Augmented Ambient: An Interactive Mobility Scenario

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Abstract. This paper presents the Augmented Ambient project that aims to construct a highly interactive mobility scenario based on augmented reality applications running on heterogeneous multimedia devices. Mobility is made available through ambient networks, which are dynamic computer networks. A case study has been performed about a virtual museum, where users join a service network that includes art pieces visualization, broadcast interview, chat, and remote live auctions. These services are implemented in Desktop, Pocket PC and Symbian OS platforms. Each one has its own limitations related to processing power and content exhibition, which are considered during media exchange. The application development process for each supported platform is detailed in the text that presents also some libraries built to simplify and speed up the development, namely OgreAR, OGRE port for Pocket PC and CIDA, beyond the ambient networks related software infrastructure.

Keywords: augmented reality, ambient networks, mobility, interaction techniques.

1 Introduction

This paper presents the Augmented Ambient (A2) project, that aims to construct a highly interactive mobility scenario based on Augmented Reality (AR) [1] applications running on heterogeneous multimedia devices and made available through dynamic computer networks, named Ambient Networks (AN) [2]. A2 approaches the emerging area of pervasive computing and communications, aimed at providing both platform and paradigm for all the time, everywhere services as a natural outcome of the advances in wireless networks, mobile computing, and interactive user interfaces (UIs). It proposes an architecture for service distribution and validation, and content adaptation which will be used in some classes of devices (cell phones, Personal Digital Assistants (PDAs), and notebooks) to access advanced communication services. It is also proposed a framework to build AR-based services running on mobile devices.

A case study has been performed, where some services are released by creation of dynamic networks as result of incoming users to the virtual museum area network.

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Offered services are users VoIP intercommunication, access to virtual auctions, visualization of virtual art pieces and live conferences and interviews watching. Therefore, users can meet each other, build networks dynamically to exchange ideas and discuss opinions, participate in auctions and watch live interviews.

Using AR-based applications, visitors may realize art pieces that are not physically in the museum ambient. These pieces have been inserted on fiducial markers that are part of a complex and sophisticated system composed by a Head Mounted Display (HMD), a webcam and a device that can be a notebook, a PDA or a cell phone. In the PDA's and cell phone's case, they will work as a "Virtual Magnifier", displaying virtual content when the user points the camera to the desired marker.

Different media types can be displayed by devices depending only on processing and exhibition power. In this case, beyond images, users can watch videos, listening audio tracks or see virtual objects that "in fact" do not exist in real world.

AN have been proposed in order to allow competition in a context where exists a need for resource sharing, service releasing and cooperation between networks. They represent a new point of view in the network area that aims to enable the creation of a brand new solution to wireless and mobile networks, permitting a good quality, scalable, easy to use, and not expensive communication service provision.

The remainder of this paper is organized as follows. Section 2 presents some related work, including mobile AR systems and AN systems. Section 3 gives an overview of the A2 project. The defined and built AR frameworks are described in Section 4; there have been developed AR applications for the Desktop and Pocket PC platforms. Issues related to the interaction methods and techniques applied are presented in Section 5. Finally, Section 6 highlights the contributions of this work.

2 Related Work

A2 project involves many knowledge areas in an interdisciplinary way. To understand the research, as well as the conception and development of A2, some works were reviewed, like Höllerer and Feiner [3], which provides a detailed introduction to mobile AR technology with in-depth reviews of important topics, such as wearable display, tracking, user interaction, heterogeneous UIs, collaboration, wireless communication and AR challenges. Further subsections detail aspects related to concepts and experiences that compose A2 project.

2.1 Mobile Augmented Reality Systems

A benefit of A2 project is its development of many mobile AR services/applications on a single project. In a similar way, the work of Reitmayr and Schmalstieg [4] should be cited. Concerning A2 services, there are relevant experiences related with them.

Resembling to interview service the most relevant works are Billinghurst et al. [5] (focused in AR teleconferencing) and the Tangible Teleconferencing study [6]. The first one discusses the technology used and the expected advantages achieved. Beyond, it presents the use of ARToolKit in this kind of research, reviewing 3D Live project and exploring the concept of AR remote collaboration. The second one uses some fiducial markers to interact with the application, manipulating the position and orientation of virtual objects and allowing the user a full view of them; it is also analog to the way one interacts on the A2 virtual auction service. The concept used in the application developed by Woods et al. [7], in which the user plays a game locating patterns containing solar system planets, is very similar to the one present in A2 visualization service, as well as the Handheld Augmented Reality Displays work [8].

A2 project relies strongly on AN technology. Due to this, other AR works using this technology were researched, like the study named Face to Face Collaborative AR on Mobile Phones [9], that has developed a peer-to-peer (P2P) communications layer to allow devices to interact and collaborate each other. The mentioned study also works with a port of ARToolKit to Symbian OS [10], as well approached by A2.

2.2 Ambient Networks

AN is a novel networking concept that has its goals validated through technical solutions developed by proof of concept activities [11]. As A2 is one of them, it has some features related to areas (multi-access networks, content adaptation, network composition and policy-based management (PBM) being studied to deliver an integrated and flexible architecture to AN projects.

Internet was designed for wired links and fixed end systems, but the widespread use of mobile devices and the popularity of wireless communications have led to heterogeneous networks with different access solutions (as WLANs (Wireless Local Area Networks), Bluetooth, 2.5G or 3G cellular systems). A2 uses wireless technologies, such as Bluetooth and wireless LANs to increase its services availability.

In order to make a service capable of receiving multiple types of connections, media adaptation is essential permitting multimedia delivery and presentation on mobile devices. A2 client applications are responsible for device and network capabilities detection, informing the application server so it can adapt the media accordingly.

Network composition is a key concept of the AN project, aimed at enabling control-plane inter-working and sharing of control functions among networks. Composition can be thought of as a mechanism for automatic negotiation of roaming and/or Service Level Agreements (SLAs), which today are done manually.

PBM is used to address the problem of complex network infrastructures administration, in an automated way. Policies can be used, for example, to manage and control the access to network resources by high-level abstract levels of rules and decisions. As A2 was developed using the X-PBMAN (Policy-based Management for Ambient Networks) prototype framework [12], it adheres to the P4MI, a P2P Policy Management Infrastructure, an enhanced version of the PBM framework developed by the IETF (Internet Engineering Task Force).

3 System Overview

A2 project conception may be detailed by many aspects, like services, software modules, topology and AN infrastructure. A case study has been performed about a virtual museum, where users make use of AN concepts to join a service network that includes art pieces visualization (pictures, sculptures etc.), broadcast interview, chat between users and remote live auctions. These services are implemented in three platforms: Desktop (notebooks and compact PCs), Pocket PC (PDAs and Smart Phones) and Symbian OS Series 60. Each platform has its own limitations related to size, processing power and content exhibition that are considered during media exchange, improving the service use experience.

To get access to the services, users perform a composition with the museum network. In this process, an initial authentication takes place and then an automatic network configuration occurs. After composition, services may be accessed in a seamless way, as being local. If a required service does not belong to the current network, it will compose with the network that offers the requested service, without notification to the user that must not be concerned with the service location or provider.

In visualization service, exposed trackable markers are recognized and used to recover data that will be rendered at marker's position and orientation. The information about what content will be displayed on each marker and the media object itself may be acquired through requests by the service protocol at startup or at the right moment of markers' detection, at runtime. When a device with a lower processing and/or exhibition power asks for a virtual object, this will be transmitted with some changes, such as fewer polygons, fewer files to transmit, and lower resolution textures.

Interview service uses fiducial markers, as well, to show up the 3D model of the interviewer. The actor's image is based on video channels that are interpolated by an image server using the markers' orientation to establish the correct mix between video flows acquired by cameras surrounding the actor. Due to the huge amount of processing involved in audio and video handling, only the Desktop platform implements completely this service (remaining ones have only audio transmission implemented).

Chat service allows users from distinct museum areas to communicate through voice messages. Voice interaction was chosen in order to override the usual text based interaction, which is harder to use with smaller devices and rather impossible in the desktop version, since the user can not use a keyboard and will be wearing data gloves and a HMD. The choice of voice codecs that control media exchange differs among platforms according to their processing power. The negotiation to choose the appropriate codec is under charge of the chosen protocol, the H323, that holds an open implementation ported to the Pocket PC platform. In virtual auction service users may place a bid and offer a higher price to an object, and manipulate objects through a tangible interface build upon a cube of markers, using an AR-based interface. This cube may be used to scale and inspect the virtual object chosen by the user. The suggested interface for the auction service is easy to handle and allows more immersive interaction to users in all platforms. The application development process for each supported platform in the A2 project is detailed in Section 4.

3.1 Hardware and Software Setup

In A2's case study, some hardware items were specified in order to arrange the test environment. A HP iPAQ H5500 PDA, a Nokia 6600 cell phone and a miniaturized board (ADL855PC) running a multimedia dedicated operating system were used as client platforms, all of them having an integrated camera, due to the AR interface. As support equipment and backend infrastructure, PCs were used to process the services and act as media servers.

The topology of A2 is composed by a policy server for the museum network, one more for the auction network, an auction's application server, and a visual applications server. This network was interconnected using gigabit Ethernet (IEEE 802.3z), required for large amounts of data generated by the cameras, which will be composed in a central server in order to redistribute an optimized data flow to the clients.

The network infrastructure of A2 was built using the X-PBMAN [13]. Its general architecture is focused on the role and implementation of the Ambient Control Space (ACS). The ACS may present three types of implementations in PBMAN: PDN (Policy Decision Network) ACS, User ACS and PEP (Policy Enforcement Point) ACS.

The better way to understand the infrastructure of A2 is following data path of an offered service, as seen in Fig. 1 – the visualization service for the Pocket PC. As the sequence of explanations evolves, each concept presented will be explored.

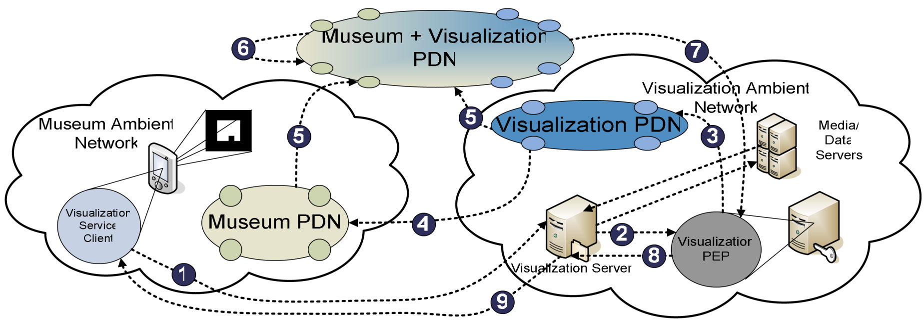

Fig. 1. Data path of the visualization service

The Visualization Service Client tries to access the Visualization Server (1); since the Visualization Server is located at a different network from the one where the user is (e.g. the server is at the Visualization AN and the user at the Museum AN), request is forwarded to the Visualization PEP (2). PEP agents are software and/or hardware services providers, which must enforce right of use, security, and accounting policies.

The Visualization PEP sends a request to the Visualization PDN (3) that detects the user is subscribed to Museum AN, and negotiates a composition with the Museum PDN (4). In case the negotiation is successful, the Visualization PDN and Museum PDN proceed to create a new PDN ring and republish all relevant information (5); the new PDN performs a policy selection process and the Auction service is granted (6).

To finish the process, the PDN sends a response to the Visualization PEP (7) that responds to the Visualization Server for it to resume its pending session with the Visualization Client (8). Finally, the Auction Server sends the adapted information located at the media server, according to the device capacity, about the item that the client wants to display (9). In order to compose all the proposed services, some software modules were developed for A2 and other existing libraries were used, as well. On the client's application side, the libraries used were OGRE, CIDA [14], OgreAR [15] and the OGRE port for Pocket PC [16]. Chat service uses OpenH323 and PWLib libraries to transmit data and develop tasks such as encode and decode voice chunks.

On Pocket PC platform, to construct graphics interfaces and the OGRE port, Klimt and OpenGL ES libraries were used. OpenGL ES was also used on Symbian OS platform. ARToolKit Plus was used to manipulate and detect markers, as well as an ARToolKit port for Symbian OS. At last, X-Peer was used to distribute application data, and also to provide media server and PDN communication. Some aspects about software modules created during this project are better described in the next subsections.

3.2 Support Libraries

Some libraries were developed around the conception and implementation of A2 services. CIDA (Chaotic Interaction Devices Abstraction) is an input devices management platform developed by the authors that provides an abstraction layer between interactive systems and interaction devices [14]. Through this platform, all devices having required features to interact with the application (buttons, axes, degrees of freedom etc.) can be supplied at runtime.

OgreAR [15] is a library to provide an interconnection of applications based on OGRE and the basic elements of AR, such as real-time video acquisition and marker detection. In addition, its design favors portability of applications, since they do not depend on the libraries that are being used for performing the AR functionalities.

Conceiving the existence of high level graphics engines for the Pocket PC platform would be extremely useful for the creation of AR applications. Therefore, the authors have ported the OGRE library for this embedded operational system [16].

4 Augmented Reality Frameworks

This section presents some libraries used to construct the A2 services. They were catalogued to make part of an AR framework, valid for all platforms enclosed by A2, with the purpose of accelerating the development process and make it easier.

4.1 Desktop Platform Development

The Desktop platform has an adequate profile for services which demand more processing and visualization capabilities. However, this platform mobility is a little compromised by the quantity of equipments the user must carry and their weight.

In this profile notebooks or miniaturized computers can be used. Fig. 2 shows the hardware and software setup for this platform. Connected to these devices, an HMD is used for 3D visualization and a camera captures the environment image for the AR interface. As input devices, a data glove is used for gesture based interaction and a tracker for capturing hand movements and passing this data to the application.

In order to manipulate the services, a management interface was created, based on objects modeled using physical simulation, that when handled, enable the corresponding services, send services to the background or finalize them. The PhysX was the physics engine used, chosen among others because it provides both hardware and software implementations. All integration with these objects is done through the data glove and tracker, which are accessed using CIDA. The software modules used on this platform architecture can be clearly seen in Fig. 2.

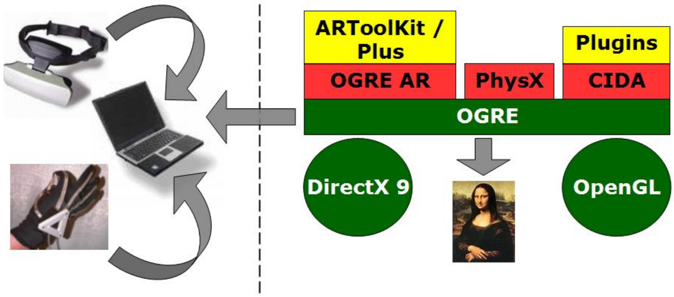

Fig. 2. Desktop platform setup

4.2 Pocket PC Platform Development

Initially, OGRE was ported and used as the underlying graphics infrastructure also on the Pocket PC. However, the low frame rates of the demos, which ranged between 6.561 and 13.390 frames per second (fps), made the use of the engine with AR applications unworkable. The absence of hardware acceleration on the device impacts on the fps reached. Marker tracking is done with ARToolKitPlus. Some screenshots of the A2 services running on Pocket PC are shown in Fig. 3.

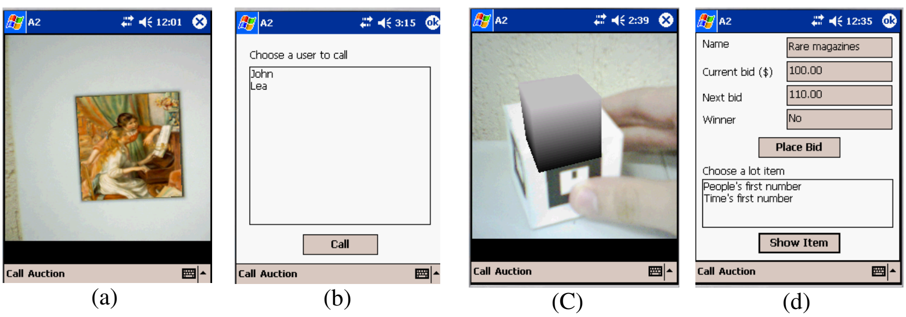

Fig. 3. A2 services on Pocket PC: a) visualization; b) chat; c and d) auction

Some services are not offered, since the performance is insufficient, especially in the case of video exhibition. Therefore, the interview service is not available, and in the visualization service, only the pieces of art are presented, without additional video information about it (Fig. 3a). In the auction service, the objects related to each lot item are much simpler than the ones used in the Desktop platform (Fig. 3c and Fig. 3d). The chat service is the same provided to desktop users (Fig. 3b). The user interacts using the pen and the touch screen. Due to all these factors, the UI is simple. It is also different from the desktop UI. The communication is done via Wi-Fi.

5 A2 Interaction Techniques

This section presents information about the 3D interaction techniques that have been specifically developed for A2 project . VR interaction techniques have been classified according to the task performed by user: manipulation and selection, navigation, system control and symbolic input techniques [17]. A2 uses techniques from these four categories.

5.1 Manipulation Techniques: Tangible Interfaces

Tangible UIs (TUIs) are the ones where users interact with physical objects, tools, surfaces and spaces to interact with systems, which is a very intuitive and natural way. In AR systems, physical objects are mapped in a one-to-one relation with virtual objects operations. These systems are based on fundamentals of TUIs being complemented with a visualization display. A2 project uses TUIs, as illustrated in Fig. 4.

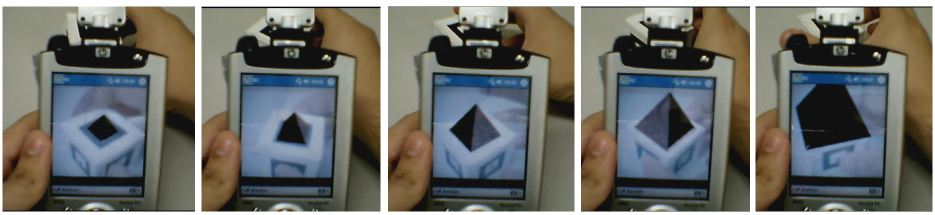

Fig. 4. Tangible interface – user inspects and scales the virtual object rotating the cube

5.2 Navigation Techniques: Walking

Walking is simply to physically walk through a 3D environment. An important aspect is providing vestibular cues during walking, in order to promote spatial understanding (especially in mobile AR systems that rely on user's interaction with the real world along the virtual one). Real walking is not always practical or feasible, since it is limited by space and technology. A2 uses the walking technique since users may utilize the system during movement, as illustrated in Fig. 5a. In A2 the 3D objects may be visualized and manipulated by the user according to its physical location in the virtual museum. A user wearing the Desktop platform is shown, interacting through walking.

5.3 System Control Techniques: Gesture Commands

Spontaneous gesticulation, mimic and symbolic gestures are used as input, implying more learning for the user. Fig. 5b shows a user wearing a data glove and making two postures, namely an open hand and a closed hand posture, respectively.

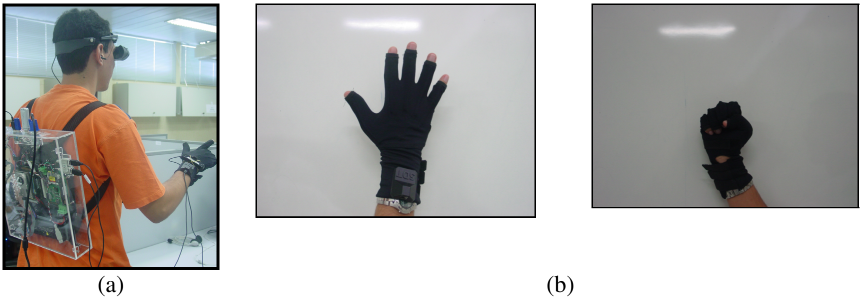

Fig. 5. Navigation techniques: a) user wearing mobile Desktop platform; b) gesture commands

The gesture commands were included in A2 using a data glove, which can detect many pressure degrees for each finger, and a tracker. The combination of one or more finger sensors activations performs a gesture. User can freely combine one of these actions with a movement of the tracker to perform actions.

5.4 Symbolic Input Techniques

In many situations symbolic input would be useful, such as leaving a brief, precise annotation, entering filenames for open/save operations, adding labels to virtual objects, specifying numeric properties (e.g. thickness, position) and setting parameters in a scientific visualization. These applications could be generalized in scenarios that involve immersive virtual or augmented worlds where a common text/number-input technique would be demanded and where speech input alone would likely not suffice.

These techniques for 3D UIs are necessarily different from traditional ones (e.g. keyboards) because of the inherent differences between 3D (non-desktop) and 2D UIs. Mobile computing (Pocket PC platform onto A2) uses pen-based input in which user writes characters, symbols, or other gestures with a pen/stylus on device.

6 Conclusion

This paper has presented A2, an interdisciplinary project that gathers research areas like AR, HCI and AN to allow more interactive multimedia services using innovative interfaces onto the last mobile network generation, beyond 3G, expected to be available for popular use in five to ten years.

Using three platforms (Desktop, Pocket PC and Symbian OS) that represent the different levels of mobility and processing limitations, it prooves that content adaptation and the others AN concepts have worked fine on top of the designed architecture.

Frameworks were assembled, with several parts implemented by the authors, to make the interface, the interaction model and the services intercommunication with AN. In this case study, the described topology has been used to test and prove the concepts cited in this paper. As expected, the Symbian OS platform requires some workarounds, since the device used has lower memory capacity and the system itself is more complex to be developed and tested. Some libraries have been developed in order to make A2 work properly, beyond the AN related software infrastructure.

Finally, some well known interaction techniques have been implemented in A2 according to the platform used based upon guidelines suggested by in the literature.

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