Visualizing Living Architecture: Augmented Reality Visualizations of Sensors, Actuators, and Signal Flows

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As the built environment becomes increasingly more complex and integrated with new technologies – including the emerging Internet of Things (IoT) – there is an urgent need to understand how embedded technologies affect the experience of individuals that inhabit these spaces and how these technologies can be most appropriately used to improve occupant experience, comfort, and well-being. In addition, the IoT provides an opportunity as well as a challenge when it comes to helping users understand how these intelligent systems gather and process information such as sensor data and internal feedback loops.

The Visualizing Living Architecture project aims to help system architects, designers, and general audiences understand the inner workings of tightly coupled sensor-actuator systems that interlink machine and human intelligence. It aims to empower many to master basic concepts related to the operation and design of complex dynamical systems and the IoT. Specifically, it uses architectural blue prints of living architecture installations together with real-time data streams to visualize the operation of Living Architecture installations (Figure 1). Created by the Living Architecture Systems Group at the University of Waterloo (Canada), these installations can move, respond, and learn; they grow themselves and are adaptive and empathic toward their inhabitants. Börner's team at Indiana University (USA) adds dynamic visualizations to the installations to help visitors, academics, and designers understand the many sensors and actuators used in the design of complex architectural systems, along with artificial intelligence processes rapidly being integrated into next generation architecture.

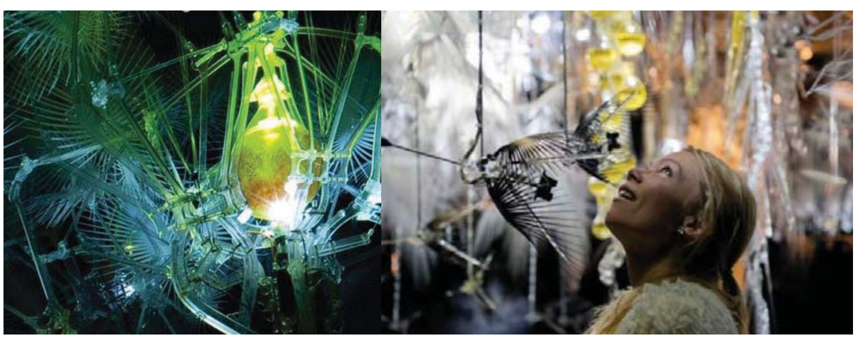

Figure 1 Details of LASG installation Epiphyte Grove as exhibited Trondheim, Norway (2012).

The visualizations detail how sensory system input (collected via movement, light, and sound sensors but also cameras) is processed by artificial intelligence control circuits and used to control an array of actuators (sound, light, movement) within the living architecture.

In the initial phase of the project, a Cyclops testbed was setup comprising one light sensor (the Cyclops' eye), three actuators, together with hardware and software required to position and drive the sensors/actuators.

The open-code Unity game development software is used to create augmented reality Visualizing Living Architecture applications (VLA app). The VLA app reads the three-dimensional CAD drawing of a Living Architecture installation, e.g., the Cyclops, together with real-time data streams recorded for this installation. The VLA app can be installed and run on laptops, smartphones, and other mobile devices. It geo-registers the Living Architecture by means of a predefined key image or three-dimensional shape then goes into a data visualization mode which visualizes sensor/actuator positions together with signal flows (Figure 2).

Initially, we are interested to answer the following questions: What visual metaphors work best for communicating different sensor and actuator types, positions, and activations? How can signal flows (type and speed) and processing (local and remote) best be communicated? Does speeding up and slowing down time help gaining a more holistic understanding of human-machine intelligence interaction patterns? What visualizations are helpful for experts aiming to optimize Living Architectures? What extensions, if any, are needed to the Visualization Framework (Börner & Polley, 2014, Börner, 2015) to cover these visualizations?

Future work will also aim to answer: What meaningful and qualitative human-machine interactions can be understood from data? How can we design informative and playful augmented-reality environments to engage untrained users with living architectures? How can we enhance data visualization literacy by exposing users to an intelligent system with the comfort and help of our app?

The research will provide a means to analyze and visualize the underlying dynamics within existing interactive architectures, to understand dynamics between space and people, and its larger social impact. The development of novel interfaces will in turn enable individuals, designers, and architects to modify architectural behaviour for greater agency and more meaningful interaction.

Figure 2 Augmented reality visualization of Cyclops sensor and actuator positions.

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