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Augmented Reality Greenhouse

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ABSTRACT

The unstoppable evolution in diversity and capacity of information and communication technologies at our disposal, in particular the growing features of collection and data storage, communication facilities and associated action, which can be integrated in mobile and collaborative solutions, created a window of opportunity to innovate and create decision support systems that allow us to put on the field at the disposal of farmers and agricultural technicians sophisticated information systems that support decision making by providing updated information, at the right time and in the most appropriate format. The delivery of information to the end use is nowadays receiving increased attention and to deal with this challenges one of the possible approaches is to launch Business Intelligence (BI) platforms. The present work addresses the last step of these BI platforms, the user interface challenge and proposes for the agricultural field the usage of smartphones and augmented reality as an effective mechanism to deliver in the field and in a transparent way information for decision making. With that purpose we present a augmented reality prototype to deliver information for decision support in a greenhouse using a BI approach and a smartphone Layar augmented reality interface.

Keywords: Decision support, augmented reality, greenhouse, Portugal.

1. INTRODUCTION

The increasing diversity and capacity of information and communication technologies at our disposal, created a window of opportunity to innovate and create decision support systems that allow us to put on the field at the disposal of farmers and agricultural technicians sophisticated information systems that support real time decision making namely using Business Intelligence approaches.

A Business Intelligence (BI) platform in an organizational environment has traditionally four main components: data sources; a data warehouse; a business analytics component; and a user interface. In general and particularly important in the case of the agricultural sector, the last component, the user interface, which has to give simultaneous answer to “What information?”, “For whom?” and “How to present it?” is an area of increased concerns very dynamic and with innovative solutions being delivered to the market continuously.

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The present work addresses this BI platforms user interface challenge and proposes for the agricultural field the usage of smartphones and augmented reality as an effective mechanism to deliver in the field and in a transparent way information supply for decision making. With that purpose we present a augmented reality prototype to deliver information for decision support in a greenhouse using a BI approach and a smartphone Layar augmented reality interface.

2. OBJECTIVES

The evolution we can nowadays witness in the information and communication fields, namely in the mobile computing and remote sensing, making available in the market devices with growing processing capacities and smaller sizes which are able to offer sensing functionalities, wireless communication, integrated energy source and action capacities, are posing a very interesting challenge to the agricultural sector. This new reality places agronomic knowledge under the lights since these technologies can be seen as amplifiers of our data collection and storage capacities, challenging the farmers and the agricultural experts to develop processes that can convert data into information/knowledge and deliver it to the decision maker in order to support the everyday business actions.

Nowadays Business Intelligence (BI) platforms are being used to answer this challenge, and the final step of any such platform, the user interface layer is the key component of the system since it will be the interaction contact point of the user with the platform. We include in this layer the digital dashboards and information transmission tools that offers the users an integrated and comprehensive vision of the BI platform metrics, trends and exceptions, combining information from multiple sources. The present work addresses precisely this BI platforms final step that consists in the information delivery for user decision-making. For that purpose we propose the usage of smartphones and augmented reality as an approach capable of making available in the field and in an transparent way a effective information transmission mechanism to support decision making.

The main objective of this research was to develop an augmented reality early warning system prototype for B. cinerea in a tomato greenhouse supported by a wireless network of air relative humidity and temperature sensors installed inside the greenhouses. Our goal is to demonstrate the potential of this approach and the utility of the prototype we built as a tool for growers and technicians to improve climate and disease control in the greenhouse.

3. AUGMENTED REALITY

The term "Augmented Reality" was initially suggested by Caudell and Mizell (1992) who described it as the act of combining computer generated elements with the real world. However, the first experiences with "augmented" realities date back to 1962, when Morton Heilig recorded the patent of a machine, called Sensorama, which had the ability to reproduce movies while adding wind, vibration, smell and three dimensional images.

Although there is no exact definition for smartphone, mostly due to the rapid technological changes in this context, a smartphone can be described as a communicating device with advanced processing skills, equipped with a video camera and means to access internet, namely 3G technologies and Wi-Fi. A smartphone device also incorporates motion sensors and a GPS navigation system. These characteristics make mobile phones (or smartphones) a privileged access point for information, and like a 2010 report from the International Data Corporation points out "*vendors shipped a total of 302.6 million smartphones worldwide, up 74.4% from the 173.5 million smartphones shipped in 2009*" (IDC, 2011), smartphones represent a significant share in the global market.

More recently new platforms and paradigms emerged to propel AR development in smartphones like Layar (2011), Junaio (2011) and Wikitude (2011). All of these companies embraced a new concept which consisted in an Augmented Reality browser with a number of features that allowed developers to produce Augmented Reality content according to a specific set of rules, and, finally, allowed end-users to view computer generated elements (audio, video, images and animations) superimposed to the live camera view of common smartphones. These AR browsers are compatible with most mobile operating systems like the Android (2011), the iPhone OS by Apple (2011), or the Symbian (2011).

Smartphones' interaction potential, combined with AR technologies, represents the starting point for our prototype that is to be applied to a BI platform that collects data from a tomato greenhouse wireless sensors network. We are focused on testing a new information delivery interface of mixed realities where access to information and the possibilities for exploring and interacting can be enhanced.

Smartphones are nowadays a communication tool that allies portability, which is fundamental for the agricultural sector, with the access to an important bundle of information and localization services. At the same time, Augmented Reality – or the act of overlaying virtual elements over images captured in real time – is taking advantage of the growing processing capacities of smartphones and we have nowadays at our disposal several applications that take advantage of wireless networks, positioning detection capacities and movement sensors to deliver new and innovative information interfaces.

2. Augmented Reality Greenhouse Prototype

As referred previously, one of the most well known Augmented Reality browser for smartphones is Layar (http://www.layar.com), available free of charge for IOS and

Android, and for which it is possible to build information layers, published as web services, and consumed by Layar being visualized in the AR browser upon activation by the user. In that context and supported by a augmented reality framework developed by the authors it was tested the use of smartphones and augmented reality on Layar, with a prototype that was built and we will present to deliver the information in a Business Intelligence platform for an early warning system of Botrytis cinerea Pers. in a tomato greenhouse. The prototype takes advantage of a Layar browser for smartphones and augmented reality to enable in the field and in realtime the visualization of the environmental conditions in the greenhouse, identify and characterize the plots, as well as diagnose irrigation needs.

2.1 Augmented Reality Framework

The publication of the information to be consumed by the Layar browser in the smartphones is based in ISEGI-NOVA AR Project, a work developed previously (Cardoso and Neto, 2013). The ISEGI-NOVA AR Project consisted in developing and deploying an Augmented Reality system to assure a multitude of services, directed to the smartphone medium. These services, making use of existing AR third party technologies, allow users to interact with multimedia layers (images, sounds, video, web content, animations) superimposed to the image captured by the smartphone camera.

2.1.1 Architecture Overview

The AR project was developed in compliance with Layar's architecture requirements. Fig. 6 displays Layar's architecture (Layar, 2012) alongside the ISEGI-NOVA AR Project's architecture, which contains all components that were developed within the project's scope. Using the third-party Layar infrastructure requires some registration and configuration steps on the Layar site but, essentially, to be able to play an AR experience on a smartphone, the key aspect that the ISEGI-NOVA AR Project must assure is that a JavaScript Object Notation - JSON (JSON, 2012) message is delivered whenever a proper request is received. In the end, a smartphone with the Layar AR Browser installed, can then translate the JSON structured message into everything the points of interest (POI) the user sees and everything the user is allowed to do in the AR world.

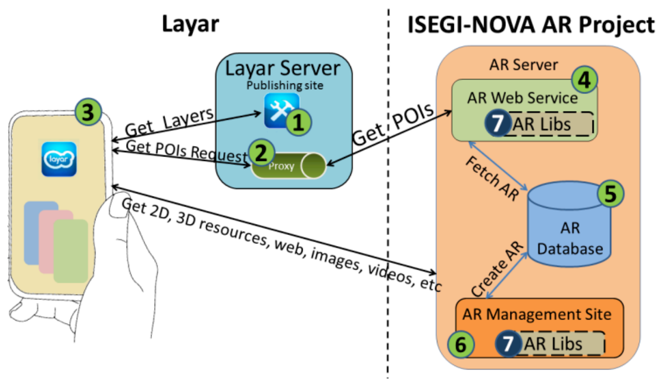

Figure 1. Architecture Overview

To explain how the AR content is brought to the smartphone we will use Fig. 6 as an example:

a) The ISEGI-NOVA AR Project's content provider creates an AR experience using the AR Management Site (item 6, Fig. 1), writing the contents to the AR Database (item 5, Fig. 1). The AR creation process makes use the AR Libs intelligence (item 7, Fig. 1), that knows all about the JSON language that the Layar AR Browser (item 3, Fig. 1) understands.
b) The user opens the Layar application on the smartphone, finds our content layer through the application's search tool, and opens our AR world. This initial connection, which retrieves existing layers, is made between the smartphone (item 3, Fig. 1) and the Layar Publishing Site (item 1, Fig. 1);
c) Once the world is opened, the smartphone's Layar API performs content requests to the Layar server, forwarded via proxy (item 2, Fig. 1). These requests are redirected to the AR provider's web service (item 4, Fig. 1) – we are the provider, in this case. The request contains information like the AR world's ID, the GPS coordinates of the smartphone which performed the request, among other attributes;
d) Once the AR provider's web service (item 4, Fig. 1) receives a request, it accesses our AR Database (item 5, Fig. 1) and, using our AR Libs intelligence class library (item 4, Fig. 1), prepares an answer in a JSON format that is returned to the Layar server which, in turn, forwards the response to the smartphone's AR browser;
e) After the AR browser API on the smartphone receives the JSON response, it can translate the structured language into visual information, and the user can finally engage in the Augmented Reality experience. Since the JSON response may contain portions that point to external links (images, video, sounds, webpages), for performance purposes, the AR browser will access these links directly, without using the Layar proxy as intermediary.

2.1.2 The AR Web Service

The AR Web Service is prepared to handle HTTP requests and to return a JSON response. As illustrated in Fig. 8, the access point for the AR Web Service is the AR HTTP Handler which, in fact, is a generic ASP .NET Generic Handler class. The class implements the *HttpHandler* interface (MSDN, 2012) and defines a default *ProcessRequest* method which receives the HTTP requests and returns the JSON output to the browser responsible for the request. The mentioned *ProcessRequest* method receives an *HttpContext* object as argument which encapsulates several elements associated with the request: the request parameters, the application state, and information about the session, to name a few.

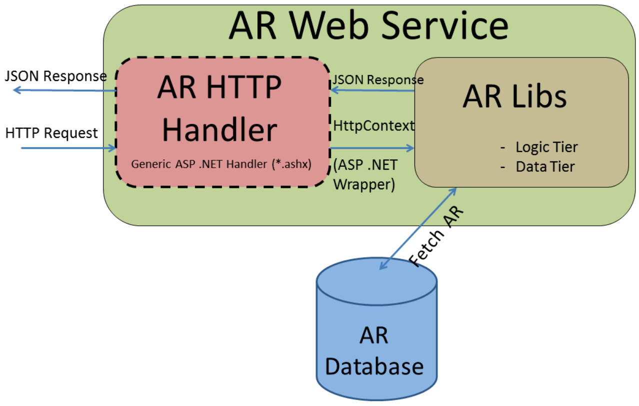

Figure 3. AR Web Service

2.2 Greenhouse Augmented Reality Prototype

Tomato is a very important crop in the Mediterranean region in general and in Portugal in particular being the production for fresh consumption made essentially in greenhouses. One of the most important diseases affecting greenhouse tomato crops is Botrytis cinerea Pers.: Fr., the causal agent of grey mould disease and high relative humidity and the presence of free water on the plant surfaces have been recognized as favourable to the development of this disease.

In previous research Neto et al. (2011) proposed a business intelligence approach to create an early warning system providing to the tomato grower alerts with information of the potential favoured conditions for the grey mould disease appearance in its early stages or even before since they can have a very positive impact in reducing the economic and environmental impacts due to a more rational and efficient disease control management. The proposed early warning system was supported by a sensors wireless network and technologies such as SMS, e-mail and Web access to deliver the warnings.

Nevertheless, taking into consideration in one hand the developments in AR and the work of the authors in the field and in the other the known need to create new innovative ways of delivering information to the farmers, it was considered relevant to create a prototype that linked the above referred greenhouse tomato early warning system with the ISEGI-NOVA AR Project.

Our goal was to demonstrate the potential of this approach and the utility of the prototype we built as a tool for growers and technicians to improve climate and disease control using smartphones and Layar browser to deliver richer information in real time in the greenhouse. With this objective in mind a dynamic data connection was made between the data warehouse of the early warning system and the ISEGI-NOVA AR Project which supported the publication of a specific layer of information to be consumed in the greenhouse (Figure 4)

Figure 4. AR Greenhouse prototype

The AR Greenhouse prototype was tested in the field covering three different types of information to show the potential of this approach to present relevant POI for decision-making, namely:

a) Identification – information regarding the crop, installation date, variety information, etc.
b) Performance – information concerning soil water content status with the possibility of clicking the POI to obtain further information about irrigation scheduling.
c) Environment – information and several environment metrics, such as temperature, humidity, CO_2, etc.

4. CONCLUSIONS AND FUTURE WORK

The plataform prototype that was built to test the the usage of augmented reality in a greenhouse following a business intelligence approach and taking advantage of Layar technology was sucessfull and the field tests were very promising.

One of the next developments will be on the Points of Interest potencial use to add aditional information. If for instance, we are seeing a temperature POI in the AR browser we can use a thermometer to display the actual reading in the greenhouse in that moment, or we can use a gauge as a POI with a red to green gradient scale to present a metric making very easy to understand not only the value but also the meaning.

Finnally, altough in the present work we only presented the prototype and the results of the first field tests, we are now developping a large scale evaluation of the concept altogether we the inclusion of image processing for crop diseases identification through the usage of Layar Vision technology.

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