

# IoT Visualization & Amatria

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Scientific Visualization Workshop Series  
Visual Insights Studio, Luddy Hall, SICE, Indiana University  
Wednesday October 10<sup>th</sup>, 2018



# AVL Visualization Workshop Series – Fall 2018

## Wednesdays @ 4:00pm – Luddy Hall Vis Lab (IQ-Wall)

| Date      | Topic  | Presenter                   |
|-----------|--|-----------------------------|
| Aug. 29   | Introduction to Scientific Visualization         | Bill Sherman                |
| Sep. 5    | Scientific Visualization with ParaView (on RED)  | Bill Sherman                |
| Sep. 12   | 3D Digitization                                  | Jeff Rogers & Tassie Gniady |
| Sep. 19   | Virtual Reality for Visualization                | Bill Sherman                |
| Sep. 26   | Augmented Reality for Visualization              | Chauncey Frend              |
| Oct. 3    | Visualizing lidar datasets using QGIS on RED     | Justin Peters               |
| ✦ Oct. 10 | <b>IoT Visualization &amp; Amatria</b>           | <b>Andreas Bueckle</b>      |
| Oct. 17   | Volume Rendering Visualizations                  | Bill Sherman                |
| Oct. 24   | InfoVis with Vega & D3.js                        | David Reagan                |
| Oct. 31   | Advanced Media & Ultra-Res Displays for Research | Chris Eller                 |
| Nov. 7    | VTK VTK.js                                       | Bill Sherman                |
| Nov. 14   | Data Visualization Literacy and Make-A-Vis UI    | Katy Borner & Bruce Herr II |
| Nov. 21   | (no talk – Thanksgiving Eve)                     | N/A                         |
| Nov. 28   | Molecular visualization with VMD (on RED)        | Bill Sherman                |
| Dec. 5    | Brain Diffusion Imaging with DIPY                | David Reagan                |



**RESEARCH  
TECHNOLOGIES**

INDIANA UNIVERSITY  
University Information Technology Services



**PERVASIVE TECHNOLOGY  
INSTITUTE**

INDIANA UNIVERSITY



# Outline

- ▶ What is the Internet of Things?
- ▶ Introduction to Amatria
- ▶ What is augmented reality?
- ▶ Challenges & opportunities
- ▶ How can we improve data visualization literacy?
- ▶ Example projects:
  - ▶ Lifting the Veil
  - ▶ Dendrite Moth Field Array
  - ▶ Amatria 24h data stream
  - ▶ Tavola
- ▶ Conclusion & outlook
- ▶ Q&A



# What is the IoT?

“[The Internet of Things] is the ever-expanding collection of connected devices that capture and share data. Any object, outfitted with the right sensors, can observe and interact with its environment.” Omes (1)



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| By | Date     | Status | Rev By | Rev Date |
|----|----------|--------|--------|----------|
| MH | 01/03/08 | Draft  |        |          |
|    |          |        |        |          |
|    |          |        |        |          |
|    |          |        |        |          |
|    |          |        |        |          |

DRAWING LEGEND

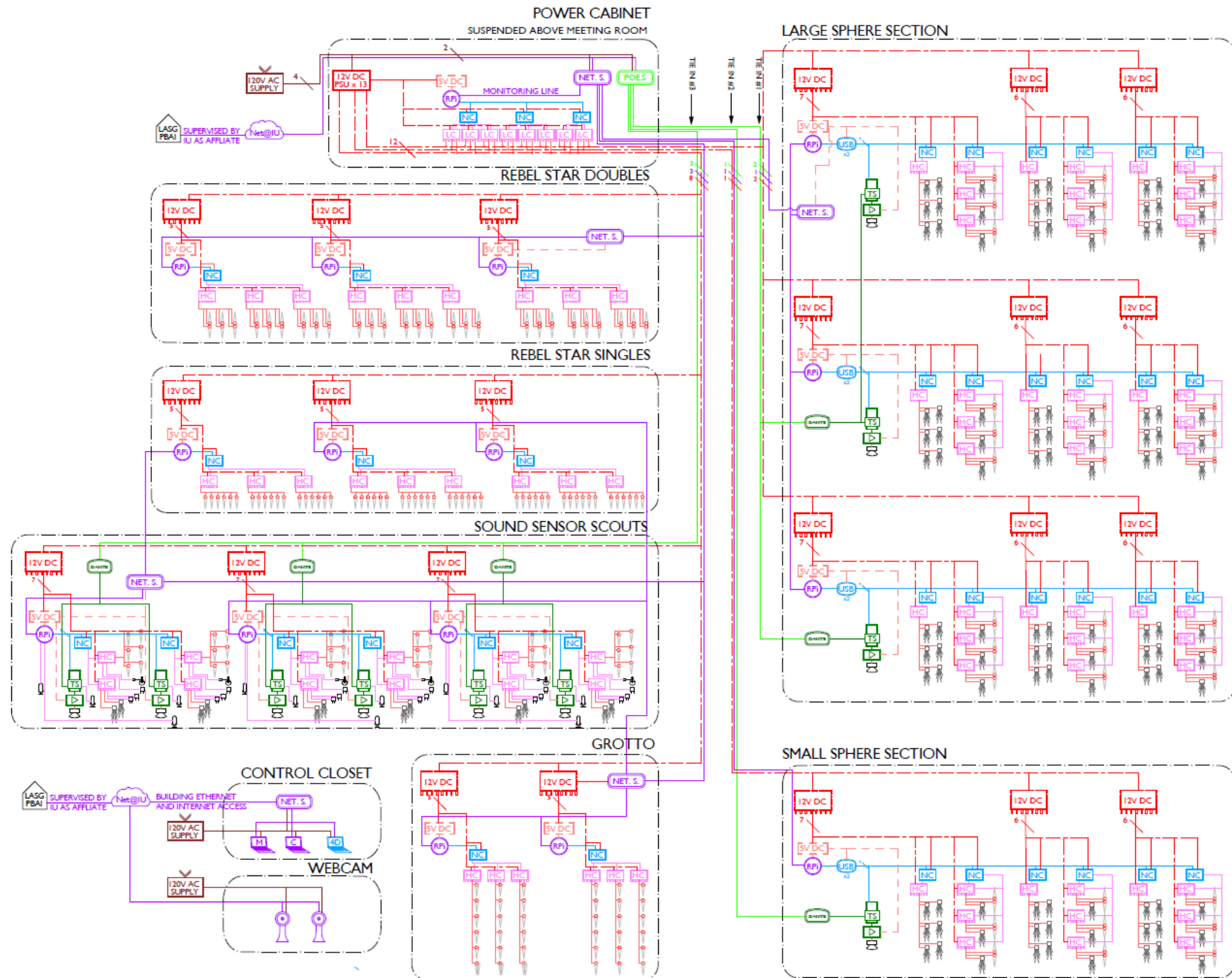


Phase  
Design  
Development

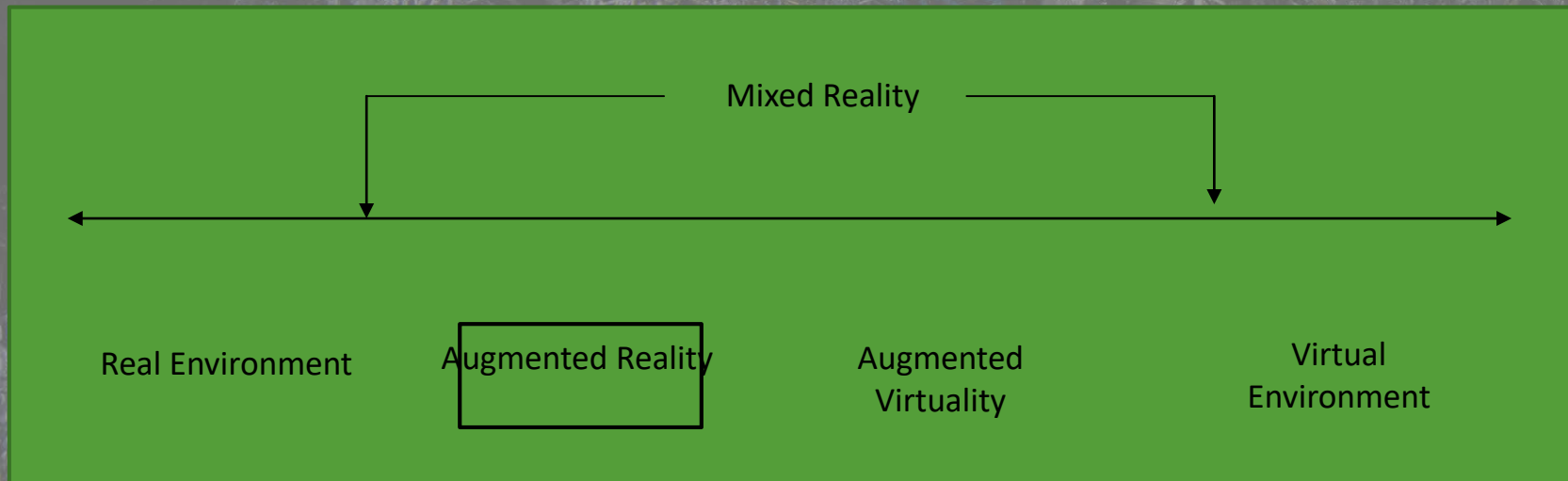
Project  
17540 Luddy Hall

Drawing Title  
Electronic Schematic

Sheet  
IS103



# What is augmented reality?



According to Milgram & Kishino (2)



# AR + IOT: Opportunities

- ▶ On the first look, plenty!
- ▶ Visualize physical location of data
- ▶ Quicker debugging
- ▶ Increased immersion
- ▶ Direct manipulation of IoT system (2-way communication)



# AR can aid graph comprehension

“1) Graph comprehension involves

- ▶ a) Bottom-up processes in which people extract visual chunks that explicitly represent a limited number of quantitative facts or relations. Information that is not explicitly represented in those visual chunks must be computed by inferential processes that are difficult and error prone.
- ▶ b) Top-down processes in which knowledge of semantic content also influences viewers' interpretations of data. “ Shah (3)



<https://www.ptc.com/en/products/iot/thingworx-platform>



**FUEL  
BLOCKAGE**

TAP TO INSPECT PARTS

**Hands-Free**

AR experiences



<https://www.ptc.com/en/products/iot/thingworx-platform>





# AR + IoT: Challenges

- ▶ Lacking maturity of AR devices:
  - ▶ Tablets
  - ▶ HMDs
- ▶ Occlusion
- ▶ Lack of shared experiences
- ▶ Difficulty of setup
- ▶ Lack of voice control
- ▶ Lack of standards for data streams, software deployment, etc.

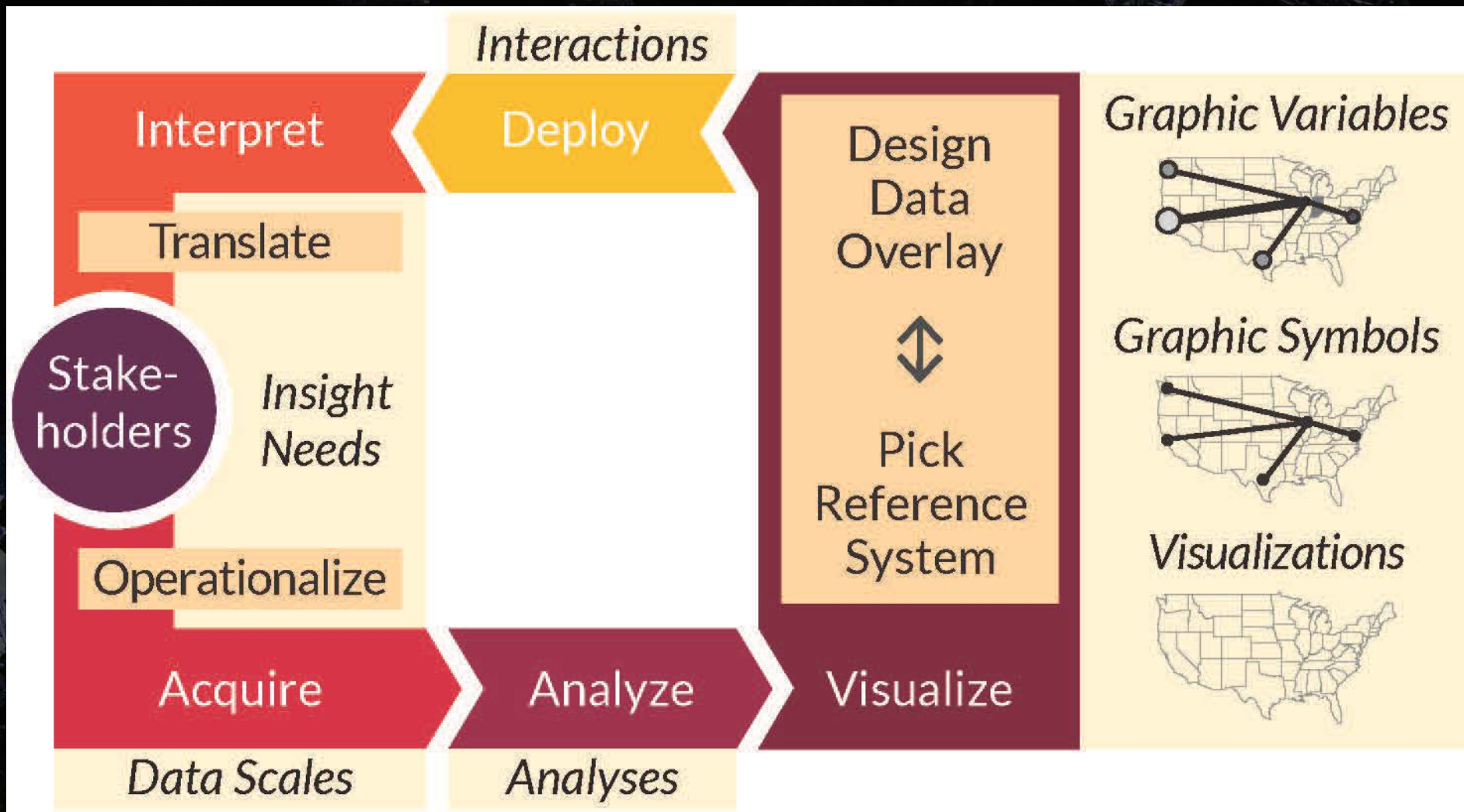


However...



# It's a chance!

- ▶ ...to advance data visualization theory!
- ▶ Develop data visualizations for
  - ▶ IoT debugging and optimization
  - ▶ IoT education and training



From the  
Data Visualization Literacy Framework



|         |          |             | Geometric Symbols |                | Linguistic Symbols | Pictorial Symbols |
|---------|----------|-------------|-------------------|----------------|--------------------|-------------------|
|         |          |             | Point             | Line           |                    |                   |
| Spatial | Position | X<br>Y      |                   |                |                    |                   |
|         |          | Form        | Size              |                |                    | Text Text Text    |
| Shape   |          |             |                   | Text Text Text |                    |                   |
| Retinal | Color    | Value       |                   |                | Text Text Text     |                   |
|         |          | Hue         |                   |                | Text Text Text     |                   |
|         |          | Saturation  |                   |                | Text Text Text     |                   |
|         | Texture  | Granularity |                   |                |                    |                   |
|         |          | Pattern     |                   |                |                    |                   |
| Optics  | Blur     |             |                   | Text Text Text |                    |                   |
| Motion  | Speed    |             |                   |                |                    |                   |

From the Data Visualization Literacy Framework

## In summary

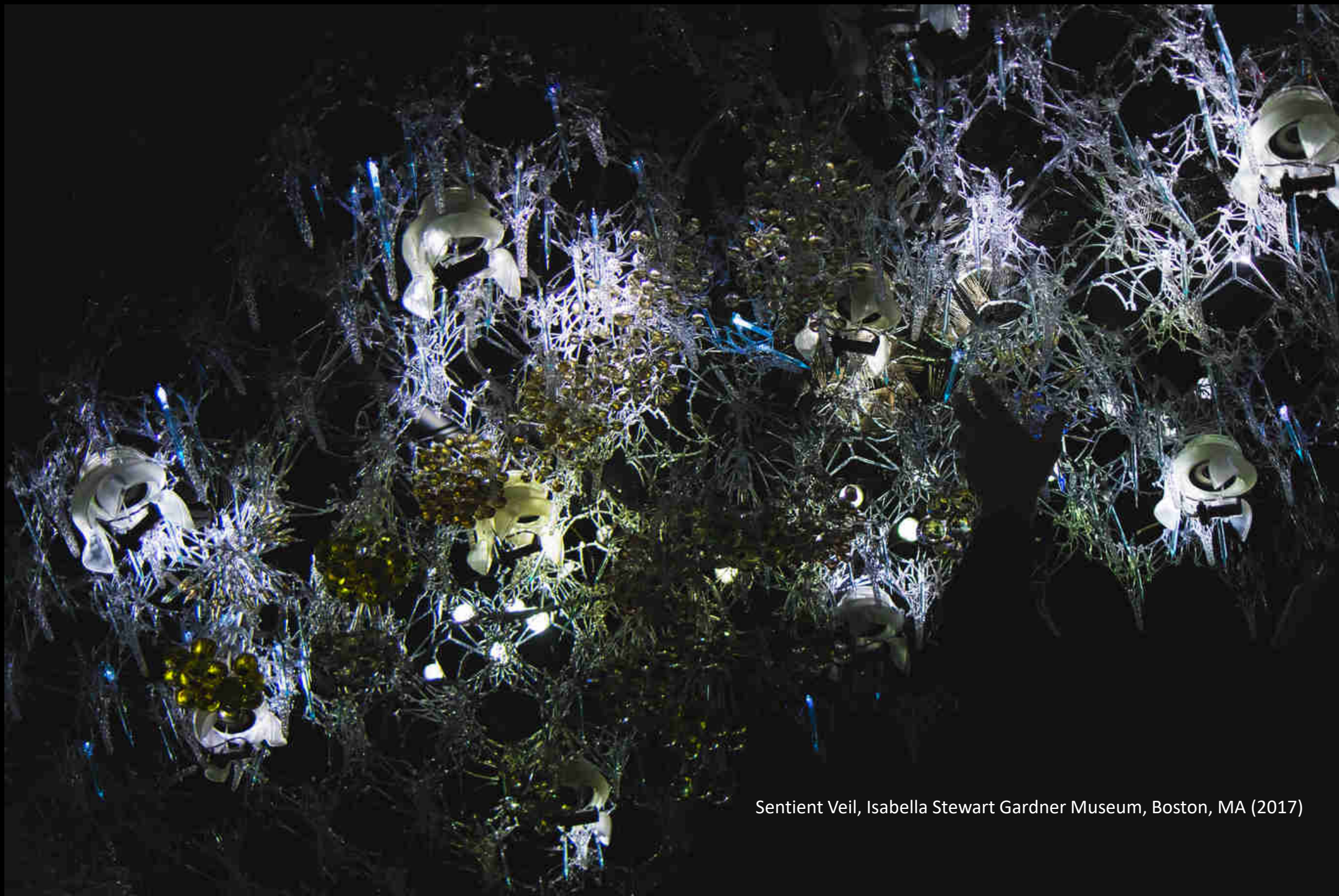
- ▶ AR is not foolproof
- ▶ AR is not established
- ▶ The IoT necessitates many kinds of literacies and skills
- ▶ Developing applications for AR + IoT is new terrain
- ▶ Difficulties related to
  - ▶ Skill
  - ▶ Technology
  - ▶ Security



# Example projects – Lifting the Veil

- ▶ Sentient Veil, Boston (MA)
- ▶ February 2017
- ▶ Goal: Visualize actuation pattern in Sentient Veil sculpture
- ▶ Target audience: visitors

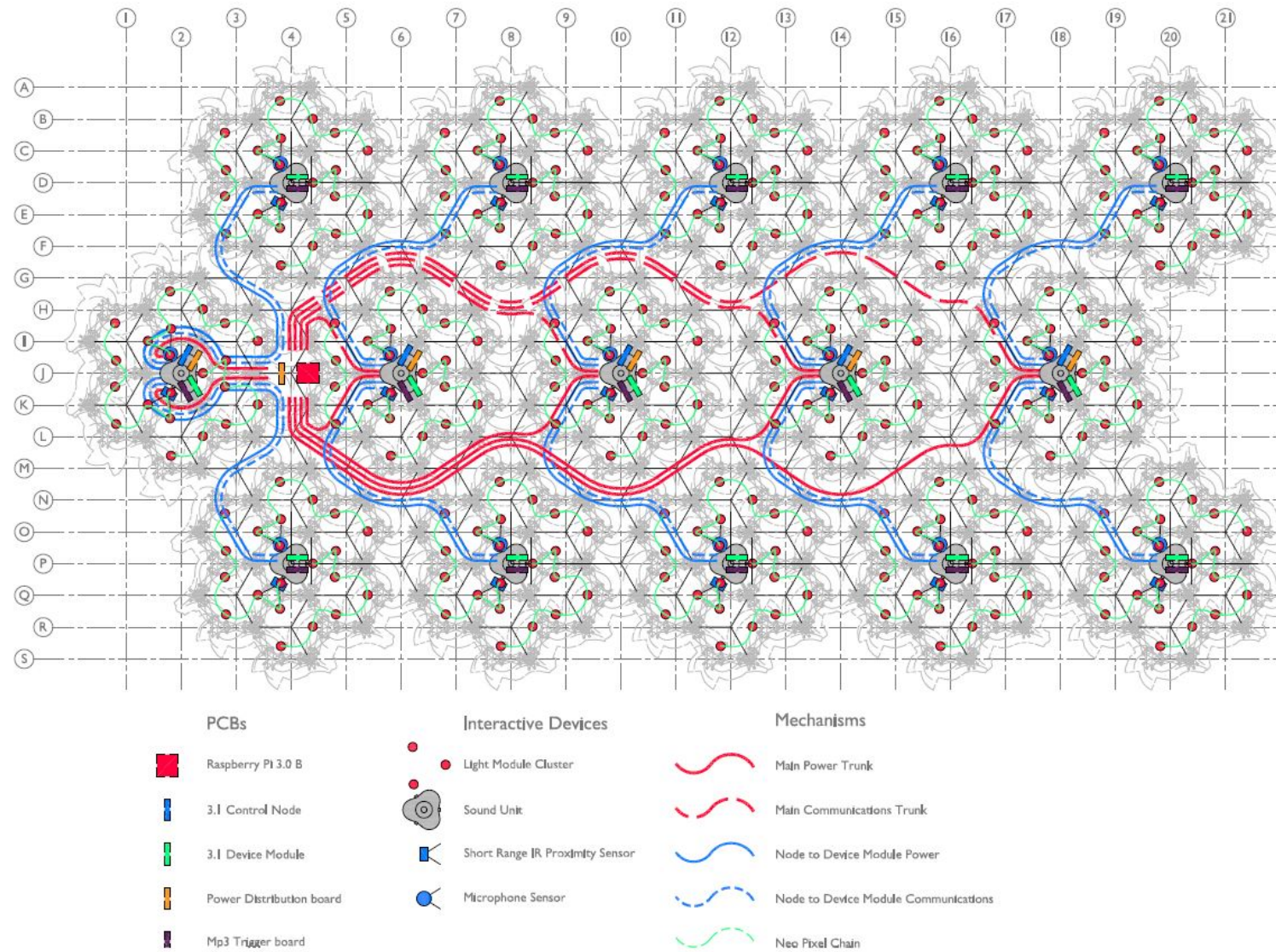




Sentient Veil, Isabella Stewart Gardner Museum, Boston, MA (2017)

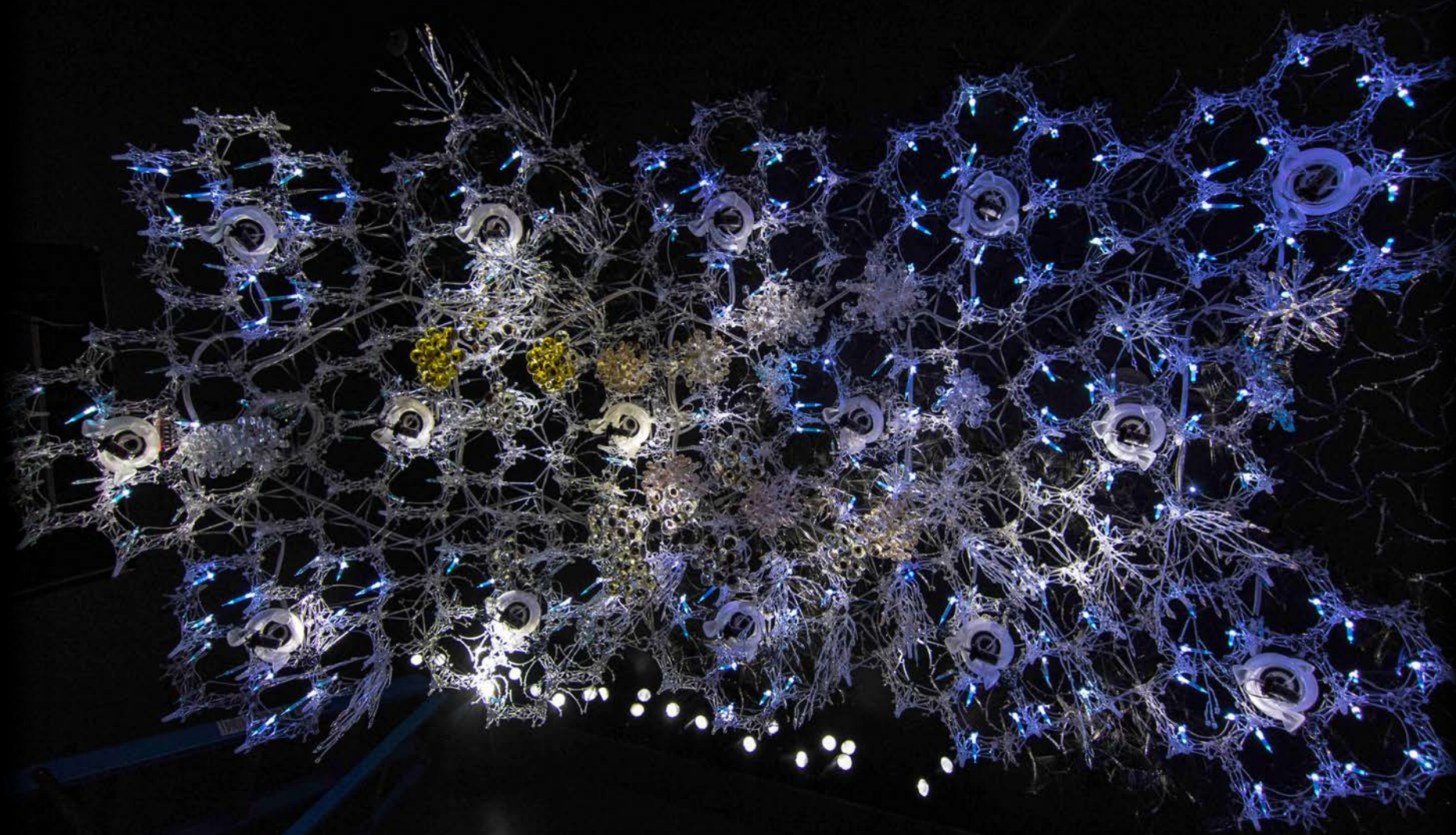


Sentient Veil, Isabella Stewart Gardner Museum, Boston, MA (2017)



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

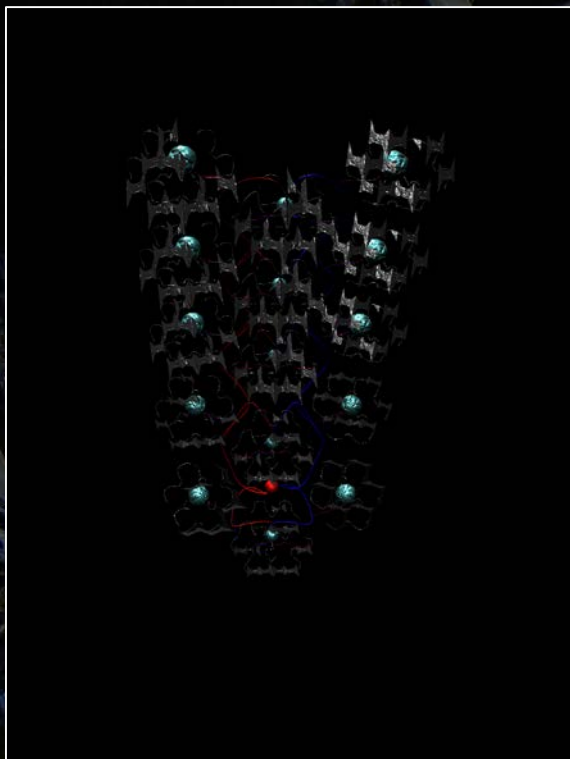




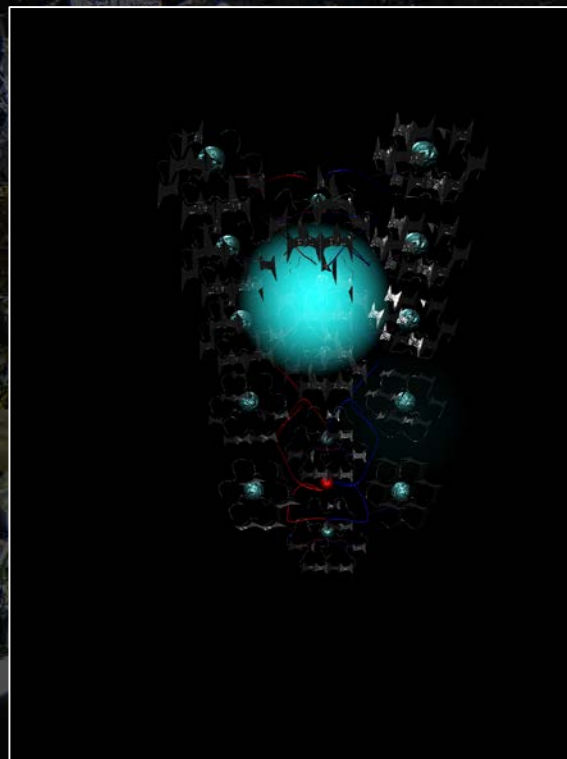
Sentient Veil, Isabella Stewart Gardner Museum, Boston, MA (2017)



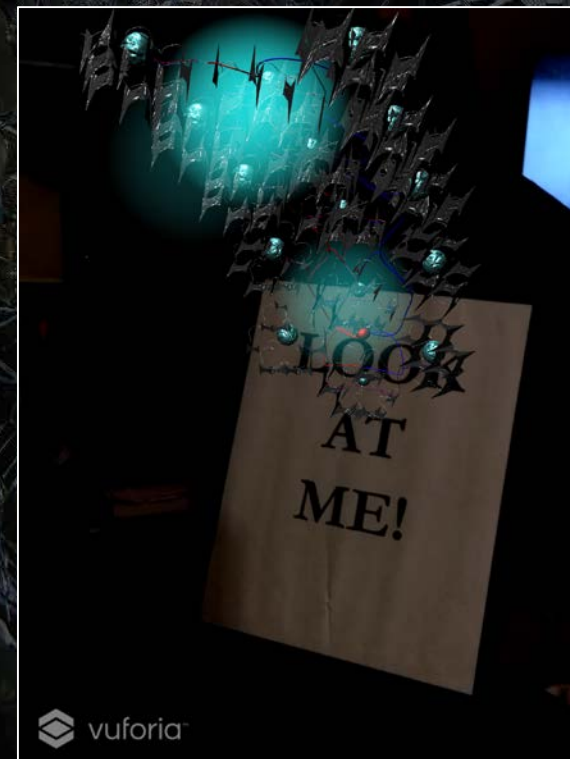
# Lifting the Veil App Development



Lifting the Veil Virtual  
0 sensors triggered



Lifting the Veil Virtual  
1 sensor triggered



Lifting the Veil AR  
2 sensors triggered



## Example projects – Dendrite Moth field array

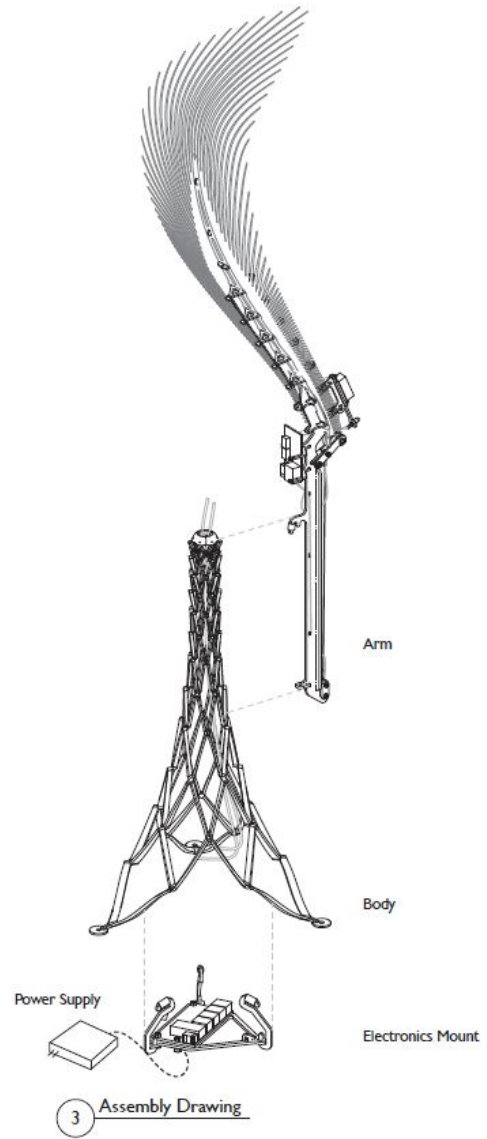
- ▶ VIS Lab
- ▶ November 2017 – present
- ▶ Goal: Create small-scale IoT setup for debugging & visualization development
- ▶ Target audience: makers



1 Dendrite Field: Perspective



2 Dendrite Field: Elevation



3 Assembly Drawing

Living Architecture Systems Group

213 Sterlin Road  
Toronto, Canada  
M6R 2B2  
web: lasg.ca  
tel: 416 766 8284  
fax: 416 604 3946

| Inv | Date     | Status      |
|-----|----------|-------------|
| JP  | 17/03/29 | Preliminary |
| JJ  | 17/04/28 | Prototype   |
|     |          |             |
|     |          |             |
|     |          |             |

Notes:

Status:  
Draft for Production  
Project:  
2017 IU Summer  
Camp: Dendrite  
Drawing Title:  
Grouped Dendrites  
and General Assembly  
Sheet:  
I-R2







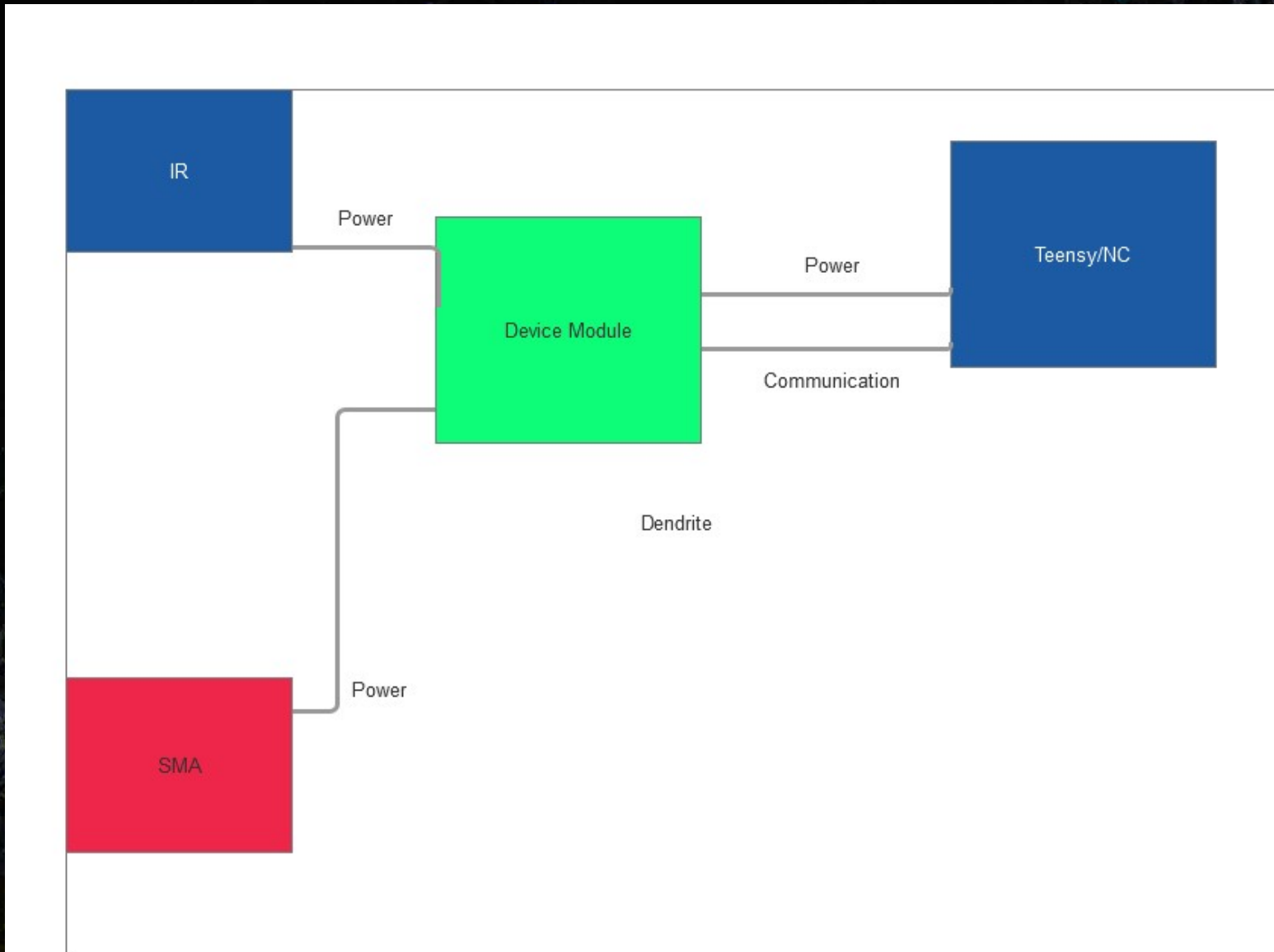


<http://cns.iu.edu/photos.html>



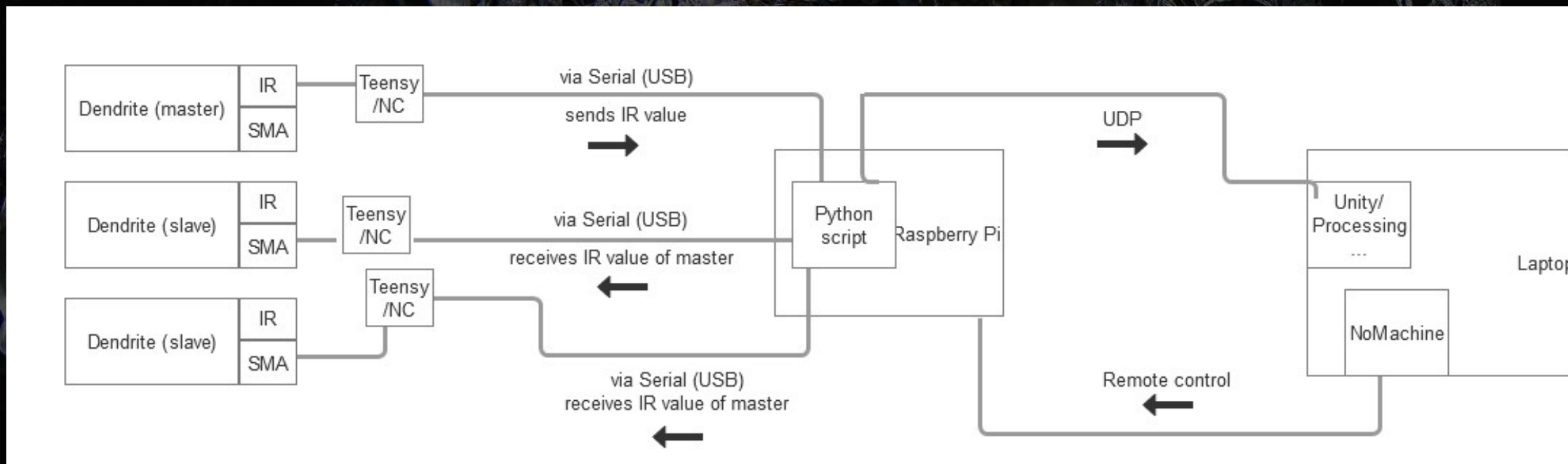
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FULFILLING *the* PROMISE





See <https://github.com/pbarch/1714-IU-Summer-Camp> for code

# Dendrite Field Array Schematics





# Demo: Tablet-based AR with IoT

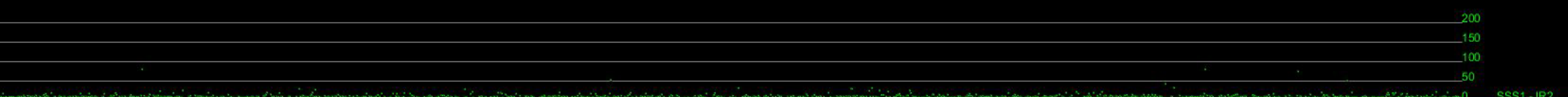
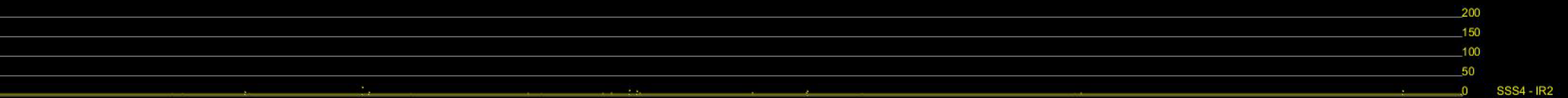
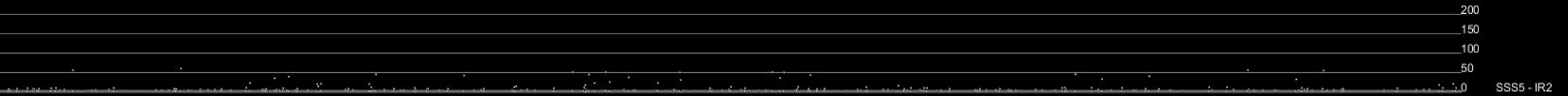
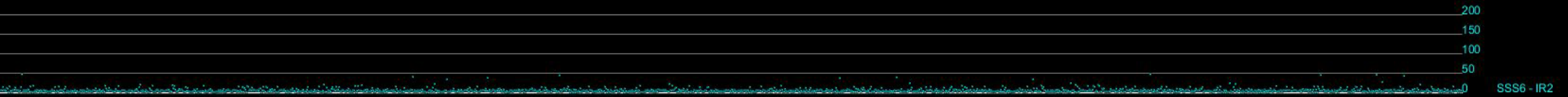


# Example projects – Amatria 24h data stream

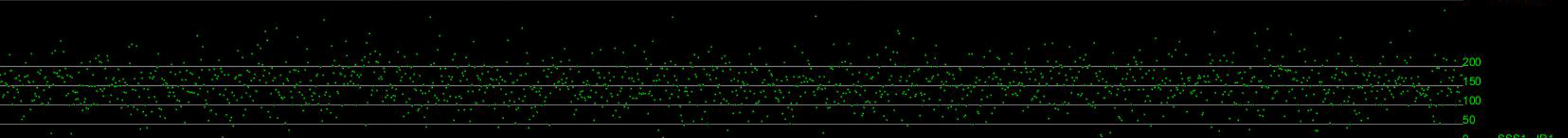
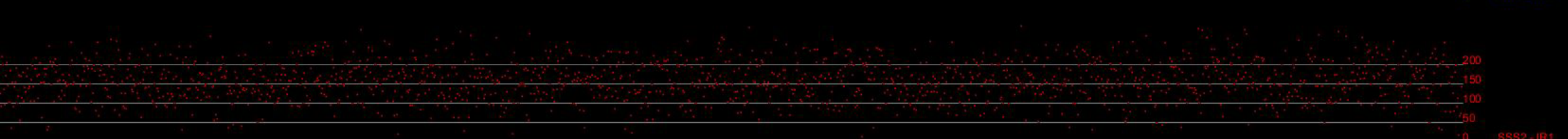
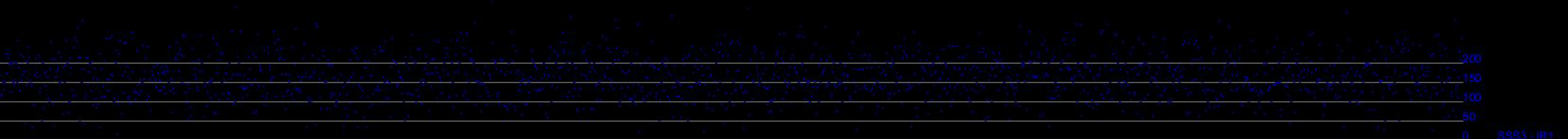
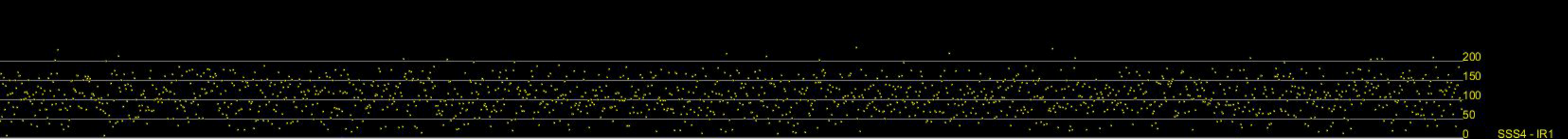
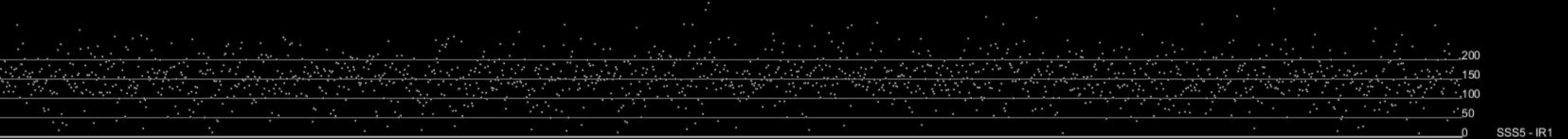
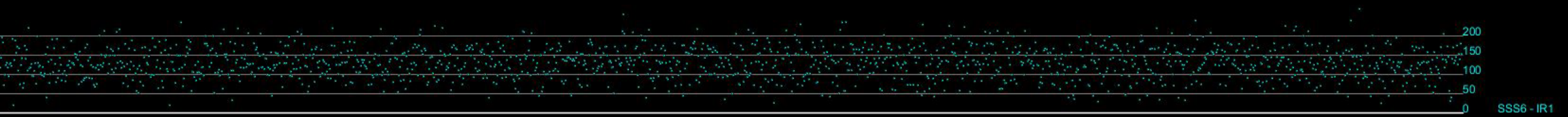
- ▶ Amatria
- ▶ May 2018
- ▶ Goal: Visualize raw sensor values
- ▶ Goal: optimize threshold values for sensors
- ▶ Target audience: makers



AMATRIA 24 hrs IR sensor values, May7-8 2018, ©Andreas Bueckle



AMATRIA 24 hrs IR sensor values, May7-8 2018, ©Andreas Bueckle





# Example projects – Amatria 24h data stream (cont'd)

- ▶ How could AR improve this visualization?
  - ▶ For visitors:
    - ▶ Increased immersion
  - ▶ For makers:
    - ▶ Improved guidance
    - ▶ Plug-and-play workflow



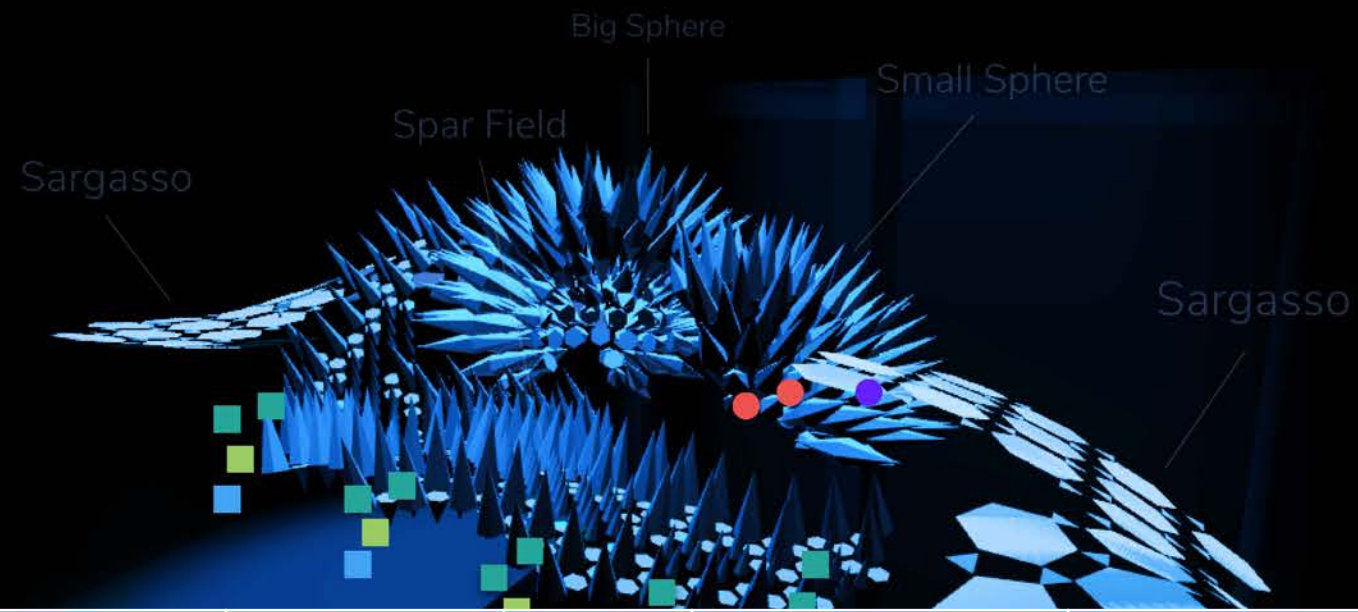
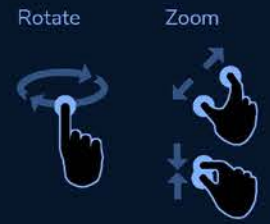
# Tavola

- ▶ Most current project
- ▶ Goal:
  - ▶ Enhance maker workflow
  - ▶ Enhance visitor experience
  - ▶ Both through visualizations



# Demo time!

CAMERA



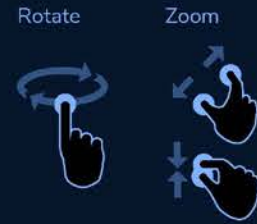
| Insight need | Data scale type | Analyses   | Vis type | Graphic var type | Graphic symbol type | Interaction type |
|--------------|-----------------|------------|----------|------------------|---------------------|------------------|
| Comparison   | Nominal         | Topical    | Chart    | Color hue        | Volume              | Zoom             |
| Locating     |                 | Geospatial | Map      | Shape            | Area                | Filter           |

**SENSORS**    ● Infrared    ● Microphone

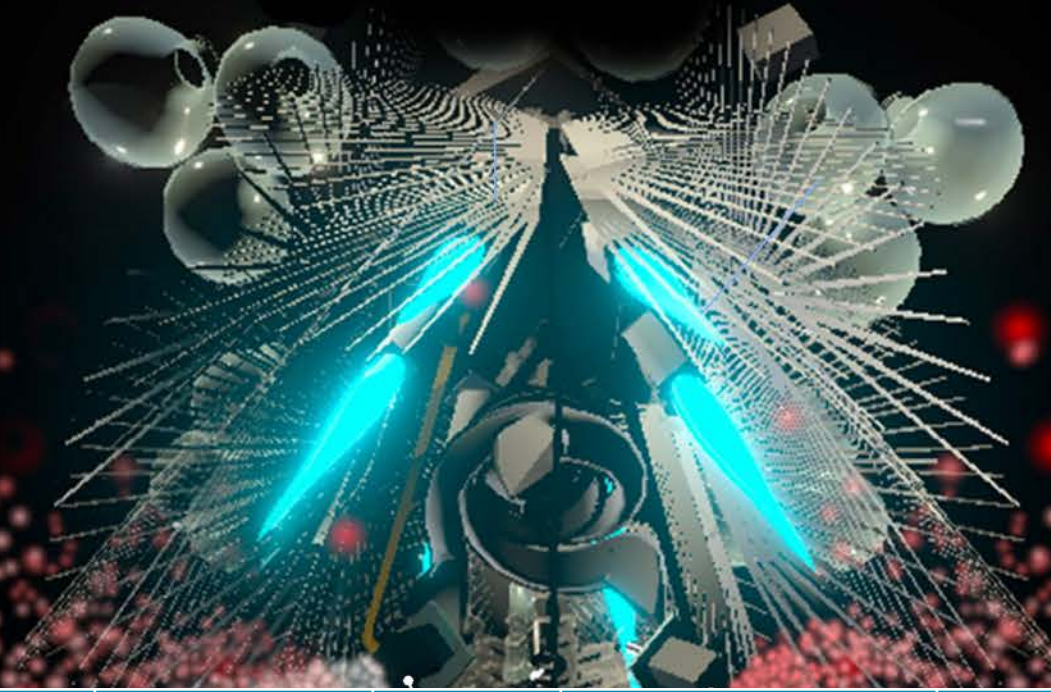
**ACTUATORS**    ■ Speaker    ■ Light    ■ Vibration Motor



CAMERA



SENSOR ACTIVATION



| Insight need | Data scale type | Analyses          | Vis type | Graphic var type | Graphic symbol type | Interaction type |
|--------------|-----------------|-------------------|----------|------------------|---------------------|------------------|
| Comparison   | Ratio           | Temporal (Bursts) | Chart    | Color intensity  | Volume              | Zoom             |
| Correlation  |                 |                   | Map      | Angle            | Point               |                  |

PROXIMITY TO SENSOR

# Conclusion & outlook

- ▶ Essential for academia: integrate AR into existing data visualization frameworks
  - ▶ Deconstruct
  - ▶ Develop
  - ▶ Test, test, test
- ▶ Essential for industry:
  - ▶ Offer unified solutions for development and deployment
  - ▶ Develop affordable hardware & software
- ▶ Essential for educators:
  - ▶ Include AR (and VR) into curriculums for STEM students



# Questions?



# References (Excerpt)

- ▶ Börner, K., & Bueckle, A. (2016). Visualizing Living Architecture: Augmented Reality Visualizations of Sensors, Actuators, and Signal Flows. In *White Papers*, edited by Beesley, Philip, and Ala Roushan, p. 109-112. Riverside Architectural Press.
- 1. Ornes S (2016) Core Concept: The Internet of Things and the explosion of interconnectivity. *Proceedings of the National Academy of Sciences* 113(40):11059-11060.
- 2. Milgram P, Kishino F (1994) A taxonomy of mixed reality visual displays. *IEICE Transactions on Information and Systems* 77(12):1321-1329.
- 3. Shah P (1997) A model of the cognitive and perceptual processes in graphical display comprehension. *AAAI Fall Symposium*:94-101.



# 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.
- ▶ Andreas Bueckle. Tavola App, Misc.
- ▶ Philip Beesley Architect Inc., Misc.
- ▶ [https://media.licdn.com/mpr/mpr/shrinknp\\_200\\_200/AEEAAQAAAAAAAAAI AAAAJDFIMzIzMThhLWlyOTMtNGJhNy04NThjLWY5N2VhN2FmNmFiMw.jpg](https://media.licdn.com/mpr/mpr/shrinknp_200_200/AEEAAQAAAAAAAAAI AAAAJDFIMzIzMThhLWlyOTMtNGJhNy04NThjLWY5N2VhN2FmNmFiMw.jpg) (photo of Matthew Sprenulli)