eCAADe 2018

Computing for a better tomorrow

Volume 1

Editors
Anetta Kępczyńska-Walczak and Sebastian Białkowski
Faculty of Civil Engineering, Architecture and Environmental Engineering
Lodz University of Technology

1st Edition, September 2018

Computing for a better tomorrow – Proceedings of the 36th International Conference on Education and Research in Computer Aided Architectural Design in Europe, Łódź, Poland, 19th-21st September 2018, Volume 1. Edited by Anetta Kępczyńska-Walczak and Sebastian Białkowski. Brussels: Education and Research in Computer Aided Architectural Design in Europe; Łódź: Faculty of Civil Engineering, Architecture and Environmental Engineering, Lodz University of Technology, Poland.

ISBN
9789491207150
978-94-91207-15-0

Publisher: eCAADe (Education and Research in Computer Aided Architectural Design in Europe) and Faculty of Civil Engineering, Architecture and Environmental Engineering, Lodz University of Technology.

Cover Design: Mateusz Pankiewicz

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Sebastian Białkowski

EventMode

A new computational design tool for integrating human activity data within the architectural design workflow

Panagiotis Chatzitsakyris[1]
[1]Aristotle University of Thessaloniki / UNStudio
[1]panosarc@gmail.com

Architectural designers are currently depending on a multitude of elaborate computational tools in order to explore, manipulate and visualize the geometric form of their building projects. However, if architecture can be perceived as the manipulation of geometric form in direct relation to human activities and events that take place inside it, then it is evident that such design parameters are not sufficiently represented in the currently available modeling software. Would it be possible to introduce the human activity element in the aforementioned computational tools in a way that informs the design process and improves the final building product? This paper attempts to answer this question by introducing a new experimental design tool that enables the creation of parametric human activity envelopes within three-dimensional digital models. The novel approach is that this tool enables the parametric interaction of these components with the actual building geometry and generates novel visual and data representations of the 3D model. The goal is to improve the decision-making process of architects as well as their clients by enabling them to evaluate and iterate their designs based not only on the building's form but also on the human spatial events that take place inside it. A prototype implementation demonstrates the tool's practical application through three design examples.

INTRODUCTION

Supported by widespread technological progress, computational design tools have been gradually becoming commonplace among architectural studios and design practitioners. These tools have managed to analyze and visualize algorithmic interpretations of important design parameters (geometric form, materiality, illumination, structural rigidity etc.) in an efficient and productive manner. As a result, extremely accurate digital geometric models are being utilized as the centerpieces of every design stage of building development.

Nevertheless, as a human cognitive process that targets the improvement of physical space, architectural design is inherently dependent on how the users of the space are moving, interacting and perceiving the designed space. This human presence and interaction is implied throughout the development of any architectural project, albeit in a simplistic and abstract manner: the design brief usually designates how each space will be used and corresponding functional text tags are depicted in 2D drawings and in room matrix schedules. However, within the 3D modeling software, where the actual design decisions usually take place, any indication of the human presence is absent. The goal of the proposed tool is to take advantage of the increased computational resources that are currently available and to offer an enhanced and flexible 3D representation of human activity data that could be integrated into popular modeling software. By adding another layer of information into the digital 3D environment and parametrically linking it with existing geometric elements, the assumption is that the designer's point of view will be augmented and that novel ways of visualizing and understanding the building geometry will emerge.

COMPUTATIONAL PRECEDENTS

The first instance of computational design tools that were loosely related with human activity and spatial events can be traced to practical implementations of the theoretical ideas of Christopher Alexander (1964) and Bill Hillier (1989). Alexander's efforts had limited success due to insufficient technical resources while Bill Hillier's team was more successful in creating computer applications (Axman, Spatialist) based on the space syntax theory. These tools have been quite popular among urban planners and designers as they provide data analysis and simulation of road or path networks. On the contrary, their usability in architecture is limited because they only analyze potential movements and not clusters of human activity in individual interior spaces. The same is true for various other applications (Legion SpaceWorks) that promise reliable simulation of human movements in urban contexts or in emergency evacuation scenarios (Figure 1).

More recently, the theme of algorithmically generating spatial configurations based on social and environmental references can be found in the work of Madkour, Neumann and Erhan (2009). Their research focuses on the parametric design of the layout of a housing tower that can be adjusted by human-related criteria such as privacy, sociability, multi-functionality and max occupancy. Although this approach cleverly attempts to introduce human-based data into the 3D parametric design workflow, the actual implementation is limited and fails to capture the actual complexity and richness of the human activities and events that take place in architectural spaces.

Apart from academic computational research, during the last decade there has been a noticeable interest in commercially available tools that address the theme of human activity within the context of architectural visualizations. There are several tools (Populate, an(i)ma, RailClone) that are focused on the distribution of animated avatars within a render-ready three-dimensional model. Although these tools are undeniably useful, they are treating human avatars as simple geometric decorative accessories that are independent from the building components and that are inserted after the design process is concluded.

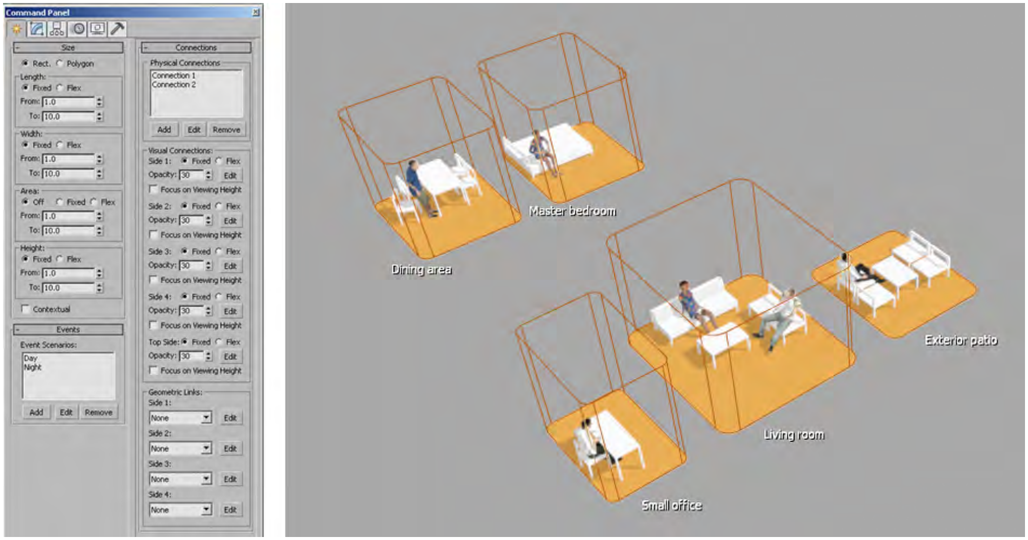
Figure 1
Snapshot of the application Legion Spaceworks

THE NEW TOOL

This paper introduces a new type of digital tool that augments the existing three-dimensional digital modeling software by implementing a mechanism for manipulating and visualizing the human activity and events that might take place inside the designed spaces. The objective is to enable the designer to create computational models where the human presence interacts with the geometric formal elements during the architectural design process.

To facilitate its process, the software introduces a new parametric component that can be described as a transparent, volumetric human activity enve-

Figure 2
Part of the user interface of the plugin within 3DS Max (left) and Event Platforms after the creation of the various events (right).



lope. This component is called Event Platform and its goal is to encapsulate, in an algorithmic manner, the wide range of representations that correspond to how the end users will interact with their contextual surroundings: They can be used as simple, abstract volumes with functional designations based on the project brief but also as clusters of human events with animated avatars that interact with their surroundings. It should be noted that the Event Platforms are separated entities from the actual physical elements of the building. The objective is that, through the proper utilization and manipulation of these elements, the architect would be able to create a separate "human-activity" layer that could be overlaid on and parametrically interconnected with the geometric elements of the model.

The proposed tool operates in two ways: as a modeling tool and as a visualization mechanism.

MODELING

During the modeling phase the user can create Event Platforms and control them through a diverse set of parameters that are organized into three distinct groups: size, events and connections (Figure 2). Apart from controlling the dimensions of each Event Platform (width, length, area, etc.) through the size parameter group, the events parameter group gives the designer the option to assign various event scenarios to each platform. By utilizing established techniques from other digital fields (character animation), the proposed tool enables the designer to create simple avatar sequences with minimal hassle through the assistance of pre-established motion capture libraries (Figure 2).

The third parameter group (connections) regulates how the Event Platforms connect with each other and with the actual geometric elements of the 3D model. By assigning connections between certain platforms, the designer can establish how the human users can move between the platforms. Therefore, the passageways from each space to the neighboring ones can be positioned in a parametric manner. At the same time, the architect can adjust the intended opacity of individual borders of each platform to control the optical relationships among the different Event Platforms as well as their visual connections with the environmental context (Figure 3).

Finally, the designer can assign parametric geometric panels (Figure 4) to specific borders of the Event Platforms. The concept is that the embedded physical characteristics of the panels (type and distribution of openings, materiality, topology of their surfaces, etc.) are informed by the opacity of the borders and the positioning of the platform-to-platform connections to algorithmically produce the final geometry. In a sense, the geometric form of the building can conform and wrap around its human activity underlay (Figure 5).

Apart from assisting the architect during the conventional manual modeling phase of the project, the Event Platforms are also capable of automatically producing alternative potential spatial configurations of the designed outcome. Since each component has embedded knowledge of its preferred physical and visual connections, the software can algorithmically create large numbers of iterations and consequently evaluate them based on the designer's preferences. In the end, the designer is presented with a small number of solutions that best comply with the desired connections. This computational feature takes advantage of the parametric nature of the platforms and slightly shifts the creative process from manual to semi-automatic (Figure 6).

VISUALIZATION

In order to adequately encapsulate the complexity of events and human activities in space, the proposed tool utilizes the positioning of the avatars of the Event Platforms and creates various digital cameras around them by adhering to established cinematic conventions. After creating a large number of cameras, a representative sample of the best shots is algorithmically compiled into an animation matrix that shows up to 25 different frames (Figure 7). This human activity animation matrix constitutes a new visualization mechanism that offers a fresh representational perspective during the design process.

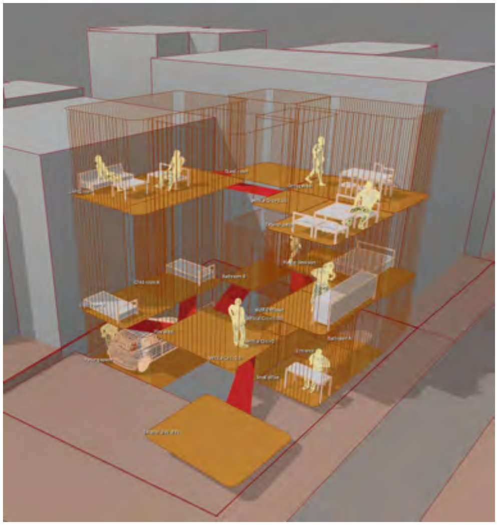


Figure 3
A configuration of Event Platforms with physical and visual connections between them.

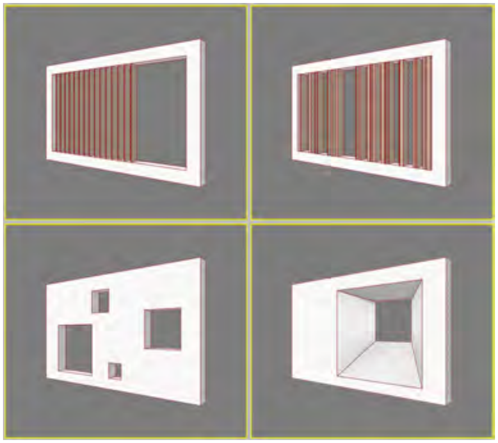
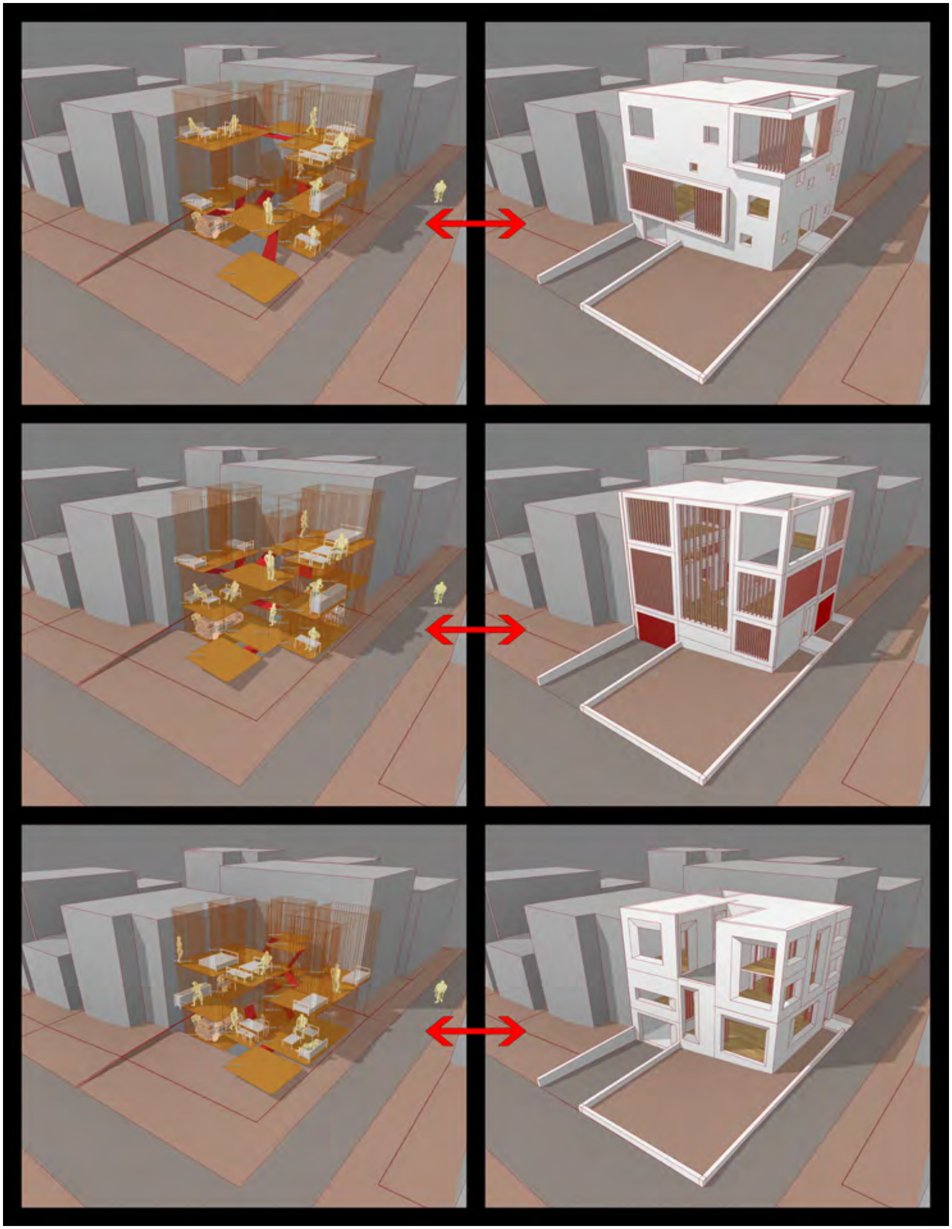


Figure 4
Four types of parametric panels for a certain project.

In addition to the animation feedback, the Event Platforms are capable of analyzing the frames of all the point-of-view cameras and extracting useful data

Figure 5
Three different configurations of Event Platforms with the corresponding panels that are linked based on their physical connections and visual opacities.



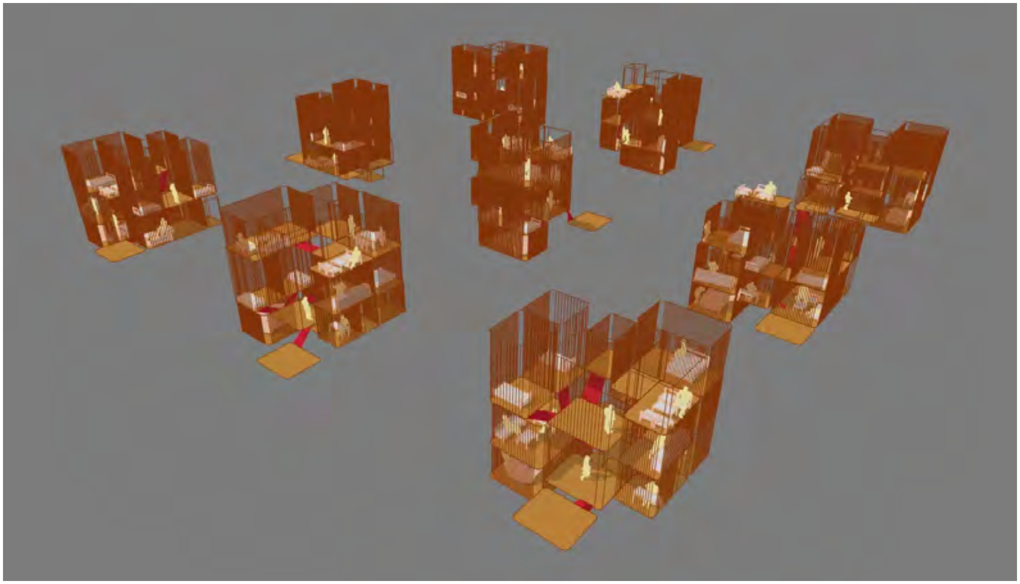


Figure 6
Automatic generation of 9 alternative configurations based on the Event Platforms desired connections.

Figure 7
An animation matrix consisting of nine cameras depicting various events inside and outside of the designed building.

out of them. Apart from the visual imagery that they provide, the viewpoints of the avatars can provide additional information that could be translated into useful diagrams (Figure 8). The digital tool can currently monitor data about the contextual environment (how much environment is visible to each avatar), other avatars (how many of the other avatars are visible to each avatar) and average spaciousness (the average distance of the first obstacle in front of every avatar).

Figure 8
A typical data diagram.

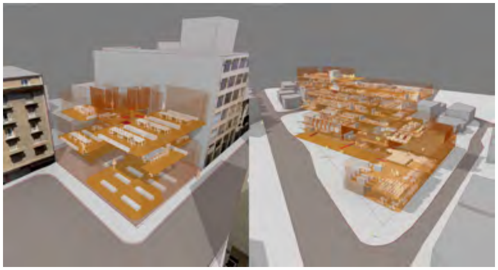


Figure 9
An office building (left), a bank headquarters complex (right) and the small residence depicted in Figure 4 were the three experimental design examples.

EXPERIMENTATION AND EVALUATION

In order to illustrate the use and benefit of this proposed software, a prototype 3DS Max plug-in has been implemented and has been put into use through three diverse experimental design projects: a small residence, an office building and a mixed-use complex. These examples differed in scale and complexity and focused on evaluating and critiquing the usefulness of the tool workflow under a diverse range of test-cases (Figure 9).

In each case the design brief was translated into Event Platforms which were further enhanced by the insertion of animated avatars that represent human activities. Consequently, these platforms were parametrically connected with each other based on their desired relationships and manually placed within the building site in order to achieve a first initial configuration. The tool was then utilized in order to automatically generate two additional configurations of the Event Platforms. Subsequently, all three configurations of each design example were assigned various parametric geometric panels in order to produce the finished building models.

At that point, each model was evaluated based on tool-generated animation matrixes and data diagrams and was optimized accordingly. This feedback loop was repeated until the resulting model was deemed satisfactory.

CONCLUSION

The design experimentation has demonstrated that the proposed plugin could have a quite positive impact during the architectural decision-making process. By operating both at the more abstract scale of functional areas and at the more experiential scale of moving avatars, the Event Platforms manage to integrate human activity data into the 3D geometric model. This additional information layer can prove beneficial both for modeling and for visualizing architectural projects.

As a modeling aid, the plug-in is able to quickly generate different adaptive façade options, based on the Event Platform configurations. At the same time, the tool has the ability to automatically generate alternative spatial configurations of the Event Platforms based on the parameters that the user provided. Most importantly, the software encourages the designer to establish bidirectional connections between the Event Platforms and the parameters of the physical elements. This results in an enhanced digital building model that enables a much more comprehensive understanding of its spatial relationships while constantly maintaining interactive flexibility.

At the visualization level, the avatar-based cinematic animation matrix and the data diagrams demonstrate novel representational features that are missing from existing visualization techniques. The experiential quality of the multiple cinematic camera views as well as the quantitative data diagrams of the avatars' positioning and point-of-view are not only contributing to the augmented understanding of the human-enhanced model but are also suitable for the effortless generation of presentation material for each project. Therefore, although this tool is originally intended to be used during design development, an architect may opt to use it strictly as a visualization tool after the design is concluded.

The future development of the tool targets three areas of improvement. The automatic generation of alternative spatial configurations can be optimized by inserting customized parameters that can better guide the process based on the designer's aspirations. Another point of emphasis is the integration of VR export capabilities for the human activity animation matrix. Finally, the data categories that are depicted in the diagrams can be expanded to include more complex information about the human activities that take place within the platforms.

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