

**[Title]**

Surfing in the ocean, and surfing online, both give people a great sense of freedom.

I'm going to show you now how we can surf the Universe just as freely. And my goal is to show you a new way of learning.

**[Advance...shows Earth]**

Here's the Earth. You might expect a zoom out to the Universe now, but I want to **zoom in** first, and tell you a story...

**[Advance...zooms in]**

Last weekend, I, like many of you, was at a barbecue. This one was here, at my sister's home in Wellesley, in the backyard. It was a beautiful day.

**[Advance...shows outdoor photo]**

My sister, who is a lawyer, doesn't usually show too much interest in my so-called "nerdy" work, so, at the party, when she told me that I "had to come with her" to the other side of the patio to meet some people, I didn't guess that the urgency had anything to do with astronomy, data, or anything even remotely nerdy. But, it did. Apparently, she had been talking about me and my work to all the techie types in her office and her neighborhood. She had told them all that I was working on something "very cool" called "WorldWide Telescope" and she had boldly claimed that it offers a new way to understand the Universe... To my great surprise, she wanted me to go inside the house, right then, and give a demo!

**[Advance...shows laptop]**

...My sister grabbed her laptop. She put it down on the kitchen counter, and said, *"here--show them!"*

**[Advance...shows 9-panel demo]**

So, I complied, as quickly as I could, since I didn't think all these people wanted to be inside on a gorgeous day! I explained that WorldWide Telescope is a free program developed by my brilliant friends at Microsoft Research, and that I'd been collaborating on the project and using its many features in research and in teaching. I sped through quick demos of a variety of WWT's capabilities, shown here, explaining that the program can be used to explore any or all of the Sky, at

nearly any wavelength, that millions of sky objects are connected by a couple of clicks to more information about them on the web, and that a user can explore the surface of Earth, and of other planets. I showed how users can add in their own data, and I showed how users can experience panoramic virtual environments, including the surface of Mars. I also explained how users can create and save scripted paths (called “Tours”) through the program, like the one I’m showing you now... and I explained that both experts and learners make these Tours to communicate about the Universe, and that many narrated Tours are available online.

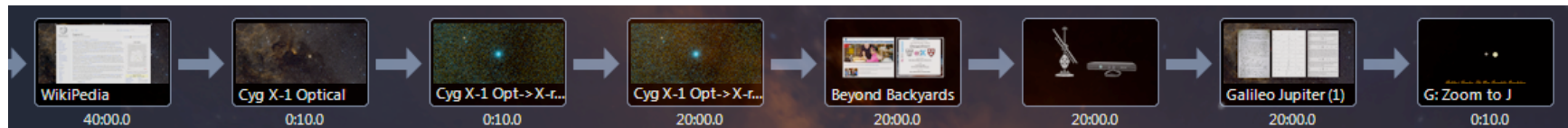
After nearly 15 minutes of “really, wow, that’s amazing,” I was finally allowed back outside...until, a few minutes later one of the adults asked if I could show his 12-year-old son Luis WWT too. He explained that Luis is a budding scientist. The first question Luis asked me, when we were still outside, was *“is the black hole in our Galaxy’s center more massive than the Chandrasekhar Limit,”* so, I knew this was serious. I went back inside and give Luis a small rerun of what I had shown the adults, including a quick demo like this...

[Advance...**Orion**]

...go out of Tour... zoom in/out, flip through other wavelengths, use finder scope...

Luis seemed perfectly comfortable, and very engaged, so I left him inside to surf the Universe on his own and tried again to go get a beer.

About 1/2 an hour later, Luis came outside and asked “can I enter coordinates into the program to find an object”? I said, “yes, of course, I will show you how.” On our way back inside, I asked why he wanted to enter coordinates, and he explained that his favorite black hole, Cyg-X-1, didn’t seem to be marked in WWT and that he wanted to find it on the Sky.



[Advance...**Wikipedia, Cyg-X-1**]

Luis had already opened the Wikipedia page for Cyg X-1. We checked that in fact Cyg X-1 was not obviously marked in WWT, so we entered the coordinates, and we saw this:

[Advance...**Cyg X-1 optical**]

Luis looked a little disappointed, since there was nothing visibly all that interesting on the screen. I explained that Cyg X-1 has an “X” in its name because it is a famous source to *X-ray astronomers*, not *optical* astronomers, so we switched to an X-ray view of the sky and saw this:

[Advance...**Cyg X-1 optical to X-ray fade**]

Luis’ face lit up when he saw the bright X-ray source, but he was disappointed that we couldn’t “fix” the oversight of his favorite source’s anonymity in WWT right away. So, we edited the Cyg X-1 Wikipedia page to give it a link at the bottom that will open WWT in a web browser right to Cyg X-1’s position. (Try that at home.) Luis was satisfied. He and I got to experience a new kind of learning and teaching, an interactive, rich, experience, where the best data and literature are literally at our fingertips, and questions about the Universe can be answered in real-time, by collaboration between learners and experts.

[Advance...**edX and WWTA**]

Luis’ story is not at all atypical. We are using WWT as a teaching and learning tool at all levels now. The WWT Ambassadors program--run by Pat Udomprasert, sitting in the front row--sends experts out to science fairs and classrooms to do just what I did in my sister’s kitchen. And, just last week, we had a great event showcasing 14 interactive teaching modules developed as a capstone project in my graduate Interstellar Medium course. Three of the modules used WWT, and this fall, those modules will be featured on Harvard’s new online learning platform, HarvardX, not as a standard course, but as interactive tools offering a new kind of customizable learning.

[Advance...**Galileoscope and Kinect**]

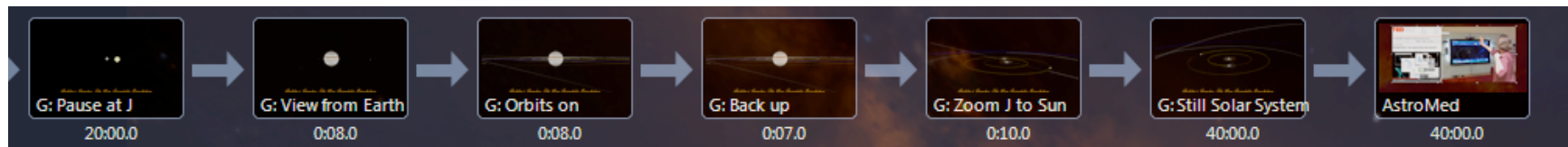
Now, I want to really show you the future, and I’m going to use a gaming device to do it. I’ve shown you how to surf the Sky, but now I want to show you how to really surf, in three dimensions. Galileo is credited with starting the scientific revolution thanks to his telescopic observations of the sky, but really understanding and building on what he did required a three-dimensional appreciation of what he learned.

[Advance...**Galileo notes etc.**]

These are various versions of the records of Galileo's observations of Jupiter and its moons, as viewed through his telescope. Experts know, and Galileo figured out, that the changing positions of the moons with time is caused by their orbiting around Jupiter.

[Advance...**Jupiter & Kinect**]

Now, though, we can see what Galileo only imagined, and we can surf through it. Let me show you, and then we'll really surf.



narrate the following live--takes 1.5 minutes

[auto Advance...**Jupiter from Earth**]

[auto Advance...**Orbits on**]

[auto Advance...**Back up**]

[auto Advance...**Center on Sun**]

--pause tour--

demo Kinect functionality

[advance...AstroMed]

The implications of being able to interact with 3D information go far beyond just surfing the Universe. Over the past several years, my colleagues and I have been working closely with medical imaging experts to learn and borrow techniques from each other. You can watch my fantastic graduate student Michelle Borkin's TED talk on our

“Astronomical Medicine” work to learn about how well that works, but I want to close today with a quick explanation of our next challenge. If you think about selecting a region in an image on your computer, you think about drawing an outline around it with your cursor on a 2D screen, or even with your finger on a touch screen. But, there is not yet an analog to that kind of selection in 3D. So-called “natural user interfaces” like the Kinect should offer a solution to this unsolved problem, and that solution will help us visually select data on particular bits of star forming regions we want to analyze, but maybe more importantly it will also help surgeons isolate diseased tissue in planning robotic surgery or treatments.

Thanks for listening.