Application of contextual QR codes to augmented reality technologies

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***Abstract*— Augmented reality is a technology that involves digital content deployed in the physical world in real time through the use of devices and sensors that allow users to interact with the resulting hybrid environment. Likewise, QR codes have become popular and accepted by the general public. They are useful for conveying information in the physical world and thus connect to the digital world in a practical and simple way. This paper presents an application of QR codes for generating augmented reality environments. Using the notion of *contexts,* a complete user interaction is enabled in terms of the relationship of QR codes and augmented reality. We present an analysis of augmented reality technologies supported by this approach as well as the architecture and operation of a system that implements these concepts.**

***Keywords*—Contextual QR Code, Augmented Reality, Ubiquitous computing.**

I. Introduction

Augmented reality (AR) enables different experiences that bring digital content overlayed with the real world through hardware sensors under various location–based technologies in real time. As noted in [1] there are three key features of AR systems: (1) Mixing virtual images with the real world, (2) three-dimensional registration of digital data, and (3) interactivity in real time. However, it may be complicated to bring augmented reality technologies to users in a ubiquitous manner across different platforms effectively. This is mainly due to hardware or software restrictions imposed by devices, so developers need to generate various applications that meet user needs for augmented reality on each device, depending on the information content they want to take the user. Nowadays, Quick Response codes (QR Codes) offer a practical means to provide a link for the user from the physical world to different types of digital content through the use of a digital camera sensor, which can identify and recognize the codes printed in the real world. This enables the development of interesting applications to be integrated with other technologies. Currently, using QR codes in AR [2] has been carried out in a way that presents an interesting behavior by separating applications from content. However *context QR codes* [3] is a recent approach which introduces a different view for managing content, by merging public (QR Code) and private (the user's device that scanned the code) part of information, which generates new interesting experiences for AR technologies.

In this paper we describe novel ways for carrying the user into AR ubiquitously by providing the benefits of *contextual QR codes* [3], such as changing the AR content and technologies depending on the location, current time, hardware and software features, and so on.

The paper is organized as follows: In the following section, we provide additional background concepts on QR codes. Then, we discuss briefly some salient projects in AR. We then proceed to discuss the notion of Context QR codes and how they can be used for AR applications. Then we describe a system that integrates these concepts. Next, we present an application scenario in order to understand the main concepts proposed by this research. Finally, we provide an overview of work in progress and preliminary conclusions from this project.

II. Background

Recent work with augmented reality with QR code application [2] illustrates an interesting system which allows the user to create custom QR codes with an embedded URL. This URL links the application to custom AR content; the system gets the content through a network connection and deploys the content using the QR code itself as a marker to track and locate the place to present the AR content using the respective API.

As demonstrated by [3], context QR codes allow for extensions to QR code functionality by providing an embedded URL within the code that links the application to a XML document, in which some behavior is triggered given the user context situation. Contexts may vary their content depending on the user location, date, time and also hardware and software configurations, such as the kind of device, device version, operating system, version of the system, and so on. This implies that contextual QR codes can be used to produce different responses to the user, depending on specific situations.

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It is clear that both AR and QR could work together. Also, AR technologies are soaring because of progress experienced by mobile devices. As we can see in [4], new technologies are being discovered and implemented with augmented reality. Moreover, QR codes have demonstrated great social impact [5]. This approach makes this technology useful to bring new experiences to the user.

III. AUGMENTED REALITY

As noted in [4], augmented reality is a rapidly evolving technology in which the form of user interaction can be classified into different technologies and tracking algorithms. Table 1 shows a classification of the various augmented reality technologies identified thus far by our research. Most augmented reality applications agree on an essential function, which is to display digital content, but differ on how to locate, identify and trace the area to display the content in the real world. Some of the key AR technologies are discussed by [4] and [6]. As mentioned in Table 1, first of all we see the use of augmented reality technology using markers [7]. This is the most basic application for the development of augmented reality. In this approach, physical marker cards are used for locating the points to display.

T. Kan et al. [2] use QR codes as card markers in order to display augmented reality content, but additional functionality provides a link to the augmented reality content to be downloaded from a server on the Internet. It is worth noticing that this approach is the main influence on our project, as the use of QR codes may go beyond their use as a marker, as discussed later.

J. Choi et al [8] use another technology, which consists mainly of floating labels that are displayed on the screen at locations identified by coordinates that satisfy a GPS positioning. This deploys augmented reality content that depends on a position at a pre-defined location..

K. Akaho et al [9], use an approach in which augmented reality is generated using a default map, which is displayed on the user's route. This approach generated possible routes and recommends an optimal route for a driver to reach a destination, mainly by displaying roads and arrows on the screen and overlaying them on real world images.

A. Comport et al [10], use an approach in which we can see the recognition of shapes and forms to locate areas of content delivery in an augmented reality environment.This is carried out by using algorithms for search and content determination positioning of augmented reality. Research is needed for enhancing algorithms and make them resistant to changes in real time to such factors as light exposure, high contrast, foreign objects, and so on.

M. Yuan et al [11], use augmented reality face recognition, namely the display of information around or at certain points on people's faces using an algorithm to detect forms of human faces.

TABLE 1. Augmented reality technologies

Name	***Tracking Description***	***Support Libraries***
AR card-based markers [6,12]	Defined with a marker card that identifies an area, location and space in which graphical content that interacts in real-time with the environment is displayed.	ARtoolkit [12], Layar, Wikitude, Junaio [6], Qualcomm Vuforia [13]
AR using a QR code as marker card. [2]	Similar to the basic use of markers cards, but in this case the augmented reality content is stored in the QR code for its deployment.	Layar, Junaio, ARtoolkit [6,12]
AR based on points of interest (POI) [8]	The most frequently used; consists of an object that is positioned by using GPS coordinates and its location is shown as a floating label.	Wikitude, Layar, Junaio [6]
AR with navigation maps. [9]	Used for navigation maps to show routes in real time and to suggest the best route.	Wikitude drive [6]
AR with element recognition [10]	Consists of AR content displayed in a particular location recognizing physical elements with predefined shapes that are overlaid in the real world.	Qualcomm Vuforia [13]
Augmented reality based on face recognition [11]	Recognizes human faces in order to display AR content.	Layar [6]

Augmented reality is an experience in which the form of user interaction can be classified into different recognition algorithms and features; this is because augmented reality is currently limited due to hardware or software conditions, so we can set different techniques and strategies that are used to detect position or elements in an environment to meet different needs.

Augmented reality technologies may vary in the way they trace the location to display augmented content and in the experience offered to the user. Also, it is noteworthy to say that many technologies have different supporting libraries to work with, as noted in the third column of Table 1, by separating AR technologies. This analysis provides us the necessary feedback to understand the technologies that could be helpful in supporting the notion of context discussed below.

IV. QR CODE

QR codes refer to a type of two-dimensional, physical code developed by Denso Wave[1]; its main features include the quick response reading and storage capacity, which allow the user to be linked instantly into specific digital content [3, 14]. This content could be, e. g., plain text, location coordinates, contact cards, phone numbers, SMS text, and so on. Also, QR codes have shown to be user friendly, and well accepted for social interaction [5]. This is helpful to bring specific content to the user.

A. Contextual QR code

As we can see in [3], given that the content of a QR code is statically stored, its data cannot be changed. However, an embedded URL in plain text may lead to content that can change dynamically on the Web. It is thus possible to use a URL embedded in the QR code to change the content of a response depending on the user's context. This is possible with a XML description that refers to different situations or contexts in which the user can be found. System responses will adapt to each possible situation. As in [3], this approach is referred to as *contextual QR code*. Fig. 1 exemplifies different attributes assigned to a contextual QR code for augmented reality purposes.

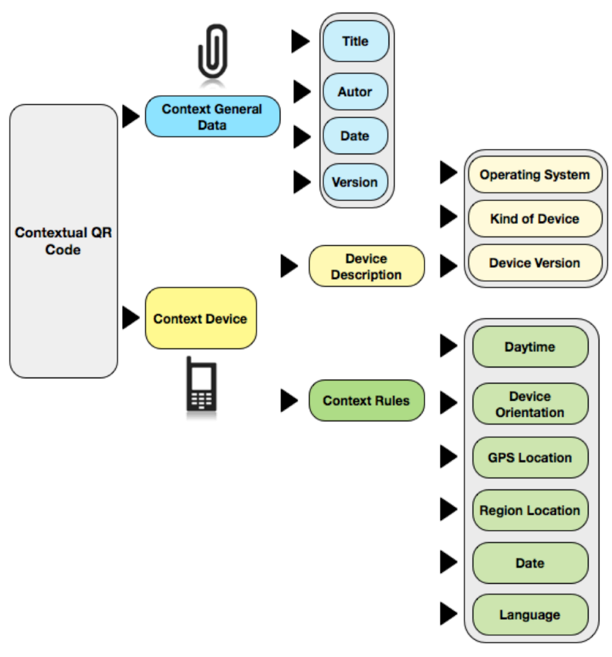

Figure 1. Context QR code attributes.

[1] http://www.globaldenso.com/en/, Web site of Global Denso, a subsidiary of Toyota. Last accessed on Nov. 29, 2012.

B. Contextual QR codes for augmented reality

Each contextual QR code has an associated XML description, as shown in Fig. 2, which is formed by the general data of the context document, which is important to identify the document's state. This includes author information, description, date and version. Context definitions follow the general description, one per device type or considerrng software or hardware features such as operating system, or whether the device is a Smartphone or a Tablet. Moreover, contexts also can be defined depending on dynamic data such as the user's position (given a location using latitude and longitude position coordinates in order to know where the user is in real time), the date or the preferred language. Each context provides the path to augmented reality content (which is packed on a Zip file in this case) and the technology to be implemented with the appropriate API. The XML description in Fig. 2 shows that it is very straightforward to integrate technology with their content among devices in terms of hardware and software. In this case, different augmented reality content can be displayed on iOS mobile devices. The deployment of these technologies depends on whether the user is at a given location, and the content will be displayed using the augmented reality technology for each context.. As we can see, it is very straightforward to define a XML description document for contextual QR codes. Also, notice that the system takes the benefits of using a camera to read QR codes and reuses the camera for displaying augmented reality content.

```
<?xml version="1.0" encoding="UTF-8" ?>
<augmentedrealityqrcode>
    <generaldescription>
        <title>Context Test</title>
        <autor>Francisco S. Gutierrez</autor>
        <version>1.0</version>
        <date>23082012</date>
    </generaldescription>
    <context src="test1.zip" augmentedrealitytechnology="cardmakers">
        <device>
            <operatingsystem>ios</operatingsystem>
            <kindofdevice>smartphone</kindofdevice>
        </device>
        <rule>
            <location lat="18.868420" long="-97.101241" range="5"/>
        </rule>
    </context>
    <context src="test2.zip" augmentedrealitytechnology="cardmakers">
        <device>
            <operatingsystem>ios</operatingsystem>
            <kindofdevice>smartphone</kindofdevice>
        </device>
        <rule>
            <location lat="18.846525" long="-97.093083" range="5"/>
        </rule>
    </context>
</augmentedrealityqrcode>
```

Figure 2. Context document description

V. SYSTEM DESCRIPTION

We have designed an AR system based on contextual QR codes which follows six main stages, as illustrated in Fig. 3: The first step requires a validation of QR codes so as to make sure that the data provided refer to valid URLs which lead to valid XML documents. This prevents invalid QR codes from entering the system. Then we proceed to get the XML document which includes context descriptions. The document is obtained from a Web server. Next, the features described in the document are validated so data integrity is maintained. Afterwards, the document is interpreted so contexts are identified and their characteristics are linked and compared with the client device. If this is valid for the situation or for the current user environment, the system proceeds to the fifth stage, where the system downloads the characteristics corresponding to the actual context. Finally, if the context so permits, augmented reality features are displayed according to the characteristics presented in the document description using the appropriate API for the available technology, and under the rules defined by the context document.

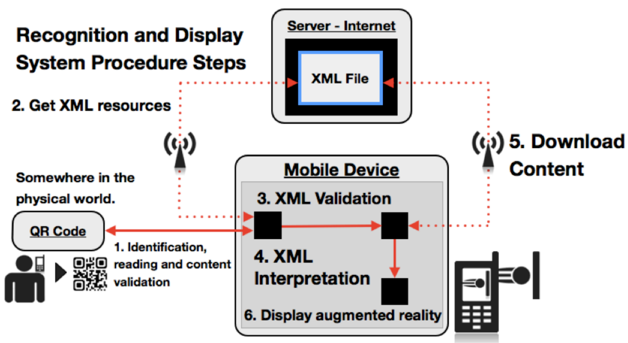

Figure 3. System description

VI. SYSTEM ARCHITECTURE

Our design follows a client-server architecture [15], which makes it possible for clients to download XML contents from a server as required by the process described in the previous section, since the XML document establishes rules for the deployment of context augmented reality. Clients which will use this information to select appropriate components for deploying augmented reality content for different technologies,, since current augmented reality developments are not supported on all augmented reality technologies. We need of the use of several APIs to meet this need, since currently most APIs maintain a connection to their own servers for processing and content validation. Moreover the inclusion of the Model View Controller pattern [15], to manage communication with user interfaces and promotes independent paths between information manipulated by the program and the user interaction with the information. For this application the model for this system is very simple, consisting of an XML library that brings the XML features in a requested document. The application controller is more ellaborate, since it implements various augmented reality technologies and maintains a permanent connection with the context where the content is displayed for the user interaction. An example of the system architecture based on an iOS application is illustrated in Fig. 4.

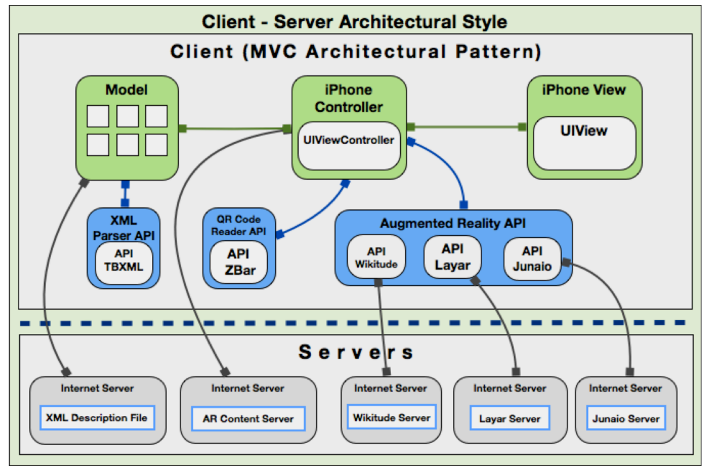

Figure 4. System architecture

As shown in Fig. 4, the system architecture is defined by a MVC architectural pattern (the green components) in which they interact with different libraries (the blue components), the model interacts with the API which parse the XML document and also uses a client-server architectural style to get the context description file through an Internet connection, next, the controller uses distinct APIs in order to shown different augmented reality technologies, for achieve this each API work with dedicated servers online using a client-server architectural style, also the controller uses a QR code reader API in order to decode information, the controller has a second connection with a client-server style in order to get AR content described in the QR code XML file which is stored somewhere in a server. Finally, the view provides the interface to use the device's built in sensor-camera to display the augmented reality and to read the QR codes.

VII. APPLICATION SCENARIO

Given the system description and the system architecture just described, we have designed a scenario in order to demonstrate the system's capabilities as the basis for further work. Let us give a practice scenario in which we have one person who has a mobile device, a technology that has increasingly been used to implement AR [16,17]. Consider a smartphone that runs an iOS operating system, with our application installed, and let us say this person finds in a physical location a contextual QR Code compatible with our technology. Our user scans the code with our application and a XML document is downloaded, validated and integrated into the client device. After this point, the XML URL is stored into the device, which now asynchronously downloads the content description and starts a comparison within the XML description and the device features. If the application finds similarities, it adds them to an event handler. At the time, the user is notified that there are some augmented reality events happening for the device. Notice that some context events only happen for a given location, or a date, so if the events match the scenario they are presented to the user. After this, the user goes to the events screen and selects an event of interest. The application uses the URL in the XML document and downloads the specified augmented reality content for the device and the given event. The application follows the description and displays the augmented reality content with the corresponding component for the technology mentioned on the description file. Also notice that if the user moves to another place, or different users have distinct language configurations on their devices, different content with different languages or images would be displayed. Let us say that some user has an iOS device with Spanish language configuration. The application could manage that context and download the augmented reality content in that language, but if the user has configured the device in the English language then all the information downloaded will be in that language. This is the central motivation of our approach: Delivering distinct augmented reality technologies depending on each context situation in a way that is transparent to the user.

As shown in Fig. 5, four major steps make up the process of displaying AR content given different conditions and determining how the system reacts to them: (1) the system scans the QR Code; (2) an XML document is interpreted, given different conditions to be satisfied: condition 3 is a not valid context for this device since it is an Android device;, condition 2 satisfies the context for the user but it is a context that it is not currently happening, as the user's smartphone may be configured for the Spanish language and condition 2 is related to English; and condition 1 the context is matched, in Spanish, the contexts are complete and in the last step the content of augmented reality is downloaded from a Web server and is presented to the user with the appropriate augmented reality technology component.

VIII. Ongoing work

We are currently working on the development of an iOS-based mobile application as a prototype. Nowadays, a smartphone has the advantage of hardware sensors used by augmented reality technologies as well as a powerful and solid software API in which we are defining a case study by applying the system we have designed to the application scenario. Also, we plan to use various augmented reality technologies for application in different contexts. Further work will extend the system to consider new trends involving augmented reality technologies. Also, we will explore the development of the system in different platforms to make this system accessible to more users.

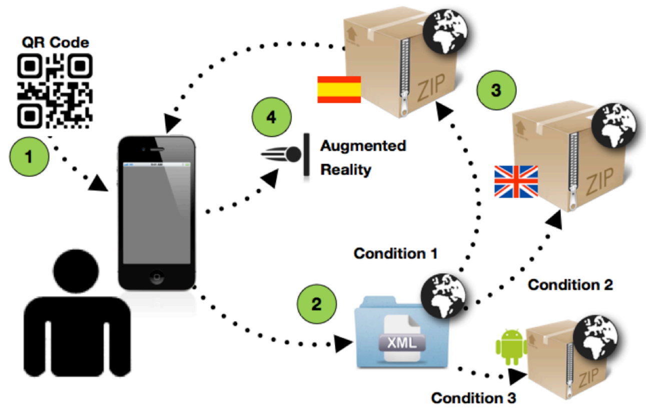

Fig. 5 Application scenario

IX. Conclusions

Context QR codes can provide great value when used in situations that dynamically change depending on the context. Augmented reality is an interesting field for the application of this concept, as it enables user interaction with different technologies. Depending on the context, the characteristics of contextual QR codes assist users to bring them closer into augmented reality and enables content access from different experiences immediately and transparently by taking advantage of the features provided by contextual QR codes. This paper has presented a system that uses contextual QR Codes to activate different actions to deal with different devices and user situations. Our system will demonstrate that it is possible to implement different augmented reality technologies under different contexts.

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