# Pictures

The following pictures show our current augmented reality sandbox prototype. Click each picture for a higher resolution version.

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| [IMG_256](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/SandboxLayout.png) | Simple diagram of the sandbox's layout. |
| [IMG_257](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/Sandbox1.jpg) | The sandbox turned off, in the River lab in the Earth & Physical Sciences building. The projector and Kinect are suspended above the sandbox from a pole attached to the back. The sandbox hardware was built by project specialist Peter Gold.  The Linux computer running the sandbox is on the desk behind it, to the left of the pole. A secondary screen to use the computer and control the sandbox is overshadowed by the 55" 3D TV directly behind it. |
| [IMG_258](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/Sandbox2.jpg) | Close-up of the projector/Kinect assembly. The Kinect is looking straight down onto the sand surface, and the projector is positioned above the back edge because it is a desktop projector with an above-axis projection.  In retrospect, a center-projection projector would have led to better image quality, but it would have made the assembly much less stable. |
| [IMG_259](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/Sandbox3.jpg) | Projector/Kinect assembly from behind. Both components can be adjusted individually for optimal calibration. |
| [IMG_260](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/Sandbox4.jpg) | Another view showing the entire sandbox assembly from the back. The pole is not really bent, that's distortion from the camera's wide-angle lens. |
| [IMG_261](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/Sandbox5.jpg) | View of the sandbox when turned on, but not running the AR sandbox application yet. The GLSL source code shown is the slope/flux/temporal derivative shader part of the GPU-based water flow simulation. |
| [IMG_262](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/Sandbox6.jpg) | View of the sandbox immediately after the AR sandbox application is started. The sand surface is rippled because someone tried to make a Zen garden. |
| [IMG_263](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/Sandbox7.jpg) | A few moments later, after some digging. |
| [IMG_264](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/Sandbox8.jpg) | Close-up of the mountain seen in the previous picture, from the opposite side of the sandbox. Due to the off-center projection, this side is generally brighter and more in focus than the other. That's a detail we are likely to change in future versions. |
| [IMG_265](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/Sandbox9.jpg) | Extreme close-up of the sand surface to show the sand's fine texture (the white spots are individual grains that happen to reflect projector light directly into the camera), and the detail in the topographic contour lines. The contour lines are rendered by a fragment-shader implementation of a Marching Squares method. In this picture, the contour lines are exactly 0.75cm apart. |
| [IMG_266](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/Sandbox10.jpg) | Close-up of a virtual lake at rest. The water surface is not still because residual noise in the Kinect's depth measurements constantly agitates the water. Unless surface updates are temporarily turned off, the water simulation behaves as if there were constantly ongoing small-scale earthquakes. |
| [IMG_267](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/Sandbox11.jpg) | Changing a few lines in the surface rendering shader to turn water into lava -- presto, instant volcano. |
| [IMG_268](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/Sandbox12.jpg) | ... and back to water. Shader code can be edited on-the-fly while the AR sandbox application is running and immediately affects the display. |
| [IMG_269](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/Sandbox13.jpg) | Here, surface updates from the Kinect are temporarily disabled, letting the water surfaces come to rest. The Saint-Venant shallow water flow simulation is well-balanced, meaning that all surfaces will be completely flat, and completely still, once all residual wave energy dissipates due to viscosity and bed friction.  Note the wave propagation and the eddies in the center lake, and the water lapping over into the upper lake, due to constant water influx from the stream down the side of the mountain. |
| [IMG_270](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/TERC-Sandbox1.jpg) | The museum-grade AR Sandbox installed at the Lake Tahoe Environmental Research Center (TERC). Photo credit: Jim Markle. |
| [IMG_271](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/ECHO-Sandbox1.jpg) | The museum-grade AR Sandbox installed at the ECHO Lake Aquarium and Science Center. Photo credit: Julie Silverman. |
| [IMG_272](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/ECHO-Sandbox2.jpg) | The museum-grade AR Sandbox installed at the ECHO Lake Aquarium and Science Center. Photo credit: Julie Silverman. |
| [IMG_273](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/ECHO-Sandbox3.jpg) | Grand unveiling of the museum-grade AR Sandbox installed at the ECHO Lake Aquarium and Science Center. Yes, those are Sen. Patrick Leahy and Robert F. Kennedy, Jr. Photo credit: Julie Silverman. |
| [IMG_274](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/GlamorShot1.jpg)   [IMG_275](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/GlamorShot2.jpg)   [IMG_276](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/GlamorShot3.jpg)   [IMG_277](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/GlamorShot4.jpg)   [IMG_278](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/GlamorShot5.jpg)   [IMG_279](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/GlamorShot6.jpg) | Recent series of "glamor shots" for use in publications etc. Click on each of the thumbnails to download the full resolution picture (caution: huge). |
| [IMG_280](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/WhiteHouse1.jpg) | The new "Mark I Standard AR Sandbox" at the White House Water Summit in Washington, DC, prior to adding sand. |
| [IMG_281](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/WhiteHouse2.jpg) | Calibrating the Mark I Standard AR Sandbox (calibration step 7, calculating the projector calibration matrix). |
| [IMG_282](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/WhiteHouse3.jpg) | Mark I Standard AR Sandbox from above, after adding Kinetic sand, but with projector turned off. |
| [IMG_283](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/WhiteHouse4.jpg)   [IMG_284](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/WhiteHouse5.jpg)   [IMG_285](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/WhiteHouse6.jpg) | Mark I Standard AR Sandbox during exhibition. |
| [IMG_286](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/USASEF1.jpg)   [IMG_287](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/USASEF2.jpg)   [IMG_288](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/USASEF3.jpg) | Assembling the Mark I Standard AR Sandbox for the USA Science and Engineering Festival in Washington, DC. |
| [IMG_289](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/USASEF4.jpg)   [IMG_290](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/USASEF5.jpg)   [IMG_291](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/USASEF7.jpg)   [IMG_292](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/USASEF8.jpg) | Our exhibit at the USA Science and Engineering Festival in Washington, DC, as part of the larger NSF booth. |
| [IMG_293](https://web.cs.ucdavis.edu/~okreylos/ResDev/SARndbox/USASEF6.jpg) | Overview of about a quarter of the entire USA Science and Engineering Festival expo floor. Our exhibit is indicated by the red arrow. |