

# An Augmented Reality Guide for the “Open Sky Museum” in Valparaíso

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**Abstract.** The “open sky museum” in Valparaíso, Chile, is an art exposition set in a wide area, over the walls and streets of an emblematic hill of the city. It consists of a series of 20 murals, close to each other, turning the landscape into a space for the promotion of art and culture. However, the picturesque houses, passages and gateways in the hill form an intricate maze that can frustrate impatient tourists. On the other hand, Augmented Reality (AR) is a technology that is growing as fast as the smart phone market; it uses different sensors of these devices to show a vision of the physical environment combined with virtual information. We develop a navigation guide for the open sky museum that is presented to the user as a layer of augmented reality and can be accessed through the “Layar” publication system. Tourists near the museum, can access this guide to see walking paths, location of the art works, and artist information. In addition, we implement a method to deal with the lack of altitude data on Global Positioning System (GPS) units to correctly display objects with respect to the user altitude.

## 1 Introduction

The use of mobile devices has been experiencing an explosive growth in recent years, this due to the increased benefits that these devices are including and of the variety in terms of hardware. For example, it is common to find, included in those devices known as smart phones, high-resolution screens, cameras, camcorders, and even sensors such as magnetometers, accelerometers and gyroscopes that are hard to find together in other products. Thus in a Smartphone, the user get a device that integrates the functionality of a GPS, a compass, a camera, etc. making it an ideal platform for mainstream applications, it is attracting the attention of many developers.

Augmented reality (AR) technologies can make use of these technological elements to generate an experience of digital information, which presents a vision, for example through a camera, of a virtual environment integrated in the reality, it allowed obtain information from a digital source that is displayed using geospatial

information of the user, like his position and orientation. As a result, the user accesses a vision that mixes the real with digital information.

These technologies can be used in various fields, but where you can see a greater impact is in the development of navigational guides in three-dimensional spaces. In this context, the AR is suitable for the development of guidelines for visitors to open spaces that have some degree of complexity such as parks, exhibitions and outdoor museums. Moreover, the AR can be used to provide visitors with additional information that enriches the travel experience on these spaces.

In Section 2, we introduce the reader to Augmented Reality technologies and give him some examples of the current applications, section 3 explains the Layar platform for the development of geo-referenced AR applications, in section 4, we explain the museum guide design and implementation. Finally, in section 5, we provide a method to solve the lack of altitude information that is common in the actual Global Positioning System (GPS) units, this method is applicable to emplacements with known altitudes and can be used to correctly draw objects altitude in the Augmented Reality. The preparation of manuscripts which are to be reproduced by photo-offset requires special care. Papers submitted in a technically unsuitable form will be returned for retyping, or canceled if the volume cannot otherwise be finished on time.

## 2 Augmented Reality

Augmented reality is the enrichment of a direct or indirect vision we have of a physical environment in the real world, the elements are combined with virtual elements to create a real-time mixed reality. This can be achieved using a set of devices that add virtual information to the existing physical information. The digital information on the environment and objects can be recovered as a layer of information that superimposes computer data to the real world.

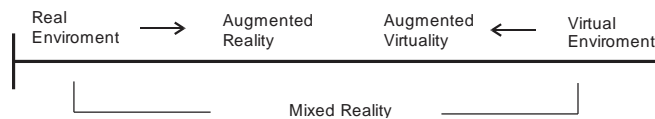
There are two formal definitions for the augmented reality concept in [1] and [2] that are commonly accepted today, in the former AR is described as:

1. combines real and virtual
2. is interactive in real time
3. is registered in 3D

In the latter, Paul Milgram and Fumio Kishino, in [2], defined the "Milgram's Reality-Virtuality Continuum" (see figure 1); a continuum that spans from the real environment to a pure virtual environment. In between there are Augmented Reality (closer to the real environment) and Augmented Virtuality (closer to the virtual environment).

Augmented reality is growing in a variety of fields. For example, in architecture, AR can be employed to simulate planned construction projects, in military and emergency services, AR systems can provide information such as instructions, maps, enemy locations, and fire cells into the field of view.

On the other hand, the use of AR is not limited to critical applications and is also suitable for massive use applications like the advertising where Marketers can use AR to promote products via interactive applications.



**Fig. 1.** Milgram's Reality-Virtuality Continuum

In the technical aspects, it has been used several techniques to map and synchronize the tridimensional space of the real vision with the virtual data. Some systems use graphical data recognition to localize and locate a specific object in the space or use it as a reference coordinate. Other systems are assisted with external geo-positioning data provided by sensors and internal orientation data provided by orientation units, this is the case of the systems that use the data from the Global Positioning System (GPS) in combination with magnetometer and accelerometer inside the device that capture de real view.

### 3 The Layar Platform

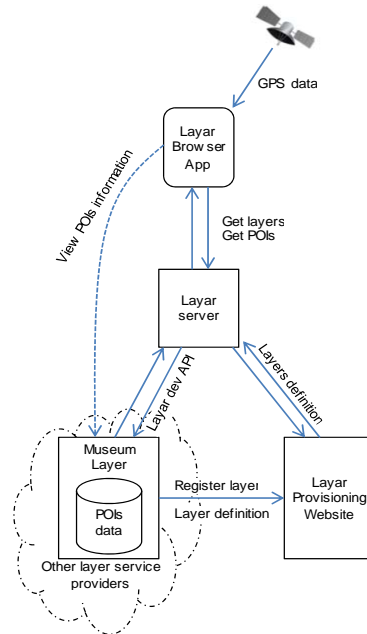
Layar is the name of a platform for the development and publishing of outdoor navigation AR applications, it provides developers with an API for the creation of custom applications and content that is presented to the users as “layers” of augmented reality that are rendered over the image of the phone camera (Site 1). Figure 2 shows this architecture interacting with the museum layer that we developed.

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Layar has two parts: the browser to experience the content layers, and the publication system to serve and publish the content layers.

The browser can use the GPS (or AGPS) on the mobile device to determine in real-time the geo-positioning of the user, and the accelerometer and magnetometer (or gyroscope) to know the phone orientation. This information can be used for an application layer to trigger specific actions and show any kind of information objects in the phone display.

When the layer developer requires a publication, the Layar team made a revision on the definition and functionality of the application; if it complies with the technical requirements and its content is approved, the layer is made visible for any user of the layar browser near the location where the layer applies.



**Fig. 2.** Laya platform architecture

## 4 Building the Museum Guide

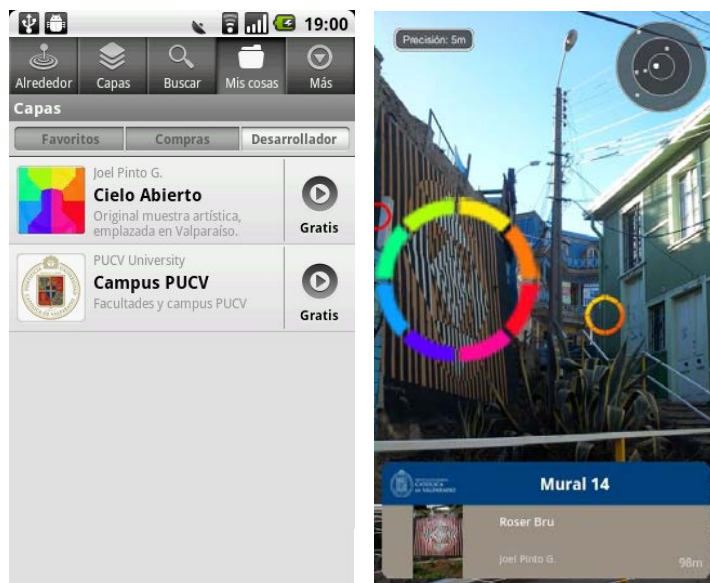
The guide provides information to visitors wishing to tour the museum and the art works through augmented reality, showing the geospatial location of certain points of interest in real time. These points of interest correspond to the works (murals), major access to the circuit, or places where you can see a number of works referred to as “gallery”. Moreover, to murals, the user is presented with the option to display bibliographic information about the author. The Laya browser displays the available AR layers selection menu from where the user can access our layer (figure 3, left hand side), and on activation, our information layer is drawn in the display of the phone when a user is looking around the museum (figure 3 right).

### A. Service Architecture

Our development of a navigational guide to the open sky museum, involves 2 main components:

1. A database that stores all information concerning points of interest such as works, access, galleries, and information related to the actions defined for each of these points together with the definition of GUI objects to be used to display this information.

- The second component is the service end-point consisting of a server that processes requests sent from the Layar browser in the user's device and sends a "JSON" formatted response that contains information about points of interest near the user and the actions defined for each of them.



**Fig. 3.** Screenshot of the AR vision of the museum taken from a Google Nexus ONE

These two components integrates with the Layar publication platform described before to be available to anyone with internet access through a smart phone that is within an area near the site of the museum.

Geospatial coordinates of each of these points are stored in the "POIS" table of the database, along with the meta-data used in the GUI to display the information.

When the user accesses the AR layer, the first action is a request of all the points of interest that are within a certain range of the user to the server guide data. This request from now on referred to as "GetPOISrequest", consists of a HTTP GET request that is accompanied with a set of parameters, table 1 explains the most important.

Our layer server, processes the GetPOIS request, and prepares a JSON formatted response containing an array of points of interest objects and arrays of the actions defined for each of the POIs, plus other meta-data required to build the GUI objects that are drawn over the phone camera display to show the information to the user. Each of the POI objects (see table 2) has a set of data that define the geo-location to localize the object in the AR vision, and a set of data whose meaning varies depending on whether the object is an art-work, a museum access or a gallery.

**Table 1.** Some parameters send in a GetPOIS http request

Key	Description
userId	Unique ID of the end-user, anonymized. It is a hashed code. In most cases the IMEI is used to create the hash, otherwise another unique ID.
version	This indicates the version of the API that the phone is using.
lat	Latitude of current position (GPS coordinate).
lon	Longitude of current position (GPS coordinate).
countryCode	This is the home country of the user, as determined by the network provider of the SIM card in the phone.
action	Indicates whether the client is requesting a full refresh of the layer or just an update: This can be caused by refresh parameter(fullRefresh) or by an intent containing the "action=update" command.
alt (optional)	The current altitude of the user. This is not always known on the client and will only be passed when there is a gps fix.

**Table 2.** POI object data send in the GetPOIS JSON response

Key	Description
id	A unique id for the POI, this is used to track the POI's when refreshing the list.
lat	The integer value of the latitude for the POI: the decimal GPS coordinate value is obtained dividing this data by $10^6$
lon	The integer value of the longitude for the POI: the decimal GPS coordinate value is obtained dividing this data by $10^6$
alt	Real altitude of object in meters.
relativeAlt	Altitude in meters of the object respect to the user's altitude.
Type	The type of POI, from which the client determines which GUI object use. The type can be '1' for art-work, '2' for a gallery or '3' for a museum access
actions	An array of actions defined in the database, Some of these actions can be invoked when the user clicks on the POI Object. The various actions are displayed as a list of buttons in an overlay sheet specified for the POI object.

## B. Guide functionality

Our Museum navigation guide defines 3 POI objects that are shown to the user

through the AR browser: POIs corresponding to the geo-location of the art-works, POIs corresponding to accesses where a visitor can start to tour the museum and POIs corresponding to places where several art-works can be sighted that we call “galleries”.

For the art-works POIs we show a circular icon in the AR vision (see figure 4), then when a user focus on one of the POIs, the name of the piece, and the name of the author, plus a small preview image are displayed in a box while not leaving the AR vision. Also, we define an action button called “about the artist” that displays in full screen the artist biography as is shown in Figure 4. The user can return to the AR vision by pressing the back button in his phone. For entry to museum POIs, we only place an icon in the AR vision and display the street name when user focus the POI, and for the gallery POIs we show a list of the art-works that can be sight from there.



**Fig. 4.** POI action selection layout and artist Biography, screens taken from a Samsung Galaxy i570

For all the POIs objects, user can use an action button named “how to reach” that shows the POI geo-location in the map. The map is drawn using the Google maps API.

## 5 Solving Altitude Inaccuracy

The Global Positioning System (GPS) can deliver very accurate tridimensional positioning information (3 mt. error ratio) in the form of latitude, longitude and altitude data. However, this is accomplished in a favorable scenario, where the GPS receiver

has a stable signal from a certain number of satellites. Furthermore, the availability and accuracy of the altitude will be determined by the number of satellites available, and it is common to take more time to calculate this data, or in some cases not available at all.

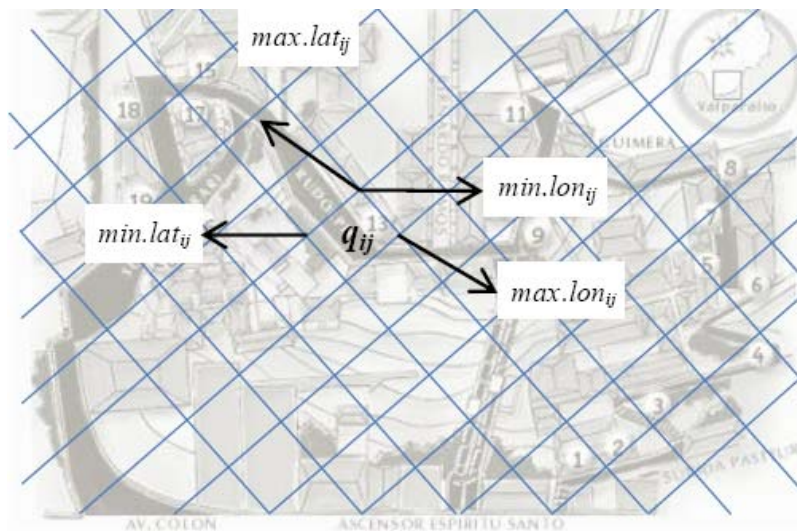
Considering that the museum is housed in a fairly rugged zone and points of interest that will be presented are at different altitudes (parameter stored for each point of interest as ‘absolute altitude’ in the database), it is necessary to have at least an estimate of the altitude of the observer.

To deal with this problem, we made a mapping of the know altitudes for the places where the user can access de layer in the form of a quadrant matrix that help estimate the user altitude based in the latitude and longitude. The quadrants results from partitioning the museum surface into squares that cover the area between determined latitude and longitude coordinates. Each element  $q_{ij}$  of the matrix is a representative value of the altitude of the corresponding quadrant. The size of the quadrants is defined in a way that minimizes the altitude variation inside. When the altitude parameter is not present in a request, the quadrant where a user is located  $q_{lat,lon}$  is determined based on the latitude and longitude reported by the GPS unit in his device (see figure 5).

Then, to draw objects altitude correctly, we use a parameter called “relative altitude” ( $rel.alt$ ) that will be returned instead of the absolute altitude ( $abs.alt$ ) when the real altitude of the user is unknown.

Relative altitude is calculated by subtracting the altitude defined for the quadrant where the user is, to the absolute altitude of the POI defined in the database before is sent to the user browser:

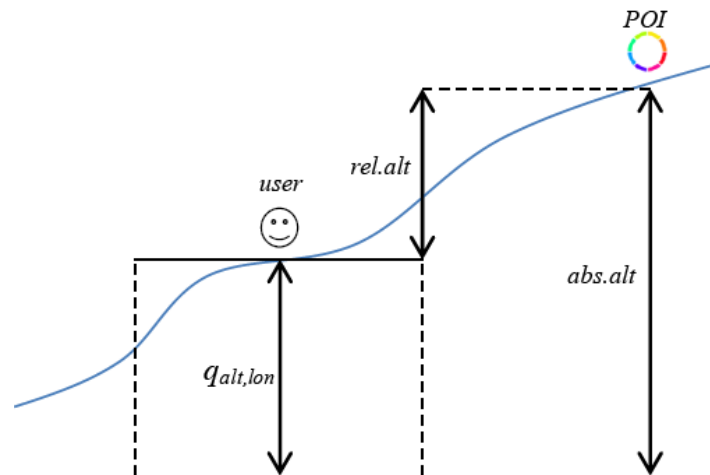
$$rel.alt = abs.alt - q_{lat,lon} \quad (1)$$



**Fig. 5.** Quadrants of the know altitudes matrix



Finally, in the Layar AR browser, relative altitude is drawn against the altitude of the user, so, if a POI response comes with a relative altitude of 50, the POI object is drawn 50 meters above the user (see figure 6).



**Fig. 6.** : Fixed altitude send to the user

Some considerations must be taken in the definition of the size of the quadrants; the size does not need to be too small, since the GPS latitude and longitude accuracy can vary typically from +3,-3 to +10,-10 meters [3], so there is no guarantee that a high number of quadrants will provide a better mapping of the terrain. On the other hand, if the size is too large, there will be too much loss of altitude variation information. These considerations will depend heavily on the nature of the area that will be mapped.

In some cases, a visitor using the AR museum guide will be moving around without refreshing the data, so the relative altitude at which the points are drawn should be updated to reflect the change in the user altitude. As visitors of the museum must travel known paths, we place proximity triggers in the center of each quadrant defined in the known altitudes matrix. A proximity trigger defines an action that will occur when the user comes in proximity to a location, so, in this case, the action defined is a call to refresh the relative altitude of all the points of interest in the user visible range.

## 6 Conclusions

The development and publication of the museum guide was accomplished in a very reasonable period of time showing that the Layar platform is a good choice for the implementation of similar geo-navigation applications for massive use. Added to this, the fact that users of the Android and IOS (iPhone) operating systems can view and access the layers through the Layar directory for free, assures it can be used for the

majority of the smartphones market end-users.

Though some AR applications require high precision positioning data to accomplish its objectives, others like out-door geo-navigation don't lose functionality with a 10 meters precision and the GPS system brings the sufficient horizontal accuracy. In some cases the inaccuracy of the altitude data given from the GPS is too much to correctly display the vertical position of a virtual object in the AR vision.

## **Web Site List**

Site 1: Layar Website, Platform description  
<http://site.layar.com/create/platform-overview/>

## **References**

1. Azuma, R., A Survey of Augmented Reality Presence: Teleoperators and Virtual Environments, August 1997.
2. Milgram, P. and Kishino, A.F., Taxonomy of Mixed Reality Visual Displays IEICE Transactions on Information and Systems, 1994.
3. GPS Standard Positioning Service (SPS) Performance Standard, 4th Edition, September 2008.