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Digital Media Lab Portfolio 2017-2018

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Author

Mcavoy, Scott Patrick

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Digital Media Lab

Project Portfolio 2017-18

This document describes a diverse range of projects undertaken by the UCSD Digital Media Lab, performed or coordinated by Scott McAvoy, lab director from 2015-2022, talented student employees, and academic collaborators.

DML staff have collaborated widely and produced a large number of media projects over the past year. Most projects revolved around 3D printing, but the uses and data sources necessitated new technical skills and higher-level design considerations. This document is incomplete, and currently describes 33 projects important projects we've engaged in over the past year. Projects undertaken since 2015 can be seen on the [Digital Media Lab's Knit blog](#).

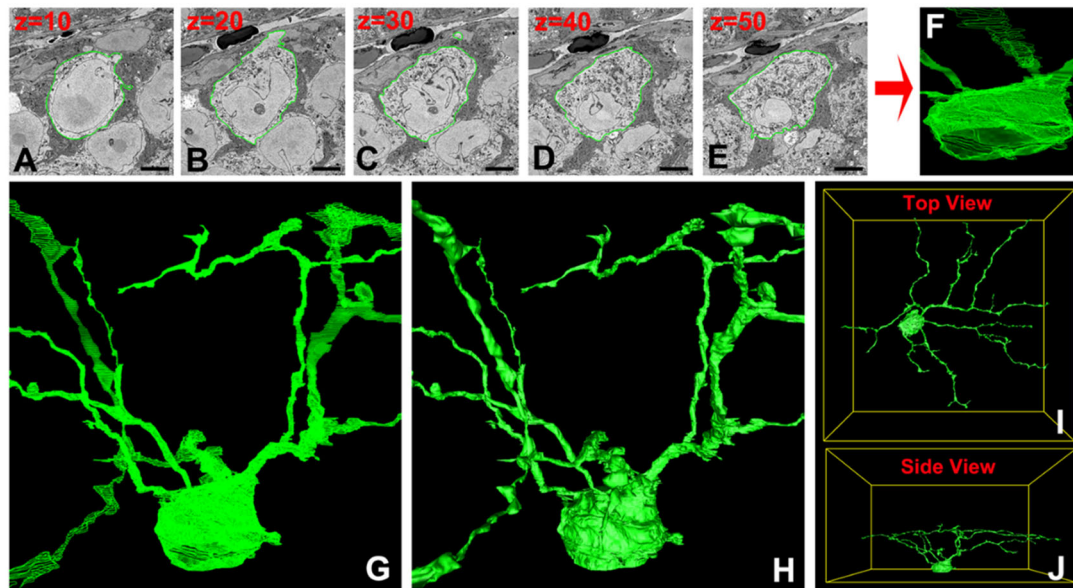
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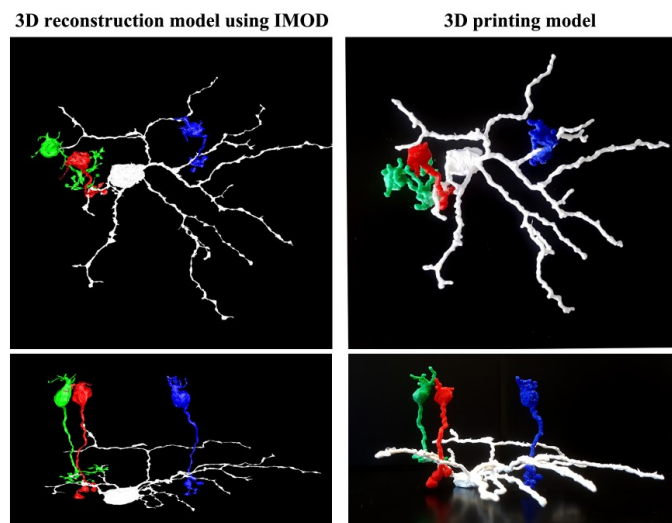
3D Printing Retinal Neuron

We worked with Dr. Keunyoung Kim, a researcher from the National Center for Microscopy and Imaging Research, to create a 3D printable neuron model. Keunyoung employed a high school student to trace the cells outline one thousands of sliced electron microscope images, then combined those slices into a 3D model.

<https://csef.usc.edu/History/2018/Projects/S0814.pdf>

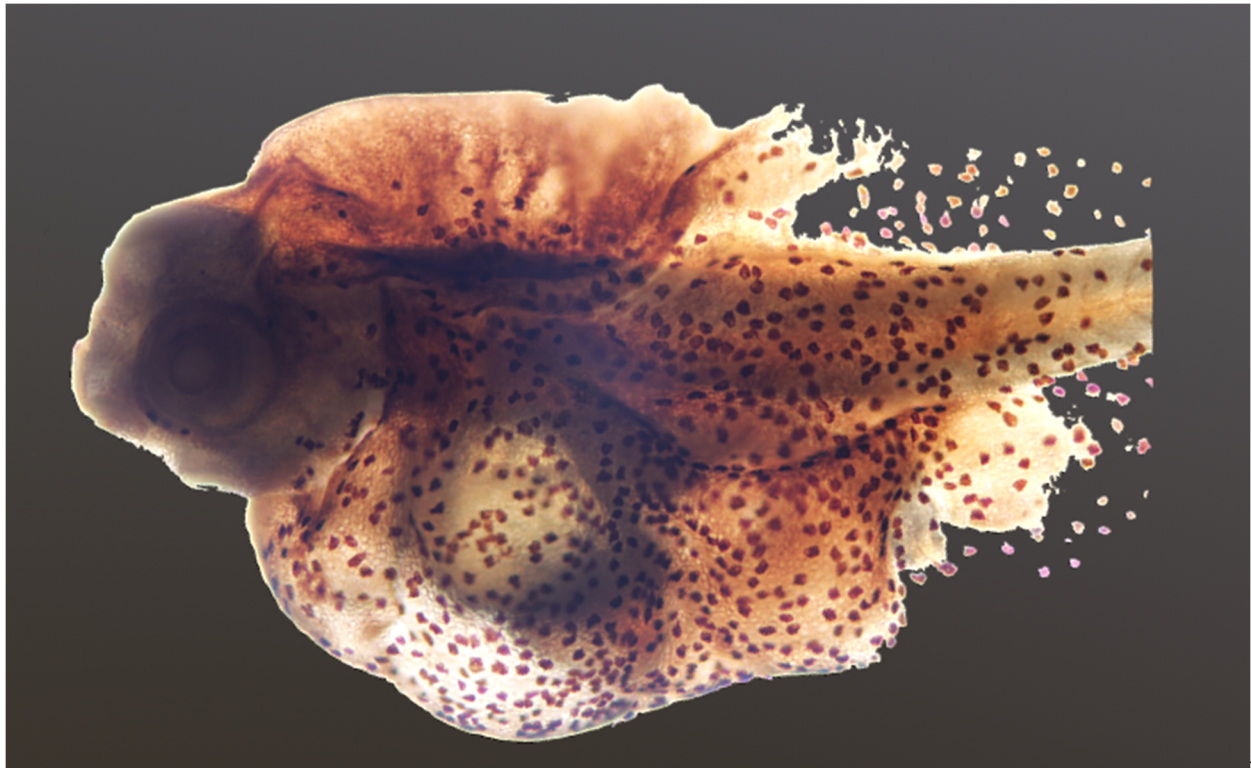


We spent a lot of time making the thin tendrils strong enough to print, ultimately thickening the model. The end result was included in Dr. Kim's published paper and was the subject of a research poster intended to communicate micro-structures to the blind.



Focus Stacking: 3D Microscopy

Researchers take microscopic images at different focus levels, and then stitch those photos together into one single photo where everything is focus. This is the nature of microscopy, most of the time it's very difficult to get any one complete structure in focus, so you have to post process a batch of images. We worked with a researcher to find a way to take those images and extrapolate 3D structures. If every focus level corresponds to a different depth, you can split it up into tiers of different heights, then smooth the curves between them. We created a 3D model of this fish larva which the researcher used to accurately estimate surface area, a metric he'd previously had to calculate from flat imagery.



1 the focus stacked version



2 the larva turned on its side, you can see 5 levels, for the 5 pictures with different focus levels. the leftmost model is normalized by maximum height

Roman Coins

Last year we began a project with history Professor Edward Watts of the, and Kirk Wang in the Digital Library Development Program, involving 3D scanning a collection of 20 Roman coins. We've [published the collection online](#) and have consulted with Research Data Curation Program staff to investigate ways to include these models in the library's Digital Collections site. Most of these coins were over 2,000 years old, some made of pure gold. The striking process and the stories told by the symbols and portraits made this project especially interesting for library staff.



We used the DLDP studio, usually equipped for book scanning, to take 4k images of each coin face from multiple angles, and later stitched them together as 3D models in the DML. The coins were smaller than dimes, so the close up high res photos gave us a new perspective, highlighting scratches, grooves, and even colors which were otherwise indiscernible to the naked eye.



Iridescent Materials

Every 3D model can be rendered as a high resolution CG still. We have a lot of control over lighting, camera bounds, and materials properties. We were able to create a special material using Blender's Cycles rendering engine, programming a system to change color based on each polygons position and tilt relative to the viewer's position. We were inspired by the iridescent glow of sea urchin larva skeletal fibers to see if we could replicate the effect digitally, which we did with some success thanks to a large [online community of Blender experts](#). We can apply this material to any object now, it's a great way to quickly generate interesting background graphics.

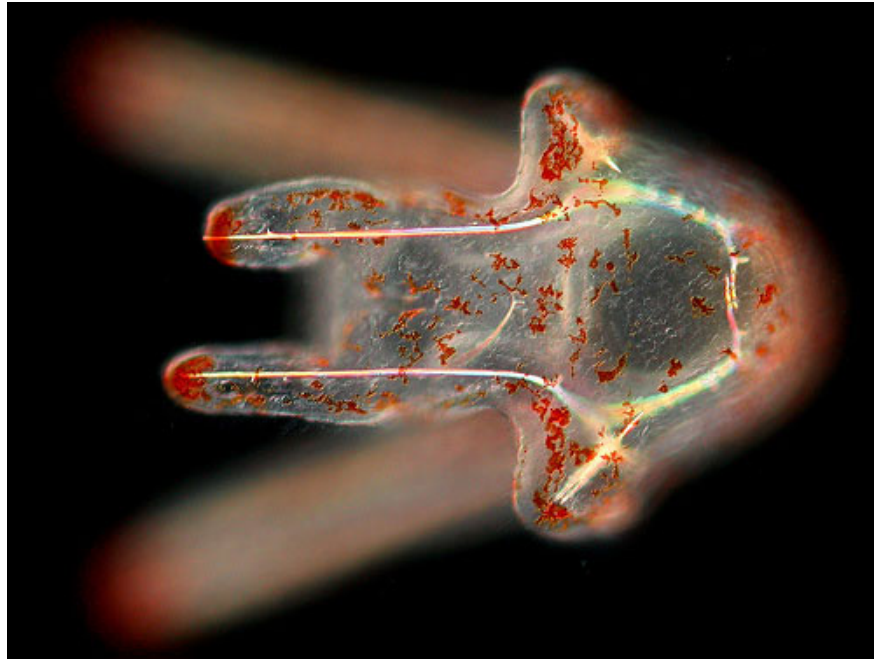


Figure 3 Sea urchin larva under microscope

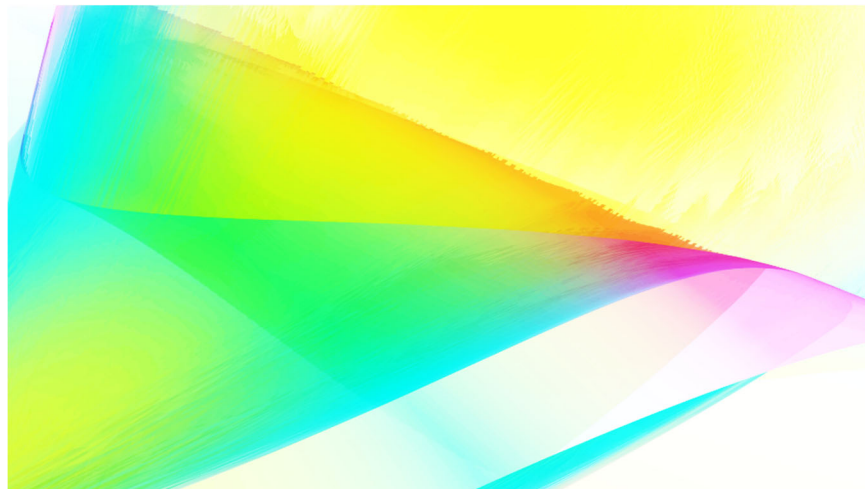
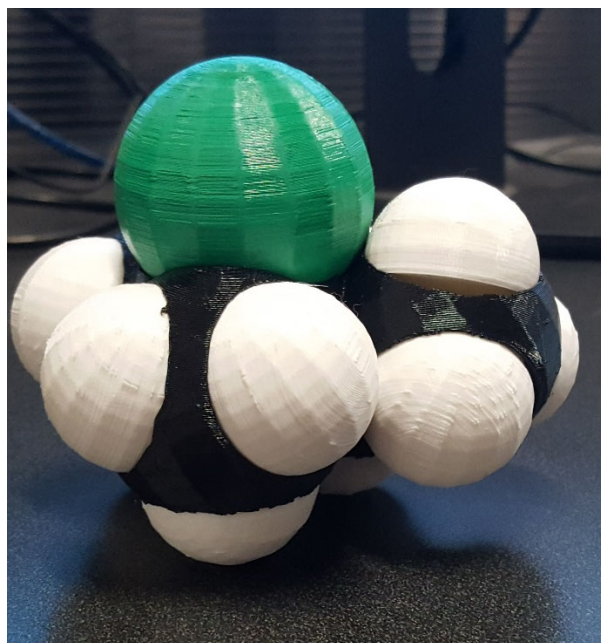


Figure 4 CG image, our iridescent material applied to intersecting cones

3D Printing Multicolor Molecules

Emily Eisner is a chemistry undergrad working under Dr. Jeremy Klosterman. She wanted to format .pdb molecular files into multi-color 3D printable models. We can only print one color at a time, and painting complex spherical structures is difficult. We found a way to separate elements to be printed in different colors, and then reassembled. Emily presented this poster at an undergraduate research symposium.



Hands-On Molecules: WebMO and 3D Printing as Interactive Tools for Teaching Sterics and Reactivity in Organic Chemistry
Emily Eisner, Scott McAvoy,[†] and Jeremy K. Klosterman^{*}
Department of Chemistry and Biochemistry, UCSD Library Digital Media Lab + MC San Diego

Student Success in Organic Chem
Students struggle to identify, visualize, and use 3D models. They require representations (images and spatial reasoning) to understand molecular structure. But color and molecular models are difficult to represent. We have found a way to separate elements to be printed in different colors, and then reassembled.

Visualizing Sterics with CPK Models
Space-filling (space-filling) models, developed in 1960s, are the best representation for steric hindrance. They show the relative sizes and shapes of atoms and how they pack together. They are used to visualize steric hindrance and reactivity. They are used to visualize steric hindrance and reactivity.

3D Printing Molecular Structures
3D printing is a process of creating three-dimensional objects from a digital file. It is used to create physical models of molecular structures. It is used to create physical models of molecular structures.

WebMO: Building Structures
WebMO is a web-based molecular modeling software. It is used to build molecular structures. It is used to build molecular structures.

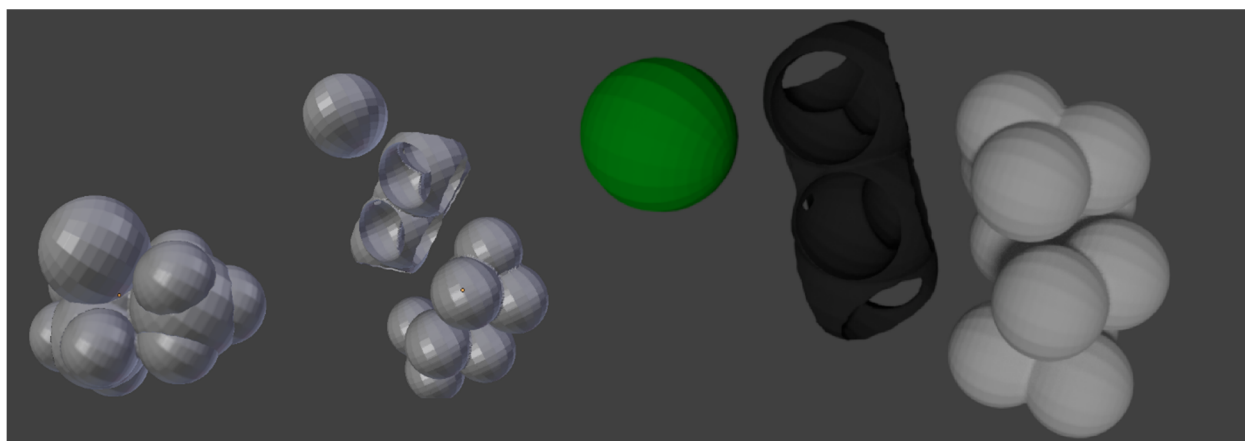
Visualization & Transformation
WebMO allows users to visualize molecular structures. It is used to visualize molecular structures. It is used to visualize molecular structures.

3D Print! Hands-on Molecules
3D printing is a process of creating three-dimensional objects from a digital file. It is used to create physical models of molecular structures. It is used to create physical models of molecular structures.

Color & Reactivity
Color is used to represent different elements in a molecule. It is used to represent different elements in a molecule. It is used to represent different elements in a molecule.

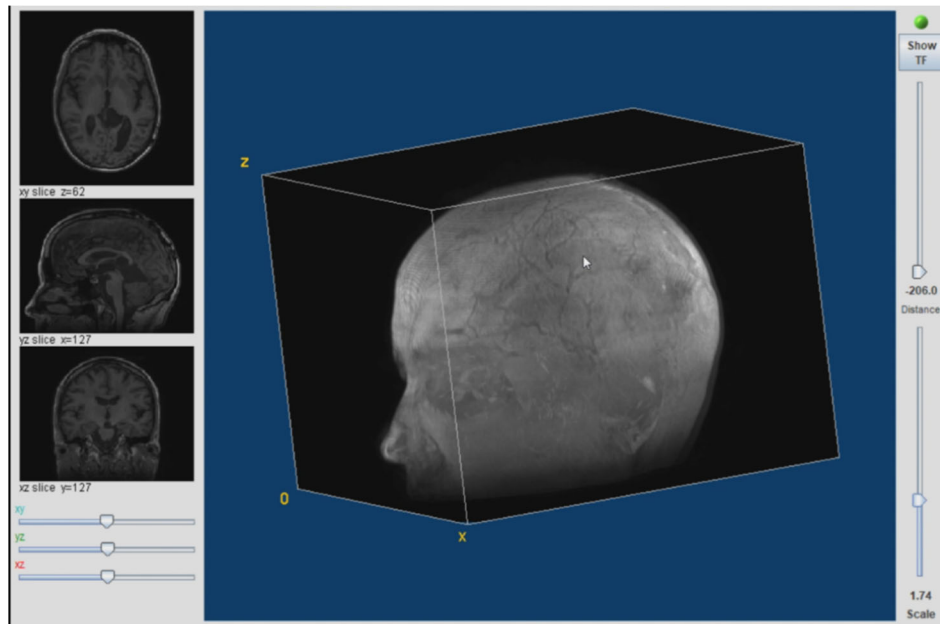
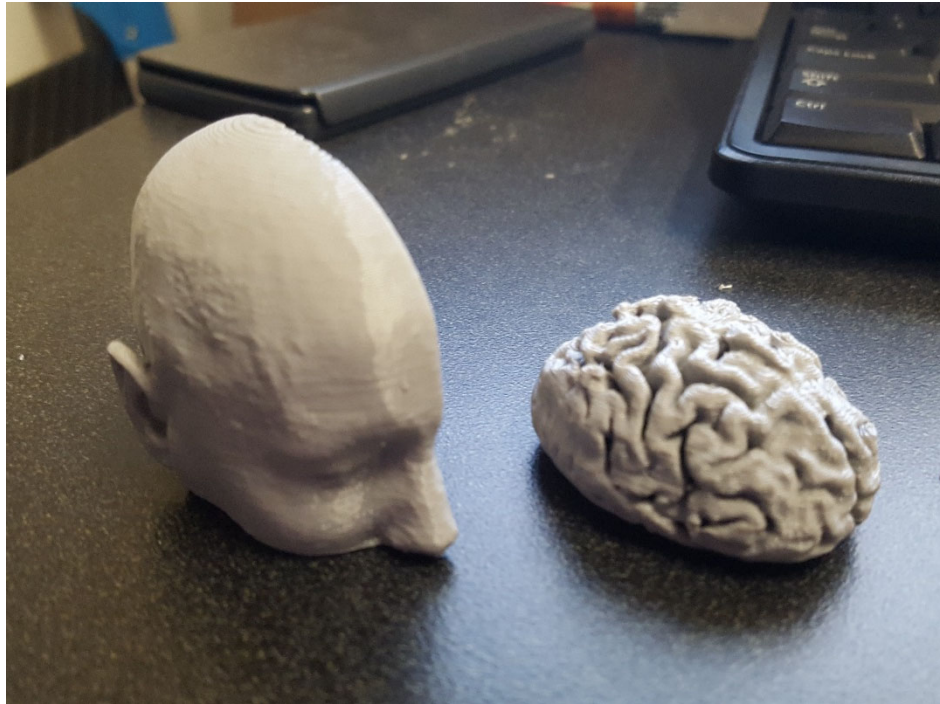
Summary & Outlook
3D printing is a process of creating three-dimensional objects from a digital file. It is used to create physical models of molecular structures. It is used to create physical models of molecular structures.

References
1. J. K. Klosterman, S. McAvoy, and E. Eisner, *J. Chem. Educ.*, 2018, 95, 1234-1245.
2. J. K. Klosterman, S. McAvoy, and E. Eisner, *J. Chem. Educ.*, 2018, 95, 1234-1245.



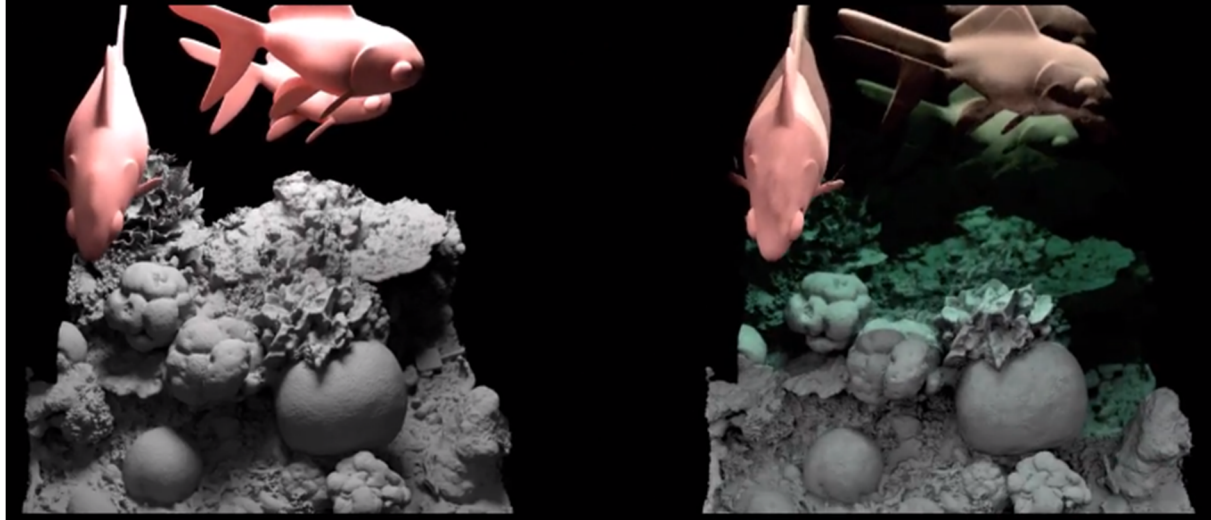
3D Medical Imagery

The means to view and format medical imagery has become accessible for non-medical professionals. We can download free anonymized human medical imagery databases and segment them to separate structures. Here we've taken set of images showing an individual who'd had a brain tumor removed. We've separated the brain from the rest of the head. This process allows us to make a wide range of custom medical training models.

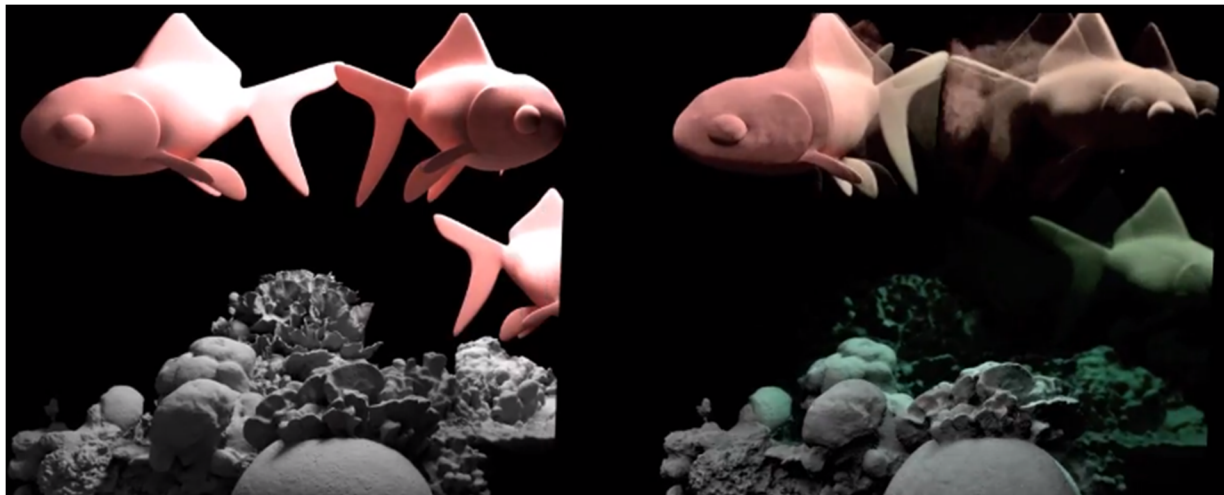


Aquarium Refraction Simulator

Harry Helling, director of Birch Aquarium, had an idea for an exhibit which used a giant 3D printed coral model, cut in half with one half on the inside of the tank, and one half of the outside, bit butted up against the glass to make an experience which gave the user the feeling that they were sharing an environment with the sea life inside. We used a program called Blender to create a simulator to which helped us visualize the way objects are distorted inside the tank.



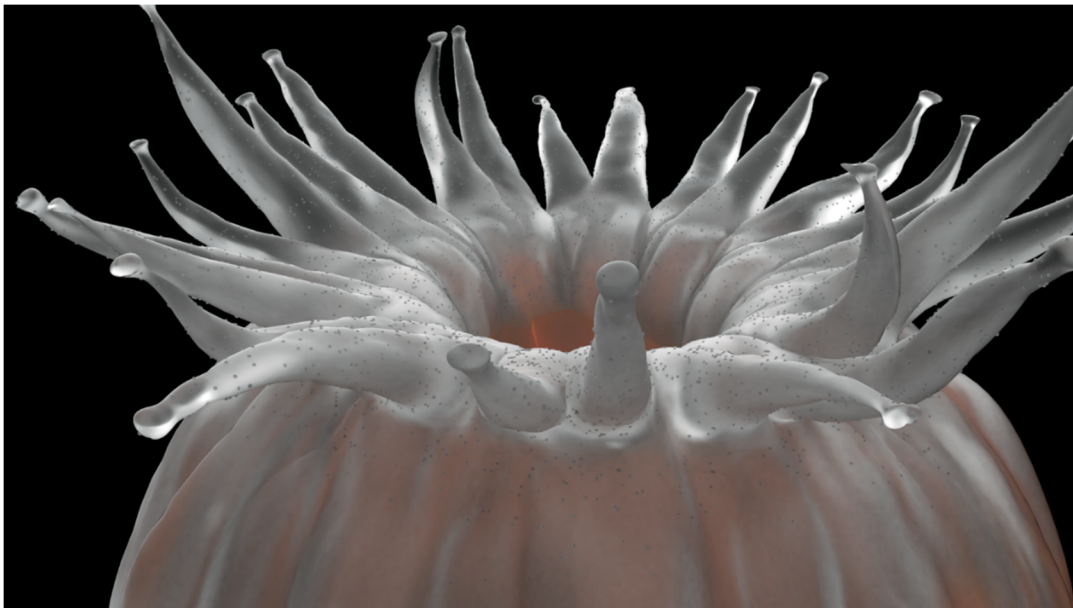
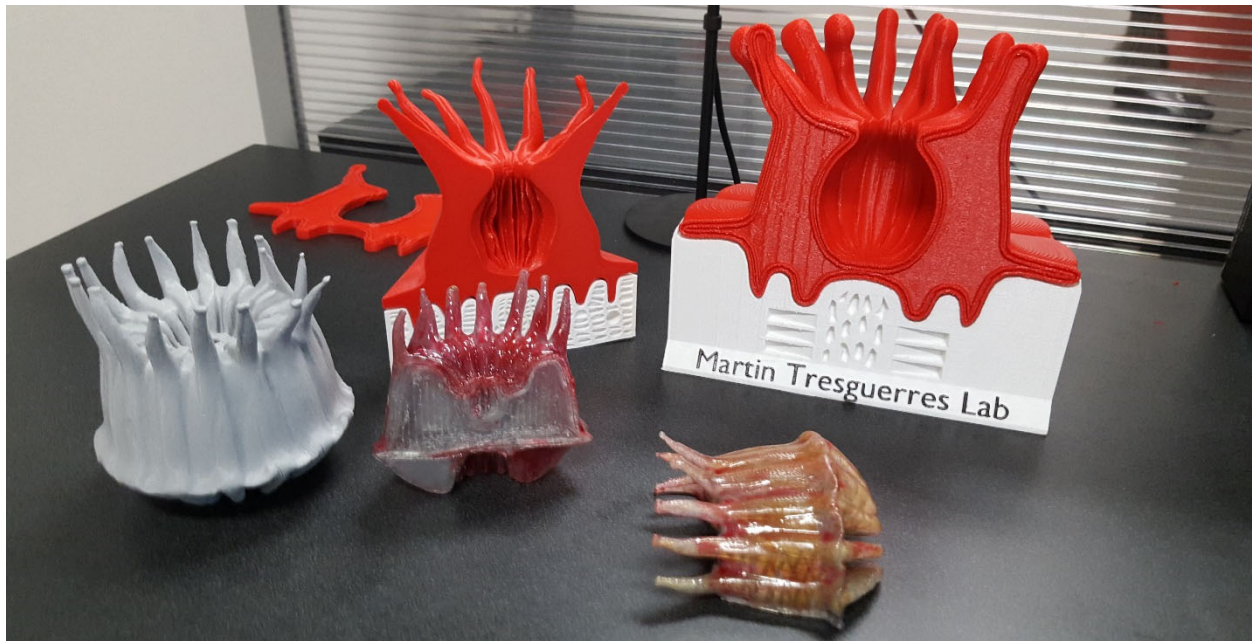
With 5 inches of acrylic and water lighting simulated we can see the way objects bunch up forwards and change in color. With this in mind we could actually modify the inner model to lessen this effect, by making it longer than it would be normally, and changing color tones to feel more continuous.



Coral Polyp Models

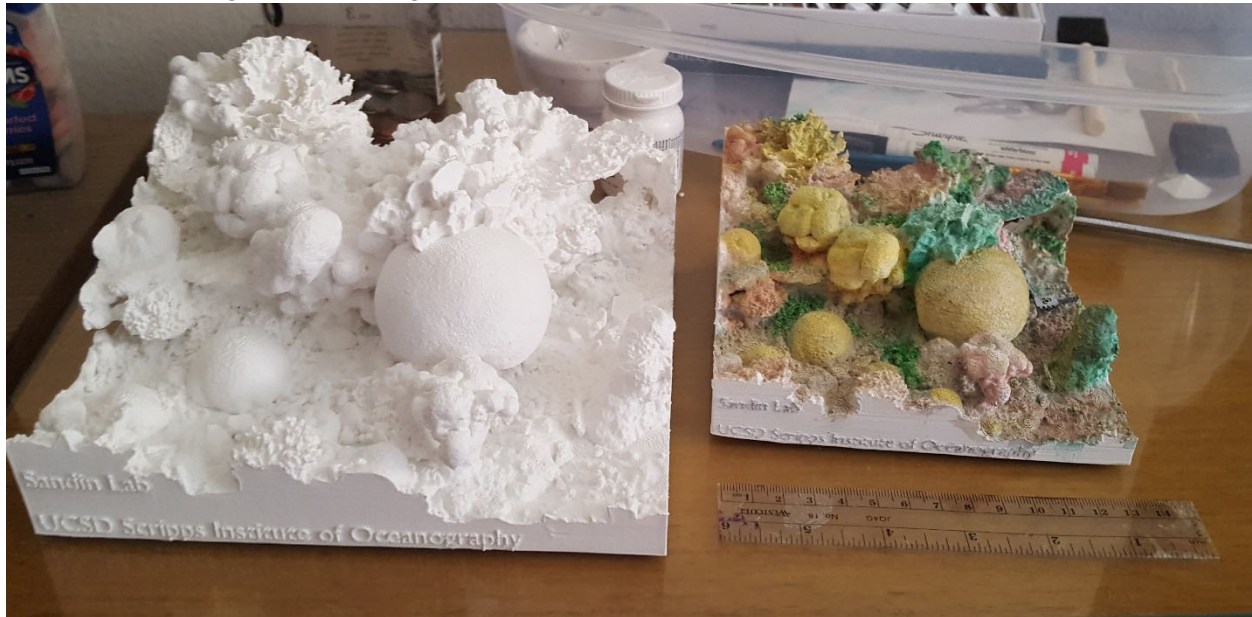
Mikayla Ortega is a PHD student in the Martin-Tresguerres lab at SIO. She studies the biological processes which create calcium carbonate, the substance coral skeletons are made from. Mikayla wanted a 3D printed model of an individual coral polyp to use in her outreach efforts and thesis defense.

We created a number of prints for her, along with a high quality CG rendering, which has been used in a number of outreach events.



3D Printing Coral Reefs

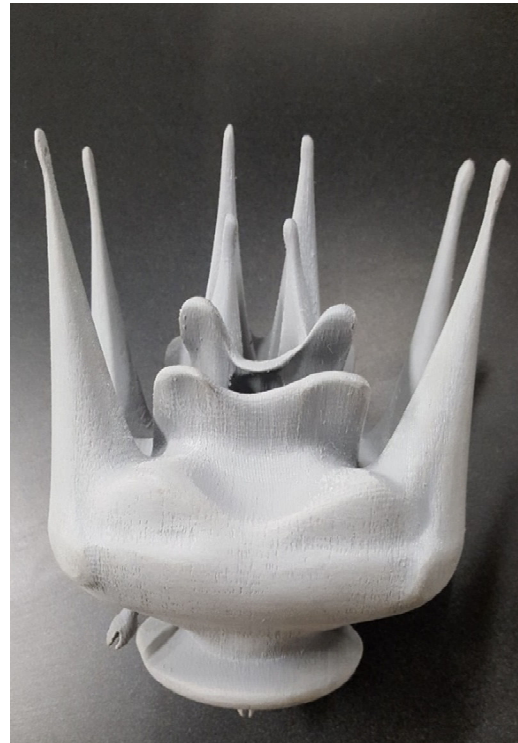
We've collaborated with Clint Edwards, a PHD student working for the Sandin lab in SIO, to format and 3D print their [beautiful underwater photogrammetry scans](#). Scott painted the one on the left to match their footage. This lab keeps their huge data sets on library servers, and initially came to us through a RDCP organized pitch and demo hosted in the DML.



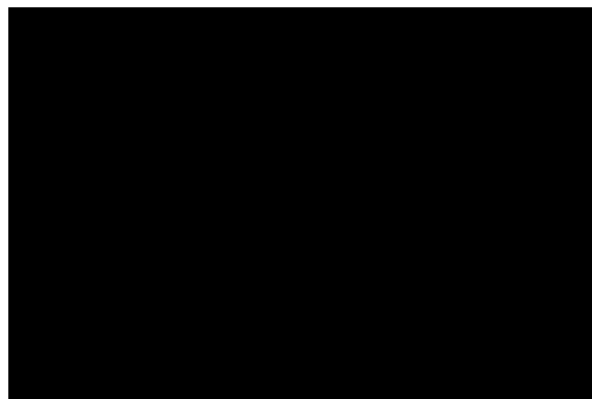
Birch Aquarium was interested in making a larger version for an exhibit, and we tried and failed to help with it. We were recently able to put them in touch with Dr. Falko Keuster's drone lab, who printed a huge version on their giant 3D printer (3ft x 3ft x 1.5ft). It took the better part of a week to complete.

Sea Urchin Larva Sculpture

Kate Nesbit is a PHD student working in the Hamdoun lab at SIO. Kate works with sub millimeter sea urchin larvae. These organisms are very difficult to visualize, as they're mostly clear, floppy, and changes shape along with pressure and current. We helped sculpt and 3D print a custom model to help Kate's lab assistants grasp the anatomical makeup of these creatures at a glance.



We used that same model to create an animation showing the urchin's transition through multiple larval stages.



3D Squidtoon

Garfield Kwan is a researcher at SIO's Martin-Tresguerres laboratory. In his spare time Garfield creates webcomics about oceanographic research called [Squidtoons](#). He's recently published a book of his comics and wanted to make a [3D version](#) to help promote his new book. We helped sculpt a 3D version of his comic, and implemented a cartoonified 3D system which resulted in the model having a 3D outline from every angle. This involves wrapping the model in a secondary shrink-wrapped skin, which is then flipped inside out, and the inside is made invisible. That way it's only ever visible on the peripherals, never blocking the main model. We then 3D printed a version for him to use at his promo events. (Kwan 2018)

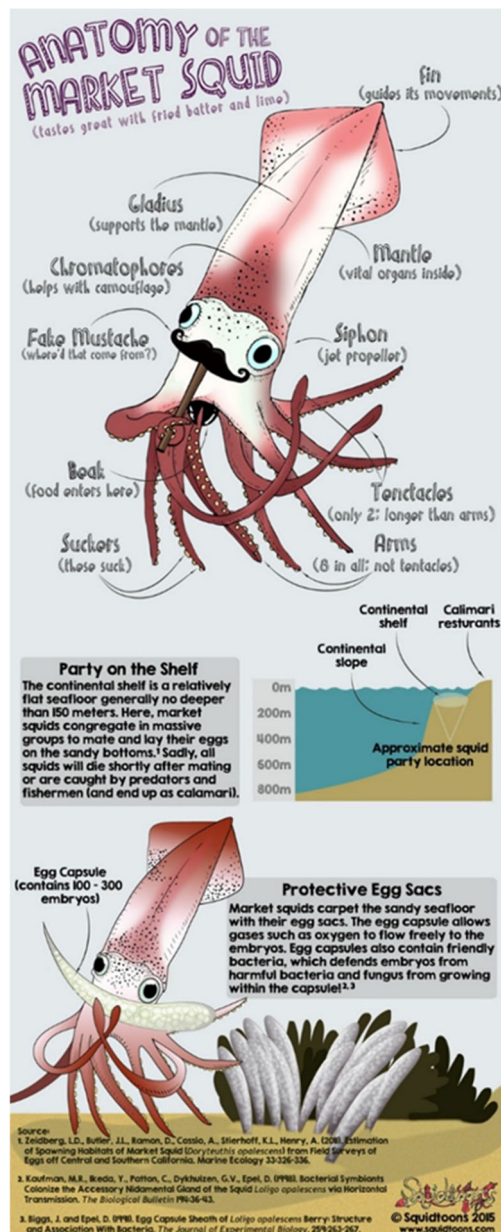


Figure 5 3D printed version, pre painting

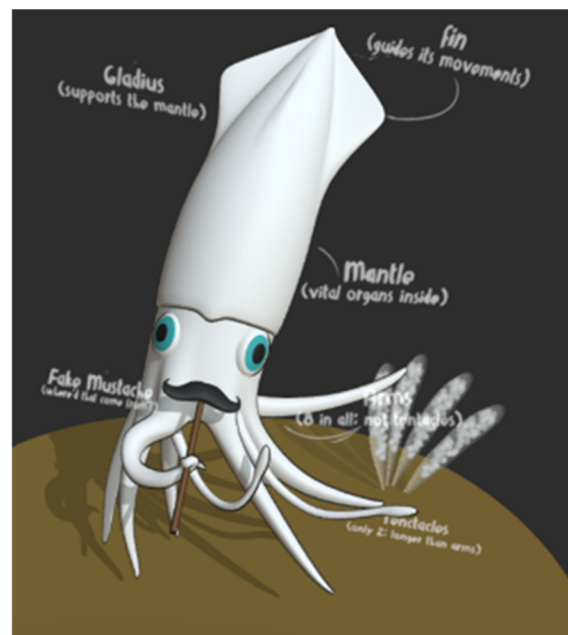
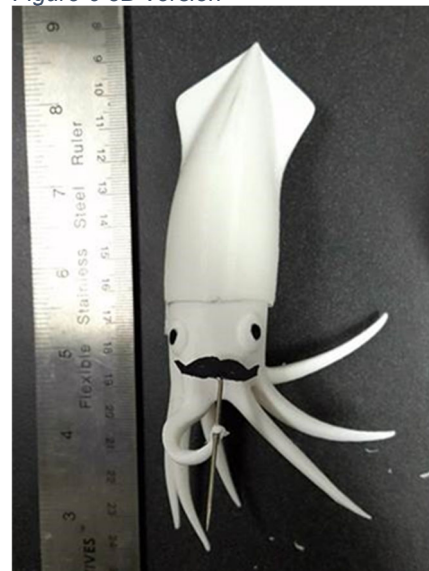


Figure 6 3D version

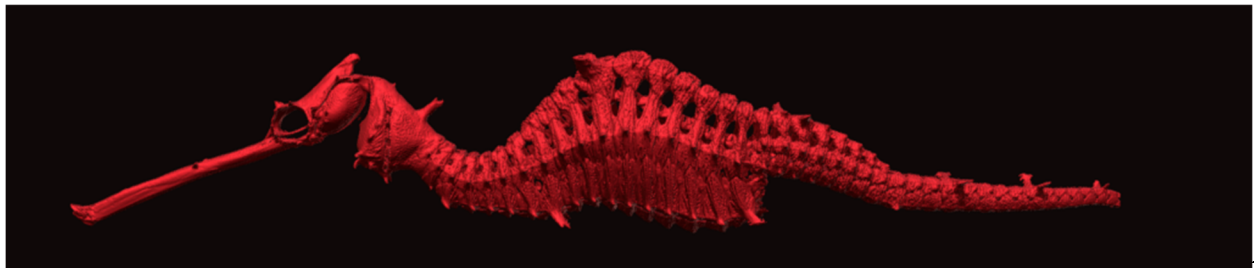


Birch Aquarium Oddities Exhibit

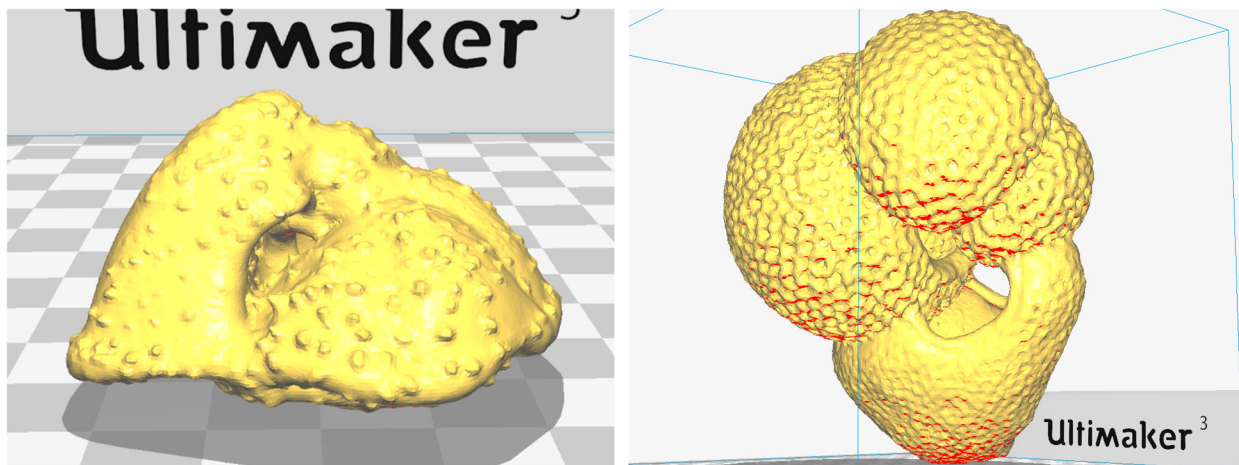
We worked with Charles Langsett and Robert Raad from the Birch Aquarium Exhibits department to help create two features at the new Oddities exhibit, which opened June 2018.



The first portion involved the formatting and display of a ruby sea dragon CT scan, shown as an interactive 3D display.

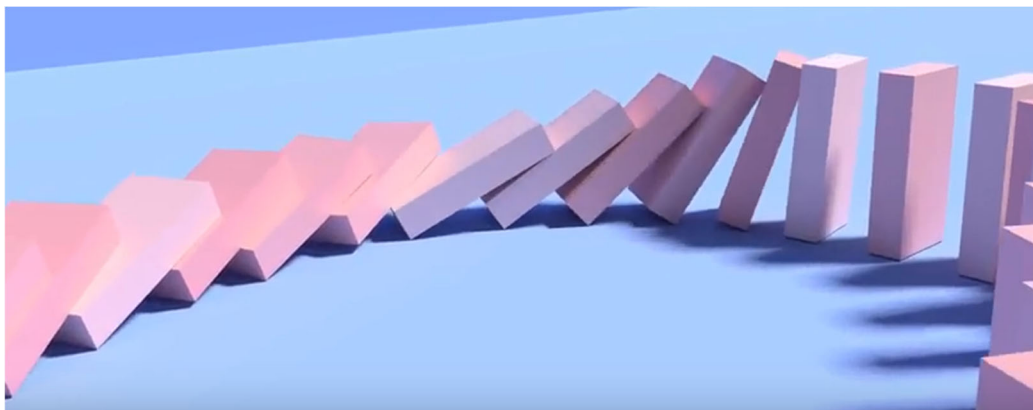
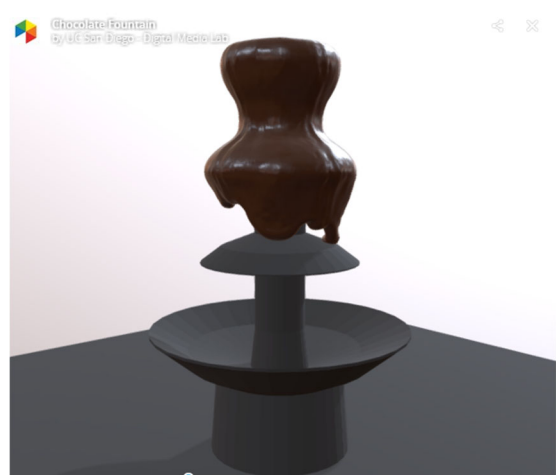
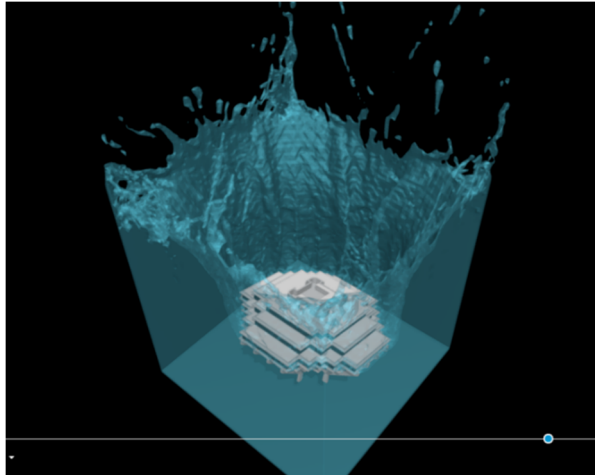


The second component involved 3D printing a number of small creature models to be shown in display cases. This included several pachyderma, as shown below, and radiolarians.



Physics Simulations

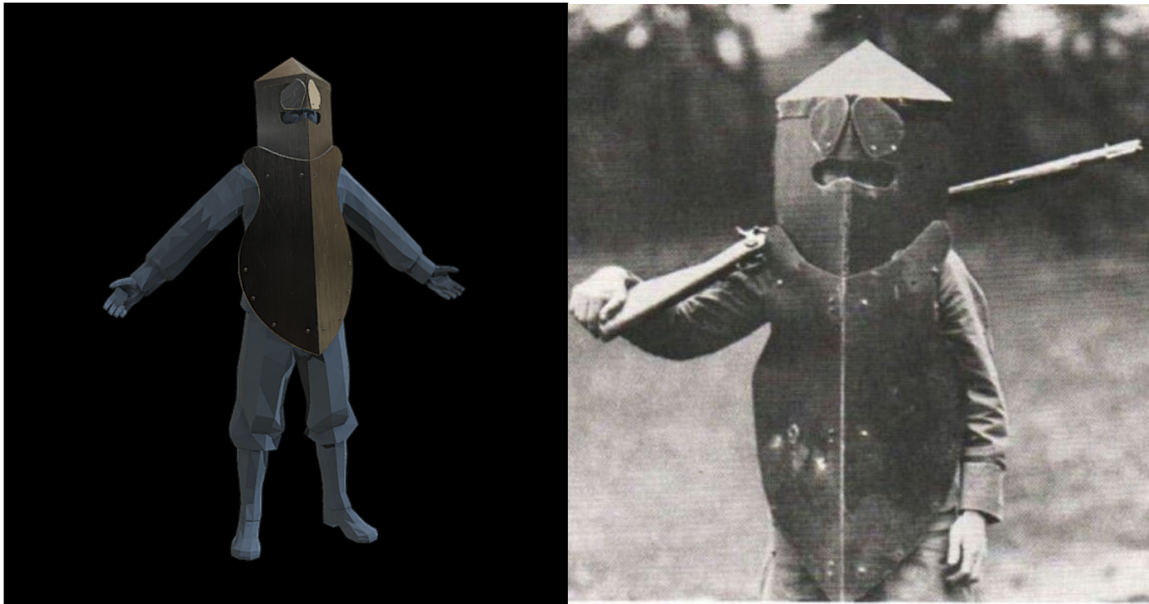
Blender gives us the ability to simulate fluid flows, glass shattering, smoke, impact, and cloth draping. These are useful for animation and complex modelling, but the effects are only aesthetic. Janice Zhao, our recently graduated lead student consultant, spent a lot of time building these beautiful sims. We're looking at alternative tools geared more towards scientific applications, which would allow us to create simulations with properties dialed in for specific materials. See the video [here](#).



Artifact Reconstruction: Brewster Body Shield

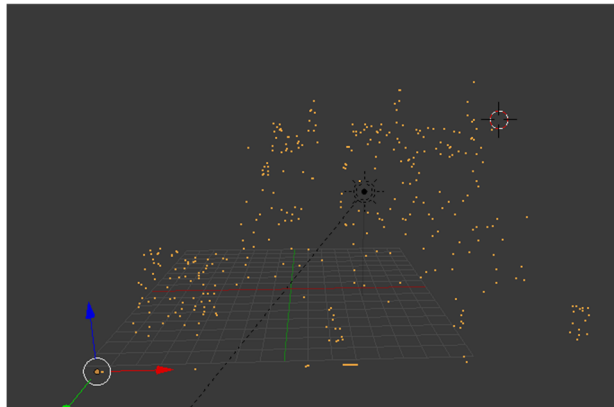
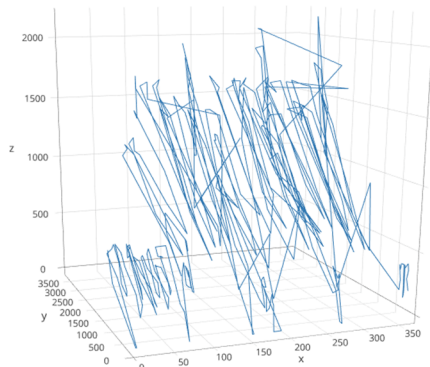
This World War I body armor never saw combat, it was far too clunky, heavy, and ridiculous. We were taken with the absurdity of the design and decided to research and reconstruct it as a training project. The whole thing weighed 40 pounds.

There were 3 different versions shown in just a reference photos photographs, it took some digging to get the proper dimensions for one set. we have no idea what the internal spring suspension mechanisms looked like.

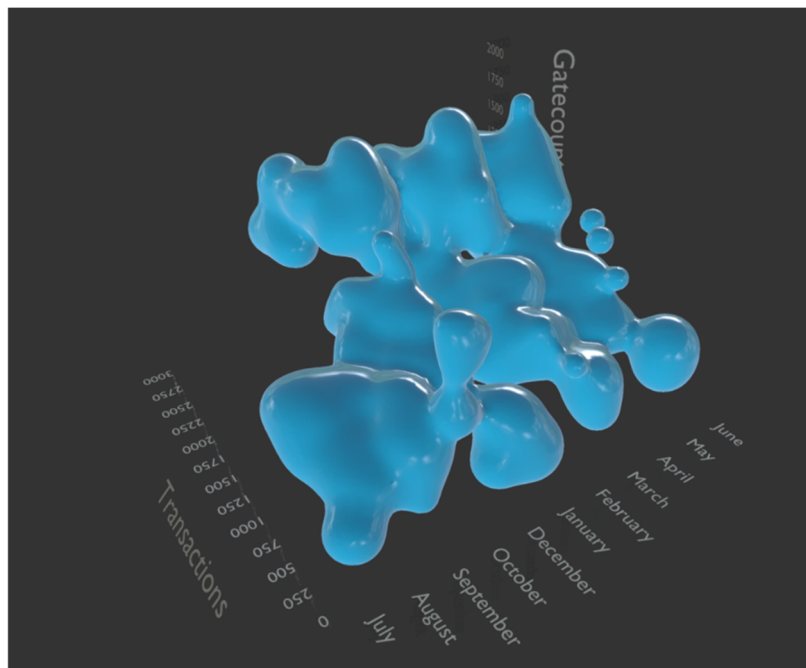


Data Glob: 3D Printable Graph

We took library gatecount and transaction data and [plotted them in 3D](#). We thought that these two metrics would be closely correlated, but the 3D plot allowed us to see a number of interesting outliers. We can see the peaks and troughs as quarters begin and end, and high traffic with low checkout use during days where large tours are conducted.

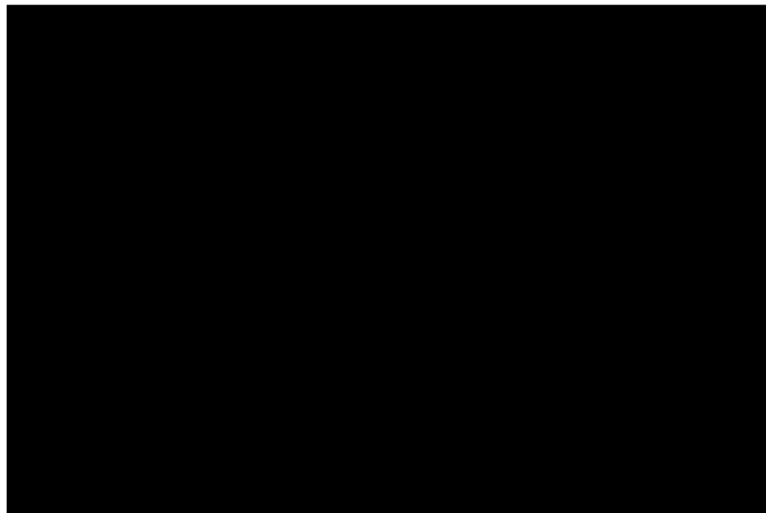
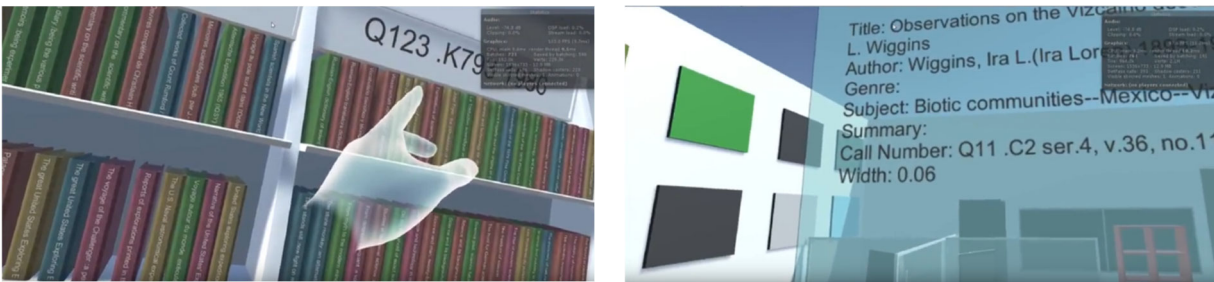


The tabular data was taken from an excel sheet and converted into xyz coordinates. Each point was then assigned a meatball, a shape which is attracted to other shapes, giving us a [3D printable glob](#). As far as we can tell we've invented this method, and already gotten a lot of community interest from it.



VR Library

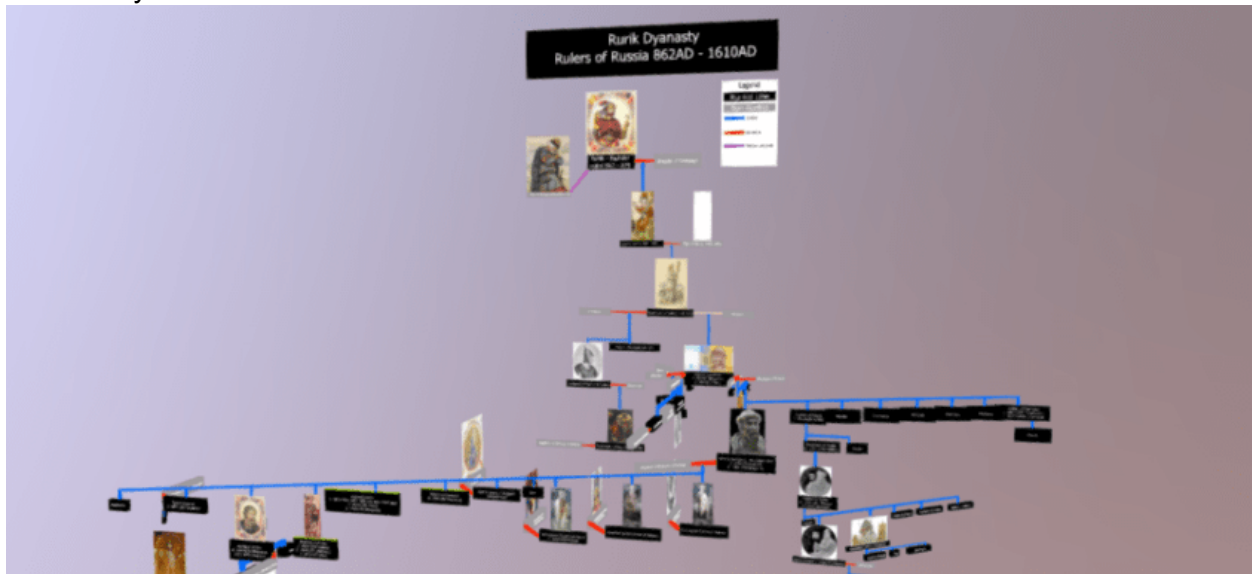
Declan Fleming, former director of Library ITS, wanted to create a VR application which would allow users to browse the entire physical collection. He had some extra money and decided to sponsor a student developer to be supervised and housed in the DML. We hired Jean-Luc Thumm, a sophomore in the computer science program as a Programmer Analyst 1. Jean Luc modified an existing 3D model of the DML to include an endlessly scrolling bookshelf, which generated books using a spreadsheet of 2.5million book records, supplied by Kourtney Murray in Metadata services. We concluded that the current ILS could not realistically support a live system, one which could constantly update to reflect collection availability. We decided to build out a concept which used this static database instead, hoping that the new ILS would allow us some greater utility.



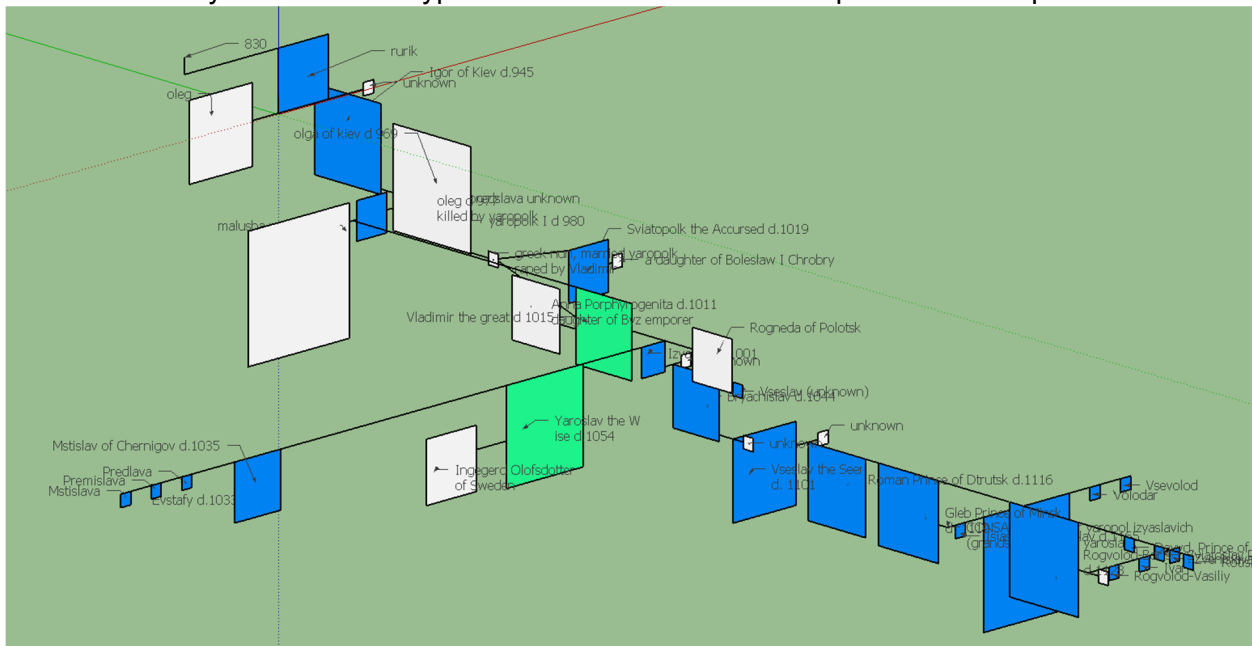
Declan presented the project at Code4Lib 2018 and we've made the project publicly available for download. It saw significant traffic following Declan's talk. There was initially some talk of a continued collaboration with NC State, whose ILS does possess the functionality for a live update version, but it fell apart as both Declan and our developer have moved on. We were happy with the outcome and liked the staffing model, hiring a student developer for a one-year project.

3D Genealogies Concept

The Rurik Dynasty ruled Russia for over 700 years before the Romanovs. The family is of Norse origin, and included some of the most famous figures in Russian history, Olga Kiev, Vladimir the Great, Ivan the Terrible... the list goes on. The international reach of the Rurikids in terms of marriages and relations is pretty astounding. Even a thousand years back Kings of England, Byzantine Emperors, nomadic Khans, Norse warlords, all married into the Rurikid family. Also astounding is the number of children some of these Tsars produced. Only in a 3D medium could we communicate the complexity of these relationships, when one man produced dozens of children by 7 different wives.



We took it a step farther and plotted time on the z axis. Now box size corresponds with lifespan, and we can see which individuals were alive at the same time. We feel these visualizations have wider utility for other data types and will continue to develop similar concepts.



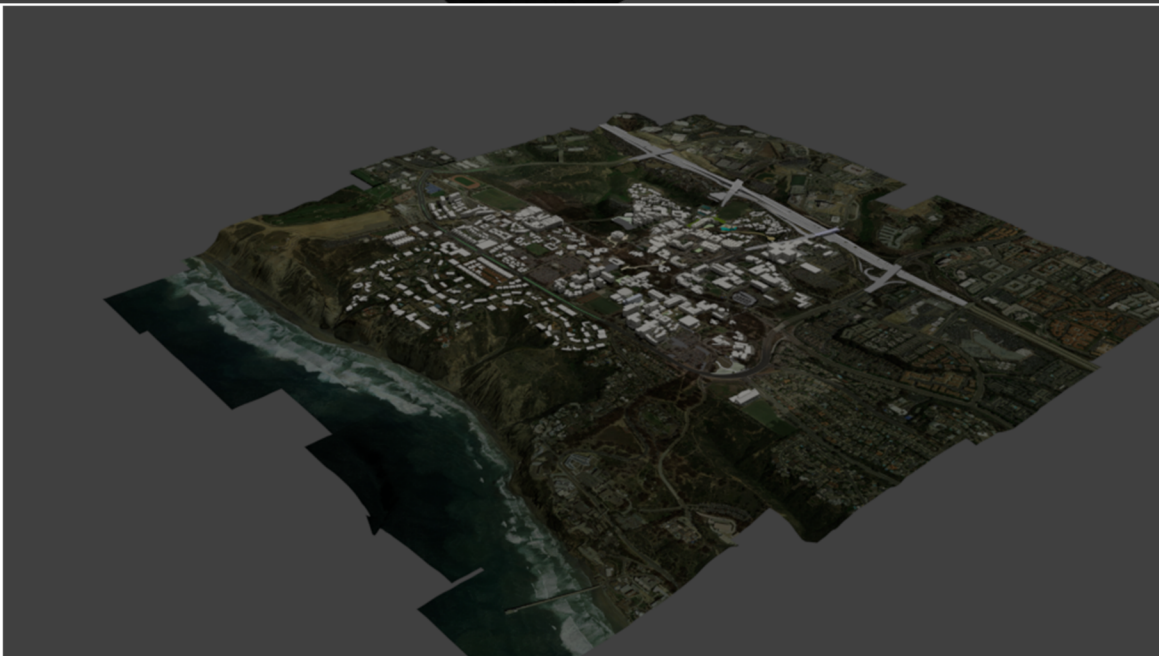
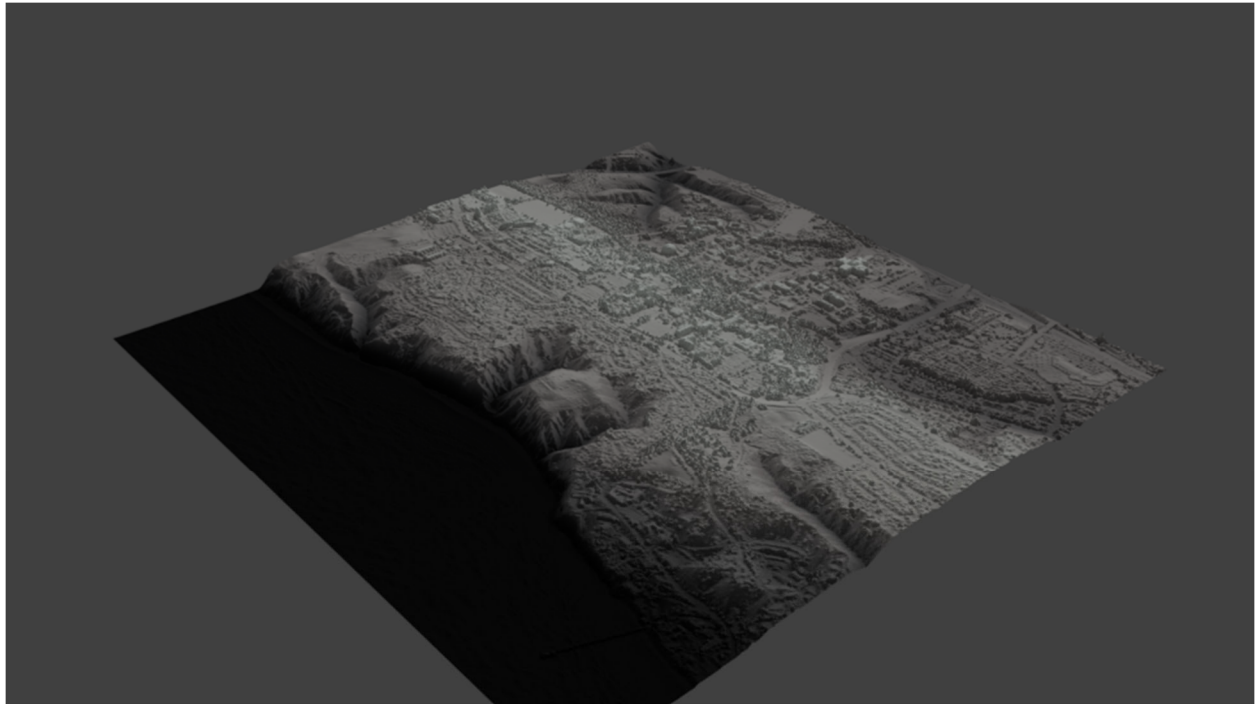
California Terrain Map

Using the STRM radar dataset, we were able to get large scale terrain data for the American West and print it for a poster sized frame. The terrain was broken up into 30 smaller tiles, each printed individually and reassembled. We'd hoped to use this to project map animations over the white terrain, but were unable to realign map projections. We'll come back to this project later, as we continue to build the necessary GIS expertise.



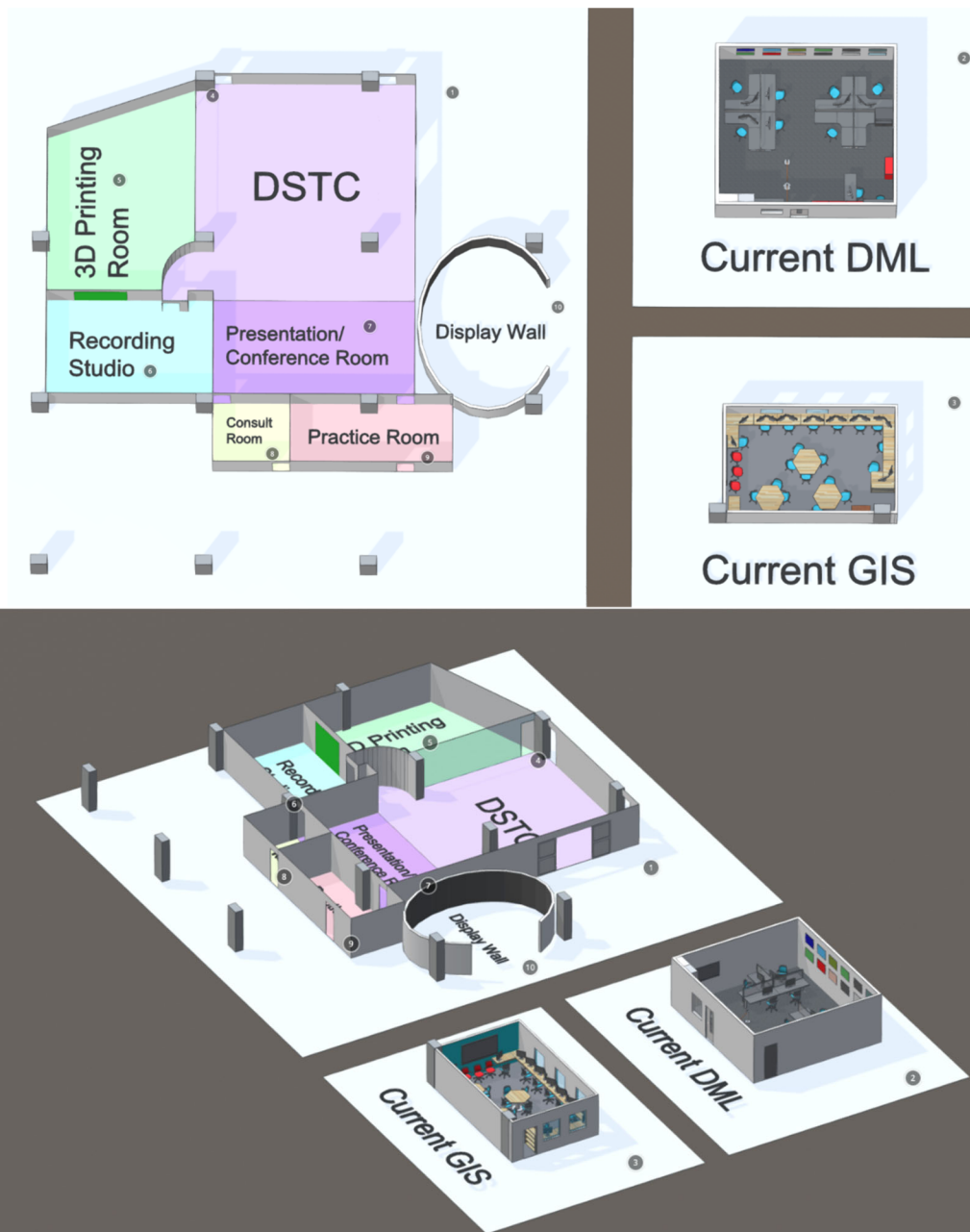
UCSD Terrain Model Compilation

Last year we'd obtained a data set from the campus planning office which included 3D models (of varying quality) of every building on campus. We've been slowly formatting this data for student use, as the data provided took 20 minutes to open on a high powered DML workstation. In the process we've also built 4 other UCSD 3D data sets and will make these available for student use in the coming year, likely as a collection in the DAMS.



Architectural Planning Model: Digital Scholarship & Technology Center

The Library had been planning a new space which would consolidate technology user services. We took the architects pencil sketches and plotted them in CAD to create a to scale 3D model to help us plan. We build or found models for the furniture in the two existing labs, and arranged them in the new rooms to get a sense of the space. We even walked around the new rooms in VR. We moved these digital furnishings around as a group, with one person manipulating the model while others walked up to the large projector and described what they wanted. It was a lot of fun, planning committee members found it to be very engaging.



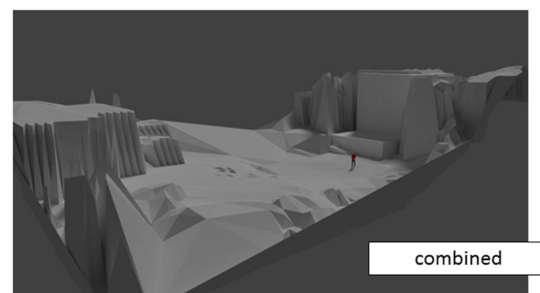
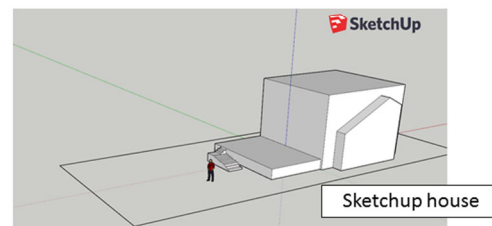
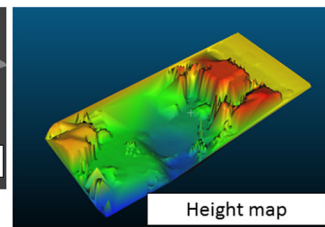
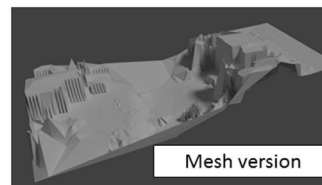
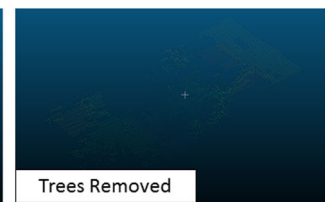
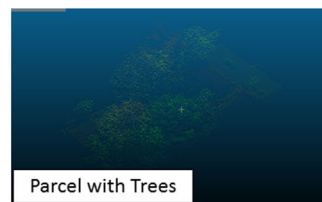
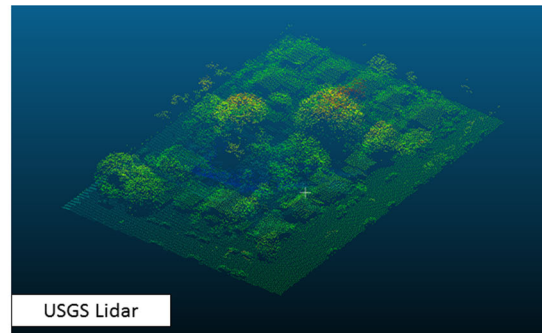
Small Property Terrain Modeling

We used these same USGS lidar datasets on some smaller property modeling projects too, isolating individual property parcels and formatting them for us in renovation planning.

This example uses our ITS director's backyard, which has a very strange valley in the center of a small block, with a giant ficus covering the whole property.

We cut away the foliage layer to reveal the terrain below (some laser points penetrate through foliage) and then connect it into a perfectly scaled 3D printable model.

This whole process used 4 different data sets and 3 different tools, but was all accomplished within a total hour and a half of work. It's a highly accessible and impactful capability which we'll be advertising to users in the coming year.



Locating Hidden Archaeological Sites with Lidar

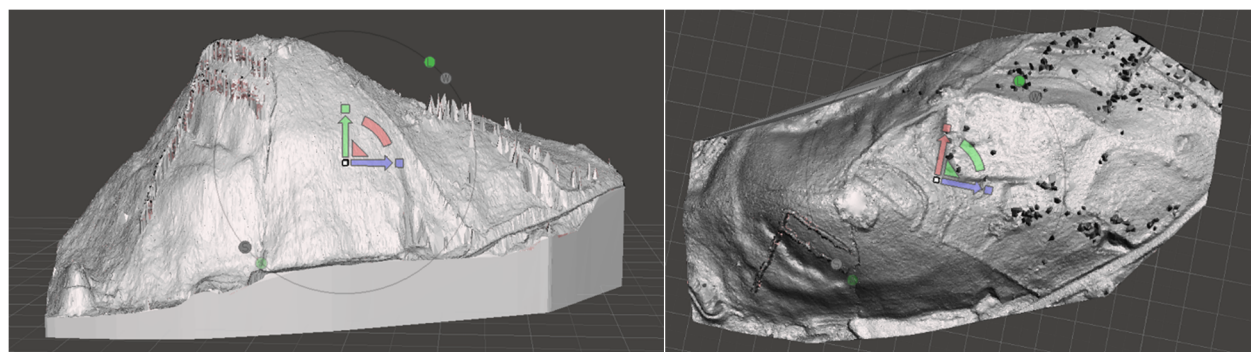
While attending the 2017 American School of Oriental Research (ASOR) in Boston, we met an Archaeologist named Dr. Jeff Howry from the Harvard Semitic Museum. He was interested in replicating a process by which Lidar data formatted for analysis of old overgrown structures. We chose to try it with a site called Mackerel Hill in Waltham Massachusetts. We used publicly available data from the USGS earth explorer. The hill is mostly covered by trees, but because lidar can penetrate leaves to the ground below, we filtered out the trees, leaving a clean 3D terrain model.



An F shaped mound appears, showing the location of 18th field boundaries, this land had once been cultivated.

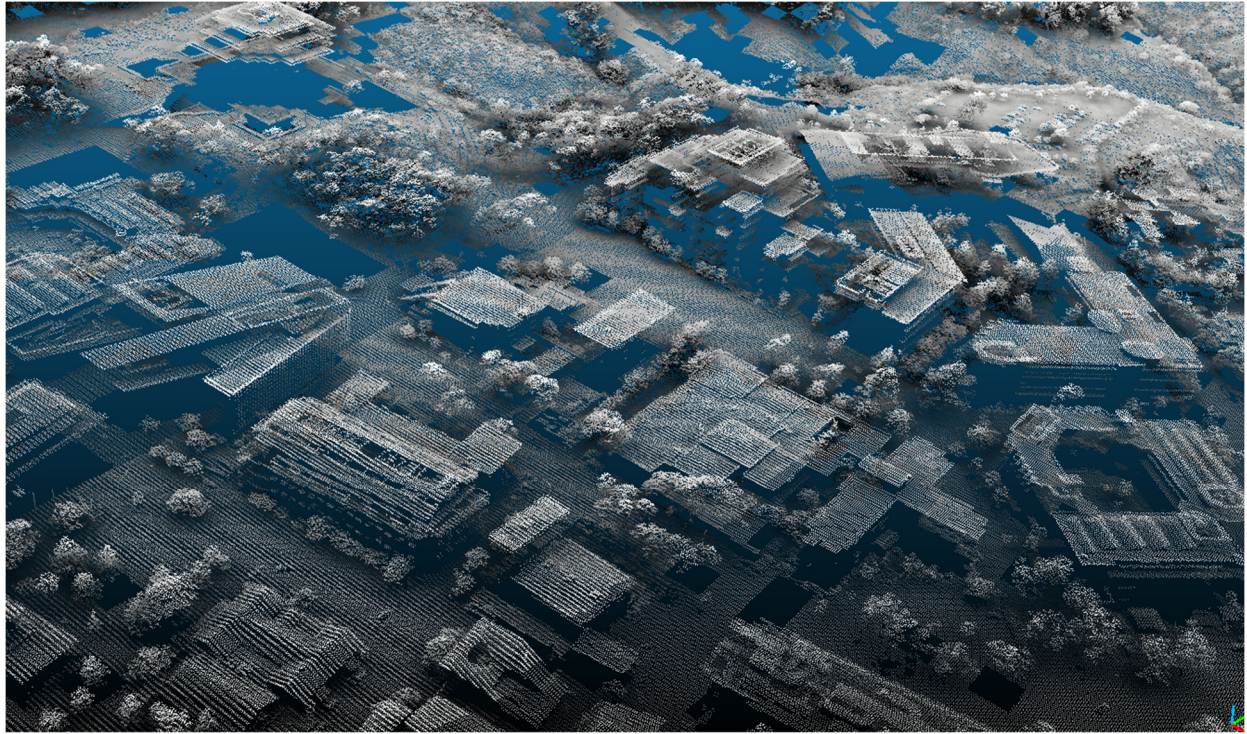


We exaggerated the height of the terrain to highlight these subtle features.

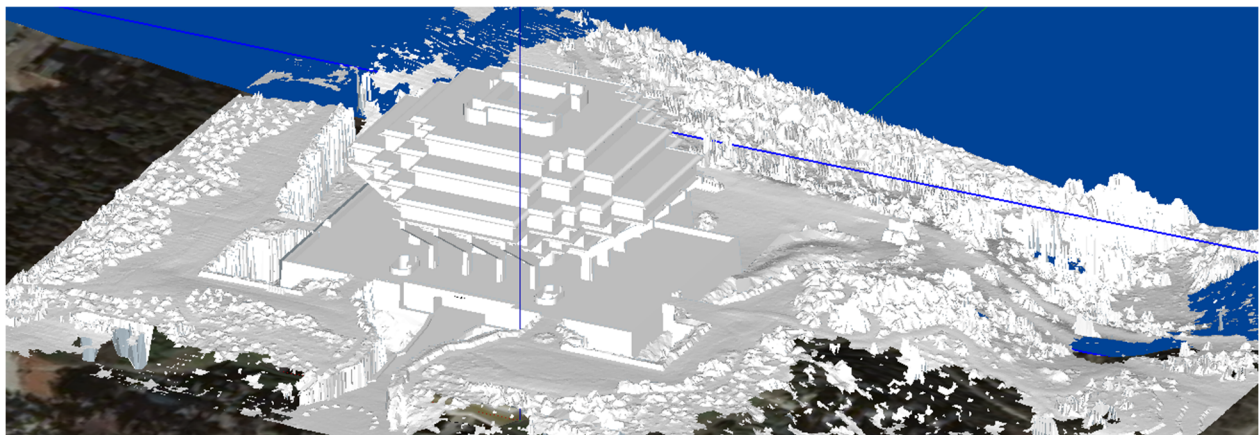


Lidar Geisel Library Model

We've done a lot of work with lidar this year. There's a lot of publicly available aerial point cloud data available through the USGS. We used it to grab models of the whole campus, as well as individual property terrain. As this data is generally used by GIS experts, it became an opportunity for collaboration between DML and GIS labs. Below is a lidar point cloud showing campus center, with the library in the top left corner. Lidar shows only horizontal surfaces, and trees are just clouds of points.



We used this data along with satellite imagery and the DML's existing Geisel Library tower model, to create a 3D printable mesh of the entire Geisel Library exterior, including forum level and terrain. It required a lot of cleanup, as trees turn into weird jagged spikes when points are connected into polygons.



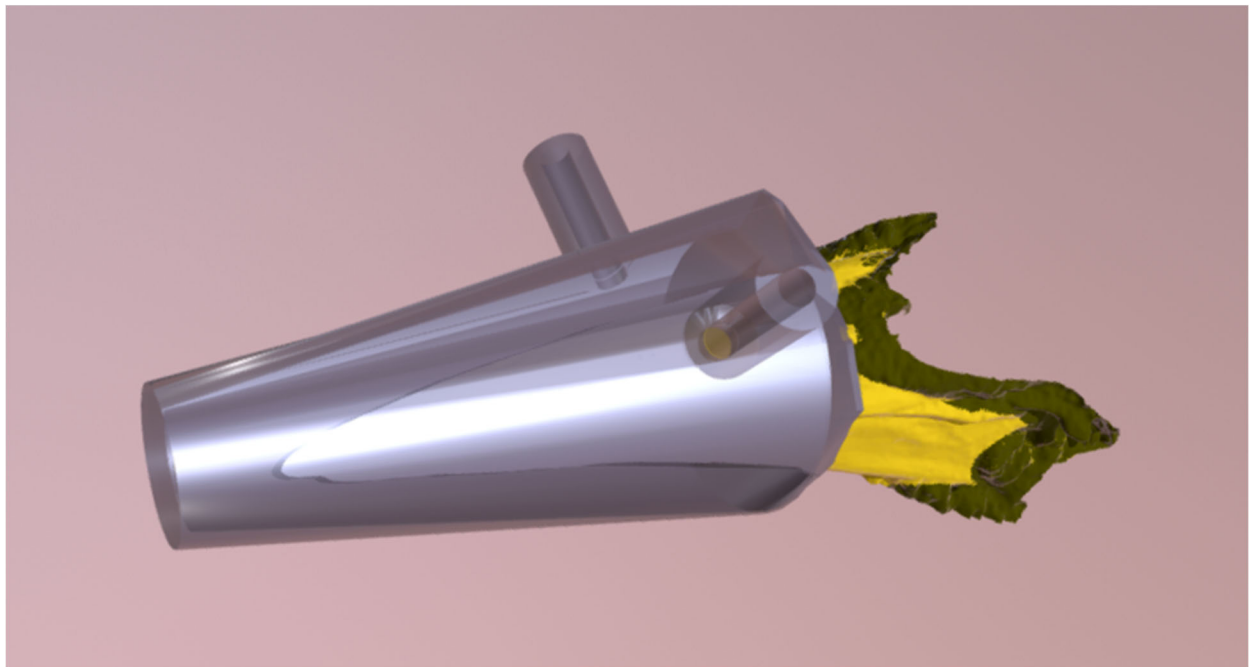
Human Ear Surgical Training Model

In collaboration with Dr. David Bracken, an ear nose and throat surgeon an instructor at the UCSD School of Medicine, we've taken CT scan imagery from a real person, isolated the ear and its internal structures, and printed a 3 piece system which allows emergency medicine surgeons to practice puncturing ear drums (simulated by a piece of blue nitrile glove stretched across the ear canal, and deposit a drainage stent. The last prototype was done with a rubbery material for the ear, which simulated the properties of cartilage. The ear is now being outsourced for printing in alternative materials, and should be part of a medical journal article sometime in 2019. (Bracken et. Al. 2020)



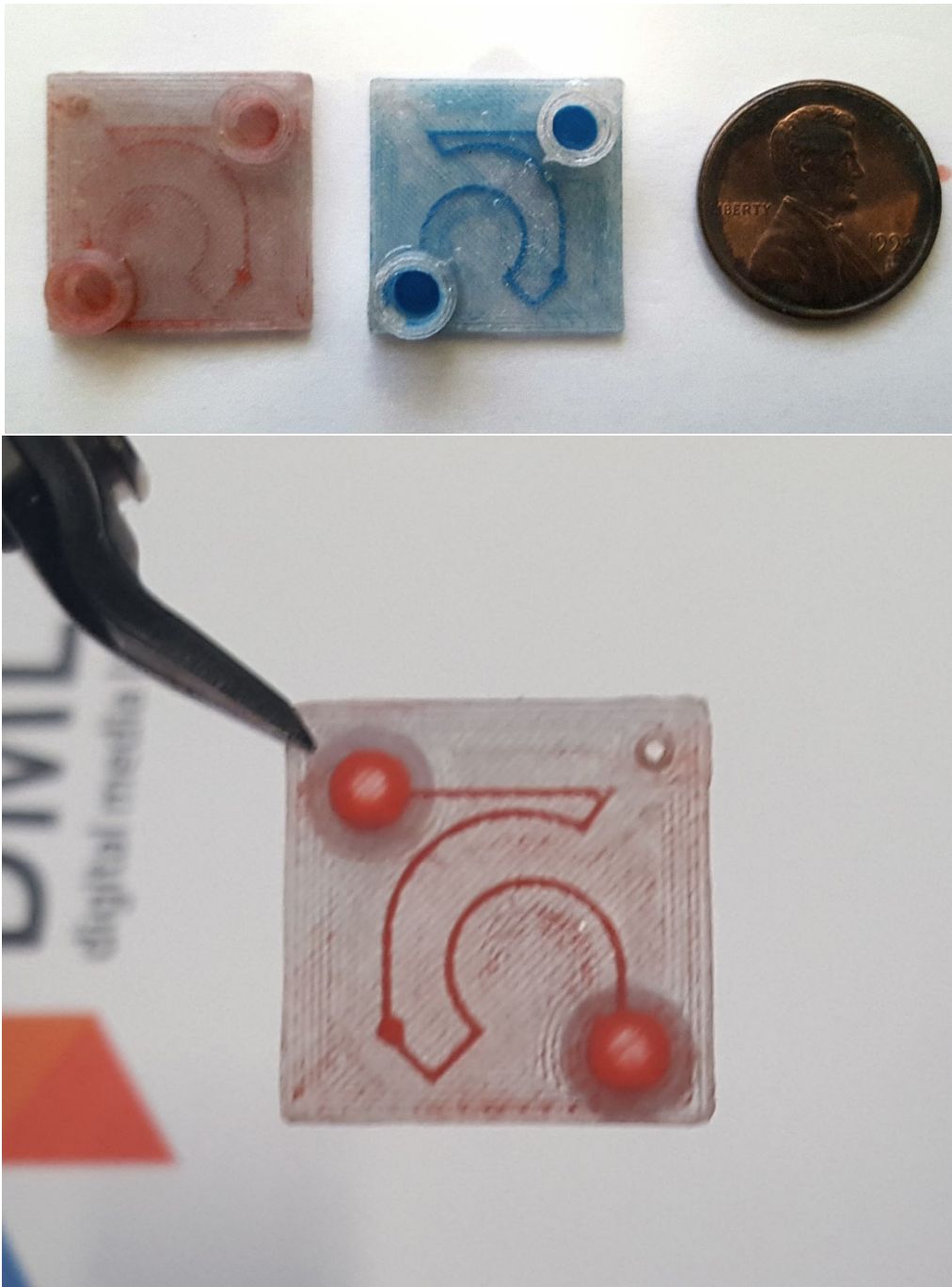
Bird Anesthesia Masks

Daril Brown is a Bioengineering PHD student working in a lab which performs neurological linguistics research on birds. He's an engineer turned bird surgeon. Unfortunately, their surgical equipment is not optimized for bird research. We helped Daril scan his birds to create custom anesthetic masks and form fitting sensor hoods, which should reduce surgery time and mortality rate. Daril's lab works with starlings and two varieties of finch, we've designed custom masks which conform to their unique beak profiles. We were also able to find a free database containing thousands of high quality 3D beak models to aid us in the design process.



Microfluid Mixers

We worked with Biology undergrad Yousif Slaiwa to prototype a number of microfluid mixers, meant to guide tiny amounts of different fluids through precisely sized channels. We had limited success with our own printers, you can see that colored water from our tests seeped out through the prints' layer matrix. We did end up designing a few to be printed by 3rd party services, those worked as required.



Sea Turtle Shell Brace

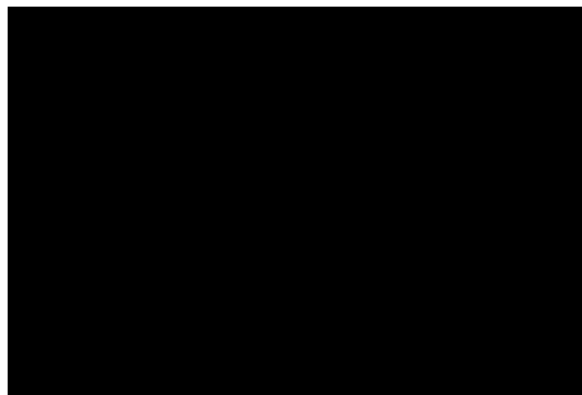
We were approached by Dr. Jenn Moffat, director of animal husbandry at Birch Aquarium, soon after our initial collaborations with the Sandin lab. Jenn needed to fabricate a custom brace which would keep this turtle's damaged shell from growing inward on itself. The process was somewhat simple. Lindsay Bonito of the Sandin lab created a 3D model of the shell using high quality photos. We were able to use this model to create a form fitting brace which fit perfectly inside the complex gap.



The story was picked up by CNN health and 3Dprint.com, subsequently spreading to hundreds of other local tv news stations and websites.

<http://www.cnn.com/2017/12/09/health/turtle-3-d-shell-trnd/index.html>

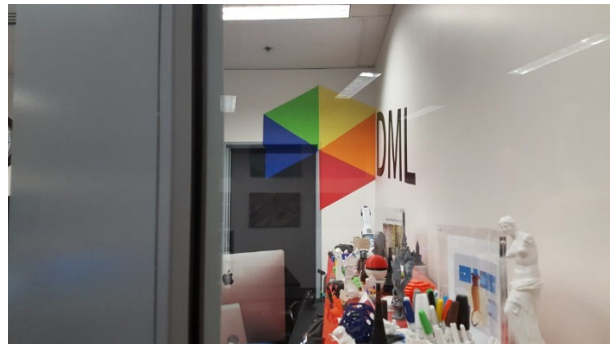
The story was later picked up by BBC Earth, who sent out a crew to film the turtle at Birch and the DML.



Birch Aquarium was very generous in sharing credit with the Library, and a number of other collaborations spun off from this project.

Forced Perspective Mural

We've been experimenting with projection mapping. The idea is that you look at the wall mural from a spot right in front of our service desk (where most people stand to get help) and see a flat image, but as you move around you see how distorted it is. We put this up with removable masking tape. It'd have been better if planned from farther away so human stereoscopic vision and height variation were less of an issue.



Video Motion Tracking

We have the ability to take our 3D assets and overlay them in video scenes. Select tracking points in the video, and the camera's movement is imported into the 3D scene. Their motion matches the shake and movement of the camera, making it seem like the object is in the scene. We made this video for a photogrammetry workshop. 3D scanned our lab gnome and put him in a video.

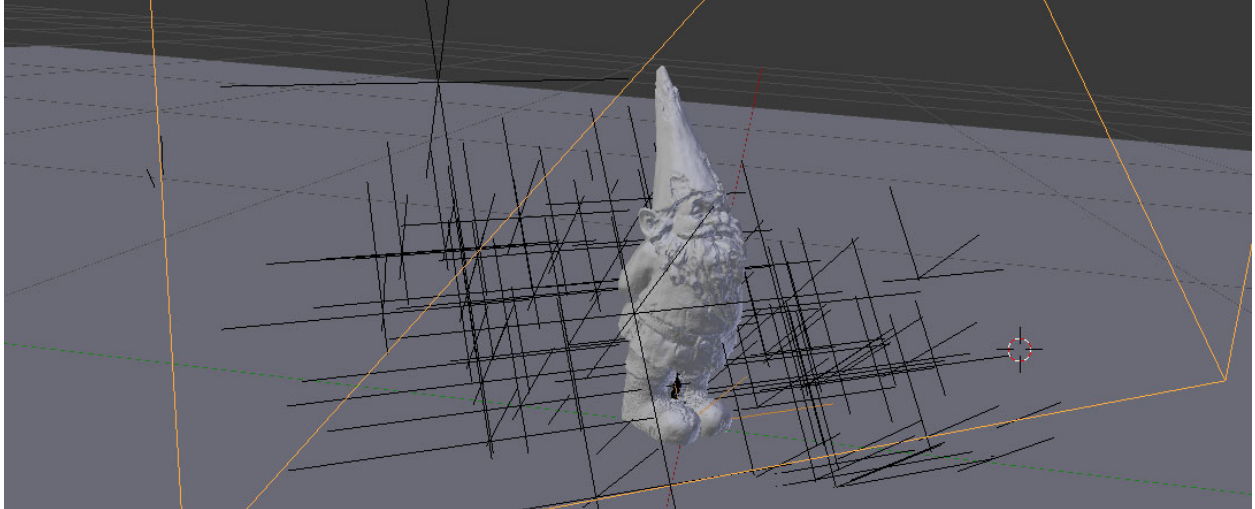
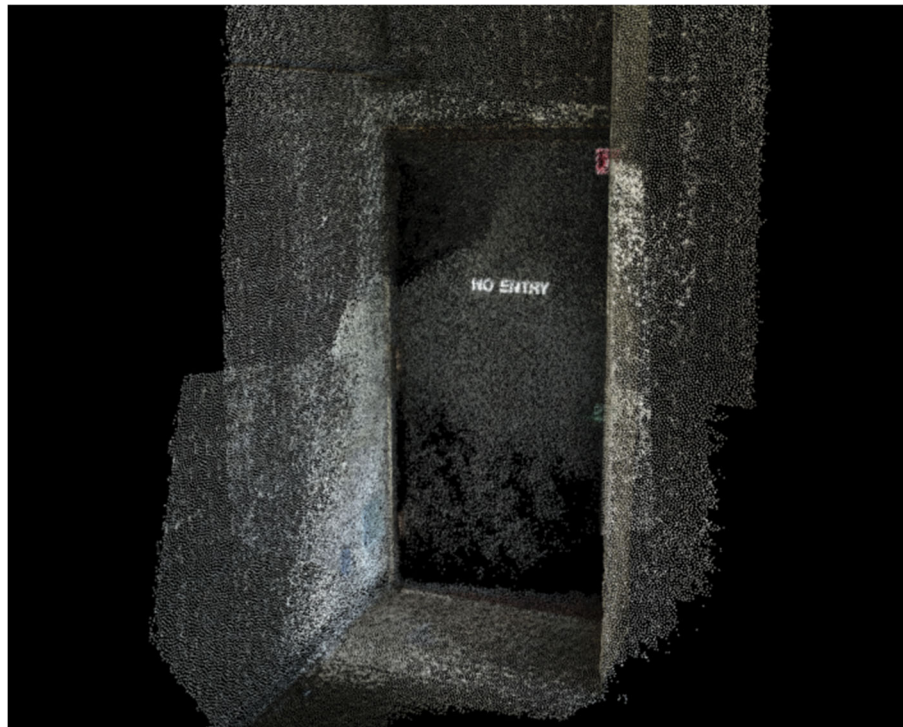
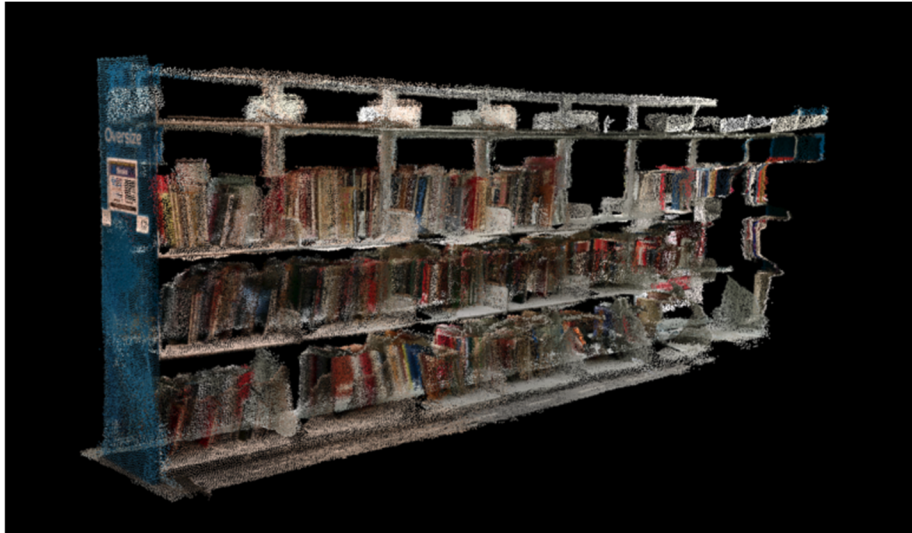


Figure 7 <https://youtu.be/4bljiR5s-lk>

Sparse Point Cloud Scanning

Some smart phones are built with IR emitters which make point cloud scanning very quick and simple. These models were each scanned in less than 3 minutes. They're not useable for most media application because they're made of individual unconnected points, but they can be very useful in scanning rooms for reference measurements or for XR applications tracking objects and spaces.



References

Bracken, David; Coffey, Charles; McAvoy, Scott (2020). Myringotomy Trainer - 3D printable files. figshare. Media. <https://doi.org/10.6084/m9.figshare.11944950.v4>

Kwan GT, Song D. (2018) Squidtoons: Exploring ocean science with comics. Andrew McMeel Publishing. (ISBN:9781449490249).