TOLLAN-XICOCOTITLAN: A RECONSTRUCTED CITY BY AUGMENTED REALITY (EXTENDED)

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ABSTRACT

Work In Terminal presents the analysis, design, implementation and results of Reconstruction Xicocotitlan Tollan-through augmented reality (Extended), which will release information about the Toltec capital supplemented by presenting an overview of the main premises of the Xicocotitlan Tollan city supported dimensional models based on the augmented reality technique showing the user a virtual representation of buildings in Tollan phase.

KEYWORDS

Databases, Visual Programming, Augmented Reality, Virtual Reconstruction, Archaeological Site.

1. INTRODUCTION

The Archeological Zone of Tula, is the most important of tolteca culture. It's conformed by a set of buildings with a religious symbolism, for example the Central Altar, the Coatepantli (wall of Snakes), Burnt Palace, ball games and the Tzompantli. The National Institute of Anthropology and History (INAH) opened in Tula a museum about Tolteca Culture.

Thanks to science and technology have made great discoveries and changes in society over time [1]. Nowadays, it is possible to combine virtual and real objects within the same environment, to create supplemented views from somewhere that people are viewing [2]. This process is called Augmented Reality (AR) [3] [4].

The project applies AR together with archaeological knowledge of the Tollan-Xicocotitlan city, in Tula, Hidalgo. In order to obtain a system that models projecting three-dimensional (3D) showing the architecture of the buildings constructed there and complemented with written information about each campus.

This paper describes how to reconstruct a building using three-dimensional models design based on AR. We validate our approach using the buildings of the Xicocotitlan city of Tollan.

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Indeed, the reconstruction allows displaying any building that is in ruins, presenting it in threedimensional model of the structure information. Besides the system provides support in order to have better idea of the constructed buildings in the past. The system can be applied in various places, with desired display information from the Toltec culture, a museum, exhibition or educational institutions where they are taught subjects related to the teaching of the Hispanic cultures.

AR supports markers located on a fixed surface, such as the ruins of a temple, a pyramid or a display in a museum. Such markers are detected by the input devices that should be placed in a specific position for the brand to be recognized and to be viewed on virtual model for the whole environment.

The viewer appreciates a virtual city by means of the system which builds boom in architectural, or reconstruction of events occurred in the past.

As a result, AS does not absolve the user from the reality, all experiences become more interesting for visitors, who are immerse in a particular event occurred in the past.

2. PRINCIPLE

To construct a model system the engineer would consider some restrictions:

a) Postulation: It reduces the number of permutations and possible variations to reflect the problem in a rational way by the model.
b) Simplifications: It creates the model on time.
c) Limitations and restrictions: It helps to delimitate the system and guides the way to create the model also the approach it takes to implement the model.

Based on the above definitions the restrictions on our system are described below:

Postulation:

- The system should store three-dimensional models of the main buildings in the city of Tollan-Xicocotitlan.
- The system displays information submitted buildings.
- The system will offer the opportunity to comment on the experience in using application, also may make recommendations for improving the application.
- There will be a manager who will be watching the publications made in the system.

Simplifications:

- Only the main venues of the city will be modeled.
- Only relevant and concise information on the site submitted by the visitor will be present.

Scopes:

- Visitors can view the graphic images from their different perspectives.

- The system may be entered in any display outside the archaeological site, allowing more people to know about the Toltec culture.

- The system could be adapted to real buildings that make Tollan-Xicocotitlan appreciated.

Actors involved in the requirements definition.

- **Archaeologists:** With the knowledge we have about the archaeological site, the Archaeologists help to define the project providing information on main buildings of the Tollan-Xicocotitlan City.

- **Visitors.** Visitors can share concerns and attractive to consider important on the site and can add visual and operational aspects they would like to see in the system.

Technical environment of the system or product to develop.

An application or modeler will be used to generate models of the main buildings, libraries that allow recognition of patterns Augmented Reality and a programming IDE for the conjunction of the elements used.

Requirements analysis.

The requirements analysis is one of the most important tasks in the life cycle of software development; it sets the planning of the application.

The requirements analysis can be defined, as the process of studying the user needs to get a definition of the system requirements, hardware or software, and the process of study and refinement of these requirements, definition provided by the IEEE [10]. Also a required is defined as a condition or ability that the user needs to solve a problem or achieve a determined goal [10]. This definition extends and applies to the conditions to be met or have a system or a component to satisfy a contract, standard or specification.

Based on the above definitions have been found the following list of functional requirements and not functional for the present system:

Functional Requirements

ID	Functional Requirements	Description	Priority
RF1	Visualize the building focused.	Allow the user to view a reconstruction	High
RF2	Show relevant dates from the building.	It will show to the visitor the information building.	Medium
RF3	Recognize the A.R. brand that is set to each building.	To load a virtual model, it is important to recognize the mark assigned to each building.	High
RF4	Guarantee the right over position of the virtual objects.	The system should provide the ideal model for each virtual	High

Based on the functional requirements we begin a technique using the UML system which is not shown in this paper because of it size.

Augmented reality

AR techniques add virtual elements to real world, scientists have been constructing prototypes, the first was created for Ivan Sutherland, it was in 1960 when he used an 3D images display device to see 3D graphics, lately in 1962 the “Sensorama” was created for Morton Heilig.

Augmented Reality can be used in: a) Scholar projects: They are used in museums, exhibitions or thematic parks due to the price isn’t enough to be improved in the domestic area. B) Simulation: It’s used to simulate flights, and land paths, or military entrainment.

Emergency services: In case of emergency, Augmented Reality can show instructions of what to do to evacuate the place.

AR adds virtually to real parts, staying in the world where they below, and enhancing them with other elements, without disconnecting altogether and without leave to travel from other virtual environments. Moreover isolates virtual reality world in which we live, i.e., the individual is disconnected from the real environment and go onto another world.

AR environment adds more information to the real one observed by users.

AR and virtual reality are related each other. Firstly, we want to clarify some concepts that distinguish both (see Figure 1). Virtual Reality (VR) is defined as "a computer-generated environment, interactive, three-dimensional in which the person is immersed" [8]. While AR is providing an efficient location to interact with the space. VR provides experiences where space and time can be completely controlled, allowing users to interact simultaneously on multiple types of spaces (RA&VR). At the same time, the environments can be beneficial for a large number of applications, like architecture, chemistry and marketing.

Virtual Reality [12]. Augmented Reality [11]..

Fig. 1 Virtual vs Augmented Reality.

Operation of reality increased

Three basic key elements of AR are:

- Display (output),
- Location of virtual objects in the real world (registration),
- Methods interaction (input).

Multimedia information plays a principal role of character, handled through photos, videos, extra-sounds, and with the three dimensions models, to present virtually acclimate.

The main point in the development of an AR application is a motion tracking system. RA technique relies on "Bookmarks" or an array of markers within the field of view of the cameras, such that a computer system has a benchmark on which superimpose images.

These markers are predefined by the system and the pictogram can be unique for each image to be superimposed or simple shapes, such as picture frames, or textures within the field of view.

A computer system can be more intelligent, able to recognize simple shapes, such as the floor, objects like chair, table, simple geometric shapes, to name a cell phone on the table that can be used with a brand or even with the human body that can be used with the same purpose. The following figure shows an example of the marks described in the previous paragraph.

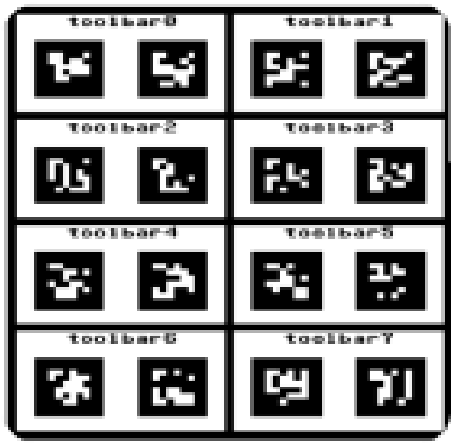

Fig. 2 Joint monitoring card use in typical RA

Below is a table with some projects, which have been developed by companies already consolidated, and Educational institutions:

Company or Educational Institutions.	Application	Description	Release Year
INAH		Temporary Exposition of Culture Museums. México D.F.	2010
Total Immersion	Interactive Kiosks	Exhibitions of human body parts in a museum.	2009
Metaio		3D Add charged in a scientist magazine.	
I.P.N. ESCOM	"Reconstruction of real scopes by augmented reality". (Fig. 3)	Generate a reconstruction of archeological buildings	2008
UNAM	Virtual "KALAKMUL"	Virtual tour of the Kalakmul City.	2002

Table 1. Description of applications by Augmented Reality.

Fig. 3 Model of the reconstruction of real scopes by augmented reality.

Artoolkit

ARToolKit is a set of libraries for C / C + +, that are useful for building AR applications. It includes a number of computer vision techniques for video capture and pattern searching for capturing images.

Users believe that only in the real world it is possible to perform transformation on objects. But, we want to show that it is possible to perform this kind of transformation on virtual objects. Users are able to see this transformation via the camera or by capturing them, taking into account

position, size, orientation, and lighting, as these objects would be perceived by the user in the real world, if they were actually there. This is possible thanks to the libraries of ARToolKit.

A square-shaped templates is used, which are composed of a black square with a white square four times smaller at its center, and a simple picture inside the white square (see Fig.

2). The application, using the features and functionality provided by ARToolKit, is able to spot one of these templates in the video images captured.

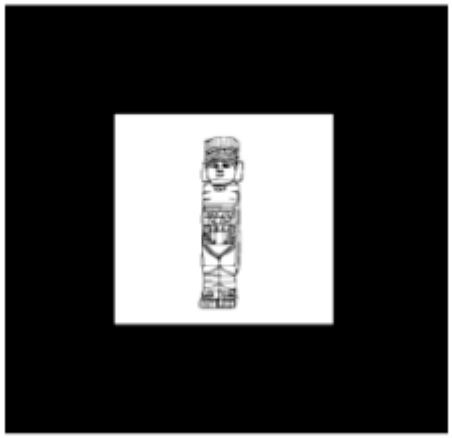

Fig. 4 Proposed Mark of pyramid B

Once a template is detected within an image, studying the orientation, position, and size of the template, the application is able to calculate the relative position and orientation of the camera, and relative to the template. Using this information, you can draw the corresponding object on the captured image by means of the ARToolKit external libraries (e.g., GLUT and OpenGL). In this way, the object appears on the template, in the position, orientation, and size corresponding to the view taking by the camera (see Fig. 3). Due to the number of possibilities are big, the application take a decision to select one, taking into account the information of other various operations.

Operation of an application artoolkit

The basic operations of ARToolKit application are as follows:

- Firstly, a frame captures real world through a camera.
- The image is modified taking into account a certain threshold value. Thus, the pixels whose intensity exceeds the threshold are converted into white pixels. The remainder is transformed into black pixels.
- They seek and find all black frames as the existing brands in the image.
- Compare the inside of the frame with the markings of the stored information.
- If the shape of the brand and the brand analyzed stored matches, using the size and orientation information of the mark stored for comparison with the brand that has been detected in order to calculate the position and orientation of the camera relative to the mark, and stored in an array.

- The matrix establishes the position and orientation of the virtual camera (processing chamber view), equivalent to a transformation of the coordinates of the object to draw.
- Having put the virtual camera in the same position and orientation as the real camera, the virtual object is drawn on the brand, and renders the resulting image is displayed, containing the image of the real world and the virtual object superimposed, aligned on mark
- It performs the same process with the following frames.

Nyartoolkit

ARToolKit, NyARToolkit provide a trail marker based AR. However, the software has been optimized for easy portability among different programming languages. In order to develop an application running AR on different platforms and operating systems, NyARToolkit libraries are the best option.

NyARToolkit include some key features, like:

- Bookmarks AR based tracking.
- Support for desktop and mobile platforms.
- Scoreboard optimized and enhanced survey.

Blender

Blender is a tool for creating mainly modeling animation and creation of three-dimensional graphics. Some features are:

- It is a cross-platform tool, is free software and complies with the functionality provided similar commercial tools.
- Along with the animation tools including inverse kinematics, armature or grid deformations, loading and particle vertices static and dynamic.
- Features interactive games such as collision detection, dynamics and logic recreations

3. EXPERIMENTAL RESULTS

Modeling with Blender

We have made some 3D models of the city of Tollan. The following images have developed in Blender:

Fig. 5 3D Model of “Atlante de Tula”

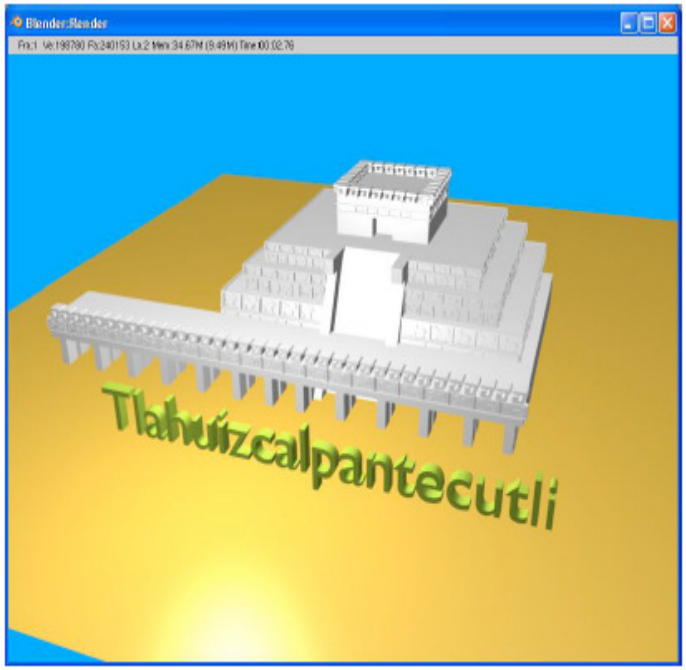

Fig. 6 Test of Pyramid B

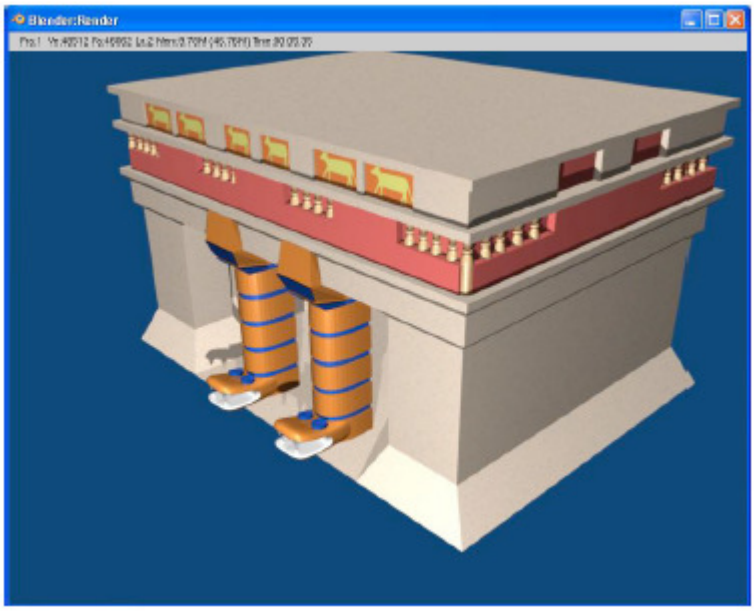

Fig. 7 Tlahuizcalpantecuhtli Temple

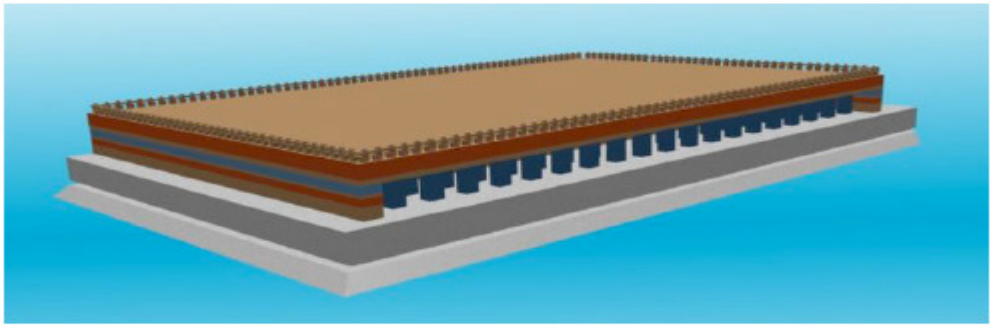

Fig. 8 Palace burnt.

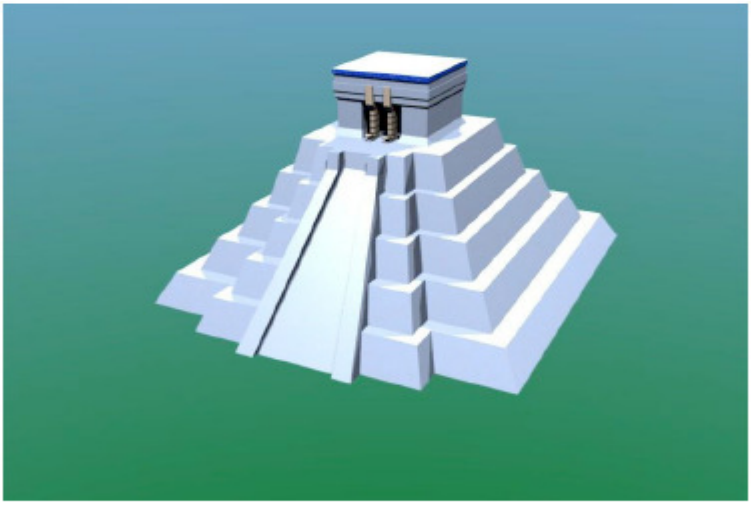

Fig. 9 Sun Pyramid.

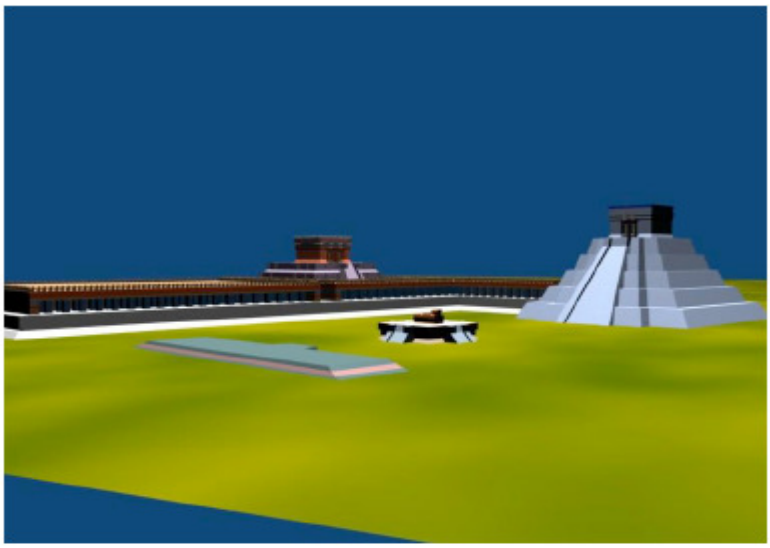

Fig. 10 Tollan Xicocotitlan View.

Tests with ARToolKit

Various tests were performed to understand the operation of ARToolKit, like markers included within the environment of the working tool.

We used a VRML file to check the brand recognition. ARToolKit is responsible for recognizing the associated brand and rendering a three-dimensional model. The result is as follows.

Fig. 11 Test art whit ARToolKit

Note the superposition of a three dimensional object (a cube) on the mark before the House RA.

Tests NyARToolkit

Test was conducted in NyARToolkit development environment C #. where it was possible to load a three-dimensional model on screen. The result is shown in the following diagram.

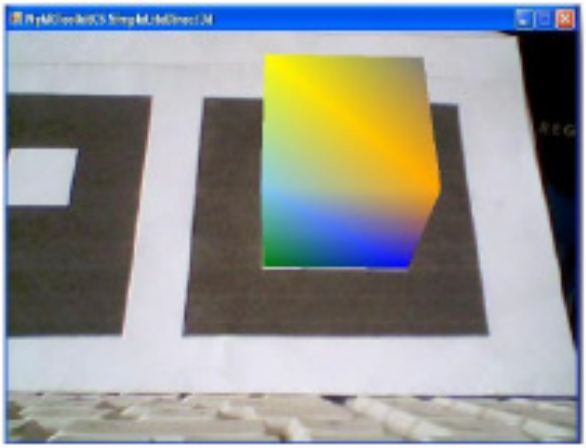

Fig. 12 Test whit ARToolKit

After understanding the operation of the libraries were established own brands of RA and generated three-dimensional models that would be superimposed on these markers. The results are shown below:

Fig. 13 Own brand of RA.

Fig. 15 Three Dimensional model

Fig. 16 Final Result of RA using own brand and model.

Development

The system is divided into two main modules User and Manager.

The user module is in charge for presenting 3D models of each building, in this module, users can visualize a pyramid in 3D and can also comment on the experience that let them use this type of system.

The Administrator module allows administrators to upload new handling system, just as you can modify the information associated with each building, this section administrators perform the query of comments made by users of the system.

Here are some screens that make up the system and a brief description as presented.

Main menu

Fig. 17 Main menu of the system

Add comment

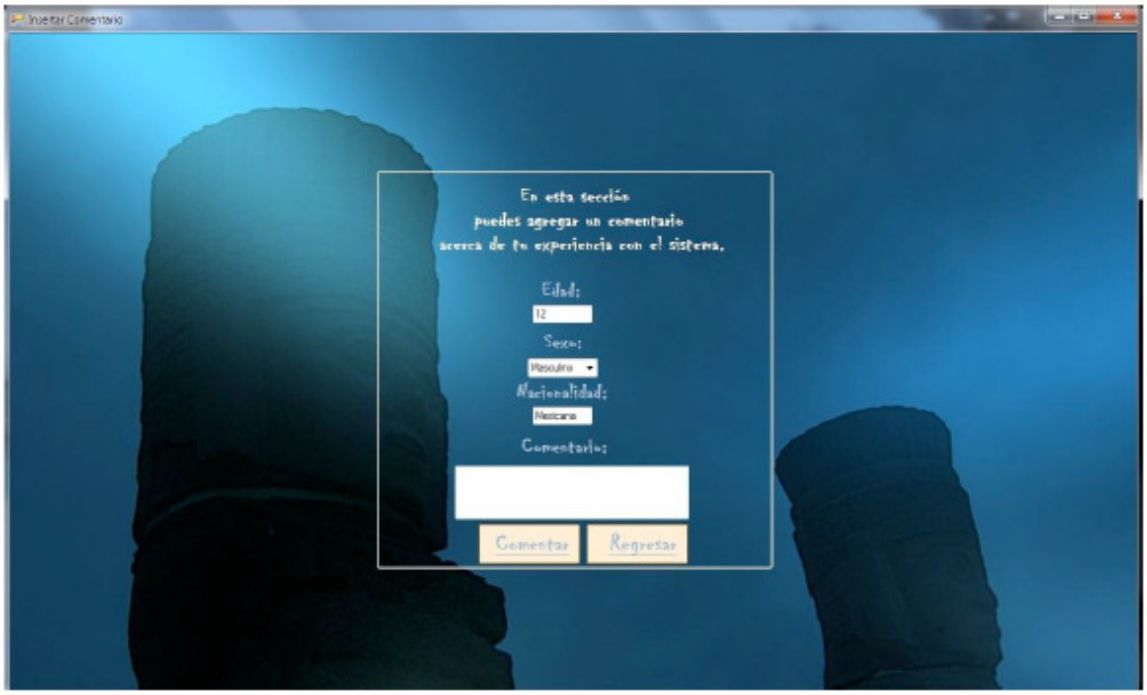

Fig. 18 Add a comment in the system

Manage Menu

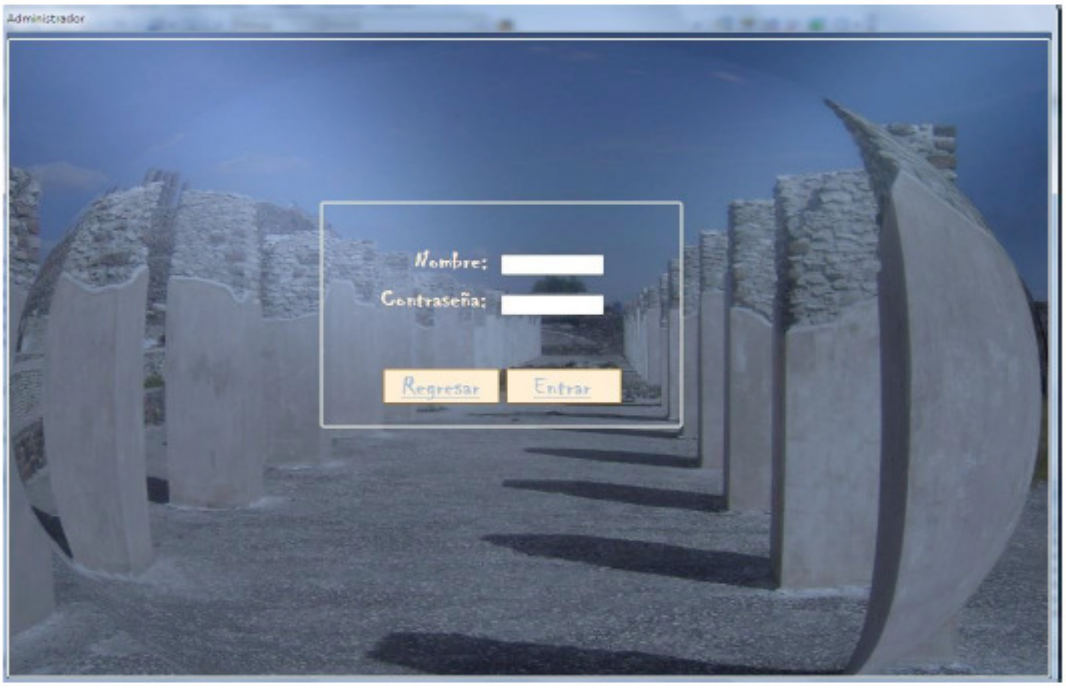

Fig. 19 The manage menu

Creation of marks

We have generated our own marks to system purposes, which will allow to over put the 3D models that will be showed to the final user. The pictures below show that marks.

Fig 19 Proposed mark to burnt palace.

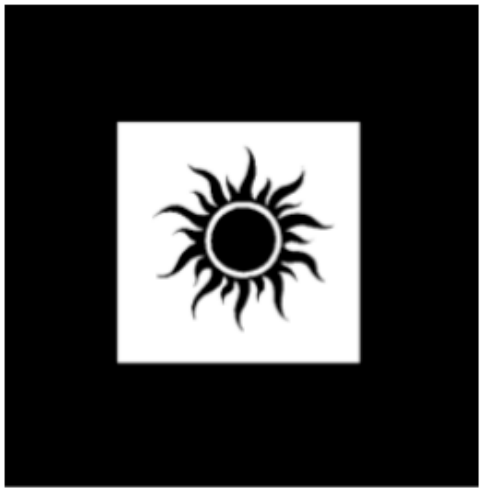

Fig 20 Proposed mark to pyramid C.

4. CONCLUSIONS

Our approach fulfills with the aim of presenting three-dimensional models of the major archaeological sites of the city of Tollan Xicocotitlan. Augmented Reality technology has been used to present a model to show the marks of RA defined for the system and having the display city in its architectural boom, achieving user interactivity, in a nice and easy way to manipulate objects.

By means of our approach, it is possible to travel through archeology museums, exhibitions or in the same archaeological site as presented to the general public or as ancient cultures and civilizations had been developed. Old civilization can be shown its culture.

To validate our application, we choose Xicocotitlan Tollan, that was one of the most important cities in the history of Mexico and served as the basis for the development of other cultures, as the Mayan culture.

AR places virtual objects in a real environment, allowing users to get a view of what is supplemented watching and with the possibility to transform these virtual objects, such as observing the virtual object from different perspectives views.

The aim of augmented reality is to set virtual objects of the real world, complementing what the user is watching and he can manipulate the virtual objects. In this case, Augmented Reality presents an interactive way to know the architecture of the Archeological Site Tollan, making a friendly system for the user to enrich the knowledge about this Culture.

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