# Concept and Applications of In-Situ AR Mashup Content

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# ABSTRACT

With the recent advent of mobile Augmented Reality (AR) applications, spatially appropriate content is overlaid on the real scene for a quick and intuitive information provision. In this paper, we introduce a concept of in-situ AR mashup content (AMC) as a new type of end-user created content for AR applications and as a concentrated digital trace that reveals Social and Community Intelligence (SCI). Especially, we present an AMC-based application for an art gallery that focuses on a specific representation format for AMC and the underlying architecture that enables such user participation. The proposed in-situ AR mashup elevates, otherwise passive users to active contributors of the content ecosystem by adding informational and experiential content. As a result of such content mashup activities, currently limited and frozen AR content ecosystem can be enriched and revamped. At the same time, the user-generated AMC implicitly leaves rich and multi-dimensionally structured digital traces that can be collectively used to build SCI.

# **Author Keywords**

User-generated content, mashup, CAMAR, SCI.

#### **ACM Classification Keywords**

H.5.1 Information interfaces and presentation (e.g., HCI): Multimedia Information Systems.

# **General Terms**

Algorithms, Design, Measurement.

# INTRODUCTION

Recently, many mobile Augmented Reality (AR) browsers are introduced through various smart phone platforms which provide rich information according to user's current location. In these applications, AR content is characterized as a physical realization of an information-enriched and valueadded link between virtual content and the real-world. Yet, the content used for AR is limited to the contents specifically provided by the service and content providers. Therefore,

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Figure 1. Concept of in-situ AR mashup content.

the role of end-users in AR applications is restricted as passive viewers only, where they have no roles in producing or contributing to the contents used in those AR applications. In this paper, we introduce a concept and applications of insitu AR mashup content (AMC) as an empowering tool for end-user participation and raw data serving for various applications. The proposed AMC is anchored on a real-world object via intuitive *interaction with mobile device* and combines already existing contents from *SNS and web services* which result in multiple and rich meta-data in forms of *personal and social digital trails* as depicted in Figure 1.

In this paper, we report on our work-in-progress in following aspects. (1) An architecture for generating in-situ AMC. (2) Representation of AMC that can be indexed with different categorial information for further re-use. (3) Exemplar application demonstration for an art gallery.

#### **RELATED WORK**

User participation was a key factor for the success of Web 2.0 where it served to form collective intelligence, knowledge and experiences. In a paradigm of citizen sensing [8], humans take a role as active sensors who create and share their views (human-centric) which are collectively used with machine-centric approach to yield an enhanced experience. Similarly, the importance of reusing the digital traces left by people while interacting with cyber-physical spaces is high-lighted in social and community intelligence (SCI) [14][15].

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Traditional Web Mashup



#### AR Mashup



Figure 2. Comparison of mashup concept.

Nowadays, generating user-generated content such as personal photo and video is easier than ever with the widespread of mobile phones. Especially, with some technical knowledge and experience on web services, API, and database, people can create their own mobile service [5]. One such approach is known as mashup, which combines multiple resources to create a new service. Through the trend of opening up web services via API, people have accesses for combining different web services, its functions, and data to make mashups in desktop environment [13], but hardly on mobile platforms [10]. It is beneficial to provide different levels of programming platform according to distinct expertise as explained in [2]. However, most current mashup via API requires background on programming and the web, which targets developers rather than end-users. In our work, we also adopt the notions of citizen sensing and SCI, but shifts mashup activities from web-based developers to end-users in mobile AR environment.

Several so-called AR browsers are available in different mobile platforms over the last few years. Argon is based on KHARMA framework [3] that uses web-based technologies such as HTML, CSS, and JavaScript to create contents for AR. Layar (www.layar.com) provides different information layers which can be customized and filtered over the real world view using GPS. Sekai Camera (sekaicamera.com) provides location-based contextual data as AirTag which can be filtered by different preference and objectives using Air-Filters. Wikitude (www.wikitude.com) uses compass, accelerometer, GPS and camera to find and augment information such as geo-coded Wikipedia articles. Similarly, AcrossAir (www.acrossair.com) introduced a number of applications to augment additional information on nearby places, wikipedia articles, tweets, and subway using user's location information. Junaio (www.junaio.com) also presents different channels of geo-referenced information. Apart from browsing, LibreGeoSocial (www.libregeosocial.org) supports labeling objects at different altitudes.

Current mobile AR browsers share two characteristics. First, augmentation of content relies on GPS. Second, the provision of content for AR is limited to only developers with technical background yielding a "frozen" content ecosystem. Compared to the related works, our approach initiated in CAMAR project [9][11], is an object-based approach at a finer visual granularity and provides simpler and instant interface for end-user level mashup.

# **USER-GENERATED IN-SITU AR MASHUP**

#### Preliminaries

Azuma categorized AR systems with three characteristics [1] and Woo further defines AR as 1) A 3D link between real and virtual world with additional information, 2) Apply to all senses, not just sight: sound, haptics, etc., and 3) Natural interactive UI/UX on the fly. According to this categorization, content in the aforementioned AR browsers are not registered in 3D, but only registered roughly with the use of GPS and compass sensor. So we define in-situ AR mashup with this definition of AR and adoption from our previous work [11] and Figure 2 illustrates the differences between traditional web mashup and in-situ AR mashup.



Figure 3. Architecture of in-situ AR mashup.

**In-situ AR mashup** is seamlessly combining additional contextual information to a real-world object to enrich content in one or more senses, where mashup process and its outcome are enhanced with context awareness and visualized with augmented reality for intuitive UI/UX.

Since the term mashup refers to either the process or the outcome of the process, we explicitly state AR mashup content (AMC) for the generated content as the result of authoring. In traditional web mashup, programmers or developers use two or more APIs from different web services, and combine them through mashup editors or by programming to prepare for the presentation. In comparison, our in-situ AR mashup makes selection step easier by using a camera to detect Object-of-Interest, then extract keywords for searching and recommending contents for mashup.

## Architecture

Figure 3 depicts the overall architecture. Similar to traditional web mashup, in-situ AR mashup also involves steps for selecting components, *Real Component Selection, Virtual Component Selection*, and *In-Situ Mashup*.

#### Real component selection

Since we are adding more information to an already existing object in the real world, we need a means to recognize certain objects. In domain of AR, many computer vision-based recognition and tracking methods are available and we use recognition method specialized for the planar (2D) object [4][7]. With a camera on user's mobile phone, user can select an Object-of-Interest to recognize the target object. As an output of *Object-of-Interest Recognition*, it returns an ID of an object as well as corresponding 3D pose which is used to augment contents accurately on the target object.

## Virtual component selection

Once a real target object is selected, then we extract metadata from the ObjectDB. ObjectDB stores object ID with descriptive keywords for each category of 5W1H (WHO, WHEN, WHERE, WHAT, WHY, HOW) information. These extracted keywords are displayed as a default text in Cube UI as shown in Figure 4.

In the cube UI, there are 6 slots, the last slot is reserved for displaying a signature of the creator, such as QR code for the creator's web page or avatar. We use 6 types of content



Figure 4. Cube user interface for selection.



Figure 5. Selecting from the retrieved list of contents.

to be used for mashup, because 6 is a number that can be perceived by a user using a mobile device also a 3D cube is made up of 6 faces for visualization. When a category is selected, the default is used as a seed query or user can input another keyword in *Query Request* to search and find relevant information from web services such as Flickr, Picasa and Twitter as shown in Figure 5. The retrieved result, a contents list is ranked in *Context-based Ranking* according to user profile and keywords. Virtual component selection part includes most typical web-based mashup processes such as REST request, REST response, and parsing but all are hidden under the simple cube user interface.

#### In-situ mashup

When the user finishes the selection, metadata for the generated mashup content is automatically added in *Mashup Formatting* and *In-situ Context Tagging*. These include attributes shown in Table 1, which is defined in an accordance with [6]. These metadata for mashup content is later used for different purposes such as identification, sharing, recommendation, search, filtering, and augmentation. Then the result is visualized in *Mashup Visualization*.

Attribute	Туре	Category	Use
AuthorName	String	WHO	Ι
AuthorID	Integer	WHO	Ι
Recommendations	Key-Value	WHO	SH, R
CreatedDate	Date	WHEN	S, F
Location	GPS,Pose	WHERE	А
TargetObjectID	Integer	WHERE	S, F
ContentID	Integer	WHAT	Ι
Description	String	WHAT	S
SourceInfo	MashableContent	WHAT	S, R
Tags	String	WHAT	SH, R
Hits	Integer	WHAT	R

Table 1. Representation format of AR mashup content, I: Identifica-<br/>tion, SH: Sharing, R: Recommendation, S: Search, F: Filtering, A:<br/>Augmentation.

## **Prototype Demonstration**

By creating a user-generated AMC, we strengthen two aspects of user participation. First, AMC contributes to the content ecosystem by enriching the number of available contents and also breadth of content by combining different types of resources from different point of views. Particularly, depending on the nature of information mashed-up, we categorize mashup content into informational and experiential mashup content.

Informational mashup content supplements information that is currently missing or presenting different explanation or interpretation of the same fact. In most AR applications, whenever an object is recognized we can get a content provided by the content provider. For example, when a painting is recognized, an AR application may augment paintingrelated information supplied by the content provider by default. By creating mashup content beyond the default information, user can supply missing information or create different interpretation by selecting different components such as pictures, tweets that enrich the default information. When AMC is further expanded as different combinations by multiple users, the collection of AMC results in digital traces on the target object that captured important values. Also informational mashup content is highly structured, with 5W1H categorical information. For example, an alternative explanation on "Why Vincent van Gogh draw so many paintings on sunflowers?" can be made into an AMC by using the selected keywords in Figure 6 as queries.



Figure 6. Information according to 5W1H.

A more relaxed and free-form mashup content is experiential mashup content. For creating this type of mashup content, users can supply his or her own experience as an extended form of user comment, user review or Like/+1 on the target object to better express one's own experience.

## **APPLICATIONS**

As an exemplar application of AMC, we elaborate the use of AMC for social and community intelligence with an art gallery tour system. In an art gallery, there are many art paintings. A number of paintings are grouped in a section and posted in a same exhibition. As users visit the art gallery and create AMC for paintings of their interest, multiple AMC are generated and anchored to the each painting. Since the user-generated AMC has rich set of metadata as described in Table 1, many useful meanings can be extracted.

**AMC Recommendation.** In a case of certain paintings with multiple AMC, highly relevant content should be presented to users, especially in mobile AR environment. For this purpose, relevant AMC can be recommended by *createdDate* for freshness and *sourceInfo, description, tags* for relevance. Also most contents selected for AMC have social relationship information such as follower/followee for Twitter, Friends for Facebook, and Subscriber for YouTube, this social relationship information is considered to recommend socially relevant content with credibility.

**Painting Recommendation.** If a painting has many AMC attached, this indicates popularity or interest of the painting. Along with attributes such as *recommendations* and *hits*, a popular section with popular paintings can be recommended for visitors in a generic recommendation. Further, if a user profile with his or her preference is known, user preference can be matched with *tags* and *description* for personalized recommendation.

**Path Recommendation.** Since we can recommend AMC and painting, the idea can be further expanded to tour recommendation. Similar to using multiple user-generated GPS for itinerary recommendation [12], a sequence of paintings that maximize available time use and personal interest can be recommended.

## CONCLUSION

In this paper, we presented in-situ AR mashup approach to create new contents for AR applications and explored how the associated digital trails can be put to use. We introduced an object-based architecture and representation format for AMC that can be utilized in many applications such as recommendation services. For future work, we will explore how different types of mashup content (informational and experiential) could be visualized in AR environment for effective browsing and retrieval.

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