Augmented Reality Supported by Semantic Web Technologies

Tamás Matuszka

Eötvös Loránd University, Budapest, Hungary
tomintt@inf.elte.hu

Abstract. Augmented Reality applications are more and more widely used nowadays. With help of it the real physical environment could be extended by computer generated virtual elements. These virtual elements can be for example important context-aware information. With Semantic Web it is possible among others to handle data which come from heterogeneous sources. As a result we have the opportunity to combine Semantic Web and Augmented Reality utilizing the benefits of combination of these technologies. The obtained system may be suitable for daily use with wide range of applications in field of tourism, entertainment, navigation, ambient assisted living, etc. The purpose of my research is to develop a prototype of general framework which satisfies the above criteria.

Keywords: Semantic Web, Augmented Reality, Ontology, Mobile Application.

1 Motivation and Research Questions

Before my doctoral research I dealt in detail with Augmented Reality and Semantic Web, but I worked in two areas independently. Thanks to my acquired experiences I recognized the opportunities which follow from the combination of these two different technologies. It is these facilities what I try to exploit during my research (e.g. to link physical places, objects and people to digital content). Both areas are dynamically growing fields thus there are several papers in field of Semantic Web and Augmented Reality. The experiments of combining these two technologies mostly come from the last few years therefore the common literature is not sophisticated. According to the statement of Gartner's 2012 Hype Cycles Special Report [1] both technologies are in the peak and have at least five years to the mainstream adaptation. It is also a motivating factor to research in this field.

Augmented Reality is such technology which is able to combine the physical environment with virtual elements generated by computer in real time. These elements could be, for example, 3D models, videos, images, music, animations, information, etc. The system created this way is located between the real and the virtual world. There are two kinds of Augmented Reality: one called marker based and another called location-based. The first one uses so-called marker, which usually is an arbitrary photo. With help of the marker the system is capable to compute the position

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and orientation of the virtual elements in the physical environment. The virtual element will appear on the marker. A good example for this is to display the 3D model of a molecule structure in chemistry textbook because it could be hard to imagine using only the two-dimensional representation. The second one is related with the physical position of the user. Computing of this position is usually based on GPS coordinates. The system shows the virtual elements depending on the location. For example, one could view the restaurants located in a given range, represented by virtual icons on the display of mobile device.

Today there are several location based Augmented Reality applications (e.g. Wikitude[1], Layar[2]) but they extract the needed data typically from one given data source. Nowadays with using of Semantic Web we can access a lot of public datasets, see the LOD cloud [2]. With the help of the LOD cloud the visualization capability of Augmented Reality could be extended. It would be useful to extract the displayable information from the public datasets located on internet instead of one given data source.

Currently accessible applications are typically made for a specific area, about this we could read in Section 2. I did not find any framework which was sufficiently general, or which was appropriate to develop arbitrary Augmented Reality application. To reach the general purposes we have to separate the data model from specific application area, because this is not a typical property of the accessible applications. For the above reasons I feel necessary to develop a general Augmented Reality framework, which is able to separate the data model and the logic of the application using Semantic Web and to provide the showable information from continuously expanding public datasets. To achieve this aim I have to examine semantic mobile applications and semantic database management system solutions, work out architectures and approaches, develop a prototype and test the efficiency of this system.

Based on the aforementioned facts the following questions are arising: How can static databases used by AR applications be connected and extended with semantic datasets? What kind of architecture and information model is necessary for the effective implementation and for ensuring the generality? What are the needed functions of the system? In which application fields could the system be used?

2 State of the Art

The literature has several application areas which use both Semantic Web and Augmented Reality (e.g. navigation, ambient assisted living, manufacturing, etc.). This section shows some of them.

In a previous paper [3] we describe an indoor navigation system which uses Augmented Reality to visualization. Storing of the map's data was based on an ontology and to generate the possible paths we ran rule-based inferences.

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1 http://www.wikitude.com/

2 http://www.layar.com/

Hervás, García-Lillo and Bravo present in [4] a mobile application for supporting daily life of elderly-people. They propose an adaptive model to transform physical information into virtual representation. To do this they use the accelerometers and digital compass of device. Users and their environment are represented in a formal context model. Based on this model and using semantic axioms and inference rules they can determine what the users want to do.

Schmalstieg, Langlotz and Billinghurst [5] intended to combine Web 2.0 and Augmented Reality. For this they implemented a location-based mobile Augmented Reality application, which enhances creativity, collaboration, communication and the reliable information sharing. Based on their system, they developed an indoor navigation system called Signpost [6] which is used for location-based conference guide.

According to Schmalstieg and Reitmayr [7] the data model has to be independent from specific application and their implicit assumptions. The georeferenced Semantic Web provides such a data model. In the paper they investigate how this model fits the requirements of Augmented Reality applications and how such a system can be developed.

Nixon et al. [8] suggest a possible solution for the cooperation of Semantic Web and Augmented Reality. They present how things of internet are described semantically and how can link into the LOD cloud. They implemented an application which is capable of manual annotation of concert posters (i.e. posters in the street advertise concerts and clubs.). The application can recognize these posters and then displays the extracted information.

There exist some touristic applications in [9] and [10], applications which support manufacturing processes in [11] and which use of robotics in [12].

We can see there are many solutions in different fields but it is conspicuous, that there is not any tool which is capable to make arbitrary Augmented Reality applications. The investigated programs are typically only marker based or only location-based. The system what I will to develop has to answer several open questions. One of the important factors is to specify the information model. To efficient operation of framework I should design the needed architecture. It is a problem, that there is not standardized evaluation method for location based applications

3 Proposed Approach

The aim of my research is to create a general Augmented Reality framework which exploits the advantages of Semantic Web. The framework could be divided into two parts. Arbitrary marker based application can be created with the first part. The idea is similar to the approach in [8], but the application area of that solution is limited to using concert posters. In my case it would be possible to create any marker based Augmented Reality applications with my framework. The second part of the system will be a location-based Augmented Reality application which combines the advantages of existing solutions and complements their incompleteness.

To create such kind of model is mandatory to separate the data model from specific application areas. In order to achieve this goal it is needed to design the information model. This model requires various new ontologies and linking existing ontologies to each other. These ontologies (which are made in OWL language) describe the conceptual hierarchy of the members which are located in different levels in the system.

One of my main objectives is the richer description of the existing georeferenced POIs (Point of interest) based on the LOD cloud. Information could also be taken from the LOD cloud in the case when some POIs do not have enough description (e.g. a POI has latitude and longitude but has not altitude). With help of Semantic Web and the LOD cloud I will dynamically link context-aware physical objects to virtual information, content and services. For this purpose different SPARQL queries and RDF datasets are needed. Let us consider an example. Suppose that we get the information about a building based on existing POIs. Afterward we can complete the given information from the LOD cloud (e.g. who was the architect of the building and what did he designed nearby.)

Social networks and Web 2.0 solutions are very popular. Therefore I feel important that my framework could share content in the various popular social networks (e.g. Facebook, Twitter). Using the location-based module of the framework the users would be able to share their current activities, to rate the viewed places, etc. To reach this aim, it is necessary to develop a user system. Handling of the profiles would happen with ontology. This ontology also provides the personalization.

After my framework is done, users could create applications which are capable to use arbitrary markers navigate through any area, finding different places, create and share content with the location-based module. The system could even serve as a base for smart city applications. My system will be built using client-server architecture or maybe on cloud architecture and it will be able to use the available services provided by Internet. The clients could be various devices, etc. smartphones, tablets, even Google Glass too.

4 Planned Research Methodology

In the first steps of the research I plan to explore and analyze the related work. Also an important objective is studying the basic ontology methods in this phase. With the possession of obtained knowledge the next steps are searching semantic mobile applications, examining semantic database management system solutions and finding new areas where the Semantic Augmented Reality is applicable.

After the preliminary study and determining the application the next step is to design the detailed specification of the prototype.

The implementation of the prototype follows the specification. This part can be divided into multiple parts because of modularization. The first part is specifying the information model which is the base of the system. For this purpose various ontologies are needed to describe the elements and their relations and the rules of the system. When the information model is done, I will implement the marker based and the location based modules. For this it is necessary to observe the existing open source solutions. If there are not such solutions, I have to develop it. Integration of the developed modules is also needed.

It is a problem, that there is not standardized evaluation so I will overview the frequently applied evaluation methods. On one hand I will test my framework with heterogeneous group and surveying, and on the other hand I will compare my system with the existing similar applications.

5 Schedule

This is the first year of my doctoral studies. I will specify the information model and extend the existing mathematical model by the end of the first year. I plan the beginning of implementation of the prototype and the server and the location-based module in the second year. Furthermore I hope that I also finish the marker based module in that year. At the end of my studies I will finish and evaluate my prototype of the framework, will make the connection to the social networks and write the dissertation.

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