Sentient Architecture: Visualizing Signal Flow in Intelligent Systems

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April 7, 2017

Intelligent & Interactive Systems Talk Series, SOIC, IU
April 10, 2017

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Outline

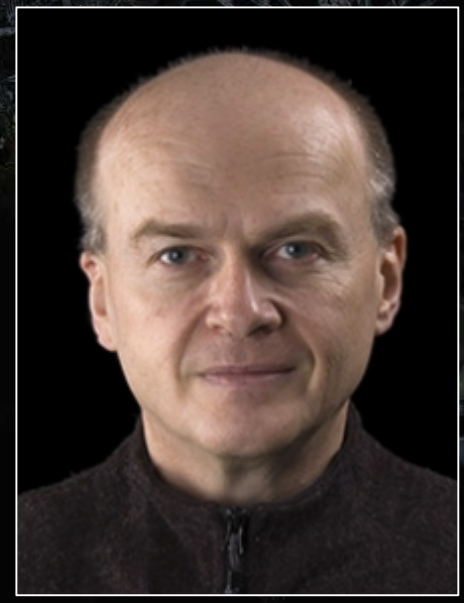
- Background: What is Sentient Architecture?
- Research Goal(s)
- Process & Methods
- Outlook

What is Sentient Architecture?

What is Sentient Architecture?

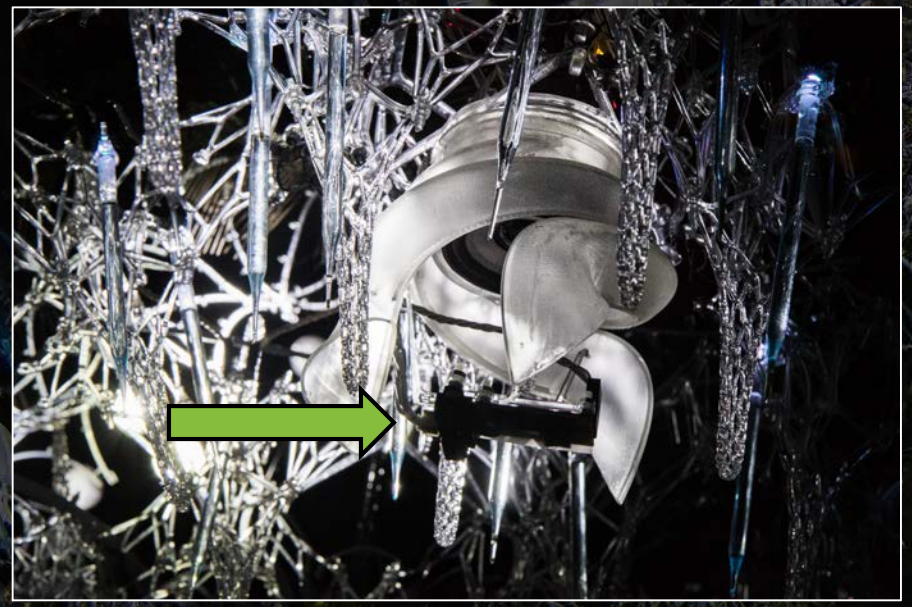
- Intelligent systems composed of
  - Sensors
    - Infrared (IR)
    - Microphone
  - Actuators
    - Kinetic
    - Light
    - Sound
  - Processors

Philip Beesley



https://uwaterloo.ca/architecture/sites/ca.architecture/files/styles/sidebar-220px-wide/public/uploads/images/P_Beesley_0.jpg?itok=vp0HURO5

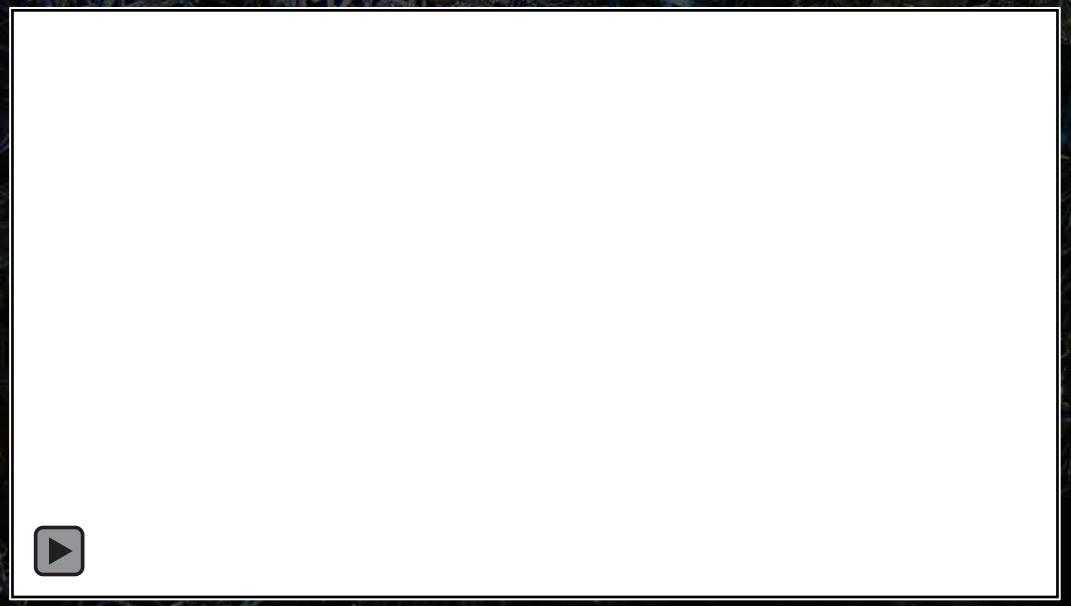
What is Sentient Architecture?



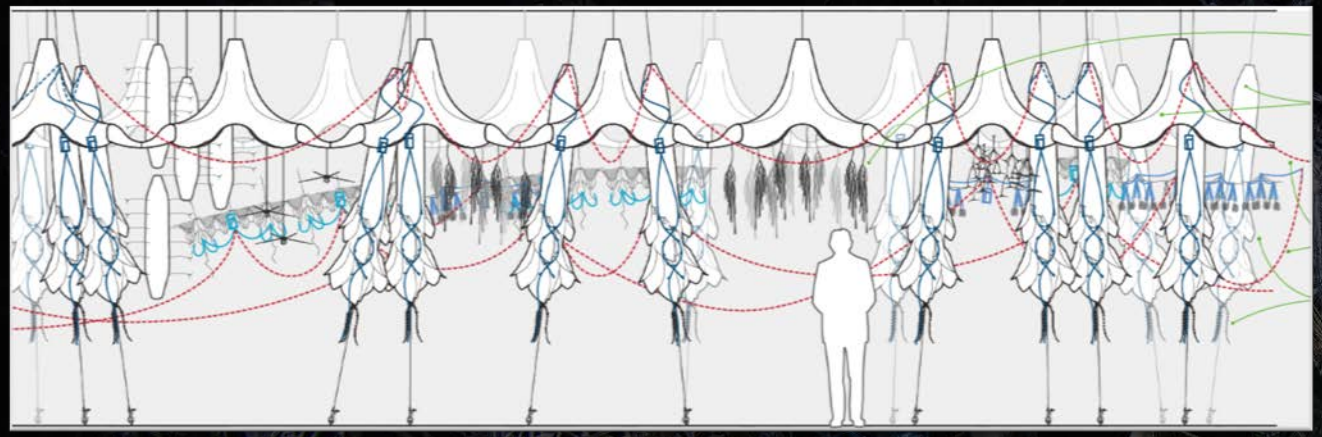
Sensor (IR)

Actuator (Sound)

What is Sentient Architecture?



Actuator (light + kinetic)



Drawing of a test-bed with architectural prototypes

Internet of Things?

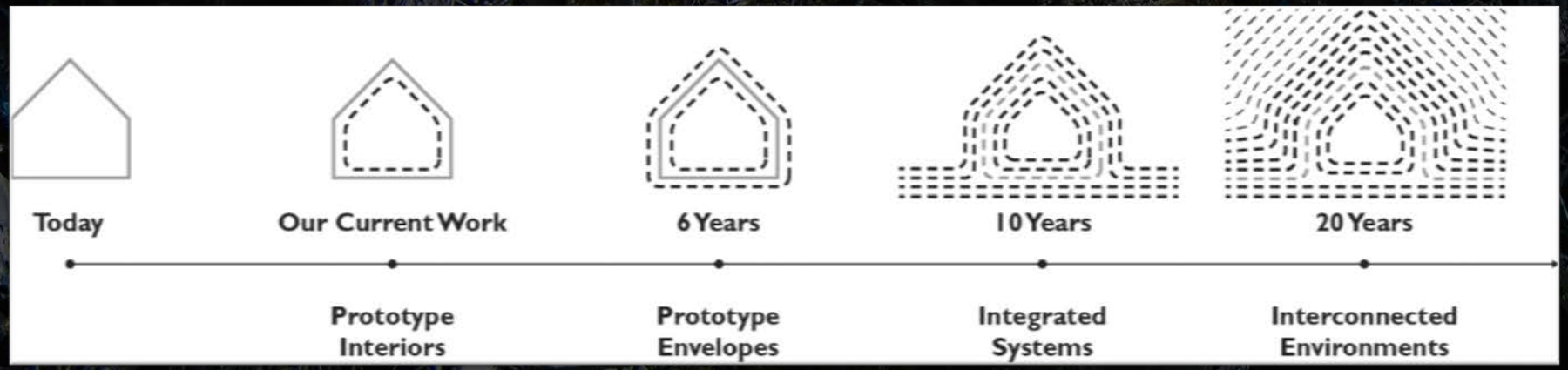


Diagram of LASG and Information Visualization Lab's long-term evolution of prototyped Living Architecture, accompanied by complex system visualizations, expanding from interiors, to exteriors, to interconnected buildings and environments.

Research Goal

How can we use data visualizations to educate museum visitors, students about the inner workings (=data flow) within cyber-physical systems?

How can we illuminate the structure and dynamics of those systems?

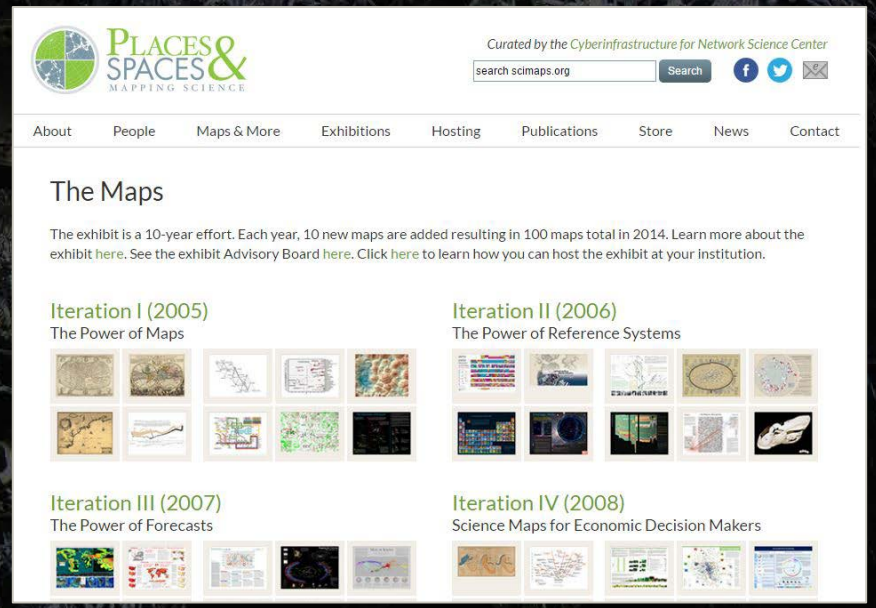
Our Expertise: IVMOOC

- Information Visualization Massive Open Online Course
  - Taken by students from 100+ countries since 2013
  - Residential and online sections
  - Teaches state-of-the-art data analysis and visualization
  - Offers self-paced learning option for free
  - Importance of visualization literacy and education

Source: http://ivmooc.cns.iu.edu/

Our Expertise: Places & Spaces

- Places & Spaces Exhibition
  - Curated by CNS
  - Objects: maps, charts, graphs, etc.
  - Set of over 100 maps over past decade
  - Goal: to educate people about reading visualizations



Source: http://scimaps.org/

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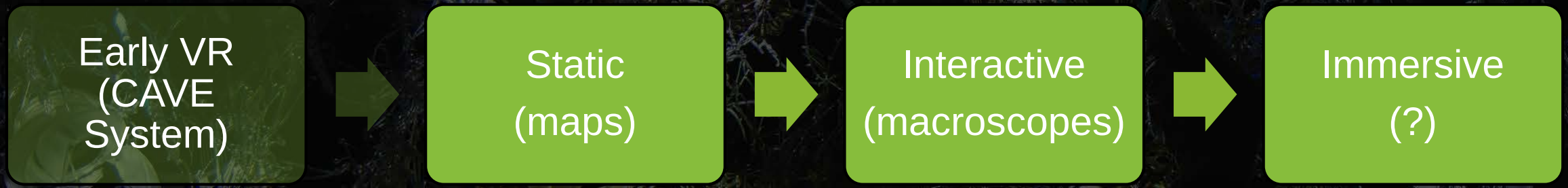
Our Expertise: Macroscopes

Source: https://www.youtube.com/watch?v=Ef3tAxoW9mE

Our Expertise



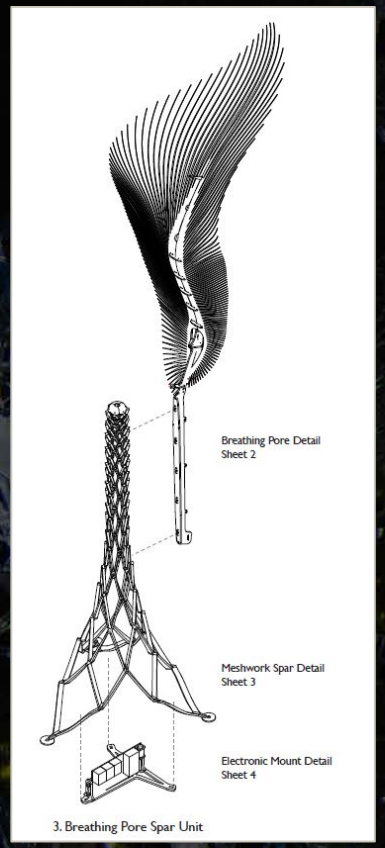
Process & Methods

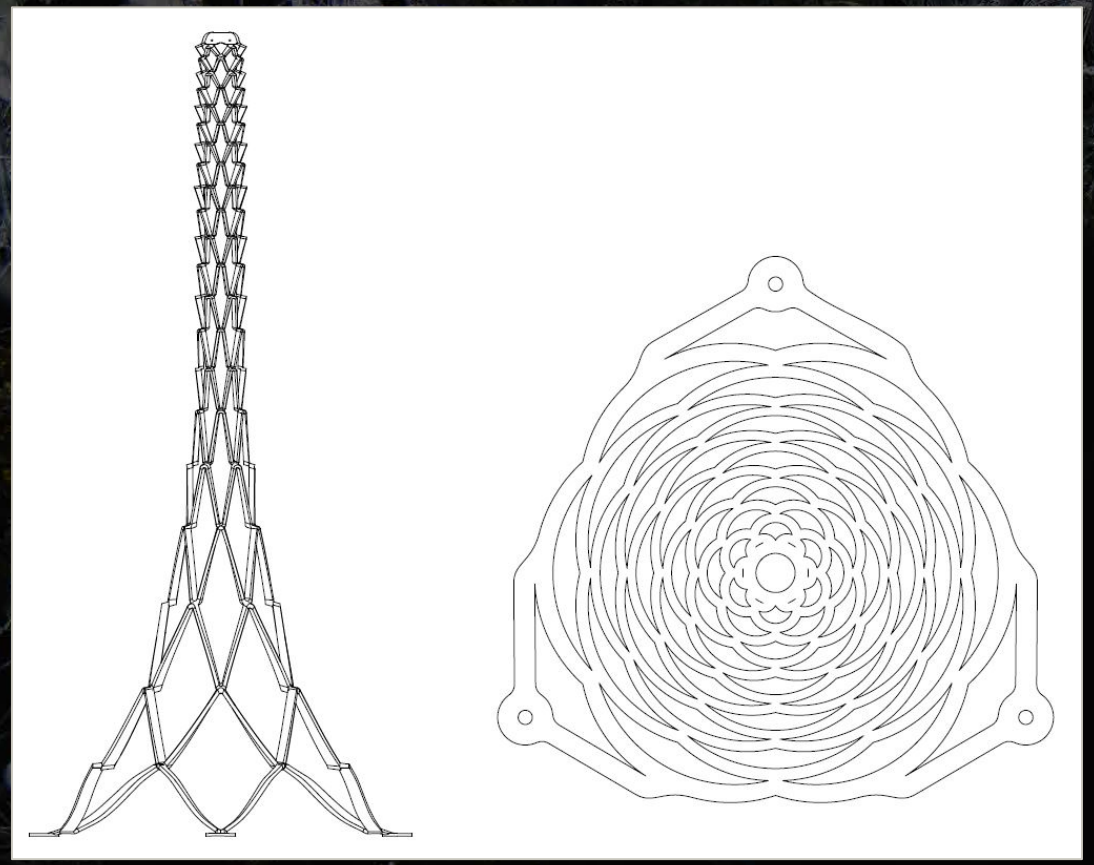
- 3 projects currently in development:
  - Sentient Architecture Summer Camp 2017
  - XRAY app development for Isabella Stewart Gardner Museum, Boston (MA)
  - Augmented Reality Summer Camp 2017

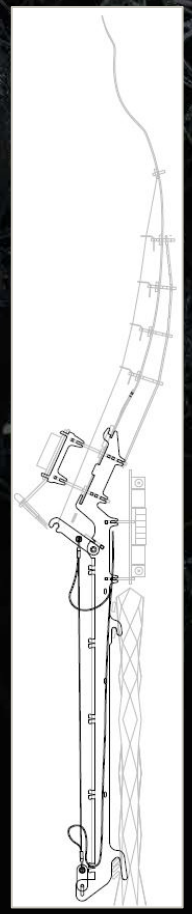
Sentient Architecture Summer Camp 2017

- June 12 to 16
- Organized by Department of Intelligent Systems Engineering at IU
- 20 students (age 16 and up)
- Students will build 2 sculptures from *Dendrite* kit

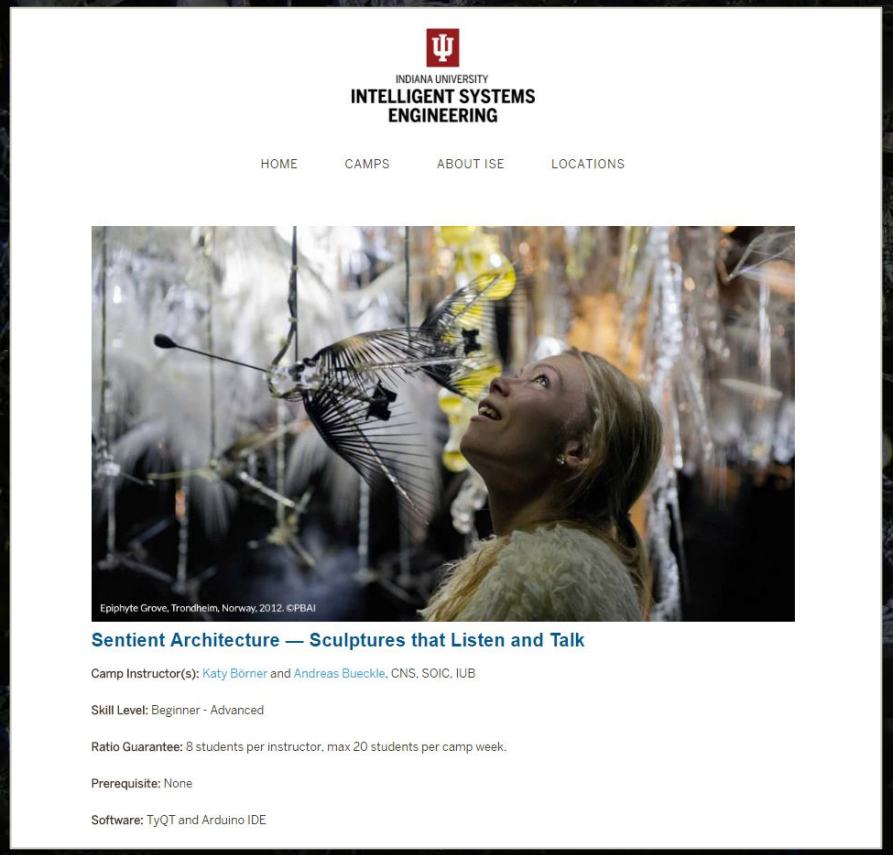
Sentient Architecture Summer Camp 2017







Sentient Architecture Summer Camp 2017



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HOME CAMPS ABOUT ISE LOCATIONS

Sentient Architecture — Sculptures that Listen and Talk

Camp Instructor(s): Katy Börner and Andreas Bueckle, CNS, SOIC, IUB

Skill Level: Beginner - Advanced

Ratio Guarantee: 8 students per instructor, max 20 students per camp week.

Prerequisite: None

Software: TyQT and Arduino IDE

http://camps.engineering.indiana.edu/sentient-architecture.html

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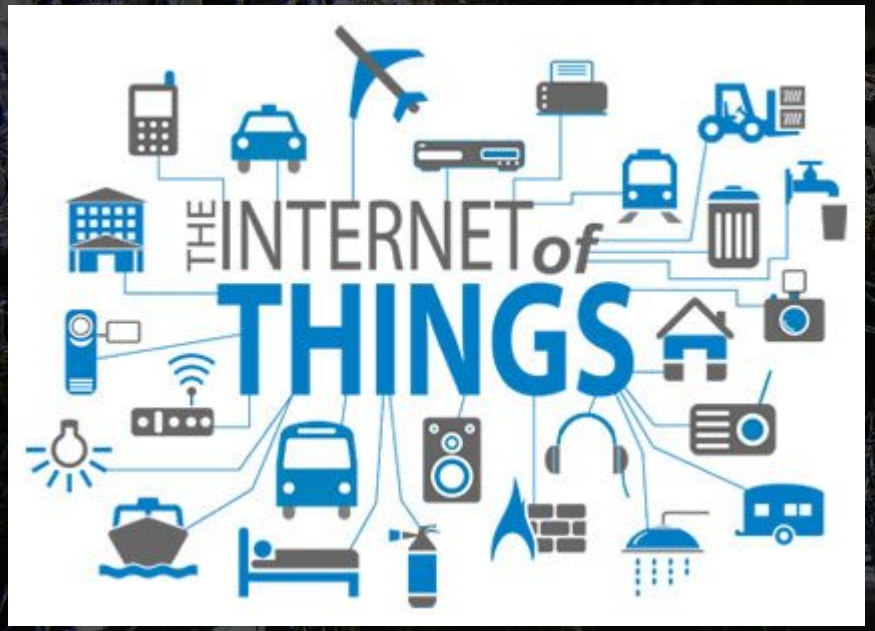
Sentient Architecture Summer Camp 2017



Source: http://images.huffingtonpost.com/2016-07-12-1468314021-5633148-internetofthings.jpg

Research Ideas

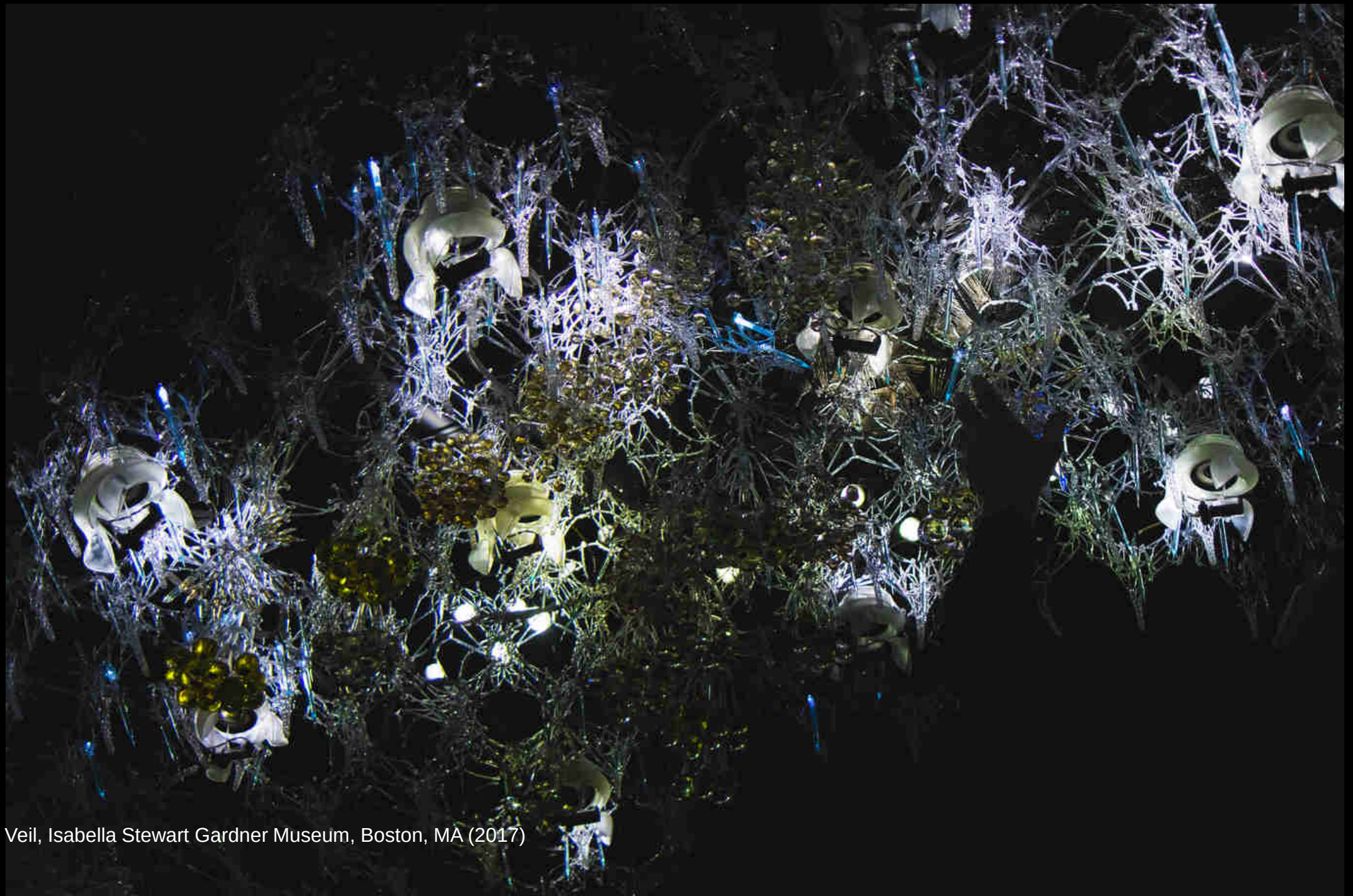
- Before building a *Dendrite, w*hat do teens know about the Internet of Things (IoT)? How do they conceptualize it?
  TEST: Ask them to make a drawing and generate brief description of how Dendrite works.
- After building a *Dendrite*, what do students now understand?
  TEST: At the end of the camp, ask them to make a drawing and generate brief description of how *Dendrite* works.
- If they see Dendrite, how do they explain its functionality?
  TEST: Have them interact with Dendrite and then ask them to make a drawing and generate brief description of how Dendrite works.
- How can we best help teens understand how it works? Are augmented reality (AR) overlays helpful? Are circuit design layouts helpful? Are conceptual drawings helpful?
  TEST: Show them AR, CAD drawings and then ask them to make a drawing and generate brief description of how *Dendrite* works.
- How does the camp promote creative/innovation thinking and engagement in STEM and IoT?
  TEST: pre- and post-experience surveys, interviews during and at the end of the camps, post-camp creative thinking survey
- How well do students with homogenous vs. non-homogenous interests work together at the task?

Learning Objectives

- Explore sensation and actuation/input-output/information processing as components of intelligent systems
- Unveiling the Black Box that is the Internet of Things
- Learn the basics of programming in the process
- Train students in creative and innovation thinking skills as they develop their project

XRAY App Development

- Our goal:
  - Allow people to peak behind the curtain
  - Encourage visitors to ask questions
  - Educate user to read data generated from an intelligent system
  - Do research about data visualization literacy in intelligent systems
- Conduct user study with Sentient Veil sculpture at Isabella Stewart Gardner Museum in Boston



Sentient Veil, Isabella Stewart Gardner Museum, Boston, MA (2017)

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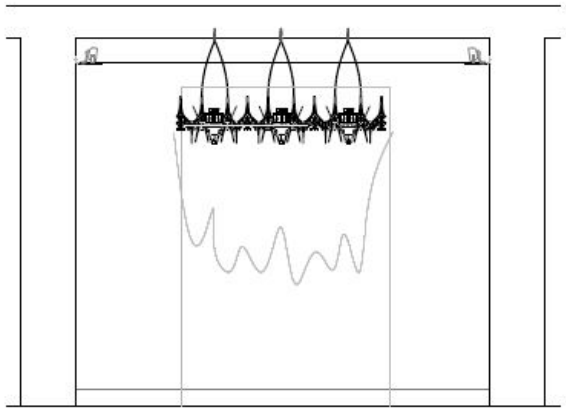
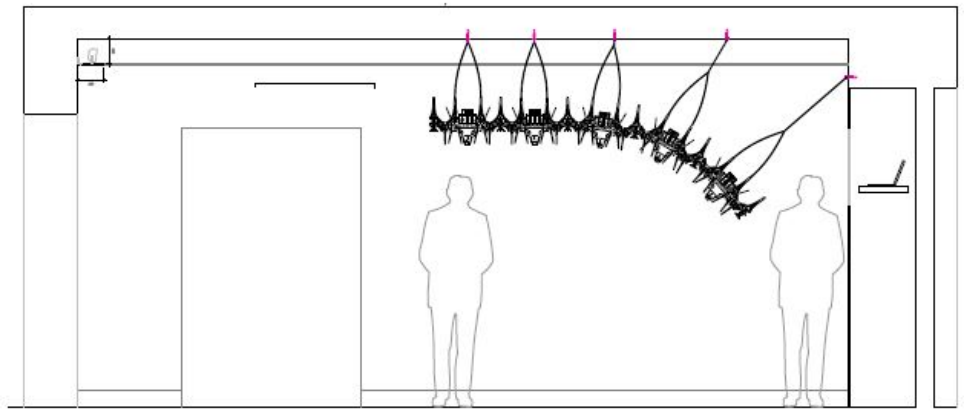
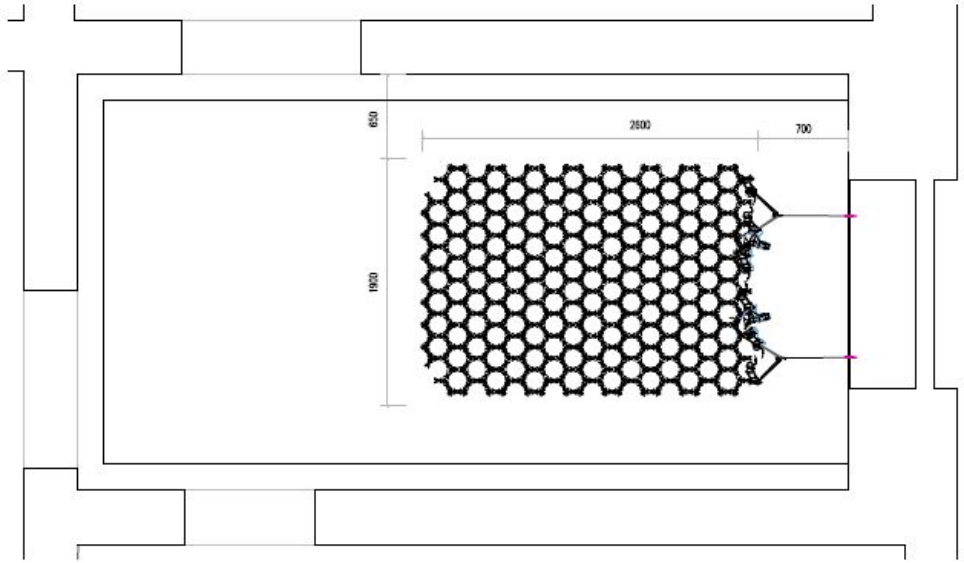


B3 Short Section

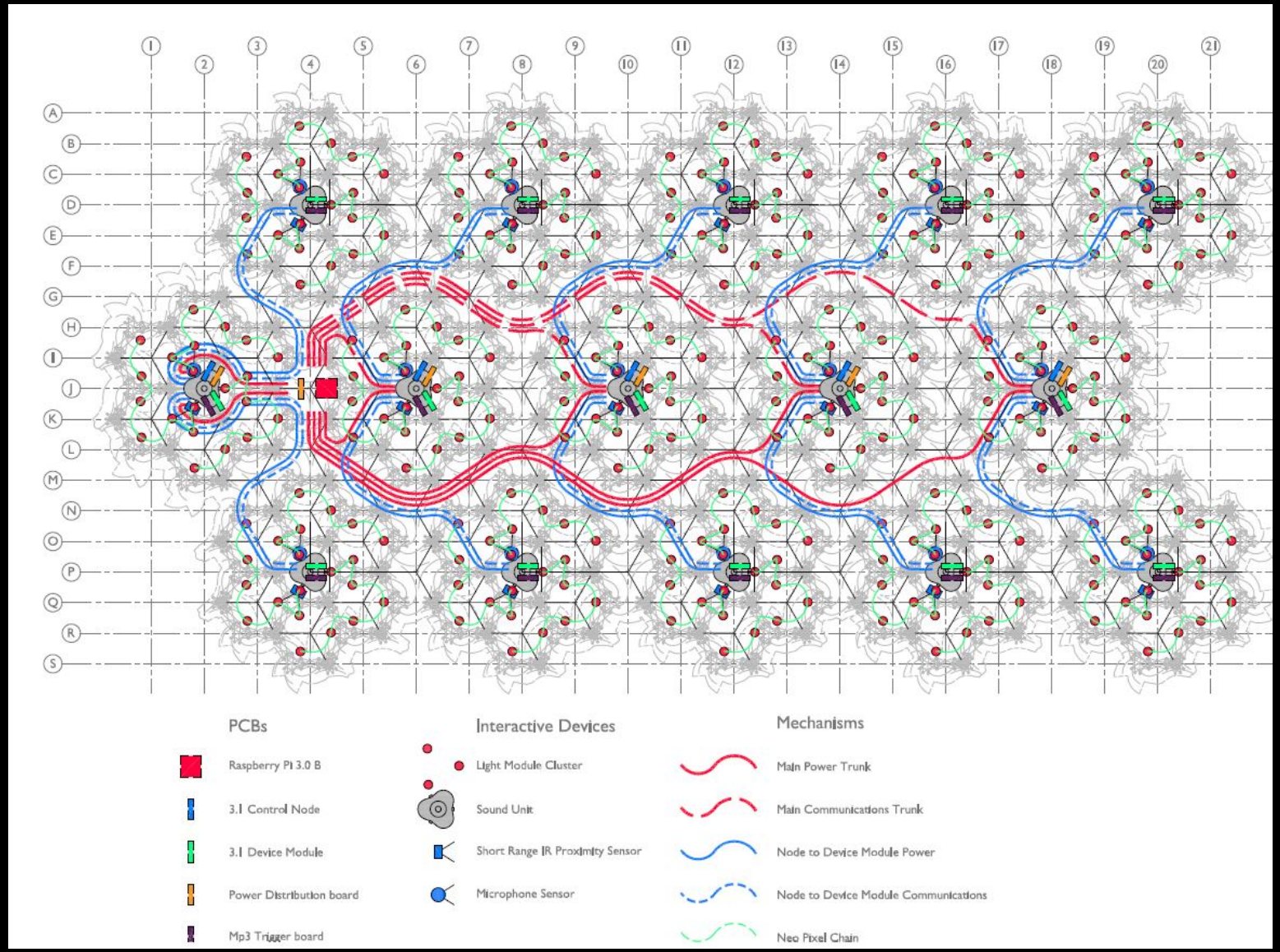


B4 Long Section



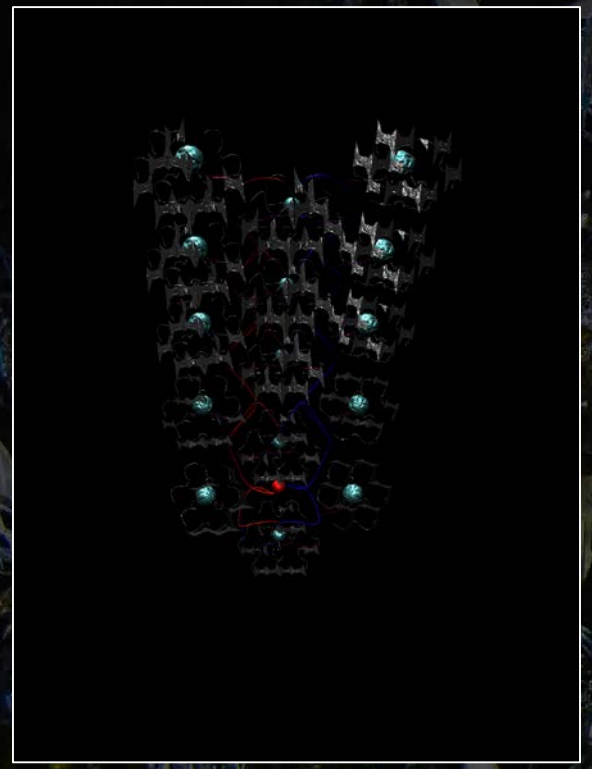
Reflected Ceiling Plan

Sentient Veil, Isabella Stewart Gardner Museum, Boston, MA (2017)

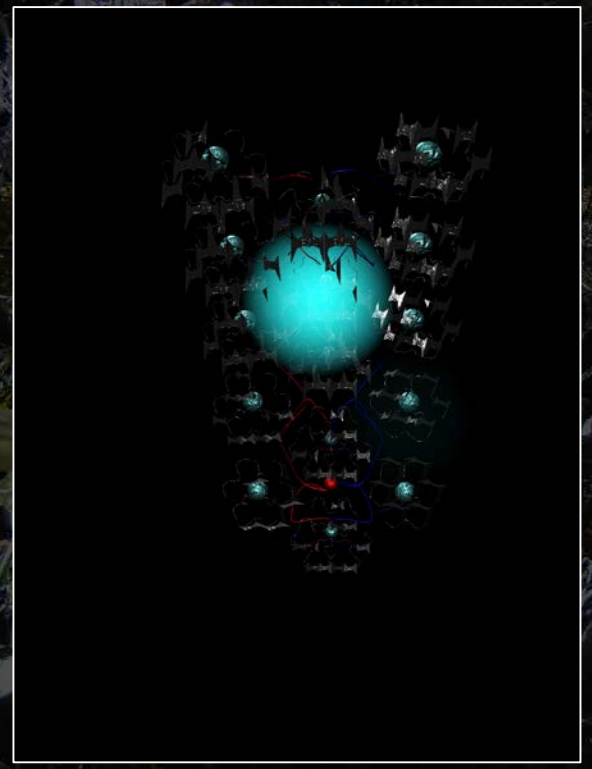


Sentient Veil, Isabella Stewart Gardner Museum, Boston, MA (2017)

XRAY App Development

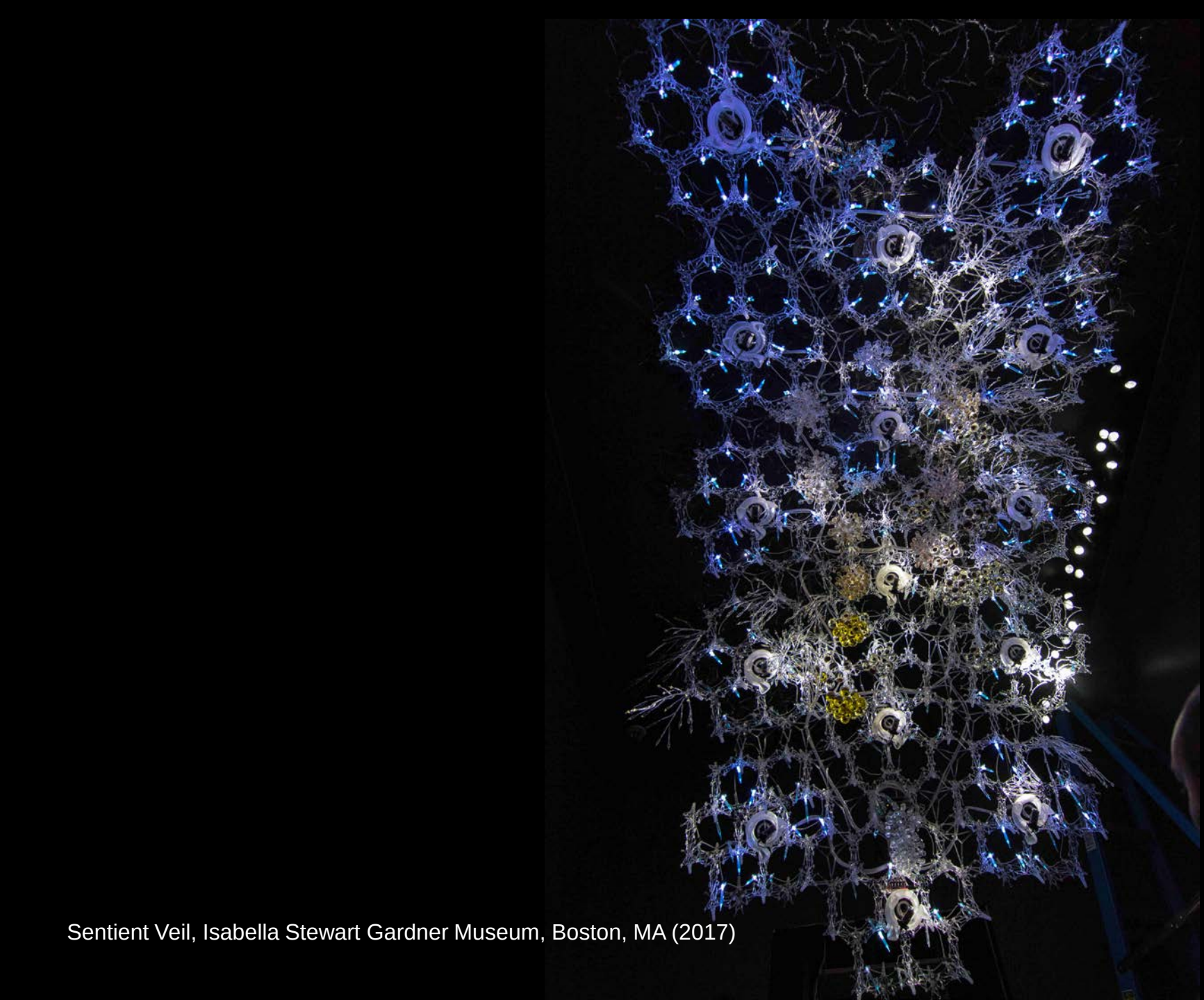


XRAY Virtual
0 sensors triggered



XRAY Virtual
1 sensor triggered

XRAY AR
2 sensors triggered



Sentient Veil, Isabella Stewart Gardner Museum, Boston, MA (2017)

Augmented Reality Summer Camp 2017

- Our goal:
  - Educate students to use Unity 3D to create AR overlays
  - Using information visualization framework by Katy Börner
  - Understand cyber-physical systems
  - Understand state management
  - Establish data pipelines
  - Understand interactivity in virtual systems

Research Plans

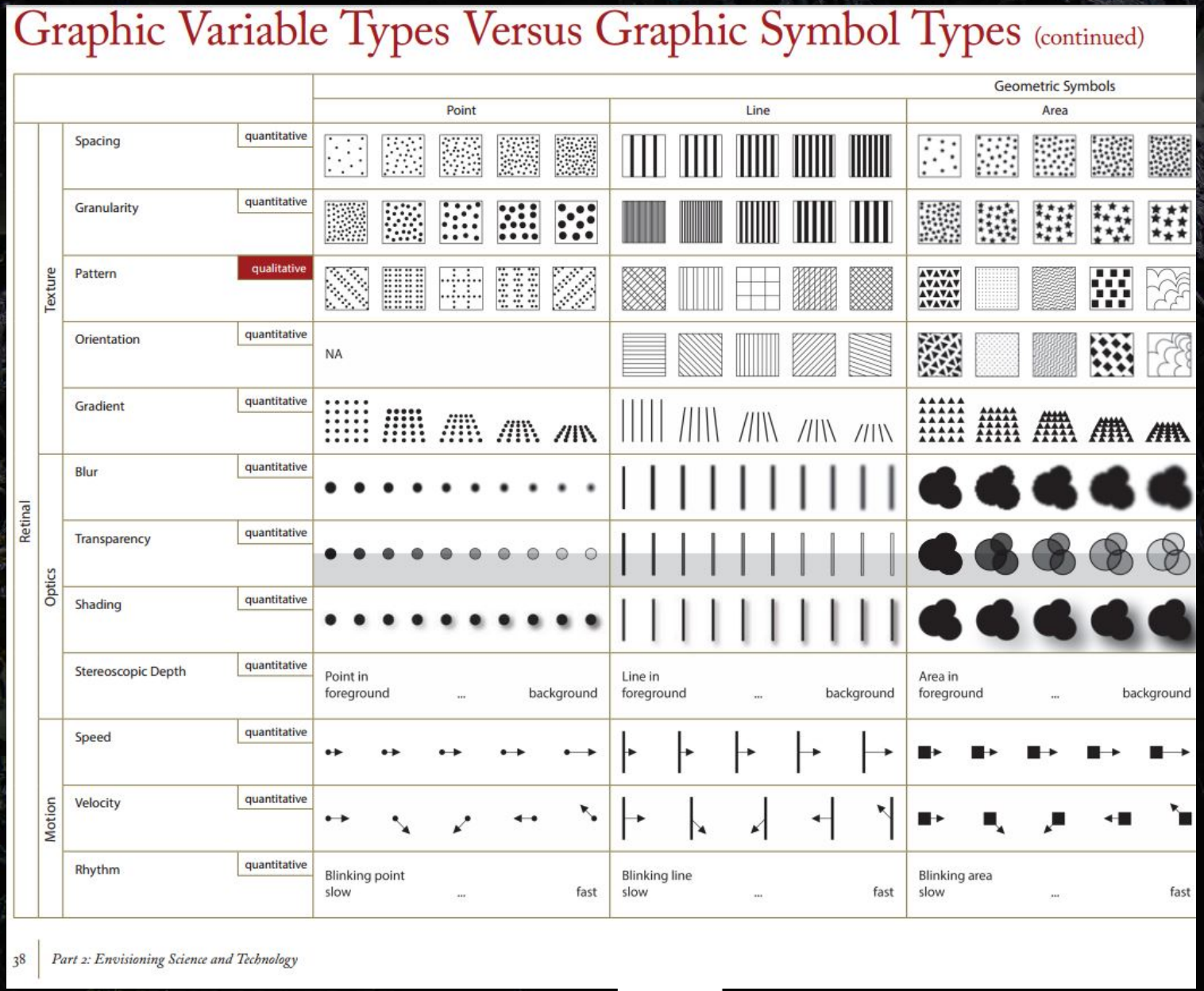
- What virtual tools can help students understand signal flow and processing in SA/IoT setups?
  - HoloLens vs. tablet
  - Virtual vs. augmented
- Create typology of 3D visualization techniques on the continuum of static/dynamic/immersive technologies, for example:
  - Static, printed 2D plot --- interactive 2D plot --- photo of sculpture with dynamic overlay --- virtual model with data overlay --- AR tablet --- AR HoloLens --- completely virtual model VR with Oculus Rift or HTC VIVE

Research Plans cont.

- Extend Börner's information visualization framework to include
  - 3D AR/VR immersive media
  - 3D interactivity
- Define Data Visualization Literacy (DVL)
- Develop metrics to measure DVL, compare different approaches to increase DVL, test with AR/VR setups that allow interaction with intelligent systems (IoT)

Extend information visualization framework

Graphic Variable Types Versus Graphic Symbol Types (continued)



			Geometric Symbols: Point	Geometric Symbols: Line	Geometric Symbols: Area
Retinal	Texture	Spacing — quantitative			
		Granularity — quantitative			
		Pattern — qualitative			
		Orientation — quantitative	NA		
		Gradient — quantitative			
	Optics	Blur — quantitative			
		Transparency — quantitative			
		Shading — quantitative			
		Stereoscopic Depth — quantitative	Point in foreground ... background	Line in foreground ... background	Area in foreground ... background
	Motion	Speed — quantitative			
		Velocity — quantitative			
		Rhythm — quantitative	Blinking point slow ... fast	Blinking line slow ... fast	Blinking area slow ... fast

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From Börner, K. (2015).
Atlas of Knowledge: Anyone Can Map.

Defining “Data Visualization Literacy” (DVL)

- “the ability to make sense of vast amounts of data and to render insightful visualizations”
- “power of data visualizations not only to help locate us in physical space but also to help us understand the extent and structure of our collective knowledge, to identify bursts of activity, pathways of ideas, and borders that beg to be crossed”
- “systematically render data into insights together with tools that support temporal, geospatial, topical, and network analyses and visualizations” (Börner, 2016)

Defining “Data Visualization Literacy” (DVL)

- literacy (ability to read and write text, e.g., in titles, axis labels, legend)
- visual literacy (ability to find, interpret, evaluate, use, and create images and visual media)
- data literacy (ability to read, create, and communicate data)

The Team

Philip Beesley

Katy Börner

Rob Gorbet

Andreas Bueckle

- Further collaborators and supporters:
  - Living Architecture Systems Group (LASG): Matthew Spremulli, Adam Francey, Filip Vranes, Reza Nik, Lucinda Presley
  - IU: Christian Mckay, Alex Shroyer, Chauncey Frend (Advanced Visualization Lab)

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Questions?

References (Excerpt)

- Börner, K. (2015). Atlas of Knowledge: Anyone Can Map.
- Börner, K. (2016). Data Visualization Literacy. Proceedings of the 27th ACM Conference on Hypertext and Social Media - HT '16, 1–1. http://doi.org/10.1145/2914586.2914604
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- Börner, K., & Polley, D. E. (2014). Visual insights: A practical guide to making sense of data. MIT Press.
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- Herdal, T., & Pedersen, J. G. (n.d.). Designing Information Visualizations for Elite Soccer Children ' s Different Levels of Comprehension.
- Kwon, B. C., & Lee, B. (2015). A Comparative Evaluation on Online Learning Approaches using Parallel Coordinate Visualization. In 34TH ANNUAL CHI CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS, CHI 2016 (pp. 993–997). 1515 BROADWAY, NEW YORK, NY 10036-9998 USA: ASSOC COMPUTING MACHINERY. http://doi.org/10.1145/2858036.2858101
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- Maltese, A., & Balliet, R. N. (2015). Investigating aspects of data visualization literacy using 20 information visualizations and 273 science museum visitors. http://doi.org/10.1177/1473871615594652

Image Sources

All pictures from the one of the following sources unless marked otherwise:

- Sentient Veil, 2017, Isabella Stewart Gardner Museum, Boston, MA. Photography by Andreas Bueckle
- Sentient Chamber, 2016, National Academy of Science, Washington, D.C. Photography by Andreas Bueckle
- Dendrite Schematic Drawings, Philip Beesley Architect Inc., Toronto, ON (Canada)
- Sentient Veil Schematic Drawings, Philip Beesley Architect Inc., Toronto, ON (Canada)
- Andreas Bueckle, XRAY App, Misc.
- Philip Beesley Architect Inc., Misc.