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Computational, Human, and Material Modalities: An Augmented Reality Workflow for Building form Found Textile Structures

Authors : James Forren

Abstract : This research paper details a recent demonstrator project in which digital form found textile structures were built by human craftspersons wearing augmented reality (AR) head-worn displays (HWDs). The project utilized a wet-state natural fiber / cementitious matrix composite to generate minimal bending shapes in tension which, when cured and rotated, performed as minimal-bending compression members. The significance of the project is that it synthesizes computational structural simulations with visually guided handcraft production. Computational and physical form-finding methods with textiles are well characterized in the development of architectural form. One difficulty, however, is physically building computer simulations: often requiring complicated digital fabrication workflows. However, AR HWDs have been used to build a complex digital form from bricks, wood, plastic, and steel without digital fabrication devices. These projects utilize, instead, the tacit knowledge motor schema of the human craftsperson. Computational simulations offer unprecedented speed and performance in solving complex structural problems. Human craftspersons possess highly efficient complex spatial reasoning motor schemas. And textiles offer efficient form-generating possibilities for individual structural members and overall structural forms. This project proposes that the synthesis of these three modalities of structural problem-solving – computational, human, and material - may not only develop efficient structural form but offer further creative potentialities when the respective intelligence of each modality is productively leveraged. The project methodology pertains to its three modalities of production: 1) computational, 2) human, and 3) material. A proprietary three-dimensional graphic statics simulator generated a three-legged arch as a wireframe model. This wireframe was discretized into nine modules, three modules per leg. Each module was modeled as a woven matrix of one-inch diameter chords. And each woven matrix was transmitted to a holographic engine running on HWDs. Craftspersons wearing the HWDs then wove wet cementitious chords within a simple falsework frame to match the minimal bending form displayed in front of them. Once the woven components cured, they were demounted from the frame. The components were then assembled into a full structure using the holographically displayed computational model as a guide. The assembled structure was approximately eighteen feet in diameter and ten feet in height and matched the holographic model to under an inch of tolerance. The construction validated the computational simulation of the minimal bending form as it was dimensionally stable for a ten-day period, after which it was disassembled. The demonstrator illustrated the facility with which computationally derived, a structurally stable form could be achieved by the holographically guided, complex three-dimensional motor schema of the human craftsperson. However, the workflow traveled unidirectionally from computer to human to material: failing to fully leverage the intelligence of each modality. Subsequent research – a workshop testing human interaction with a physics engine simulation of string networks; and research on the use of HWDs to capture hand gestures in weaving seeks to develop further interactivity with rope and chord towards a bi-directional workflow within full-scale building environments.

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