A Survey on Tools for End User Authoring of Mobile Applications for Cultural Heritage

Christos Fidas, Christos Sintoris, Nikoleta Yiannoutsou, Nikolaos Avouris

***Abstract*—Effective and efficient approaches are required in order to develop and maintain cultural heritage applications and services that meet user requirements and expectations. This is particularly relevant to cultural heritage mobile applications which support diverse usage scenarios among a variety of stakeholders and diverse contexts of use. In this context, a promising approach is to engage non-technical cultural heritage experts in using end user authoring tools for creating mobile applications for cultural heritage. To this end, a plethora of such end user authoring tools has been proposed. In this paper, we provide a survey of such tools by emphasizing on approaches which allow end users to assign geo-location tags to multimedia information of cultural heritage. The purpose of this review paper is to categorize some of these approaches and to conclude with promising directions for future research in this area.**

***Index Terms*— Cultural Heritage Mobile Applications, End User Authoring**

I. Introduction

In the era of cloud based and ubiquitous computing there is an increasing interest in designing systems that promote cultural heritage through the use of mobile devices and applications [1]. In this context, mobile devices play an increasingly important role in enhancing audience interaction with cultural heritage. Interactive mobile phone museum guides and tourist guides, location-based games, stories and other applications provide information and support for visitors of sites of cultural interest, taking advantage of the proliferation of powerful mobile devices with internet connectivity and sensing capabilities [2].

Lately, an increased number of these applications allow, for non technical end users, to supply content and modify the application characteristics aiming to create more customized, engaging and immersive mobile experiences. Such authoring tools provide a solution to the ever increasing requirements of non technical cultural heritage experts to actively participate in the creation of interactive cultural heritage experiences and to become content suppliers (or even game designers) in order to customize the software they use and to contribute to the design of their own interactive experiences which are bootstrapped to their audience or diverse target groups [3]. In this context, "*end-user development can be defined as a set of methods, techniques, and tools that allow users of software systems, who are acting as non-professional software developers, at some point to create, modify or extend a software artifact*" [4]. The underlying idea and assumption of such approaches is based on the fact that end-user authoring approaches will lead to a new age where it will be quick and easy for anyone to contribute and maintain content of digital cultural heritage assets [5]. These solutions can take the form of crowd sourcing applications that augment and modify the content or creation of links between cultural assets, tools that allow modification of games and stories or collaborative creation of new such instances based on frameworks and templates [6, 7]. As mentioned in [3], the design of systems that enable end user authoring activities requires a shift in the design paradigm, which must move from user-centered and participatory design to meta-design, which literally means "design for designers".

The paper surveys first the main characteristics such end user authoring applications, putting special emphasis on the need to assign geo-location tags to multimedia information of cultural heritage and the need to facilitate the process of semantic connections of assets. In addition special emphasis is put in the need for relating the action and information to physical location, and thus the authoring tools need to be implemented on mobile devices that simulate the run-time user experience. Subsequently, a number of authoring tools for end users are presented and discussed. Among them, the development of LoCloud project that allows for using cultural digital assets of Europeana by local cultural institutions [8], TaggingCreaditor [9] that allows for editing of digital cultural assets to be used for linking games, LMAC [10] that is used for creating scavenger hunt type of games by end users, CHEF [11] for a framework on cultural heritage applications authoring. Finally special emphasis is given to arisgame.org an open-source platform for creating and playing mobile games, tours and interactive stories by end users.

The paper is organized as follows. Firstly, we review existing end-user authoring tools that can be used for the creation of mobile applications within the context of cultural heritage. We present existing approaches based on conceptual, technological and user interaction design factors. Subsequently, we discuss the main findings of this research endeavor, reach our conclusions and describe promising directions of future work.

II. Related Work

With the aim to provide a comprehensive overview of end user authoring tools we present in this section case studies which allow end users to create augmented reality experiences, alternative reality games and location based games.

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A. Hoppala: content Management Platform for Augmented Reality

Apparently, the use of augmented reality and with geo-localized digital content is becoming increasingly important within the cultural heritage application domain. As mentioned in [12], "*augmented reality (AR) is a live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data*".

In this context, Hoppala [13] supports an end-user authoring content management system for creating and managing geo-based content that can be used in augmented reality mobile cultural heritage applications. Nowadays, it is probably the world's largest developer community, with several thousand end users who are engaged in content creation for geo-based augmented reality. This authoring tool received international recognition for rebuilding the Berlin Wall in AR on a consumer mobile device [14].

Figure 1. Screenshot of *Hopalla*.

Conceptual and User Interaction Design: As it is depicted in Figure 1, from a conceptual point of view the authoring system provides an easy to use direct manipulation interface which associates physical world objects (regions, buildings, monuments etc.) with digital multimedia content. In this context, it permits end-users, to specify points of interest using a geo-location interface integrated with Google Maps [15] and correlate them with spatial information and virtual multimedia elements. These virtual elements can take the form of documents, websites, videos, audio, 3D models or pictures and can be compared with content uploaded by other users. Every point of interest is arranged in layers and users can use virtual elements from a pre-populated inventory which is composed by assets that have been uploaded by other users supporting therefore a crowd sourcing solution.

Architectural and Technological Design: From an architectural point of view, it provides a cloud based solution to end-users which allows hosting their applications on cloud based premises. One of the main technological advantages of Hoppala is the possibility to publish its content in the most knows augmented reality browsers: Junaio [16], Layar [17] and Wikitude [18]. Finally, the end users have to create their own channel, on one of the aforementioned browsers, and align it with the Hoppala API endpoint URL.

B. ARIS: an open-source platform for creating and playing mobile games, tours and interactive stories

ARIS, Augmented Reality and Interactive Storytelling [19], is an alternate reality game (ARG) authoring tool that uses the real world as a platform and uses storytelling to deliver a mobile experiences that may be altered by players' ideas or actions [27]. In this context, it allows for rapidly producing locative, interactive, narrative-centric, educational experiences. In addition to the software, the project contributes a global community of active designers and a growing set of compelling mechanics for learners in such designs.

Conceptual and User Interaction Design: From a conceptual point of view, it is based on two basic pillars: a) a web based authoring tool and b) an iPhone based game engine application which is required to be downloaded by game players in order to participate in location sensitive games that have been created through the ARIS authoring tools. As depicted in Figure 4, the ARIS editor provide to its end-users several functionalities like, creating and maintaining a list of games, identifying the location in which the game is supposed to be played. Subsequently, the user has to define objects/items (e.g. multimedia objects, link to web pages, hints etc.) and place them on specific GPS coordinates on the map. These objects, which represent points of interest to the game players, can be hidden, public viewable or can be active based on specific game play situations e.g. when a game player approaches the predefined location. These objects can also inherit interactive behaviors like the ability to be droppable which allow users to pick them up or let them down in other location of the city.

Furthermore, the editing platform allows the end users to create and maintain characters within their game design. The game characters can be placed anywhere around the specific area in which a game takes place. These game characters can be used in order to create more interactive storytelling experiences as they can take the form of virtual game instructors or advisors by giving hints on how to proceed with the game play. For this purpose a player can only interact with a character under some certain conditions like in cases in which he poses some certain game items etc.

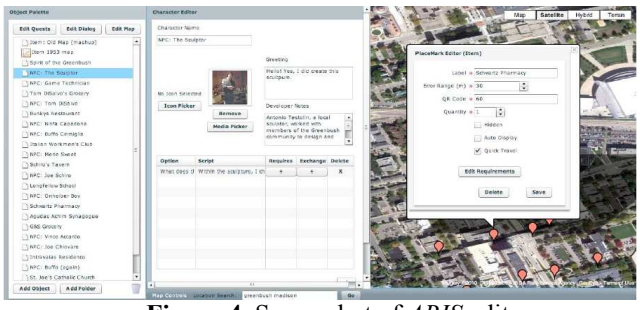

Figure 4. Screenshot of *ARIS* editor.

Architectural and Technological Design: From a technological point of view, the authoring tool is developed using the Adobe FLEX 3.5 SDK along with a number of supplemental open source libraries (provide QR-Code identification, robust network infrastructure and JSON parsing etc.) and the Google Maps API. Communication with the server is done through the AMF3 protocol. The iPhone client is written in objective-C and communicates to the server using the JSON protocol.

C. *TaggingCreaditor: A tool to create and share content for location-based games for learning*

TaggingCreaditor [9] is a content authoring tool for indoor and outdoor location based games [20,21,22,23,27]. It aims at supporting interactive learning activities in cultural heritage sites. It is based on the idea of connections between digital content and the physical world. In this context, the authors provide an abstraction in the frame of an end-user authoring tool that can be used in order to adapt content under a variety of use case scenarios from different stakeholders like teachers, curators etc. The overall idea is to engage visitors in linking games which is a process of discovering relationships between museum exhibits and objects that are not included in the public exhibition.

The vision of this approach is stated by the authors as follows: "*…such a tool would allow the users to create content for any type of location-based game that challenges the players to link the real world with entities of the digital realm, and allow that game to be played in any location. Such a content editor would allow developers of location-based games to launch their games in a large number of locations, but it would also allow other interested parties, such as educators, curators, or residents of an area to create end-user content for existing games.*"

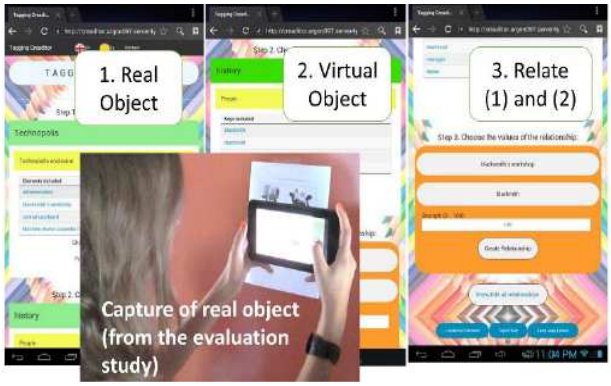

Figure 3. Screenshot of *TaggingCreaditor*.

Conceptual and User Interaction Design: From a conceptual point of view, the underlying idea is based on an ontology with several layers of abstractions which correlates the physical world *elements* (real-world branch containing objects like exhibits of a museum, monuments or buildings, historical places etc.) with respective virtual world elements (virtual branch containing mainly multimedia content). The linking between the real world branch and the virtual world branch is based on *key* elements. Within a game play the games need to establish the correct relationships among the physical world and the virtual world entities which awards credit to a player. From a user interaction point of view, as it is shown in Figure 2, the mobile version can be used by an end-user to: (a) define a real object, (b) define a virtual object and (c) create a relationship between the two.

Architectural and Technological Design: From a technological point of view, the client is based on an Android application and the user authoring tools is implemented both as a mobile and desktop application, which offers the possibility to end users to easily create, edit and/or mix content for these games. Finally, it is worth to mention that a marker based approach is followed to align virtual objects to physical objects by using QR codes or NFC tags.

D. *LoCloud: Local Content in a Europeana Cloud*

LoCloud [24], envisions to become the common access point to the different kind of collections of European libraries, archives and museums from all around Europe. Simultaneously, it provides an open access European digital library for all researchers, professionals, students and the public. In this context, it is supporting small and medium-sized institutions in making their content and metadata available to Europeana, by exploring the potential of cloud computing technologies. Furthermore, the opportunity is given to end users to easily set-up their own digital library, museum or archive in the cloud [25]. For this purpose the end-user can organize their content into multiple collections and they can choose from several website designs and make further adjustments [25].

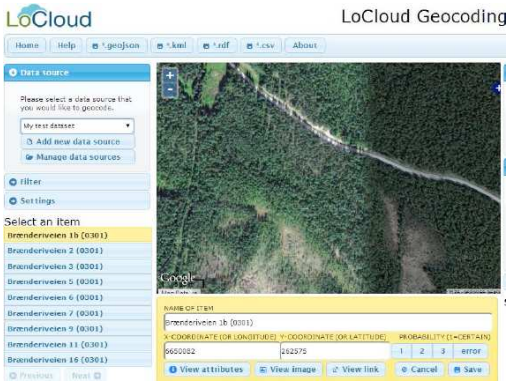

Figure 4. Screenshot of *LoCloud*.

Conceptual and User Interaction Design: From a conceptual point of view, the LoCloud project is targeting in enriching cultural heritage content with specific geo-located information. This is achieved, bearing in mind that the majority of heritage metadata contains some form of implicit or explicit geographical reference which are indirectly referenced through textual or formal references such as addresses or geographical names. From this perspective, spatial metadata with map coordinates are used to visualize the location of a resource and to infer meaningful relationships between two or more resources based on the proximity of their spatial metadata.

Architectural and Technological Design: From a technological point of view, LoCloud provides web services that can be used by content providers in order to upload and maintain their digital contents. *The Gazetteer*: a service for supporting the organization and maintenance of geographic data, by providing storage, data integration, and search services; A Gazetteer consists of a list of geographic names, together with their geographic locations and other descriptive information. *The Geoparser*: a service that uses information extraction techniques to automatically identify names of places and time periods that are mentioned in unstructured text. It works together with the Gazetteer to be able to assign coordinates and dates with the mentioned names of places and periods.

LoCloud accepts metadata in one of the following three intermediary schemas: LIDO, CARARE Schema (v2.0) or EAD. Thus, content providers are asked to convert their original metadata to one of these three alternative schemas. All metadata supplied by content providers to the LoCloud aggregation infrastructure are converted, without user intervention, to the Europeana Data Model (EDM) [26].

E. CHEF: a User Centered Perspective for Cultural Heritage Enterprise Frameworks

CHEF provides a direct manipulation visual environment where cultural heritage domain instantiate design schemas with the proper multimedia contents, and generate high quality hypermedia applications for different delivery platforms without learning any specific implementation technology. CHEF ultimate goal is to empower cultural heritage professionals to create and maintain their hypermedia artifacts without the need for in-house trained programmers or expensive outsourcing.

Figure 5. Screenshot of a cultural heritage application created through *CHEFF*.

Conceptual and User Interaction Design: From a conceptual point of view it aims at providing an enterprise framework which denotes a "reusable, "semi-complete" application skeleton that can be easily adapted to produce custom applications in cultural heritage. It inherits a meta-data model which allows non technical end-users to re-use software components. CHEF distinguishes two major roles for CHEF users: *editorial designer* and *editorial author*. The editorial designer operates at design time, and defines, for the application under development, the information, navigation, and presentation schemas. The editorial author operates at instantiation time and defines the context that must be available in the final application for each device.

Architectural and Technological Design: From a technological point of view, the framework is modeled into three logical categories of objects: Model, View, and Controller. *Model* objects represent application domain data, *view* objects are responsible of rendering the contents of the Model and forwarding user commands to the Controller. *Controller* objects are responsible to map user requests to operations on the Model, to execute them, to build the proper View, and to return to the client. The architecture of the dynamic generation components exploits a well known approach in web engineering, separating the application business logic from its presentation and control logic. The presentation logic manages user interaction and data presentation on the client side. The control logic, which is mainly rules running on the server side, receives and handles the requests from the presentation level, manages the functionality defined by the business logic (e.g., data retrieval or update, composition of the required HTML page), and returns an HTML page to the presentation level via the network infrastructure using the HTTP protocol.

F. Location-based Mobile Application Creator creating educational mobile scavenger hunts.

Picker et al., (2014) present a location-based mobile application creator (LMAC), a framework for creating different mobile location-aware applications that has been used for creating content for guided tours or scavenger hunt type of games in sites of interest. Applications can be created either as simple applications with informatory setting, or as playful scavenger hunts with game design elements to make the experience more engaging. The games can be designed either in a collaborative or competitive way. A collaborative game can be developed by creating different scavenger hunt applications for each user (or group of users). Because the knowledge and skills of many persons is required to find the final target point, the users have to work together to reach the target. In a competitive setup, users try to find all target points on their own (or in groups), and try to be the first (or quickest) at the final target point. The software is flexible and reusable, allowing thus the creation for different application scenarios. This can either be the creation of (1) an application helping tourists to gain information about a city, (2) an application for gaining information about unknown areas, such as during a tour through a large university complex, or (3) an application for learning about the environment, such as historical information or geological highlights while hiking.

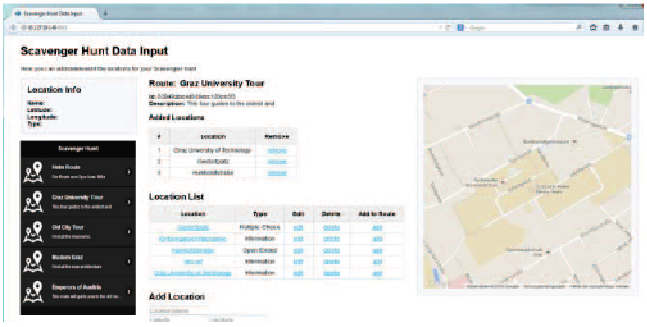

Figure 6. Screenshot of the web-interface of *LMAC*.

Conceptual and User Interaction Design: From a conceptual point of view, as it is depicted in Figure 6, LMAC is designed as an online editor for creating mobile applications, which use geographical information and can trigger events when a special location is close to a target point. Each target point (or point of interest) is linked to an activity, which is triggered when the user of the mobile app is close to this point. The interface of a running scavenger hunt is based on a map view, which displays location and distance to the closest target point. When the user gets close to the target point, the linked activity pops up. The user has to process the information (e.g. watch a video) or do a task (e.g. answer a question), and will then receive the location data of the next target point.

Architectural and Technological Design: From a technological point of view, the interfaces of the mobile applications, created with the LMAC web based editor, are mobile web applications designed with a focus on cross-platform compatibility. Thus, jQuery1 Mobile, a HTML5-based system for creating responsive web sites and apps, is used. This allows the application to be used on different mobile devices with different operating systems, and does not limit the use on Android or iOS.

III. Conclusion and Future Work

Mobile interactive applications especially when they need frequent updates and modifications require cost effective methodologies and approaches that can be used in order to be responsive in a timely and cost effective manner to new requirements of various stakeholders. Especially within the cultural heritage application domain the design of cultural heritage mobile applications must compile with the diversity of end-users, as content consumers, who commonly have different goals and motivations but as well to various end users, as content suppliers, who desire to actively participate in the creation of their own products, games and ideas in cultural heritage sites. Therefore, the traditional software development model which involves the active participation of software developers to address new requirements does not provide a viable solution in the cultural heritage domain.

A solution to this challenge is provided through the provision of end user authoring tools which promote end user development approaches. The underlying idea of such approaches is to allow non technical cultural heritage experts to design and deploy the final application devoted to visitors of cultural heritage sites. To this end, numerous attempts have been proposed. Some of them have been analyzed in this paper with regards to their conceptual and architectural approaches. Special emphasis has been put in authoring tools which allow the creation of location sensitive mobile applications by exploiting the capability to specify geo-location information of museum exhibits or other physical objects of cultural interests.

A general conclusion derived from the survey is that the main challenges in providing efficient end user authoring tools within the cultural heritage application domain are related to the following aspects. From a conceptual point of view the main challenge is to define a set of primitive elements which can be used by cultural heritage experts as abstract building blocks with the aim to support the creation of various cultural heritage experiences which embrace a variety of user interaction workflows and multimedia content without the direct help of professional developers.

From the presented case studies we can conclude that different researchers used different sets of primitive elements in order to assist cultural heritage experts in using their authoring tools. The provided primitive elements were strictly related to the genre of the cultural heritage application and embraced semantics related to the underlying engine of the authoring tool. For example, for creating location specific cultural heritage multimedia applications the end users needed just to identify, on a map, points of interest and correlate them with multimedia content. However, for creating location sensitive linking games, end user interaction were more demanding since the end users needed to understand and use the semantics of such primitive elements which associated physical and virtual objects and keys within a game play. Finally, for creating alternative reality games the primitive elements embraced several static and dynamic attributes and represented literally an object oriented approach of primitive classes. In this context, an interesting future research attempt would be to streamline efforts with the aim to create meta-models of such primitive elements and to align them to cultural heritage mobile application genres in order to identifying common patterns of requirements which could lead to the development of more sophisticated end user authoring tools for the cultural heritage domain.

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