

3Demos: A collaborative visual calculus system

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What is 3Demos?

Technical architecture

Free software in higher education

Future directions

About me

Nikolas Nyby

- I'm a software developer at Columbia University's Center for Teaching and Learning.
- Love working with graphics, and improving the tools I use
- Background: startups in varied industries like art, medicine, and digital media
- Past work with GNU LibreJS
- nikolas@gnu.org

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Learning objectives

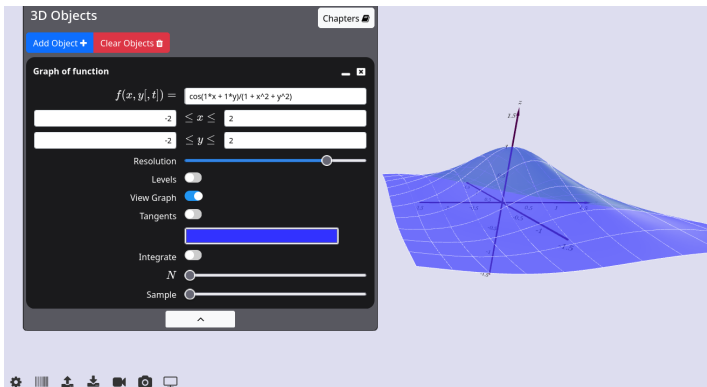
3Demos started as an application of “learning intervention”, put together by Drew Youngren, Lecturer in Applied Mathematics at Columbia University.

- Develop an interactive learning intervention that fosters small group debate
- Focus on the process of logical reasoning rather than a specific end result

Development timeline

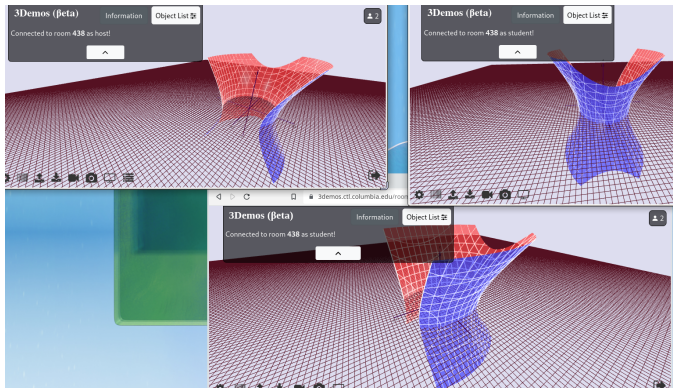
- 2020: Started early in the pandemic, as a hobby programming project by Drew Youngren.
- 2022: The Columbia University Center for Teaching and Learning was hired to develop new features and make the tool ready for the classroom.

What is 3Demos?



This project can be thought of as a 3D graphing calculator with object primitives used for illustrating concepts in multivariable calculus.

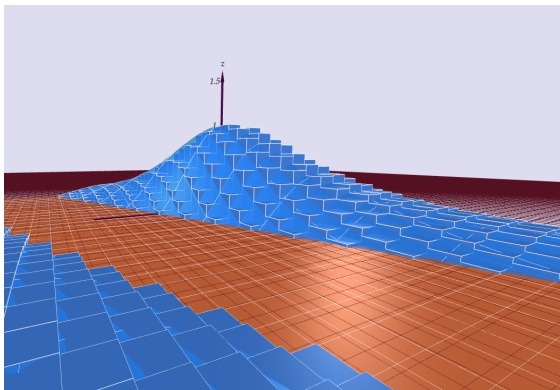
Shared scene



3Demos can be used in a multi-user context, typically used for teaching in a lecture hall.

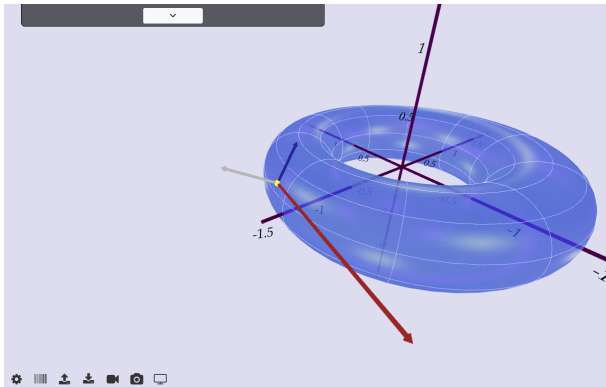
Students can also use the tool from home to collaborate among themselves.

Object display



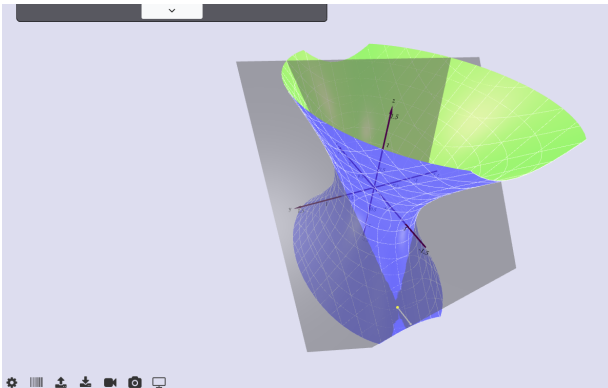
3Demos objects have various display features tied to them, like tangents and integrals.

Parametric surface



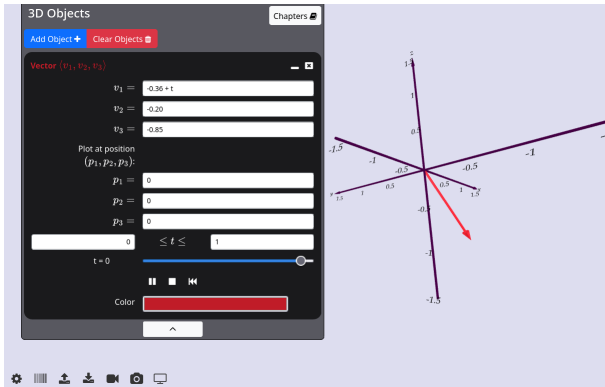
Parametric surface with tangents and a normal vector

Level surface



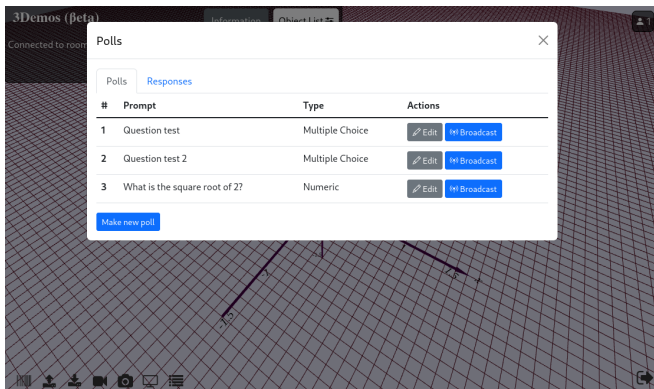
Level surface and a tangent plane

Animation



I can use the t variable to animate arbitrary parameters.

Works in progress



- Interactive poll system
- UI Redesign (unified look + standard responsive behaviors)
- Story mode: interactive lessons

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Web client

- Three.js
- Math.js
- JavaScript + HTML

Central server

The main components of the application can be used without a central server. The server is used to co-ordinate WebSockets requests, so it's required for the collaborative aspects of the application.

- Django Channels / Daphne
- Redis

Motivations

- Easy to distribute
- We now have WebGL and WebAssembly, allowing for full-featured graphical applications like this on the web.
- Accessibility (MathML)

Roadblocks and challenges

- Input validation with math.js
- Learning curves
- Time (other project work + responsibilities)

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Long-term sustainability of projects

- Ansaf Salieb-Aouissi, Logic Learner:
<https://logiclearnerctl.columbia.edu/>
- Thomas Groll, EconPractice:
<https://econpracticectl.columbia.edu/about/>
- LocusTempus: <https://locustempusctl.columbia.edu/>
- Mediathread: <https://mediathreadctl.columbia.edu/>

Politics in academia

The academic environment has a complicated set of stakeholders, including:

- Faculty
- Deans
- Provost
- Trustees
- Students

Within the multi-faceted academic community, there are as yet unrealized opportunities for free software.

My perspective

I believe that somewhere in the maze of politics that is academia, there are other motivations and end goals at play. Of course, universities can be seen as a sort of business, and they need plenty of money to survive. But there are also higher purposes in education, like sharing human knowledge.

My vision

- Collaboration across universities
- In education, you can make things that aren't possible elsewhere, because of the unique environment and the goals of promoting learning and sharing knowledge.
- A university's community ostensibly supports values like creativity and access, and we can find new ways to cultivate those values.

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- Interactivity between components
- More animation functionality
- Future collaboration between my department + Drew Youngren
- Outside interest

Thanks!

- Live environment: <https://3demos.cctl.columbia.edu/>
- Source code: <https://github.com/ccnmtl/3demos/>

