MAUGRY: AUGMENTED REALITY GUIDE FOR MUSEUMS. FROM PROOF OF CONCEPT TO MUSEUM AS A SERVICE

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Abstract: *Augmented reality solution development for mobile devices is a rather young domain. There are very few guidelines and practically no patterns or mature frameworks for application developers. In this paper we present an evolution of an augmented reality guide for museums, we demonstrate possible solutions for major problems that were encountered. We discuss possible uses of augmented reality for mobile guide development and propose a possible alternative for augmented reality: a technique we call Smooth Transition. We demonstrate that for mobile guide a blend of Smooth Transition and Augmented Reality is the best solution. We analyze several approaches to exhibit recognition including: barcode recognition, special marker recognition and image of exhibit recognition. We analyze several major augmented reality frameworks based on practical experience of mobile guide development. Also we argue that a mobile guide must have user navigation capabilities, which allow users to find their route in an exhibition. We propose two different approaches to user navigation: spatial and semantical: first allows user to see a general layout of exhibition, while second helps user to navigate between thematically close exhibits. We also outline the basic components of a service-oriented architecture we call museum as a service. Museum as a service is a system which will allow any museum to promptly and with minimal expenses deploy a mobile guide application based on augmented reality and smooth transition.*

Keywords: *Augmented Reality; Museums; Mobile application development.*

ACM Classification Keywords: *H.5 Information Interfaces and Presentation: H.5.1 Multimedia Information Systems – Artificial, augmented, and virtual realities.*

Introduction

Rapid evolution of mobile devices has already significantly changed ways people solve problems. State-of-the art mobile device is often an irreplaceable tool for business operations, an always-present means of communication and recreation. One of many ways in which this evolution impacted computer science is the appearance of a new and still widely unclaimed market for augmented reality solutions. Contemporary mobile device is capable of real-time video processing and analysis and usually carries a number of sensors including video camera, accelerometer, gyroscope, geolocation sensor, making it a perfect platform for augmented reality applications.

Although augmented reality (AR) is a known scientific/application area there are still a lot of diffent problems and types of problems (including fundamental, project management, computer vision and technological) that need to be addressed in order to develop new applications. This paper presents some of these problems and solutions which were found while developing an Augmented Reality Guide for Museums application called Maugry.

Providing multimedia information for museum and exhibitions visitors is a natural domain for AR solutions. Nowadays museum attendee often is an individual less interested in group excursion who still wants to get a high level of service and personalized experience. Mobile device is a perfect medium for providing such service and experience.

In order to illustrate AR solution development problems and proposed solutions for them we are going to follow evolution of Maugry through 3 phases:

1. Demonstration prototype developed as a proof of concept.
2. Working prototype developed for Perm State Gallery.
3. Museum as a service. A work in progress to create an Internet portal which will allow any museum, exhibition or unaffiliated user to create an augmented reality guide.

Term definitions

Real space – real world space. Users move in real world space. Real space is divided in separate locations.

Scene space – background and all objects which form the scene (image that is displayed to user).

Augmentation point – place (point) in real space where augmentation object should be located.

Scene in augmented reality application is formed by displaying real world image and augmentation objects. Hence real space is called augmented space and collection of all augmenting objects is called augmenting space.

Maugry demonstration prototype

One of fundamental questions of AR solutions is "When should AR be used?" Demonstration prototype of Maugry (Maugry 0.1) was developed to answer this question for museum excursion domain (museum domain). The major capability of AR is that it allows to make content:

– Adaptive/Personalized. Displayed content can be modified to better address interests of a particular user, can be based upon his profile including his language preferences.

– Interactive. Content can react to user actions, interact with user.

– Multimedia enabled. AR allows presenting audio, video, cartographic information.

– Three dimensional. AR allows displaying 3d objects.

One of the alternatives for augmented reality is a technology we call smooth transition (ST). Upon augmentation point recognition ST replaces (instead of augmenting) whole real world scene (video stream) with content corresponding to augmentation point. One of major requirement for ST solution is to provide seamless transition from real world scene to content and back.

Major advantage of AR applications over ST applications is their ability to present augmented content side-by-side (in context) with real objects, allow real objects to interact with augmented objects without need for any transitions.

General algorithm of major component of AR and ST application is practically the same

1. Get video stream from camera and if necessary data from other mobile device sensors.

2. Analyze video and sensor data. Find first (all) augmentation point.

3. Construct the scene.

AR and ST solutions differ in way they construct the scene that is presented to user. Further analysis demonstrates that AR usually demands more sophisticated and computationally intensive algorithms for image analysis.

Maugry 0.1 heavily uses OpenCV library (a de facto standard library for computer vision applications) [OpenCV, 2012]. Maugry 0.1 is capable of recognizing three different exhibits and displaying corresponding content through a smooth transition to this content. Content is presented via interactive HTML 5 pages with audio fragments. Additionally this prototype is capable of presenting short text messages which appear near specific parts of a different exhibit and basic 3d objects which are displayed side-by-side with real exhibits.

Maugry 0.1 was presented to potential users. Upon receiving feedback from them several important conclusions were drawn.

1. It is hard and often impossible to use AR for displaying large amount of multimedia information. But AR allows creating unique and engaging applications where small chunks (separate objects, sentences, small video fragments) of data are sufficient to present the necessary material. One possible exception to the first conclusion is audio content. But in order to make application truly interactive we still recommend using short audio records (less than 30 seconds long).

2. AR ability to present 3d objects is a major advantage of this technology that should be used extensively. AR with 3d content can be used to demonstrate exhibits from different museums or even destroyed or non-existent exhibits side-by-side with real ones.

3. ST is a more capable technology for presenting large amounts of multimedia information.

4. Same computer vision components can be used for AR and ST application.

For domain of museum excursion we recommend to develop solutions which combine AR and ST components and allow to present complex multimedia information. To make porting (from one mobile platform from another) mobile applications simple we recommend using C++ based components for computationally intense tasks like video analysis. Content can be stored and viewed as HTML 5 pages for ST. In our application we used 3ds files to describe 3d models displayed through AR. 3ds format model can be imported/exported in/from most of major 3d computer graphics packages.

Maugry Industrial Prototype

Industrial prototype (Maugry 1.0) was developed for Perm State Art Gallery wooden sculpture exhibition.

One of major problems of AR and ST applications is augmentation point recognition. Following three methods are the most popular approaches to solving these problems:

1. 2D barcode recognition and QR-code recognition in particular.
2. Special Maker recognition (Marker-based AR).
3. Image recognition (Markerless AR).

The first approach based on 2d barcode recognition can primarily be used for ST applications, because they do not need to compute transformation matrix for content modification. Furthermore usage of 2D barcodes allows to embed information about content (for example its URL) directly into the code which simplifies development of ST application for expanding domains. However QR codes are hard to call esthetically appealing and in museum domain where composition of exhibition very often requires sustaining a certain style even in markers this disadvantage can be very important.

Alternatively markers specifically designed for AR can be used. They inherently allow reliable transformation matrix computation and several types of them allow markers to contain arbitrary images (which can be chosen to fit the style of a particular exhibition).

The third most common approach in AR is to recognize objects or images of objects. This approach is usually referred to as markerless AR [Ferrari, 2001]. According to feedback we got from potential users of augmented reality in museums this approach is the most suitable for museum domain, but it is also the most computationally intensive approach

We analyzed existing libraries and frameworks for AR solution development. For our purposes we analyzed and tested ARToolkir [Kato, 2000], ARTag [Fiala, 2005], Vuforia [Vuforia, 2012] and Layar [Layar, 2012]. Thorough testing result analysis is beyond the scope of this paper, but according to out result Vuforia demonstrates most stable and effective behavior on mobile devices and practically does not constrict developers in choosing ways of delivering their AR solution. Vuforia can also be used as the image recognition component for ST solution.

We used Phonegap framework [Phonegap, 2012] to develop parts of applications that are not computationally intensive. This allowed us to create easily portable solution.

Content for ST is stored on server in HTML 5 pages and retrieved by mobile client when exhibit is recognized. HTML 5 page can contain text, image, audio, video and interactive content. Also usage of HTML 5 pages allowed us to use standard web server (IIS 7.0) as a server side component minimizing complexity of server side development. Content for AR is stored in 3ds files and is similarly retrieved from server on demand.

Museum as a service

We are developing museum as a service portal which main goal is to allow different museums all around the world to use our mobile augmented reality guide.

Museum representative will be able to register on the portal and create an exhibition (a collection of exhibits). Then representative will provide means of recognition for each exhibit, which will constitute either photographs of the exhibit to be recognized or an image which will be used in special marker or representative may choose to use QR code. Also representative will provide additional content which should be displayed when exhibit is recognized. At first we plan to introduce only ST capabilities in our application because it is much easier for users to understand how to prepare content for such application. As a separate service we are planning to provide capabilities to introduce AR elements designed either by user or by our company.

Mobile application on museum visitors’ device will be able to get data necessary for exhibit recognition from our portal. When exhibit is recognized museum visitor will be presented with multimedia content provided by museum.

However AR and ST alone are not enough to allow user to get maximum information about exhibition. Museum guide should also be able to assist visitor in navigation. In order to facilitate navigation trough exhibition we show user two lists of exhibits that are close to the currently recognized one:

1. Exhibits which are spatially close.
2. Exhibits which are semantically close.

In order to find semantic distance from one exhibit to another we use a special metric on concept lattice. Concept lattice is constructed via a Gartner algorithm [Ganter, 2005]. Exhibits are considered objects, attributes are taken from attributes created by museum representative and extracted from text (using a keyword search algorithm).

Museum as a service is in many way architecturally more complex solution than a stand-alone application used in Maugry 0.1. In our Museum as a service solution we use MongoDb as a primary DBMS. Every museum can describe its exhibits differently; furthermore different exhibits in one collection can have very different sets of attributes. Choice of non-relational DBMS to store data about exhibits and exhibitions proved to be a more adequate solution (previously we were using MySQL DBMS and we found its capabilities ill-suited for museum domain). To allow full-text search and text mining algorithms implementation we also use Lucene [Lucene, 2012] indexing capabilities.

Server-side application is a .Net web-service which implements standard create, read, update, delete capabilities, and specifically designed query language to allow for schema ignorant querying. This approach allows us to abstract data layer specifics from service clients and change data-storage mechanics without affecting client applications.

We use Phonegap framework to develop parts of mobile applications that are not computationally intensive. Mobile client also implements a special cache level to minimize number of round-trips between client and server. It also features a "micro-query language" to allow mobile client to work with structurally different exhibits after they have been fetched from server without having to rely on server-side implementation of querying.

Conclusion

This paper has presented the evolution of Augmented reality museum guide application called Maugry. Each step of evolution was used to demonstrate solutions for different problems that typically arise when creating an augmented reality application. Advantages of AR usages were examined and ST alternative proposed. Fundamental architectural principals for AR solution development were demonstrated by example. Several questions of general architecture for museum as a service solution were discussed.

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Major Fields of Scientific Research: Artificial intelligence, Neural networks, Ontology Driven Development, Augmented Reality, Mobile Application Development