Sentient Architecture: Visualizing Signal Flow in Intelligent Systems

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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


Cyberinfrastructure for Network Science Center

INDIANA UNIVERSITY
FULFILLING the PROMISE
What is Sentient Architecture?

Sensor (IR)  Actuator (Sound)
What is Sentient Architecture?

Actuator (light + kinetic)
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/
Our Expertise: Macroscopes

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

- Early VR (CAVE System)
- Static (maps)
- Interactive (macroscopes)
- Immersive (?)
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

http://camps.engineering.indiana.edu/sentient-architecture.html
Sentient Architecture Summer Camp 2017

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

- Before building a Dendrite, what 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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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

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

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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)
Questions?
References (Excerpt)

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.