**2PM**

7PM in London (GMT), 4AM in Tokyo (GMT+9)

**Visualizing Intelligence**

**Moderator:** Katy Börner, *Indiana University*

**Presenter:**

- Tavola Visualizations of **Amatria** by Andreas Bueckle, *Indiana University*

ENVISIONING INTELLIGENCES

Aurora Mititelu

# Andreas Bueckle

Andreas Bueckle (https://andreas-bueckle.com) is the **Research Lead** for CNS at the Luddy School of Informatics, Computing, and Engineering (Luddy SICE) at Indiana University Bloomington (and affiliated with the Luddy Data Science Program). His research interest is **interactive information visualization** in **virtual reality (VR), augmented reality (AR), mixed reality (MR)**, and other technologies for **extended reality (XR)**. Born and raised in Germany, he holds a B.A. in Media Studies from Eberhard Karls University in Tuebingen, an M.A. in Communications from Berlin University of the Arts, and a Ph.D. in Information Science from Indiana University. After working as a video journalist, videographer, and director of photography on projects in Germany, France, India, and the US, he obtained his Ph.D. in Information Science at Indiana University Bloomington.

Andreas has a **TEDx** talk titled "Living and Learning in the Metaverse," which you can view on YouTube and on the TED website. In 2025, he was awarded a **R03** award entitled "3D Human Reference Body: Multiscale Exploration and Visualization of Biomolecular Data in Virtual Reality" (Opportunity Number RFA-RM-24-006, 2025-2026). You can read the details in this entry in NIH Reporter, this Luddy news item, and this SenNet Sentinel News Item. Before that, Andreas won two NIH JumpStart Fellowships, enabling workshop, hosted by the Bioinformatics and Computational Biosciences Branch (BCBB, https://www.niaid.nih.gov/research/bioinformatics-computational-biosciences-branch) at the National Institute of Allergy and Infectious Diseases (NIAID) in October 2023 and 2024 (workshop 1, workshop 2):
https://cns-iu.github.io/workshops/2024-10-24-jumpstart-workshop/

# A Tour of Amatria and Her Children

Outline:

- Amatria herself (with demo!)
- Tavola
- Dendrites and Moths (with demo!)

Housekeeping:

- This talk covers intelligent sculptures by Philip Beesley and team. Our work centers on **visualizing** data from these, e.g., with **Tavola**.
- This hour includes two live tours of some of these sculptures here in Luddy Hall. I will **switch** to my phone for those. Thank you in advance for your patience!
- I have a **back-up video** of Tavola in case the live demo does not work.

Me putting together this talk.

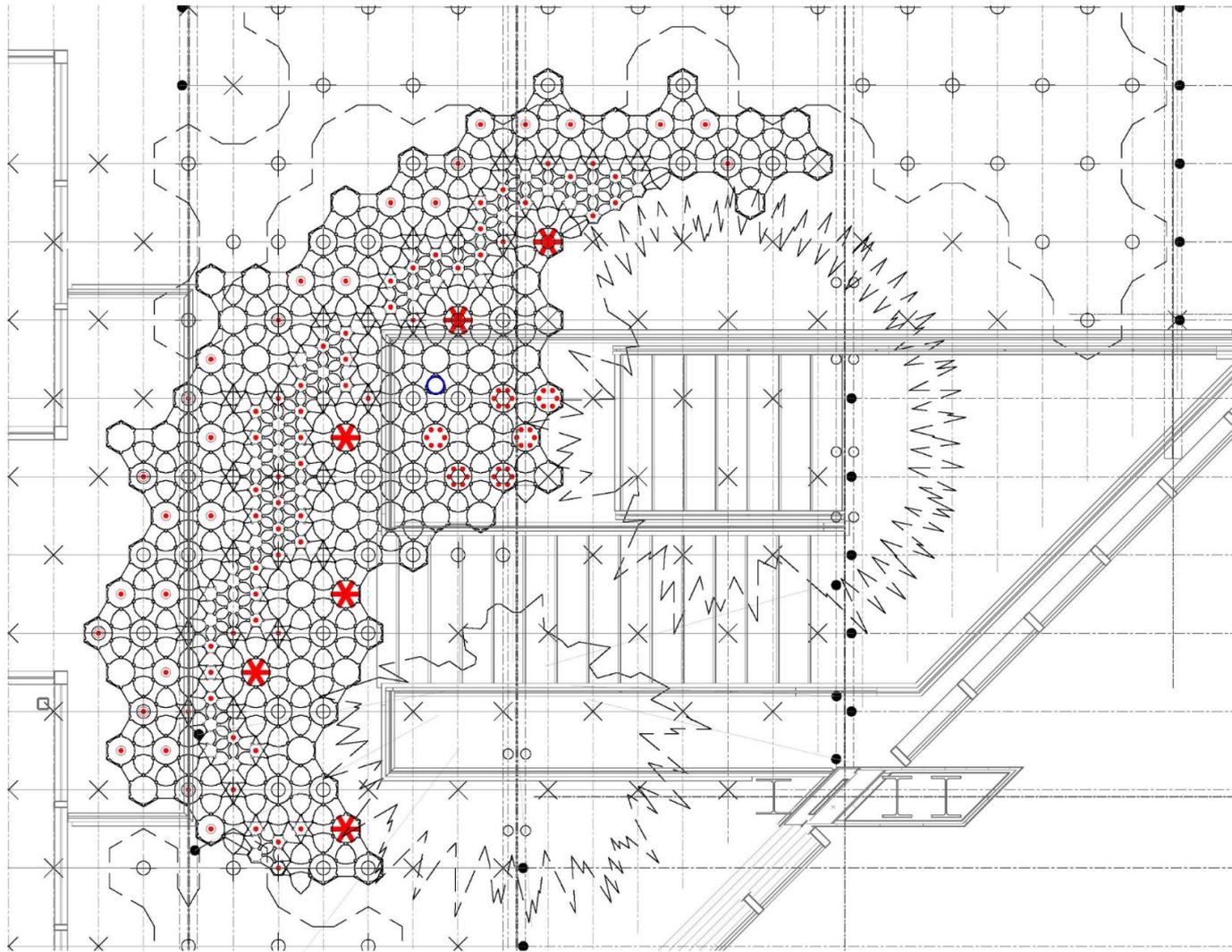# A Tour of Amatria and Her Children

## Amatria herself



Photo by Ann Schertz

# DEMO TIME!

**POWER CABINET**
SUSPENDED ABOVE MEETING ROOM

**LARGE SPHERE SECTION**

120V AC SUPPLY

12V DC PSU x 13

NET. S.  POE6

MONITORING LINE

LASG PBAI SUPERVISED BY IU AS AFFILIATE  Net@IU

TIE IN #3  TIE IN #2  TIE IN #1

**REBEL STAR DOUBLES**

12V DC  5V DC  RPi  NC  NET. S.

**REBEL STAR SINGLES**

12V DC  5V DC  RPi  NC

**SOUND SENSOR SCOUTS**

12V DC  DANTE  NET. S.  5V DC  RPi  NC  TS

**CONTROL CLOSET**

LASG PBAI SUPERVISED BY IU AS AFFILIATE  Net@IU  BUILDING ETHERNET AND INTERNET ACCESS

NET. S.

120V AC SUPPLY  MH  CL  IO

120V AC SUPPLY

**WEBCAM**

**GROTTO**

12V DC  NET. S  5V DC  RPi  NC

**SMALL SPHERE SECTION**

12V DC  5V DC  RPi  USB  NC  DANTE  TS

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

**DRAWING LEGEND**

Toronto Studio · IU Secure Network · Control Laptop · Monitor Laptop · 4D Audio Laptop · Dante Adapter · Network Switch · POE Switch · Raspberry Pi Computer · Powered USB Hub · Node Controller · High Current Device Module · Low Current Device Module · Tracer Sound Unit · Amplifier Module · Speaker Module · Acetic Battery · IR Sensor · Mic · Main Actuator · Single Rebel Star · Double Rebel Star · 120 Volt 100 Amp Building Power · 12 Volt DC Power Supply x24 · 12 Volt DC Splitter 8 Port · 5 Volt DC Power Converter · Webcam

120V AC Cable · 12V DC Cable · 5V DC Cable · Internet Cable · POE Ethernet · LED Cable · Actuator Cable · Balanced Audio Cable

**Phase**
Design
Development

**Project**
17540 Luddy Hall

**Drawing Title**
Electronic Schematic

**Sheet**
IS10••

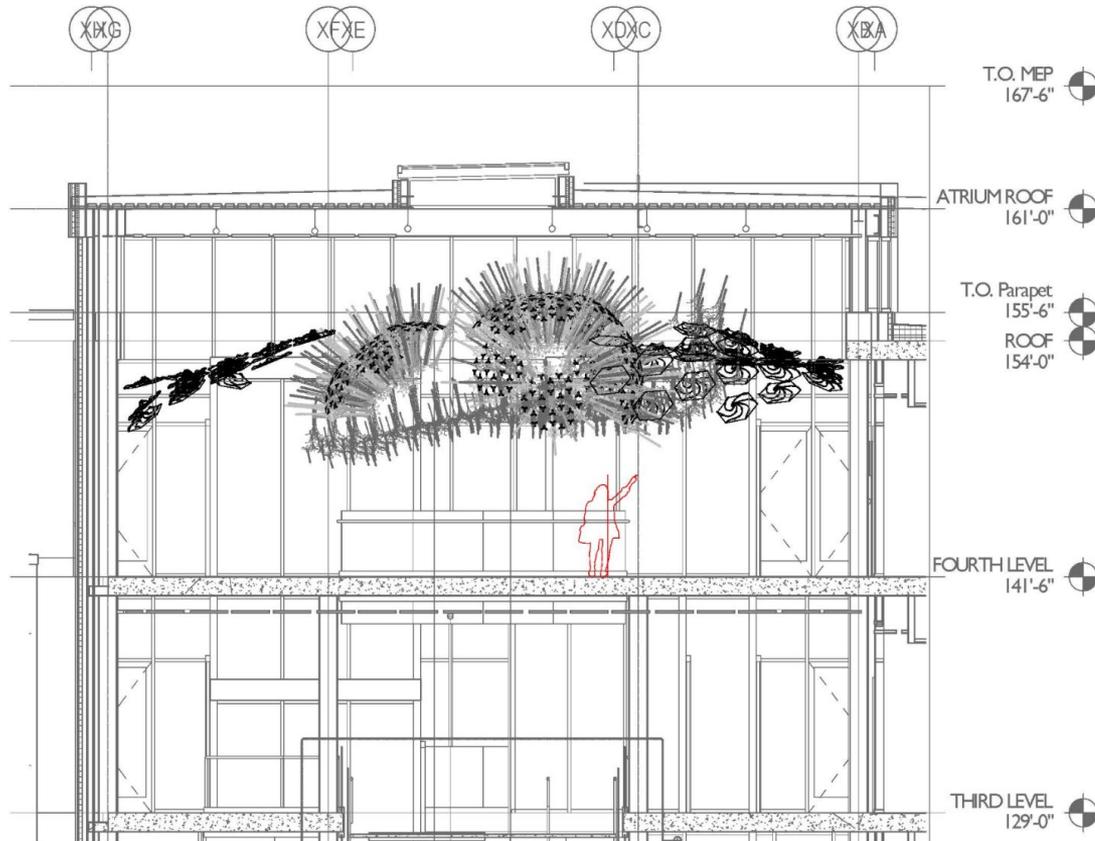| By | Date | Status | Rev By | Rev Date |
|----|------|--------|--------|----------|
| TB | 18/02/09 | DRAFT | MF | 18/02/09 |
| TB | 18/02/13 | DRAFT | VF | 18/02/13 |

**Notes**

**Phase**
Schematic Design

**Project**
17540 Luddy Hall

**Drawing Title**
Spar Field Detail Plan -
IS Components

**Sheet**
A107

Zip tie strain relief
3m
350m.

Connection piece

HC

16

48 cable

Cable comb

2.2

32408

350mm
6

strip to expose ~5mm

30mm
42
478  12mm 176mm
826m
224
574   272mm
622
320
670

10Ca?
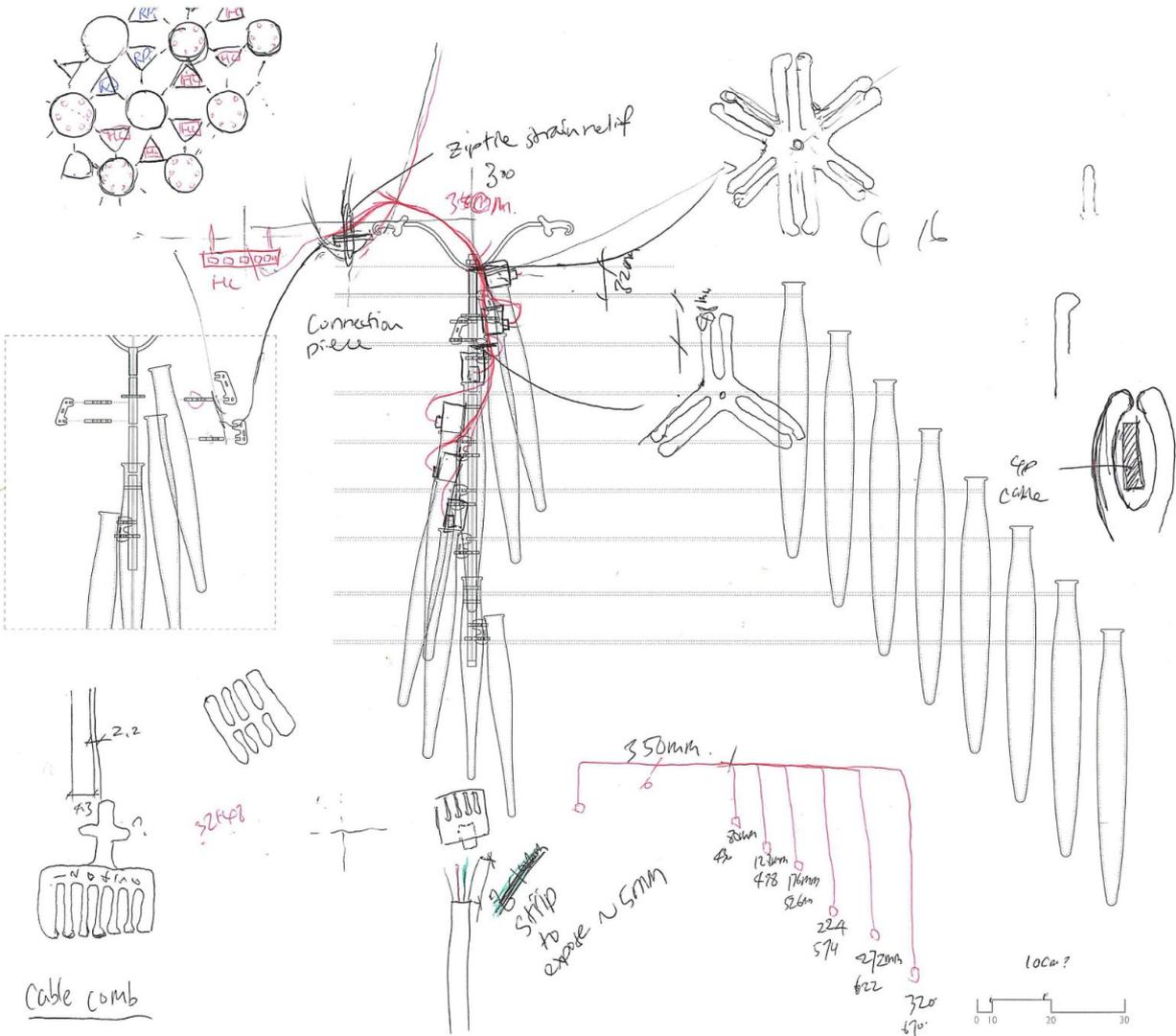
| By | Date | Status | Rev By | Rev Date |
|----|------|--------|--------|----------|
| MH | 18/02/26 | | | 18/02/26 |
| | | | | |
| | | | | |
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| | | | | |

Notes:

Phase:
Design Development

Project:
17540 Luddy Hall

Drawing Title:
Grotto Cable Detail

Sheet:
IS109

0  10    20    30

| By | Date | Status | Rev By | Rev Date |
|----|------|--------|--------|----------|
| TB | 18/02/06 | DRAFT | TB | 18/02/06 |
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| | | | | |

**Notes**

**Phase**
Schematic Design

**Project**
17540 Luddy Hall

**Drawing Title**
Transverse Section

**Sheet**
A11••

T.O. MEP
167'-6"

ATRIUM ROOF
161'-0"

T.O. Parapet
155'-6"

ROOF
154'-0"

FOURTH LEVEL
141'-6"

THIRD LEVEL
129'-0"

· · ·

VOLUNTEERS NEEDED to assist with on-site assembly of the "Amatria" sentient sculpture installation on the 4th floor of Luddy Hall between 10am–5pm through March 31. Hands-on training and snacks provided. Drop in or sign up at http://bit.ly/2C52x2T
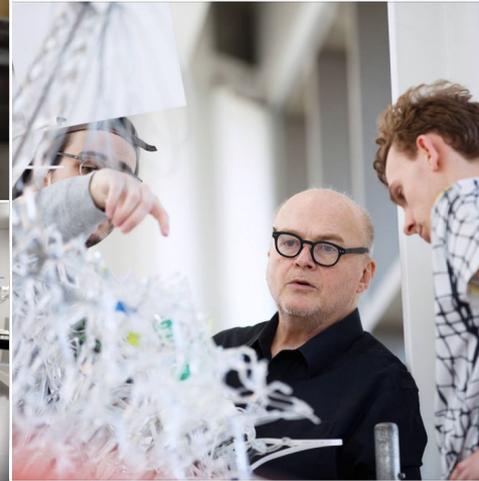
# Amatria's 1st Birthday Celebration (04.11.2019)

# Internet of Things Wearables in Motion Symposium (04.26.2019)

# Amatria's 2<sup>nd</sup> Birthday Celebration (04.13.2020)

Event recording on Youtube:
https://www.youtube.com/watch?v=w3wIoIAkjL0&t=332s
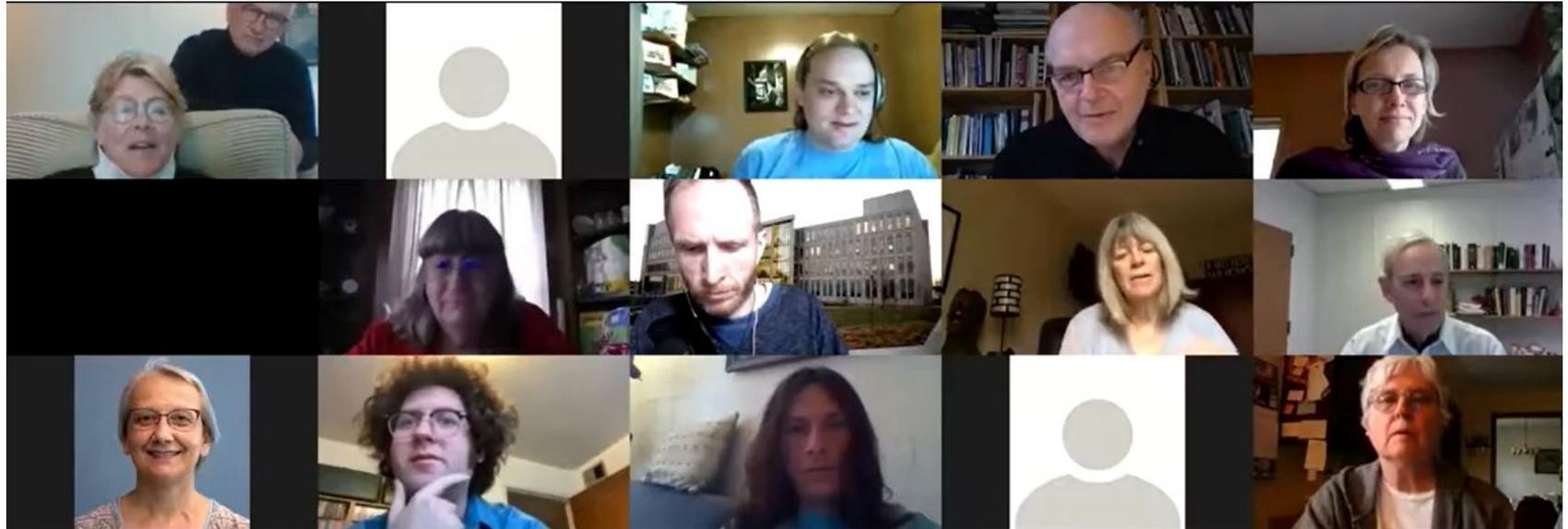
# Amatria's 3rd Birthday Celebration (04.12.2021)

Event recording is available on Youtube:
https://www.youtube.com/watch?v=fR0GdoUimL0
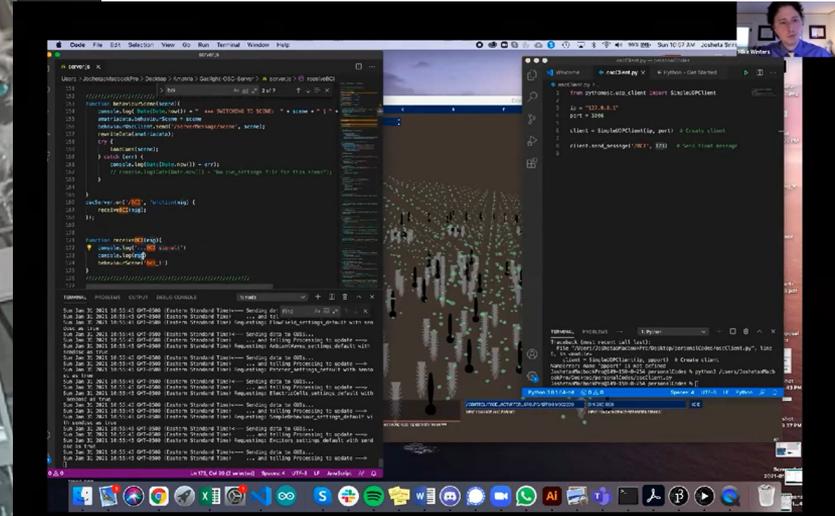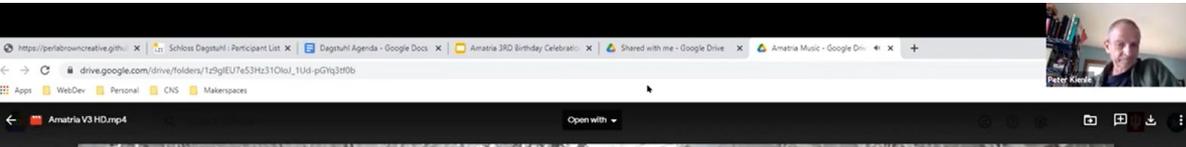
# Amatria's 4ᵗʰ Birthday Celebration

# Amatria's 6th Birthday Celebration (4.11.2024)

# A Tour of Amatria and Her Children

## Tavola (2018/2019)



*Image* Tavola, a 3D interactive visualization of Amatria

Indiana University Bloomington
School of Informatics, Computing, and Engineering
Department of Information and Library Science
Andreas Bueckle, Olga Scrivner
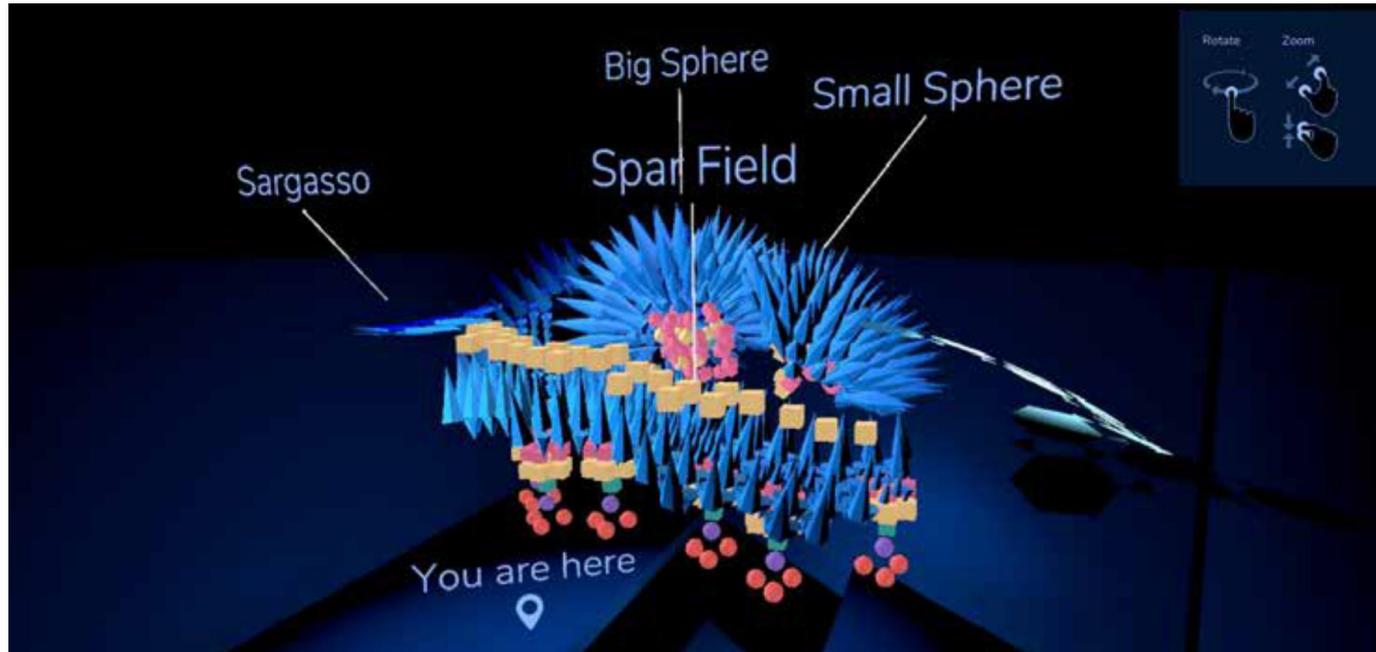
## "Previewing the Future" Development Project Proposal

By Andreas Bueckle & Olga Scrivner

### A. Overview

a) The Microsoft HoloLens is a revolutionary tool not just because of its cutting-edge technology, but also because of the technological context in which it is embedded. Video game engines such as Unreal Engine or Unity 3D are at a level of unseen usability and ease-of-use with relatively little training. While it has been demonstrated how the HoloLens could be used for prototyping built structures (e.g., in connection with an HTC Vive), there aren't yet too many cases of designers or artists using the HoloLens to prototype their own work. This proposal details a planned project that envisions the use of the HoloLens for architectural pre-visualization in collaboration with Philip Beesley Architect Inc. and the Living Architecture Systems Group from Canada. Katy Borner, Distinguished Professor of Engineering at IU, and PhD student Andreas Bueckle, along with other IU students, staff, and faculty, previously worked with them to make the IU Engineering Summer Camps happen.

### B. Goals

Philip Beesley Architect Inc. and the Living Architecture Systems Group conduct research and development of Sentient Architecture, an art and science form thinking ahead and prototyping living spaces that adapt and react to the humans in it. They achieve this with sensor-actuator couples and microprocessors. For photos of an installation on display until recently, please visit this page.
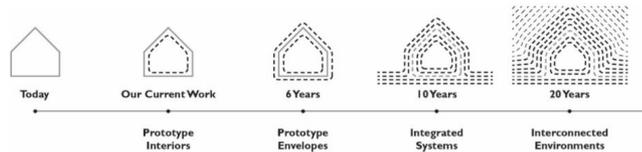


Fig. 1: the future of smart environments

The idea is to design spaces that are aware of the humans in it, and able to react to them. As can be seen from their website, Beesley and his team have developed and deployed their Sentient Architecture for the better part of a decade. Quite recently, Sentient Architecture came to IU with the fabrication of the Dendrite sculptures during the aforementioned IU Engineering Summer Camps.



Fig. 2: schematic drawing of the Dendrite

There are many possibilities for research with Sentient Architecture, the most important one for our academic unit being the chance to harvest data from Sentient Architecture, and enhance the space shared by the sculpture and the humans passing it by. The next big step in bringing this fascinating kind of development to IU is a sophisticated installation at Luddy Hall, to be installed in a modular way starting in spring 2018. In order to facilitate the designers' work, we aim to develop a HoloLens application based on a 3D model of the lobby of Luddy Hall (or wherever the sculpture will be), and use it to previsualize the actual installation. By doing this, we want to make use of the HoloLens' greatest feature: its spatial mapping capabilities that make it to superior to similar products, or to image-based augmented reality frameworks. We will use 3D models supplied directly by the designers.

[INSERT DRAWINGOF PLANNED LUDDY HALL INTALLATION]

LIVING ARCHITECTURE SYSTEMS GROUP

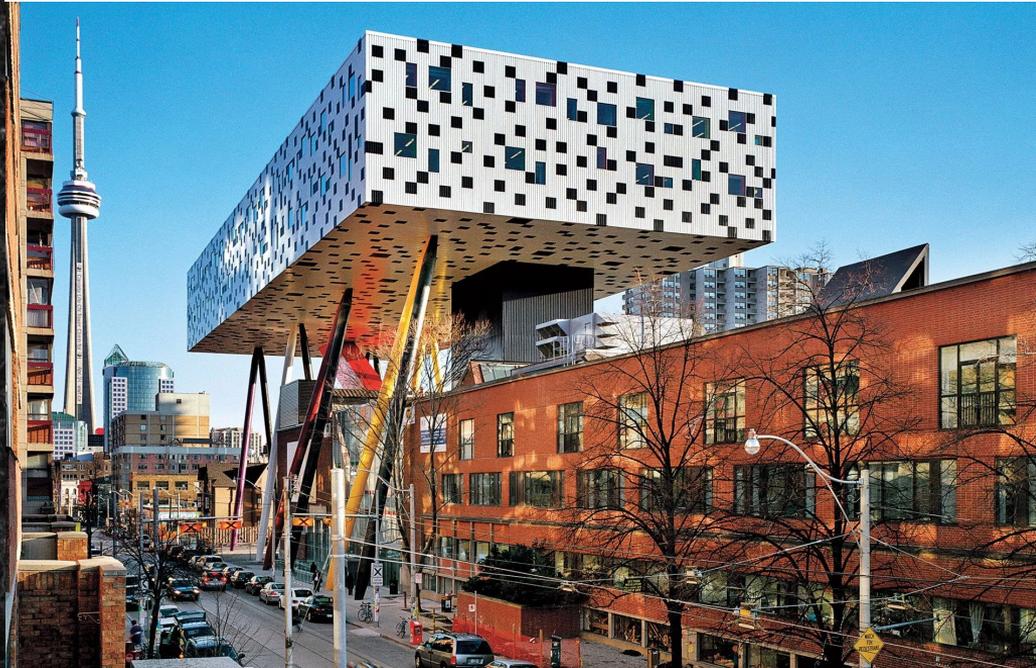# Symposium 2019 Proceedings

R

# Symposium 2019

Ontario College of Art and Design University & University of Waterloo

**Friday–Sunday, March 1–3 2019**
100 McCaul Street Toronto M5T 1V7

## Keynote

# Envisioning the Internet of Things

## Katy Börner with Andreas Bueckle
*ISE and ILS, School of Informatics, Computing, and Engineering*
*Indiana University, Bloomington, USA*

*Image* Tavola, a 3D interactive visualization of Amatria

In this talk, we present two streams of extended collaboration between the Living Architecture Systems Group (LASG) and the Cyberinfrastructure for Network Science Center (CNS) at Indiana University (IU). Both collaborations revolve around the *Amatria* sentient sculpture on display at Luddy Hall, IU Bloomington, USA since Spring 2018 (https://cns.iu.edu/amatria.html).

First, we will introduce our joint work on Dendrite and Moth kits that resemble *Amatria* and are meant to introduce Internet of Things (IoT) setups to general audiences. So far, seventy "children of *Amatria*" have been built, discussed, interconnected, taken home and brought back to *Amatria* for events.

Second, we will present Tavola, an app visualizing the location of sensors and actuators in *Amatria* as well as the value of one infrared (IR) sensor. Tavola enables deeper exploration of the Amatria setup and aims to add another dimension to the visitor experience. We will discuss the research and development process of Tavola that uses the data visualization literacy framework (DVL-FW) to design insightful visualizations together with challenges and future developments.
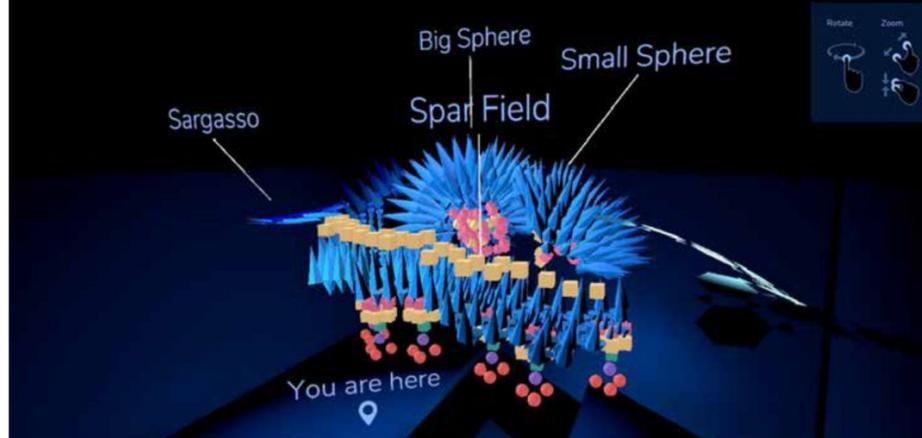
Katy Börner is the Victor H. Yngve Distinguished Professor of Engineering and Information Science in the School of Informatics, Computing, and Engineering, an Adjunct Professor at the Department of Statistics in the College of Arts and Sciences, a Core Faculty of Cognitive Science, and the Founding Director of the Cyberinfrastructure for Network Science Center at Indiana University, Bloomington, IN. She is a curator of the international Places & Spaces: Mapping Science exhibit that features large-format maps and interactive data visualizations. Börner holds a M.S. in Electrical Engineering from the University of Technology in Leipzig, 1991 and a Ph.D. in Computer Science from the University of Kaiserslautern, 1997. She is a member of ACM and IEEE and is an American Association for the Advancement of Science (AAAS) Fellow and a Humboldt Research Fellow.

Andreas Bueckle is a Ph.D. candidate in Information Science in the School of Informatics, Computing, and Engineering at Indiana University. Coming from a background in video journalism and media, Andreas performs research and development of data visualizations in augmented and virtual reality, exploring the possibilities to visualize and allow for immersive interactions with data in 3D worlds. He holds a B.A. in Media Studies from Eberhard Karls University in Tüebingen and an M.A. in Communications in Economic and Social Contexts from Berlin University of the Arts (Germany).
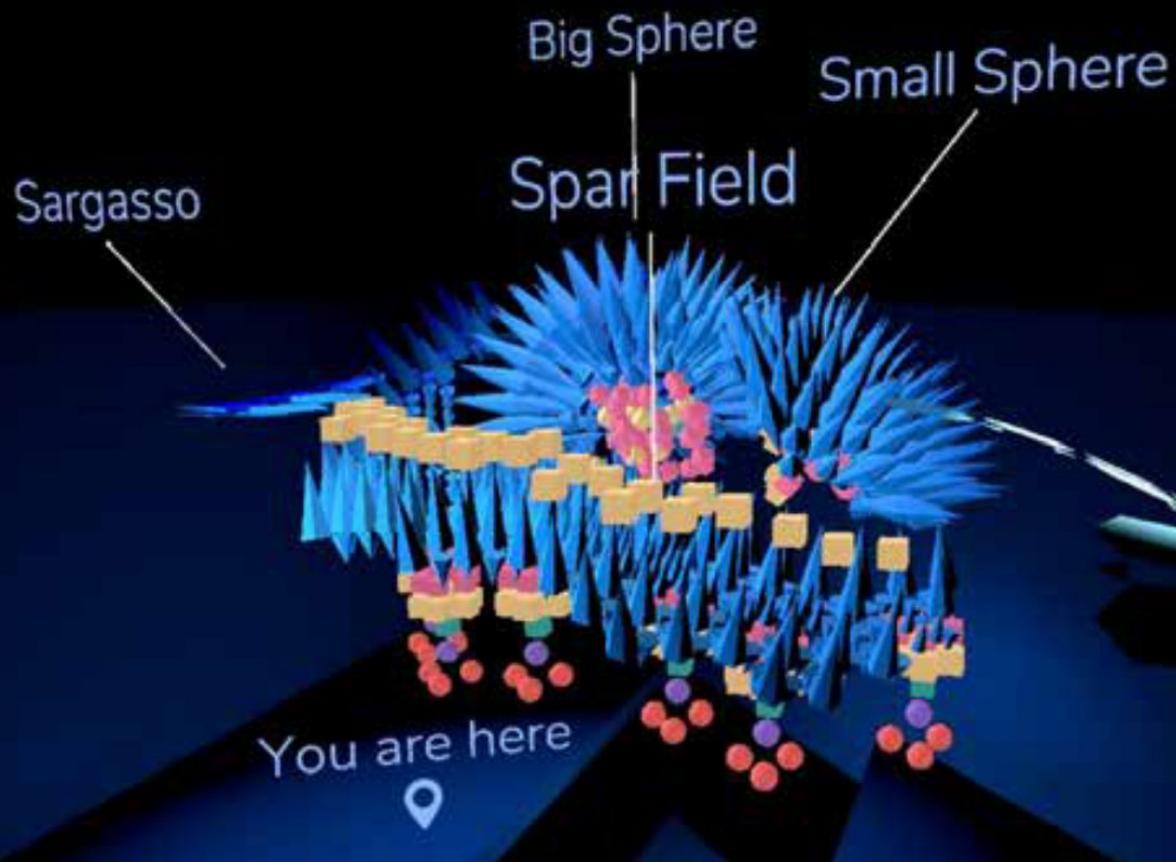
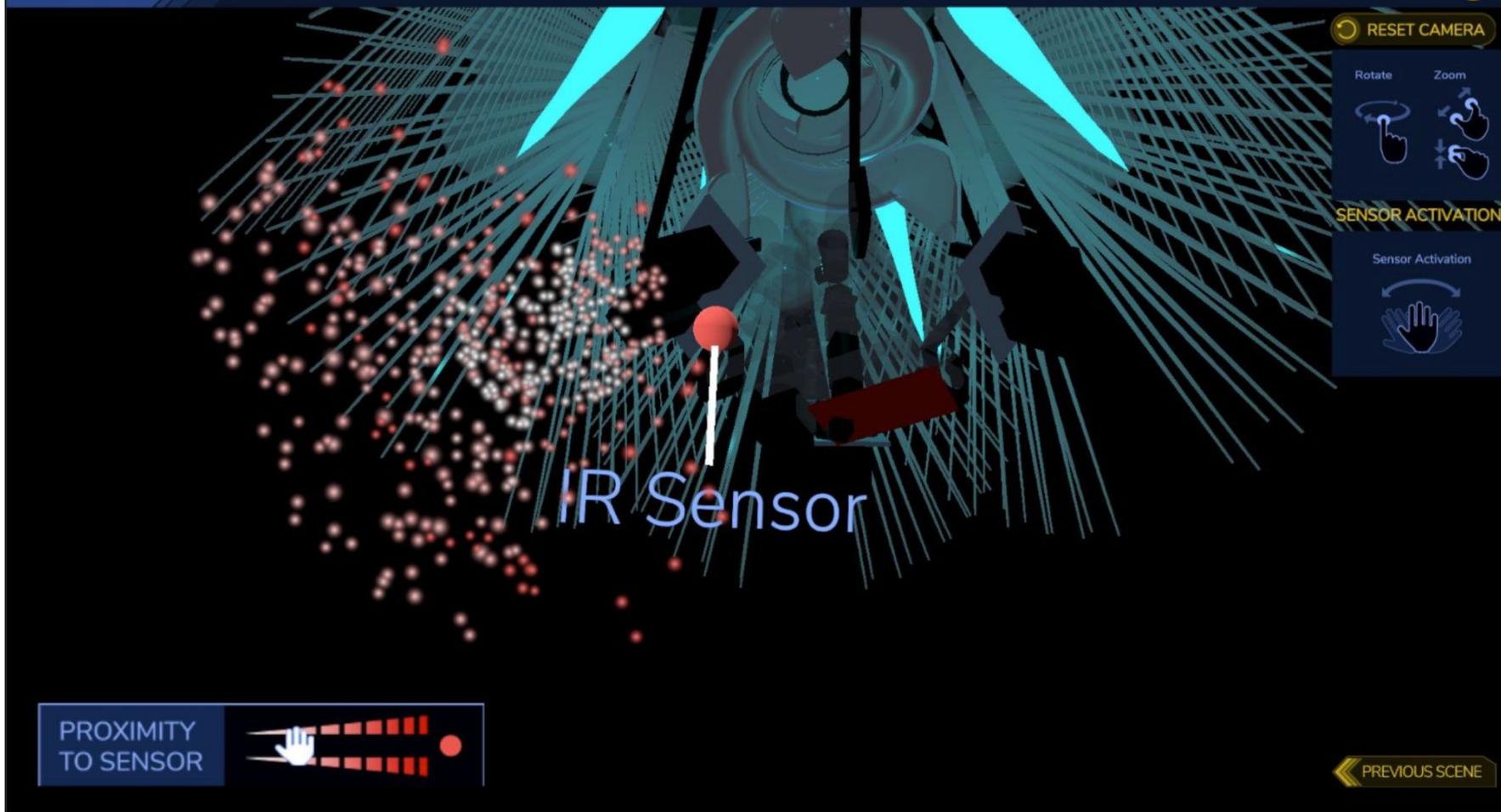*Image* Tavola, a 3D interactive visualization of Amatria

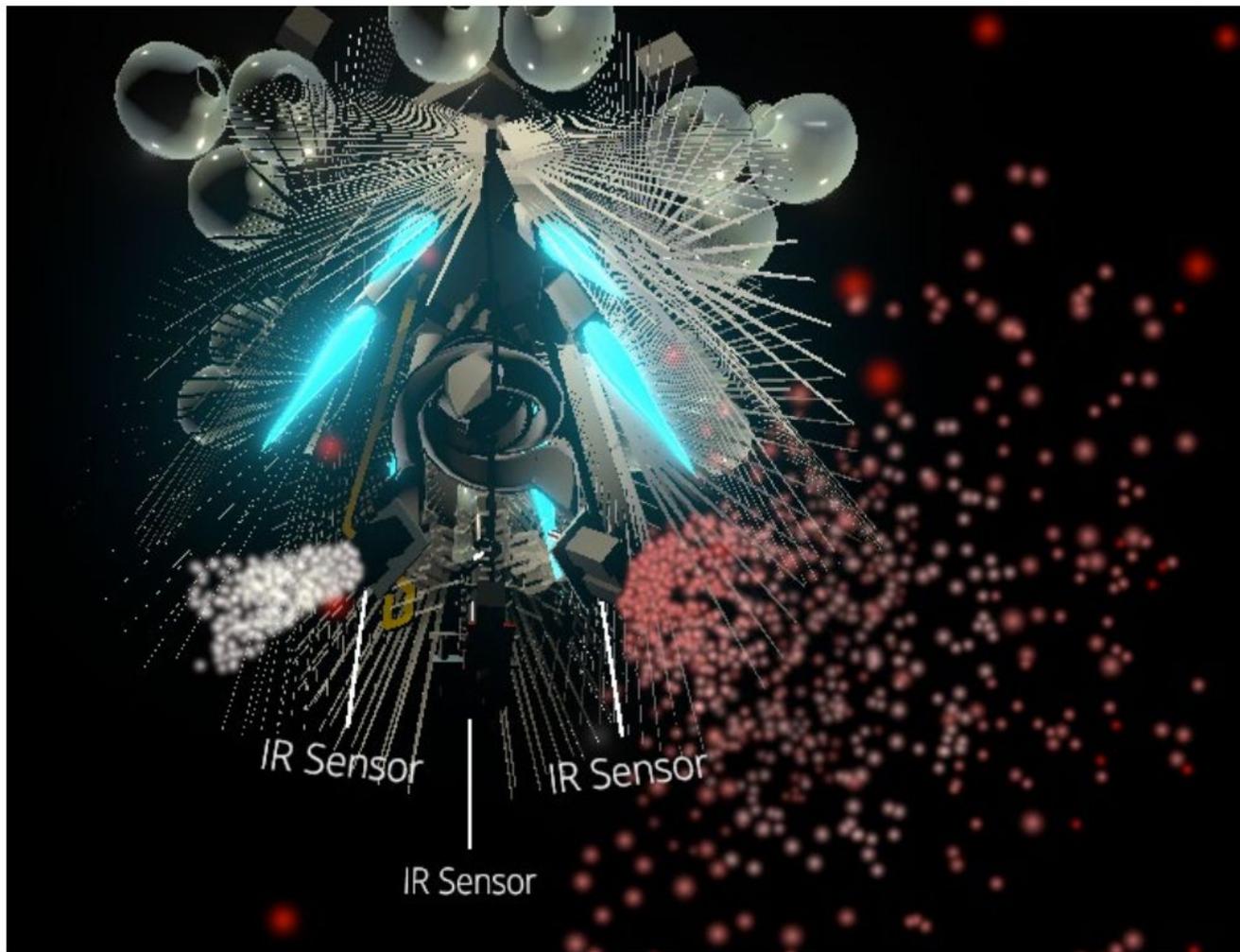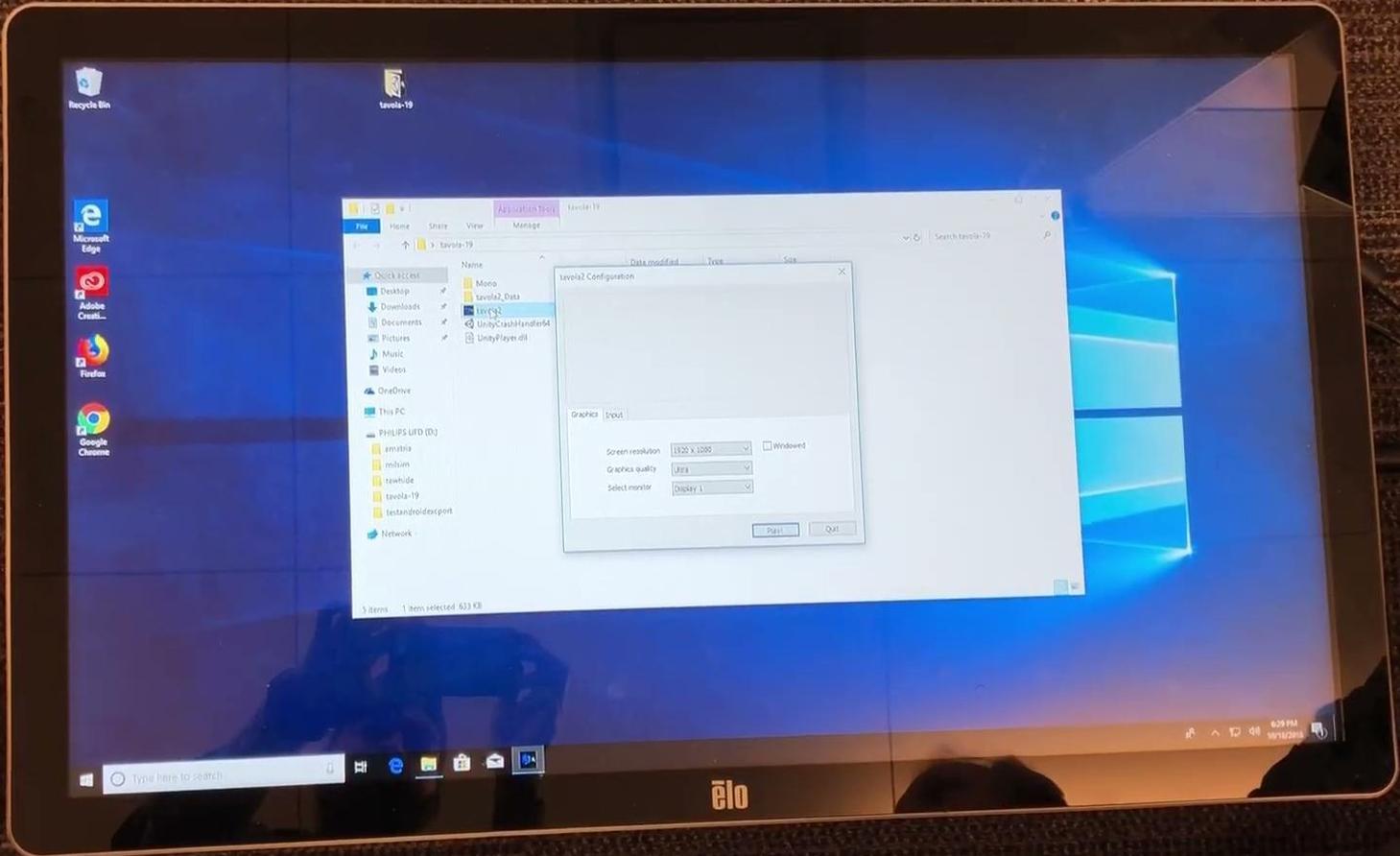**Fig. 5. Tavola, scene 2: Amatria Sound Sensor Scout.**

**Fig. 6. Early prototype of Tavola where the IR sensor on the right reports consistently high proximity values.**

END
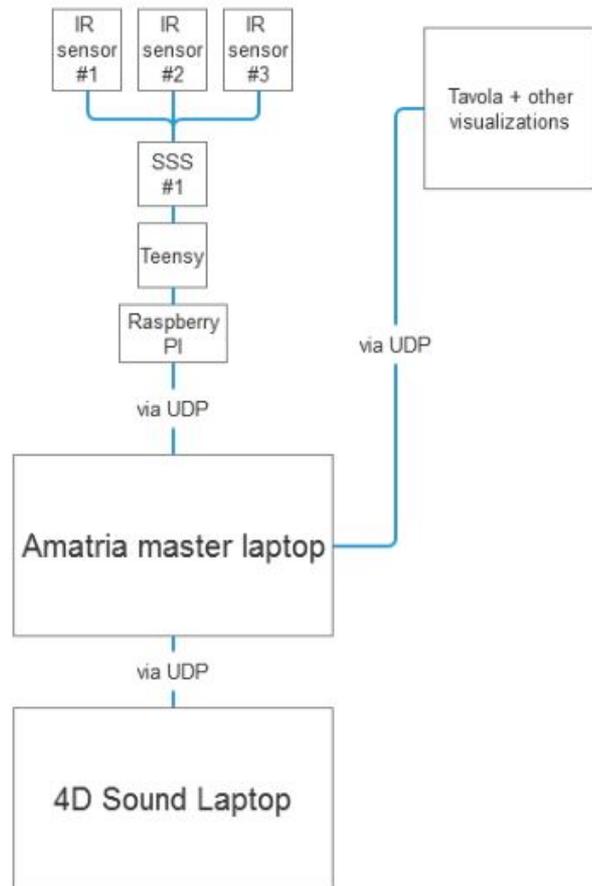
b'TV/TRIGGER/SSS2/105/4/1'
b'TV/TRIGGER/SSS5/207/1/1'
b'TV/TRIGGER/SSS4/163/0/0'
b'TV/TRIGGER/SSS3/142/36/2'
b'TV/TRIGGER/SSS6/198/4/2'
b'TV/TRIGGER/SSS1/199/1/3'
b'TV/TRIGGER/SSS2/86/4/6'
b'TV/TRIGGER/SSS5/213/1/1'
b'TV/TRIGGER/SSS4/154/0/0'
b'TV/TRIGGER/SSS3/198/31/2'
b'TV/TRIGGER/SSS6/200/15/17'
b'TV/TRIGGER/SSS1/258/1/4'
b'TV/TRIGGER/SSS2/62/2/4'
b'TV/TRIGGER/SSS5/126/1/1'
b'TV/TRIGGER/SSS4/132/0/0'
b'TV/TRIGGER/SSS3/192/37/6'
b'TV/TRIGGER/SSS6/155/1/3'
b'TV/TRIGGER/SSS1/308/24/10'
b'TV/TRIGGER/SSS2/237/0/2'
b'TV/TRIGGER/SSS5/221/1/1'
b'TV/TRIGGER/SSS4/45/0/0'
b'TV/TRIGGER/SSS3/196/27/5'
b'TV/TRIGGER/SSS6/162/3/1'
b'TV/TRIGGER/SSS1/257/2/4'
b'TV/TRIGGER/SSS2/177/7/0'
b'TV/TRIGGER/SSS5/246/1/1'
b'TV/TRIGGER/SSS4/83/4/0'
b'TV/TRIGGER/SSS3/255/24/5'
b'TV/TRIGGER/SSS6/256/1/1'
b'TV/TRIGGER/SSS1/226/7/12'
b'TV/TRIGGER/SSS2/200/8/4'
b'TV/TRIGGER/SSS5/201/1/1'
b'TV/TRIGGER/SSS4/38/0/0'
b'TV/TRIGGER/SSS3/204/26/1'
b'TV/TRIGGER/SSS6/205/1/3'
b'TV/TRIGGER/SSS1/217/8/11'
b'TV/TRIGGER/SSS2/115/0/5'
b'TV/TRIGGER/SSS5/203/1/1'
b'TV/TRIGGER/SSS4/52/0/0'

**Fig. 3. Simplified system architecture (left); raw data stream from Amatria master laptop as logged in Python shell (right). The three numbers at the end of each message are IR sensor values.**

**Table 1. Graphic symbol types vs. graphic variable types in scene 1 of Tavola.**
**\* qualitative**
**\*\* quantitative**

| | | Graphic symbol types | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | | Volume | | | | |
| **Graphic variable types** | Shape* | Sphere: sensor | | Cube: actuator | | |
| | Color hue* | #EF5350 (red): IR sensor | #9575CD (purple): microphone sensor | #FFCC 80 (yellow): light | #26A69A (green): speaker | #f06292 (pink): vibration motor |
| | Color intensity* | Opacity: 0%: graphic symbol turned off<br>Opacity: 100%: graphic symbol turned off | | | | |
| | x-position** | Location of sensor or actuator in 3D space | | | | |
| | y-position** | | | | | |
| | z-position** | | | | | |

**Fig. 7.** Raw sensor data from six Amatria IR sensors (labeled "IR2") plotted over 24 hours
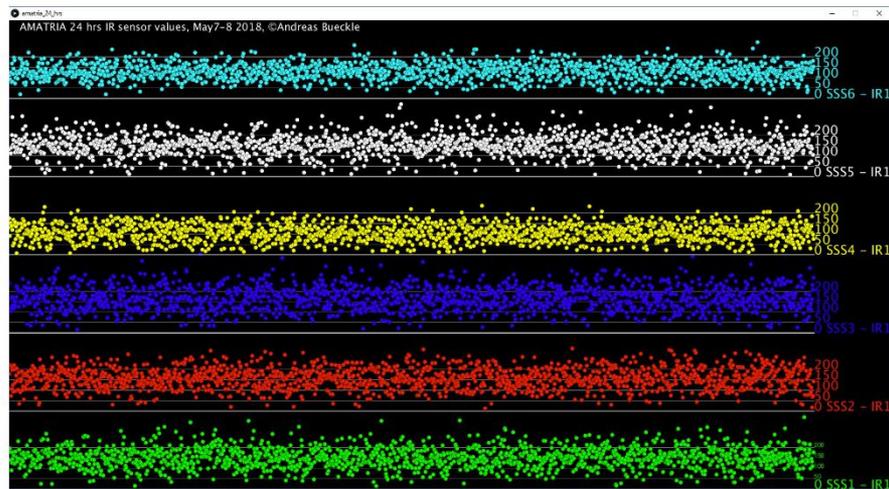


**Fig. 8.** Raw sensor data from six Amatria IR sensors (labeled "IR1") plotted over 24 hours

Two **trend**-related insights can readily be gained from these graphs: No threshold change for IR sensors seems to be needed based on differences between day and night. But more importantly, we found that the consistently high sensor value for IR sensor #1 on SSS #1 is not an isolated incident; in fact, we encountered the same problem for all 6 SSS, specifically in their IRs #1. This actionable insight hinted at a challenging problem for the Amatria and Tavola team that is going to be tackled in the future.
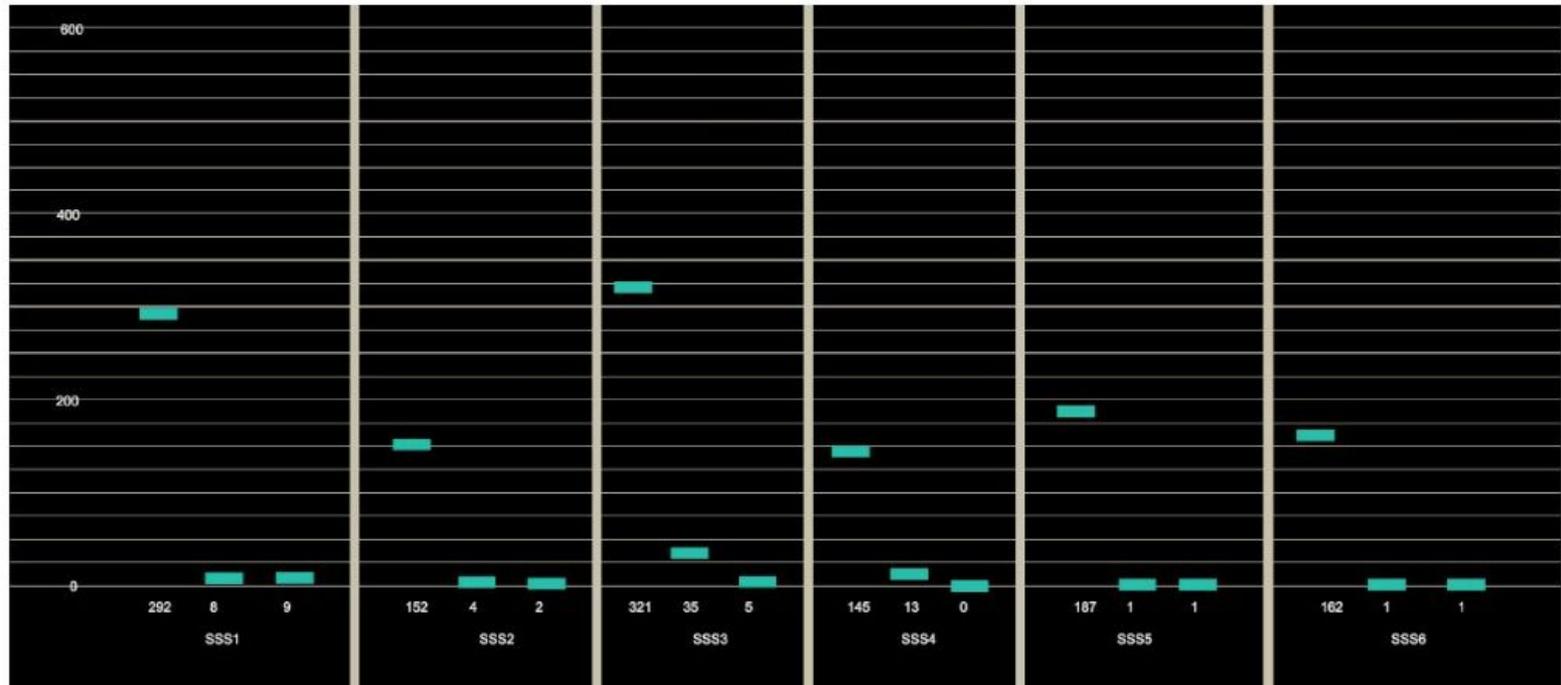


**Fig. 9. Bar graph visualization showing all 18 IR sensor values in real-time.**

# A Tour of Amatria and Her Children

Dendrites and Moths (2017)
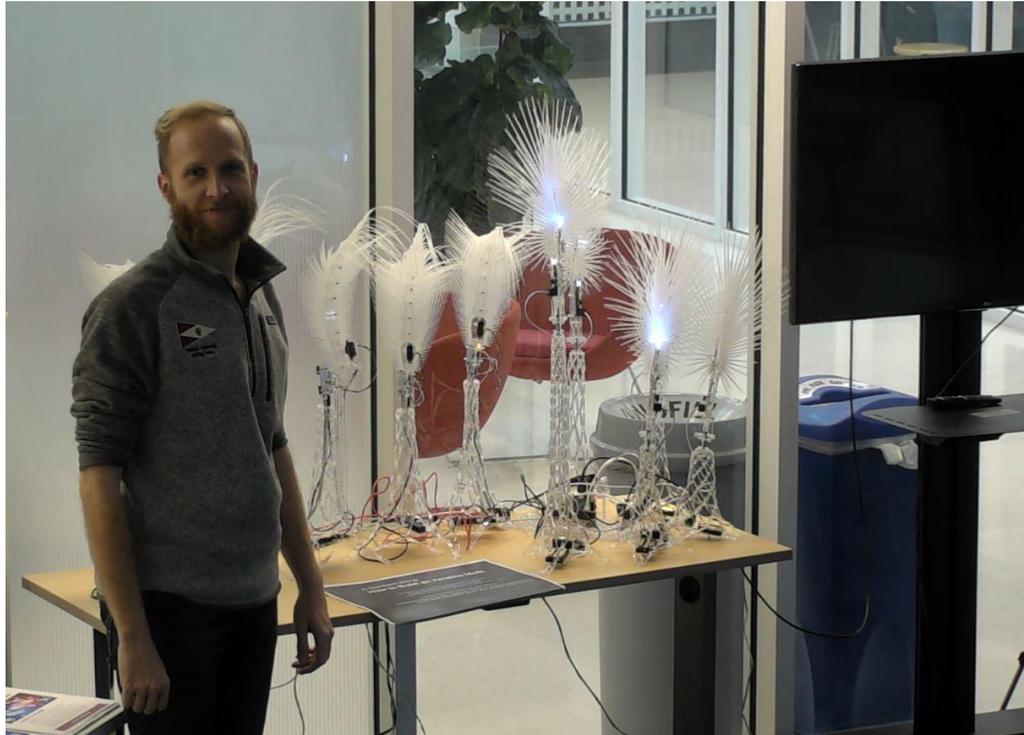
# DEMO TIME!

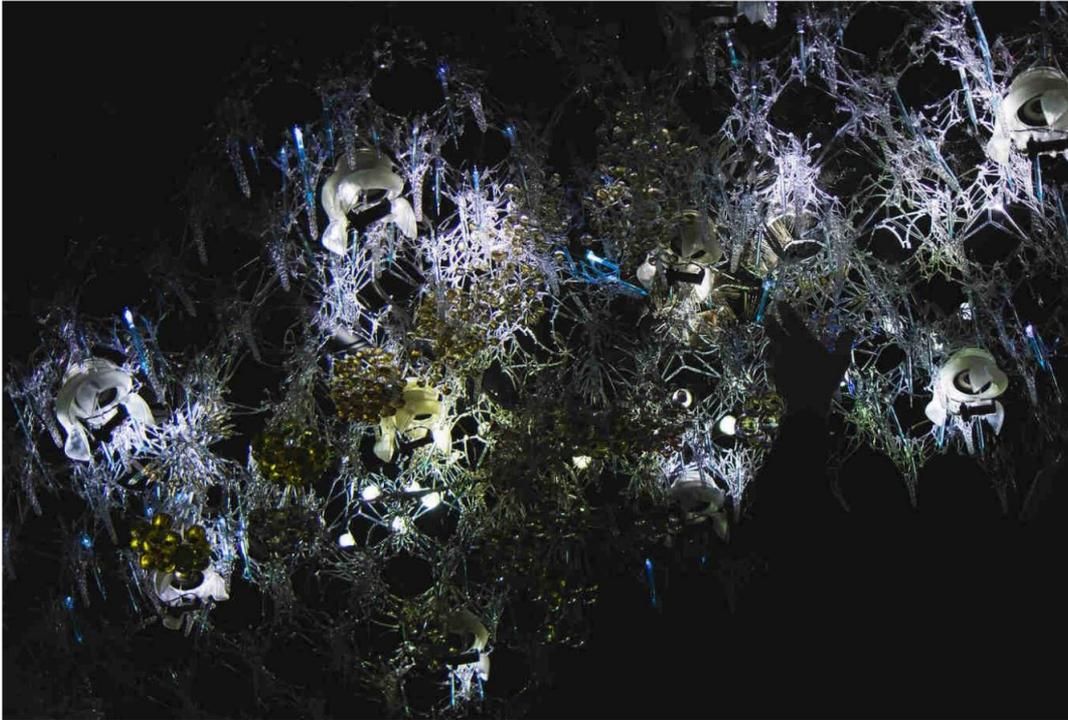# A Tour of Amatria and Her Children

## The Sentient Veil (2017)



Fig. 8. Wide-angle shot of the entire Sentient Veil sculpture as seen from below.

https://cns.iu.edu/docs/publications/2017-Lifting-the-Veil.pdf

# Andreas "Andi" Bueckle

## A Tour of Amatria and Her Children



*Future Technologies Conference (FTC) 2017*
*29-30 November 2017| Vancouver, Canada*

# Lifting the Veil
### Visualizing Sentient Architecture

**Andreas Bueckle**
Department of Information and Library Science
CNS, SICE, Indiana University Bloomington
Bloomington, IN (USA)
abueckle@indiana.edu

**Katy Börner**
Intelligent Systems Engineering
CNS, SICE, Indiana University Bloomington
Bloomington, IN (USA)
katy@indiana.edu

**Philip Beesley**
Living Architecture Systems Group
Philip Beesley Architect Inc.
Toronto, ON (Canada)
pbeesley@uwaterloo.ca

**Matthew Spremulli**
Living Architecture Systems Group
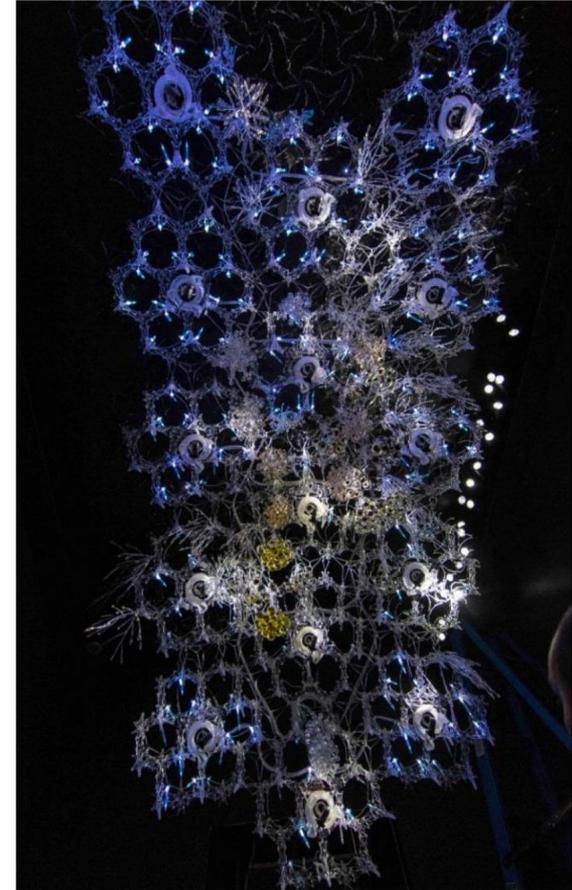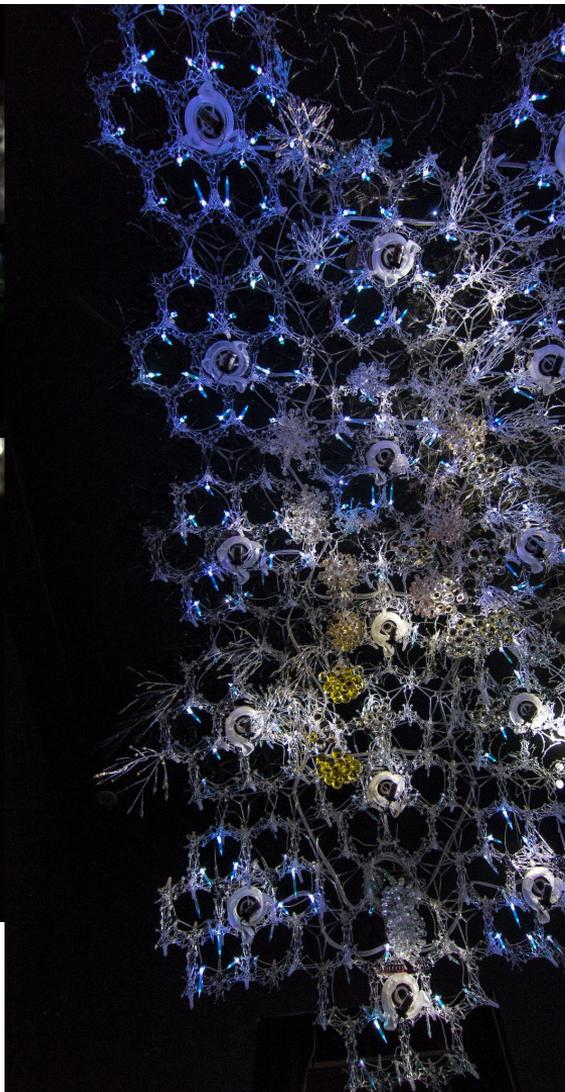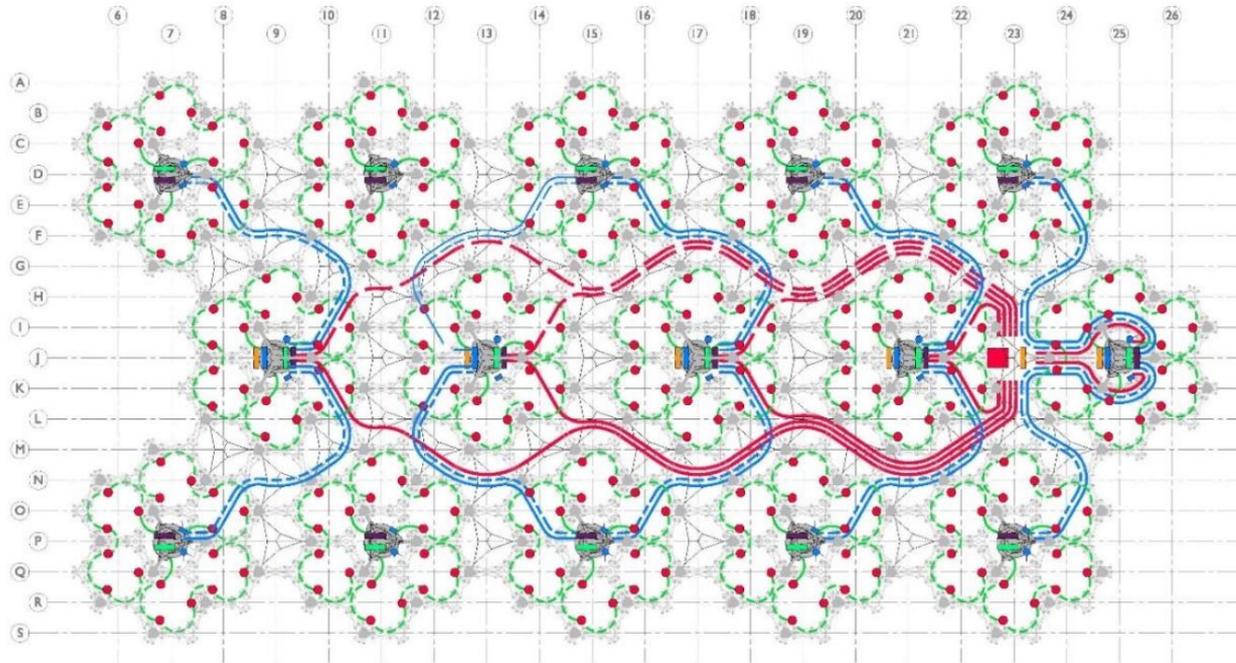Philip Beesley Architect Inc.
Toronto, ON (Canada)
mspremulli@lasg.ca

Fig. 1.   Sentient Veil at Isabella Stewart Gardner Museum, Boston (MA): the

| Rev | Descrip. | dd/mm/yy | By: | Check: |
|-----|----------|----------|-----|--------|
| 01 | DD Package | 08/01/17 | JP | |
| 02 | | | | |
| 03 | | | | |
| 04 | | | | |
| 05 | | | | |

Notes:

**PCBs**

- 🟥 Raspberry Pi 3.0 B
- ▌ 3.1 Control Node
- ▌ 3.1 Device Module
- ▌ Power Distribution board
- ▌ Mp3 Trigger board

**Interactive Devices**

- Sound Unit
- ● Light Module Cluster
- Short Range IR Proximity Sensor
- Short Range IR Proximity Sensor

**Mechanisms**

- Main Power Trunk
- Main Communications Trunk
- Node to Device Module Power
- Node to Device Module Communications
- Neo Pixel Chain

Project Name:
**1526 Gardner Museum**

Project Address:
Isabella Stewart Gardner Museum
25 Evans Way
Boston MA
02115

Status:
**Design Development**

Drawing Title:
**Overall Sculpture
Plan Interactive System**

Scale:
0    10    20

Sheet:

**B2**

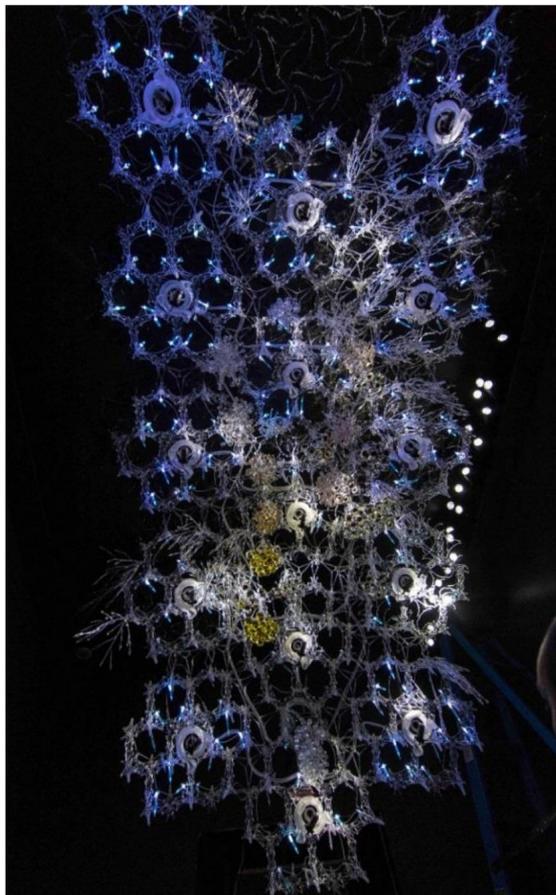Fig. 9.    A schematic drawing of the Sentient Veil.

Fig. 1.  Sentient Veil at Isabella Stewart Gardner Museum, Boston (MA): the sculpture as seen from the floor (see 3D model in Fig. 3 & 4).



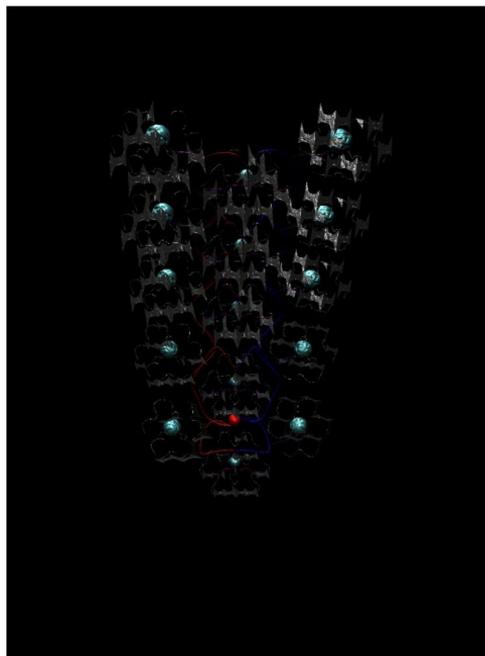Fig. 2.  Two speakers and two arrays of LEDs (so-called "cells").



Fig. 3.  *Lifting the Veil* in idle mode.

been added visually. For example, the Raspberry Pi is colored red, similar to a heart in a drawing of a human body. Also, note the blue and red colors of the communication and power cables (left and right, respectively).

*Dynamics* denotes the domain where the user sees the sculpture in action. Here, animations are played based on data input from the physical sculpture. *Dynamics* are invisible to the naked eye which is why this visualization project aims to illuminate these hidden processes. While actuation is perceivable by humans, current flows and data transmission are not. To implement this domain, simple animations are added to *Lifting the Veil* (see Fig. 3 and 4).
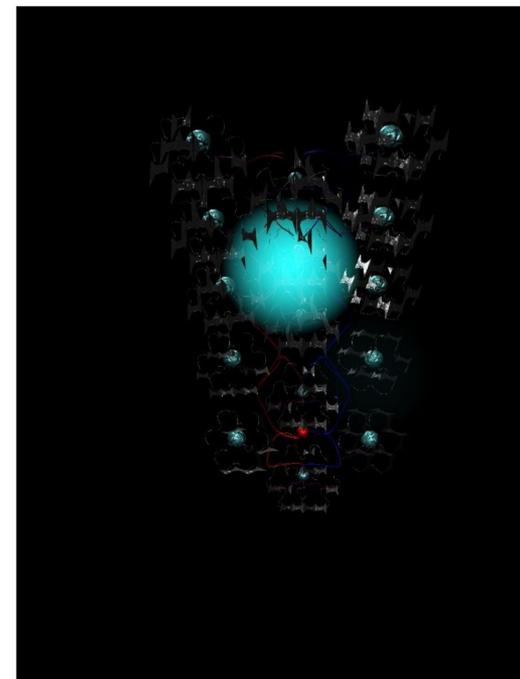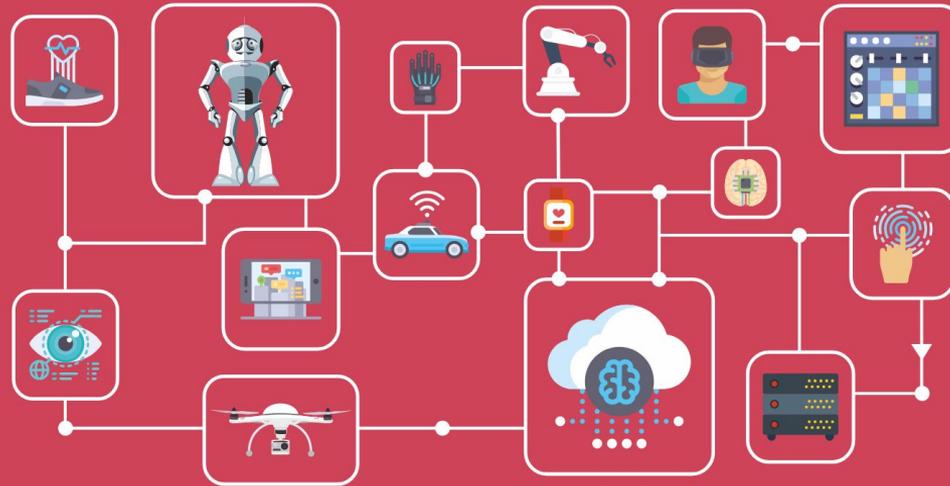


Fig. 4.  *Lifting the Veil* playing a triggered animation.

Finally, *state* denotes a domain that has not been

# Future Technologies Conference (FTC) 2017

November 29-30, 2017, Vancouver, Canada

#FTC2017

**CONFERENCE VENUE**

Pan Pacific Hotel Vancouver
Suite 300-999 Canada Place, Vancouver
British Columbia V6C 3B5, Canada

260 – Exploiting Chaos for Fun and Profit (Presenter: Tjeerd olde Scheper, United Kingdom)

290 – Iteratively-Reweighted Least-Squares Fitting of Support Vector Machines: A Majorization–Minimization Algorithm Approach (Presenter: Hien D. Nguyen, Australia)

358 – An Automated Avoidance Approach for Multiple General-Aviation Conflicts (Presenter: Yousra Almathami, United States)

426 – Leveraging Different Learning Rules in Hopfield Nets for Multiclass Classification (Presenter: Arti Arya, Pooja Agarwal, India)

481 – Lifting the Veil: Visualizing Sentient Architecture (Presenter: Andreas Bueckle, United States)

453 – A Randomized Heuristic Algorithm for Cyclic Routing of UAVs (Presenter: Shell Ying Huang, Singapore)

247 – Performance Monitoring of Centrifugal Compressor System using LSTM based Deep RNN (Presenter: Nataraj Paluri, India)

250 – Real-Time Control of a 2-DoF Helicopter Via Model Matching H□ Matrix Modulation Approach (Presenter: Jeevamma Jacob, India)

**7PM**

12AM in London (GMT), 9AM in Tokyo (GMT+9)

**Panel: Video Games and Intelligence**

**Moderator:** Andreas Bueckle, *Indiana University*

**Panelists:**

- Ted Castronova & Ivica Ivo Bukviz, *Indiana University*
- Chabane Maidi, *Tutemic*, *Dallas, Texas*

ENVISIONING INTELLIGENCES

Aurora Mititelu

# Open Discussion

- What is your favorite interaction mode with Amatria?

- Do you have any favorite children?

- Which of the songs, poems and other artworks designed for Amatria are your favorite?

- What brain or other UIs would you like to see in the future?

- Which visualizations to Amatria's hard-, soft-, and emotion-ware would you most like to design?

**24h Envisioning Intelligences**
event slides and video recordings:

Call for exhibit submissions:

https://scimaps.org/call-for-submissions

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