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PostCarbon

Assessing augmented reality for design-build education

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Augmented Reality (AR) has been used in Architecture, Engineering, and Construction (AEC) industry by offering digital overlays on top of the physical world. AR includes two categories of devices. The first is the head-mounted displays and glasses such as Hololens or Magic Leap. The second is hand-held devices such as mobile phones and tablets. AR brings virtual objects and data into the physical world rather than immersing the wearer in wholly virtual reality. For instance, Hololens actively maps the physical space in three dimensions using several types of cameras on the visor and uses this data to place virtual objects realistically within. Holographic virtual objects are superimposed within physical space using light reflected off a transparent lens into the eyes. Thus, the non-physical hologram cannot obscure the physical world, but they can be interacted with.

Over the past few years, AR has been used in the AEC industry for project planning and management, workforce training, BIM integration, and construction site inspection. The AR technology is becoming an 'ultimate display' that will allow us to explore, discover, evaluate, and improve our design. (Tang, 2018) [1] This research focuses on assessing Microsoft HoloLens AR for design-build education, specifically using AR to assist the physical model making. Students were empowered to consider using AR to help various responsibilities architects, engineers, and builders provided in practice. This pedagogical method actively questions where the "translation between immaterial and material can be learned from both architects and builders." (Tang, 2021) [2]

We taught how to use AR to enhance both small-scale and full-scale architecture installations through several design-build courses. With the emergence of digital modeling and fabrication technologies, a growing obsession with digital formalism is more evident in the new generation of students. This tech-heavy process often results in increasing complexity of 3D form. However, digital technology is usually being harvested as a tool to create unique formal complexities but has little ground in the traditional build process. Renzo Piano adds that "An architect must be a craftsman… someone who does not separate the work of the mind from the work of the hand" (Piano 1992). [3] "Craft" is associated with materials and tools and is traditionally understood as making with physical materials. We define and explore the nature of craftsmanship or builders' role in today's digital, analog or hybrid environments, including AR technology.

The team has implemented the AR through Fologram App in Hololens and Grasshopper-driven UI. The AR interface allows image tagging and hand gestures to interact with the virtual objects. The focus is on whether the AR can help the designer achieve accuracy during the "making" process. The team experimented with installations that investigated AR to assist the small-scale and full-scale construction processes. Joint, material and new assembly methods were examined while utilizing Microsoft HoloLens. Precedent research was conducted to compare and understand relations between hologram and other mobile-phone-based AR methods to gauge their impact on the AEC industry.

1. Large Scale project. AR for project planning and management
In this project, several full-scale wood frame installations were constructed without AR. The AR model is used for students to test veracious "decorating" schemes using various materials and assembling methods. The AR model provided an onsite visualization for the designers to evaluate how their proposed add-ons will affect the spatial experience. Then the selected proposal is fabricated and installed. AR helped to pinpoint the joint position during construction.

The following three small-scale projects experimented with AR to augment the build process. "We must not separate the work of the mind from the work of the hand." (Tang, 2016) [4]. Specifically, the following projects are trying to find a new augmented build process essential for architecture students and construction workers in the AEC industry.

2. AR for assembling work
AR is used to augment the "assembling" process in this project. AR provides visuals for a complex spatial frame structure. The 3D coordination of each frame is rendered in Hololens. Students use a hot-glue gun to weld all the frames following the holographic reference.

3. AR for cutting work
In this project, an image tag is attached to a hot-wire foam cutter to provide real-time anchoring for Hololens. A cutting guideline is provided through AR to the sculptor to control the angle of each cut. A digital sculpture is rendered in Hololens to provide sections and the normal direction of each surface.

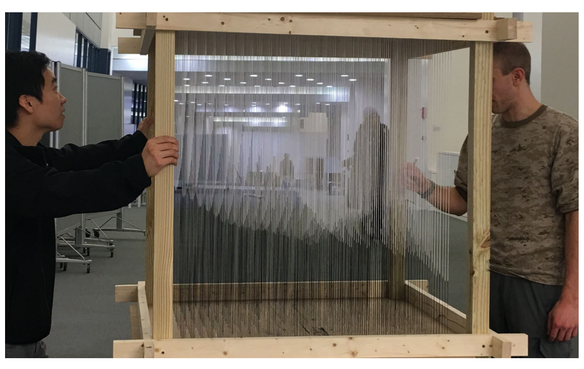
4. AR for marking work
The installation includes hundreds of wool threads stretched in 3D space in this project. The challenge for students is to paint black ink to cover a section of every single thread. The goal is to create an optical illusion of a continuous 3D surface. A 3D holographic surface is rendered in Hololens to provide the anchor points for black ink for every thread. Students then painted the yarns with accuracy rapidly.

Conclusion
If there is a line between the physical world and the virtual world, that line has been blurred today with the emergence of AR. Perhaps, as David Pye suggested that the "workmanship of certainty" is an automated process where the result is predetermined before a single salable thing is made (Pye 1995). [5]. These AR approaches demonstrated the convergence of digital and analog methodologies influenced by these new build strategies. The new approach of the design-build process received much positive feedback from students. It would be a challenging task if we did not have AR-based 3D anchors, spatial mapping, and holographic overlay methods. However, these processes need a comprehensive understanding of the new build process and a customized UI to facilitate, requiring architects, builders, and AR developers to work as a team.

Reference

[1] Tang, M. Architectural visualization in the age of mixed reality. Journal inForma. 11. Autumn 2018.
[2] Tang, M. Hu, Y., Hamaker, W., Mitchell, E. Architectural Interventions. Design-build collaboration on a global scale. UC Press. 2021. ISBN: 978-1-947603-14-1
[3]Piano, Renzo. Renzo Piano Building Workshop: in Search of a Balance. Tokyo: Process Architecture, 1992.
[4]Tang, M., Jordan, T. Digital Craft: New Mix of Process, Tools, and Material.Blur: d3:dialog, international journal of architecture + design. published by d3. 06. 2016
[5]. Pye, David. The nature and art of workmanship. 2nd ed. München: Herbert, 1995.


Project 1. Hololens overlay



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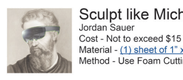
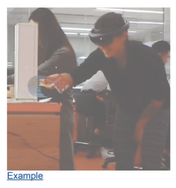
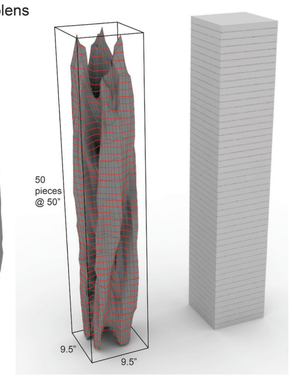
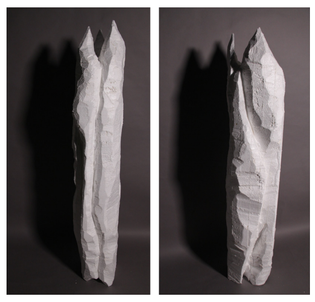

Sculpt like Michelangelo with Hololens
Jordan Sauer
Cost - Not to exceed $15
Material - (1) sheet of 1" x 4' x 8' Insulating Sheathing
Method - Use Foam Cutting Pen and Hololens


Example


Front

Side





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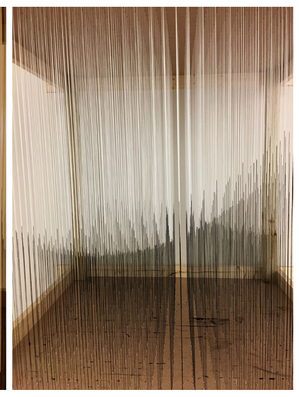
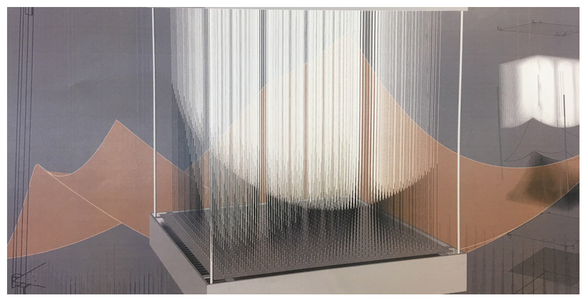
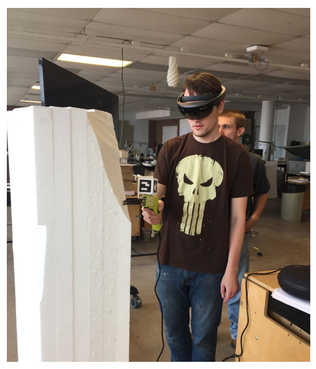
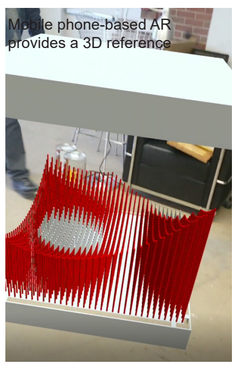
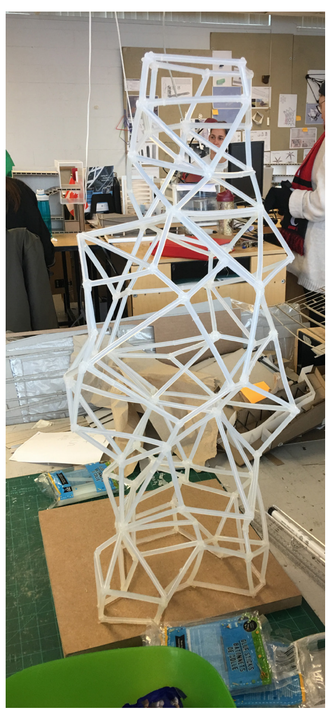


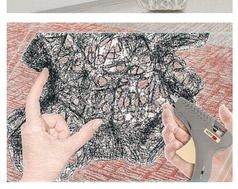


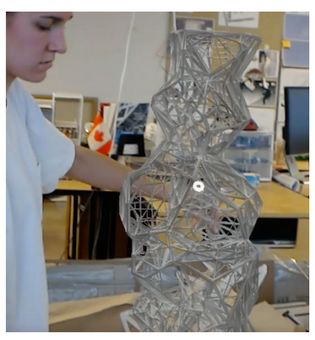

A digital hot-wire cutter is visible through Hololens and cast video on the TV.

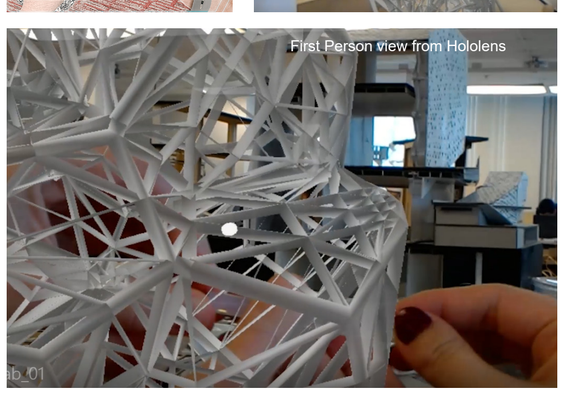



Mobile phone-based AR provides a 3D reference










Tracker images are used to send the real-time position of the physical cutter into Hololens.