Le Corbusier in Bogota: A 3D Immersive Model in an Urban Heritage Context

Jhon Alejandro Triana Trujillo
Universidad de los Andes, Colombia
✉ ja.triana955@uniandes.edu.co

Diana Fernández Prieto
Universidad de los Andes, Colombia
✉ dian-fer@uniandes.edu.co

Juan Camilo Ibarra
Universidad de los Andes, Colombia
✉ ju-ibarr@uniandes.edu.co

José Tiberio Hernández
Universidad de los Andes, Colombia
✉ jhernand@uniandes.edu.co

ABSTRACT.

Le Corbusier in Bogota 1947-1951, was an exhibition that presented the contrast between the urban development proposal of *Le Corbusier* in the fifties and the current city. A system has been developed in order to provide the audience with an interactive 3D visualization in the exhibition. This paper describes the *focus-context* model used to show the differences between the current state of the city and the design by *Le Corbusier*, as well as some aspects about human-computer interaction to design the user experience based on audience assessments. The exhibition was held in Bogota from April to June, 2010.

KEYWORDS: immersive visualization, urban heritage Bogota, Le Corbusier in Bogota, human-computer interaction, usability test.

Today, Latin American cities have high growth rates, and this uncontrolled growth pushes them into unplanned development to satisfy their needs and to provide the resources they require. Urban planning and government policies try to control the situation by establishing parameters to stop the ungoverned development (DeMattos, 2002, 5 -10). Historically, city administrators and citizens have recognized the importance of urban planning and regulating policies, particularly in developing Latin American cities like Bogota. A lot of projects and plans have been designed, but only a few of them have been implemented because of political, economical, cultural or social reasons. Inherited buildings, public spaces and urban infrastructure, as well as implemented and proposed plans are considered urban heritage (Rojas, 2002).

Charles-Edouard Jeannneret Gris (Chaux-des-Fons, 1886 - Paris, 1965), a brilliant and polemic architect known as "*Le Corbusier*" (O'byrne, 2010) arrived in Bogota in 1947, where he found a historical city situated on a staircase landing surrounded by mountains, an ideal place to share his unique ideas. After some conferences and academic activities in 1949, he was hired to design downtown Bogota. The proposal was very innovative but unfortunately it was not completed due to political reasons (Tarchopulos, 2006). Currently, the proposal is a reference for urban planners, architects, engineers, students and the general public; it is part of Bogota's heritage. In 2010 the book "*Le Corbusier en Bogotá 1947-1951*" (O'byrne, 2010), was published; it is a compilation of Le Corbusier's work in Bogota. As part of the study and the publication, an exhibition to divulge Le Corbusier's work and Bogota's urban heritage was mounted.

Le Corbusier's proposal consisted of approximately 80% free space; today the situation is completely the opposite. In the past 60 years, downtown Bogota has increased its construction density dramatically. This growing density has not been accompanied by quantitative and qualitative improvement of circulation systems and public spaces. The interactive application developed highlights the current lack of public space in downtown and shows that the existing public space is unevenly distributed and is mostly paved. To better understand the city that Le Corbusier created, the exhibition offered visitors an interactive installation where it was possible to compare the civic center proposed by Le Corbusier with the current downtown.

This article aims to illustrate to offer the readers a historical context, a review of related works, the model design and development, a description of user interface, an experience assessment, results, and conclusions.

Related Work

Visualization and interaction techniques have been used to help the human cognitive process in many disciplines. For this reason we find interactive interfaces almost anywhere, from industrial plants to classrooms, and recently in museums. Currently, virtual environments are used to complement exhibitions in public places and museums. Similar cases were analyzed to build the virtual environment that complements the exhibition "*Le Corbusier en Bogotá 1947-1951*".

The first work that was studied was *Reconstructing Leonardo's Ideal City - From Handwritten Codexes to Webtalk-II: A 3D Collaborative Virtual Environment System* (Barbieri, 2001). This example uses virtual environments oriented to cultural heritage and collaborative virtual environments. The application was developed using a framework called WebTalk-II based on Java 3D. This application displayed the most important ideas that Leonardo developed for an ideal city, and the model contains buildings, water channels, and machines designed by Leonardo.

Another project that was studied was Virtual Rome, which was developed on web-based infrastructure in order to support its distribution. The application was created to help archaeologists by giving them the possibility to visualize different models and compare them. The users could visualize current landscapes, ancient landscapes, ancient vegetation, interiors and other interesting views. The project required web integration, 3D models, natural elements, and visual quality effects (Calori, 2009, 177-180).

Building the Model

Building physical models involves integrating several disciplines, in this particular case, architecture and computer and systems engineering. The complete model is made up of the model of Le Corbuiser's vision, the current downtown model and the spatial context for both models.

The school of architecture generated the first 3D model according using the original data sources such as blueprints, presentations of the proposal and the Director Plan for Bogota (O'byrne, 2010). In the first stage, the blueprints were scanned by layer, and the most relevant layers were selected and overlapped to generate a complete layer. After the generation of this layer, the buildings designed and described by the Director Plan were placed on the model based on an architectural view. The model was rendered and exported to a generic format supported by the final application.

The second stage was building the model of downtown as it is today. The information used to build the model was provided by district cadastre and it consists of geo-referenced buildings and their heights and other important information. The generation of the model of current downtown Bogota began by reading shape files. Then, the shapes were extruded to obtain the volumes of the buildings. The 3D forms were scaled to fit the coordinate system and finally, the most representative buildings or landmarks such as historical churches and public places were built and added to the model.

To complete the model, it was necessary to recreate the environment and provide users a geographical reference object inside the model. The most important objects for the model were the mountains and the geographic coordinates or compass rose. In Bogota's case, some of the most representative spatial objects were the mountains, *Monserrate* church and *Plaza de Bolivar* square.

Designing the Interface

This section describes how the user interface was developed. The first section describes the graphical user interface development using visualization and interaction techniques; the second section describes the physical user interface used and its control schema.

Graphical User Interface (GUI)

The GUI developed for this application is a 3D stereo visualization. This technology allows users to have a more realistic and immersive experience by taking advantage of the model characteristics. In this case, we chose a passive stereo projection. This type of projection is possible to set up using common projectors to which polarized filters are added. The users should wear polarized glasses to perceive the tridimensional effect. In figure 1 a screenshot of the GUI is shown (Fig.1).

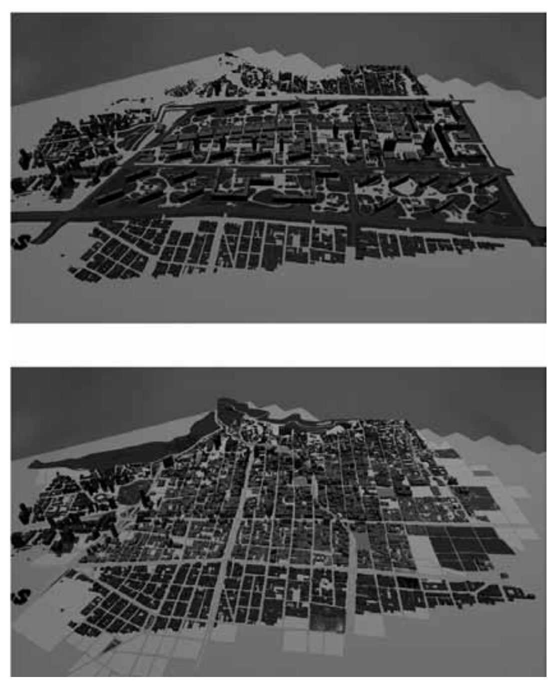

Figure 1. Application screenshot

Physical User Interface (PUI)

The interaction device selected is a commercial steering wheel. The wheel is connected to the computer in which the application is working and it sends data to the application for changing the camera's position inside the model. In order to provide users a full experience, it was designed using a specific control schema for interacting with the application. The control scheme is shown in figure 2 (Fig.2).

Usability test

This usability test (Rubin, 2008, 65-91) was designed to gather assessment data about the effectiveness of the 3D interactive model as a tool for exploring urban architectural spaces.

Objectives

- Measure the user experience with regard to performance and self-reported metrics.
- Understand the differences between users (more confident with technology but less knowledgeable about the city and vice versa).
- Identify key aspects when developing a 3D interactive model as a tool for exploring urban architectural spaces.

Description

The application developed allows users to travel through the civic center proposed by Le Corbusier as well as downtown Bogota as it is today. A steering wheel like those used in the racing games offers users the possibility of moving in different directions and at different heights within the city. A button allows users to interchange the two models while they travel through the city, allowing them to compare the size of the buildings, roads and green spaces of the civic center with the current city. A picture of the system in the exhibition venue is shown in figure 3 (Fig. 3).

All the participants tested were visitors to the museum and the only requirement made of them was that they had a minimal amount of previous knowledge of the downtown area. The participants were asked to perform three tasks:

Task 1: Identify the cardinal points in the 3D model
Task 2: From a default starting point, drive to the middle of the Plaza de Bolivar square and stay at ground level
Task 3: From the Plaza de Bolivar square look at Monserrate church by changing the camera's direction and inclination

An additional task was included in the test without the knowledge of the participants:

Task 4: Discover a hidden button that allows the user to interchange views in the application.

We collected data about time-on-task for each task as well as qualitative data about the experience of the participants interacting with the application.

Participant Characteristics

The test was conducted with a total of 12 participants who were selected based on their satisfying four different conditions concerning their previous experience; participants self-reported belong to one of these experience conditions. These conditions, as well as other participant characteristics, are described in table 1.

Results

Performance metrics: time-on-task (Tullis, 2008, 74-81) was the measure selected to assess performance, and it consists of the time elapsed between the beginning of a task and the end of a task. This measure helps to analyze the effectiveness of the interaction proposed for different types of participants.

Table 2 shows the time-on-task for each participant classified in a specific experience condition (Table 2). The average time-on-task for all participants of each experience condition is shown in (Fig.4).

Self-reported metrics: these metrics were used to gather "subjective" or "preference" data from users (Tullis, 2008, 123-128). The method used to collect this data was open-ended questions in which users provided their opinion of a specific

Figure 2. Interaction device and control schema

Figure 3. System installation

Type	
Museum visitors	12
Age	
11-20	6
21-30	4
31-40	1
41-older	1
Gender	
Female	4
Male	8
Experience condition	
1. More confident with technology, less knowledgeable about the city	3
2. Less confident with technology, more knowledgeable about the city	3
3. Confident with technology and knowledgeable about the city	4
4. Not confident with technology and not knowledgeable about the city	2

Table 1. Participants' characteristics

Participant	Experience Condition	Time-on-Task (expressed in seconds)			
		Task 1	Task 2	Task 3	Task 4
Participant 1	4	90	160	75	16
Participant 2	1	76	44	18	170
Participant 3	3	18	91	69	54
Participant 4	2	30	160	60	NULL
Participant 5	3	12	29	20	NULL
Participant 6	2	43	105	34	30
Participant 7	3	10	77	21	46
Participant 8	1	43	60	27	NULL
Participant 9	4	150	30	17	44
Participant 10	2	7	236	41	12
Participant 11	3	20	38	22	9
Participant 12	1	10	55	23	3
Average		**42.42**	**90.42**	**30.58**	**42.67**

Table 2. Time-on-task data

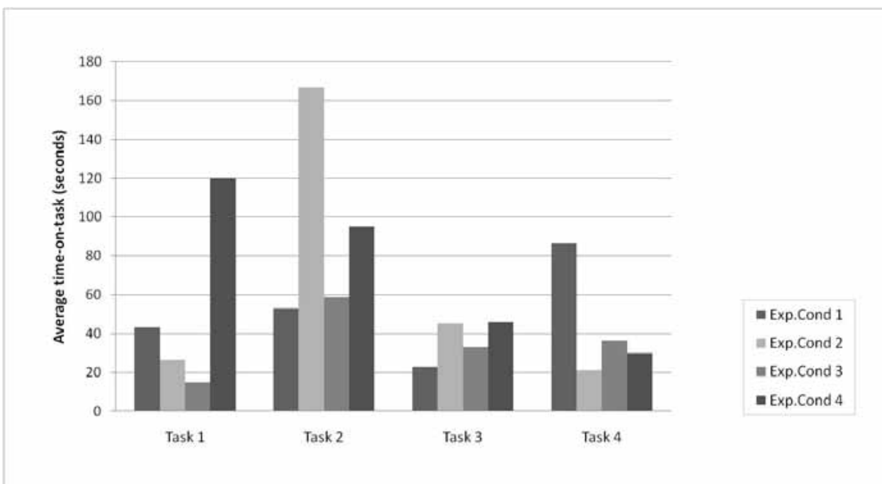

Figure 4. Average time-on-task for each type of experience condition

subject. Here are some of the aspects highlighted by participants at the end of the test:

- In general, the participants were satisfied with the experience and emphasized the value of the application as a tool for promoting knowledge about urban heritage.
- The participants were impressed with the difference between the two models. They stated that it was easy to compare them thanks to the landmarks included in the models.
- The participants with less knowledge about the city highlighted the importance of including landmarks in the models.
- The participants with less confidence with technology highlighted the importance of having an intuitive interaction for exploring the models.
- The participants suggested a version of the models with more details such as the texture of the buildings or lighting effects.

Conclusions

Based on the analysis of the test realized with the public sample presented, it is possible to outline some issues that must be considered for the successful execution of a 3D immersive application of an urban architectural space. These issues are:

Spatial Model Realism

Sources: by source we mean the blueprints, detailed descriptions, sketches and other documents that specify the materials, dimensions and spatial references of the model. The quality of these sources largely determines the realism of the model.

Details: the information sources and the level of detail to be implemented in the model.

Cost-benefit analysis: the balance between the quality of navigational "time delay" and the cost of building the model.

User Immersion Factors

Spatial orientation references (landmarks): highlighting some places that can be easily recognized by users will help them to position themselves within the model, enriching the experience.

Ambient and scene details: adding realism to the model by including light effects, textures and ambient objects such as trees, persons or cars will improve the user immersion levels.

Interaction design: well defined interaction will help users explore the model with confidence; this includes the selection of the physical user interface, its integration with the graphical user interface and the controls schema design.

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