Liminal Mechanisms

Encoding and Biofabricating Architecture

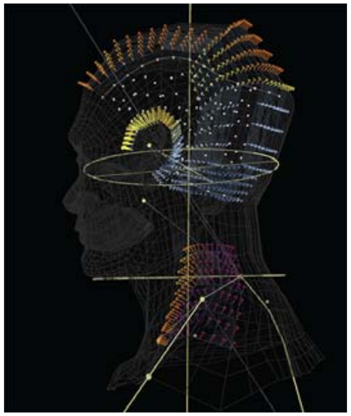

Figure 1: Digital drawing of body morphologies

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Overview
Several technologies are converging to drastically change local and global spatiotemporal relationships, including autonomous robotics, cyber-physical systems, ubiquitous sensing networks, and synthetic biological systems. These technologies provide architects and designers with opportunities to redefine models of human-machine-environment interactions that encompass more complex methods of simulated intelligence and nuanced response across a range of scales from the micro to the macro. This paper will present architectural design research into machinic instruments that emerge as morphological responses to biotic and abiotic phenomena at the interface of bodies and ecological systems across a variety of scales. This includes the design and production of a series of small scale wearable devices that operate as liminal mechanisms, creating a dynamic boundary between the body and the environment through the use of biometrics and environmental data. This conceptual framework for architecture as an extension of the body is achieved through the implementation of computational tools, sensing technologies, and biofabrication processes.

Author Keywords
Biofabrication; Biometrics; Cyber-Physical Systems; Physical Computing; Sensing; Synthetic Biology

ACM Classification Keywords
H.5.m.: Miscellaneous

Figure 4: Removing and drying the living tissues after a 3 week growth period in a static culture.

Computational Tools

Advances in Physical Computing and Cyber-Physical Systems (CPS) have significantly altered traditional methods of architectural design by enabling an evolved means of measuring, understanding, and organizing data from complex systems and networks. These platforms support the design of interactive systems that sense and respond to fluctuating biological and environmental conditions. As computational and sensing technologies are becoming ubiquitous and easier for the non-specialist to implement, individuals across the globe are appropriating these technologies to design highly responsive systems. [Figures 1 and 2].

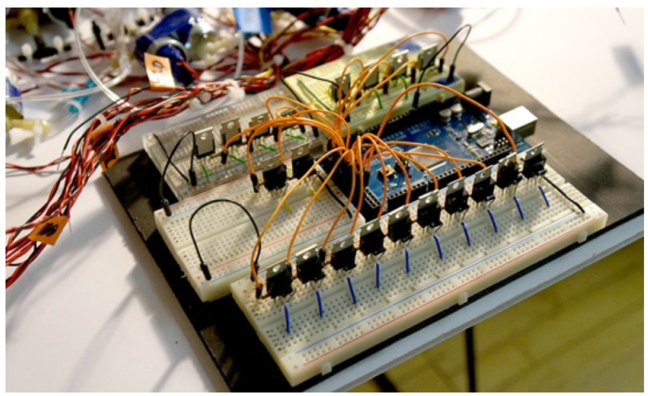

Figure 2: Physical computing and sensing platforms.

Sensing Technologies

This paper will present the potential architectural applications that utilize and integrate biometric data (heart rate, electro dermal activity, brain electrical activity) and atmospheric flows (temperature, light) in determining body-machine-environment relationships. In this scenario, inhabitants of buildings are not treated solely as users acting within a static built environment, but as stakeholders that hold agency, and act as catalysts for an architecture that can adapt to changing materials, environmental or ecological demands. These technologies alter our ability to imagine constructed systems in highly nuanced relationships between internal bodily signals and surrounding atmospheric data, requiring an expanded view of networked and object oriented relationships between bodies, designed devices, and regional and global environments. [Figure 3].

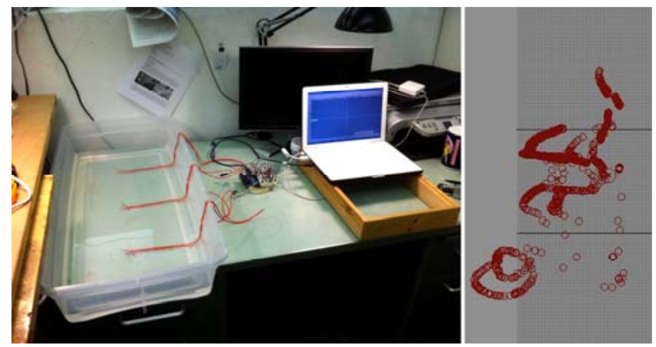

Figure 3: Use of sensors to detect subtle differences in glucose levels within fluids in which the data is output to visualize patterns.

Biofabrication Process

This research utilizes bacterial cellulose, as a means of growing biomaterials for architectural membranes. We experimented with the strains from *Acetobacter*, in particular *Acetobacter Xylinum* bacteria being the most common and efficient type to use for a series of experiments and material testing samples. This particular strain is used to make Kombucha tea. The ingredients necessary for biofabricating the bacterial cellulose, are available globally, however, regional and micro climatic conditions can potentially affect nuances in the growing process through the use of local resources available in the region. This provides opportunities to calibrate ecological systems and ecological feedback loops that reduce the waste of local resources. The spinning of cellulose is achieved through the fermentation process of bacteria, glucose, and oxygen within water.[1,2] Nanofibers of cellulose are spun by bacteria into layers, forming a mat on the surface of the water, which can be removed and dried to produce a translucent sheet of material. Synthetic biological process offer the potential to grow materials into specific forms and shapes for the biofabrication of architecture. [Figures 4 and 5].

Figure 5: Growth experiment using a perspex mould.

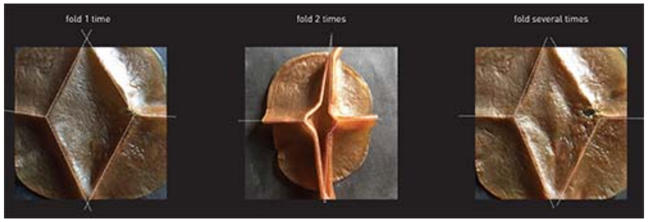

Figure 6: Folding, testing material affordances.

Envisioned Project

We present the first formal iteration of one body device where the main goal is to develop an understanding of the biomaterial first through principles, material production based on material properties and tests [Figures 6 and 9], and to develop criteria to make reasoned choices for the implementation of this particular kind of material in body devices. We have grown the material in a static environment [Figure 4] and with a perspex mould [3] [Figure 5] in iterations of three week growth and experimented with its affordances with the intent to identify intrinsic material properties, exploiting production forming logics for developing a 1:1 prototype detail assembly for ergonomic evaluation and testing [Figures 7 and 8].

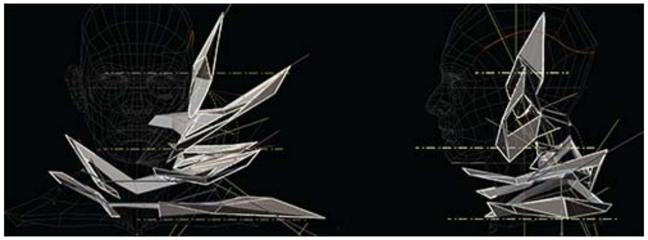

Figure 7: Digital formal studies for a body device

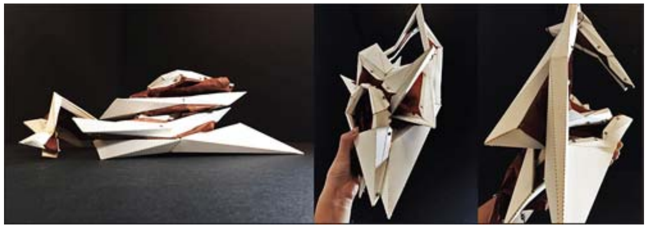

Figure 8: Mock up the device in cardboard and paper.

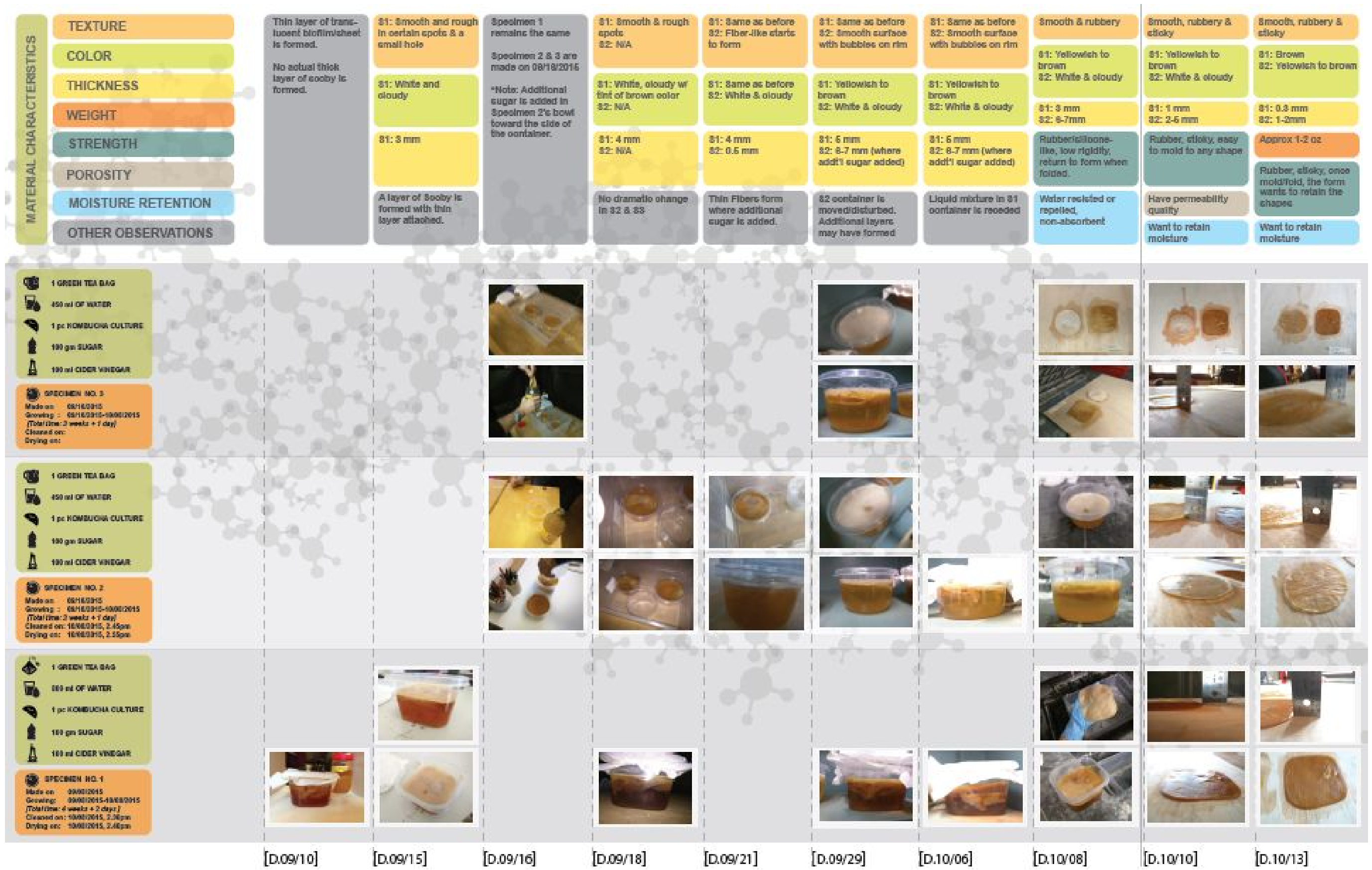

Figure 9: Documentation of material properties both during the growth and dried stages.

During the next stage we will be using the bacterial cellulose as the main material in the prototype. We will investigate a top down and bottom up strategy investigating ‘micro-turbulences’ within an architecture framework. We will establish a sensing platform to evaluate dynamic spatial performance against a set of environmental and biometric criteria. It is our hope to develop a series of bio-materialised extensions of the human body that sense and map both inner and outer flows – this new ‘field’ sets up the possibility of imagining different programmatic activities and, in the pushing of lines of force, an alternative basis for the previously established architecture built forms.

Acknowledgements

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References

1. Lee, Susan. “Grow Your Own Clothes”. Filmed March 2011. YouTube Video, 6:40. https://www.ted.com/talks/suzanne_lee_grow_your_own_clothes?language=en

2. Gama, M., Gatenholm P, Klemm, D. Edited (2013) Bacterial NanoCellulose: A Sophisticated Multifunctional Material, CRC Press.

3. Araya, Sergio, Ekaterina Zolotovsky, and Manuel Gidekel (2012) Living Architecture: Micro Performances of Bio Fabrication, In Physical Digitality: Proceedings of the 30th eCAADe Conference, 447-457. Vol. 2. eCAADe: Conferences 2. Prague, Czech Republic: Czech Technical University in Prague, Faculty of Architecture, 2012.