AUGMENTING REALITY FOR AUGMENTED REALITY

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There are two competing narratives for the future of computationally augmented spaces. On the one hand, we have the Internet of Things [1], where the narrative is one of making our environments more aware of us and of themselves, and generally making everything “smarter” through embedded computation, sensing, and actuation. On the other hand, we have current approaches to augmented or mixed reality, in which the space remains unchanged and instead we hack our perception of the space by superimposing a layer of media between us and the world [2,3]. In this article we present examples of three projects that seek to merge these two approaches by creating and fabricating playful material elements that can be integrated with camera-based AR systems but that are independently meaningful objects in their own right. We argue that this new wave of physically grounded AR technologies constitutes the first steps toward a hybridized digital/physical future that can transform our world.

AUGMENTED AND MIXED REALITY

The technology space of augmented reality (AR), sometimes characterized using the more general term mixed reality, is one of the more exciting frontiers to emerge from HCI research in recent years [3]. However, like many frontiers, it is chaotic, overhyped, and misunderstood. In the absence of existing best practices to guide development of this new design space, a number of competing visions have taken hold, each of which seeks to colonize the future of our digitally augmented world. Microsoft’s version of this future is embodied by the HoloLens, an untethered standalone visor running Windows 10 that superimposes translucent “holographic” overlays into the center of a user’s field of view. HoloLens feels like the big brother to Google’s Glass project, which traded computing power and graphical fidelity for mobility. Glass was designed to be worn in daily life, a decision that didn’t factor in the social consequences of wearing a highly visible digital surveillance...
A parallel track of research on computationally augmented environments is the Internet of Things (IoT). The IoT focuses on enhancing the physical world with technology, allowing objects and systems to communicate with one another and with user-accessible display terminals [1]. The focus of the IoT is typically on tagging, tracking, and automating everyday objects and processes. The idea of the IoT has remained fundamentally connected to infrastructures for sensing, automating, and data processing. Most future visions of the IoT imagine a world where every physical object (and all of its associated data) has a digital presence and can connect with other objects.

However, this vision often does not contain details on how people actually understand and use the augmented objects, or how to incorporate the meaning of things into the Internet of Things. This is best exemplified by products like Belkin’s WeMo line of home automation devices that include so-called smart power outlets, smart light bulbs, smart coffee makers, smart humidifiers, smart home surveillance security cameras, and many more smart devices for your hyper-intelligent home. This vision of the smart home that IoT applications enable hasn’t evolved much from the 1950s vision of the future of automation, domestic robots, and technological convenience for the modern home.
We designed Phylactery to explore the possibility space for an Internet of Meaningful Things. It is technologically simple: A laser-cut wooden altar contains an RFID reader, a Raspberry Pi, and a pair of speakers. A connected microphone is activated whenever a tagged object is placed on the altar, allowing a user to narrate a memory or story about the object. Subsequent interactions allow the user to replay the stories associated with objects.

**Terraform** is a civilization-building strategy game that uses 3D-printed objects, the printer bed, and AR to explore the playful use of personal fabrication technology (Figure 2). In Terraform, the player takes on the role of an AI system, offering advice and guidance to a collection of simulated colonists on a distant planet. Using a tablet PC, the player selects the priorities the colonists should address, and in response the game produces “facilities” using the 3D printer as a “construction bay.” Each facility includes a 3D-printed fiducial marker as its base, so it can be tracked, registered, and augmented by an AR system incorporated into the game engine. This allows us to combine game-state information, interface elements, and special effects with the physical printed objects.

In **Laryngoscopy AR**, distance-education paramedics students use an augmented-reality app combined with 3D-printed instruments to practice foreign-body removal with a laryngoscope and forceps as a skill prior to attending the compulsory residential school. The project stems from a need for more opportunity for distance students to practice skills that otherwise can be practiced only in a five-day, hands-on residential school. Students were provided with traditional 2D images and 3D-printed instruments, a mobile phone with an AR/VR simulation application, and a tutorial video to practice with prior to the residential session (Figure 3). To assist in immersion and accuracy, the 3D-printed laryngoscope was a 1:1 scale replication of actual physical tools that could be tracked and simulated virtually. The aim of the simulation is to follow the steps required to insert...
the laryngoscope correctly and then use the forceps to remove a foreign body lodged in the patient’s throat, with cues provided during the simulation to indicate whether the procedure has been successful.

**CONCLUSION**

There are several themes that cut across these three examples. First, they all rely upon the current generation of fabrication technology to create material components for digital/physical hybrid systems that are specifically designed to be meaningful in the absence of AR information while affording easy digital augmentation. The materiality that they participate in is significant even without an AR overlay, but part of this significance is the extent to which they are clearly intended to be digitally augmented. These objects exist as points on a continuum that cycles between the physical and digital representations. Each prototype described here started life as a digital model, and so even after being fabricated it remains legible to digital systems as an instantiation of a set of digital instructions. By existing in both physical and computational spaces, these systems highlight the ways in which the physical world is already a substrate for information manipulation, and the ways in which AR technology can benefit from being situated in a context that is designed to be computationally tractable.

**Endnotes**


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Figure 3. Steps to perform laryngoscopy for foreign-body removal, shown with a traditional 2D image and the mixed-reality visualization using 3D-printed objects and an AR/VR application.