Critical Methods in Computer-Mediated Performance and Phenomenology-Based Systems

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Abstract. *The main goal of this article is to provide a critical reflection on what computing may contribute to an open understanding of performance in architecture. We propose a phenomenological approach to computing since it combines several concepts concerning the user's experience of space. In order to study the human movement in space, we will present the results of a sequence of applications using open source software Processing, including time-lapse movies, frame differencing analysis and blending images tools. The research used the context of a existent building at the campus of Universidade Federal do Espírito Santo. A series of interviews with users were also conducted in order to validate the computing analysis.*
Keywords. *Performance; computing; phenomenology; programming.*

INTRODUCTION

The main goal of this article is to provide a critical reflection on what computing may contribute to an open understanding of performance in architecture. The idea of performance is normally associated with energetic approaches, which considers measurable factors of the environment such as solar radiation, wind direction and energy consumption. The energetic approach is extremely important, but we understand that it is only a specific portion of the broad scope of performance. In our perspective computing has the potential to disclose more interactive and appropriative factors of architecture and to complement the evaluation of its performance.

We propose a phenomenological approach to computing since it combines several concepts concerning the user's experience of space. According to Saramago (2008) a main interest for architects in phenomenology is Heidegger's consideration that every appropriation of space is movement-based, and that there is no existence without movement. In order to study the human movement in space, we conceived a sequence of applications using open source software *Processing*. It included the capture of time-lapse images, imagery processors, blending tools, in order to capture these movements. The result is a information database consisting of time-based tracking images, which offer new perspectives to analyze the performance or architecture.

PHENOMENOLOGICAL ASPECTS OF SPACE

The concept of experience is central in phenomenological studies. The way users move across the space is a substantial aspect of experience. Influenced by Heidegger's theory Saramago (2008) says that the experience of space is made by movement in a se-

ries of *nows* that succeeds each other in a temporal line. According to him the movement is characterized by a sequence of intuitive impulses that comes from our previous memories and our past experiences of space.

In phenomenology, movement is not a mere displacement, but an experience of cognition and perception based on subjective preferences. Nevertheless, mapping people's movements in space is not sufficient to understand the extension of each individual's experience, but in some way may reveal patterns of specific groups.

The phenomenological approach to architecture assumes the dynamic condition of spaces, establishing the user's perception as the main point of reference. The user experience should be an important variable in the performance equation. It should be used to complement the energetic analysis adding a user behavioral variable in the process of evaluation. The mapping process was achieved using real experiences in the context of an existent project recently built in the university campus.

Christian Norberg-Schulz (2008) defends the idea that a building must reinforce subjective connections with users by adding perceptual and sensorial openings to its tectonic structure . These openings should be perceived through kinesthetic experience of its tridimensionality: how we move, the routes we choose, how circulation elements affect our cognition and orientation. All of these dynamic aspects combined, according to Norberg-Schulz, produce a visceral experience in users, and helps to develop our subjective impressions and consequently the identity of architecture.

PROCESSING APPLICATIONS FOR MOVEMENTS

Using a combination of digital applications developed using *Processing* algorithm we sought to develop a visualization system to analyze the kinetic experience of architectonic space. The *Processing* algorithm is a text programming language specifically designed to generate and modify images (Fry and Reas, 2007). The benefit of using this kind of language lies on the freedom of access to script functionality, allowing the conception of specific algorithms for specific projects.

The global idea beneath the project was to capture movements along large period of time, and register a significant amount of information in small and easily accessible files. The combined use of time-lapse movies associated with *computer vision* techniques provided interesting patterns and results. With time-lapse movies it becomes possible to capture all kinds of movements, and the *computer vision* techniques allowed to process and extract meaningful information from each footage (Fry and Reas, 2007). The detection motion functionality called *frame differencing* was very helpful in the processing step. Fry and Reas detail this technique:

"The movements of people within the video frame can be detected and quantified using a straightforward method called frame differencing. In this technique, each pixel in a video frame F1 is compared with its corresponding pixels in the subsequent frame F2. The difference in color and/or brightness between these two pixels is a measure of the amount of movement in that particular location" (Fry and Reas, 2007).

The camera was positioned in different points around and inside the building in order to capture images every six seconds for thirty six minutes. The result of this operation was a two minutes long movie, created using three hundred sixty images, at two frames per second. The duration of capture was chosen by the convenience of the tests, and the time-lapse movie configured to better visualization of the frames. The final file format was a *Quicktime* movie (.MOV).

Processing's video library easily recognizes the notebook's webcam to capture images. The time-lapse code also requires algorithms to define time intervals of shooting and to convert all images to a movie file. The movie file is then imported to another *Processing* application with the purpose of processing the frame differencing algorithm. In this stage the application compares each pair of subsequent frames and identifies which pixels have different properties. In real life, these pixels represent

the portions of the image that moved, probably affected by a person, animal or vegetation. The moved parts imprints black pixels on the white background, much like a x-ray radiography.

The last stage of the processing is blending imprints together to achieve one final image that corresponds to a radiography overlay of all pixels that moved along the length of each footage. This image is very enlightening about the intensity and direction of flows in each angle of the camera.

THE ANALYSIS OF PROCESSED IMAGES

There are numerous aspects in the final images that deserve attention. In general the process creates a conceptual displacement in the understanding of architecture, moving from the traditional view of buildings as objects to a vision of architecture as a sequence of events and overlaps. The overlay of frames shows how complex is the number of distinct appropriations in a short period of time. It is possible to visualize main circulation routes, but also secondary tracks, areas of informal displacement, spaces of isolation, conurbation and crossings. Between these routes, we can recognize overlapping areas, normally on crossings and borders. According to Alexander (1966) these overlaps are essential for creating a deeper social experience in any environment. The concept of a good environment is, for Alexander, an opposition to a physical receptacle. In his construct, the main idea is connected overlap-

ping systems mix together like a network.

In the cases showed in Figure 1 it is possible to identify how informal paths (on the left side of the figure) have the same intensity as designed pathways (right side of the figure). In this case, it is important to consider that the distance comprised by each one of the paths is the same, what indicates that the choice option of one or another may have subjective or cultural motivations. In Figure 2 we can see how the intensity of people's flow makes a trail at the ground, indicating a constant use of this informal path.

In Figure 3 the majority of displacements occur in the formal path, but the frames overlays reveal the presence of a user on the informal path. Figure 4 reveals what seems to be a small group of people standing in the base of the ramp for a few minutes, probably chatting or wandering. The location where they are standing configures an overlapping zone in the crossing point of two paths.

Some minor details could be noticed only through the analysis of the raw data in the time-lapse movie before the *frame differencing* step. The reason is because the *frame differencing* and the blending process tend to equalize the differences and the particularities of each frame, generating a sort of summary image. The frame-by-frame analysis shows unexpected appropriation of some parts of the building. One example is a recurrent use of the second floor circulation by some users who wants

to take a break, smoke or just contemplate the view. In Figure 5 we can observe this place marked by a white square. The architect admitted that this portion of the building was the end of a corridor and had no practical use in the circulation flow of the building. It was just an open-use space left for appropriation. The privileged view of this place from the surroundings and the borderline position to formal circulation may have favored this appropriation.

In general, the areas around crossing paths are constantly appropriated by informal situations, such as bicycle parking, chatting, meetings, as we can see in Figures 6 and 7. The design of the building had the intention to connect its circulation areas with the existent flows of the surroundings. As a scientific method, the time-lapse movies offers very accurate examples of space appropriation by its users, and might be useful for landscape design, post-occupation analysis, and building performances evaluations.

The idea of monitoring and mapping movement is not new in architecture and urban planning. The Space Syntax project gave important contribution to movement-based modeling, expanding the theoretical vision of the space as a dynamic and complex system. One of the basic goals of this project is to detect some sort of sense in the apparent disorder of urban paths. In our project, the applications also allowed the identification of different patterns of use, both in position and in intensity. We named

this situations as informal. A direct contribution of Space Syntax project is the concept of connectivity. According to Hillier (1998), the connectivity is based in the evaluation of how many possibilities of integration a building produce concerning its surroundings. Although this idea of connection is related to physical integration, it also reflects Norberg-Schulz's idea that a building must offer openings and possibilities of connections, subjective ones (Norberg-Schulz, 2008).

The concept of connections should be certainly adopted as a criteria for performance evaluation of every building. As we can see in Figure 8, there is a direct continuity of external movements through the ground level of the building, which indicates a natural opening between the space inside building and outside space. The *frame differencing* tool shows patterns in chaotic behavior and at the same time shows deviations in the pattern movements. The

Figure 6
Users appropriate the sur-
roundings for bicycle parking.

Figure 7
Point of crossing paths is a
meeting area.

movement's linearity in Figure 8 is a result of isolated frames of *frame differencing*. The movements of each person represented in the figure probably took place in different times.

INTERVIEWS

A series of interviews with the users was conducted at the same time of the time-lapse capture. The idea was try to identify some similarities between the time-lapse analysis and user's personal impressions of the architecture. In the interviews users were asked to comment in a few worlds: the personal occupation in the building, the sensorial perception (light, heat, sound, orientation), the places used in breaks, the aesthetic evaluation, formal analogies or building elements that draw attention, the potential sight views, unusual aspects noted. The interviewers

Figure 8
The blending image shows the
linear path implemented by
pedestrians.

were also asked to take a picture of something representative. The questions were intentionally open in interpretation, in order to capture subjectivities in each response.

Listening the interviews, the first impression of all users is that they had no affective relation with the architecture. All of them said that their relation with the building was strictly functional. But implicitly, it was possible to note positive observations provided by the relation inside-outside, expressed by the visibility of the surroundings offered mainly by circulation areas and the lobby of the building. They cited the sight from the ramp and from workspaces as the better places to contemplate the campus and the outside vegetation. Figure 9 was taken from the lobby entrance by interviewed employee, as the most representative situation of her daily experience in the building. The pictures taken by users may indicate symbolic values of each one experience, or something that users cannot explain into words. It helps to identify what Norberg-Schulz (2008, p. 450) defines as *concrete space*. In this case the picture helps to reveal a *continuum* of inside-outside relation of the user with the surroundings. For some users it was a pleasant feeling.

The qualities of the lobby as a *continuum* of the outside space into the building and its position next to overlapping areas of movement creates favorable conditions to informal meetings. In the interviews users confirmed this fact, as well as in the second

floor, where the employees met to smoke, take a break and appreciate the view. This situation was detected in the time-lapse as shows Figure 5.

Another aspect that helped to identify subjective connections in user's experience was their formal impressions of architecture. They associated the red columns of the building's lobby with brazilian-italian architect Lina Bo Bardi's architecture, and the ramp with the architecture of Oscar Niemeyer. They also associated the shape of the building with a stapler. Figure 10 shows the *frame differencing* process of the ramp, and it is possible to note significant movement on it. The ramp constitute, both in the subjective impressions of users and in the circulation function of building, an important element of the architecture.

CONCLUSION

We understand that the association of computing techniques with a phenomenological approach to architecture is a good contribution to the understanding of performance in building analysis. The time-lapse movies enables the record of long periods of time in small files, the *frame differencing* helps to process the images recorded identifying differences in the frame sequence and the blending application shows the patterns and the deviations in all processed images. It is important to highlight that all applications and scripts were made 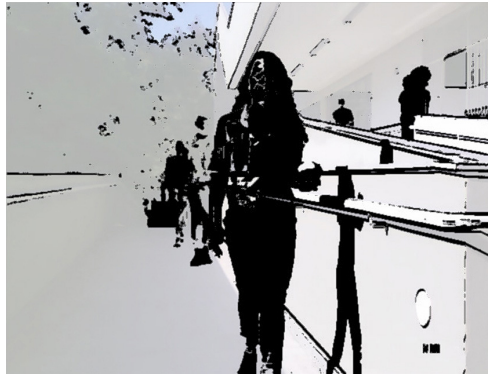in open source software, proving that it is possible to develop accessible scientific methods through free platforms of programming.

In our vision, the evaluation of every building should consider as an fundamental criteria the dynamic condition of users appropriation. The images prove that the way users appropriate architecture is based on both formal and informal actions, objective and subjective thinking, and the building must offer strategic openings to this differences.

The computing techniques still need more development in order to become more accurate. The selection of views and intervals of time-lapse movies also need more adjustments. Some minor programming problems remain unsolved but it will soon fixed and debugged.

The lines of code used in this research are available [1].

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