The Real-Time Section: Augmented Construction and Representation

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Keywords: Representation, BIM, Augmented Reality, Simulation, Phenomenal Transparency, Construction Sites.

Technologies guiding building production introduce architectural techniques of vision. Beyond changes in the management of design and construction, BIM, integrated with new hardware such as augmented reality devices, produces new forms of perception and visualization. These shifts in the social-visual order of architectural production are abundant. They can be seen in promotional videos for augmented reality headsets as well as architectural schools and offices. An analysis of images and videos made with augmented reality hardware (integrated with BIM) suggests ways that architects can relate emerging construction technologies to aesthetic and disciplinary forms of knowledge, connecting historical conceptions of representation and abstraction to emerging modes of practice.

Rather than relegate technologies of modeling, managing, and visualizing to presentations and construction administration, this paper examines the way these technologies transform spatial perception, pedagogical methods, and ideologies of representation. With the ubiquitous use of computational imaging technologies and modeling software, the 'drawing' as the site of design has been dramatically altered. Section has been tethered to certain ways of working on, understanding, and abstracting architecture. The x-ray, panorama, and information rich environments suggested by recent visual hardware require an addendum to the section drawing as a medium tethered to the social and spatial characteristics of buildings.

These techniques of vision also find historical affinities with spatial vocabulary such as phenomenal transparency. The spatial superimposition, simultaneity, and 'space-time' established by Rowe and Slutzky in part presage the optical qualities of augmented construction sites. Computational image environments put forth a version of real-time transparency. Bringing new techniques of vision into the discourse around section is a means to build a foundation for examining their effects and impact. It suggests that these techniques both build on historical formats of representation and are fundamental to new modes of understanding architecture.

INTRODUCTION

Technologies developed for industrial purposes and construction often introduce architectural techniques of vision, representation, and new disciplinary conventions. Despite the historical separation of drawing and building, the constraints and protocols of materialization continue to guide architectural methodologies of abstraction. Beyond shaping the instruments, methods, and techniques of practice, computational environments have become a major shaper of knowledge practices and pedagogies that software programs demand of users.[1] Over the past couple decades, few technologies have had as pervasive an impact as Building Information Modeling (BIM). This impact is not relegated to design implementation and construction administration. BIM has transformed the epistemology of design, its socio-technical order, and the drawing-centered process of project documentation at the core of studio-based architectural education.[2]

While much discursive attention has been devoted to BIM's managerial restructuring—closing the gap between design and construction—this paper examines a particular form of visualization tethered to information-rich models in the form of augmented reality hardware. Much as novel systems of materialization inform the conditions of architectural abstraction, new techniques of vision have radical implications for disciplinary practices around spatial perception and representation. An analysis of four images rendering the experience of BIM-integrated augmented reality produces a visual vocabulary to situate these forms of vision within historical and contemporary criteria, including a rethinking of the role of the section drawing. The analysis focuses attention on the shifting boundary between representation and visualization, suggesting ways to connect historical theoretical models to emerging modes of practice.

AUGMENTED REALITY AND BIM

Augmented reality hardware and their integration with BIM brings together two distinct technological regimes with their own social propositions, forms of visuality, and growing bodies of theorization. With mostly distinct trajectories until the past decade, the roots of their historical development are relatively contemporaneous. Ivan Sutherland, widely known for Sketchpad, a prototype for computerized interactive representation, subsequently designed what has been identified as the first augmented reality interface in 1968. The 'Sword of Damocles' overlaid binocular video with wireframe computer graphics in order to co-register a virtual environment with architectonic space.[3] Despite intermittent projects in the following decades, augmented reality in roughly its current conception wasn't introduced until the 1990s. The term itself, 'augmented reality', was introduced by an engineer at Boeing,

Figure 1. Image One. Trimble Civil Engineering and Construction, “Microsoft HoloLens: Partner Spotlight with Trimble,” video uploaded April 29, 2015, 1:48, https://www.youtube.com/watch?v=sgFYl_JdWR0.

Thomas Caudell, who in 1990 developed a headset for training purposes in the manufacturing of aircraft.[4]

Augmented reality (AR) includes the projection of digital assets over physical surroundings in real time. Unlike virtual reality, in which the field of vision is entirely replaced, AR juxtaposes paramount reality[5] with digitally generated imagery. Technical definitions of AR focus on the inclusion of four main components: hardware (including a processor), displays (monitors, headsets, and/or glasses), sensors (gps, accelerometers, gyroscopes, etc.), and software (various programs running on hardware and incorporating sensor feedback).[6] AR does not reflect a specific augmentation of vision or other senses. Its interfaces operate along the reality-virtuality continuum,[7] possible compositions of real and virtual objects. AR builds on the idea of computer graphics outlined by Friedrich Kittler “as an illusory discontinuity or continuity”[8] by merging digital ‘illusion’ and surrounding views. The incorporation of AR in architecture more broadly comes as no surprise given its sitedness at precisely the juncture of physical and virtual that is an increasing architectural concern. “In connection with the rise of digital culture, [the architects’] main contribution may very well lie in the domain of augmented reality, that is, dealing with the interface between the physical and the virtual, rather than focusing almost exclusively on the latter.”[9] While in this case Antoine Picon uses ‘augmented reality’ in an expanded sense of the term, it is exactly its metaphorical portability that suggests the allure of AR within a disciplinary trajectory.

In a technical sense, BIM perhaps needs no definition. Its operating procedures—placing a digital model at the center of design coordination—connect real-time digital labor with vast repositories of information, material simulation, and codified knowledge. It is worth noting however that architectural discourse around BIM continues to document the effect of managerial and construction-based technology on architectural education and design practices. Moving beyond technological positivism that deals with BIM as a frictionless solution to AEC problems, it is evident that the use of BIM introduces new politics to design production,[10] redefines the nature of architectural authorship,[11] and is embedded with stereotypically “straight” ideologies.[12] As the demand for training around BIM platforms has entered studio-based design education, the constructability-centered characteristics of information modeling platforms has changed the form of architectural outputs. These changes have occurred not only in more common drawing formats (plan, section, elevation, perspective), but have elevated mechanical, electrical, and plumbing (MEP) visualization to the status of reified representation. NL Architects’ BIM output for the Groninger Forum, published as “BIM is Beautiful” is included in works sold by the firm’s gallerist.[13] London’s Royal Academy show of 2017 titled “Architecture as in ‘Instruction-Based’ Art”, curated by Farshid Moussavi, included BIM coordination drawings from various firms.[14] Examples of the effect of BIM platforms on practice and pedagogy are ubiquitous. It is in the particular combination of BIM and augmented reality that this analysis moves from the general to the specific to focus on ways that these technologies pose questions to spatial perception, visualization, representation, and a shifting relationship between these categories.

REAL-TIME PROJECTIONS

A description of four images related to BIM-integrated augmented reality establishes a visual vocabulary of this emerging, and often speculative technology. Analysis of these images provides a constrained site for investigation and suggests a methodology for connecting historical notions of representation to techniques of vision developing in the building industry.

Figure 2. Image Two. Daqri, "DAQRI Smart Helmet Case Study: Mortenson and Autodesk," video uploaded November 15, 2016, 2:12, https://www.youtube.com/watch?v=U9t6Osl1Lbc.

These images share a number of attributes. They are each video stills selected from online videos demonstrating the use of augmented reality headsets on construction sites. Each image includes an overlay of digital models onto images of physical space. They are also all proprietary to varying degrees. While some images are taken from videos specifically produced by the maker of the augmented reality product, others are made by journalists featuring the benefits of specific products. The reason for selecting these particular images is their ubiquitous dissemination. They constitute a sample of popular representations of augmented reality implemented on construction sites. These videos are the primary means through which a public audience has access to the techniques of vision rendered visible by this developing technology. Rather than endorsements for particular products, they are collected in the spirit of Bernard Tschumi's Advertisements for Architecture. The format of the advertisement for Tschumi was a means of "confronting the dissociation between the immediacy of spatial experience and the analytical definition of theoretical concepts."[15] Similarly, the proprietary video stills capture the phenomenology of augmented reality BIM displays, establishing a vocabulary for analysis and discussion.

In Image One, two subjects interact in the partially-framed interior of a construction site. A digital model is overlaid on the view with both noticeably-rendered elements in blue and green and more photo-realistically material-mapped elements in the background. The on-site person is wearing a yellow safety vest and an augmented reality headset. The second person is rendered as a featureless blue avatar identified as "Igor" by a hovering nametag. Both figures' eyesight is directed at the rendered green column in front of which is a "Transition Issue" tag reading, "I'm worried about the transition between the old and new building annex." A pair of ladders, seemingly part of the physical scene, lean against a wall, partially obscured by the blue rendering of the digitally-overlaid wall.

This image makes clear a few significant aspects of BIM-integrated augmented reality. In the first instance, it presents an example of how technology and construction companies, in this case Hololens and Trimble, envision the implementation of augmented instruments in construction. The headsets facilitate coordination between people in an office and those on site through an overlay of the centrally-shared digital model. Secondly, the production quality of the image entails an intense blurring of the distinction between physical space and rendered imagery. The seemingly real foreground merges with the semi-transparent blue wall across a gradient of opacity, blending the two together in front of a photorealistic yet rendered background approaching the uncanny valley. This staged interaction presents a scenario in which spatial perception and real world actions may be altered by digital overlays. In a study of the effects of augmented reality, Stanford researchers found that after people experienced augmented reality their interactions in the physical environment changed as well (even after removing AR devices).[16] People in the study avoided sitting

Figure 3. Image Three. Elizabeth Woyke, "Augmented Reality Could Speed Up Construction Projects," MIT Technology Review, August 10, 2016, 0:27, https://www.technologyreview.com/s/602124/augmented-reality-could-speed-up-construction-projects/.

on a chair where they had just seen a virtual person seated. The overlay of avatars, text tags, future construction, and the physical environment suggest a potential shift in the lasting perception of a construction environment.

Image Two depicts a similar scene of framed metal studs. Unlike the first image, the field of view is taken directly from the perspective of the augmented reality display. The unbuilt ceiling plane is overlaid with digital renderings of MEP. The ground plane is overlaid with a two dimensional plan drawing projected perspectivally into space and slightly askew from the physical ground plane. In the foreground a menu presents options for displaying model layers including "Structural", "Architectural", "Ductwork", and "Electrical" among others. The vision-directed cursor displays in the center of the screen in the process of selecting the layer for "WaterPipes." This video still, taken from a demonstration of the Daqri Smart Helmet, offers an image of a mixed-media environment in which the architectural plan drawing is projected into image space as one layer among many of a BIM model. While in many ways the BIM model displaces the drawing as the site for coordination, here they sit side by side or one on top of the other. Slight transparency in the digital overlay makes the physical construction barely visible in the background. As Amelyn Ng has described, "[X]-ray vision seems to obscure rather than explain technical labor."[17] What is delivered by this image is less a pictorial construction of coordinated labor, than an obfuscation of both spatial perception and the labor inscribed in different formats of representation. The flattening of drawing, digital model, and physical space dissolve the medium specificity that historically have supported architectural acts of translation.

In the third image, a digitally modeled fragment of a wall section sits on the ground of a construction site. It is unclear if the digital overlay is co-registered in the actual location of its future construction. The digital brick, concrete foundation, insulation foam, and other elements forming the wall section sit directly on the physical background of dirt and gravel. A few less distinct digital elements hover in the background as the scene is centered around a red dot, the augmented cursor. In its depiction of a wall fragment, the image less describes a to-be-constructed reality than a digital mock up. If the physical mock-up has historically been the site of testing details and assemblies of material, the intentions behind the digital mock-up could be described as the visualization of specification data. While BIM-integrated augmented reality demonstrations primarily celebrate coordination, on-site instruction, safety, and client presentations, this image speaks to on-site capacities for design as procedures of selection. In a reflection of the changes to design posed by BIM, Richard Garber writes, "[w]hile it might not be a direct replacement for actual experience, information modelling points to a new combination of experience, so-called pre-modern intuition, and data in the development of a design scheme."[18] It is this last element, data, that is rendered so

Figure 4. Image Four. SRI International, “Augmented Reality Solutions for Construction Inspection,” video uploaded October 23, 2017, 0:51, https://www.youtube.com/watch?v=8lY4qaVvR8c.

clearly in image three. While design may have always entailed protocols of selecting materials, details, and products, BIM connects designers to vast repositories of data representing architectural assemblies and corollary attributes: aesthetic effects, environmental performance, cost, and labor. If design is frequently a practice of navigating and selecting, augmented reality shifts design from locations of discrete computing to the cloud-enabled construction site. The mock-up is less a site for testing details and materials than for juxtaposing BIM components with their physical surroundings. As the wearer of the augmented reality headset appropriately asks, “This mockup that I’m looking at, is this is in real life?”[19]

Image Four is captured the moment a digital model transitions from 0% to 100% opacity, partially obstructing the view of physical construction. Against the background of a wood frame structure, the overlaid BIM imagery shows a series of purple and cyan ducts and vents. Surrounding surfaces of ceilings, walls, and structural supports are rendered in a neutral white distinguishing themselves from the colorful MEP. Several elements of the digital model are tagged with either a green check mark or a yellow exclamation point signaling either previous verification or items requiring attention. Similar to the previous two images, the field of view is presumably that of the augmented display or the wearer of hardware, in this case framed by an overlay of crop marks. In the upper right corner is a wifi icon, a battery level indicator, and time stamp. In this image, notation dominates the view. In establishing a definition of notation, Stan Allen argues that, “An architectural drawing is an assemblage of spatial and material notations that can be decoded, according to a series of shared conventions, in order to effect a transformation of reality at a distance from the author.”[20] Likening the notational quality of architectural representation to musical scores, texts, and scripts, notations in this sense are necessarily reductive and abstract.

While the notation in this image, and BIM visualization more generally, have historically been the purview of the building industry, comparing these notational marks to Allen’s encoded systems allows us to trace both changes and continuities from drawing to BIM. The widespread use of computation visual technologies like BIM has dramatically altered the drawing as the site of design. Yet like architectural plans and sections, these visualizations are also measured formal descriptions. In many cases, they also measure time, cost, and methods of assembly among other quantitative information. Although measurement and precision are values already embedded in digital models rather than overlaid onto designs, they still rely on systems of notation to communicate abstract and non-visual ideas. The introduction of augmented reality extends the capacity for notation to articulate a “specific interpretive community,”[21] albeit rendered through a different set of instruments across disciplines and trades. A challenge to this useful continuity, contained in image four, is the shift from the shared conventions of drawing to the proprietary notational systems of distinct software companies. While relying on shared conceptions of

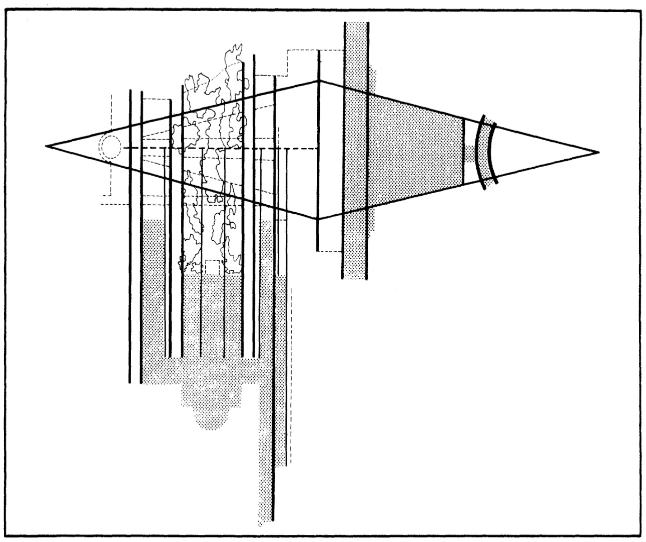

Figure 5. Analytic diagram of Le Corbusier's 1927 proposal for the League of Nations, from Colin Rowe and Robert Slutzky, "Transparency: Literal and Phenomenal," Perspecta vol. 8 (1963): 53.

notation to some degree, each software retains its own graphic system, posing problems for the cultivation of loose notational communities and the heralded 'democratization' of design offered by BIM.[22]

REAL-TIME TRANSPARENCY

> "Frontality, suppression of depth, contracting of space, definition of light sources, tipping forward of objects, restricted palette, oblique and rectilinear grids, and propensities toward peripheric development are all characteristics of analytical cubism. In these pictures, apart from the pulling to pieces and reassembly of objects, perhaps above all we are conscious of a further shrinkage of depth and an increased emphasis which is now awarded to the grid. We discover about this time a meshing together of two systems of coordinates."[22]
>
> —Colin Rowe and Robert Slutzky, "Transparency: Literal and Phenomenal"

Colin Rowe and Robert Slutzky provide this list of qualities as a departure point for describing the characteristics of phenomenal transparency. Although discussing analytical cubist painting, many of their points might serve as an analysis of the four images provided here. The spatial superimposition, simultaneity, and 'space-time' established by Rowe and Slutzky presage the optical qualities of augmented construction sites. Computational image environments put forth a version of real-time transparency with impacts for the means of production, built forms, and spatial perception.[24] The flattened diagram of Le Corbusier's proposal for the League of Nations (Figure 5.) visualizes the "continuous dialectic between fact and implication"[25] central to phenomenal transparency. The active intellectual effort required by an observer to distinguish between "real and ideal space"[26] in Rowe and Slutzky's conceptualization is replaced by an active cognitive process of simultaneously interpreting real and model space in augmented reality. In their position across the reality-virtuality continuum, augmented reality displays encompass both literal and phenomenal transparency.

This anachronistic textual overlay has limitations. As Emmanuel Petit has pointed out, today "the assumption that architectural form is decoded from the vantage point of an ideal observer in the dialectic between real and ideal diagrams seems out of sync with the way architects conceive and think of spatial structures."[27] The plan drawing as the generator of spatial relationships, central to both Le Corbusier and Rowe and Slutzky's essay, is displaced by the computational information-rich digital model—a dialectic between physical and virtual experience. Rather than require an ideal observer with a deep knowledge of architectural history and visual literacy, BIM-integrated augmented reality makes multiple, often contradictory readings of space accessible in real-time. Augmented techniques of vision, like their CAD predecessors, will structure new understandings of design practices based on the requirements of virtual environments. As studies have described, what is modified by augmented reality applications is less the environment than "the observer's intellectual experience [which] greatly multiplies social-cognitive opportunities"[28] or, in other words, learning opportunities around spatial perception.

AUGMENTED VISUALIZATIONS AND REPRESENTATION

Discourse on the management of data and information is frequently relegated to the building industry and struggles to find disciplinary avenues around new forms of image-making. BIM however has overcome marginalization in part through a situating of its underlying technology in discursive practices around representation. Beyond an instrument for production and visualization,[29] BIM encapsulates new forms of abstraction central to architectural knowledge practices and pedagogy. The data-rich platforms of information modeling might be most closely tied to the historical values assigned to section drawings. The vertical cut has been the primary mode of understanding spatial qualities in relation to their technical articulation. Section cuts across notions of architectural objecthood, tying relationships of labor, technology, material, and performance together part by part rather than as geometric wholes. In their Manual of Section, LTL Architects conceive of the section as "the intersection of structural, thermal, and functional forces" as well as the "site where space, form, and material intersect with human experience."[30] This definition of the section conforms to Peter Eisenman's proclamation that "plan and section have been, since the development of orthogonal projection, the repositories of animating principles that define architecture in the classical Western sense."[31] By now, however, with sufficient distance from the 'digital turn', we might distinguish between section drawings and images produced by computer-aided design software.

Computer images are the output of digital models. As John May puts it, “Using the ‘Make2D’ command is not at all the same as drawing an orthographic plan. What we see on postorthographic surfaces is simulated representation—electrical simulations of the orthographic formats that once represented the world.”[32]

Contemporary techniques of computation and vision have dislodged the ‘animating principles’ and traditional understanding of section as a drawing type. Yet with an understanding of the historical discontinuity between orthography and simulated models, it is possible to refashion expanded notions of section capable of transposing sectional modes of designing and evaluating architecture to information modeling. The images of BIM-integrated augmented reality suggest a specific, if speculative, means for grounding discourse on technical and abstract representations to emerging visual technologies. Rather than the simulated vertical cut, the digital and physical overlay produces descriptions of layers through transparency—literal, phenomenal, and instantaneous. The thickened cut line is displaced by superimposition and gradation. The simultaneity of the digital model at the core of BIM and the real environment renders the intensely technical representation of structure, material, building systems, and labor in juxtaposition with the spatial, social, and experiential characteristics of site. The augmented overlay describes a new form of real-time section. In this scenario, section can be expanded from a definition as a drawing type to a set of related concerns, demands, information, and associated techniques of visualization.

CONCLUSION

While the above analysis and arguments examine a collection of nascent, proprietary visual tools, they are intended to suggest ways that the field can learn from technologies developed in construction and building management. Socio-technical regimes, like those encountered in BIM-integrated augmented reality, produce new observational subjects and alter the technical conditions of abstraction. As software and hardware that initially operate at architecture’s margins are adopted in design practices, architects should play a role in theorization, positioning, and directing their application. Spatial arguments (like Rowe and Slutzky’s) and discursive practices formed around particular drawing types (such as the section) can be extended to incorporate even the most applied forms of building technology. The inertia of disciplinary knowledge, particularly around representation, can be a productive force for theorizing changing conditions of architectural labor if it can accommodate new forms of spatial perception and subjectivities. The real-time section proposes one such model. Architects should take advantage of these critical moments of technological formation to interrogate and project forward valuable toolsets, pedagogical strategies, and professional practices.

ENDNOTES

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