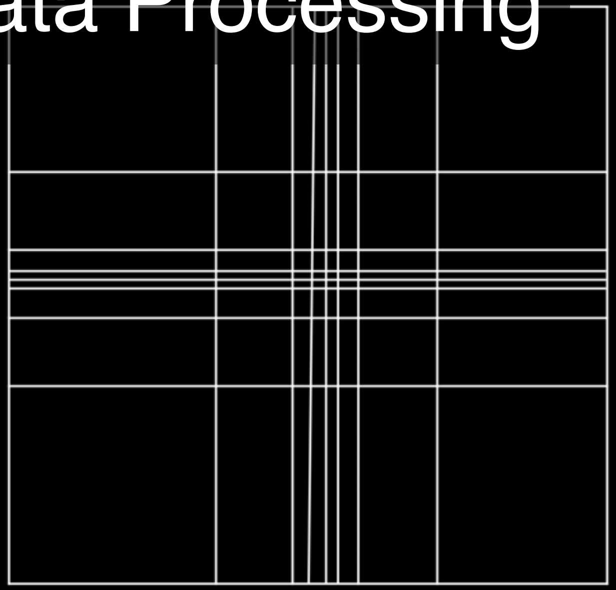
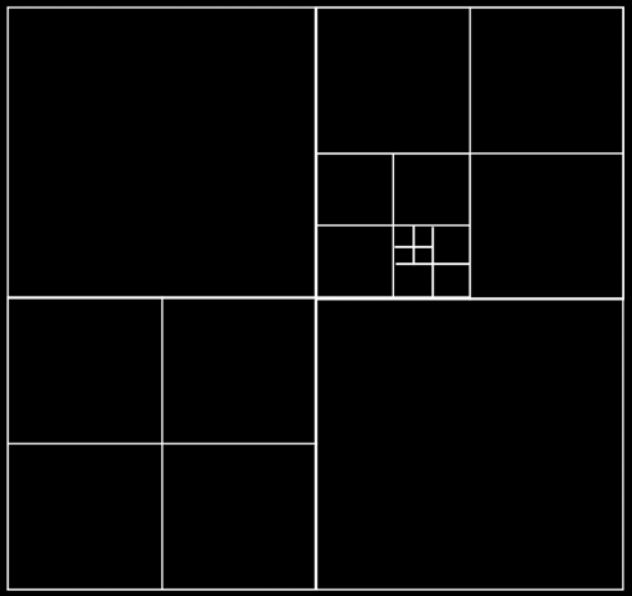
Kalina Borkiewicz

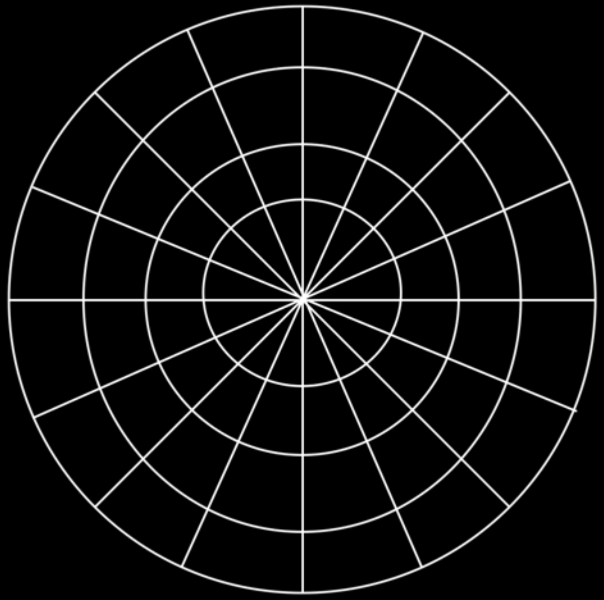
Senior Research Programmer

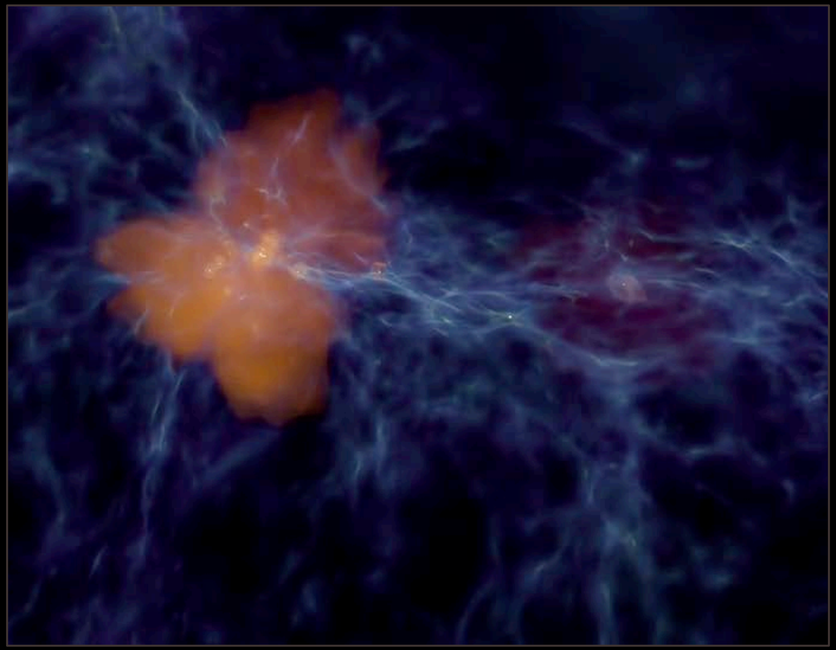
Advanced Visualization Lab

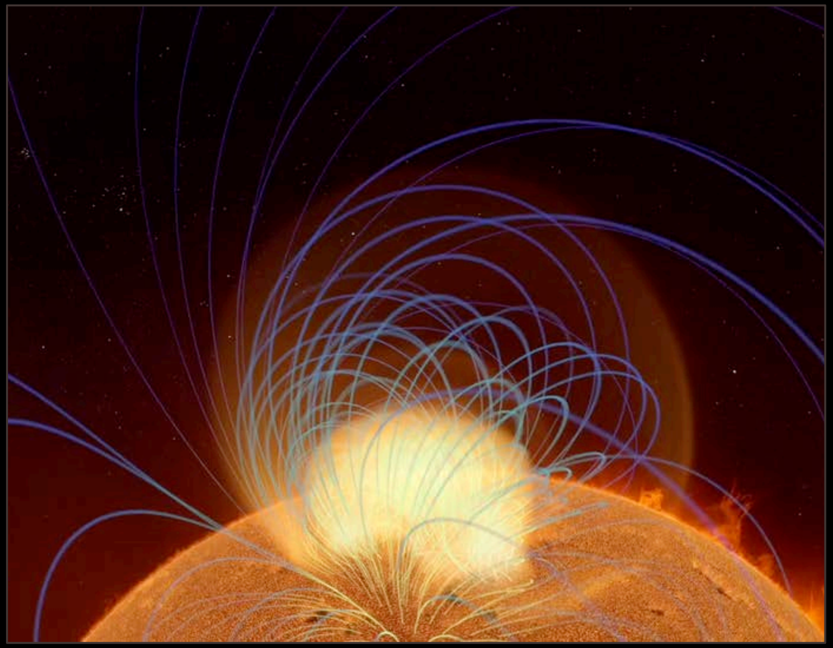
Data Processing



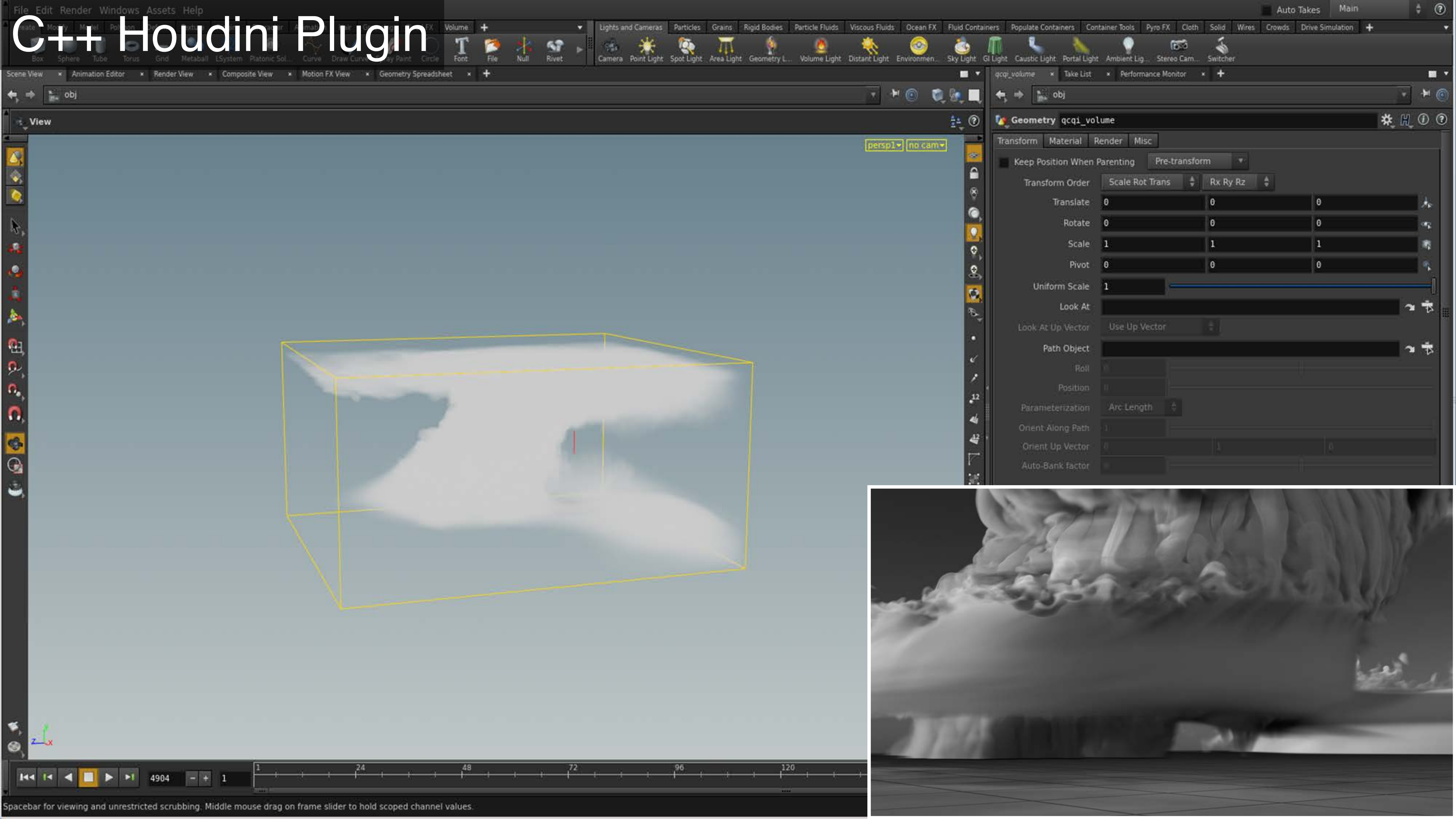




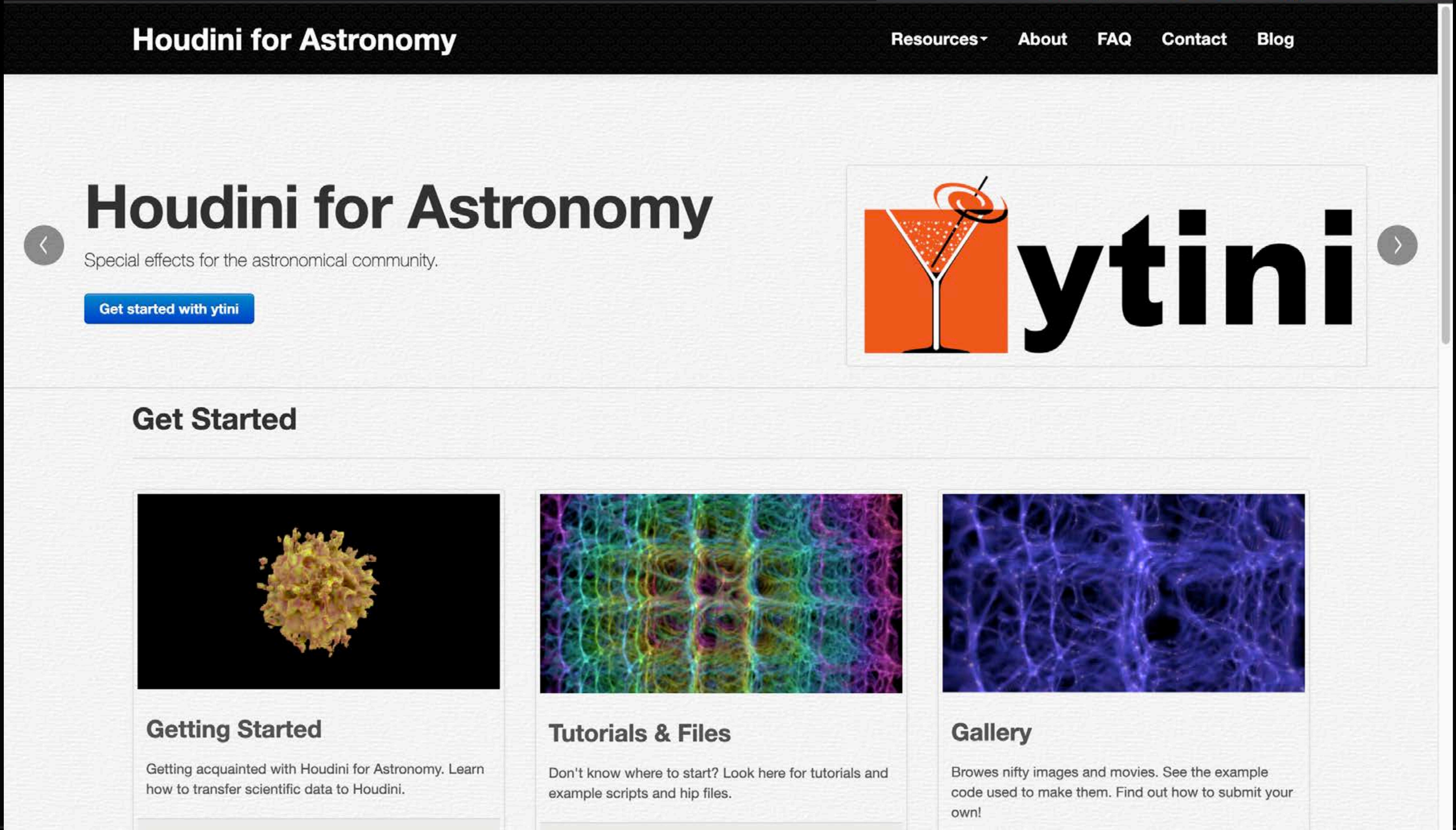




C++ Houdini Plugin



Open Source Visualization Middleware



Papers and Web-Based Tutorials

Cinematic Visualization of Multiresolution Data: *Ytini* for Adaptive Mesh Refinement in *Houdini*

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Received 2018 March 8; revised 2019 May 2; accepted 2019 May 3; published 2019 June 11

Abstract

We have entered the era of large multidimensional data sets represented by increasingly complex data structures. Current tools for scientific visualization are not optimized to efficiently and intuitively create cinematic production quality, time-evolving representations of numerical data for broad impact science communication via film, media, or journalism. To present such data in a cinematic environment, it is advantageous to develop methods that integrate these complex data structures into industry-standard visual effects software packages, which provide a myriad of control features otherwise unavailable in traditional scientific visualization software. In this paper, we present the general methodology for the import and visualization of nested multiresolution data sets into commercially available visual effects software. We further provide a specific example of importing adaptive mesh refinement data into the software *Houdini*. This paper builds on our previous work, which describes a method for using *Houdini* to visualize uniform Cartesian data sets. We summarize a tutorial available on the website www.ytini.com, which includes sample data downloads, Python code, and various other resources to simplify the process of importing and rendering multiresolution data.

Key words: miscellaneous

1. Introduction

Data visualization is defined as the display of information in a graphical format and can refer to different types of data (e.g., relational and spatial) and different styles of graphics (e.g., two-dimensional graphs and three-dimensional renderings). Either type of visualization serves two purposes: data analysis and communication. Visualization and traditional numerical analysis are complementary methods of analyzing relationships between variables or spotting regions of interest in large data sets (Goodman 2012). Additionally, visualization is a way to communicate findings, whether in academic papers, presentations to peers, or when communicating complex concepts to the general public (Barnes & Fluke 2008; Punzo et al. 2015; Vogt et al. 2016; Borkiewicz et al. 2017).

In this paper, we focus on cinematic data visualization for purposes of science communication. The aim of cinematic visualization is to be not only educational and compelling but also aesthetically pleasing and entertaining in order to have broader appeal. Pandey et al. (2014) suggested that data visualization is more persuasive than communicating with tables or numbers, and Cawthon & Moere (2007) found that aesthetic visualizations are more educational than unattractive ones. By leveraging the familiar visual language established by Hollywood films, a cinematic presentation of science thus creates interest in topics that may otherwise be thought of as dull and difficult to learn (Dubeck et al. 2003; Serra & Arroio 2008; Arroio 2010). As alluded to in Chen (2005), aesthetic is a critical and as of yet unsolved problem in data visualization, growing only more important as data become more complex (Moere & Purchase 2011; Kim & Park 2013).

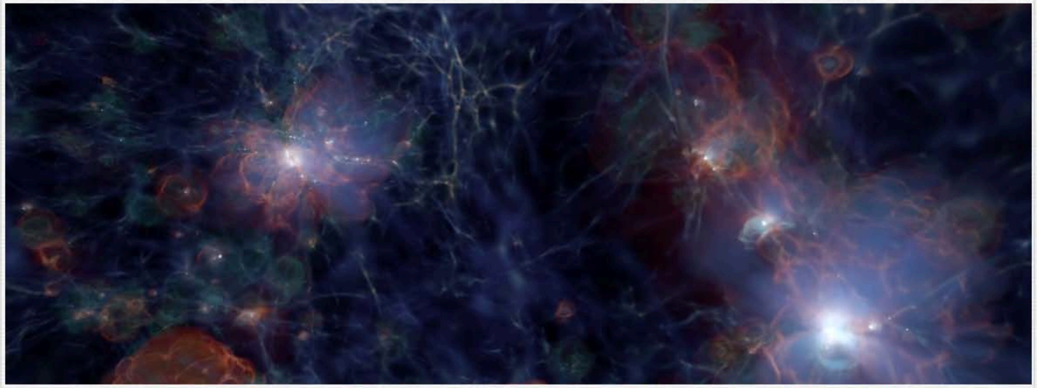
Providing scientists with the means to generate cinematic imagery from their data allows them to create more impactful, educational, pleasing, and broad-reaching imagery by taking a more aesthetic approach to visualization. Free online platforms such as YouTube or Vimeo can be used directly by scientists to share their visualizations with the broader public. Welbourne & Grant (2016) showed that user-generated science content (i.e., videos created by scientists or science enthusiasts) is far more popular on YouTube than videos made by professional science communicators. While a cinematic approach to visualization is not yet part of the day-to-day workflow of a typical scientist, it can be used at the end of a research project to communicate with the general public through teaching or outreach, with peers through presentations and publications, and with funding agencies. Cinematic data visualization is also of use to visual effects designers who desire to incorporate real science into film (e.g., James et al. 2015; Li 2018). This paper focuses on methodology specifically applicable to astronomers. Though cinematic visualization is computationally expensive, looking to the future, this cost will decrease as technology and techniques improve.

1.1. Current State of Visualization Tools

Several established and well-adopted tools already exist for data visualization (*ParaView*[4] from Ahrens et al. 2005, *VisIt*[5] from Childs et al. 2012, *yt*[6] from Turk et al. 2011), and likewise for visual effects and animation (*3DS Max*,[7] *Blender*,[8] *Houdini*,[9] *Maya*[10]). However, neither category of tools is well suited for cinematic data visualization. Table 1 compares a

4 https://www.paraview.org/
5 https://visit.llnl.gov/
6 http://yt-project.org/
7 https://www.autodesk.com/products/3ds-max/
8 https://www.blender.org/
9 https://www.sidefx.com/
10 https://www.autodesk.com/products/maya/

AMR Data Data Within Data Within Data



"First Light in the Renaissance Simulations: Formation of the Very First Galaxies in the Universe" Image Credits

The cosmology simulation used to make the beautiful header image contains many Adaptive Mesh Refinement (AMR) levels, many variables, and took a team of professionals many months to make look that good. Let's start a little simpler.

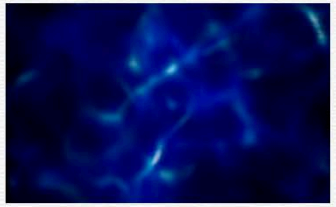
The problem with AMR is that Houdini likes nice, simple, uniform grids - but astrophysicists oftentimes don't. So, how do we render AMR data with Houdini? Here is the formula for Enzo, Athena, and FLASH (FITS coming soon). There are two main parts:

1. Part One: External Scripting
   - 1.1 Download the Data
   - 1.2 Convert AMR data to VDBs with Python
2. Part Two: In Houdini
   - 2.1 Create the Geometry in Houdini
   - 2.2 Set up the Shader in Houdini

Before starting this tutorial make sure you've installed pyopenvdb as discussed in the Install PyOpenVDB Tutorial and make sure all of your yt and pyopenvdb paths are in your PATH variable as discussed in both the Install PyOpenVDB Tutorial and the Getting Started page.

1.1 The Data

Begin by downloading the Enzo Tiny Cosmology sample dataset from here. Take note of the directory where this is being saved. Go there, and unzip the folder.



1.2 The Code

Download the writeAMRVDB.py Python script from our Bitbucket repository. Take note of the directory where this is being saved.

Open the file in a text editor. Search for the line that starts with `datafilename =`. Write in the path to the data file you downloaded.

Search for the line that starts with `outfilepath =`. Write in the path to the directory where

Publications

PUBLICATIONS

JOURNALS

Sener, M., Levy, S., Stone, J. E., Christensen, A. J., Isralewitz, B., Patterson, R., **Borkiewicz, K.**, Carpenter, J., Hunter, C. N., Luthey-Schulten, Z., Cox, D. (2020). Multiscale modeling and cinematic visualization of photosynthetic energy conversion process from electronic to cell scales. *Under review, pending acceptance.*

Aleo, P. D., Levy, S. A., Naiman, J. P., Christensen, A. J., **Borkiewicz, K.**, Patterson, R., Cox, D. J., Turk, M. T., Lock, S. J. (2020). Clustering Methods for Cinematic Astrophysical Data Visualization. *Astronomy And Computing, accepted, pending publication.*

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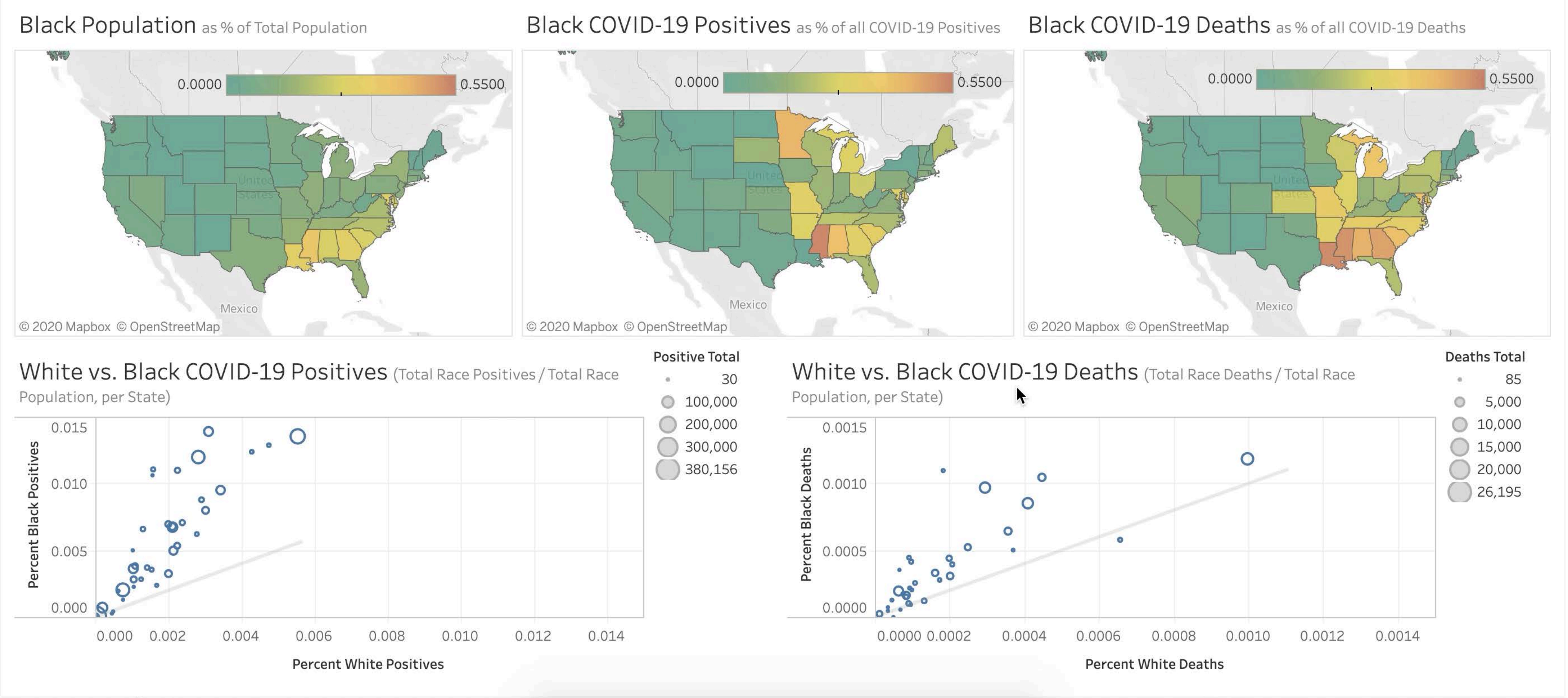
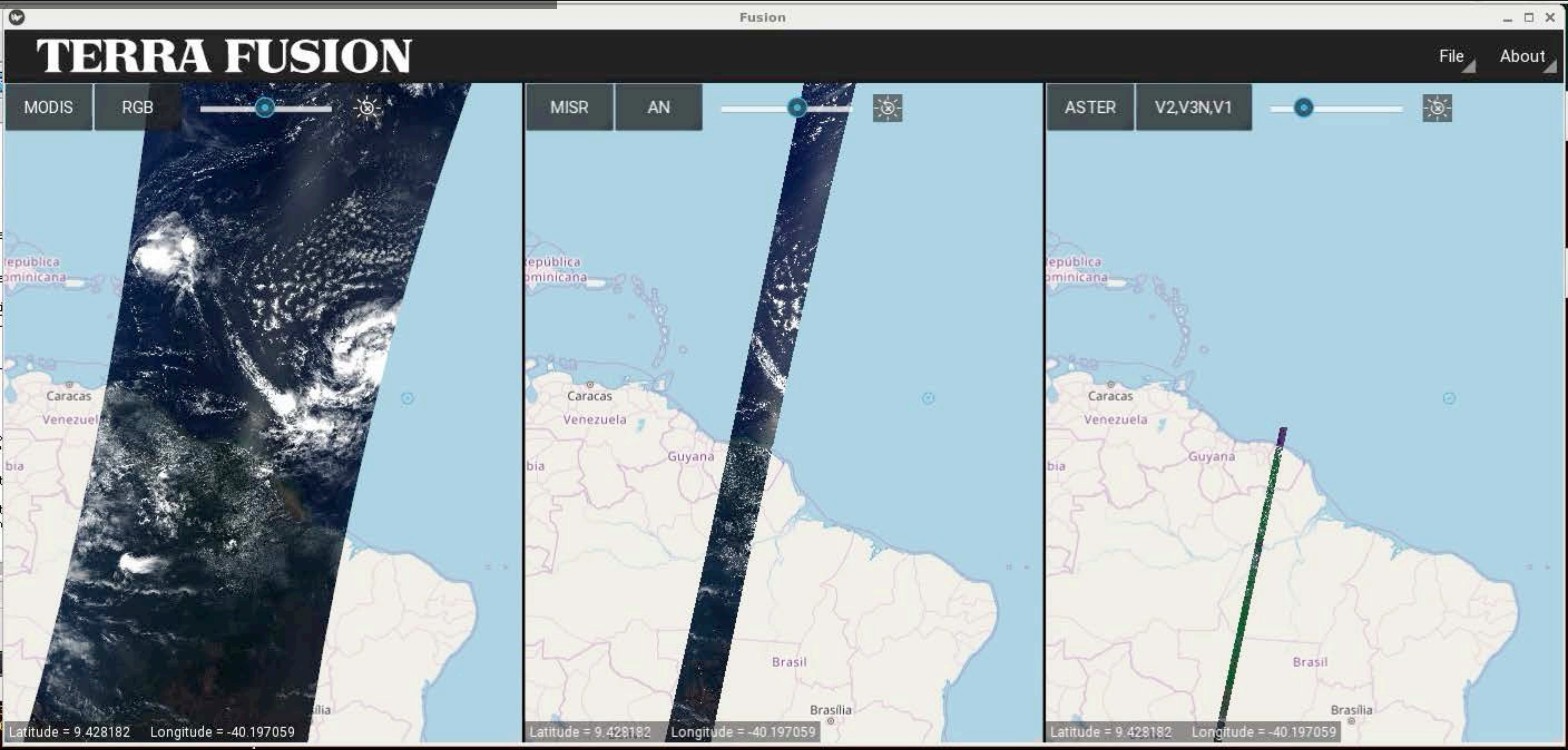
Pipeline Development

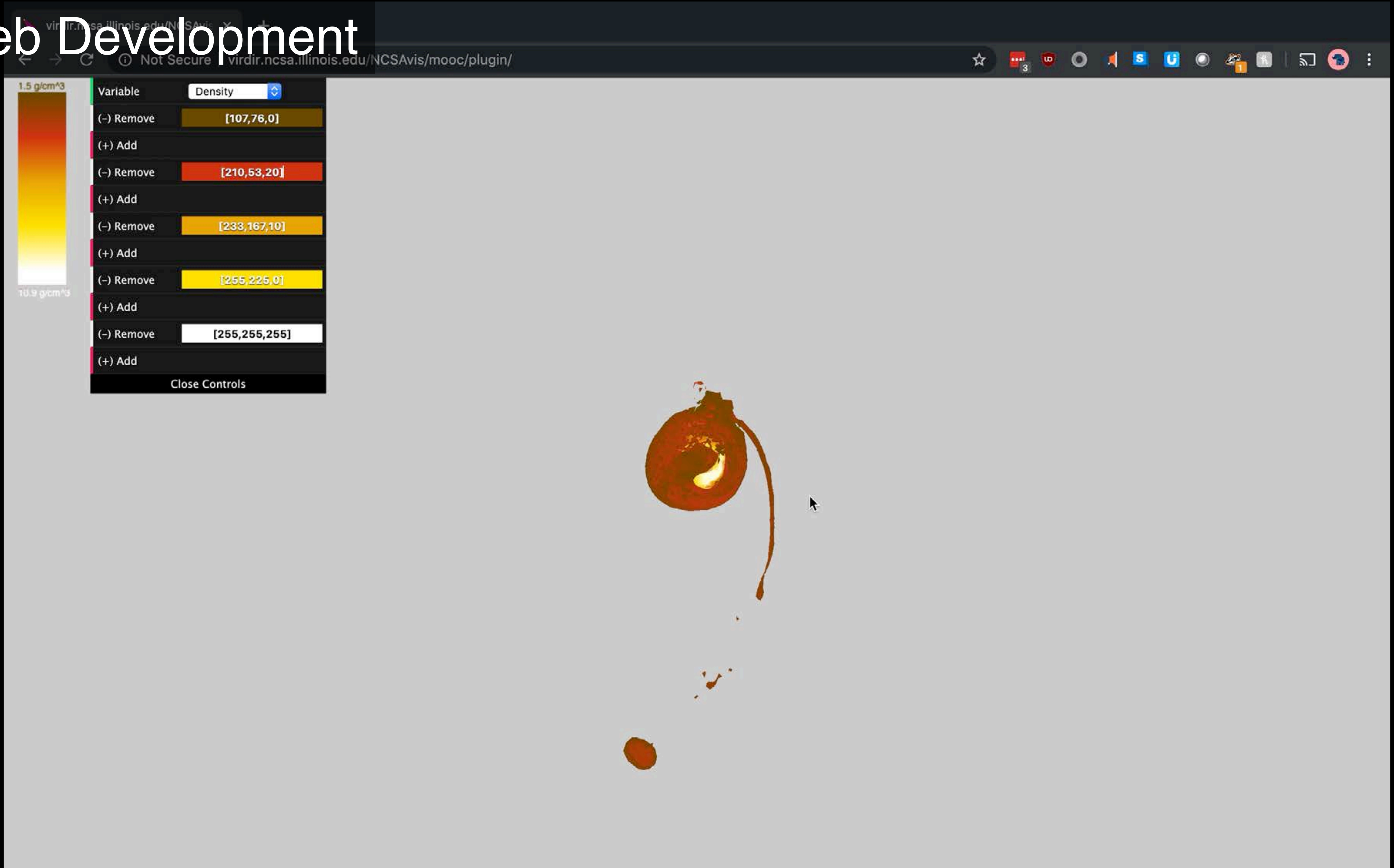
Interactive Information Visualization



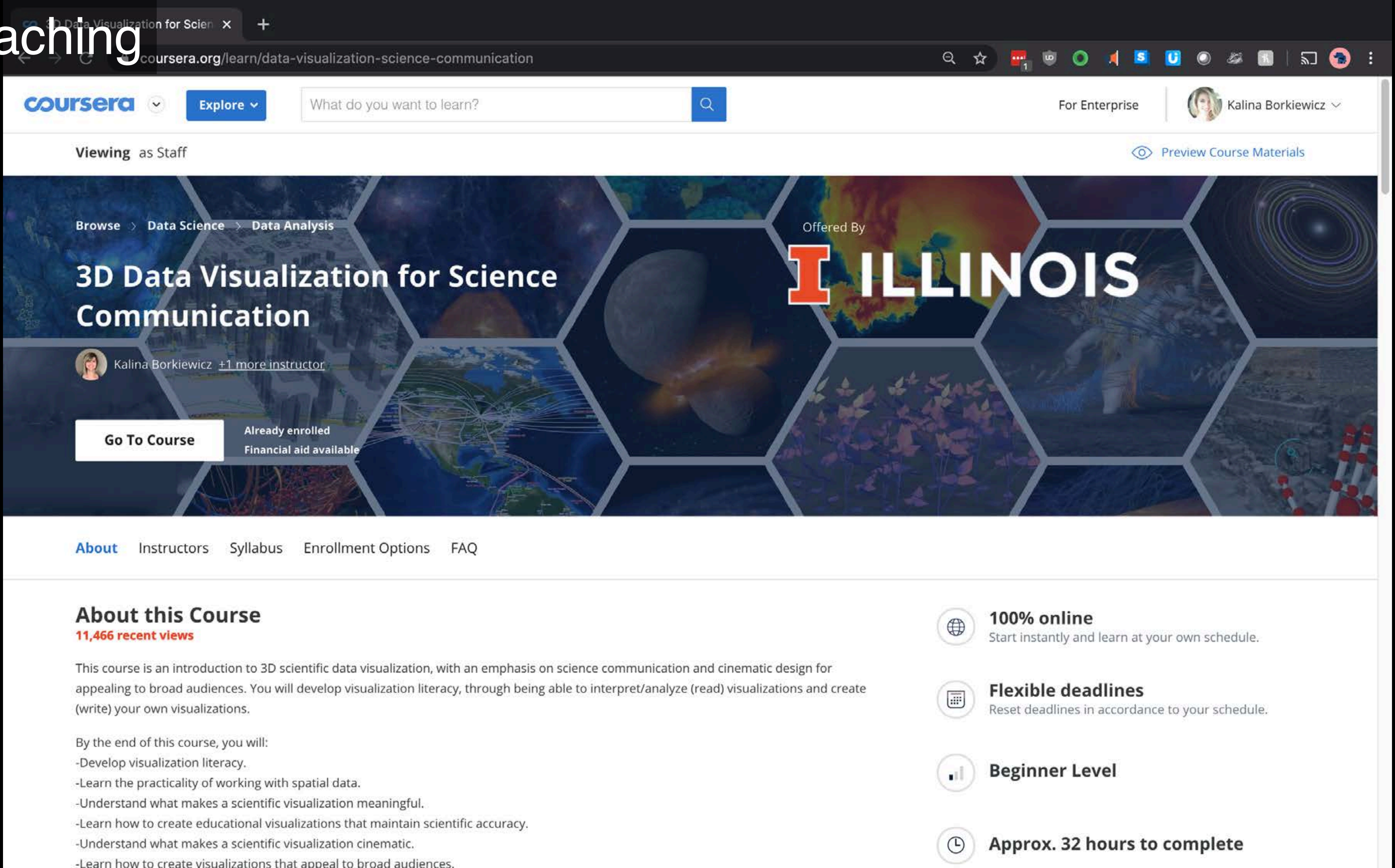
Software Development



Web Development



Teaching


3D Data Visualization for Scien
coursera.org/learn/data-visualization-science-communication
coursera
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What do you want to learn?
For Enterprise
Kalina Borkiewicz
Viewing as Staff
Preview Course Materials
Browse > Data Science > Data Analysis
3D Data Visualization for Science Communication
Kalina Borkiewicz +1 more instructor
Go To Course
Already enrolled
Financial aid available
Offered By
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Instructors
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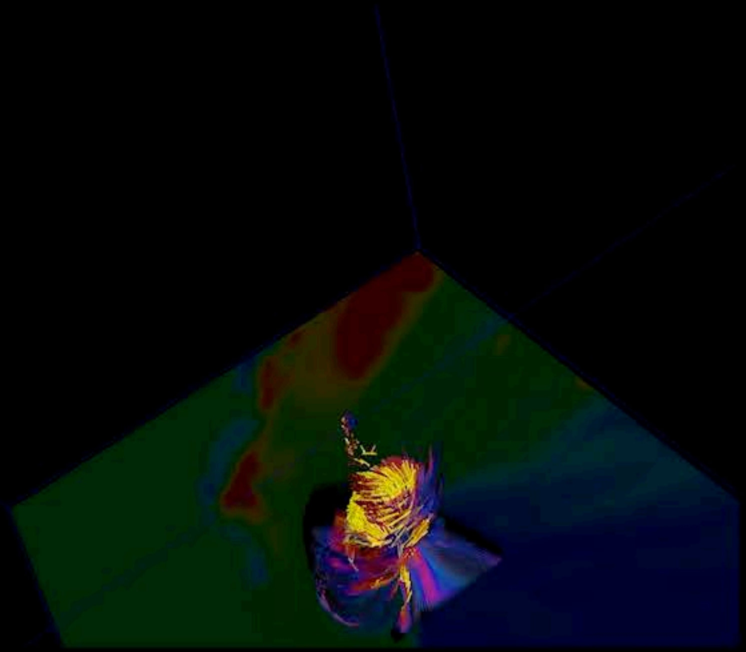
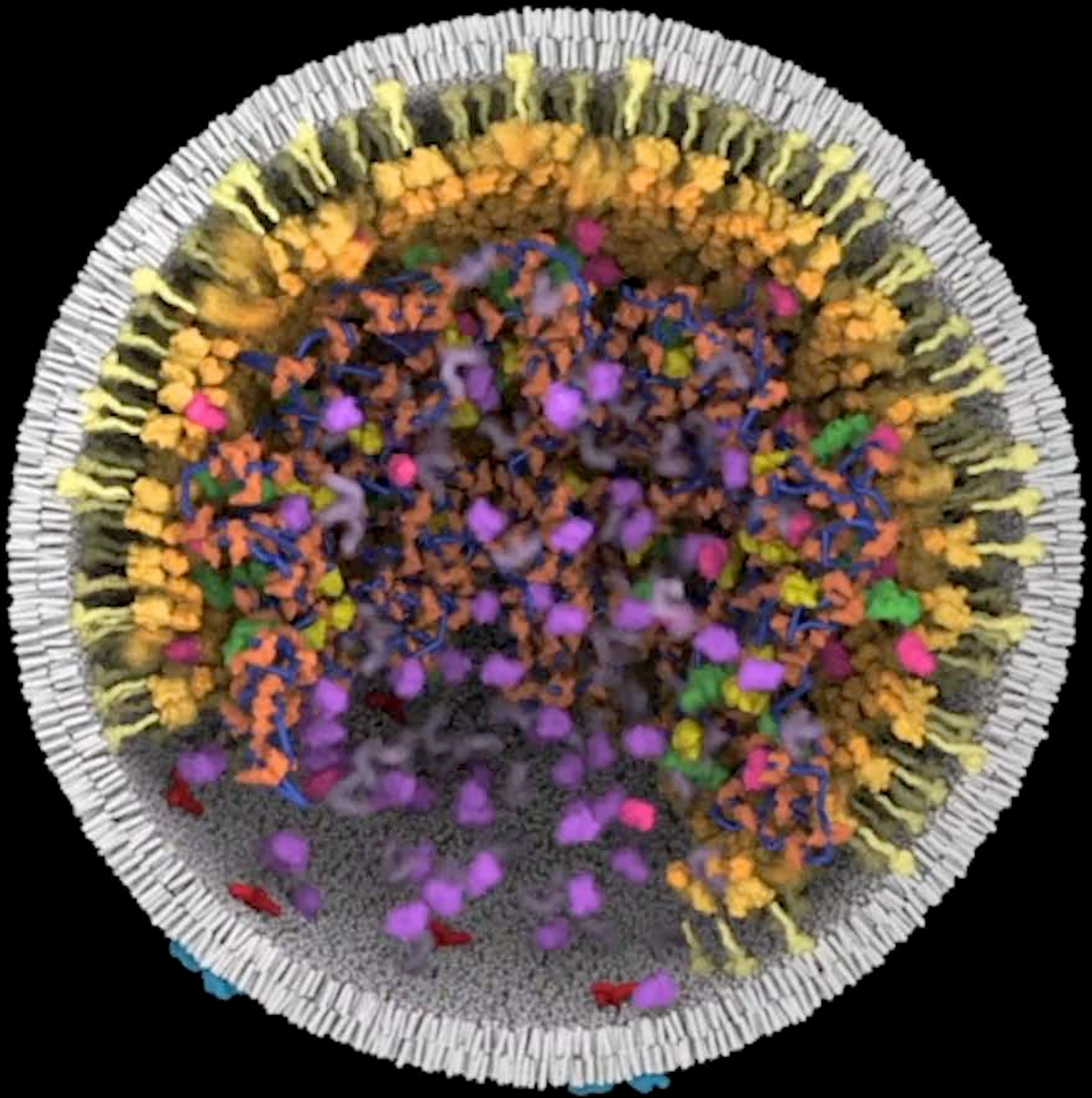
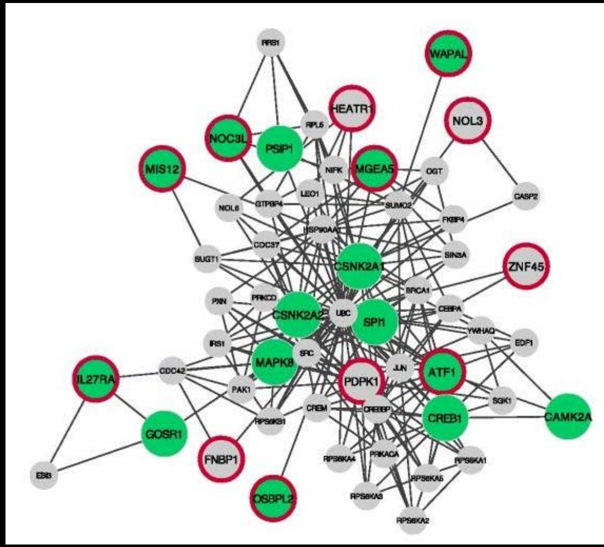
Enrollment Options
FAQ
About this Course
11,466 recent views
This course is an introduction to 3D scientific data visualization, with an emphasis on science communication and cinematic design for appealing to broad audiences. You will develop visualization literacy, through being able to interpret/analyze (read) visualizations and create (write) your own visualizations.
By the end of this course, you will:
-Develop visualization literacy.
-Learn the practicality of working with spatial data.
-Understand what makes a scientific visualization meaningful.
-Learn how to create educational visualizations that maintain scientific accuracy.
-Understand what makes a scientific visualization cinematic.
-Learn how to create visualizations that appeal to broad audiences.
100% online
Start instantly and learn at your own schedule.
Flexible deadlines
Reset deadlines in accordance to your schedule.
Beginner Level
Approx. 32 hours to complete

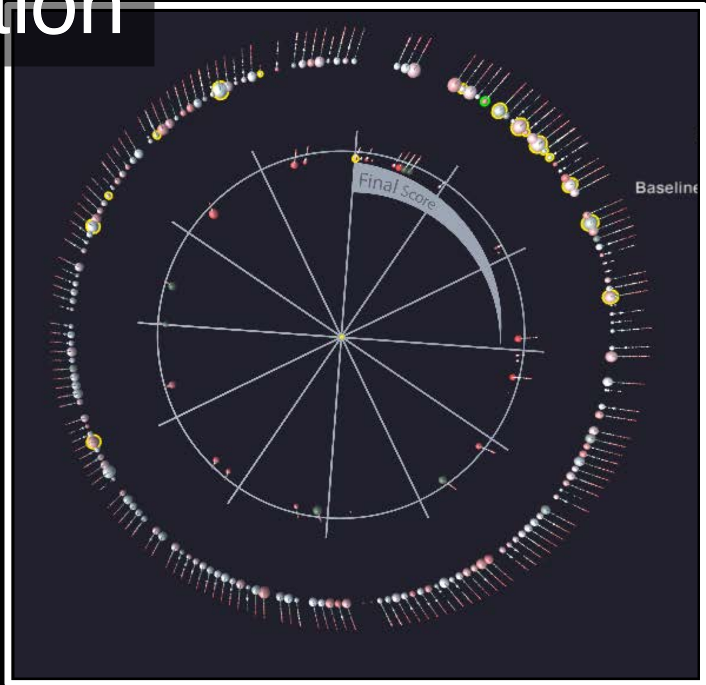
Teaching

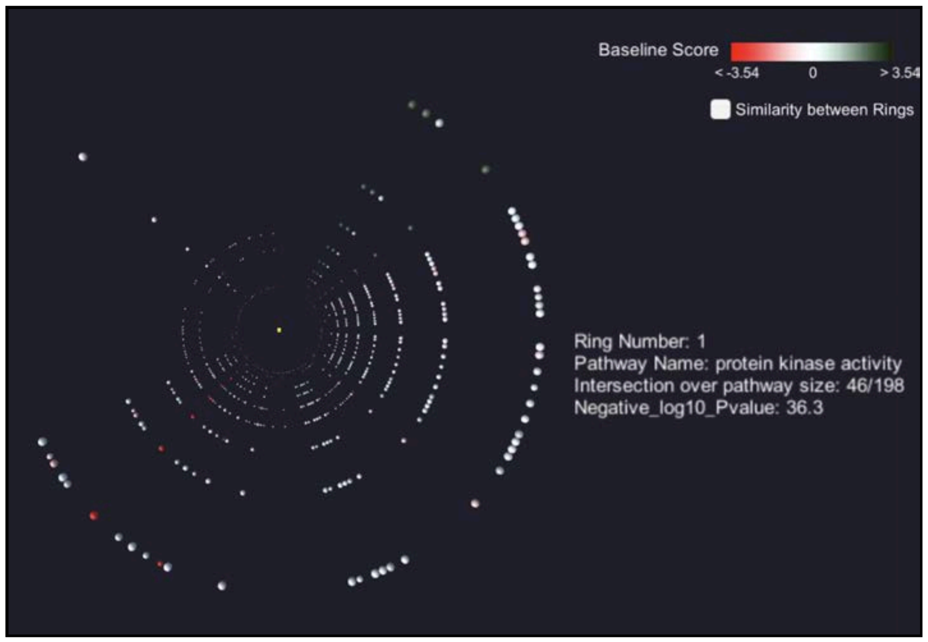


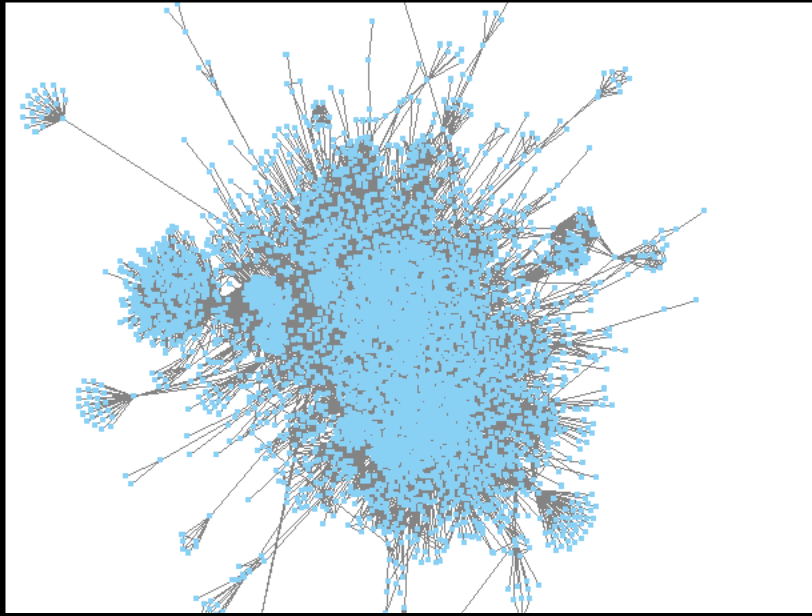


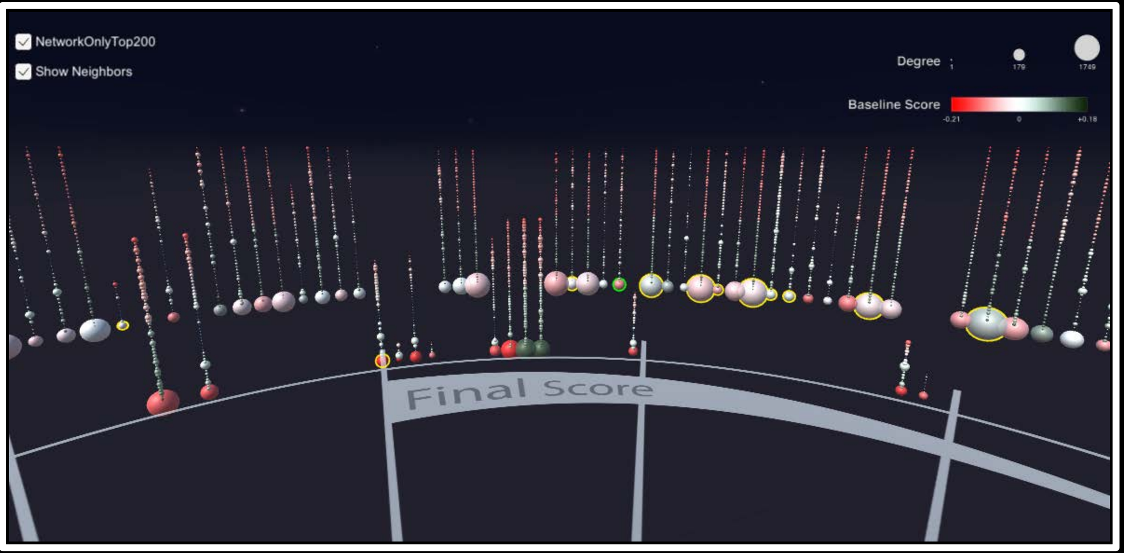
Exploratory Visualization











Mentoring Students

#1 ACM SIGGRAPH Undergraduate Research Competition – 2019

Jasmine Shih

#1 UIUC Student Employee of the Year – 2018

Dawn Nguyen

AVL Awards

2015
Solar Superstorms
Honorable Mention,
Espinho Fulldome Festival

2016
Solar Superstorms
Award Winner,
Jena Fulldome Festival

2016
Solar Superstorms
Audience Award,
IPS Brno Fulldome Festival

2016
Solar Superstorms
Official Selection,
Gwacheon International Film Festival

2016
Solar Superstorms
Official Selection,
SIGGRAPH Electronic Theater

2016
A Beautiful Planet
Truly Moving Picture Award,
Heartland Film

2017
Solar Superstorms
Official Selection,
Astra Film Festival

2017
First Light in the Renaissance
1st Place Best Scientific Visualization,
Supercomputing

2017
Milky Way Analogue Isolated Disk Galaxy
2nd Place Best Scientific Visualization,
Supercomputing

2017
A Beautiful Planet
100% Rating,
Rotten Tomatoes

2018
Solar Superstorms
Official Selection,
Macon Film Festival

2018
Solar Superstorms
Annual Dome Film Award,
Beijing Film Festival

2019
Photosynthesis in a Chromatophore
Official Selection,
SIGGRAPH Electronic Theater

2019
Birth of Planet Earth
Director's Award,
IPS Brno Fulldome Festival

2019
Birth of Planet Earth
Best Astronomical Visualizations,
Reflections of the Universe Fulldome Festival

2019
Birth of Planet Earth
Official Selection,
Macon Film Festival

2019
Birth of Planet Earth
Official Selection,
Astra Film Festival

2019
Birth of Planet Earth
Official Selection,
Immersive Film Festival

2019
Birth of Planet Earth
Best Educational Dome Film,
DTLA Film Festival

2019
Birth of Planet Earth
Honorable Mention,
Immersive Cinema Festival IFF

2019
Photosynthesis in a Chromatophore
Official Selection,
SIGGRAPH Asia Electronic Theater

2019
The Collision that Formed the Moon
Official Selection,
SIGGRAPH Asia Computer Animation Festival

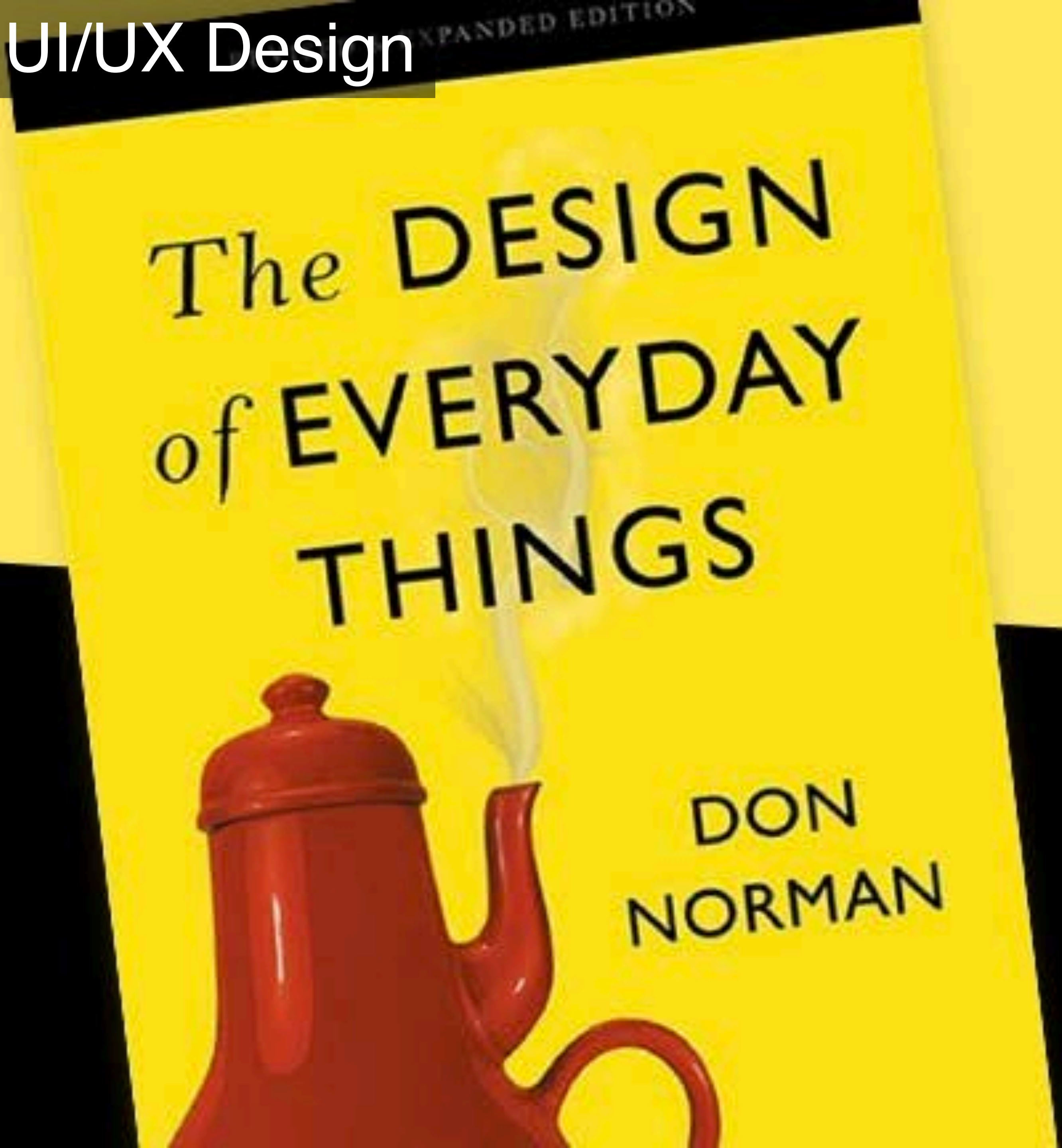
2019
Photosynthesis in a Chromatophore
1st Place Best Scientific Visualization,
Supercomputing

2020
Birth of Planet Earth
Official Selection,
Dome Under Festival

2020
Birth of Planet Earth
Official Selection,
Korean Fulldome Festival

Diversity & Inclusion

UI/UX Design

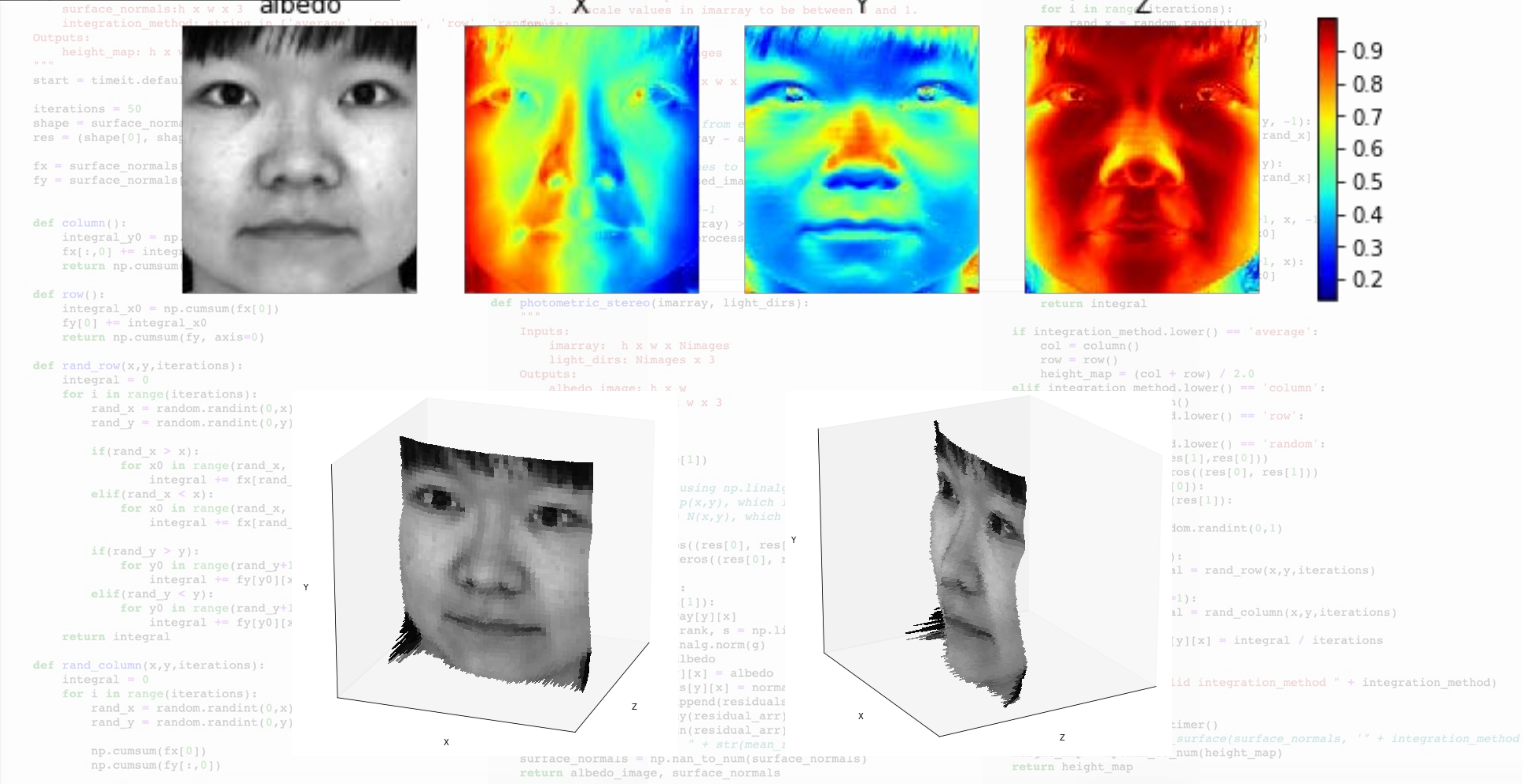


HUMAN FACTORS INTERNATIONAL

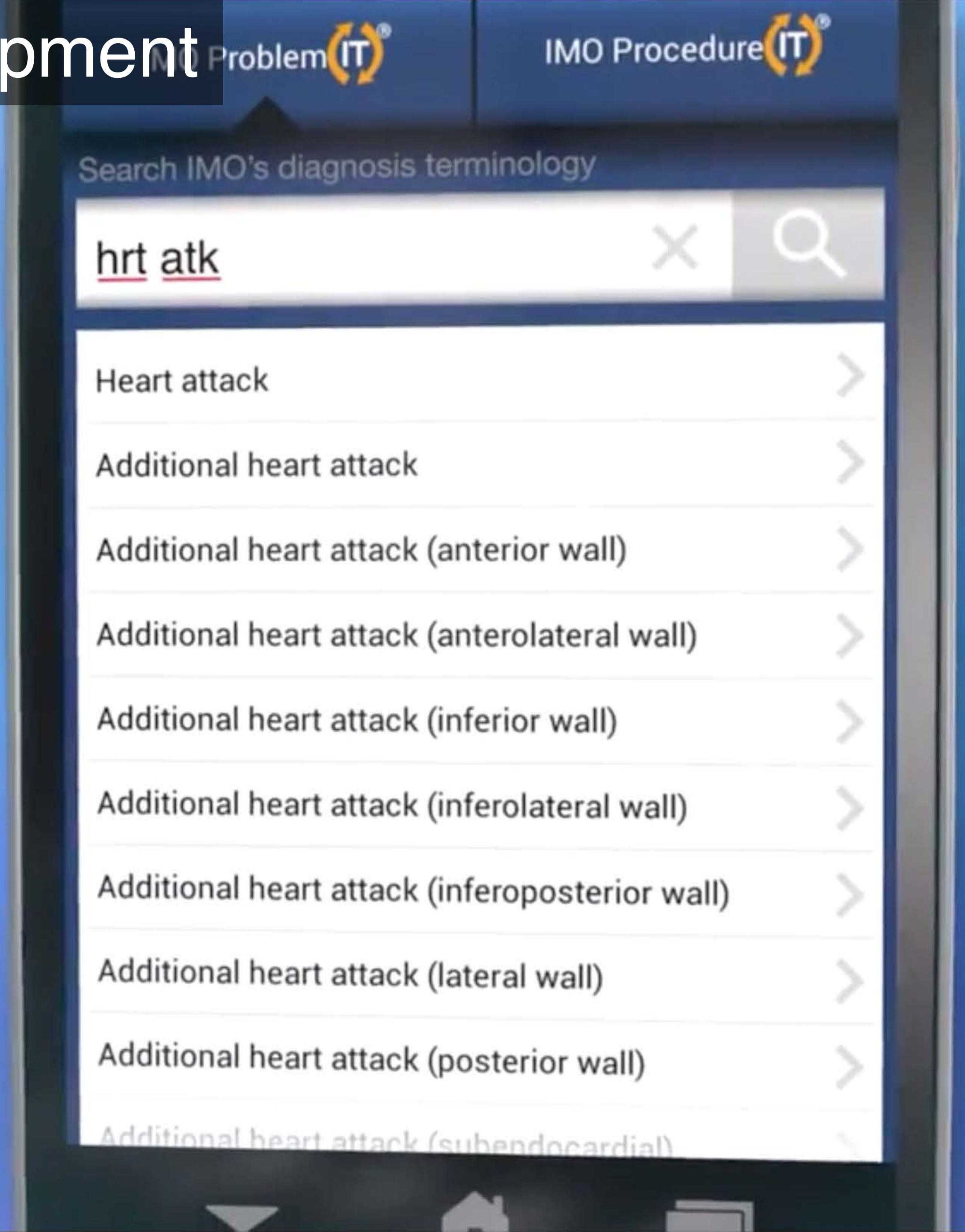
Kalina Borkiewicz
2018-6972

CERTIFIED USABILITY ANALYST

Computer Vision



Android Development



Summary

- Programming
  - Python, C++, JavaScript, Bash…
  - Ytini, Blurend, HAVLI plugin…
- Data
  - Processing, wrangling, translation…
- Design
  - Visualization, software, UX
- Teaching
  - ACM SIGGRAPH, MOOC…
- Research, papers, & proposals
- Women@NCSA