# Differentiation as a Form of Knowledge Production in Architecture

**Brad Benke, Mike Christenson**

North Dakota State University, Fargo, ND

ABSTRACT: Architectural models and photographs, foreground some perceptual aspects of architecture while minimizing the presence of others (Bermudez & King, 2000; Boge & Sullivan, 2006). Photographs highlight the value of a point of view, framing, and cropping. Digital models also embody points of view, as well as less obvious attributes such as the sequential order of construction (which may or may not correlate to the order of construction of the building being modeled).

Using Villa Savoye as a test case, we examined the degree of differentiation between online models, and how these differences can be mapped and extrapolated to illuminate conditions potentially suggestive of architectural significance in themselves – independent of any consideration of the models' verisimilitude. We then asked: Are there limits to how "wrong" a model can be and yet still be capable of provoking significant insight? In reflecting on our processes, we questioned how the tools we have developed may facilitate forms of knowledge production historically essential to architectural epistemology but often overlooked in a contemporary discourse dominated by hyperaccurate models, predictive simulations, and photorealistic renderings.

Our questions are aimed at making visible that which is essential to a critical architecture in which processes and tools generate and sustain a non-destructive environment for architectural research.

KEYWORDS: architecture, Villa Savoye, differentiation, models, photography

## INTRODUCTION

Generative design approaches in architecture use algorithms to generate multiple iterations for evaluation with respect to stated criteria. In such approaches, it is usually assumed that criterion-driven selection processes will result in optimized forms, provided the algorithms are robust and the criteria are well-defined (Caldas & Norford, 2002; Terzidis, 2006). Differentiation is understood as a generative process which occurs over multiple iterations.

By contrast, in this research, we are interested in differentiation as a process of reading, as a trajectory within the larger project of architectural epistemology. Beginning with a set of 45 digital models of Le Corbusier's Villa Savoye (Figure 1), we considered differentiation of two types. Type 1 differentiation asserts that each of the models differs in more-or-less significant respects from the built Villa Savoye: any given model contains inaccuracies with respect to the actual house, affecting the model's value under certain conditions. For example, supposing a model is used for the purpose of producing accurate photorealistic renderings of Villa Savoye, its fidelity to the referent (in terms of sizes, proportions, materials, and so on) is a major concern: an inaccurate model would result in inaccurate renderings. As software developers strive to produce tools that not only enable one-to-one correspondence between models and referents, but that also attempt to make this correspondence as efficient as possible (Gomez, 2007), and as digital models are expected to support ever more-demanding interpretative and simulative performance requirements, it follows that reducing Type 1 differentiation has obvious value.

In our work, we assert that a high degree of Type 1 differentiation between an existing building model and its referent is a rich source of interpretation. Stated differently, the existence of a "mismatch" allows the model to be an "interpretation of" the referent rather than a "description of" the referent. It follows that the differences between one model and another offer potential value to interpretation. Thus, Type 2 differentiation registers the differences between the models in a collection. For example, consider a subset of models, each member of which exhibits a unique configuration for Villa Savoye's internal ramp. Type 2 differentiation does not consider which of the modeled configurations is "correct," but rather recognizes the extent of disruptions and discontinuities among the subset. The significance of Type 2 differentiation is not obvious, and with the goal of exploring its characteristics and ramifications, in an effort to illuminate the value of information that might be considered different, imprecise, or even erroneous, we set out to identify and highlight its extent within a set of models.

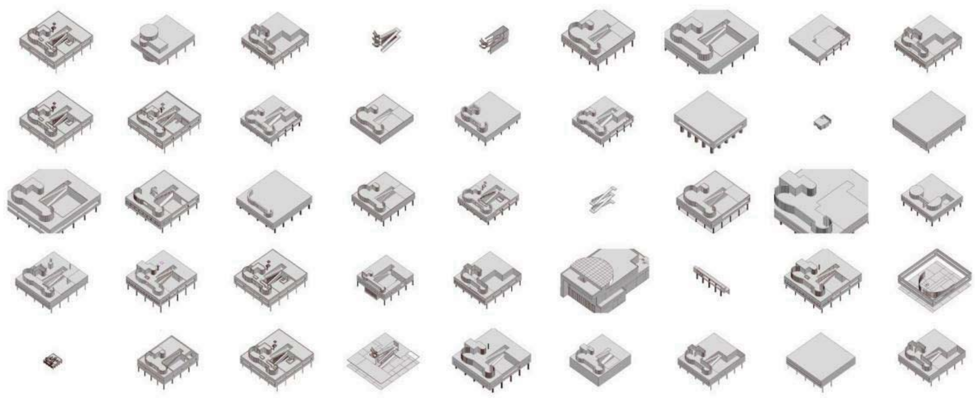

**Figure 1:** 45 models of Le Corbusier's Villa Savoye.

## 1.0. MAPPING DIFFERENTIATION

We built our set of digital Villa Savoye models with an online search limited to freely available models in a common format (Trimble 3D Warehouse). The models, constructed by various authors over time, ranged from highly detailed and documented representations of the actual building to geometric configurations hardly recognizable as Villa Savoye. In order to identify differentiation between the models, we first categorized them by the number of times they had been downloaded – citations indicating the models' apparent worth or popularity to the online community. We then stripped the models of populated content, that is, anything not physically part of the referent (i. e., people, cars, trees, ground, etc.). This homogenizing of the models allowed us to view them through an identical lens in order to discover their individual peculiarities and differences in a consistent manner. No building geometry was added, removed, or distorted in the homogenizing process. After achieving a desired level of homogeneity, we generated three views (top, front, and isometric) of each model for evaluation.

Unsurprisingly, the models that appear to most closely represent a one-to-one relationship with the actual Villa Savoye - i. e., those that minimize Type 1 differentiation - also ranked the highest in terms of online downloads (Figure 2, top). Presumably, authors and users of these models share the goal of eliminating imprecision and inaccuracy so that the possibility of (mis)interpretation is reduced. At the opposite end of the spectrum, where models are nearly indistinguishable offspring of Villa Savoye, the intent and purpose of the models becomes far less obvious. Some of these deviations (Figure 2, bottom) include radical distortions of geometry and severe generalization of specific building elements.

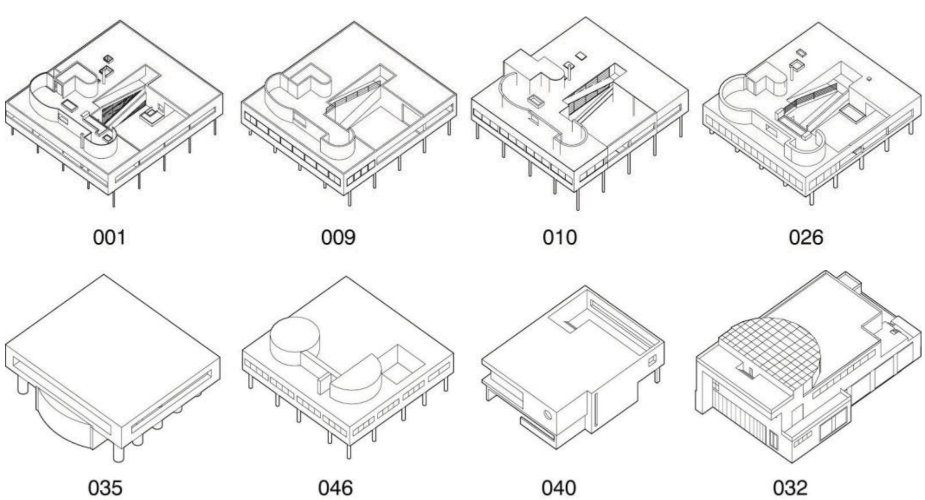


**Figure 2:** Villa Savoye models with low Type 1 differentiation (top row) and high Type 2 differentiation (bottom row)

## 1.1. Mapping differentiation: Isovists

Two-dimensional isovists (Benedikt 1979) provide a way of registering the planar permeability of a space as perceived from a fixed station point. We relied on a combination of software applications to construct isovists as a means of revealing differentiation among our set of models. Beginning in Sketchup, we sectioned each model at a consistent level of six feet above the second-floor terrace level, with the intent of representing the locus of human eyesight. We exported each section in .dwg format, and using AutoCAD, we converted the sections to polylines, re-saved them and opened them in Rhino 3d. We used a Grasshopper script to create a circle based on a fixed station point (in this case, the approximated center of the second floor terrace); the script has a built-in query to detect polylines as boundaries (in this case, the walls of the section cut). The result is a two-dimensional isovist that can be updated in real time and exported in many formats. Isovists reveal a kind of differentiation that is not immediately obvious from inspecting or comparing the models from their exterior (Figure 3).

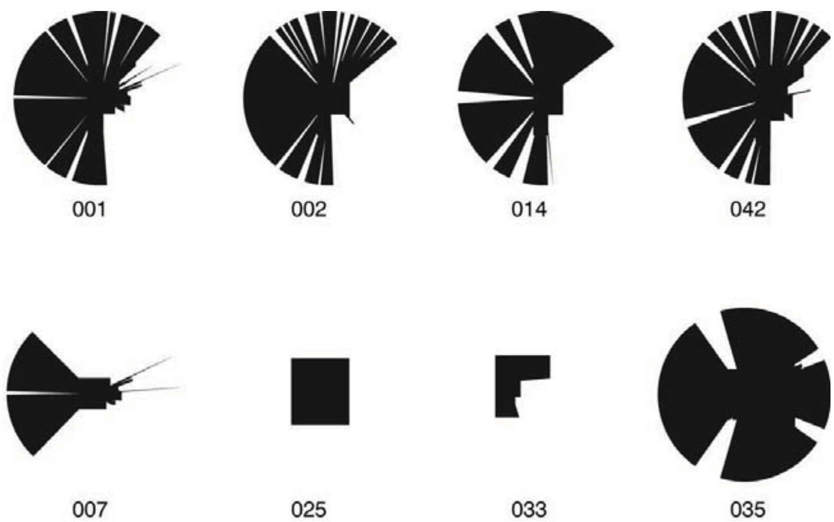


**Figure 3:** 2D isovists at second-floor terrace of Villa Savoye

The isovists for several models – for example, models 001, 002, 014, and 042 - indicate a common bias in visual permeability, suggesting that if the models are viewed from the station point inside the terrace, visibility would be largely unobstructed to the upper left sides of the isovists, while being blocked on the right side. These near-identical isovists indicate correspondence between their respective models, at least as far as visual permeability of the terrace is concerned. (Without comparing them to the referent, however, their "accuracy" is not guaranteed.) Other isovists, such as the ones corresponding to models 007, 025, 033, and 035, are relatively unique within the set of models. Even assuming that the unique isovists are likely to differ significantly from a hypothetical isovist resulting from an accurate model, their apparent inaccuracy does not preclude their utility in prompting speculations about Le Corbusier's approach to horizontal visibility. For example, isovist 007 heightens the symmetry between the two sides of the terrace, while isovist 025 prompts us to consider the terrace as completely impermeable to vision. Isovist 033 can be seen as a refinement of isovist 025, while isovist 035 inverts it, appearing to represent a fully permeable terrace where visibility is blocked only by corner columns. These apparently inaccurate isovists, considered in comparison with each other, are capable of highlighting possible interpretations of the space - interpretations that are latent within but obscured by the more accurate models. This ability of architectural mediating artifacts to highlight latency brings to mind David Leatherbarrow's proposition that "the purpose of architectural drawings is to discover and disclose aspects of the world that are not immediately apparent and never will be" (Leatherbarrow, 1998).

## 1.2. Mapping differentiation: Parametric model

To further examine differentiation between online models we created a digital model of our own. Our sampling of free digital models were analyzed and indexed on several building elements such as floor dimensions, ramp configuration, percentage of glazing, and column thickness to name a few. Building data were collected from a consistent (x, y, z) format aligned respectively to the building's orthogonal axes. Information was recorded only where possible. For instance, in the case of model 032 (Figure 2), no data were added to the index since it was not identifiable with the larger population. To visualize the degrees of differentiation between the available models, we developed a Grasshopper script (Figure 4) that generates a simple massing model of Villa Savoye based on the entire range of sampled dimensions. We chose to limit the script to generate a mass for the first floor, the second floor, as well as the columns and their given thicknesses. The script will generate variations in dimension, but not variations in topology. It represents an agreed-upon arrangement of parts from its model authors.

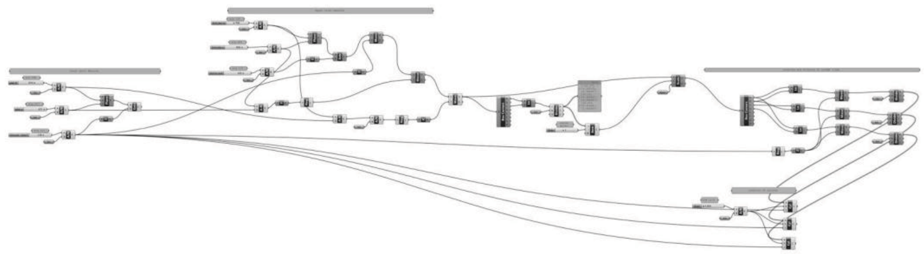

**Figure 4:** Grasshopper script for generating massing models

The model's dimensions are placed on a parametric slider and are able to update in real-time. This comprehensive parametric model is thus able to represent all of the dimensional values from our entire sample of online digital models as well as "in-between" dimensions (Figure 5). Not only can the model display unique values from unique model authors, the values can also be combined to generate new building geometry and configurations. The models in Figure 5 were created at 4 different values: the most popular (the values from the most downloaded model), the average values of our entire sample, the maximum values, and the minimum values.

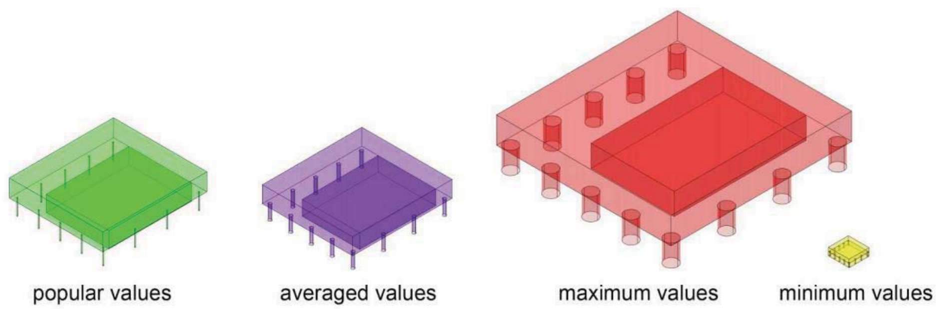


**Figure 5:** Generated massing models in 3D

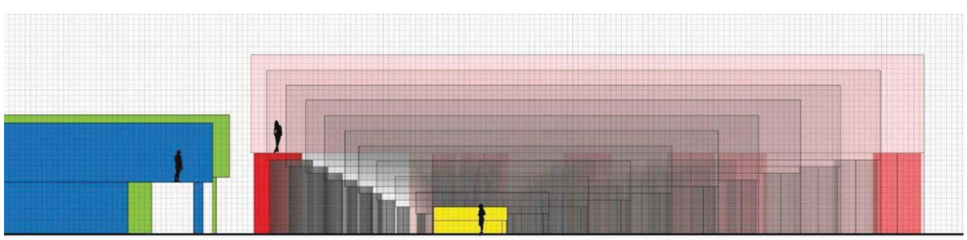

**Figure 6:** Sections of generated massing models

When juxtaposed, the degree of Type 2 differentiation reveals that the most popular model and the averaged model are very close to the same with the averaged model being only slightly smaller in massing but having thicker columns. This supports the notion that the majority of online authors strive for a one-to-one correspondence (minimizing Type 1 differentiation) between their model and the actual building. In contrast, the degree of Type 2 differentiation between the first two models and both the minimum and maximum value models is quite large. Furthermore, the degree of Type 2 differentiation between the minimum and maximum value models is even more drastic. Since the models represent an agreed-upon topological arrangement of parts, the most interesting differentiation is the degree to which some model authors are willing to disregard Type 1 differentiation in reference to the scale of specific elements (even to the point of modelling a non-liveable structure) while still being conscious of an the overall configuration of the building. In these models' most drastic levels of dimensional inaccuracy, their specificity in building topology is still able to highlight particular aspects of Villa Savoye such as column arrangement and floor configuration. Since the script allows us to visualize the entire range of both Type 1 and 2 differentiation, we also generated a range of models at equal intervals from the maximum to minimum values (Figure 6). This section image revealed the way different model authors may have been exploring the building's scale and how it relates to the human body.

### 1.3. Mapping differentiation: Initial views

When a model is opened in Sketchup, the most recently saved view is displayed. These initial views, because they are the first thing seen upon opening the models, have the potential to shape how the model is subsequently used. Assuming that the model authors are responsible for determining this initial view (along with any other preset cameras within the models), we considered the views as a significant feature of the models. As described elsewhere (Christenson 2011) a set of photographs of a given building can be mapped into a composite representation of photographers' positions, fields of view and directions of view, described as a point-of-view/field-of-view map, or POV/FOV map. We used a similar methodology to register the simulated photographs associated with viewing our set of digital models in simulated space (Figure 7).

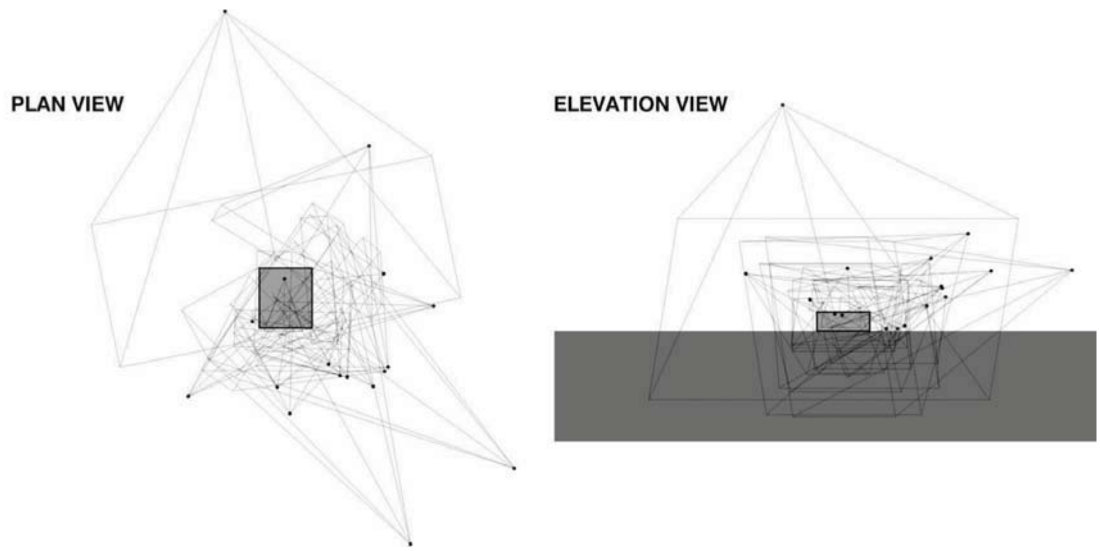


**Figure 7:** POV/FOV map of initial views for the first 20 models in our set

However, not all of the initial views were mappable in this format. Specifically, we excluded a handful of models with initial views in orthogonal format (plan, elevation, or isometric). Also, a few models with exceptionally large Type 1 differentiation (such as model 032, illustrated in Figure 2) could not be reliably oriented to correspond with the other models or the referent, and so were excluded from the map.

The plan POV/FOV map (Figure 7, left) of the initial views of the first twenty models shows that the station points tend to cluster around the point in the models corresponding to the northwest corner of Villa Savoye, facing the rounded entry wall. In contrast, just one of the mapped views is stationed on the opposite corner of the models, providing a wide, distant view. Model authors apparently have a clear preference for viewing the Villa Savoye models from the northwest corner. Moreover, the elevation POV/FOV map illustrates that most of the initial views cluster around a height of approximately two to three times the height of the model, looking down on it. Thus, most of the simulated views do not attempt to recall or predict a visual experience of Villa Savoye but are rather more like the experience of viewing a small physical model of the Villa displayed on a table. There are also a small number of initial views situated within the models.

Interestingly, the models which exhibit the lowest apparent degree of Type 1 differentiation - i. e., the most "accurate" models - do not show a trend for simulating visual experience through their initial views. Stated in another way, although many model authors may strive to accurately construct model geometry, those same authors appear to be less concerned with guiding others to understand the model as a device for simulating specific, achievable views. Just as often, model authors with an apparent lack of concern for strictly accurate geometry have chosen to present their models as if viewed from achievable viewpoints. We proceeded with the understanding that whether or not the growing database of online information as well as the mental images they create are able to alter the direct experience of an architectural work through the establishment of preconceived assumptions, they offer an increasingly rich amount of content to study architecture from remote places.

## 1.4. Photo-mapped height field model

Three-dimensional height field models are generated by assigning a given rasterized pixel color a specific dimensional ‘height’. Commonly used by cartographers for modeling terrain, the same tools have been integrated into various software programs to generate 3D forms from any rasterized image. The tool was of specific interest to our research in that it allowed us to transpose photographic coverage of a building into three dimensional geometry. Figure 8 (left) shows a potential opportunity for digital modeling afforded by the combination of our comprehensive parametric model as well as the available photographic coverage of Villa Savoye. We began by generating a massing model of Villa Savoye using our script and proceeded to apply height field data to identifiable facades. The roof is modeled from a height field of our ‘most popular’ model’s top view. For our images, lighter values were interpreted as higher heights, and darker values were interpreted as lower heights. Thus our top view required a color inversion to be accurately interpreted. The two vertical facades were modeled from height fields from a Google image of the building taken from the most popular vantage point as determined by our POV/FOV maps. The facades also required some manipulation to make them orthogonal. They were then placed onto their respective facades in Rhino, converted to height field surfaces, and scaled to fit our massing model. Although our model was generated from content based on a national monument and icon of modernism, it is plausible that the ever-increasing amount of online imagery and models could yield similar results for any building in the world. The use of Google Street View, bird’s eye Bing maps, and various user-uploaded photo websites already constitute an enormous source of content for such an endeavor.

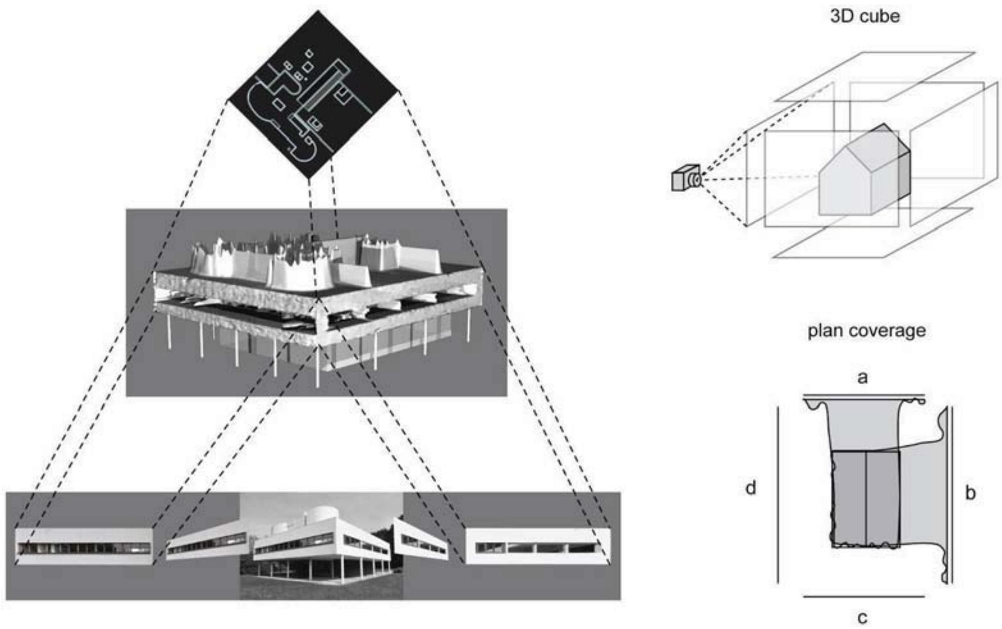


**Figure 8:** height field model and diagram

For our height field model, no one source (digital models, photos, drawings, etc.) could effectively construct the form. It required the combination of multiple forms of representation. This may not always be the case. Figure 8 (right) shows the potential for a generalized tool that could model a form from height fields alone. Assuming that every building could hypothetically fit inside a cube, and a photograph could be taken from all but one plane, a simple set of rules could be set up:

***If*** *geometry ‘a’ intersects with geometry ‘b’*
***then*** *create intersection ‘a + b’*
***else*** *delete*

An automated tool as described could potentially produce a crude model of an entire city. Such a model would require information that might not be ‘popular’ or in support of mental images that have been established. Due to the nature of height field modeling, the resulting geometry would be inherently anexact - working more interpretive geometry through a set of rules than exact one-to-one tracings. As we have shown, these inherent inaccuracies would not be downfall of the proposed tool but rather a specific method of study that has the potential to create new ways of seeing.

## CONCLUSION

Throughout our work, we've found ourselves confronting and challenging a prevailing assumption that accurate models (i. e., models with low Type 1 differentiation) are more valuable to architectural knowledge than inaccurate ones. While this assumption is certainly valid in many cases for obvious reasons, we proceeded with the understanding that architectural representations, whether in the form of diagrams, maps, or drawings, derive a unique kind of value not from their ability to trace what is already known, but in their ability to open the possibility of new worlds. Their generative potential is created through their distinctness from that which is being represented rather than their replication of it (Allen, 1998; Corner, 1999; Evans, 1997). By examining digital models in light of their distinctness from their referents, we can begin to speculate about their intention and purpose independently of the architect's own purposes, design approach, or intentions. (It is for this reason that we deliberately chose to focus our research on 'representations of Villa Savoye' rather than on the building itself, or on Le Corbusier's unique design approach.) While it's possible to associate distortions, generalizations, and inaccuracies in models with a lack of competence on the part of model authors, it's also possible that the authors may be attempting to disclose latent architectural attributes or features which are obscured in more comprehensive, 'realistic' models. Whether intended or not, what the authors of these models have created is an opportunity for their audience to read the models in a different way - to open up possibilities for generative interpretation.

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