PAPER[space] Architecture: A tool kit for Speculative Digital Drawing

Abstract

Despite exponential developments in technological manufacturing and computational design, the act of drawing still plays a role as the central vehicle for speculation in architectural practice. Historically, drawing has been tied to not only advances in architecture, but advances in technology and culture as well. From Alberti's *Lineaments*, to da Vinci's *Machines*, to Thomas More's visions of Utopia, Laugier's *Primitive Hut*, Ledoux's *City of Chaux*, Boullee's *Cenotaph to Newton*, and Hugh Ferriss' visions of New York, innovation in the field of architecture over the last 600 years has inextricably been tied to speculative drawing. In a world of computational networks and new interfaces providing designers with unprecedented perspectives of the built (and unbuilt) environment, the use of the speculative drawing is in a state of flux. Coupling advanced digital representation technologies such as augmented reality with computational methods of interpretation provide designers the ability to expand the realm of the drawing – giving designers the opportunity to explore new worlds of abstract architectural space within a new hybrid architecture derived from their speculative drawings. Through a computational tool this project aims to bridge the gap between abstract drawing and architectural space in the contemporary paradigm of digital information models.

1 Introduction

Innovation in the field of architecture has historically been tied to speculative drawing, or the representation of a potential architecture that pushes forward the contemporary paradigm of practice. During the post-modern period and the subsequent questioning of high modernist ideals, abstract drawing returned to the forefront of theoretical practice. Contemporaries who have continued this tradition include Daniel Libeskind, Douglas Darden, Brodsky + Utkin, Lebbeus Woods, Thom Mayne, and Neil Spiller; each working to reimagine a world of architecture through the representation of formal experience through abstract drawing.

Given this rich history of architectural speculation through drawing, advances in computational means opens the potential to reimagine how to represent the form and space depicted in drawings. During the last 15 years of practice Building Information Modeling(BIM) has changed the way architects realize buildings. This change has led to a new paradigm of practice; Richard Garber describes what Manuel DeLanda calls the ‘virtual paradigm’. This theory, supported by other design theorists’ such as Sanford Kwinter, describes the contemporary architect as ‘post-representational’(Kwinter 2003). Garber states “whereby the previous method of architectural delivery, the ‘possible to real’ is being supplanted by a new and seamless method, the ‘virtual to actual’” (Garber 2009, p.237). In the previous paradigm of architectural practice designers relied on someone other than themselves to realize their buildings through two-dimensional representations. This inevitably resulted in a translation of what the designer intended and what was realized. In this new paradigm, computational models exist as an alternate reality that allow the designer to truly craft architecture without the limitations of traditional realization, ultimately bridging the gap between the designer’s intentions and their formal manifestation. To DeLanda, the architecture that exists in this virtual reality is just as ‘real’ as the architecture that has been erected in actual reality (DeLanda 2002). The freedom to design architecture in its ‘purest state’ is in fact just as ‘real’ as any other. This idea offers the potential to further speculate on new spatial possibilities and gives designers new means to demonstrate their theories.

Mario Carpo extends upon this notion of advanced computation to facilitate a more streamlined dialog between the analog and the digital.

“today’s digital tools can model the tremor of each trait of the hand, the wavering of the lilies in the field, or the passing of clouds in the sky, without converting these feeble and uncertain, fuzzy traces of chance and nature into the scripted rigor of geometric objects... the Analogue and the digital are no longer foes, and may soon join forces - on paper or elsewhere, and in the visual imagination that is already giving visible shape to a forthcoming new age of digital untidiness, messiness and slightly disturbing uncertainties” (Carpo 2013, p. 133).

Carpo postulates the advances in computation as not being in opposition to traditional speculative drawing techniques, but can be understood as stating the design process will soon become more streamlined from the designer’s hand to the physical realm of architecture.

2 Methods

This project aims to develop a parametric process for the realization of diagrammatic architectural space derived from abstract drawing through a series of parametric operations that interpret both a drawing and a proposed context within which the drawing is sited. As observed in Figure 1, a workflow is postulated from conceptual drawing to digital information model, with the potential for conceptual realization through virtual/ augmented reality or digital fabrication.

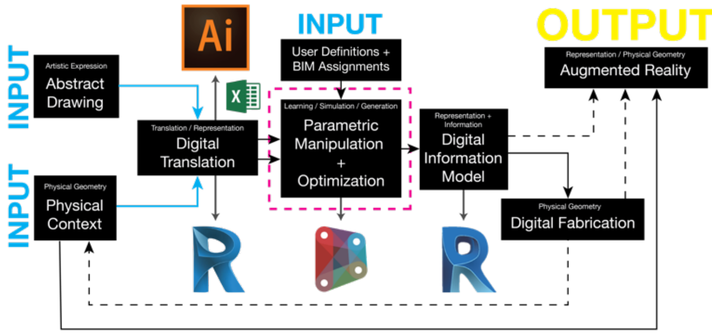

Figure 1. Workflow Logic Diagram.

The process of interpretation begins with the computational interpretation of the abstract drawing by creating a high-resolution scan, which is then brought into *Adobe Illustrator or Adobe Capture*. By running the *live-trace* function, scalable vectors are generated from the raster scan. The vector drawing is then exported for operation within a digital modeling environment. The vectors are imported into the Autodesk *Revit* environment for interpolation and manipulation using *Dynamo*, the built-in visual scripting interface for Revit (figure 2.).

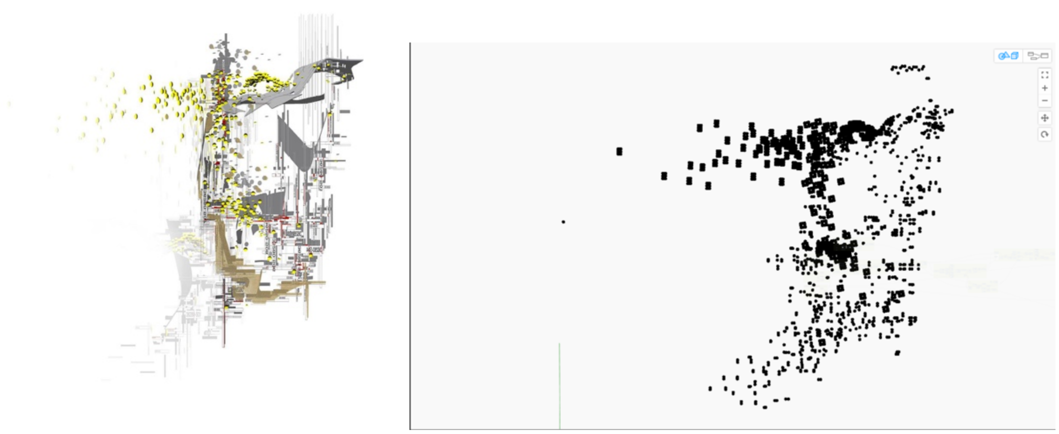

Figure 2. Morphosis Architects, *Perot Museum conceptual drawing*, From: Morphosis Architects http://www.morphosis.com (accessed January 4, 2017) and Dynamo representation of curves and control points.

By referencing the line work, the process of interpretation starts with a series of operational tests to derive strategic groupings of curves within a drawing based on their inherent hierarchy and logic. The first test is to determine whether each instance of information within the drawing is either a point, a curve, or a plane. Within the script, a point is defined as a curve object with a single control point, while a curve is defined as an open network of control points and inversely a plane is defined as a closed network of control points. To test for open vs. closed, an operation determines the start point and end point of a curve and tests their location (x, y, and z) for coincidence as described in figure 3. The operation also tests for rectangularity by measuring the distance along the curve from control points, a rectangle consists of four control points, while a square has four control points that have congruent edge curves.

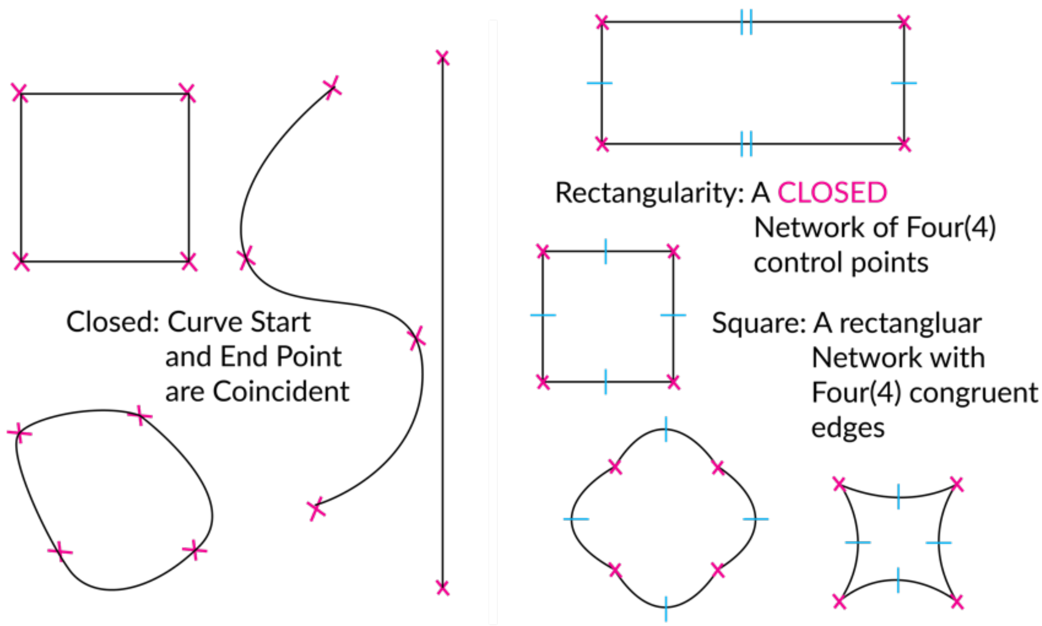

Figure 3. Operational rules for openness and rectangularity.

The next operation is to determine a specific curve type. This test categorizes curves into 4 groups, the Jitter, Jump, Wiggle, and Swipe. The jitter is defined as local groupings of control points that occur at relatively equal distances along the curve. The Jump is defined as a single cluster of control points located on the curve. The wiggle is defined as an even distribution of control points across the curve. The Swipe is defined as a minimal number of control points across the curve, often resulting in a gentle curvature. This algorithm also tests for local and global proximity in line type. By testing each curve's 'score' against other line scores within a user defined radius and across the entire drawing, patterns of lines emerge as another grouping method.

The third operation tests for line curvature ratios, resulting in a total line score factor. This test measures both the linear distance from one control point to the next, and tests it against the distance along the curve from control point-to-control point. The total line score is generated based on a user input factor for the minute control of grouping with a slider. The rule for testing the curvature factor against the line score is displayed in figure 4.

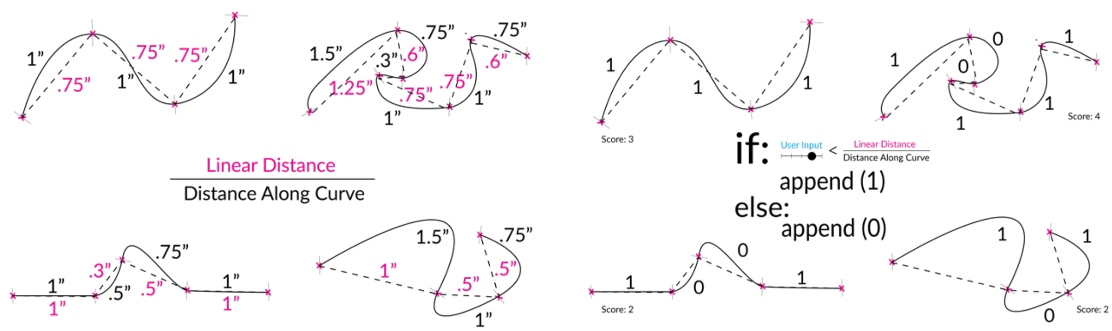

Figure 4. Line Curvature Analysis and Score.

The final operation test examines each curve's relative average tangency. By determining the curve's normal vector at the midpoints between control points, the script generates a general direction based on the sum of the vectors (figure 5). This is then used as an additional layer of information in the categorization of the linework in the drawing.

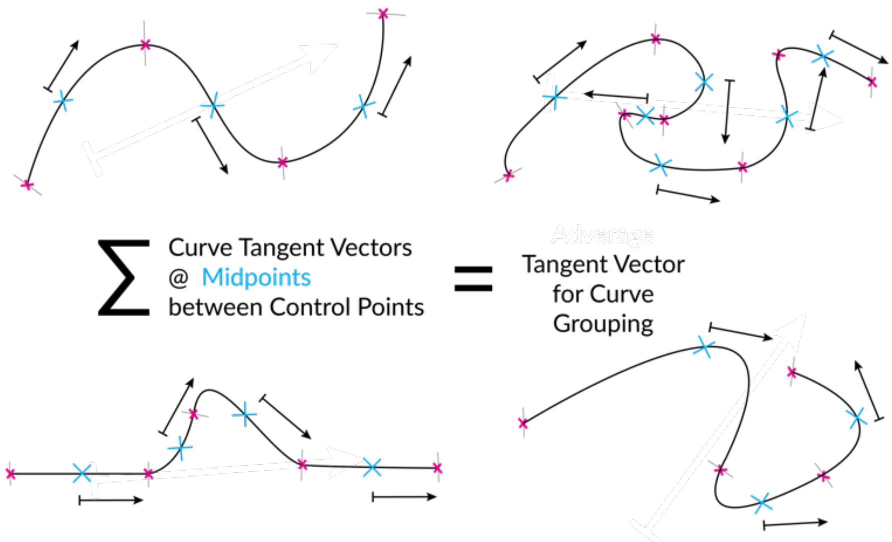

Figure 5. Line Tangent Vector for grouping.

The second input in the logic diagram (figure 1) is the desired context for the drawing. This is generated by digitizing a real environment using laser scanning or aerial photogrammetics, or working within an existing digital information model. Using the context as a reference, the input drawing is then repositioned and scaled to the bounding box of one of the faces as defined by the user, a vertical face will treat the drawing as a section, while a horizontal face will treat the drawing as a plan. The repositioned drawing is warped to match the profile of the face by remapping the control point coordinates to the limits of the context face using a regular grid system (figure 6).

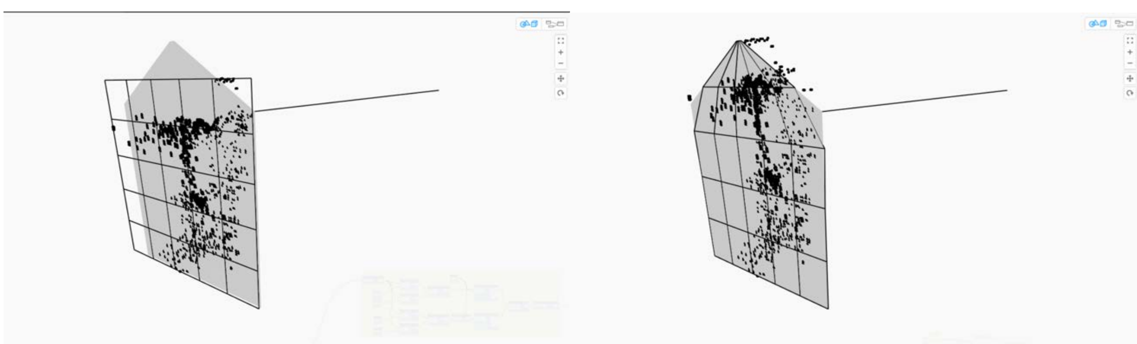

Figure 6. Extrapolated lines and resultant forms from line type analysis.

The lines are then extrapolated through the contextual form based on a preset understanding of the group types within the drawing. The generated form is displayed within the Dynamo graph as a conceptual abstraction (figure 7). The model allows for the local adjustment of the geometry given the designers preference once they have had the opportunity to understand it as a three-dimensional space.

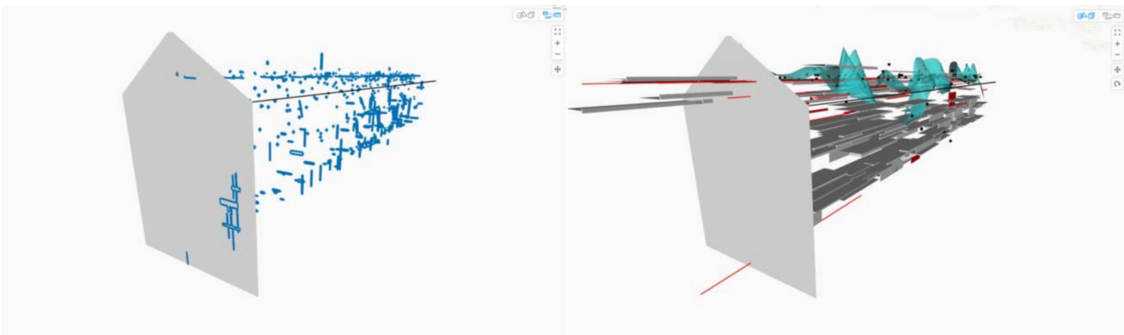

Figure 7. Extrapolated lines and resultant forms from line type analysis.

From the conceptual representation of the extrapolated drawing, the designer then can make type based associations for the forms generated in space. This type-setting of BIM objects based on the line work aligns this tool with DeLanda's postulation regarding virtual modeling in architecture, by assigning the properties of a wall, floor, light fixture or structural column to a digital object, the model takes on the inherent properties of those materials within an alternate reality. The forms are translated into BIM objects within the Revit environment as seen in figure 8. The model can then be documented using tradition two-dimensional techniques such as plan, section, or elevation but can also be used to generate perspective renderings of the model's virtual reality. Using a method for translating Revit models into the gaming engine *Unity*, the model can be experienced using augmented reality technology such as Microsoft *HoloLens* to give designers the ability to occupy the space within their drawings, offering designers the ability to perceive new spatial possibilities within the minutia of their sketches. Other means for the realization of the abstract forms generated include digital fabrication with advanced manufacturing tools or small scale prototyping with 3d printers.

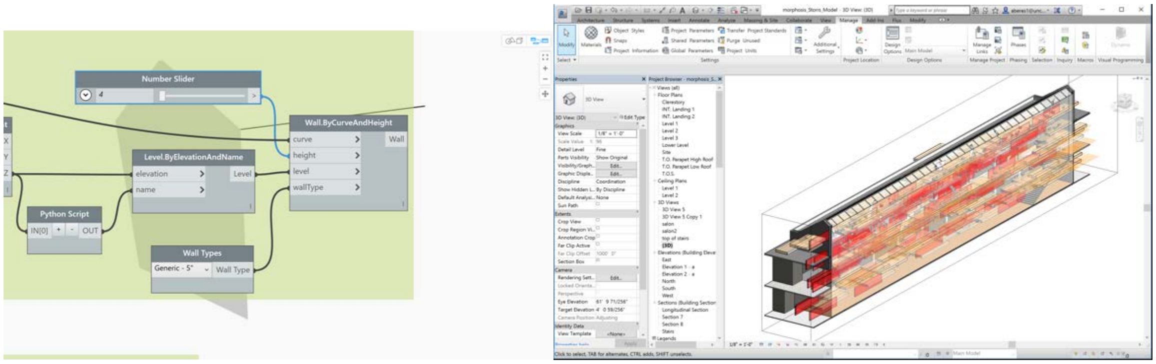

Figure 8. Type assignment and resultant Digital Information Model.

3 Results and Discussion

Through the generation of space derived from five different case study drawings, this tool kit was tested using a wide range of drawing types. The Morphosis conceptual drawing for the Perot acting as the primarily orthogonal example with some organic elements, a Zaha Hadid sketch that is completely derived from three degree curves, Lebbeus Wood's Terrain drawing comprised of similar lines that crash and collide with each other, a Frank Ghery sketch that consists of billowing forms, and a Cy Twombly drawing that consists primarily of swirls and scribbles. Each drawing generates a very different spatial effect using this method for interpretation as displayed in the matrix of drawing types (figure 9). Each drawing was tested not only in a single context, but three unique contexts. The first context is the interior atrium space displayed above, while another smaller, traditional classroom space was used for testing a small enclosed space. Lastly, a large outdoor space located within a campus quad was tested, generating a potential schematic model for an entire building based solely on the input drawing and its relationship to that context.

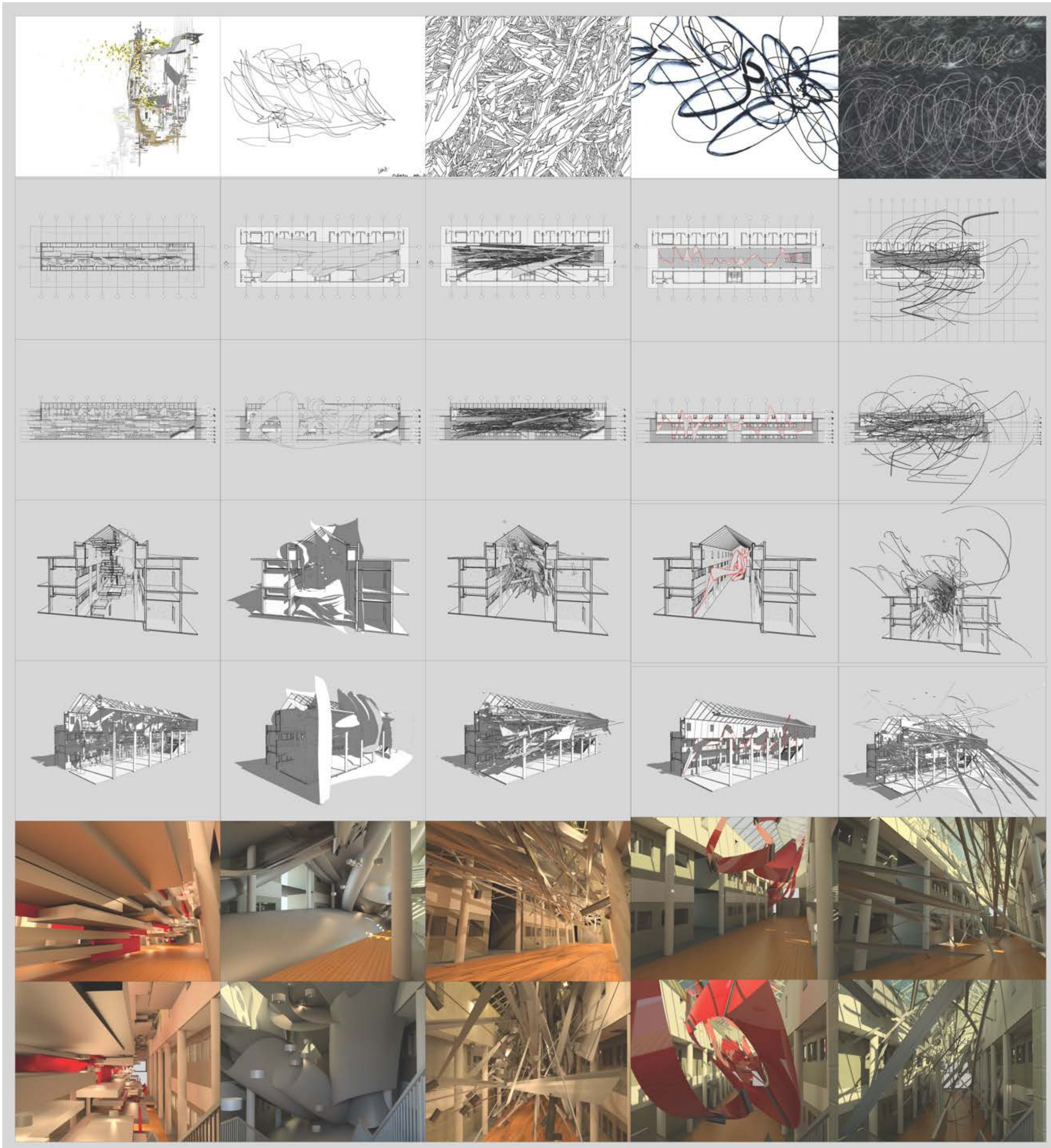

Figure 9. Five case study models generated from abstract speculative drawings.

4 Conclusion

The method developed in this project for the translation of analog drawings into digital information models offers the potential for the designer to gain more control over their design process by owning the translation of their desired geometry from paper to digital space. The need for a more widespread understanding of the implications augmented and hybrid realities will have on the built environment positions this project to act as an early adopter of advanced representation technologies for architecture space-making in a manner familiar to designers. Given the forthcoming age of increasingly hybrid environments, designers should begin to position themselves as their formal and experiential generators – taking a role alongside digital user-interface designers in the conception of the hybrid environments of tomorrow. The derivation of abstract architectural space from two-dimensional formal and compositional notions in the form of a drawing, positions this tool as a means for closing the gap between conception and realization in the contemporary paradigm of digital information models.

5 References

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