1/Kinect-2.8/*

ALIGN KINECT ABOVE SANDBOX

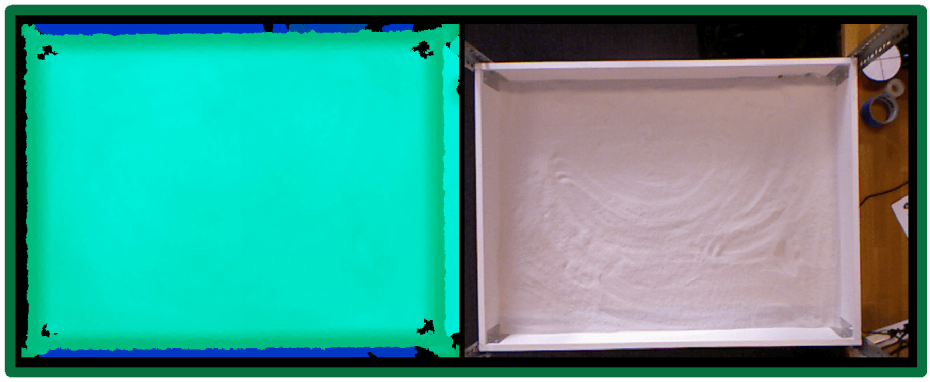
A: Open the terminal and run:

RawKinectViewer -compress 0

B: Maximize this window so it's easier to see your sandbox:



The image on the left is the depth view, the right is the standard camera view:



The Augmented Reality Sandbox only uses the depth view (left), but the camera view (right) is still helpful in aligning your Kinect.

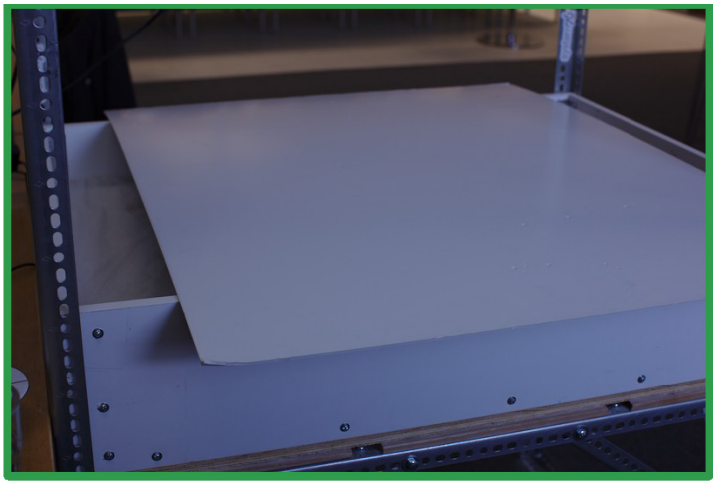
C: The depth view needs to cover the entire interior of your sandbox. It's okay if it overlaps it slightly.

D: Hit **Esc** to close the *RawKinectViewer.*

CALCULATE BASE PLANE

A: There are two ways to calculate the base plane. If you haven't yet filled your sandbox with sand, you can calculate the base plane using a region on the floor of your sandbox.

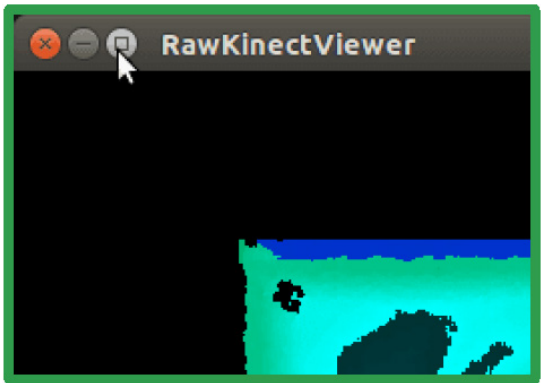
On the other hand, if you've already filed your sandbox with sand, you can calculate the base plane by placing a piece of poster board (or a similar flat surface) on top of your sandbox, which is what we'll do in this example:



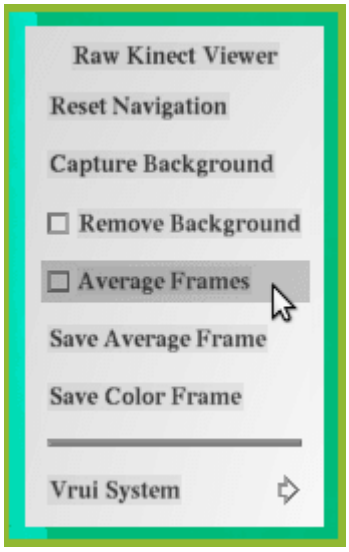
B: From a terminal, launch: the RawKinectViewer:

RawKinectViewer -compress 0

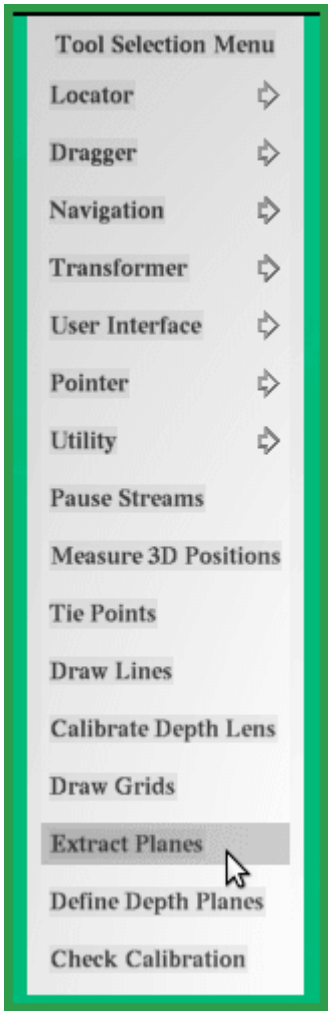
C: Maximize this window so it's easier to see your sandbox:



D: Press and hold the right mouse button, move your cursor over Average Frames, then release the mouse button:

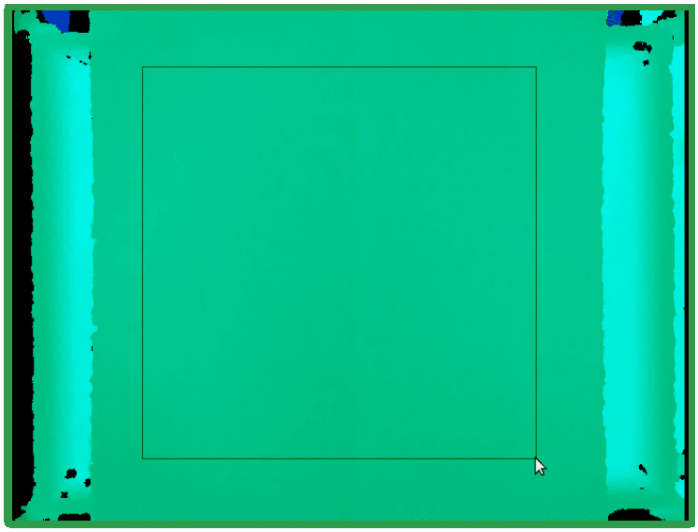


E: Press and hold the **1** key, move your cursor over Extract Planes, then release the 1 key:



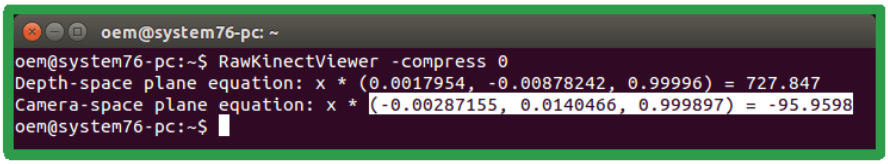
F: You now need to draw a rectangle that fits within the interior of your flat surface (in the depth view). You want some space between your rectangle and the edges of your flat surface.

Start with your cursor near the top-left corner of your flat surface. Press and hold the 1 key, drag out a rectangle toward the bottom-right corner, then release the 1 key:



G: Hit **Esc** to close the *RawKinectViewer.*

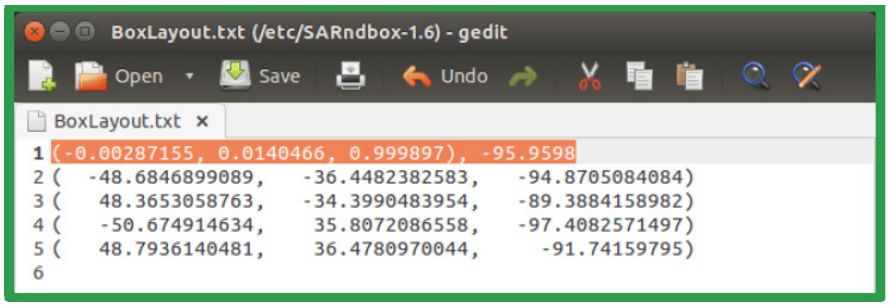
H: In the terminal you'll see two lines printed. Select the portion of the 2nd line shown below, then right click and select Copy:



I: Edit the *BoxLayout.txt* file by running this command from the terminal:

gedit /etc/SARndbox-1.6/BoxLayout.txt

J: Paste the line you just copied over the first line in the *BoxLayout.txt file.*
You also need edit this line, replacing the **"="** (equal sign) with a **","** (comma).
You should end up with a first line something like this:



K: Save the file and close *gedit*

MEASURE 3D EXTENTS OF SAND SURFACE

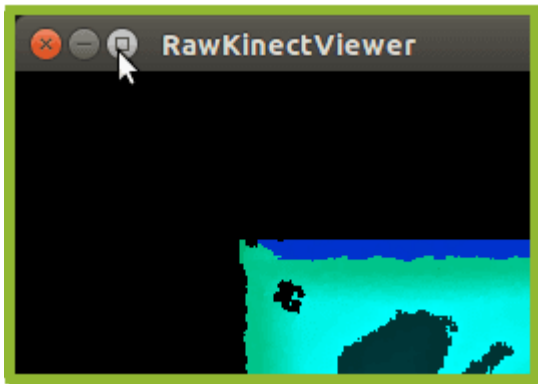
A: This step requires you to have filed your sandbox with sand. You want the sand surface to be as level as possible, but it doesn't need to be perfectly level.

If you placed a piece of poster board (or another flat surface) on top of your sandbox in the previous step, you'll need to remove it for this step.

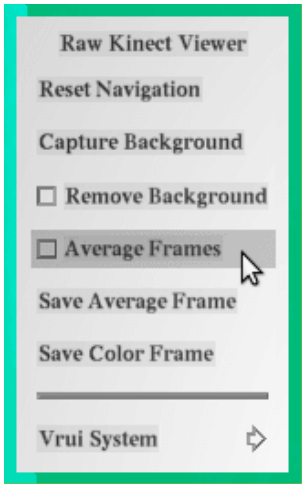
B: From a terminal, again launch: the RawKinectViewer:

RawKinectViewer -compress 0

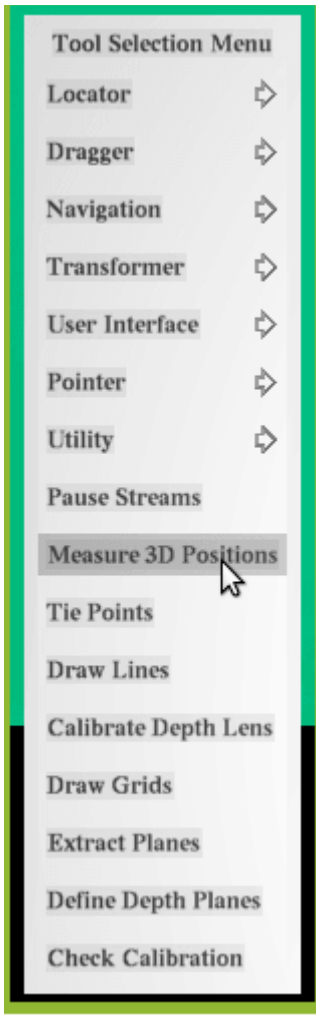
C: Maximize this window so it's easier to see your sandbox:



D: Press and hold the right mouse button, move your cursor over Average Frames, then release the mouse button:



E: Press and hold the **1** key, move your cursor over Measure 3D positions, then release the **1** key:

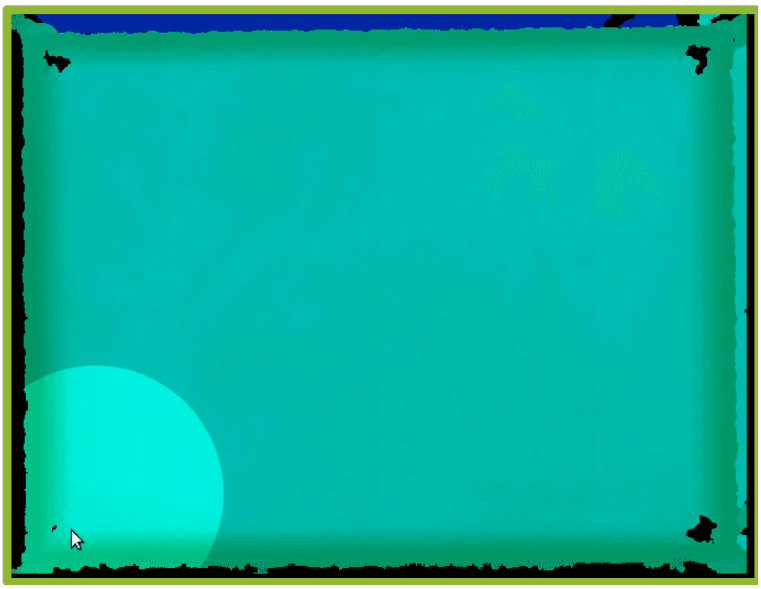


You'll now measure the 3D extents of the interior of the sandbox

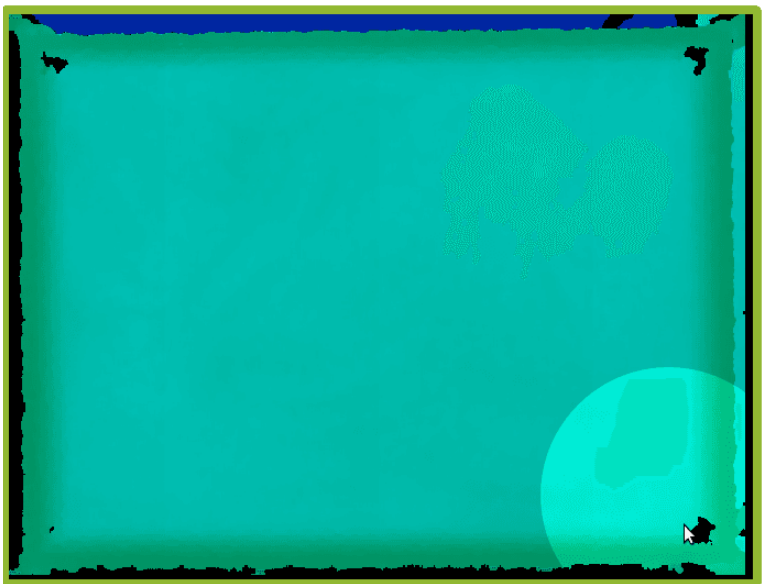
F: Use the color-coded depth map to make sure you position your cursor over the sand surface and not over the sides of your sandbox. Position your cursor so that there's a small amount of space between the sand surface and the sides of your sandbox.

First, move your cursor to the lower-left interior corner, then press the 1 key:

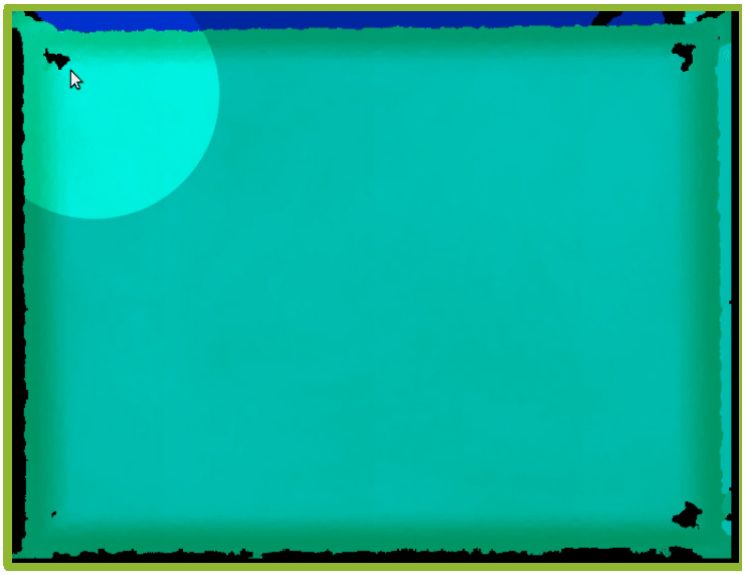
Note there is no feedback from the computer when you press the 1 key.



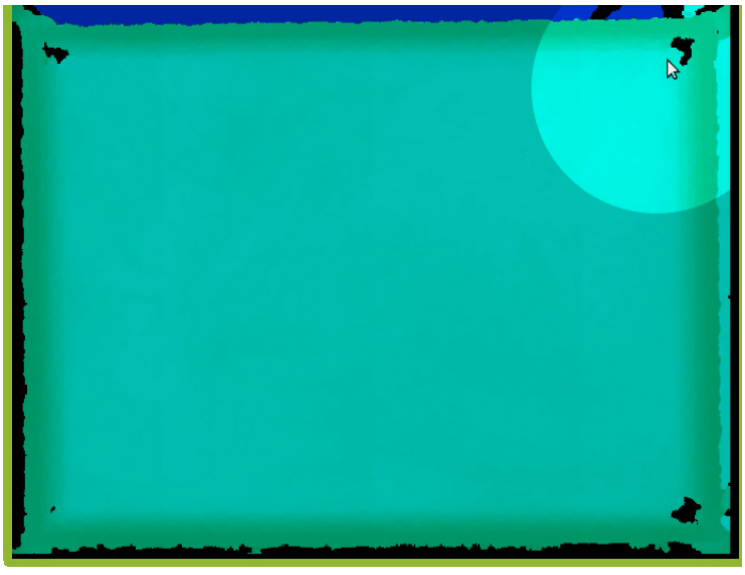
G: Second, move your cursor to the lower-right interior corner, then press the **1** key:



H: Third, move your cursor to the upper-left interior corner, then press the **1** key:

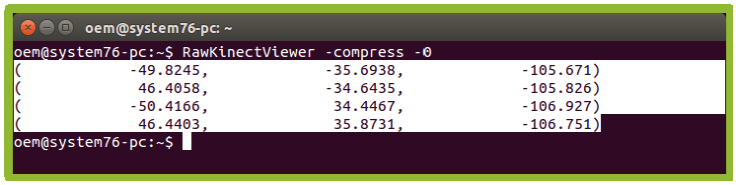


I Finally, move your cursor to the upper-right interior corner: then press the **1** key:



J: Hit *Esc* to exit RawKinectViewer .

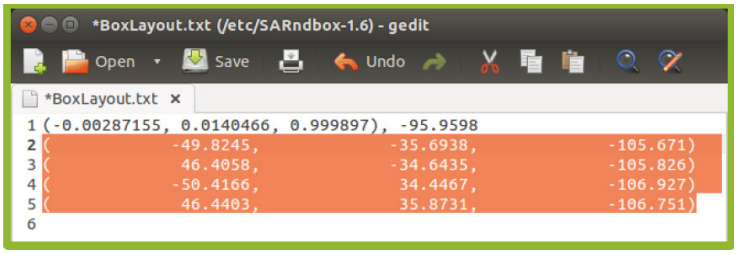
K: In the terminal you'll see four lines printed. You need to highlight these four lines as shown below, then right click and select *Copy:*



L: Edit the *BoxLayout.txt* file by running this command from the terminal:

gedit /etc/SARndbox-1.6/BoxLayout.txt

M: Replace the bottom four lines in *BoxLayout.txt* with the four lines you just copied, so you end up with something like this:

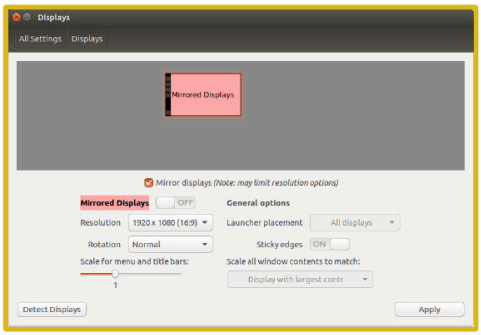


N: Save the file and close *gedit*

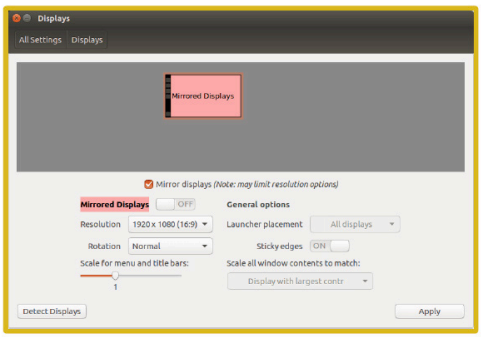
POSITION PROJECTOR

A: Turn on your projector and plug the HDMI cord into your computer.

B: If you have a dedicated display in addition to the projector, you'll find it easier if you set up the two displays to be mirrored:

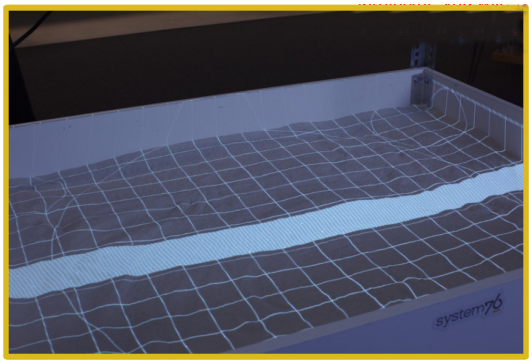


C: As the full-screen hot key for the Augmented Reality Sandbox currently dosen't work under Unity, we also recommend you set the Ubuntu launcher to auto-hide:



D: Launch the *XBackground* tool from a terminal like this:

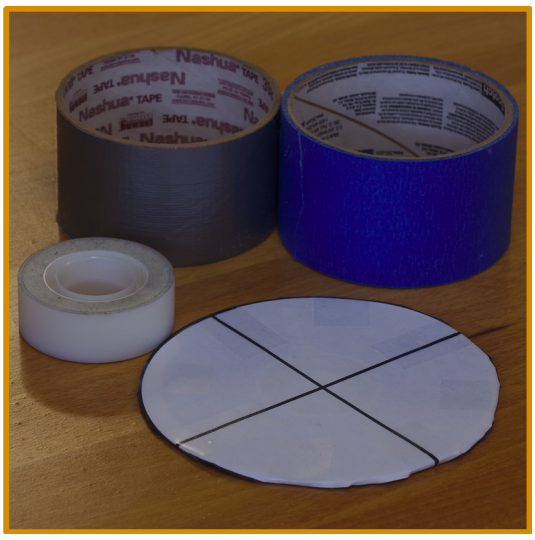
XBackground



E: You'll need to position the projector so that it fills the interior of your sandbox. It's okay if it overlaps slightly. Use the ▲and ▼buttons on the projectors remote to fill the interior of the sandbox. Each time your restart the projector, you will have to do this. If the arrows are not working. It may be that the "Menu" is still open. Close "Menu" on the projector's remote to close.

F: After you're done positioning your projector, hit **Esc** to close the *Background* application.

CALIBRATE AR SANDBOX



A: As with step 5, this step requires you to have filled your sandbox with sand. You want the sand surface to be as level as possible, but it doesn't need to be perfectly level.

B: To calibrate your sandbox, you'll need an alignment target and several spacers to help you perform the alignment at multiple heights:

The easiest way to build an alignment target is to create a target cross-hair on a piece of paper and tape it to the top of an old CD or DVD. The cross-hairs should be at right angles to one-another and be centered on the CD or DVD.

A few rolls of tape make great spacers. Note the rolls of tape need to have a diameter smaller than the CD or DVD you're using for the alignment target.

At each height, you'll capture 12 tie-points. For a decent calibration, you'll need to capture tie-points at least two heights (24 total tie-points). For an optimal calibration, we recommend capturing tie-points at three different heights (36 total tie-points)).

C: Launch *CalibrateProjector* from a terminal like this:

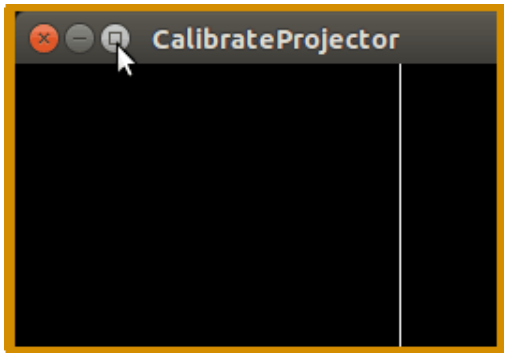
CalibrateProjector -s WIDTH HEIGHT

Replacing WIDTH and HEIGHT with the settings for your projector. The Kinect itself has a 4:3 aspect ratio, so a resolution like 1024x768 or 1600x1200 is best.

To match the resolution of the laptop we used in this tutorial, we set our projector to 1920x1080, but our particular BenQ projector allows us to force a 4:3 aspect ratio even when the resolution is a 16:9 aspect ratio. So in our case, we launched *CalibrateProjector* like this:

CalibrateProjector -s 1920 1080

D: Then maximize this window so it fills your entire sandbox:



E: Press and hold the **1** key, *move your cursor over Capture*, then release the **1** key:



F: Then press the **2** key when you see this dialog:

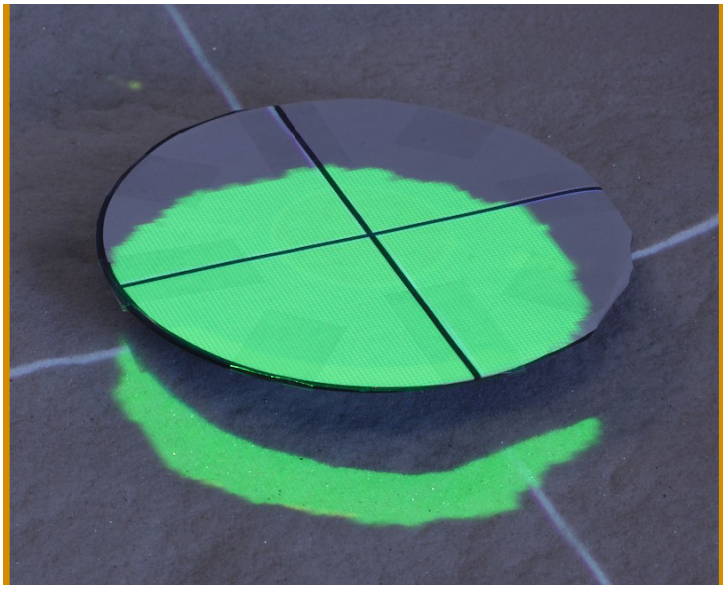


G: Press the **2** key to capture the background image, after which you'll briefly see a uniform red color projected onto your sandbox:



After this is completed, you can proceed with the calibration.

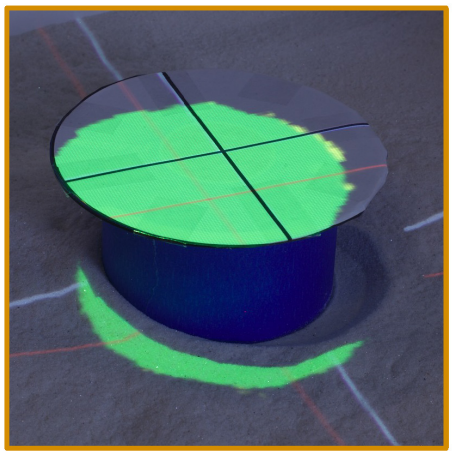
H: Next, you'll capture tie-points at the lowest height. Using your shortest spacer, line-up your alignment target under the white cross-hairs projected onto the sand surface:



Then press the **1** key to capture this tie-point. After a brief moment, the software will automatically move the projected cross-hairs to the next tie-point.

Repeat this process for the remaining 11 tie-points at this depth. Once the white projected cross-hairs are back at their original position, you're ready to switch to a taller spacer.

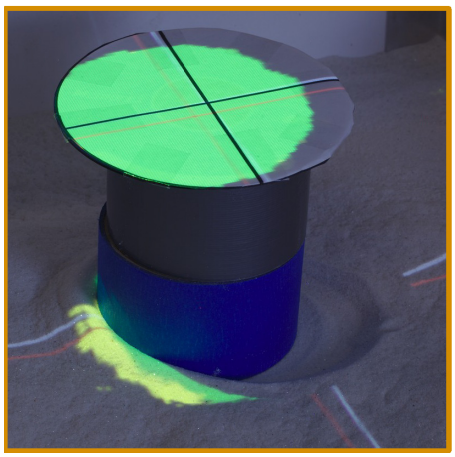
I: Now you'll capture tie-points at the middle height. Using a taller spacer, line-up your alignment target under the white cross-hairs projected onto the sand surface:



Then press the **1** key to capture this tie-point. After a brief moment, the software will automatically move the projected cross-hairs to the next tie-point.

Repeat this process for the remaining 11 tie-points at this depth. Once the white projected cross-hairs are back at their original position, you're ready to switch to a larger spacer.

J: Finally, you'll capture tie-points at highest height. Using your tallest spacer (or stacking two spacers on top of each other), line-up your alignment target under the white cross-hairs projected onto the sand surface:



Then press the **1** key to capture this tie-point. After a brief moment, the software will automatically move the projected cross-hairs to the next tie-point.

Repeat this process for the remaining 11 tie-points at this depth. Once the white projected cross-hairs are back at their original position, you're done with the calibration!

K: Once you've completed the calibration, hit **Esc** to close the *Calibrate Projector* application.

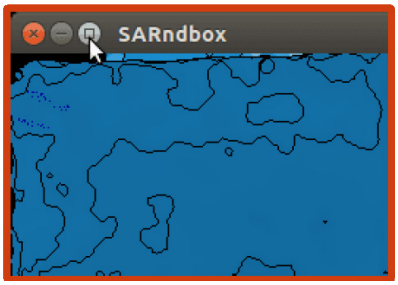
Hitting **Esc** will automatically write the calibration file in */etc/SARndbox-1.6/ProjectorMatrix.dat*

ADJUST THE "SEA LEVEL"

A: Launch the main *SARndbox* application by searching for "sandbox" in the Ubuntu dash:



B: Then maximize the application so it fills: your entire sandbox:



C: If in step 4 you calculated the base plane with a piece of poster board (or a similar flat surface) on top of your sandbox, your sea level will be too high, and you'll see something like this:



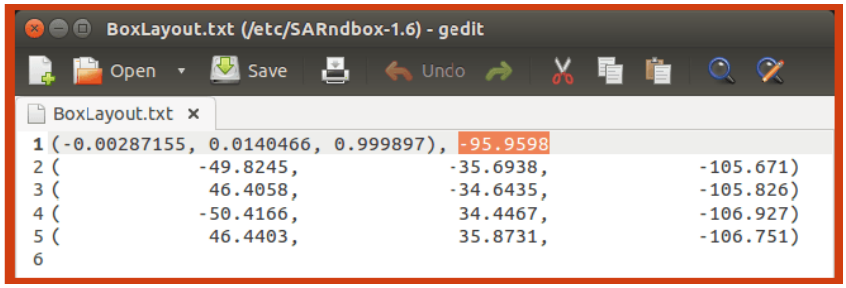
On the other hand, if in step 4 you calculated the base plane when your sandbox was empty, the sea level will be too low. Either way, you'll want to adjust the sea level so it's just below the surface of your sand when it's more or less flattened out.

D: Hit **Esc** to close the AR Sandbox D: application.

E: To adjust the sea level, edit the **/etc/SARndbox-1.6/BoxLayout.txt** by running this command from the terminal:

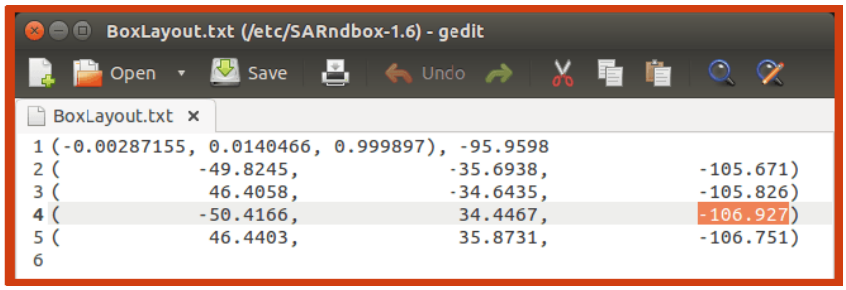
gedit /etc/SARndbox-1.6/BoxLayout.txt

The value highlighted below in **BoxLayout.txt** controls the sea-level:

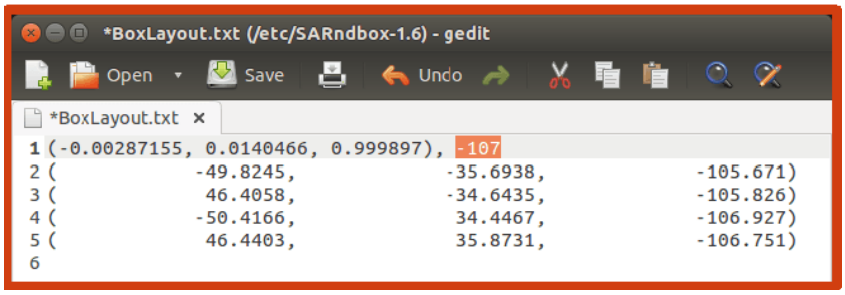


F: You'll want to adjust the final value in the first line to be roughly the same as the smallest of the final value on the four lines at the end.

In our example **-106.927** is the smallest value:

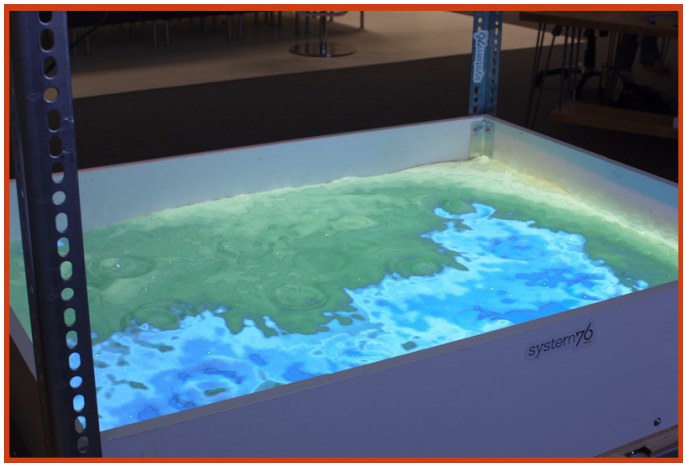


So we'll set the sea-level to -107 , like this:



G Save the file and close **gedit**

H: Re-launch the AR Sandbox application from the Ubuntu dash, maximize the window, and you'll see something like this:



You can experiment with different values for the sea-level to suite your preferences, but our recommendations here will give you a good starting point.

Note that you can adjust the sea level at any time in the future without recalibrating your sandbox.

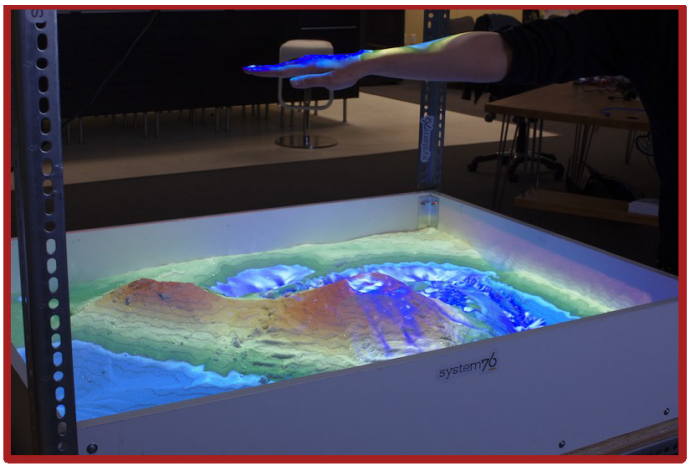
USE THE SANDBOX

A: Whew! You made it through the setup and calibration!

As long as you don't change the physical setup of your sandbox (in particular, the position of the Kinect, the projector, and the sandbox relative to each other), you never need to calibrate it again. Although now that you have the hang of it, you might want to go through the calibration again in order to achieve a more accurate setup.

B: If you hold your hand above the sand surface (like a cloud), you can "make it rain":

C: As a convenience, the System76 packaging for Ubuntu includes a launcher you can search for in the Ubuntu dash:



This is a shortcut to launch **SARndbox** with the following arguments (which you can also do directly from a terminal):

SARndbox -uhm -fpv -evr -0.01

The **-evr -0.01** bit of the above command sets the evaporation rate. Without any evaporation rate set, the sandbox will steadily fill with more and more water as you “make it rain”, which eventually will cause the real-time fluid simulation to become slow.

So you typically want to set an evaporation rate, especially when deploying the Augmented Reality Sandbox in schools or museums.

D: If our recommended evaporation rate seems too fast for your tastes, try:

SARndbox -uhm -fpv -evr -0.005

If our recommended evaporation rate seems too slow for your tastes, try:

SARndbox -uhm -fpv -evr -0.02