Digital Assemblies

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This paper examines how the intersection of real-time data and material assemblies provides novel opportunities to understand our built environment as a socially and ecologically constructed milieu. By integrating the Internet of Things (IoT) with brick-and-mortar buildings, we can create dynamic interfaces that leverage our material surroundings to contextualize a range of unseen information, such as where scholarship is being conducted, from which direction the wind blows, and what community members are posting. In framing buildings as not separate entities from growing online networks but inextricably connected to them, this investigation proposes a design methodology that blends computational design with construction methods to create interfaces that recursively integrate real-time information with the built environment, adding digital information as another material alongside concrete and wood in an expanding architectural palette.

By analyzing three design projects, this paper documents design methods that synthesize real-time data with material assemblies to provide an expanded reading of our built environment. The first is a gallery installation that locates live Wikipedia updates through an arrangement of fabric, light, and sound. The second is a digitally fabricated tea house that integrates temperature, humidity, and airflow data in the design of an interactive facade. The third is a public art project that connects one local ethnic enclave with others across the globe through the display of social media imagery in real-time. Through their interactivity and materiality, these projects seek to connect users more deeply with their surroundings, and in doing so, encourage an attitude of action, engagement, and empathy within our built environment.

INTRODUCTION

This paper asks the question, "how can the integration of real-time data with material assemblies provide novel opportunities to engage and interact with our built environment?" In a time where there is growing interest in online digital networks and assets–examples include the metaverse, non-fungible tokens (NFTs), and AI generated artwork–this investigation argues for the importance of tethering our discipline's emerging skills in computational design with our expertise in building and construction. As stewards of the built environment, contemporary issues facing our society such as climate change and social equity necessitate attention to the way we interact with our physical surroundings and one another. By leveraging our growing literacy with code along with emerging digital technologies, this paper proposes a design methodology that aligns our proficiency with digital tools with our field's historical relationship with materiality and space making. Through this synthesis of newfound techniques and disciplinary knowledge, these hybrid constructions that we term 'digital assemblies' can encourage new ways of interacting with buildings that offer an expanded understanding of our built environment.

The differences between digital and physical space have been well documented and is succinctly defined by Nicholas Negroponte's distinction between "bits" and "atoms."[1] Architecturally, this tension between the digital–characterized by its lack of scale and capacity to render information dynamically through movement and animation–and the physical–with its static materiality and tectonic adherence to gravity–has historically played out across its "kissable" surfaces and facades which Sylvia Lavin outlines as most suitable for interfacing with outside mediums.[2] Antoine Picon further articulates the "crisis of scale" and the "loss of relevance of structure as a guideline for design," as consequences of a shift towards computationally driven modes of production in which, "architectural form comes first and foremost with little regard for structural constraints."[3]

The development of the internet, advancements in computer programming, and the emergence of new technologies have combined to create opportunities for integrating code with the design of physical structures. While the architectural examples provided by Lavin are described as "impersonal," the incorporation of digital information in the design of material assemblies hold the potential of offering a deeper understanding of our built environment that is more than skin deep.[4] Casey

Figure 1. *Data Waltz* installation with LEDs showing live Wikipedia updates. Green pulses of light indicate an addition while red pulses indicate an article deletion. Their placement along the curves communicates the azimuth direction from which the edits originate. Photo by Mikey Tnasuttimonkol © Mikey Tnasuttimonkol, 2017

Reas, Chandler McWilliams, and Jeroen Barendse acknowledge this shift in stating, "code is rapidly moving outside the boundaries of the screen and is starting to control more aspects of the physical world."[5] Their argument that "code opens the possibility of [creating]…systems, environments, and entirely new modes of expression" frames computers no longer as isolated "tools" but rather "mediums" to be leveraged in the design of form.[6] Interactive architecture has embraced the overlap between computational design and the built environment and Michael Fox and Miles Kemp see novel opportunities to embed new forms of real-time information in architectural designs through software that can "actively seek out dynamic (live) content on the web and transmit this content to another type of program that manages an interactive process."[7] It is through this approach that digital assemblies take their cue in the design of feedback loops that encourage users to gain a greater understanding of the built environment through their interactions with their surroundings and each other.

The following is a series of projects by the authors that integrate real-time digital information in their design and functionality. Through their chronological presentation, this investigation seeks to reveal a reciprocal relationship in the development of their material and digital resolution.

DATA WALTZ

Data Waltz is a project that explores the cause-and-effect relationship between knowledge and our actions through the translation of real-time Wikipedia updates into light, sound, and fabric. Exhibited at the Woodbury University Hollywood Outpost (WUHO) Gallery in Los Angeles, the installation gives form to a wide spectrum of voices via mediums perceptible to the senses of sight, hearing, and touch.

Data Waltz is designed as a feedback loop for engaging Wikipedia live updates, allowing visitors to follow and produce content from their interactions with the gallery's physical environment. By inserting the human body into the conversations taking place online, individuals are able to experience this continuously updating encyclopedia through spatial terms. The interactive installation makes tangible the direction and volume of knowledge being produced in relation to WUHO

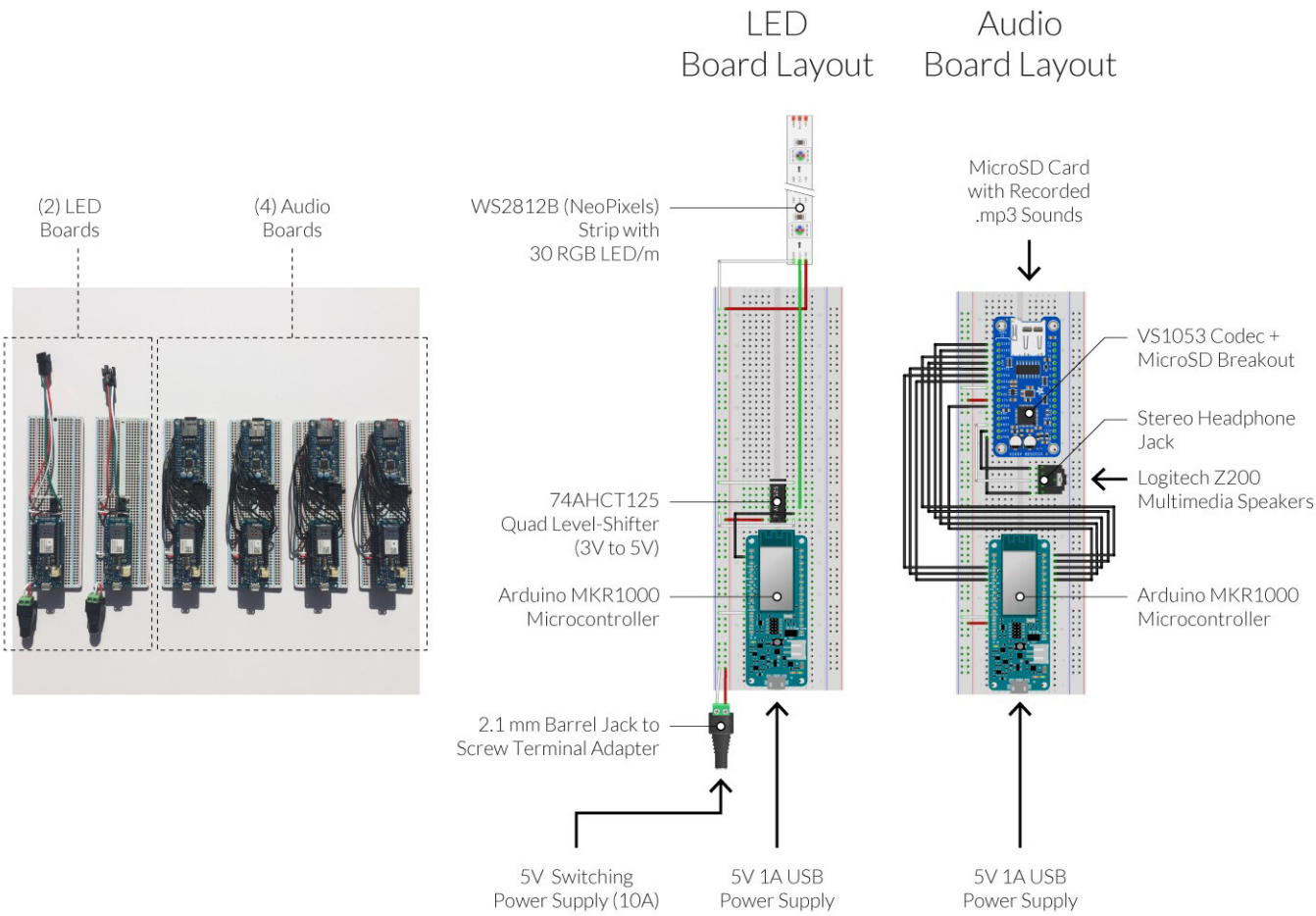

Figure 2. Installation diagram showing electrical component connections. Photo and diagram by authors.

to create an interface that allows participants to dance with dynamic bodies of knowledge.

Visitors are encouraged to create and edit content using web enabled devices within the space while simultaneously following the updates of others across the globe. Red, green, and white pulses of light indicate article edits, new articles, and locally based updates respectively. Pulses' width and location within the space correspond to the size and azimuth direction of updates taking place globally in relation to the gallery. Notes arranged on a pentatonic scale sonically communicate the size and type of Wikipedia event data, completing a composition of light and sound to engage with the site's tapestry of historical narratives and artifacts.

Data Waltz is an interface for two platforms that complement each other: the gallery–a physical space absent of content–and Wikipedia–an online community of contributors that exists online and lacks a physical presence. By integrating live updates in the design of the installation, visitors can become aware of both the north-south orientation of the gallery and contextualize the direction and volume of updates taking place across the globe. Furthermore, the project creates an interface for bringing conversations taking place online into physical space. In contrast to the growing number of Wikipedia edits done by automated 'bots,' Data Waltz leverages physical space to encourage visitors to discuss and debate article contributions face-to-face.

THE COLOR OF AIR

The second project, The Color of Air, is an interactive 84 square-foot tea house that allows visitors to understand and modulate thermal conditions within a space through their social interactions. Drawing upon Kathy Velikov and Geoffry Thün's The Stratus Project, an environment-responsive envelope system that attempts to "develop a dialogic method of inquiry and design based research" and "develop a model of collaboration that refuses to recognize or accept a split, in Latour's terms, between science and culture,"[8] this installation studies the thermodynamic principle that hot air rises through the epistemological framework of experience.[9] Four air inlets

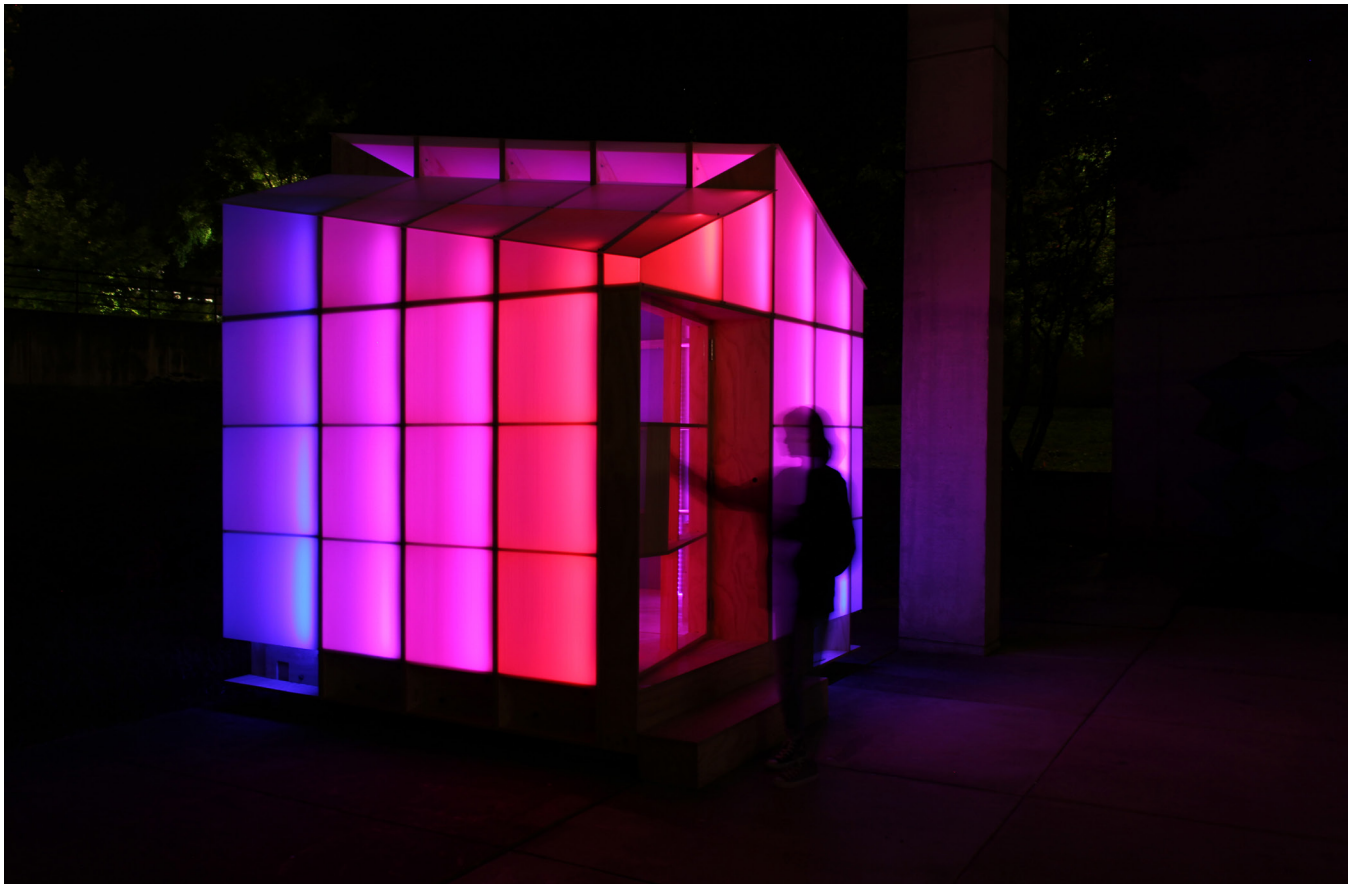

Figure 3. *The Color of Air* installation showing temperature variance between the interior and exterior, with red indicating a hotter interior and blue indicating a cooler interior. Photo by authors.

located at the corners of the floor and door and one outlet spanning the length of the roof ridge induce natural ventilation flows, creating a stack-effect within the space. Thermal sensors distributed throughout the space record changes in temperature, wind speed, and humidity, and movable furniture and an operable doorway create a system for modulating airflow through the interior. By observing changes in the project's dynamic lighting system and re-arranging the furniture and doorway, occupants can passively control their thermal comfort through their interactions with the space.

The project is designed as a feedback loop for understanding thermodynamic principles through an interface that makes tangible for visitors the temperature, wind speed, and humidity of the air around them. The installation's feedback system combines sensors, weather data, and addressable LED lights to communicate thermal conditions by comparing and contrasting building interiors with their exterior environment. Arduino MKR1000's are connected to AM2320 digital temperature and humidity sensors and Modern Device Rev C temperature and wind sensors to collect air data. Using C/C++ sketches, this information is compared to OpenWeatherMap JSON data. This comparison is then relayed to a series of WS2812B "NeoPixel" addressable LED light strips. In this three-step process, sensor data collected at the ventilation openings is measured in relation to the local weather and translated in the form of light. Using hue, saturation, and brightness to communicate differences in temperature, wind speed, and humidity respectively, the system creates a qualitative interface for understanding quantitative differences within the space. This playful digital installation creates a Post-Digital atmosphere for the project's inhabitants and spectators.

While the first installation dealt with abstract data in the form of encyclopedic information editing and transfer, this installation increases data's legibility as an architectural material assembly. Here the hues provide direct feedback for inhabitants and observers towards the thermal relationship between the interior and exterior environments. This feedback provides inhabitants with the agency to modulate their architectural environment, something not possible without the overlay of real-time data (from global networks and local sensors) onto the structure's physical materiality.

THE COLORS WE SHARE

The third project, The Colors We Share, is the winning proposal for a permanent public art installation that will be built in Los

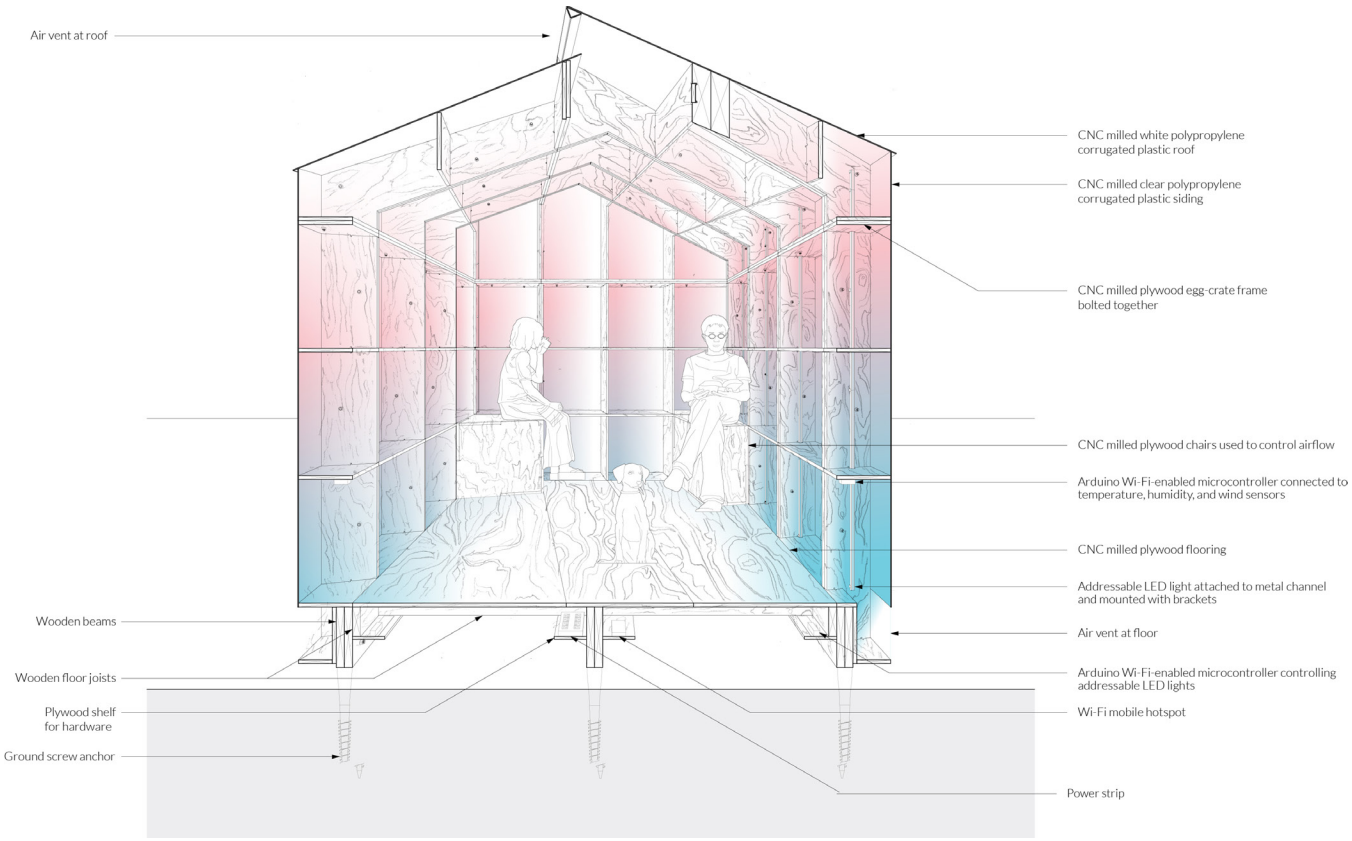

Figure 4. Section showing openings at the floor and along the roof ridge that induce natural ventilation flows within the space through a stack-effect. Drawing by authors.

Figure 5. *The Colors We Share* video still representing an image taken in proximity to the structure that is enlarged and projected through LEDs. Image by authors.

Angeles's Little Tokyo. In joint partnership with the Little Tokyo Service Center (LTSC), the installation honors the community's rich and multivalent history and celebrates the voices of its next generation through the display of archival and real-time social media imagery. This dynamic interface allows community members to see themselves in the structure and connect with others through locally, nationally, and internationally collected images. As a digital interface that draws upon Dana Cuff and Jennifer Wolch's Urban Humanities framework, this project identifies the field of interactive architecture as a potent instrument for creating novel public spaces through active community engagement.[10]

The project recognizes Little Tokyo as a central hub within a global network of Japanese diaspora and connects the local community with others across time and space through real-time data. Addressable LED light strips vertically mounted to the structure create a low-fidelity interactive display. Collected images are continually fed to the light strips, fading in and out to create a dynamic interface that overlays old memories and new. There are four concurrent feeds projected across the structure's skin.

The first and primary feed creates a connection with the community's history and cultural identity through images collected from its +LAB Takachizu archive. There are currently 154 documented artifacts, and images of these items will be displayed across the screen on a running loop.

The second feed creates a global connection with similar Nihonmachi through collected geolocated social media images. Algorithmically curated images are displayed on a section of the screen that corresponds to the azimuth direction from which the image originates, creating a connection with other communities in real-time.

The third feed allows the public to interact with the structure through the display of social media images taken in close proximity to the installation. This enables visitors to see their own interactions with the project reflected in the digital display.

The fourth feed brings awareness to current events in the community through the display of colors and images associated with programs—such as Nisei Week and Day of Remembrance—that take place locally within the area.

Continuing the trajectory established by the first two installations, The Colors We Share explores the relationship between real-time data and material assemblies at a larger scale. The integration of archival and social media images with the structure through a low-fidelity screen creates a public space for sharing. Situated at the corner of Alameda and 2nd Streets and on the edge of Little Tokyo and the Arts District, the project is designed to respond to both Los Angeles's automotive culture and the neighborhood's pedestrian-friendly context. While the first project had a window through which to engage the urban, this structure allows the digital assembly to project into the surrounding environment as a beacon along major thoroughfares.

CONCLUSION

This series of projects provides workflows and methods for making digital media tangible in a physical world. Our emergence from the global pandemic has highlighted the value of physical interactivity and engagement with the built environment. This physical connection need not be antithetical or inversely correlated with our increasing presence and engagement with digital space and systems. Instead of separating what is physical and what is digital, these projects demonstrate that digital data can be integrated into traditional architectural projects as just another type of assembly.

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