Semantics Enhancing Augmented Reality and Making Our Reality Smarter

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Abstract. This paper describes how semantic and Linked Data technology are incorporated into an Augmented Reality (AR) platform in the SmartReality project[1] and form the basis for enhanced AR mobile applications in which information and content in the user's surroundings can be presented in a more meaningful and useful manner. We describe how things of interest are described semantically and linked into the Linked Open Data cloud. Relevant metadata about things is collected and processed in order to identify and retrieve related content and services. Finally, the user sees this information intuitively in their Smart Reality view of the reality around them. We highlight how the use of semantics and Linked Data enables an AR experience which is more relevant for a user and with respect to what they have around them, and which can be automated and adapted at lower cost to content and application providers.

1 Introduction

SmartReality explores how people may be able to access relevant information, content and media about things of interest in their vicinity via Augmented Reality enhanced by the Web of data and the Web of services. This paper presents the first results and prototypes which explore and demonstrate how semantic technology and Linked Data can be integrated with Augmented Reality in order to make a user's reality "smarter". In Chapter 2 we present the state of the art in AR and in Chapter 3 the SmartReality use case and its realization as a workflow, a platform and client application. Chapter 4 walks through the workflow w.r.t. the use of semantics and Linked Data. Then in Chapter 5 we give first indications of what becomes possible with an example poster augmentation and conclude in Chapter 6 with an outlook for future work in SmartReality.

2 The State of the Art in Augmented Reality

Augmented Reality is defined as "a live direct or indirect view of a physical, real-world environment whose elements are augmented by computer-generated sensory

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input, such as sound or graphics. It's the overlaying of digital data on the real world." [Azuma, 1997], and applications like Layar[2] and Wikitude[3] offer selectable 'layers' or 'worlds' which define different topic-centred overlays over the user's smartphone camera view. These are based on POIs (Points of Interest) which are generally latitude-longitude positioned things displayable in the camera view via the use of the devices' GPS and compass. They are modeled in differing XML vocabularies. POI data carries its own (limited) content payload such as a textual title and description or image thumbnail, pointing often to full Web pages via URLs (opened separately in the device's Web browser). However, Augmented Reality today is fragmented and costly due to the need to generate individual POI repositories for each client application, while still limited both in the ability to subsequently process POIs with respect to a current context, and dynamically show relevant content in the Augmented Reality view from a selected POI. This is due to the current lack of semantic information and content interlinking around POIs.

While the POI-based approach to Augmented Reality relies on determining the device's current location (e.g. by GPS), approaches based on visual object recognition are now emerging also. Services are employed to match the visual appearance of objects in the camera view of the device to data associated with those objects within the application platform, e.g. the Blippar mobile application. Layar Vision is now opening up this model by allowing others to upload "seed" images of an object to be identified to their own servers and then provide a 'layer' which can use a visual match on the object to trigger display of some already provided data. Google's Goggles employs state-of-the-art large scale visual recognition algorithms combined with their enormous computing resources to enable visual search for a variety of object classes. The object identification is then connected to data about that object from Google's own data sources (e.g. maps and reviews for businesses) or by providing the results of a Google search on the object's title.

The value of the ideas of Semantic Web and Linked Data to the AR domain has been reflected in recent position papers, not only from SmartReality [Nixon, 2011] but also other researchers [Reynolds, 2010]. Early ideas can be seen in DBPedia Mobile, where data from DBPedia and other sources about concepts identified in the map view of a mobile device (via GPS coordinates) was displayed as a mashup with the map, or 'Mobile cultural heritage guide' [van Aart et al, 2010] which also explored use of Linked Data and faceted browsing in combination with device GPS information and cultural artefact metadata.

The vision of SmartReality is to leverage a richer description of POIs interlinked with the broad source of concept metadata found in Linked Data and from that, enable dynamic and relevant content selection and presentation at the AR client. This results in a more useful, aware and flexible Augmented Reality experience.

3 Smartreality Use Case and Realisation

SmartReality is focusing on a music scenario. Our goal is to use semantics and Linked Data to dynamically link references to music around us in our current reality to virtual

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[2] `http://www.layar.com`

[3] `http://www.wikitude.com`

information, content and services from the Internet which enhance our experience of music in our current reality. Consider a music-conscious person wandering city streets and seeing the ubiquitous street posters advertising concerts and club nights.With Smart Reality they can view an enriched version of the poster with related content automatically overlaid over the poster references to artists, events, venues and other things. This is illustrated below in Figure 1:

Fig. 1. SmartReality poster scenario

The SmartReality vision must be realised in terms of a software architecture, which forms a server-side platform together with a client application (Fig. 2):

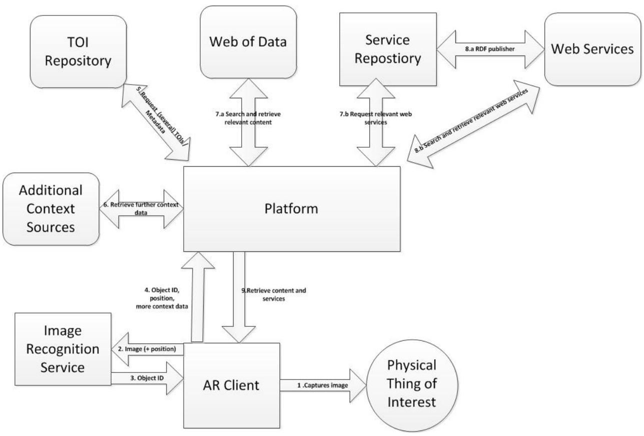

Fig. 2. SmartReality workflow

Server-Side Platform: The platform is developed as a set of server-side components which interchange messages to realize the SmartReality functionality expressed in the workflow. The platform is implemented in Ruby to loosely connect functional components in a manner that can be distributed and scaled.

Client Application: We built a client application prototype for Android smartphones. It leverages an Augmented Reality interface visualizing relevant information that is spatially registered on the physical object via Natural Feature Tracking. In order to recognize an object amongst thousands or possibly millions (as in real world scenarios) the external image recognition service Kooaba is integrated. Rendering of 3D content that is spatially registered to segments on the physical object is based on OpenSceneGraph[4].

4 Smartreality Walkthrough

The street poster scenario makes use of the SmartReality platform and client to combine a physical street poster on a wall in a city with virtual content and services about music and event booking.

Semantic Annotation: The poster annotation process is implemented via a web interface shown in Figure 3. We expect the poster owner could take charge to annotate their poster for subsequent enrichment in SmartReality. They start by selecting an existing event through an auto-completion search. If a poster image is connected to the event it is loaded into the web interface for authoring. Here, the user selects regions for triggering the appearance of content as well as regions where to actually display the content. Instead of connecting a concrete asset to the selected regions users rather one selects a LinkedData URI representing a concept (such as event, venue, artist) from an existing conceptual scheme. For the use case of event posters we provide a specific look-up of conceptual instances defined in the data.play.fm Linked Data dataset. The user however, has the option to link to any URI representing a concept that is part of any conceptual scheme (such as DBPedia, which gives an URI to every concept which has a Wikipedia page). When editing is finished, the annotation tool generates a Thing of Interest (TOI) annotation for the poster and stores it in a TOI repository. The annotation uses the TOI data model which is described at http://smartreality.sti2.org/rdf/toi**.** Additionally, the image of the event poster is uploaded to the third party image recognition service (Kooaba), which is used to identify the poster at runtime.

Linked Data Collection: By using Linked Data, metadata about concepts referred to in Things of Interest via identifiers can be crawled from the Web, or retrieved from Linked Data caching servers which already provide interfaces to the main Linked Data sources (like DBPedia). Specific sources can be chosen according to knowledge about the type of thing being discovered, using the TOI's classification (an URI of a class in an ontology or taxonomy). We focus on using the concept's classification to define specific properties to follow and depths to iterate. For example, of interest regarding Music Artists or Groups are the recordings (DJ mixes) they have made or tracks they have produced, as well as details of their performances in a given time period before or after the current moment. To implement this, we make use of the LDPath language[5]. As an example, if the resource is an instance of a Music Group, we want to crawl not only along the above facets for the group, but also for each Music Artist member of the group. We may have expressed a Linked Data crawling rule thus: `members = .[rdf:type is mo:MusicArtist]/mo:member`

[4] `http://www.openscenegraph.org`

[5] `http://code.google.com/p/ldpath/wiki/PathLanguage`

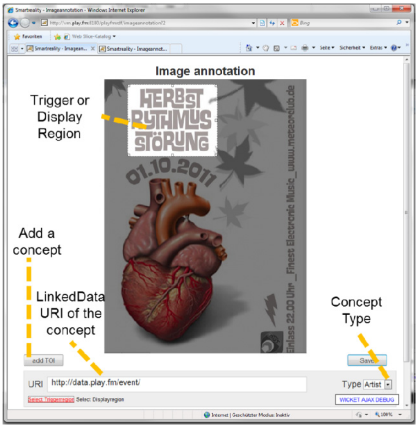

Fig. 3. The annotation web interface

This rule is stating to the Linked Data collector component of the SmartReality platform that for any instance of mo:MusicArtist crawled by the crawler, the crawler should also crawl the resource objects of the property mo:member of the subject mo:MusicArtist. For example, while the group Jack Beats may not have any performances at that moment, one member of the group - DJ Plus One - may have a performance coming up soon. The play.fm resource for the musical artist Jack Beats is at http://data.play.fm/artist/jackbeats. There are no mo:members specified in that metadata, but there are owl:sameAs links to two other LOD resources which are automatically followed (BBC Music and last.fm wrapper). The BBC music metadata identifies two further artists, Beni G and DJ Plus One, as members of the DJ collective Jack Beats, so the metadata about DJ Plus One can also be used in the enrichment of the Jack Beats poster.

Linking Virtual Objects Back into the Real World: Given we know something about the object of relevance, we feel that in SmartReality it is important to be able to link the virtual object represented in the AR browser back into the real world. After all, the object seen in the AR world is representative of something in the real world and capable of supporting some real world interaction.

In the SmartReality platform, we use a repository of Web service descriptions to store descriptions of available services over the Web for acquiring additional information, media resources and functional services around different types of things, following the approach used in Linked Services [Pedrinaci, 2010]. A semantic service description is used to express the types of thing the service can provide content for, and the type of content the service will provide as response. E.g. Seekda provides various XML services in its platform. This includes the hotel search service which allows to search for available hotel rooms within Seekda's client base. The precondition and effect are the principle hooks between the concepts we want to show content about in the AR view and the content itself, as we can now query for services based on what classes of thing exist in the collected metadata and what classes of thing we want to have information or access to services about as a result of the service execution. A

SPARQL query to look for services providing information relevant to hotels should find the (annotated) Seekda service. At this point, since Web APIs do not directly support Linked Data URIs, we have defined in the service description a means to "lower" an URI to literals which form part of the API request, as well as "lift" the API response to a set of annotated media resources which can be used in the enriched Augmented Reality view. Functional services such as reserving a hotel room are displayed using icons and open via URL the device's browser to continue the transaction.

Browsing and Viewing Content in the AR Client: This set of contents retrieved from the selected services are bundled and delivered to the client. A Content Bundle model has been defined for expressing the available content for each Thing of Interest in the Augmented Reality view of the application. The client parses these content bundles to provide content layers in the AR view of the application.

5 Example and Evaluation

Figure 6 shows the initial rendering when a TOI is identified, highlighting the segments of the poster annotated with some concept. Some initial content about the concept can be placed inline in the TOI description to allow for an initial content presentation while the platform workflow resolves additional content and services.

Fig. 6. Initial view over a street poster in SmartReality

Figure 7 shows a sample overlay over a poster of a content bundle, with images, video and widgets associated with different poster regions.

To evaluate the current prototype, in a user study at a real event poster at a public transportation stop in Vienna with 10 participants we identified following aspects: (1.) The users found the immediate availability of additional event information at the poster useful and indicated that they would use such a feature outside of the study setting, and (2.) They prefered to just quickly look at the content at the poster and then to take the information with them in an complementary 2D view for later exploration.

Fig. 7. Content overlay over a poster in SmartReality

6 Outlook and Future Work

The SmartReality project is about advancing augmented reality applications, moving away from the hardcoding of POIs and their associated (meta)data, and enabling more dynamic and flexible AR experiences which can provide contents in dynamic and richly interactive ways to the user of the SmartReality application. Through the use of semantics and Linked Data, the process of finding relevant content and services on the Web for any concept annotated in the Thing of Interest found in the user's camera view has been significantly made easier and more automated. Generic rules can be applied at each stage to avoid significant overhead for implementers to start enriching people's realities with virtual content as well as services with effects back into the real world (like buying something).

One of the barriers to richer media experiences via the Web has traditionally been the cost of annotating media and adding related content to it. The Web of Data now means there are possibilities, from a simple linkage of a part of some media to a Linked Data URI, to collect sets of related content and services from the Web and provide them to end users. The first SmartReality prototype shows this in the context of an Augmented Reality experience triggered by seeing a typical street poster advertising a club night or concert. Via Linked Data annotations, SmartReality dynamically unlocks for the user related and useful information and services about the event, driving them also to m-commerce opportunities (purchasing music, buying a ticket for the event). We acknowledge commonly known issues around re-use of Linked Data: data quality is sometimes unsatisfactory, and the completeness of information about concepts is very variable. We often had a manually correct or add missing metadata in the retrieved RDF to ensure that a satisfactory result was rendered to the end user. However, we believe such proofs of concept can help encourage data providers to realize the value of their data for new applications and work with the Linked Data community to ensure data quality and completeness. Linked Data business models can also play a role here: a commercial entity making business selling concert tickets via concerts found via Linked Data has a commercial interest in the correctness and quality of that concert data. We believe Linked Data applications and data will evolve in parallel, with the steps of improvement in data usage each time leading to better demonstrations of applications able to use that data in new and interesting ways.

Finally, once the current metadata-data-service-content workflow (Figure 4) is established we will examine how capturing and modeling semantically context information (such as user preferences or current activity) can be used to further guide each step of the workflow to offer more relevant and focused content and services in the resulting AR view of the user, since one challenge of using the Web of Data is not the lack, but the potential overflow, of data and contents being found. Being able to appropriately filter this overflow into the key information, contents and services of interest and relevance to the end user – particularly in the AR context with the limited screen space of the typical mobile device – remains a challenge for SmartReality.

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