The Limitations of Simulation Software in Architectural Design

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ABSTRACT

Pedestrian simulation software is a design tool that can be useful in helping designers make designs informed by the movement of pedestrians through a defined space. This study looked at the application of the software to a situation in which the motivations behind the movement were a key factor. This led to complications and the discovery of a better experiment for wanted results. It also led to the discovery of the limits of the software as well as the applications in which the software would be useful for designers.

Introduction

This paper describes the process in which I attempted to research the flow of people through a modeling software and ended up concluding that computer modeling is only sufficient in a limited number of situations.

Over the years various researchers and computer scientists have been working to develop accurate modeling software for the analysis of the movement of people through spaces. However the software has limitations that need to be accounted for by the user. This research was completed with the goal of developing a new approach to architectural design through the use of pedestrian models. However upon learning several programs currently at the top of the market it was concluded that this approach requires extensive knowledge beyond the software.

The philosophical framework for this research is positivism. This project is assuming an objective reality and therefor the researcher is apart from reality. This also means that the researcher is independent form what is being researched. The logic for the process is primarily adductive as the research is attempting to determine the means by which a result can be achieved. The process of simulation is defined and the results were assumed to be known and they were hoped to lead to the understanding of the architectural form.

Background information

Crowds have been studied for decades prior to 1900 and as time has progressed the methods of study as well as the theories have become more accurate as well as sophisticated. Much of the study of crowds has been focused on the phenomenon of the behavior of people in large groups and mobs. This mob mentality has been the main focal point of study for years and many researchers are still working to refine the ability to predict these behaviors.

Within the research of pedestrian movements a new method of computer modeling has become increasingly popular. These computer models try to accurate predict how people will move based on various factors. The methods that have been employed started out as very simple models and over time have employed such methods as transition matrix, route choice, fluid-dynamic, gas-kinetic, and queueing modeling. However many of these models, while maybe working at a small scale or in simple situations, were unable to reproduce the same patterns that have been long observed in large crowds. The more complex of these patterns include development of lanes, stop-and-go waves, crowd turbulence as well as oscillatory changes of pedestrians at narrow passages at higher densities.

One of the most popular methods currently is behavior-force modeling. The most recent type of which is the social-force model. This style model simulated the “forces” acting on each individual. This not only includes physical forces but also forces based on internal motivations to perform certain movements. The program will balance both the individual’s perception of the

situation and the environment as well as the personal aims and interest and uses them to simulate a behavioral reaction. In Dirk Helbing and Péter Molnár's article "Social Force Model for Pedestrian Dynamics" they prove that these motivations can be described by a social force model (Helbing & Molnár). They show that the simulations were able to accurately predict the development of lanes as well as oscillatory changes of pedestrian walking patterns at narrow passages.

Outside of computer modeling one of the most influential study was completed by William H. Whyte in 1980. Detailed in his book The Social Life of Small Urban Spaces as well as a film by the same name, the study observed several urban plazas in New York with the aim of discerning the factors that determine the success or failure of a space. Through the study he identified many innate rules that the pedestrians were generally following.

Discussion of procedure

To begin the research a site was selected Minneapolis, Minnesota that is known to have extensive amounts of pedestrian traffic around it. Then an area around the site was selected incorporating many of the common pedestrian routes of the area. Data was then gathered from the cities archives about the number of pedestrians that used the trails surrounding the site. The site was then observed for several days and data was collected at various periods to gather a sample data set. The data gathered was a count of number of people passing a certain point at various spots on the paths surrounding the site. This data was compared with the historical figures to create a working data set informed by both sets of numbers.

Beginning the modeling process required gaining a working knowledge of the selected program. In this case the software Anylogic was recommended by the advising professor. To begin, the graphical interface of the model was developed.

The goal was to use the patterns of the pedestrians within the area surrounding the site to inform the most likely or the most common entrances and exits within the limits of the site. It was presumed that the specific site could then be analyzed using these points as pedestrian sources and exits. Walls, attractors and other parameters would then be added to the space to study the changes in the patterns of movement. The goal was to create different environments and see how people would react to each change.

To develop the graphical interface, maps of the surrounding area and the site were imported into AnyLogic. On the map, walls were added blocking off the areas pedestrians would be unable to go such as streets, buildings and the lakes in the area. Using the data set created about the pedestrian movements in the area, various points on the map were created and became both the generators of the pedestrians as well as the destinations. These points were connected by the code of the simulation and the percentage of the pedestrians for each point was informed by the data set. The simulation was then run and the area around the site was analyzed for the areas of the heaviest traffic. These became the points that would inform the next stage of the research.

Results and conclusions

At this point in the simulation process it started becoming clear that the simulation software alone was going to be unable to become the medium through which the intended parameters could be studied. However this does not suggest that the software is not useful in other ways. Through learning and using the software it was determined that while the parameters that this study was focusing on exist within the simulation software, they have to be programed by the user. The main parameter where this is most evident is the attractor block. This seemed to be a truly promising block that would help determine how people would move with not only physical barriers but psychological barriers such as attractive store displays, engaging architecture, as well as other potential "attractors" present in a space. The problem that the software faces is the programming element. It is up to the user to decide how many people will be attracted and how close they have to get to the attractor to have their path altered. These elements that the user needs to define are the elements this study was seeking to study.

This realization of the limits of the program determined the failure of the research in the way that was defined but started an informed analysis of this software with the goal of determining the uses for this style software in architecture. This consisted of evaluating situations that a simulation may be needed and determining the number of parameters that the user would know or could reasonably guess verses the number and nature of the parameters the study would be focused on. If any other parameters are to be studied using the software, the researcher will need to bring a reasonable amount of knowledge to the model when writing the commands. If these commands are not informed by reasonable additional research then the results of the model must be taken as a suggestion of one possible outcome.

In this specific situation the additional knowledge that would need to be gained to effectively determine credible results would end up becoming the main focus of the experiment. The study which would have to be done in either a manner consistent with psychological studies or in the form of a review of already completed experiments, would have little use for the simulation software and it would merely be used as a design tool after the results of the study determine the way in which the software could be programed.

Implications for practice

This study provides an evaluation of pedestrian simulation software and its relationship to architectural design. It discovered that the limits of the software are related to the designers' knowledge. Since the behavior of the subjects in the model is mostly decided by the code that the user writes, the user has to determine if the variable that they are looking to study can be isolated into the few behaviors that the program does determine. There are several situations where this is the case and the software can still be relevant to architects and designers. Any situation where amount of space is the variable or where there is a defined space and another element such as number of ticket stalls, cashiers or loading docks is the variable would be a viable use for the software. Therefore, this program is useful in many situations that designers may want the software for, but they need to carefully evaluate the specific variable and situation to determine how best to study the variable.

Reference List:

Helbing, D., & Molnár, P. (1995, May 1). Social force model for pedestrian dynamics. Retrieved September 25, 2015.