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Current Challenges for Mobile Location-Based Pervasive Content Sharing Applications

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1. Introduction

Web 2.0 and social software are changing the way millions of users communicate: digital citizens are not only content receptors but also contributors to content creation, collaborating in social networks or communities.

Pervasive computing can increase this process taking our contents from everyday life, providing them in the places where there is the sharing need and often in the place where they are originated.

Until a few years ago, the ability to use technology to locate people and provide them the capability of sharing formal or informal content related to their location was limited. As an example, Prante et al. proposed the "cooperative building" metaphor, describing very expensive digital furniture, such as tabletop (InteracTable), vertical displays (DynaWall), and chairs (CommChairs) with built-in displays to support collaboration (Prante et al., 2004). However, localization technologies are nowadays more common, along with mobile devices that support them, making possible the combination of computer-mediated communication and location related data.

Top-of-the-range mobile devices allow us to adopt Augmented Reality (AR) based technologies to involve users in a mixed reality, made up of real world, observed towards the device camera, and of overlapped informative contents. In particular, the usage of AR is facilitated because of the innovative characteristics of the last device generation (on-board camera, accelerometers, compass, GPS etc.), instantly combine the preview made by the video camera with the AR information.

Several prototypes and commercial systems proposed location-based services, some of them associate textual notes to specific location, others provide awareness on places and friends for increasing informal interactions (Jones and Grandhi , 2004). Some of these systems have been successfully used, although the opportunities to innovate offered by new mobile technologies have still to be investigated in depth. The new devices, in fact, give the possibility of facing with the challenges in this field, such as creating innovative interfaces for mobile systems and implementing place-based recommender algorithms that intelligently connect people to places (Jones el al., 2004; Gartner, 2010).

Location-based pervasive applications are of growing interest for the scientific and industrial communities. Indeed, according to Gartner (Gartner, 2010b), one of the ICT enterprise world leader, Location-Based Services will be in the first ten required mobile devices applications in 2012. Moreover, the request of these services will strongly increase in the next years. Gartner predicts that Location-Based users will increase from 96 millions in 2009 to 526 millions in 2012. This kind of services is second in the top ten list for the high value that they have for users. In fact, they answer to several user needs, from productivity to social network and entertainment.

New challenges concern the development of AR applications for mobile phones supporting web 2.0 features, such as the sharing of location-based multimedia annotations in outdoor and indoor environments. Exploiting these features, the real world can be labelled using the "magic lens" interface offered by mobile devices.

The application of this technology is very wide and not limited to:

- *collaborative work*: information concerning collaboration is directly acquired and submitted in the working place, aiming at favouring formal and informal collaboration;
- *tourism and cultural heritage*: tourists uploads media and label places, monuments or pictures they are visiting;
- *learning*: teachers and students share a learning experience by uploading multimedia content in the places where they learn;
- *infomobility*: location-based information concerning transport or services to the citizen can be uploaded/downloaded in the place where there is the need;
- *commerce*: customer reviews of products shown in the store, find a store item pointing on a map, advertising in augmented reality with some form of interaction.

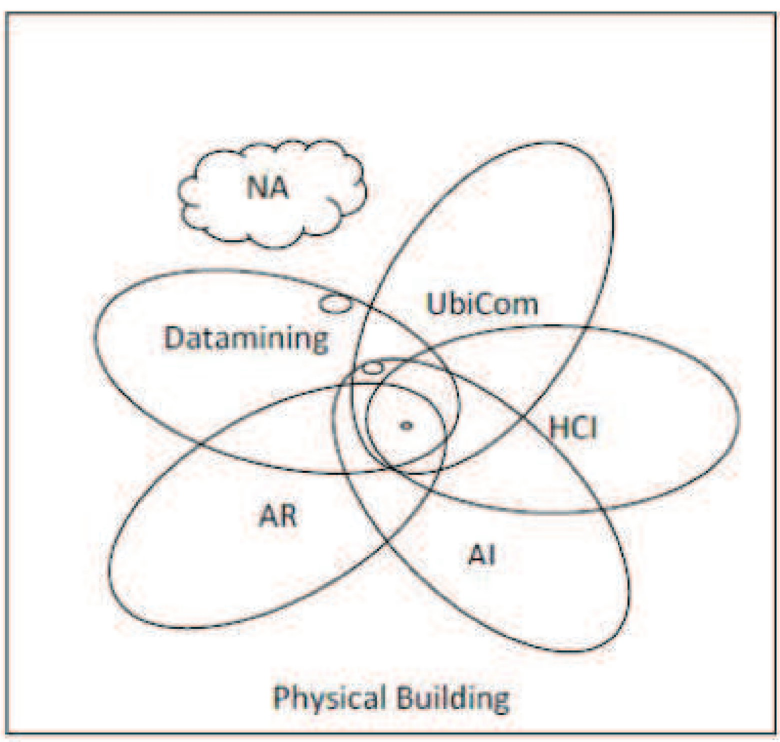


Fig. 1. Research Areas related to Location-Based Pervasive Content Applications

This chapter is organized as follows: Section 2 collects the innovative trends in the research areas related to the development of innovative mobile location-based pervasive content sharing applications, Section 3 describes some examples of this kind of applications, while Section 4 discusses how these technologies can be adopted in different application areas. Section 5, finally, concludes.

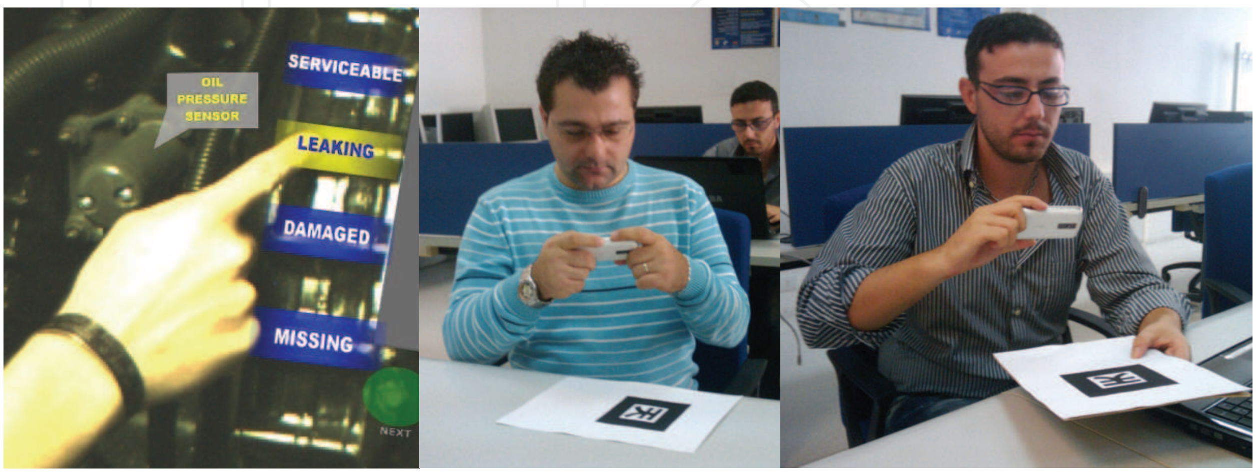
2. Research areas related to Location-Based Pervasive Content Applications

This kind of applications is very complex and has an interdisciplinary nature. Thus, this paper focuses on several research areas, as resumed in Fig. 1, all related to Location-Based Pervasive Content Sharing Applications.
In the following of this section we better detail the advanced results reached in the most relevant fields for these technologies.

2.1 Mobile AR interfaces

An important direction for the Mobile Spatial Interaction research is to investigate how spatial information should be displayed on a mobile device (Frohlich et al., 2009). To this aim new enabling technologies on mobile devices, including spatial sensors, high-end 3D graphics or augmented reality need to be considered.
Augmented Reality (AR) is a technology enabling to combine virtual information with the real world. The virtual content is superimposed to real images, and it is interactive in real time (Azuma, 1997). Mobile AR systems initially adopted a head mounted display to show virtual graphics over the real world. Innovative techniques were designed to interact with the mixed world.
As smartphones become smarter, AR degree of adoption on mobile device increases. Indeed, according to (Fitzmaurice, 93) a mobile device can be seen as a window onto a located 3D information space, enabling "to browse, interact, and manipulate electronic information within the context and situation in which the information originated and where it holds strong meaning".
Using this approach, a user acts on two information layers: the "transparent" device screen, showing georeferenced objects, and the physical surface. This interaction technique is named "magic lens" (Bier et al., 1993), "see-through interface" (Bier et al. 1994), or "magnifying glass" (Rekimoto, 95). Originally this kind of interfaces was based on GUI widgets. Actually, a magic lens interface can be used to augment the reality with 3D virtual objects and landscapes.
The first examples of AR applications for mobile phones were Mosquito Hunt and Invisible Train. In the former virtual mosquitoes are overlaid on the camera image and simple motion of the phone enables the user to fire the Mosquitoes. The Invisible Train (Wagner et al., 2005) adopts a "magic lens metaphor" as user interface. It is a mobile, collaborative multi-user AR game, enabling players to control virtual trains on a real wooden miniature railroad track. The virtual trains are shown to the players in AR modality.
Marked cards are used by (ARToolKit, 2010) together with computer vision techniques to determine the real camera position and orientation relatively to a card. In this way it is possible to overlay, in the correct perspective manner, virtual objects onto these cards. To this aim, the live video image is converted into a black and white one. Next, ARToolKit finds all the squares in the binary image, many of which are not the tracking markers. If there is a match with a marker, ARToolKit uses the known square size and pattern orientation to calculate the position of the real video camera relative to the physical marker. Starting from the real camera position, the virtual camera position is set with the same coordinates. The virtual object is then displayed by overlaying the real marker, using the OpenGL API.
Following this direction, (Popcode, 2010) combines the Popcode logo with a unique identifier. In this way, on one side the user is informed that augmented content is available, and, on the other side, the marker provides a way to access the information hosted on the

Popcode platform. A free XML language is available to developers for authoring. 3D objects, audio, and interactivity are supported.
A new research direction concerns the combination of AR with the physical manipulation of Tangible User Interfaces. In Fig. 2 (a) the user touches a virtual button to select a menu option. The camera tracks hand gestures and the device camera preview is augmented with overlaid 3D objects to provide visual feedbacks.



(a) (b) (c)

Fig. 2. Three Augmented Reality interaction approaches

(Billinghurst et al., 2009) describe the differences between interaction techniques based on the phone movement (Figure 2 (b)) and on the movement of a real object. In Figure 2 (c) the user moves the object for interacting with the application.

2.2 Methodologies for user tracking

Tracking user's position and movement in the right way is a critical aspect, especially when the content has to be displayed or created and attached considering a specific location. Indeed, the presence of an error could visualize information in a wrong place, or, if the user searches for the information, he might not find it where he expects. Thus, to take advantage of the mobility features of the new devices, wide area pose tracking systems need to be developed (Wagner and Schmalstieg, 2009).
These systems have to be capable of locating the user in a large environment, such as a building or a city. Generally, tracking is based on a model of the surrounding environment, but a big model cannot be stored in the memory of the mobile device. Thus, the model is generally maintained on a server system which has in charge the providing of localization services to the mobile devices.
Several strategies for tracking the user have been proposed in literature and they can be classified depending on if they are targeted for indoor, outdoor environments or both.
Improvements in this research area can be carried out through the usage of the sensors available on the newest devices (i.e. accelerometer, compass, camera) to provide innovative solutions and the usage of pervasive tagging (Kindberg et al., 2010).

2.2.1 Outdoor

Outdoor positioning systems are generally based on the Global Positioning System (GPS), which, recently has gained an accuracy of 10 to 20 meters.

The main advantages of this technology are that it is available everywhere outdoor and it works without a model of the world.

All the new mobile devices mount, together with the GPS, a digital compass, which provides orientation information that are useful for many mobile applications, and an accelerometer, which is a sensor measuring the acceleration applied to the mobile device. Recently, several commercial applications such as (Wikitude, 2010), NearestTube (Acrossair, 2010) and Layar (Layar, 2010) have adopted a magic lens interface to show labels selected considering the user location, determined through GPS, accelerometers and digital compass. These applications only show labels and don't enable the user to create new labels in a web 2.0 way.

In particular, Wikitude localizes the user position using GPS and compass data and overlays Wiki information on the real camera view of the smartphone.

Layar is a free application for the Android Operating System, and is now also available for iPhone, that makes sets of data viewable on top of the device camera as the user pans around a city and points at buildings (Layar, 2010). The recent 3.0 version enables also to augment reality with 3D objects.

Layar can be seen as a new type of browser, able to provide an augmented view of the world combining virtual content and reality.

When the Layar application starts, the location of the user is automatically detected using GPS and the compass detects the orientation of the phone display. Layers are the equivalent of web-pages in normal browsers, superimposed to the reality. Real estate, banking, restaurants and other companies have already created layers of information available on the platform. Each organization identifies a set of location coordinates with relevant information, constituting a digital layer. The user easily switches between layers by tapping the side of the screen.

NearestTube allows the user to see the next tube station by tilting the phone upwards. It shows the direction in which the stations are in relation to the user location. Information concerns their distance and the tube lines they are on. If one continues to tilt the phone upwards, the application will show stacked icons representing the stations further away.

(White et al., 2009) propose SiteLens, a hand-held mobile AR system for urban design and urban planning site visits. SiteLens presents on the device screen "situated visualizations" related to the environment and displayed in situ. As an example, the environmental situation concerning smoke is mapped to density. Denser smoke represents higher ppm values. The user location and the orientation of the device camera are determined by combining ARTag fiducials, GPS, and IC3 orientation sensor. Optical markers are only used to address urban areas with limited GPS satellite visibility.

2.2.2 Indoor

In indoors environments, the GPS signal cannot be used because the signal power is too reduced to enter in buildings. An open research problem is to design an indoor location sensor providing accurate spatial information that is also not expensive, scalable, and robust. Recent indoor location sensing systems range from RFID, requiring explicit installation, to standard wireless networking hardware, or Bluetooth tags, suffering of several problems, such as long time for device discovering and passing through walls (Savadis et al., 2008).

Location sensing systems relying on standard wireless networking hardware measure signal intensity and attenuation to determine user location.

Wi-Fi location exploits existing Wi-Fi equipment on personal computers, PDAs and mobile phones. Modulated Wi-Fi transmission signals detect the devices that are visible to the network. The position of the device is then calculated by triangulating the signals received from the other access points. Wi-Fi accuracy is about 3 m – 5 m.
Another approach consists in localizing a device in its environment by analyzing in real time the video provided by the device camera to recognize objects. To this aim, a model of the world has to be created and then matched against the video stream.
As an example, the VSLAM system (Karlsson et al., 2005) concurrently builds a map and detects the location of the image on that map.
Another example is the system proposed by (Hile et al., 2008). It takes as inputs a floor plan, a rough location estimate, and an image provided by the camera phone. The image is sent to the server together with the information concerning the Wi-Fi signal strength and the floor number. The server extracts the relevant features in the image, determines the search area in the floor plan using the location estimation, searches where the image can be located on the floor considering the image features, determines the camera pose, and returns the content to be overlaid on the camera flow of the client device.

2.2.3 Hybrid

The blending of physical and virtual reality can be reached through new ways of labeling the world. Labels have a great potentiality because they can not be anymore a static label, but they can be considered as an index of an online presence (Davies, 2010). The evolution of Bar codes are two dimensional codes, such as (Quick Reference) QR codes (http://www.denso-wave.com/qrcode/qrfeature-e.html). Thanks to the second dimension, these codes can contain a large amount of data in a fixed amount of space. They carry meaningful information in the vertical direction as well as in the horizontal one. By carrying information in both directions the image is more compact than a 1D bar code. Indeed, they require about 10 percent of the space necessary for representing the same information with a 1D bar code (Ebling and Cáceres, 2010). Markers with QR code stamps may encode location coordinates and elevation value. Thus, they are useful to locate the user both in an outdoor and indoor settings.
All the recent mobile devices offer applications to easily capture and decode the code using the built-in camera.
Markers encoding positions can be placed on the walls. They can be used to support Infomobility, at the bus stop, for advertising in a shop or on a manifest, or in places as museum, public offices and everywhere.
Ten years ago QR codes became an ISO international standard, named ISO/IEC 18004. They have been largely adopted in Asia, seldom in Europe.
Esquire magazine proposed in the December 2009 an issue where six AR experiences triggered by a 2D code were printed on the cover and on several articles. To start the experience it was needed to download custom software.
Not only newspaper, but also people can be labelled. As an example, Facebook creates an application that enables a user to make a t-shirt with a custom QR code. Thus, it is possible to add a friend by shooting his/her QR code with the phone camera. Fig. 3 shows an "add-to-Friends" t-shirt.
Also Google adopts QR codes for business advertising. The service, named "Favorite Places on Google", provides the business with a windows decal showing a QR code. When scanned by the phone camera, the marker enables the user to access information on the business,

including customer reviews and also enables to write a personal review. The application does not adopt an AR interaction modality.

Fig. 3. QR code for labelling not only the world, but also people.

2.3 Usability for mobile systems in AR

New interaction approaches should be considered to effectively use augmented reality mobile applications. Indeed, it is necessary to consider that mobile device interfaces are characterized by the following aspects:

- small screen,
- limited input options (no mouse/keyboard),
- need to hold phone away from the body,
- reduced processing power (even if top-of-the range devices have this problem in reduced form).

Thus, researchers have to face the challenge of designing usable interfaces for device screens with limited dimensions and invent new interaction modalities.

To evaluate the usability of a mobile location-based AR system it is important to consider that AR representations combine rendered graphics with the real world environment and require a specific type of interaction among virtual artefacts and the real world. In particular, several factors affect the user perception of an AR system (Haniff & Baber, 2003), such as the perceived graphical resolution and rendering qualities. Image disparity is also a critical factor in augmented reality interfaces. Indeed, if the AR content reproduced on the camera is offset from the real world view, the user can be disoriented. The system lag can affect the perceived system quality and impact on the manoeuvrability.

The Magic Lens interaction pattern has several drawbacks: it requires the user focuses the information with the exclusive use of at least one hand; he/she has to move himself/herself while looking inside the phone. Thus, the user can have some problem in crowds, small spaces, or in areas with fast-moving objects or people (Lamantia, 2009).

A possible solution is to use the motion of the phone to interact with the virtual objects (Billinghurst et al., 2009). In this way it is possible to overcome the problem to interact with the application while the device is handheld (De Lucia et al., 2010b).

New research directions are studying the adoption of tangible interaction techniques.

2.4 Place-based recommender and social matching algorithms

A large amount of research work has been devoted to improve the usability of mobile applications, proposing display approaches to better present a lot of information in a very little space with too few resources. Another interesting direction is towards the research of the way to reduce the amount of information to be displayed. Recommendation systems are devoted to deal with information overload and offer personalized recommendations, content, and services to the users.

During the past and recent years, recommendation systems were developed for a series of different purposes. Recently, the rise of a large number of Web2.0 applications (blog, community forums, Web Albums, Blog and Taggings, etc.) indicates that users have the very pressing requirements of direct, rapid, useful and personalized information recommendation and sharing services (Yang and Wang., 2009).

Recommender systems start from the user preferences and item properties to discover items users are likely to take pleasure in.

According to (Gartner, 2010a), the future brands have to adopt location or profile-based information for both acquiring and retaining customers and to remain competitive in the growing mobile commerce space.

In case of location-based recommender systems, user profile analysis and context network analysis are integrated with intelligent information searching and context semantic enrichment to suggest to the user places and activities, combining his/her explicit and implicit preferences with place information.

The user preferences on places and activities can be inferred from use or openly declared.

As an example, if a user frequents a specific restaurant type (i.e. Chinese), the system could deduce that the user prefers Chinese food and recommends to him/her this type of restaurants when he/she is searching for a restaurant. Social networks are useful to find similar user profiles and to recommend restaurants and shops where other users with similar preferences are used to go. To this aim, also user ratings and comments are largely used.

The main recommendation models proposed in literature include the collaborative model, the content-based model, and the hybrid model based on both the previous ones (Yeh & Wu, 2010). In particular:

- *collaborative recommendation models* adopt data mining algorithms to group user interests collected mainly form session history;
- *content-based recommendation models* are based on semantic content classification;
- *the hybrid model* combines collaborative and content-based models. It provides a better performance because this model take care both user session history and content semantic analysis.

In many commercial situations the user judgements are implicitly collected, without explicit user input. As an example, sales transactions or pageviews can be automatically collected and considered as implicit ratings and exploited by collaborative filtering systems.

Collaborative filtering can also be based on human judgements, such as ratings and comments. These user opinions are useful to determine the proximity of users' tastes. See the suggestions provided by Amazon, such as "Users who bought the item a, also bought items b and c."

(Zanker and Jessenitschnig, 2009) propose a collaborative algorithm for determining similar users and making recommendations, based on a hybrid recommendation approach that utilizes a diverse range of input data, such as clickstream data, sales transactions and explicit user requirements.

An example of location-based recommender system based on social network is GeoLife 2.0 (Zheng et al., 2009). It exploits GPS technology to allow people to share their life experiences referring to the place they frequent. The system measures the user similarity, and makes personalized recommendation on friendship.

3. Augmented reality web 2.0 applications

Geotagging is an example of web 2.0 applications enabling to add location metadata to photo, videos, etc. World-mapping is done by powerful tools such as *Google Street View*. Thus, thanks to the innovative features of the new mobile devices, Geotagging is a very common practice for both uploads and downloads.

As discussed in Section 2.1, the most part of the AR location-based application does not support web 2.0 features, but they are limited to show location based content. This kind of features requires that the users are able to choose a 3D location, and their devices should allow them to opportunely view and add content.

(Baillot et al., 2001) proposed one of the first works on this topic, where an in-situ authoring system enabled to add virtual objects to a real scene. It also supported triangulation from different views. Augmentable Reality (Rekimoto et al., 1998) allows users to annotate an environment exposing barcode markers associated to contextual information. More recently, to obtain a better label placement considering the depth, (Wither et al., 2008) adopted a laser range finder to compute the depth information from given position and orientation.

The Sekai Camera application for iPhone is a social augmented reality application (Sekai Camera, 2010). It adopts a form of labelling that supports user communication by attaching digital contents to the real world. It is a handheld application that allows to associate media to a general location, and not to specific objects.

Recently, (Langlotz et al., 2010) present an approach for creating and exploring annotations in place using mobile phones. They adopt vision-based orientation tracking to accurately register objects overtaking the limited accuracy of the compass. Vision tracking requires an image database or a three-dimensional reconstruction, predetermined or constructed on the fly. To surmount these problems, author adopts a natural-feature mapping and tracking approach for mobile phones, allowing tracking with three degrees of freedom. It assumes the user makes pure rotational movements. The system generates a panoramic map from the live video and simultaneously uses it for tracking.

To create annotation, users move into a position where they want to create it. The application generates a panoramic image of the current environment. The user touches the display at the desired position and enters a textual description or a voice annotation. The system creates 48x48 pixel sub-image centered on the chosen point in the panorama image. This sub-image is later used for template matching. Besides the annotation itself, for finding the annotation anchor point again the system uses only the sub-image information.

In 2010 (De Lucia et al., 2010a) proposed SmartBuilding, aiming at augmenting a physical building with spatially localized areas in which users can share formal and informal multimedia documents and messages.

In particular, in SmartBuilding the screen of the mobile phone is transformed into a virtual multimedia board, where real information are overlapped with virtual information. Fig. 4 shows a screenshot of a “real” board enhanced by using a mobile phone and its camera with information concerning the course the teacher is taking in that room.

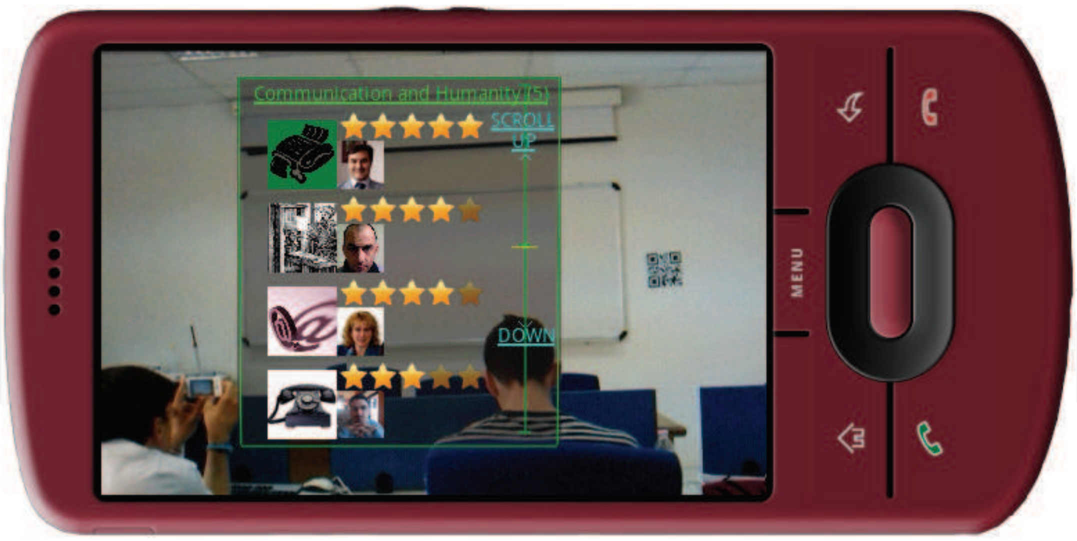


Fig. 4. An example of an Augmented Reality interface for a mobile location-based pervasive content sharing application

The user localization is performed using both QR codes and the device sensors. When a user enters into a room, he/she has to direct the camera towards the QR code by pointing a viewfinder visualized on his/her camera preview. The obtained resolution of the room marker enables us to deduct the shooting user-QR distance. In addition, the shooting angle, obtainable by comparing the shut QR side dimensions, allows us to determine more precisely the initial user position in the room. The user orientering coordinate system adopts radial orientation in the environment as main dimension and is tracked reading the Azimuth sensor, while the Roll orientation sensor is adopted, combined with the accelerometer, to detect how the camera is orientated in the space vertical dimension. The devices also communicate the current state of the Wi-Fi signals arriving from the various access points to the central server. Thus, it is possible to deduce each position variation by integrating the detected acceleration and extrapolating the new position considering the new Wi-Fi signal (Savidis et al., 2008), i.e. the strength of each access point carrier, of a user with his/her previous configurations and with those of the others. A first usability evaluation conducted in (De Lucia et a., 2010a) provides satisfying results and, in particular, verifies that system supports strong degrees of realism, thanks to the fluidity of the AR superimposed content. An innovative pagination interface enables to scroll-up and down the contribution list, using only the devices sensors.

4. Innovative trends in specific application areas

This section reports innovative trends in specific application areas of the enabling technologies.

4.1 Supporting collaboration

A research area of great interest for mobile phone based on AR interfaces is to provide support for collaborative applications. Mobile phones are already designed to support local and remote communication and thus they are a natural platform for collaboration.
According to (Szalavari et al., 1998), a collaborative AR environment provides the following features:

- *virtuality*, not existent objects are shown in the environment,
- *augmentation*, real objects are augmented with virtual information displayed considering the location,
- *cooperation,* the environment has to normally support the users interaction,
- *independence*, each user can manage an independent point of view,
- *individuality*, data can be shared but it can also be differently presented to different users.

A first form of collaboration has been provided by Invisible Train (Wagner et al., 2005). The user collaboration is performed as follows: users move around in the real world to view a virtual train set and then touches the screen with a stylus to change the position of tracks on the train set.

One of the first examples of collaboration in VR using mobile devices is the AR-Tennis game (Henrysson et. al., 2005). The application is based on ARToolkit, ported to Symbian. This game adopts the mobile phone both as an interaction tool, simulating a tennis racket, and as a display. As a consequence, the players cannot easily examine their view of the virtual world and concurrently move the device.

(Mulloni et. Al., 2008) propose a team-based competitive AR game. Players walk around the real environment to reach the goal of the game and communicate face-to-face among them.

A more recent game, Art of Defense (Nguyen Ta Huynh et al., 2010), is a strategy-based "Tower Defense" style game. Two players collaborate to defend their central tower from waves of attacking enemies. The game adopts both handheld devices and physical game pieces, creating a mixed physical/virtual game on the tabletop. The user interacts with the game trough the tangible elements. To support the control of the game, the system exploits several computer vision techniques, such as marker-based tracking and colour recognition.

For high interaction task, i.e. working together on complex independent problems, face-to-face meetings are the better way to communicate. Small group settings are generally equipped with display information technology, such as projectors, electronic whiteboards, or large monitors. Augmented Reality, location-awareness and mobile devices can be combined to share and display information for co-located collaboration.

(De Lucia et al., 2010b) proposed SmartMeeting, a component of SmartBuilding aiming at supporting group collaboration.

Each work group has assigned a Group Augmented Area, where information relevant for the group is shared. This area is permanent and represents the group reference area for formal and informal communication.

4.2 Virtual campus and collaborative learning

The rapid evolution of mobile technology enables users to communicate in very different ways. These transformations pervasively affect the way students learn: in 2005, Downes (Downes, 2005) proposed for the first time the term *elearning 2.0*. This new version of elearning principally denotes the democratization of content authoring: users are the authors and information is no longer exclusively produced by experts, structured into courses and delivered. Indeed, the students themselves produce and use content in a bottom-up fashion, with the consequent and implicit creation of learning communities. Indeed, the students of a course in Multimedia Technology provided the user requirements for mobile learning applications (Garaj, 2010). This study, among others, puts in evidence the importance of learning across contexts (i.e., to take pictures on location when students perform a visual design activity), of uploading several content types and of combining individual and group use in a way similar to Youtube, Flickr or blogs.

Several examples of the location-based virtual campuses exists in literature, but few of them adopt mobile augmented reality interaction.

In (Liu et al., 2010) authors presented a system aiming at supporting English learning integrating the usage of 2D barcodes and Augmented Reality as follows: when approaching a zone, a student used the PDA phone to decrypt a 2D code and then obtained context-aware contents from server. The students then practiced conversation with a virtual learning partner.

(De Lucia et al., 2010c) proposed ACCAMPUS, a "collaborative campus" based on SmartBuilding, originated in the physical architectural space, exposing and downloading learning contents and social information structured as augmented virtual areas, see Fig. 3 as an example of this areas. This approach supports the creation of a virtual campus trough the definition of several types of augmented areas, such as:

- *administration areas*, representing the official bulletin board (locked), where contents are provided by the university staff, such as time tables, or teacher news on specific courses;
- *student areas*, enabling the students to communicate by uploading and commenting contents. They correspond to bulletin boards open to the student community and adopted for not strictly didactic announcements;
- *group areas*, specific for group learning approaches. During a project activity, the teacher can create an area for each group.

A collaborative learning approach exploiting the features offered by this system has also been proposed.

4.3 Tourism and cultural heritage

Location-based pervasive content sharing applications can be a powerful support for touristic promotion. It will address the users to discover Cultural Heritage in a collaborative, simple and funny way, thought the adoption of mobile technologies based on AR.

Several location-based social networks, such as MyTown, FourSquare or Gowalla, enable the user to label the places he/she is visiting and to download or retrieve virtual content, without augmenting the reality.

A first example of mobile AR application for this area is LibreGeoSocial (Zoellner et al., 2010). It provides a Cultural Heritage Layers, that uses X3D for visualizing historic multimedia content superimposed on the camera view in the right place. They use markerless tracking technologies for outdoor environments. In particular, starting from few reference images of the spot, the system analyses the images from the camera and determines if the current view is from a given spot or not. If a spot has been detected, the position of the considered object is precisely recovered and tracked, then the additional content can be appropriately superimposed to the camera view.

4.4 Face recognition based applications

Face-recognition on mobile phones is a very appealing AR location-based service. Indeed, it can be very useful when we are seeing someone but we do not remember who he is. Or, we need to get information on a person we meet for the first time. An application of this kind can access to an image database of a social network, identify the person we are shooting

with the camera and report us all his public social network links. Polar Rose (http://www.polarrose.com/) proposes a facial recognition algorithm that has been adopted by several mobile applications.
Face Recognition on mobile device is a particular form of visual search. Indeed, (http://www.slideshare.net/rudydw/mobile-trends-2020 slide 55 Atanu Tanaka) it can be considered as a near future improvement of the classical web search. Searching for people is probably the first step toward an era when the users, pointing the mobile cameras in the direction of a generic object, will obtain the related information.

5. Conclusion

To better understand Mobile Location-Based Augmented Reality applications supporting content sharing, we surveyed the literature in this area. We discussed current approaches in the research areas related to the development of this kind of applications, listed some examples of this kind of applications, and described how these technologies can be adopted in different application areas.
We found that the researches on the related topics, such as usability, user tracking, collaborative filtering, collaboration and face-recognition, are still at the early stages and the interest toward this kind of applications will strongly increase.

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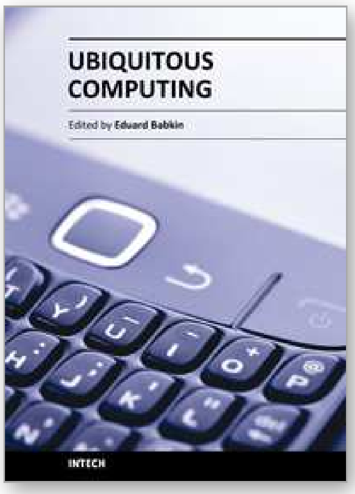

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The aim of this book is to give a treatment of the actively developed domain of Ubiquitous computing. Originally proposed by Mark D. Weiser, the concept of Ubiquitous computing enables a real-time global sensing, context-aware informational retrieval, multi-modal interaction with the user and enhanced visualization capabilities. In effect, Ubiquitous computing environments give extremely new and futuristic abilities to look at and interact with our habitat at any time and from anywhere. In that domain, researchers are confronted with many foundational, technological and engineering issues which were not known before. Detailed cross-disciplinary coverage of these issues is really needed today for further progress and widening of application range. This book collects twelve original works of researchers from eleven countries, which are clustered into four sections: Foundations, Security and Privacy, Integration and Middleware, Practical Applications.