

<u>Title:</u> Developing Narrative Diagrams for Algorithmic Modeling of Architectural Parametric Design

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Introduction:

Drawings are the traditional media used by architects to predict and communicate their design outcomes, which account for Robin Evans's statement: "*Architects do not make buildings, they make drawings of buildings* [1]." When the audiences are not AEC professionals, however, drawings usually are not the best means of communicating abstract concepts with stakeholders [8]. Video, images, comics, infographics, diagrams, and other visual narratives are often more convincing than drawings even the buildings themselves [8]. With the maturation of 3D technology, 3D visualization has become a major means of remedying the lack of narratives of 2D drawings. But while BIM applications proclaim their progress in project optimization and cost efficiency by deploying 3D visualization, educators have found that 3D visualization is not always a useful communication strategy, and claimed that BIM applications should integrate analog media in order to enhance users' access to the abstract narrative via symbolic language [2].

Architects rely on the graphic language of diagrams to bridge abstract intentions with physical design. Veloso stated there are two kinds of formal system approaches, namely cybernetic and semiotic diagrams, can be used to represent architectural knowledge in a process based on explicit rules [12]. Semiotic diagrams can be used to represent architectural design in the form of a linguistic system. But semiotic diagrams, such as the diagrams of House IV made by Peter Eisenman can usually only represent visual processes of generating forms, rather than the solving processes of design problems. Cybernetic diagrams adopt computational processes and decompose design processes into the computational flows of design information. The parametric diagrams of such algorithmic modeling tools as Grasshopper, Dynamo, and Generative Components all apply the directed graphs of cybernetic diagrams.

New design thinking and strategies have emerged with the popularity of algorithmic modeling tools in recent years. Parametric diagrams of generative algorithms can be easily associated with the rules and dependencies of generating geometries, which led Tedeschi to declare that "*Architects do not make buildings, they make diagrams of buildings* [11]." Parametric diagrams are the critical features of parametric design. According to Oxman, the knowledge of how to manipulate and explore the associative relationships and dependencies of topological geometries is the critical key to parametric design thinking [7]. Unfortunately, in practice, this kind of manipulation and exploration must rely more on algorithmic thinking and scripting skills, than on architectural design knowledge. This is because algorithmic modeling tools are developed to accelerate 3D modeling tasks through the application of algorithms, thus the rules of parametric diagrams and visual algorithms do not necessarily have spatial language, which can be used to directly describe or be associated with geometric and spatial relationships of architectural design [5].

The associative relationships between the architectural design knowledge and the algorithmic processes of generating forms are critical for architectural design at early and conceptual stages. Cognitive research on parametric design suggests that the higher frequency of spatial language used by

a designer, the more productive results in the designer's cognitive processes [5], and also indicates that algorithmic modeling tools may not be suitable for tasks involving the use of spatial concepts such as relative positions and spatial relationships. Spatial language is therefore the key to associate architectural design knowledge with algorithmic processes. If the recognition and reasoning mechanisms of spatial language can be introduced into algorithmic modeling tools as algorithmic components or procedures, this should be able to improve the narrative abilities of algorithmic modeling in describing what design intentions have been reached and how design problems are solved.

In addition to the inability to associate algorithms with spatial language, another major obstacle to the application algorithmic modeling in conceptual design is that stakeholders cannot understand those used algorithms. Unlike textual programming languages, the visual language of algorithmic modeling which cannot be easily interpreted themselves by naming parameters, functions, and classes. How to create a visual narrative of design intentions, and how to validate whether design intentions are achieved, remains a technical challenge. This paper consequently proposes an approach for generating narrative diagrams [12], which are similar to semiotic diagrams that can visually describe what design intentions are reached, and how geometric models are generated. Previous studies have proposed an algorithmic framework entitled STG*f*, which implements an algorithmic framework by applying Grasshopper and GhPython plugin as algorithm-aided design tools [6]. By providing editable clusters of topological algorithms for recognizing and reasoning spatial relationships among geometric entities, this paper aims to help architects to represent, develop, and reuse design intentions based on architectural knowledge in the algorithmic process of parametric design.

Main Ideas:

Diagrams are a popular means used by famous architects as visual narratives of design stories that bridge their intentions with the design outcomes. Some of the most persuasive examples of diagram use have been produced by the Bjarke Ingels Group (BIG), who has applied serial diagrams, such as those for the VM Houses and the Mountain Dwellings, to tell impressive architecture stories [3]. The narratives of BIG's diagrams are basically like the Japanese comics known as 'manga,' which constitute a widely known medium for narrating stories [10], and BIG therefore terms those diagrams "Archicomic [4]." Apart from their descriptive texts, the narrative capabilities of BIG's diagrams are also based on the gradual transformation of the geometries and introductive symbols, such as the associative colors, lines, and arrows in serial diagrams (Fig. 1).



Fig. 1: Two narrative diagrams of housing design by BIG: (a) The VM House in Copenhagen (left), and (b) the Mountain Dwelling (right).

In the case of architectural design, there may be completely different stories behind similar building forms, such as the Mobius ring applied by BIG and other architects in different projects. In contrast, architectural design competitions often seem to ask architects to tell the same story through different building forms. When narrating the stories behind the generative forms, it is necessary to visualize not only the generated geometries, but also the input parameters, and generative steps. And even though it may not need to visualize every result of all generative steps, however, designers must at least be able to visualize the critical steps they have selected to narrate their concepts.

While parametric diagrams of algorithmic modeling graphically narrate the generative processes of geometries on the canvas of visual scripts, the resulting narratives cannot always be recognized in the generated 3D visualization of Rhino. Grasshopper's preview function either displays only the results of a single step or overlap all steps of algorithms in the same positions. Overlapping previews cannot distinguish input parameters and generative steps, and the "baked" geometries in Rhino inevitably lose algorithmic information. For generating visual narratives of algorithmic modeling like BIG's serial diagrams, this paper employs the algorithmic framework entitled STG*f* developed in previous studies [6], then proposes an application approach for visualizing and manipulating generative algorithms through manipulating geometries in Rhino as semiotic diagrams.

Semantic Narratives of Algorithmic Intentions

The STG*f* framework applies a semantic ontology technique to store and represent chunks of design intentions. Adopting the "Subject-Predicate-Object" triple of semantic ontologies, an algorithmic component in Grasshopper presents a generative or computing process as "Predicate," which usually needs at least one parameter as "Subject," and the generated results constitute an "Object." For example, the "ExtrCrv" component with a 'Base' and a 'Curve' parameter is used to extrude "Base" along "Curve." Therefore, a simple "ExtrCrv" script (Fig.2a) can be represented as the directed graph of a "(B, C)→ExtrCrv" semantic triple. (Fig.2b)



Fig. 2: Semantic narratives: (a) The graphic script of an "ExtrCrv" component in Grasshopper (left), and (b) the semantic triple of the "ExtrCrv" ontology (right).

Although this conversion is not necessary in the case of algorithmic scripts, however, the directed graphs of semantic triples can easily be recognized by users and associated the algorithmic scripts with abstract design intentions, and thereby help to visualize semantic narratives. For example, the simple "ExtrCrv" script above may be used to represent the intention of a high-rise building mass, where the "Base" presents the shape of the standard floor, and the "Curve" presents the geometric intention concerning the building forms. To semantically narrate this intention, this script must not only indicate the semantics of input parameters and generated variables, such as "Floor" for the "Base" and "Mass" for the "ExtrCtv," but must also insert more semantic narratives into the triple, such as an "along" conjunction between two parameters, and the "Extrude" predicate between parameters and variables.

Visual Narratives of Algorithmic Intentions

The comic-like narratives of BIG's diagrams are based on the gradual transformation between illustrations and the introductive symbols connecting those illustrations. To visualize the semantic narratives of algorithmic intentions, the generative processes of algorithms should be displayed as serial diagrams. For example, the previews of the sample "ExtrCrv" script (Fig.2a) are usually displayed as overlapping geometries in Rhino (Fig. 3a). Based on the semantic narratives of the "ExtrCrv" ontology (Fig. 2b), this sample script should serially display two parameters and the generated variables in a separate manner (Fig. 3b).



Fig. 3: Visualization of semantic narratives: (a) Previews of an "ExtrCrv" graphic script in Rhino (left), and (b) the serial diagrams of the "ExtrCrv" semantic ontology (right).

Clearly, the task of serially visualizing algorithmic steps, like drawing the frames of a manga, may be rather tedious, time and labor intensive. This paper therefore proposes two approaches for semiautomatically assisting the serial visualization process: (1) sample Python scripts and (2) editable clusters of algorithmic components. Python scripts are more powerful, and can more easily generate serial visualizations of this kind, but are more difficult for users to learn and to modify the scripts. Editable clusters of algorithmic components in STGf can provide more textural and graphic introductions for how to generate serial visualizations, and can explain how to modify the visualizations in order to obtain better narratives of design concepts. Due to lack of the version control functions in Grasshopper, however, rewriting a script or modifying algorithmic clusters is often a difficult task for experienced scripters, let alone designers.

Multiple Narratives of Algorithmic Intentions

Since design competitions often ask architects to tell the same story using different narratives, designers usually would try different ideas for telling a new narrative of a known story. For example, the concepts for CCTV building by OMA attempted to break the idea of building height as a hierarchy symbol, and change the Z-axis extrusion of the building form into a circulating circle [9]. As the concept of "form follows fiction" proposed by Scheeren, the different geometric intentions concerning how to change the extruding directions of the building tell the same story in new fictional narratives.



Fig. 4: Multiple narratives of the same algorithmic intention: (a) two different approaches for collecting multiple parameters in Grasshopper: automatic or manual (left), and (b) the serial diagrams of multiple narratives of the same "ExtrCrv" script (right).

To test different ideas of new narratives, multiple parameters are necessary for the same algorithmic intention. Although most of Grasshopper's components allow input multiple parameters, however, modifying the collection of parameters sometimes cause unpredictable when a new intention is proposed. To simplify the manipulation multiple parameters of the same algorithmic intention, sample Python scripts and clusters of "Pipeline" components can be provided for designers to enable designers to automatically collecting geometries by layers, names, or geometric features (Fig. 4a), which is easier for designers to manipulate algorithmic intentions than to modify parameter collections directly. Through the visualization of algorithmic steps, designers can simultaneously visually narrate multiple design intentions of the same design story (Fig. 4b).

Conclusions:

Since the parametric diagrams of algorithmic modeling constitute a type of cybernetic diagrams, their narrative ability is naturally inferior to the semiotic diagrams. This paper proposes the approach of applying an algorithmic framework to generate visual narratives of algorithmic intentions, and the framework narrates what design intentions are reached, and how the diagrams are generated. By integrating semantic ontology and applying visualizing algorithms, this paper aims to help architects to associate design intentions with the algorithmic process of parametric design. While educators sometimes claim that "3D visualization is not a design strategy [2]," parametric design and algorithmic modeling is not always good communication strategies. In order to communicate with and convince a broader public than just AEC professionals, this paper proposes a visual strategy for manipulating and generating narrative diagrams that tell the design stories in parametric architectural design.

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References:

- [1] Evans, R.: Translations from Drawing to Building and Other Essays, Architectural Association, London, 1997.
- [2] Flanagan, R.: BIM's complexity and ambiguity BIM v. paper architecture, in: Proceedings of the 36th eCAADe Conference Volume 1, Lodz, Poland, 2018, 265-270
- [3] Ingels, B.: Three Warp Speed Architecture Tales, https://www.ted.com/talks/bjarke_ingels_3_warp_speed_architecture_tales, TED Talks.
- [4] Ingels, B.: Yes Is More: An Archicomic on Architectural Evolution, Taschen, Köln, 2009.
 [5] Lee, J.H.; Ostwald, M.J.; Gu, N.: The language of design: spatial cognition and spatial language in
- [5] Lee, J.H., Ostwald, M.J., Gu, N.: The language of design: spatial cognition and spatial language in parametric design. International Journal of Architectural Computing, 14(3), 2016, 277-288. https://doi.org/10.1177/1478077116663350
 [6] The spatial cognition and spatial language of design. Spatial cognition and spatial language in parametric design. International Journal of Architectural Computing, 14(3), 2016, 277-288. https://doi.org/10.1177/1478077116663350
- [6] Lin, C.-J.: The STG-framework: a pattern-based algorithmic framework for developing generative models of parametric architectural design at the conceptual design stage, Computer-Aided Design and Applications, 15(5), 2018, 653-660. <u>https://doi.org/10.1080/16864360.2018.1441231</u>
- [7] Oxman, R.: Thinking difference: theories and models of parametric design thinking, Design Studies, 52, 2017, 4-39. <u>https://doi.org/10.1016/j.destud.2017.06.001</u>
- [8] Quici, F.: Architecture and visual narrative, Multidisciplinary Digital Publishing Institute Proceedings, 1(9), 2017, 1082. <u>https://doi.org/10.3390/proceedings1091082</u>
- [9] Scheeren, O.: Why Great Architecture Should Tell a Story?, <u>https://www.ted.com/talks/ole_scheeren_why_great_architecture_should_tell_a_story</u>, TED Talks.
- [10] Schnabel, M.A.; Lo, T.T.; Qu, Y.: Manga architecture developing architectural narratives, in: Proceedings of the 18th International Conference on Computer-Aided Architectural Design Research in Asia (CAADRIA 2013), Singapore, 2013, 771-780.
- [11] Tedeschi, A.: AAD Algorithms-Aided Design: Parametric Strategies Using Grasshopper, Le Penseur, Brienza, Italy, 2014.
- [12] Veloso, P.L.A.: Cybernetic diagrams: design strategies for an open game, International Journal Of Architectural Computing, 12(4), 2014, 379-397. <u>https://doi.org/10.1260/1478-0771.12.4.379</u>