

A wearable computer based maintenance, diagnosis and repairing activities in Computer Augmented Environment

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Abstract

We are presenting our platform which objective is to allow to different actors in maintenance, diagnosis and repairing activities to solve the problems using wearable computers in an Computer Augmented Environment. This environment bristling with communicating objects, actives or passives, mobile or grounded making it a pervasive and intelligent environment. We are particularly concerned with innovating user interfaces and devices of Mixed Reality which can be used in industrial context, where mobility and cooperation are required.

Keywords: Wearable computer, Computer Augmented Environment, cooperative activities, contextualisation

1 Introduction

As announced by (Weiser 1991), the ubiquitous computing (also known as pervasive computing) seems to become concretizing with the massive propagation of mobile and connected devices (PDAs, TabletPCs, Smartphones, etc) and the use everyday broader of informatics resources as RFID tags (Srivasta 2005). Besides, ubiquitous computing is from 2001 integral part of the Ambient Intelligence (AmI) (AMBIENCE 2004), which merges the “ubiquitous computing” and “social user interfaces” trends to adapt user interfaces to its environment and task context, so to create the proactivity. On the other hand, the Mixed Reality (Renevier et al. 2002) better known as Augmented Reality (AR), for which the founding act can be situated in 1993 (Wellner 1993), is also in full expansion. It attempts to merge the physical and numerical worlds to facilitate the user’s task with special devices and particular interaction techniques (i.e. a physical block controls a numerical block). However, the User Interfaces used on these new mobile and connected devices and their uses (Plouznikoff 2004) are similar to the ones of desktop computers and are often inappropriate for mobile users that must realize several tasks simultaneously like talking with other persons, performing technical equipment maintenance, or visiting tourist spot. Besides, whereas these devices can be sensitive to the environment (GPS, RFID tags detection, etc), they rarely made the user benefit of this. Thus we must adapt their behaviour transparently to the user (in a proactive way)

as in an Ambient Intelligence (AmI) Environment. AR devices and techniques can be particularly convenient in this respect.

Our objective is to study, through Ubiquitous Computing and Mixed Reality domains, some innovative human computer interfaces (instrumented (Beaudouin-Lafon 1997), bi-manual, adaptatives, etc) appropriate for mobile users working in a collaborative way with an elaborate contextualization (access to contextual and/or personal precise data) in a Computer Augmented Environment in the meaning of Augmented Reality but also Ubiquitous Computing. Our main concepts are: **MoUI (Mobile User Interfaces)** denoting the user interfaces for the wearable computers as those of PDAs, Smartphones, or mobile phones, **CAE (Computer Augmented Environment)**, **MOCOCO (MObility, COoperation, COntextualisation)** depicting tasks realized collaboratively by several mobile actors, whose have access to precise and contextualized data; and the **Proactivity**, the transparent user interface adaptation enabled by an Ambient Intelligence Environment.

2 Platform presentation

For our studies we defined IMERA platform (French acronym Mobile Interfaces for Computer Augmented Environment). This platform is composed of a main workplace and three auxiliary distant workspaces. The main working area is a CAE (Computer Augmented Environment) where different actors are moving about. For us, this CAE is a more or less large area covered by a WiFi network, able to receive RFID tags, either freely set or integrated to real objects located in this space; RFID technology is our first support for the Ambient Intelligence environment. Some RFID fixed readers can also be introduced on this area. The actors are moving freely in this area with their wearable computers (PDAs, TabletPCs, etc), each of them equipped with a WiFi card and an RFID reader. These wearable computers are thus connected to the network and are able to access contextual data through RFID technology. The WiFi network allows actors to be both connected between them and with centralized systems (database servers, etc) so they can communicate and access large amount of data. Independently of this working area, several separate distant management and observation workplaces complete this platform. For our experimentations, we have at our disposal three other workplaces in our lab. A first workspace is intended to be central workplace for observation and management of the collaborative activities involving a coordination, i.e. to supervise the actions made by the actors moving on the platform main workplace. For this purpose, a TableGate equipment (figure 1) (Chalon 2004) is used. It's an interactive pressure sensitive flat-mounted table supporting Mixed Reality thanks to a video projector and a camera. This device is able to recognize the physical objects placed and shifted on it and can also act as a touch pad.

The second workspace, located in another room of our lab, is mainly observation oriented but can be used as second supervision place. It is based on a Tool Tribe device (www.tool-tribe.com), an interactive whiteboard (figure 2) hanged to the wall and completed by a video projector to display numerical data. For example, the video-projector can display the position of the actors on the platform in real-time, a paper map of the platform can cover the panel for that, but a numerical map is also usable. The interactions with the panel are done by physical pens that the system tracks. Some pens are physically writing, whereas others are just used as pointers, so we can select a

position, an actor or others objects moreover than to physically write and erase drawings on the panel as on a whiteboard.

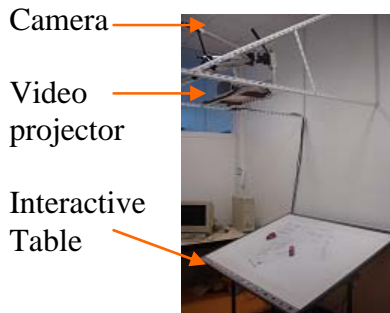


Figure 1: The Table Gate

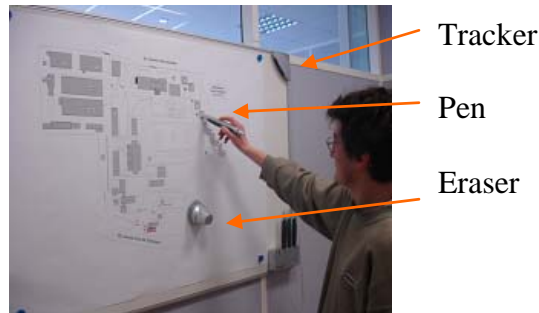


Figure 2: The Tool Tribe

Main difference between the TableGate and the Tool Tribe is that on the TableGate, the user can manipulate indifferently physical and numerical objects. In this way, the TableGate allows realizing Mixed Reality tasks, and either Augmented Reality (tasks in the Real World) or Augmented Virtuality (tasks in the Numerical World). On the contrary, the Tool Tribe doesn't allow interacting with real objects; it is used in the same way as a touch screen, to manipulate only virtual numerical objects.

The last workspace located in another lab room is devoted to the observation and the evaluation of the platform experimentations. It holds a trace server which acts as a UI message loop hook; filtering and storing all the UI generated messages sent through the different networks (Ethernet, WiFi, ...) either normally (collaborative applications) or dedicated to this purpose (single user applications).

3 Platform adaptation process

IMERA platform is used in several collaborative situations (educational, industrial, cultural and sporting events). Its main working area takes place on the corresponding space while distant workplaces can be located anywhere as soon as a WiFi network is accessible. For each situation, it is important to identify the actors and their tasks with the data to be collected and manipulated for that. We determine in this way the technologies to exhibit on the main working area and the most appropriate equipments for each actor. Firstly scenarios are expressed and formalized in a structured way following the method proposed in (Delotte & David 2005) to describe as precisely as possible all collaborative aspects. Secondly a synthesis leading to the Collaborative Application Behaviour (CAB) model is elaborated. Then, we are able to extract the roles of each actor in analysing the model from the actors' point of view; jointly to the required environment, artefacts, etc. This process helps in the choice of wearable computers and peripherals needed to realize the tasks.

4 Industrial maintenance scenario

An industrial scenario supported by the IMERA platform is the following. An engineer in charge of maintenance of industrial machines is called on a factory where such machine is out of order. Once in the factory, he equips himself with See-Through goggles connected to a WiFi PDA including a RFID reader. By reading machine' RFID tags, he gets all its features and its reparation history stored on an internet database

server, through an available WiFi access point connected to the internet. He proceeds to a first analysis and try to formulate a diagnostic. If he failed in making it alone, he contacts his supervisor. He can contact him by chat or contextualized email in which machine references are automatically included to avoid typing error and to provide exhaustive information. Then they are trying to produce the diagnostic together.

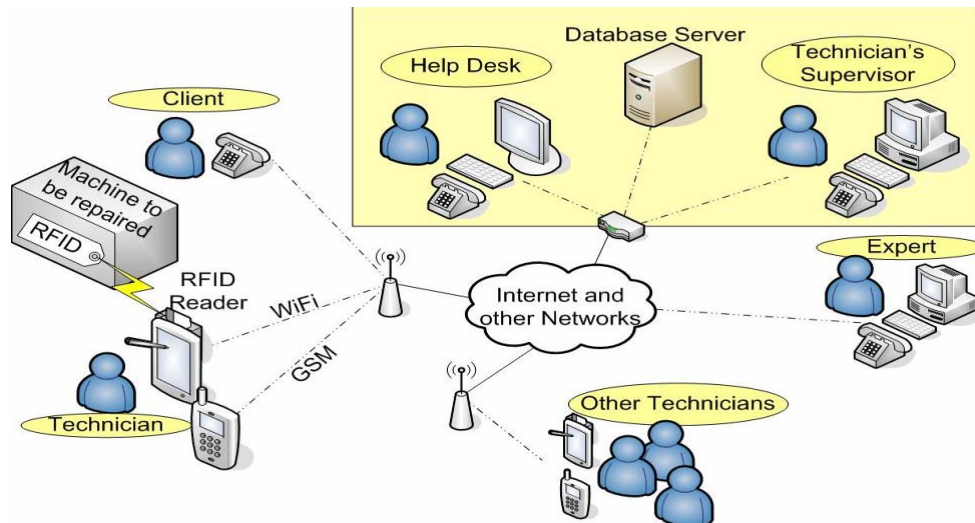


Figure 3: IMERA Platform industrial scenario

Accurate product plans and guides are at the disposal of the engineer through the internet connection to help him on the recognition of the different pieces. He can visualize them on his see-through goggles whereas he is looking at the machine. Simple vocal commands are enabling him to browse the guides. These commands are captured by his PDA microphone and are processed either on a server, being transferred through WiFi and internet or directly on the PDA, depending on the complexity of the command, and the capabilities of the PDA. If diagnostic is still not successful, he can contact a machine constructor expert to help him realize the diagnostic.

As soon as the diagnostic is established, and the malfunctioning pieces determined, he highlights them via his wearable computer on a plan of the machine displayed on his augmented goggles. Afterwards, the availability and delay for future reparation is computed. Later, when the parts are delivered, the reparation process is described on his wearable computer with eventually the visualization on his see-through goggles of an assembly plan or others relevant data. As soon as the machine is repaired, he updates the machine reparation history and replaced parts, on the server.

4.1 Choice of wearable computer and its peripherals

For different actors of a particular scenario as for different scenarios, it's important to find the most appropriate wearable computers and peripherals. Various solutions are possible (light and small hand free equipment, heavier but with better visualization capacities or better interaction performance ...). These choices are established after a study of all actors' tasks, matching requirements concerning graphics information complexity (textual, graphic schemas or precise blueprints ...), interaction complexity (writing, observation, manipulation) and working conditions (seating, standing, hands availability ...). A precise selection process based on a selection space allows

comparing different interaction ways and system implementations, with their typical supporting devices organized onto axes and classified for each axis by one of their most relevant characteristics. This process results in different configurations proposals and helps to determine the most convenient ones. The criteria are those of the designer, e.g. the devices number minimization, the interaction continuity maximization (in and between the tasks) and the adequacy with working conditions.

Main possible choices are done through the following axes: **gesture interaction** of the hand, arm and/or head; **vocal interaction** with or without feedback; **eye interaction**, also called lazy interaction; **writing and input capabilities** via a physical or virtual keyboard or a touch screen; **display capabilities** as screen integrated in glasses or see-through screen in goggles or the screen of a mobile device (PDA, TabletPC, etc); **data contextualization**; **localization** of users and objects; **communication support** as WiFi, and Bluetooth. Contextualization is done by RFID tags reading. The readers are mobile or grounded and the users wear tags to be identified and/or read tags to force their mobile user interfaces become “contextualized” (updated) with the context described in the tag content. This axis doesn’t explicit the data storage, that is often a database server. Localization is geographical (using GPS), logical (using RFID), or combination of both techniques for a better accuracy. Others devices and peripherals aren’t dismissed, these axes are the basis for the definition of our configurations, but they aren’t exhaustive and a configuration defined through them can be modified with other relevant peripherals. Besides, it isn’t mandatory to use each axis, since they are not useful for each task.



Figure 4: Goggles with integrated screen, See-Through goggles, TabletPC, RFID reader and Data glove

4.2 Examples of meaningful configurations

We are describing here three configurations with their purposes.

– **Hand free highly mobile actor**; Purpose: Eyes continuity and at least one hand free. Equipment: Goggles with integrated screen, Control through a data glove, Voice command with vocal feedback, Backpack computer.

– **Hand free Mixed Reality mobile actor**; Purpose: Integration of numerical data in the real world for tasks generally in the real world. Equipment: See-through goggles, Control through a data glove, Voice command with vocal feedback, Backpack computer

– **Head free mobile actor**; Purpose: Sizeable data support and handheld device with interactions by pointing and writing. Equipment: TabletPC (WiFi) with RFID reader.

5 Tests and evaluations

The aim of the evaluation and test of different configurations of the mobile devices (in the AR and ubiquitous environment) are their utility, utilisability and acceptability. For that, we gather several kinds of traces. Among them, the messages that generate the UI are sent through the network and stored on a trace server; these are either user oriented for single user applications or user and group oriented (messages exchanged

inside a group) for collaborative applications. The tests themselves take place in the following manner. Firstly, the subjects' profiles are determined by asking them to fill a pre-test questionnaire. During the experimentations, the subjects are filmed to supplement the UI logs; they are asked to verbalize their actions and difficulties while two observers follow them and take notes of these problems and attitudes in an observation grid. As soon as the test is finished, each subject fills up a post-test form with a set of multiple choice questions and some open questions. Finally, crossed analyses of these different data allow extracting results of these evaluations.

6 Conclusions

We have presented an experimentation platform for the study of new interaction techniques and devices uses through several configurations deployed for collaborative work with mobile actors in a Computer Augmented Environment. This platform is also an Ambient Intelligence Environment by the integration of new communicating objects grounded or mobile, active or passive, and most recent sensors and effectors are considered, including position and orientation sensors or more original captors as presence detectors. The platform supports the appraisal of concrete scenarios issued from industrial maintenance situations (machines on-site repairs, etc), for the discovery and validation of new interaction ways or devices uses. We are open to other applications to validate our approach and other scenarios are currently studied, mainly in the industrial field, especially with our partner Assetium, and some ECL students for their end-of-year works.

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