"Atlas 2012" Augmented Reality: A Case Study in the Domain of Fine Arts*

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Abstract. The article presents a case study of artistic use of augmented reality built with the Layar augmented reality application. Members of ArtNetLab, a group of new media artists, have conceptualized a series of projects for geolocated virtual objects (augments), that can be perceived by means of smart-phone or tablet-computer applications in the urban space of a city. The user experience in art is not limited to practical and efficient use of a gadget directed towards a predetermined set of actions, instead it has to involve the user in the art experience, and this opens up a broad field of conceivable contexts. Our case study presents an art project that proposes and tests a concrete solution to the latent question proposed by an existing technology, and we describe how the artists encoded meanings by using a ubiquitous mobile platform for augmented reality.

Keywords: augmented reality, new media art, virtual objects in physical environment, emblem, fine art projects, case study.

1 Introduction

Since the beginnings of the human race there seems to be the need that the man makes sense of his physical environment, usually by leaving some material marks of his existence in the environment. Large stones are, for example, still standing across large parts of Europe as remnants of Megalithic cultures, their true purpose and meaning still disputed. Even if there are no visible features in the landscape ancient peoples such as Australian aborigines overlaid the often featureless and uniform Australian landscape with a symbolic meaning. Bruce Chatwin describes how this symbolic layer can be accessed by following sacred

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pathways or "songlines" which each generation learns from their ancestors [1]. Cultural landscapes as a combined work of nature and of man slowly evolved over time. Cultural landscapes seem to be the true repository of cultural and spiritual revelations of human history where the past is made visible. Deborah Tall's "From Where We Stand" is an eloquent exploration of the connections we have with places—and the loss to us if there are no such connections [2]. The primordial Slovenian landscape, for example, seems to be green hills topped with small churches, interspersed with fertile valleys and villages in between, although this was at least partly a result of medieval colonial settlement and counterreformation movement [3].

The continuous development of cultural landscapes is normally the result of organized effort of the whole society. Individual people, however, also had the urge to leave a mark of their existence in the physical world, be it a paleolithic artist who almost 20.000 years ago left his handprints in the Altamira cave by placing his hand on the cave wall and blowing pigment over it to leave a negative image, be it American landscape artists who created monumental earthworks in the 1970s and 1980s in the American west [4]. Another intriguing example of marking the existence of ordinary individuals in the physical space is the art project "Stolpersteine/Stumbling stones" by the German artist Gunter Demnig [5]. He remembers the victims of National Socialism by installing commemorative brass plaques in the pavement in front of their last address of choice. There are now stumbling stones in over 610 places in Germany as well as in Austria, Hungary, the Netherlands, Belgium, the Czech Republic, Norway and Ukraine. Each "stone" begins with HERE LIVED ... The artist believes that "a person is only forgotten when his or her name is forgotten".

The placement of individual "signs of existence" in the modern urban society is however difficult due to the normative and legislative nature of modern human society that often overly regulates the environment. Graffiti artists are well known for breaking the rules by leaving their signatures in public spaces. Even Gunter Demnig had problems with the implementation of his project "Stolpersteine/Stumbling stones" since several German cities prohibited the placement of these brass plaques in pavements [6].

A possible way of expressing individual initiative by leaving a mark in correlation to a particular physical point without breaking any regulations is to use augmented reality. The Internet and the World Wide Web technology were initially so exciting because they removed all geographical and temporal boundaries for the exchange of information. But due to the enormous amount of information available over the web, one of the filters for limiting the search for information, particularly on hand-held devices, has become again geographical or physical proximity. Since we exist in the physical space and many types of information relate to some location in the physical space, maps and mapping applications soon evolved also on the web. For example, we developed a pilot web application for collaborative georeferencing of Slovenian works of literature based on Google Maps so that the users of the system could cross-reference the imagined locations in literary works with points in the real world [7].

Although the technology for augmented reality has been available for decades, it is only now that it is becoming ubiquitous, when augmented reality browsers (AR browsers) can be run on smart phones, as in the case of the Layar platform [8] that we eventually used in our projects. Any user can easily obtain the application on the Internet and use it. On some smart phones it is even pre-installed. For the average end user no additional coding or payments are required. In the case study that is presented in this article, artists (with no formal training in computer engineering) used the application to communicate their artistic statements. However, in collaboration with computer engineers, this case study became a foundation for interdisciplinary research, where the results of the specific use of a technology were evaluated first "intuitively" from the primary user's, i.e. artist's point of view, and second, by using the concrete findings of the first phase in a broader usability evaluation of a family of similar software and hardware solutions. Of course, while realizing the project the two phases would merge in the dialogue of the disciplines. It is important to keep in mind that when a technology is accessible, it has to be actually used in different ways to find out, how useful it really is and what are its limitations for specific uses. The interdisciplinary effort elucidates the ties of a new way of exchanging meanings with the existing "older" modes of communication.

The artists working under the framework of the ArtNetLab society [9] experimented in a series of projects entitled "Atlas" by placing virtual objects into physical locations and extending printed editions with digital content. In one of their projects they actually succeeded in informally joining an exhibition by superimposing virtual forms on the physical environment where the exhibition was taking place [10].

The article continues in the following way: Section 2 talks about the development of virtual and augmented reality, Section 3 describes the cultural and technological influences that fostered the project series "Atlas", Section 4 talks about artistic use of augmented reality platforms, Section 5 presents the exhibitions from the augmented reality "Atlas" series, Section 6 gives the technical details of our project's implementation, and Section 8 concludes the article.

2 Recent History of Imagining the Transition between Physical Reality and Virtual Reality

Virtual reality and augmented reality have been used by artists many times, even before it actually existed on computers. Illusionistic paintings, for example, can be considered as forerunners of virtual reality since they present an invented image that from a standard viewpoint looks as if it were reality [11]. The best known examples are Baroque ceiling paintings that from a particular viewpoint make a flat ceiling look like extending into imaginary architecture of domes, towers or the heaven itself.

In the 20th century augmented reality was imagined most influentially by film directors, who could create a filmic image of it, which didn't require that

the technology would actually work. An important early model of virtual reality in film was "Tron" (1982) by Steven Lisberger, where the image was created using "green-screen" technology, i.e. by compositing a filmed actor and for that time advanced computer graphics that represented the virtual environment. Film "Disclosure" (1994) by Barry Levinson showed the hero of the movie entering the virtual reality by being scanned and his avatar is instantly reconstructed as his 3D mirror image in a virtual cathedral/bank, then he walks through the rooms and almost tumbles into a virtual abyss, because he stepped onto the edge of his highly original interface for walking, a kind of a concave tracking mat. "Johnny Mnemonic" (1995) by Robert Longo, based on a short story with the same title (1981) by the famous cyberpunk writer William Gibson, uses data gloves and helmet, he juggles the data and brakes the code in a predominantly tactile manner.

The materializations of virtual and mixed reality are more limited by the possibilities of technology in the fine arts and the conceptual arts. "EVE" (Extended Virtual Environment, 1993) by Jeffery Show is a colossal interactive computer graphic installation with virtual reality. However, it is much less illusionistic than the augmented reality in the films. An industrial robot with a video projector attached is synchronized to the moves of a user equipped with a helmet and a data-manipulation stick. The robotic arm projects a rectangular video image onto the hemispherical dome that contains the installation. The CAVE (Cave Automatic Virtual Environment) technology was another notable solution since its first implementation in 1992 [12]. It models virtual reality as a synchronized video projection onto the six walls of a cubic room. However, CAVE was expensive financially as well as in terms of spatial requirements so that only few institutions have it. Its fixed spatial position in research institutions and commercial facilities limits the users' possibilities to build content for the CAVE environment.

The full-body immersion of a person into a computer generated virtual reality, as seen in previous examples, has been a rare occasion until the arrival of portable smart screen devices with augmented reality applications. When you look through the camera of a portable screen device, you see your immediate surroundings with no temporal delay as though you had looked through a piece of glass, which means that you can look at your other waving hand or at your colleague with whom you are involved in a conversation. However, your recognizable environment in which you find yourself standing and moving is filled with virtual augments, i.e. images or 3D models. The image of virtual reality is not confined to the frame of a computer screen and thus totally isolated from the environment in which the computer screen is placed, but it is combined with the three-dimensional space that extends around you, holding a smart phone in your palm, and allows you to move freely in the city. In this sense the augmented reality on portable smart screen devices comes as close as it is currently possible to the imagined possibilities of being fully immersed into virtual reality spaces. The focus of this paper are AR projects that are positioned "in" or "over"

public spaces. We are not considering a special section of interactive art installations in gallery space that involve the AR connected to some marker and displayed by a video projector. These installations confine the AR to the closed space of art institutions and are not ubiquitous.

3 Artistic Experience: Cultural and Technological Influences That Fostered the Project Series "Atlas"

In London there are several small, although very interesting, contemporary art galleries, which are hidden away in obscure streets. It would be quite impossible to find them, if there was no "London A-Z" [13], a book with extremely accurate maps of all parts of London. The (mostly fictional) anecdote says that once it used to be only a quite unusefull map of London until a lady decided to correct it by herself [14]. On her bicycle she criss-crossed every single street and alley and draw it accurately on the map—now contained in "London A-Z". Her endeavour was not a matter of hours, it was of true Borgesian [15] proportions: a translation of a huge archive into another medium at a 1:1 scale.

"Google Maps" is a similar project, only that it stretches the mapping over the whole world and therefore employs hundreds of people, who drive the streets, record the "Street View" and manually draw the exact street directions into the satellite images of the Earth's surface [16]. Computer vision and other algorithms can undertake a huge part in this project, however only to a certain level of accuracy. For the correct notation of the traffic flow human experience and understanding are still more relevant and reliable. Google's motto that better data is more data combined with the promise that huge collections of data, that cannot be mastered by a single human being, will be sorted and retrieved by computers, still involve people in the process of tagging the data and managing the archive.

A person carries in her body models of spaces that she visited in the past. Memories of a space, of key objects in it with their many details and of the path walked through the space are so strong that in history, and even half way into the modern era, this experience was used as the main mnemotechnic device [17]. Famous rhetors, such as Cicero, distributed in their minds parts of their speeches into memory loci, e.g. rooms, that they built through painstaking exercises of imagining and remembering. While delivering the speech, the rhetor walked in his thoughts through these memory spaces and on his way he met the parts of the speech in correct order and—by means of connecting them to the details of the objects in the space—remembered also the details of the argument. The art of memory, so brilliantly described by Frances Yates [17], was finally replaced by a new technology of printed media. In 18th century the famous "Encyclopedia" of Diderot and d'Alembert arranged knowledge in a new way, into the forms of diagrams [18] and "atlases" of scientific disciplines. The conceptual forerunners

of atlases of knowledge were the geographical maps ... of the world sphere that the Titan Atlas carried on his shoulders[1].

Another concept that represents the humanist's point of view on the new media technologies is the "synthetic realism", coined by Lev Manovich [19]. This type of "reality" consists of virtual models and nothing in it exists unless somebody made it. E.g. there is no aerial perspective to soften the image, no filth to add detail to the texture of surfaces. Therefore a conscious decision and effort is needed to realize every single detail of a virtual model. In a similar way allegories and emblems were built, where each detail carries a special meaning. The "Emblemata" collection by Andrea Alciato [20] was used in the 16th and 17th centuries as a collection of practical wisdom and directions about how to live, and in the contemporary society of crisis, a similar reference would be similarly useful.

4 Artistic Use of Augmented Reality Platforms

The giant carrying the globe nowadays is Google, containing the archive of all knowledge, through which anyone can search, and also the map of the world, a photographic image of the world's surface that responds to the user—who is holding a smart mobile networked screen device—with meaningful information about her measurable current geolocation. The archive of Internet-based data and the information about the user's location on the map, which are both the basis for the localized search on the Internet, provide a multi-layered mixed reality. We can have a look into virtual augmentation of reality through the camera of a smart phone or a tablet with an AR browser activated. An AR browser shows—on a "layer" superimposed over the live video stream of the surrounding reality—additional digital information, e.g. images, videos and even virtual 3D models, that are linked to geographical coordinates or to objects that the AR browser can recognize with the help of previously uploaded images.

The virtual 3D models in augmented reality are a new field of spatialized images that still have to be thoroughly explored by artists. The new possibilities are opening up in the wide use of phones-computers. Lori Waxman, an independent art critic, wrote about the guerilla project by ArtNetLab—as part of her official intervention at the "dOCUMENTA (13)"—that the emblematic models of the artists are interesting enough to be interpreted, but that it is far more important to acknowledge the existence of a whole new layer of imagery and artistic projects that inhabit the streets of Kassel and can be viewed with smart phones alongside the official selection of art works made by the director of the exhibition Carolyn Christov-Bakargiev [10].

[1] The term atlas is first used for a collection of maps in the 1595 posthumous publication of Gerard Mercator's "Atlas sive Cosmographicæ meditationes de fabrica mvndi et fabricati figvra". The Titan Atlas was tied to maps earlier by Antonio Lafreri in the engraving for his collection "Geografia tavole moderne di geografia de la maggior parte del mondo ...", however, Mercator's title page image referred to Atlas, king of Mauretania, as explained in the preface.

Since 2010 there has been a rapid development in the use of AR on mobile platforms in the fields of art and culture. The artists used AR to put the images of their artworks in renown galleries and museums such as MOMA in New York that was invaded by the international artists collective Manifest.AR in 2010 [21]. The restrictive and highly selective character of art institutions could be relativized by the possibility of exhibiting your works in those galleries, at least in a virtual form that is nevertheless open to anyone. The medium specificities of AR models in contrast to the real material models was explored in the project "the world's biggest interactive sculpture" by Sander Veenhof launched in 2010 [22]. In this case, the artist built the concept on three facts: that the virtual model can be easily multiplied, that the construction of such a simple model as a cube is cost free and that it can be effortlessly spread over the whole world since the access to any geo-location is just one click away. Additionally, the models can be manipulated by anyone, so that a simple change of color of each cube is already a visual sign of a community of users interacting with the project.

Another frequent use of AR is to recreate lost or destroyed buildings from previous historical periods. In this way the twin towers of the WTC in New York were recreated by Brian August in 2011 [23]. The virtual recreation of the Berlin wall by the companies Hoppala and Superimpose in 2010 was a part of a larger AR information system about the history of post war Berlin [24]. Another example, which involves a tourist guide aspect as well as a more playful "treasure hunt" approach is the project "ArchaeoApp Rome" [25].

5 The Exhibitions from the "Atlas" Augmented Reality Series

The current crisis of ideas and morals demands a response, which was reflected in the first exhibition in the "Atlas" series by ArtNetLab entitled "Atlas, 5. 12. 2011", which is the date when Slovenian people were deciding how to tackle the crisis in political terms on the extraordinary parliamentary elections. The project "ΜΗΔΕΝ ΑΝΑΒΑΛΛΟΜΕΝΟΣ/Never Procrastinate" by Narvika Bovcon and Aleš Vaupotič presents a virtual model of an emblem from Alciato's book [20] that speaks about Alexander the Great and his instructions for success, however, the artists' effort was not enough to (magically) help to reform the Slovenian society at that time (in March 2011 when the project started) and thus prevent the regression into an atmosphere similar to the one from the 1930s.

Augmented reality "Atlas" is a group project that consists of individual artistic statements, these however are confronted with each other to form an archive of statements themselves and of the dialogic exchanges among the authors. The archive of the "Atlas" series can be ordered by three categories: by the authors from the ArtNetLab group, by the works or by the concepts that describe the different exhibitions. Five "Atlas" exhibitions were realized so far.

"Atlas, 5. 12. 2011" in Kino Šiška [26] in Ljubljana thematized video installations in urban space. From the Celovška street through the panoramic windows of Kino Šiška building it was possible to view video projections; the videos on the

Fig. 1. The Figure shows the video installation of eight video projections at the exhibition "Mnemonic Mirrors" in SC Zagreb. The photo in the Figure was taken with a smart phone with Layar application enabled, hence an augment from the project "JET PAC" by Gorazd Krnc is visible too. The augment is a virtual model representing one of the pieces of the rocket that Jet Man has to assemble to leave the planet.

screens inside the building were integrated as part of the furniture of the bar and of the information system of the institution; one project was exhibited as city light poster near the parking lot; a QR code that led to the exhibition catalogue was attached to the walls and windows. At the entrance a video showed instructions how to use the augmented reality part of the exhibition, which spread over installations in the real space.

The exhibition "Mnemonic Mirrors" in SC Gallery in Zagreb was completely different [27]. Eight videos were projected onto a large gallery wall, ordered as a regular grid of rectangles with two rows of four videos (Fig. 1). The concept of this video installation is based on the sheets from Gerhard Richter's "Atlas" [28]—we have replaced the photographs with video projections. Augmented reality was another layer over the grid of videos, the installation and the perceivable parts of the gallery architecture.

The guerilla intervention at the "dOCUMENTA (13)" showed a possible way of a non-invasive exhibition in augmented reality, non-material, illusional and ambivalently located—at the dOCUMENTA and not an official part of it (Fig. 2). However, "Atlas, dOCUMENTA (13)" will remain a permanent addition to the Karlsaue space.

At the "Month of Design" event in Ljubljana [29], the printed catalogue with augmented pages "Atlas 2012" (Fig. 3) was exhibited at the "Design Expo" (18–19 October 2012) and a signage system for the series of exhibitions "Design in the

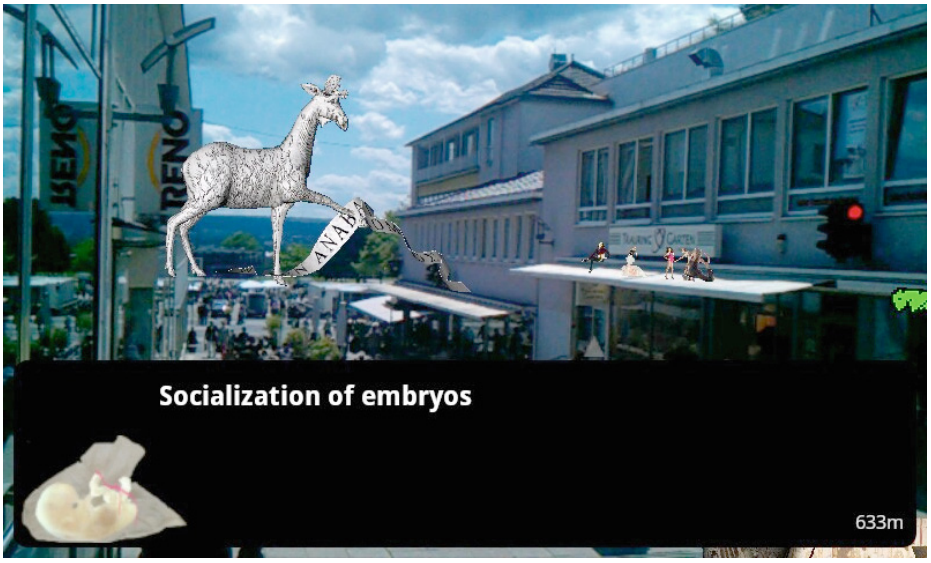

Fig. 2. The photo shows urban sculptures in augmented reality at Kassel. On a projecting roof there are Eva Lucija Kozak's virtual models of active pregnant women from the project "Socialization of Embryos". On the left side of the street there is the elk from the project "ΜΗΔΕΝ ΑΝΑΒΑΛΛΟΜΕΝΟΣ/Never Procrastinate" by Narvika Bovcon and Aleš Vaupotič. The interface of Layar application shows an image and a short text, in this case the title of the project, and the distance from the geolocation at which the virtual model is placed to the point from where the photo was taken.

City" (18 Oct.–18 Nov. 2012) was built in Layar and linked to the geolocations in the centre of Ljubljana. The virtual models by the ArtNetLab artists were placed among the signs pointing to exhibition venues as urban augmented-reality sculpturs (Fig. 4).

Another "exhibitional" realization of the" Atlas" augmented reality project is a 4cm × 4cm × 3cm miniature sculpture "Atlas Air Tagging", cast in silver (by Narvika Bovcon and Aleš Vaupotič, 3D print by IB-PROCADD, 2011)—see Fig. 5. The virtual models from the augmented reality were gathered into a compound virtual model, which was printed by using rapid prototyping in paraffin, from which a mould was made that was used for the final casting of this miniature sculpture in silver. Thus the virtual reality was materialized in a metal object and returned to the non-technologically visible reality. The piece was, however, always exhibited in the form of a video document.

5.1 The List of Authors and Their Projects for the "Atlas" Series

From the artistic point of view it is remarkable that the AR system on the mobile screen devices looks and feels surprisingly similar to the "Large Glass" (1915-23) by Marcel Duchamp. You see the ever changing flux of people and the

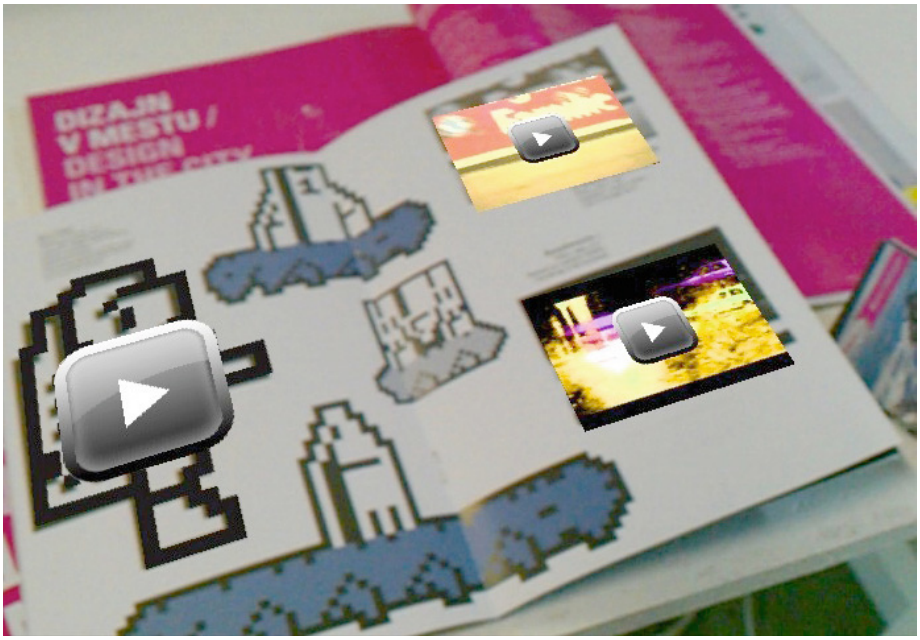

Fig. 3. "Atlas 2012" is an augmented catalogue of the "Atlas" series by ArtNetLab. The photo taken through the camera on mobile device with Layar Vision enabled shows the pages, on which projects by Gorazd Krnc are presented: there are three videos that can be played as video augments connected to the images on the page.

continuous perspective of the surroundings, while the augments float in the air, with sharp contours, flat, like strange stickers on the screen—as the chocolate grinder, the bride and the bachelors in the "The Bride Stripped Bare By Her Bachelors, Even". Isolated as shapes, containing some inexplicable meaning, yet appealing in their form and presence—the 3D models even pore so than the photos. The models look like rendered technical drawings of simple machines by Duchamp, 2.5-dimensional, since they are perceived as flat images. And yet they suggest, they are alive.

The projects used as augments were separate artistic statements encoded into emblematic images. The augments "float" superimposed over the live video stream on a smart screen device, whereas the lower part of the screen is covered with a dark rectangle with an inscription and a small icon linked to the project. The inscription provides a title or a verbal commentary on the project, while the icon is a related image, it shows a blow-up of a significant operational detail of the project or, contrarily, a wider view as a contextual image for the augment.

The artist Gorazd Krnc conceptualized an intervention into the real space by a man in a spacesuit. The viewer recognizes the familiar pixellated image of the spaceman and his disassembled rocket: it is the popular character from an old video game Jet Pac, which brings back the memories of a lost time when the computer technology altogether and we the users were much younger than today.

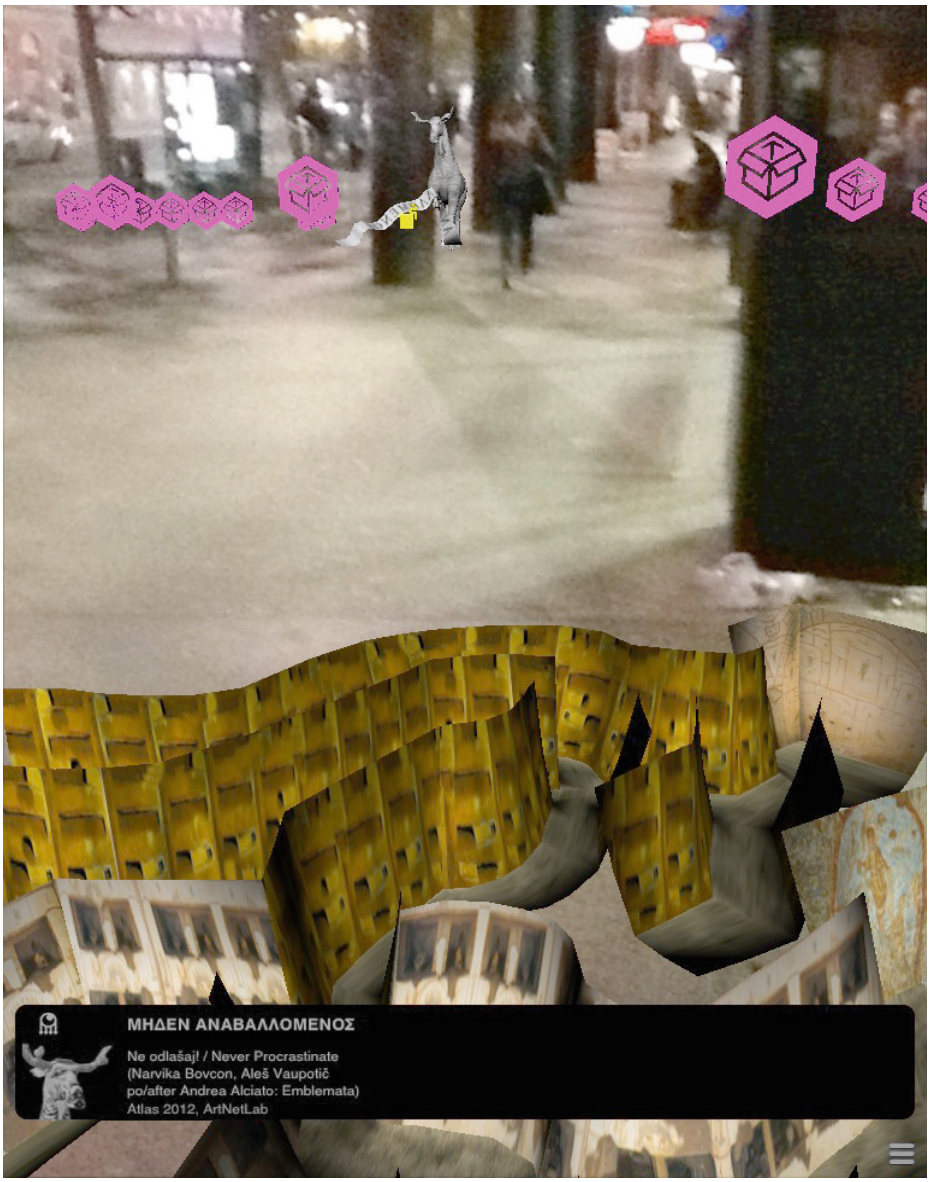

Fig. 4. By looking at the streets in Ljubljana city centre through the camera of a tablet computer, one will find on the "Atlas – Mesec oblikovanja" layer in Layar around fifty signs that guide the user/visitor to the exhibitions of "Design in the City". The signs carry basic information about each exhibition that is displayed in the black rectangle, and by moving towards the location of the exhibition, the sign gets bigger as the perspective in space changes. Among the signage for the design event there are urban sculptures by ArtNetLab artists. The bottom of the screen is covered with Dominik Mahnič's "CATACUMBAE".

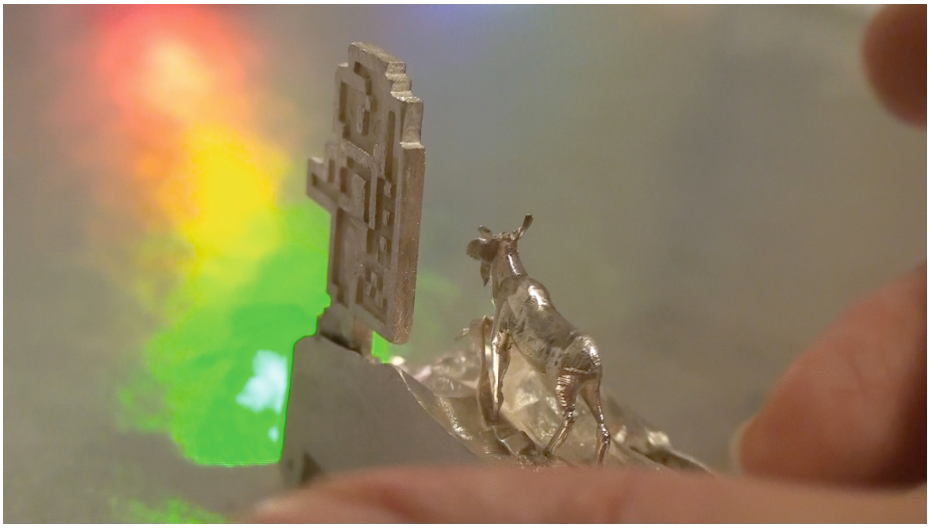

Fig. 5. "Atlas Air Tagging" is the title of a silver miniature sculpture, in which virtual models from the "Atlas" series materialise by means of 3D printing

The political connotation of the project, a quite pessimistic attitude towards our reality, resounds in the enterprise of the Jet Man: he wants to leave the planet, this is why he is combining together the parts of his rocket, to fly away. The icon shows a photo of an idyllic park as the departing point for the Jet Man to fly up into the summer sky.

Eva Lucija Kozak prepared augments in the form of elaborate tiny figurines based on images of pregnant women performing a plethora of activities, which she gathered from mass-media sources. The title of the project "Socialization of Embryos" comments on the fact that nowadays the parents are overwhelmed with the pressure to raise their children actively and responsibly, taking full advantage of each of the multitude of possibilities that are offered to everybody in the civilized world, even to the point when some future mothers start to socialize their not yet born babies by prenatally creating a Facebook page for them. The icon shows an embryo as a commodity item. In her second project "The Walk" Eva Lucija augmented a crossing of a neighborhood road with life-sized images of small children and elderly people, all of them needing assistance to cross.

Dominik Mahnič conceptualized a 3D model of catacombs and placed it beneath the users' feet extending over a vast territory. The project "CATACUMBAE" reminds us of the city of the dead below ground as a complementary city to the one that we perceive as our reality. For the exhibition "Mnemonic Mirrors" Dominik selected a video titled "Merda d'artista", showing exactly that; on the request of fellow artists, it was not projected in the grid of large video projection on the gallery wall, but was shown (or hidden) more discretely on a virtual "layer" of AR.

Vanja Mervič conceptualized the project "Thinking Colours—Hommage to Rodin" as an intervention that connects the geo-located AR layer with the augmented pages of the printed catalogue. A 3D model of a stylized Rodin's sculpture "The Thinker" was placed at significant spots in the city of Ljubljana. Each virtual sculpture of the thinker sitting on a large cube was colored in a different hue. When you come close to the virtual sculpture, then the cube covers the whole screen of your hand held device, thus you see only the color, not the shape or the surroundings. You start to contemplate—"think"—the colour. In the (duotone) printed catalogue there is a page with the map of Ljubljana with marked spots where the virtual sculptures are located. The colorless spots on the printed page—when scanned with Layar application—appear colored on the screen of the hand held device. When you click on any one of them, an e-mail is automatically generated with the Subject stating e.g. "Thinking blue" if you clicked the blue spot. You can write the e-mail and send it to the author or even to another person. Here the problem of privacy comes to the fore, since the Layar requires the user to disclose her or his identity by using the personal e-mail account.

Due to a space limitation in this article we will not explicate the meanings of the individual art projects by the ArtNetLab artists in the "Atlas" series, however, we shall list them and their projects to indicate the scope of this archive:

- Narvika Bovcon, Aleš Vaupotič: "Atlas Air Tagging", "Car", "Never Procrastinate",
- Jure Fingušt Prebil: "A Pig's Life", "Redefinition of Space",
- Eva Lucija Kozak: "Presence", "Socialization of Embrios", "The Walk",
- Gorazd Krnc: JET PAC, "Roadmovie 1", "Die unbekannte Stadt (Familie Werbung)",
- Dominik Mahnič: CATACUMBAE, "Art Slaves", "Merda d'artista", "Podnanos", "Dark Greenwood",
- Vanja Mervič: "Thinking Colours—Hommage to Rodin", "Blue", "Leaky Tension", "King Midas Room",
- Evelin Stermitz: "ArtFem.TV", "Women in War",
- Tilen Žbona: "Ikko tre", "Light Over", "Hobby AMG 63 outside", "AMG 65".

The projects were placed on different (sometimes simultaneously) levels of the augmented reality installation space: the physical objects in the gallery space, videos on screens and projections, 2D and 3D augments on GPS coordinates, the augmented catalogue pages, websites, and public presentations by the authors and curators[2].

6 Implementation

The main feature of "Atlas 2012" project is a series of virtual objects (models) on various geolocations, which are displayed as augmented reality on user's mobile

[2] Curators Narvika Bovcon and Aleš Vaupotič; Layar augmented reality co-curated by Dominik Mahnič; videos of Layar augmented reality by Gorazd Krnc.

device (Fig. 4). We wanted the augmented reality content to be accessible to as many users as possible—users of various backgrounds, with various levels of experience using augmented reality and also users of various mobile platforms. Therefore, it was not feasible to develop a custom AR browser, but we decided to select one of the existing AR browsers.

There are quite a few commercial and open source AR browsers for mobile platforms available, among others: Junaio[3], Layar[4], Wikitude[5], ARViewer[6], Sekai Camera[7], LibreGeo Social[8], Mixare[9], Arlab[10]. At the start of the "Atlas 2012" project we examined different AR browser providers to find a provider whose browser's feature set adequately covers the requirements for our project realisation.

The browser has to support displaying augments on geolocations (location based tracking), however, the accompanying "Atlas 2012" catalogue also uses marker based augments (optical tracking), which also serves as one of the entry points for accessing geolocated augments. Therefore, an AR browser that supports both geolocation and marker-based augments is needed. The virtual objects in our project are 3D models so the AR browser has to support the rendering of 3D objects as well.

Other considerations which were taken into account are: the support for 3D animations, display of video, POI actions (such as sending e-mails and SMS), offline data and caching possibilities, support of at least Android and iOS platforms, open and free publishing model, ease of use for developers and end-users, existing user base and existing web services.

Most browsers support only location based tracking or only optical (marker or markerless) tracking. The only two browsers with location based tracking and optical tracking are Layar and Junaio. They are together with Wikitude the three most used AR browsers according to survey by Grubert et. al [30]. All three AR browsers support 3D models and are open publishing platforms. Layar and Junaio are end-user and developer friendlier [31]. These properties are subject to change and there has been development on many AR browsers since the start of the "Atlas 2012" project. Examining the aforementioned features of different AR browsers at the start of the project, we decided to use Layar.

6.1 Layar AR Browser

Layar uses an architecture with three main components: client, "gateway" server and web services, which is a commonly used architecture in AR browsers [32].

[3] http:/www.junaio.com
[4] http://www.layar.com/
[5] http://www.wikitude.com/
[6] http://www.libregeosocial.org/node/24
[7] http://sekaicamera.com/
[8] http:/www.libregeosocial.org/
[9] http://www.mixare.org/
[10] http:/www.arlab.com

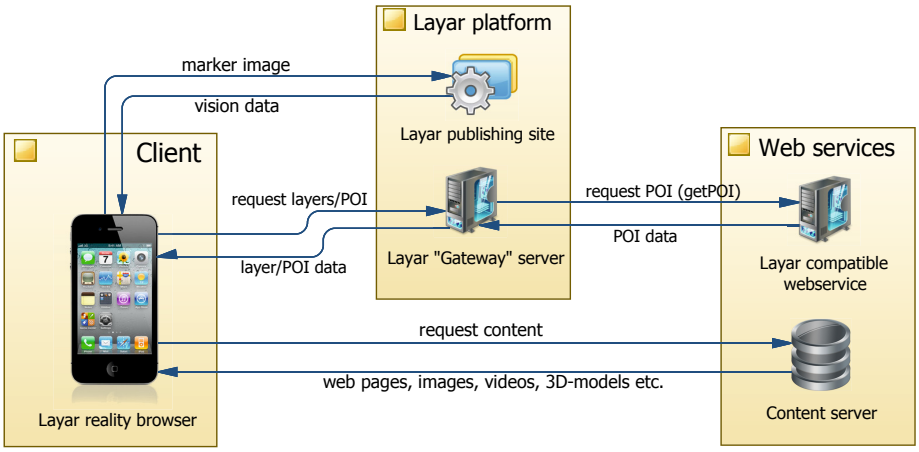

Fig. 6. A schematic view of the Layar architecture, which was used in the project "Atlas 2012"

Fig. 6 shows Layar's architecture [8], which is made up of the following components:

- the Layar reality browser, which is the client (AR browser) on users mobile device,
- the Layar server, which serves as a proxy for external Layar service providers and provides data concerning layers to clients. It also processes image markers sent from clients. Layer data can be managed using the Layar publishing web site.
- The Layar web service providers which provide POI (point of interest) data and content sources which contain the actual content. Service providers serve as interface for general content sources, which usually do not support Layar developer API.

Layar offers two possibilities to retrieve augmented reality content: geolocation and optical tracking. Geolocation based content is displayed on top of the live-camera image. The display coordinates are calculated from POI coordinates relative to user coordinates and users orientation. These are acquired from mobile device's GPS module and compass. When using marker based retrieval, the user photographs a marker image, which was in the case of "Atlas 2012" project printed in the accompanying catalogue. The image is sent to the Layar server for recognition. If the image is recognized, the client receives the corresponding augmented reality content. The content (interactive web page, movie etc.) is than displayed on top of the marker image (Fig. 3).

A typical request and response cycle in case of a geolocation layer display is as follows: the user launches the client AR browser (Layar Reality Browser) on his mobile device. The client sends a request to the Layar server, which returns layer

definitions. The layer definitions are previously set through Layar publishing website. When the user receives layer definitions, he can choose a layer and a getPOI request is sent to the Layar server. Layar server than forwards the POI request to the appropriate Layar service provider. The Layar service provider returns the POI data in JSON format to the Layar server, who validates the JSON getPOI response and, if valid, forwards it to the client. The client displays the response content to the user. The returned content can contain links to additional content like web pages, images, videos, 3D-models, which are directly accessed from web services.

For the "Atlas 2012" project we used a combination of Hoppala[11] web services for defining and serving geolocation layer POI in addition to our servers for main content—image, video and webpage data. The use of existing Layar web services greatly facilitates deployment as some Layar web service providers offer convenient web interface for defining POIs. However, if specific functionality is desired, we would have to develop our own services.

The presented architecture offers flexibility, although there are still performance issues and consequently a limit on the number of POIs is needed. However, as hardware capabilities are steadily increasing, these issues will probably become less noticeable in the future. As previously mentioned, the AR browsers are constantly changing and during the course of this project the previously free publishing of vision based layers is now subject to a fee, which may be a deterrent for similar projects in the future.

Another possible issue is the reliability of services. As can be seen on Fig. 6 the architecture depends on multiple servers and if one of the servers goes off-line, a part of the content or the whole content is inaccessible. Compared to physical world artefacts, which tend to be more persistent, the augmented reality content must be monitored if accessible to ensure availability in the future.

To enable the augmented reality content the user has to provide data to the servers. This data includes for example geolocation of the user, device identification data and images taken by camera for optical-based tracking. The images sent to the server may contain personal information (including third party personal information). This issues are usually covered by usage terms and conditions pertaining to privacy policy, which the user accepts before staring to use the service. The terms depend on the service provider, in case of Layar, the user permits the service provider to store and process the personal data to provide their services (pertaining to serving augmented reality content and associated services)[8]. However, the user has to pay attention not to send third party personal information, as submission of third party information would require the consent of the affected third party.

7 User Experience Evaluation

At dOCUMENTA(13) in Kassel the "Atlas" project was very well accepted, which is supported by the fact that one curator considered it to stand out among

[11] http://www.hoppala-agency.com/

several artistic projects. Actually, the AR aspect of the project was preferred over the other artistic media: the non-material guerilla exhibition that colonizes the real space on an augmented layer without cluttering the real space, with its versatile, smooth and ubiquitous intervention.

The augments were also very successful in the gallery of SC Zagreb, since the audience connected the images-virtual models with the projected videos in the installation of "Mnemonic Mirrors". The images and stories from the large video projections combined with the non-visible, surprising presences of the augments.

At the "Design Expo" the audiences were less inclined to appreciate the virtual objects, since they came to see the material exhibits from the industrial and fashion design domain. The whole point of design objects is their fetish existence, they are ownable, they adorn you or your living space, you can touch them, feel the textures and materials, feel the shapes in space. These are all categories and aspects that are opposite to the function of augments. Your iPhone is a design object, a fetish, but the data on it are not.

The augmented geo-located signage system for the "Design in the City" proved to be functional, playful and surprising for most users, although the technology itself is not accurate enough to allow for much experimentation. The geo-located points move substantially due to the gyroscope and GPS system limitations, the data are quite slow to load and follow as we point the hand held device in different directions, especially when we approach the limit of 50 items. With a dozen or more of them simultaneously on the screen, it is difficult to click them, particularly when they are very close together or when they become superimposed onto each other, because a certain area is required for the finger tip to touch the screen. The change in perspective, i.e. the distance dependent changeable size of the augments, gives only a vague notion of the distances to the objects, which is corrected by the information in meters displayed in writing in the lower part of the screen when an augment is selected. The above mentioned technological limitations were considered while we designed the signage system and most of the problems were solved with the right solution of the information coding by graphic design strategies. The Layar service addresses this issue by linking AR object to the reliable Google maps platform.

The printed catalogue with augmented pages was well-accepted in the gallery context and with other users that were able to experience it. The catalogue was conceptualized and realized as an artist book, experimentally, it is in fact a book of videos, of moving images. However, the functional, design oriented and educational aspects of augmented printed material soon took us into the direction of future projects of collaboration with museums. Our next step is under way, we are creating an augmented reality flyer that the visitors of a museum, especially younger audiences, can take home. They can see the multimedia documentation of the exhibition again, browse additional information, show the leaflet with videos to friends and parents and thus spread the knowledge of and on the exhibition.

8 Conclusions

We present a case study of using augmented reality in a series of fine art projects. Virtual sculptures and other objects were placed in physical space using location based tracking and a printed catalogue was enhanced with video clips using optical tracking. Augmented reality technology is now most accessible to a wider public due to hand held devices equipped with AR browsers which use built-in cameras and location tracking functions. Setting up augmented reality applications using one of the existing augmented reality systems is also fairly straightforward since it does not require any programming as demonstrated by the artists who initiated their project series using the Layar AR browser. The most serious problem that we encountered is the unstable environment which is due to the intensive development in this area. There are many competing augmented reality applications and the conditions for their use are not stable. Handling of personal information that images sent to Layar may contain is also not clearly defined.

In the future one would hope that augmented reality systems would become more universal. Virtual objects connected to specific physical locations should be accessible with any universal AR browser. In that way, any virtual object connected to a geographical location could be seen by anyone, much like web pages created by anyone can be seen with any web browser by practically anyone else. Physical landscapes as well as particular objects could therefore be overlaid by different layers of information related to history, culture, administration, economics etc. Practically any human intervention related to a particular location or object could be "seen" just by using the proper layer in an universal AR browser. Instead of a lifetime of learning the connections between our environment and its relevant information, these relations would become "evident"[12] with the proper device. First envisioned in fiction, the technical development in this direction is already well on its way[13]. How permanent and stable will these virtual objects remain in the long run is still not clear. Probably in their present form virtual objects will not be as permanent as cave paintings or brass plaques in the physical space turned out to be.

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[12] "evident"—ORIGIN late Middle English: from Old French, or from Latin evidens, evident— "obvious to the eye or mind," from e- (variant of ex-)"out" + videre "to see."

[13] Google Googles
`http://en.wikipedia.org/wiki/Google_Goggles`,
Project Glass `http://en.wikipedia.org/wiki/Project_Glass`,
Eye Tap `http://en.wikipedia.org/wiki/EyeTap`, etc.

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