Visualization of Emotions Experienced in the Use of Immersive Augmented Reality Technologies for the Real Estate Sector

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Abstract. In this study an emotional analysis was made using a brain-computer interface called Emotiv Epoc+, in order to improve the access to real estate sector using immersive environments build through AutoCAD and Unity tools where from construction plans a real estate contour is made with the help of AutoCAD to later generate a 3D model thanks to the Unity tool with which the model real estate is represented; it was found that using this kind of environments increase 4 out of 5 emotions normalized levels, being these emotions Engagement, Frustration, Instantaneous Excitement y Long-Term Excitement, it is conclude that the costs of real estate enterprises could be decreased because they would not need to build a model house, additionally with the results of emotional analysis the user experience can be improved modifying the features of the immersive environment at the user's pleasure.

Keywords: Brain activity · Brain-computer interface · Emotional analysis · Emotions · Immersive environment · Modeling · Real estate · Simulation · Three-dimensional spaces · Virtual reality

1 Introduction

Throughout history, humanity has had the need to build and obtain housing as expressed by Barrio, García and Solis in their article (Barrio et al. 2011), even at present, this need is a social problem in which politics has been involved as explained by Rincon and Campo in his article (Camelo Rincon and Campo Robledo 2016). Real estate construction projects being defined as goods that cannot be transported from one place to another such as houses, apartments, buildings, among others (Editorial Cultura 2002), can be a complex task for the real estate sector, for the time of development and changes in demand, prices, costs, investment, among others (Forcael et al. 2013). Finally, a solution to these tasks according to studies developed by Govea and Maldonado (AutoDesk 2018) is to avoid the construction of real estate models of real estate projects by promoting the use of virtual reality, that it is called any technology that allows to simulate three-dimensional spaces and visualize them through a device (AutoDesk 2018).

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Additionally, the use of virtual reality technologies stimulates the behavioral activation (Herrero et al. 2013) of the user, for this reason a brain-computer interface is used to graphically visualize this behavior, these types of interfaces measure brain activity and is able to describe the interactions of humans with their environment (Minguez 2010), in this way register the user's brain activity. According to the above, the real estate sector can be benefited by involving in its projects the virtual reality to expose its model buildings, in this way to reduce costs, reduce construction times and analyze the connection that the end user has with the property.

In the following section, the characteristics of selection of tools and methodologies for the project that are used for the development of the proposal, which is explained in the section of materials and methods, that give way to the measurement of the immersive environment in where the tests and related results are described, delivering an analysis and quantifying them, to finally establish the future works and conclusions of this study.

2 Materials and Methods

2.1 General Approach

Figure 1 shows the general approach of the scenario to be worked, in which the AutoCAD tool is used to model the contour of the property to export it and work it in Unity, which is used as a tool for the implementation of the immersive environment where the end user You can enter, move and visualize the property, finally through Emotiv EPOC + an emotional analysis is made about the experience of the end user with the visualization of real estate.

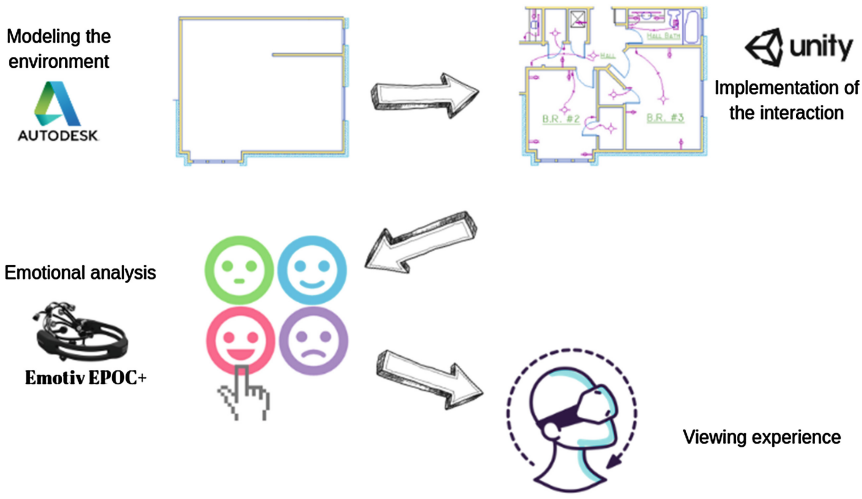

Fig. 1. General approach

2.2 Modeling the Contour of Real Estate

Through the modeling software AutoCAD, which is a 2D and 3D modeling software developed by Autodesk (AutoDesk 2019; Mora Ortiz and Medinilla Martinez 2015), the 3D model of the property is developed. Parameter is collected as square area, height of walls, number of rooms, number of bathrooms, number and location of windows, number and location of doors, among others, which establishes the scale of the model with these characteristics, which are specified in construction plans. The construction plans are always necessary and these are previously established in the construction, therefore no additional expenses are incurred.

For the modeling in this project, layers of walls, doors, windows and floor plans are taken into account with which AutoCAD works, as shown in Fig. 2.

Fig. 2. AutoCAD features

These layers grant the privilege of creating, inserting, and modifying objects within each layer used to associate objects according to their function or location (AutoDesk 2018). For each layer the floor plan is modeled, the walls, windows and doors respectively, for this a 2D model is generated as shown in Fig. 3.

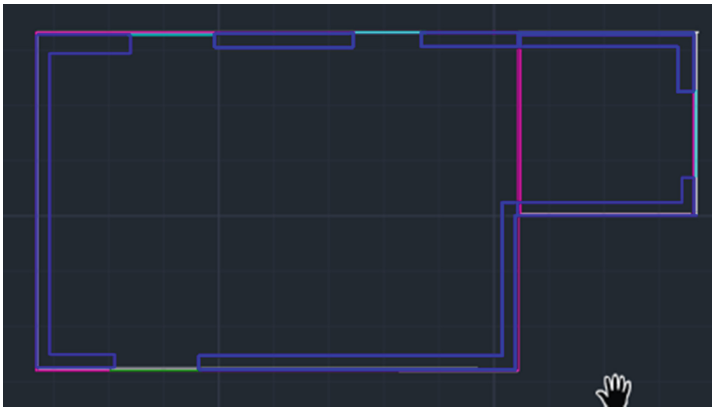

Fig. 3. AutoCAD contour

Finally the 2D drawings are taken to 3D modeling, climbing walls, locating doors and windows as shown in Fig. 4. Additionally these changes are seen in simultaneous

modeling 2D to 3D since AutoCAD allows multiple windows and each window has configuration of views.

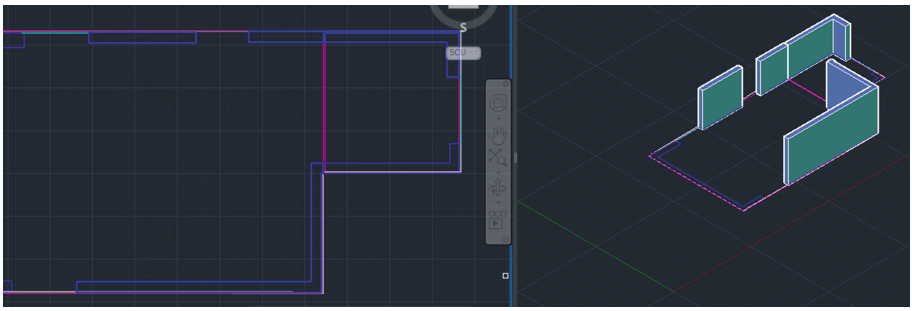

Fig. 4. AutoCAD 3D modeling

2.3 Implementation of the Interaction with Real Estate

With the model of the real estate made in AutoCAD, the implementation is carried out in Unity, which is a multiplatform video game engine created by Unity Technologies, for this specific case it is used in Microsoft Windows, it is important to clarify that after imported the model from AutoCAD to Unity no modification can be made to it, this model is presented in Fig. 5.

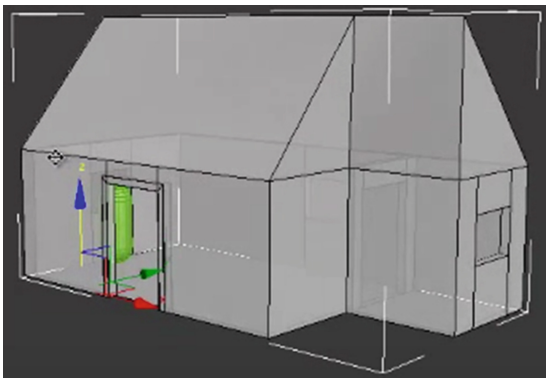

Fig. 5. Final 3D model

Regarding the development of the immersive environment, two tasks are carried out, the first the implementation of the keys or commands with which the movement is executed, and second the activation of the collisions in the imported model with the objective of not crossing walls and increasing reality in the user's experience.

For the implementation of movement commands in Unity we proceed to the creation of the two axes in which the end user can move, these are the vertical and

horizontal, each of them are assigned to main and alternative navigation buttons, the type is button or mouse button, the Axis for the horizontal is "X axis" and for the vertical "Y axis", the Joy Num is "Get motion from all joysticks" so that later it detects the commands sent remotely, the other fields are left by default, the filling of these fields is seen in Fig. 6 for the case of the horizontal axis.

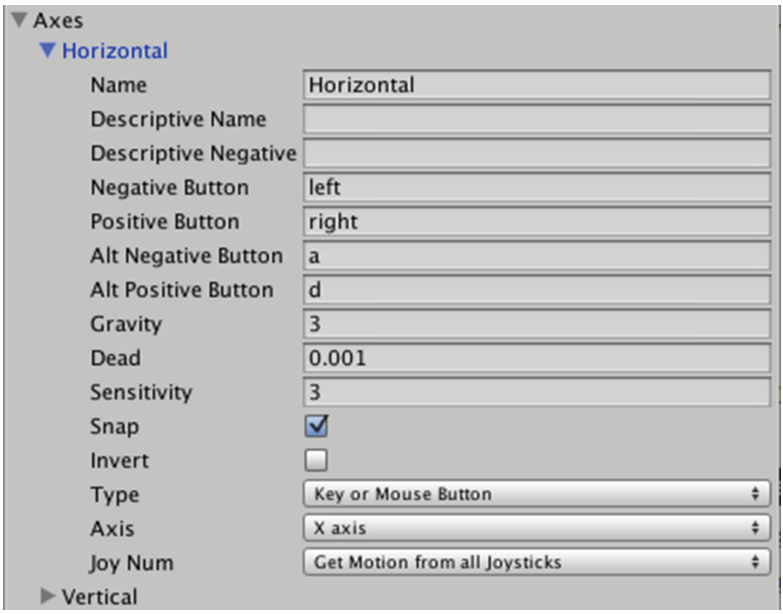

Fig. 6. Axes configuration

Now we proceed to the activation of the collisions for the imported model of AutoCAD, for this we must add a Mesh Collider to the object already mentioned, which is assigned the material and mesh as shown in Fig. 7.

Fig. 7. Collision configuration

With this, the Unity implementation for the immersive environment is finalized, which is seen as shown in Fig. 8, which shows a one-story building with doors and windows complemented by the lower flat, which for this case is the floor.

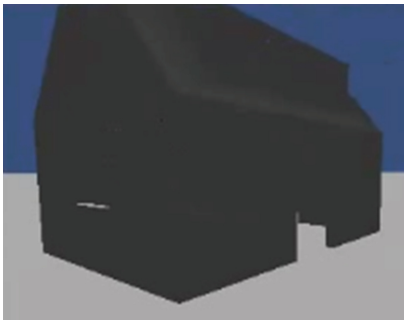

Fig. 8. Immersive environment

2.4 Emotional Analysis of the Viewing Experience

To carry out the visualization of the environment, we look for a tool with which we can have feedback, in such a way that there is a result both for the end user, who will see the property in the immersive environment and for the real estate who implements it to know the level of impact of the technology implemented.

To do this, a brain-computer interface is used, called Emotiv Epoc +, this is a non-invasive tool that aims to capture data related to the emotions experienced by the bearer, this device can be seen in Fig. 9.

Fig. 9. Emotiv Epoc+

In this case, the device is used in two moments, the first in which the end user visits a real model house carrying the brain-computer interface, where the real-time data of the emotions experienced is captured, for this capture and recording of data using the Zendesk tool, called Emotiv Xavier SDK, which allows to verify certain features of the device such as battery level and signal in addition to the emotions already mentioned.

Then the same exercise is done to visualize the model house through the immersive environment, where the same data is recorded to later perform an analysis.

3 Mesurement of the Inmersive Environment

Once the implementation has been completed, the tests are carried out, which are carried out in two stages, as shown in the presentation of Fig. 10.

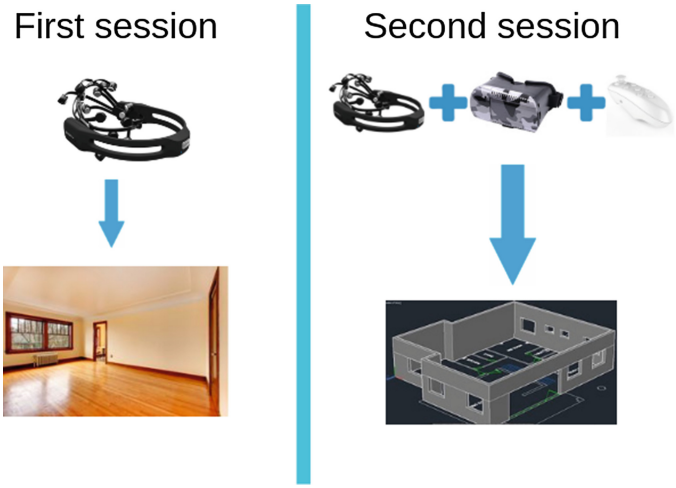

Fig. 10. Test scenario

Before carrying out the tests, the target group, the place of execution and the model implemented to perform the same dimensions as the real one are determined. As a place of execution is taken a building with apartments for sale where they had the authorization to use one of them, previously the model was developed to have it already installed in the application, externally 13 participants were summoned, who had no knowledge prior to the procedure that was carried out and they did not know each other.

In the first session the visit to a model home is made using the Emotiv Epoc+, where the user's feelings are captured from the detected brain waves, this process is visualized through the Emotiv Xavier SDK, which provides this option to see in real time and simultaneously perform the recording of data in flat files, these files are stored with time in milliseconds in which the capture is made and the normalized value, i.e. from 0 to 1, of each of the emotions, being these Engagement, Frustration, Meditation, Instantaneous Excitement and Long-Term Excitement.

In the second session the implementation developed in Unity is taken and exported in an APK (Android Application Package) to be installed in a cell phone with a minimum of 3 Gb of RAM (Random Access Memory) and 192 Mb of space either in internal storage or in memory SD (Secure Digital). Then via Bluetooth connects the cell phone with the device that performed the interaction, that for this case the joystick included with the augmented reality glasses is used, we proceed to open the application and install the cell phone inside the glasses for viewing, the installation is as shown in Fig. 11.

Fig. 11. Installation App and VR glasses

As in the previous session, the capture and visualization of the emotions is performed, graphically these are visualized in histograms, where the emotions to be displayed are selected and the update of each record is made in real time while parallel recording in flat files, in Fig. 12 an example of the histogram with some of the emotions is shown.

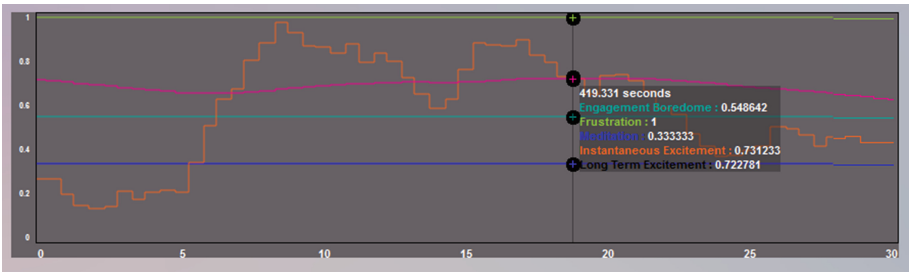

Fig. 12. Emotions histogram

It is important to clarify that none of the participants had knowledge of what was done by the others, in order to improve the final experience, and capture the records of the emotions without the participants being predisposed.

4 Results Analysis

After the tests are carried out, the captured data is analyzed individually, that is, first an analysis is carried out by each of the participants in their two experiences, separating each one of the experienced emotions, then all experiences are averaged. house real model and in another field for those experienced in the immersive environment for each emotion, obtaining the results presented in Table 1.

Table 1. Emotions averages

Emotion	Average first part	Average second part
Engagement	0.4899230	0.5289932
Frustration	0.4534791	0.4893909
Meditation	0.2353921	0.1896281
Instantaneous excitement	0.7380932	0.7583913
Long-term excitement	0.7201043	0.7303309

Figure 13 shows the difference that exists between the averages of the first session with respect to the second, where it is shown that the emotions Engagement, Frustration, Instantaneous Excitement and Long-Term Excitement have an increase when performed with the immersive environment, while there was a decrease in Meditation.

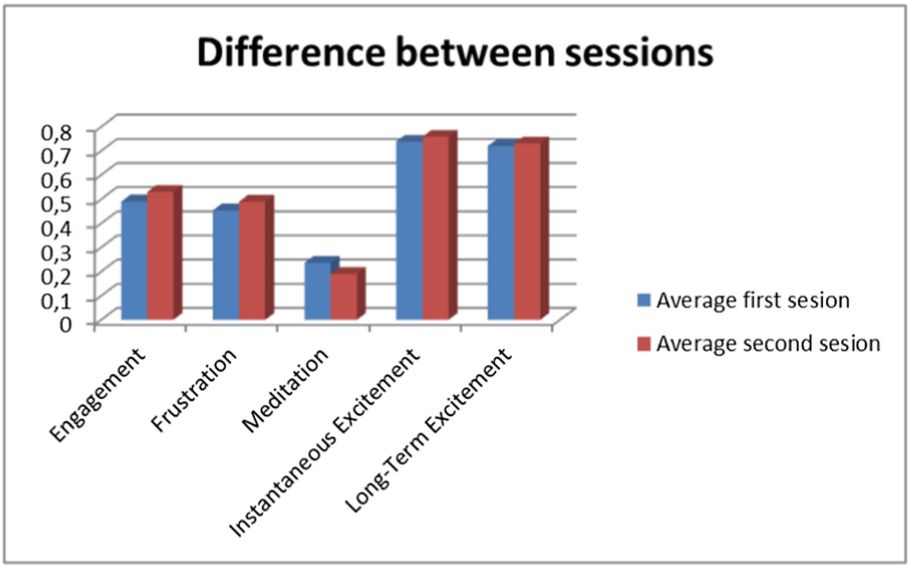

Fig. 13. Difference between sessions

On the other hand, the analysis is made by each individual where the difference value is found for each emotion and it is determined whether it increases or decreases, these results are expressed in Table 2.

Table 2. Emotion level movement

Emotion	Increment	Decrement
Engagement	8	5
Frustration	10	3
Meditation	4	9
Instantaneous excitement	9	4
Long-term excitement	8	5

Figure 14 shows through circular graphs the percentage of participants who had increased interaction with certain emotions and those who had a decrease for it, this process is performed for the five emotions.

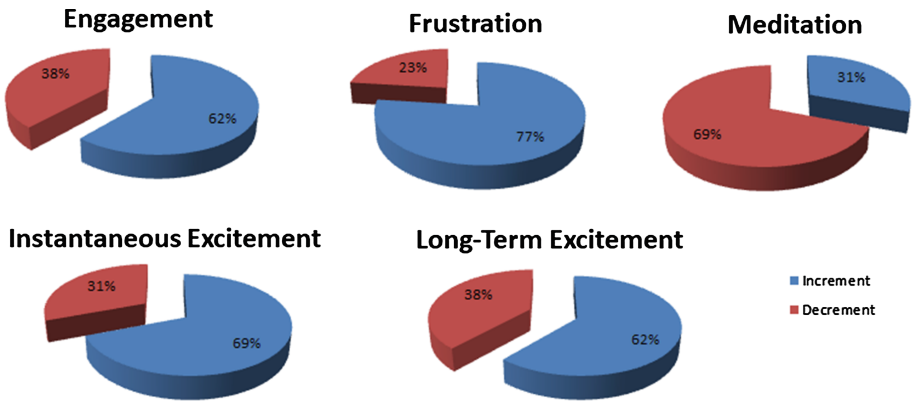

Fig. 14. Performance analysis

5 Conclusions and Future Works

As can be seen in the work presented for 4 of the 5 emotions, there is an increase when performing the activity with the brain-computer interface, with which it is seen that the impact on both instantaneous and long-term excitement has good results, based on these two emotions it is said that by using immersive technologies you can increase the connection of the property with the client as well as reduce costs for real estate if the model house does not exist and is created by technological means.

Regarding future works, studies are taken into account in which tools such as Sweet home 3D are implemented for the addition of objects with which the end user experience can be improved and thus generate more impact, as proposed in (Gonzalez Iparraguirre and Sanchez Vargas 2016) the creation of elements for the home so that the user can modify certain characteristics such as color and texture, on the other hand in (Ozakar and Ortakci 2017) the Sweet Home 3D add-on with web applications is used in which an analysis of the electricity consumption in real estate before being built

using web information systems to obtain data directly, this analysis is done both quantitatively and graphically.

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