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Towards context-aware interactions between humans and a self-organized cybercar system

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Abstract

The rising number of vehicles in many cities in the world lead to numerous nuisances such as pollution, safety, noise, traffic jams... During the last decade, many companies and research organizations have been developing a new concept of automated vehicle called: cybercars. The “cybercar” system inside the city must be flexible, robust and decentralized. We use self-organization principles to achieve this. Furthermore, with the purpose of having user-friendly human-computer interactions, for a range of different users, the system must be context-aware. In this paper, a general model and principles for modelling human-cyber interactions using UsiXML are proposed.

Keywords: Human-Computer Interaction (HCI), Self-Organization, Context Awareness, UsiXML, cybercar.

1 Introduction

Many cities in the world have problems with private vehicles. There are traffic jams, pollution, security problems and nuisances. The cybercar is a potential solution to these problems. Our research is focused on Human-cybercar interactions. Cybercars also aim to improve to quality of life by reducing the use of traditional vehicles. The cybercar is a safe mean of transport that any one can use (CyberMove, 2001). Also, with these vehicles, one hopes to reduce costs because there will not be any drivers. The cybercars must be integrated to the city's public transportation. They must complement the transportation system that already exists in a particular city. This aspect will be discussed in the following section. The user is a main element of the cybercar system. This system has to take into account who the user is, the environment that surrounds him/her, and which device he/she is using at the time of his/her request for the cybercar. Therefore, the display on the device, used by the user, has to be sensitive to the context or context-aware. It is the main objective of our ongoing research. The article begins with a description of cybercars. After this, we examine the cybercars' place with respect to the ITS (Intelligent Transport Systems). We then discuss the main principles brought by self-organization and how these characteristics will allow the “cybercar” system to be flexible, robust and decentralized. Following this, we direct our attention to “context-

awareness” and how our system will be sensitive to context. A model unifying the self-organized cybercar system, context-awareness, and a user interface is proposed. Different scenarios are then discussed where the user can be inside or outside the city and how he/she asks for a cybercar. Finally, a task is presented for requesting a cybercar outside the city. We model this task and then show an example of a website, created using UsiXML (proposed as modelling language), where the user can reserve the vehicle.

2 State of the Art

2.1 Cybercars with respect to the ACTIF model and the ITS

Cybercars are road vehicles with the capacity of complete automated driving. A fleet of these vehicles form a transport system, for passengers or merchandise, on a road network with the capacity of services on demand. Cybercars offer the advantage of functioning on any infrastructure which means that they are cheaper and more flexible (Parent et al, 2003). Many private societies and research institutions/laboratories study the technological aspects of cybercars and their impact inside the city. These projects include: (CyberCars, 2006), (CyberMove, 2001), (EDICT, 2007), (NetMobil, 2005), (CyberC3, 2007), (CityMobil, 2008). For cybercars, as for any means of transport, we have to take into account many classical aspects, like the price, safety, maintenance, travel demands... FRAME (Framework Architecture Made for Europe) (FRAME, 2008) developed the first version of the European ITS Framework Architecture. They provided seminars, international meetings, technical documents to promote the Framework Architecture to different countries. France, as well as other countries in Europe, used these ideas to create their own ITS architectures. The ACTIF (ACTIF, 2007a) (*Aide à la conception des systèmes de transports interopérables en France*) model incorporates all of these aspects. ACTIF is used here as a generic model of an infrastructure of different means of transport; complete enough to allow the positioning of the cybercar system with respect to the aforementioned aspects. ACTIF also is associated with a method and software (ACTIF, 2007b) to do the above. In the ACTIF model there are 9 functional areas: (FA1) Provide electronic means of payment; (FA2) Manage emergency and safety services; (FA3) Manage transport infrastructure and traffic; (FA4) Operate public transport; (FA5) Provide advanced systems for driver assistance; (FA6) Provide information on and manage multimodal mobility; (FA7) Enforce regulations; (FA8) Operate freight and fleets; (FA9) Manage the shared data. The functional area “Operate public transport” is particularly adapted to introduce the cybercar system. We are not going to into details in this article (for the lack of space) on how this is done. But in summary, this placement with respect to the ITS, via the ACTIF model, allows to encompass the outline of the cybercar system and link them with the other systems/areas surrounding the public transportation.

2.2 Self-Organization

Self-Organization is: *“a process in which pattern at the global level of a system emerges solely from numerous interactions among the lower-level components of the system. Moreover, the rules specifying interactions among the system’s components are executed using only local information, without reference to the global pattern”*

(Camazine et al, 2003). Self-organization is based on studies on biological systems. The main idea is not to have a centralized system, but to have “individuals” which work together towards a common goal. The characteristics of self-organized systems are robustness, flexibility, and decentralization. Bonabeau and colleagues (Bonabeau et al, 1999) suggest that using self-organization on artificial systems will reduce its costs and make them simpler. Self-organization is the main source of inspiration to conceive the cybercar system as a “naturally” autonomous group capable of adapting itself and able to face the different perturbations of a road network (i.e. traffic) without explicit configuration. This is possible due to the capacities of the cybercars which can communicate/interact locally with other cybercars, users and with the immediate environment. Routing protocols using self-organization have already been proposed in (Melki et al, 2007) which are part of the PPF project. In section 3, we will propose a general model where we include the self-organized system of cybercars. As said before, this system will use routing protocols based on self-organization, and also will communicate locally with its environment (cybercars, users, interactive terminals...).

2.3 Context-Awareness

A user of the transportation system for cybercars must be able to call or reserve a cybercar according to his/her profile, the environment in which he/she is in and the interaction devices at his/her disposal. The system must be context-aware (User, Environment, Interaction Platform). A definition of context is given by A.K. Dey (Dey and Abowd, 2000; Dey et al, 2001): *“Any information that can be used to characterize the situation of entities (i.e. whether a person, place or object) that are considered relevant to the interaction between a user and an application, including the user and the application themselves. Context is typically the location, identity and state of people, groups and computational and physical objects”*.

Thevenin (Thevenin, 2001) describes context as a triplet {user, platform, environment}: (1) *User* (Type of user or profile) - Age, Occupation (Tourist, Professional...), Handicap, ...; (2) *Platform* (material support and software that allows the interaction) - PDA, Cell phone, PC, ...; (3) *Environment* (place where Human-computer interaction (HCI) is exercised) - Geographic place (home, on the street...), Day/Night, Ambient (noisy, crowded...)...

The goal of our HCI system with the cybercars is to take into account this information concerning the user, the physical environment, the properties of the platform, the noise level, the user's location, etc. We consider also that these interfaces of the system must be able to migrate to another interaction device while preserving usability (Calvary et al, 2002; Thevenin and Coutaz, 1999).

3 Proposition of general model of user-cybercar system

Our system is composed in one part with a fleet of self-organized cybercars and in another part of a transportation system. These two elements define the application domain. The user must be able, with the appropriate context, to interact with the system in a natural way or by using a device (via a HCI platform). Our model, which is adapted from (Coutaz et al, 2007), is composed of a domain model, context model, and a user interface model (Figure 1). The **domain** describes the objects in the application. The cybercar model corresponds to every cybercar that is in the city. This model uses the

notion of self-organization. Therefore each cybercar uses local information to accomplish a particular task. Cybercars are capable of communicating with themselves, with the transportation system, with the environment and with the user (Please note that different techniques have been proposed in the research projects in section 2.1). The transportation system is a model which describes how cybercars are distributed and how they will arrive at their destination according to the routing protocol. In this article we will not go into the details of this model. The management of public transportation and cybercars as well as the routing protocols are illustrated in (Melki et al, 2007).

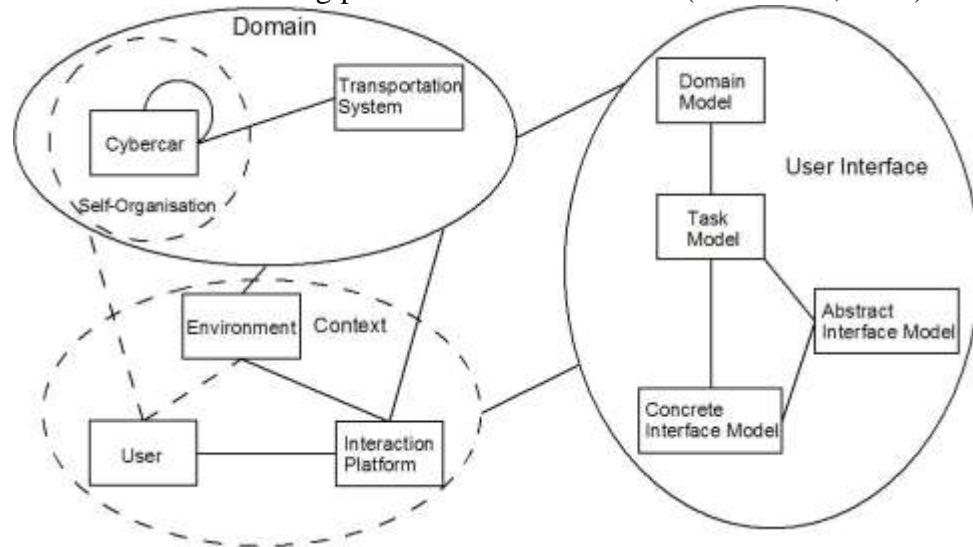


Figure 1. General Model

The user interface model describes the human-computer interactions which will be distributed on the interaction platforms which are available to the user.

The task model is a formal or semi-formal transcription of a user activity. The abstract model defines interaction spaces (task distribution between windows, pages...) and the concrete model describes the presentation (widget, layout...). This concrete model must be distributed, automatically in principal, to the corresponding platform with the appropriate context. The **context** contains the triplet {user, platform, and environment}. The user model defines the different profiles that were discussed in the preceding section. The HCI platform model defines the different available devices that the user can use to request a cybercar. The environment is very important to the cybercars because they have to take into account if it is raining, if it is noisy...

This general model allows taking into account the user inside an environment to adapt the user interface of the cybercar. If the user is inside the city, he/she can request a cybercar by using his/her PDA; he/she then can communicate directly with the nearest vehicle. If the cybercar is busy, this vehicle must inform the user and request another cybercar to take care of the passenger. The cybercars communicate with the "Transportation System" in the case there is a reservation that was done in advance by a user outside of the city. The transportation system with all of the users' information transfers these to the cybercar in the moment it has to pick up the user at a particular time and a particular place. In the next section, we define two scenarios: one where the user is inside the city and the other where the user is outside the city.

4 Scenarios

Our research is part of a project called PPF (Plan Pluri-Formation) “Coeur de Ville” which is associated with the French laboratories LAMIH, LAGIS and LGI2A. This project has the goal to treat urban transport problems by using cybercars inside the city. It will take into account problems of request management, allocation of cybercars, reallocation of cybercars after it arrived at a destination of a passenger, prices, constraints between the cybercar system and the other means of transport, perturbations. Figure 2 shows how the user interacts with the cybercars according to the two ways of utilization.

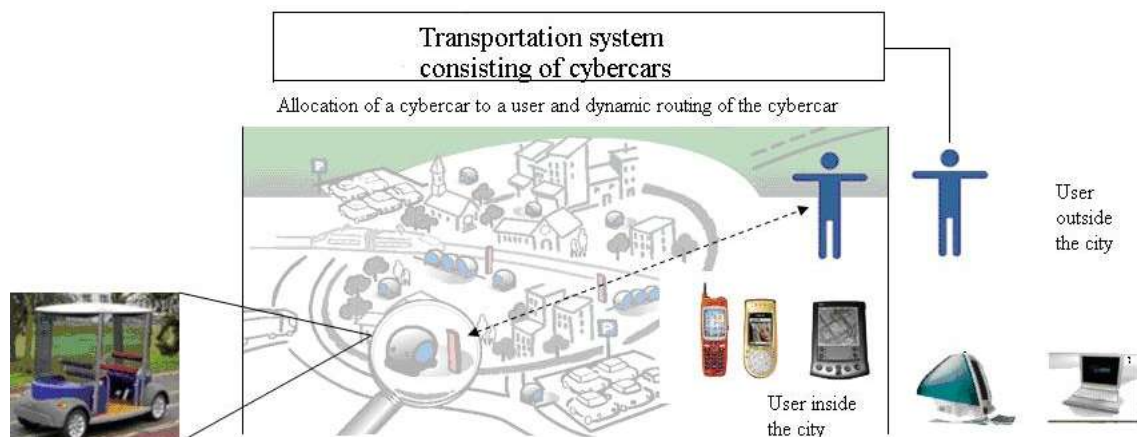


Figure 2. Main types of interactions

In the first case, the user is inside the city (where the cybercars are nearby), he/she can request a cybercar to arrive at a particular destination. The user can request a cybercar by using a mobile device (PDA, Cell phone...) or an interactive terminal. When the user uses this device, the user identifies himself/herself and is located. The authentication allows the system to recuperate the user's profile. The location assures, via the cybercar, the quickest arrival of the nearest available cybercar. Inside the vehicle, the screen (particular platform) will be configured according to the user's profile and the environment. The user will be able to view, for example, the museums, restaurants, train stations that are nearby in a city map. In the second case, the user is not inside the city and wishes to reserve a cybercar for a specific place inside the city at a certain date at a particular time. In this case, the user accesses the transportation system via a website. First of all, the user must register himself/herself if he/she is not already registered. The user profile allows the system to personalize the HCI.

5 Application

Interactions between cybercars and users imply potentially various tasks. Here we will provide a representative example by modelling an extract of the user interface which is context-aware.

5.1 Context and Task Modelling

The case study concerns the task “request cybercar from outside the city” by using a website. The user will use the website to reserve a cybercar. To begin, we will exploit CTT Environment (Mori et al, 2002) which is a task modelling environment based on

CTT (ConcurTaskTrees) (Paterno, 2000). The task model plays a very important role because it indicates the logic of the activities that the application must support; each task represents an activity that must be implemented to arrive at a goal. Figure 3 shows how the task to request a cybercar is decomposed. According to this model, to request (or reserve) a cybercar, the user gets in contact with the transportation system. The user must identify himself/herself, must include the date, place and time that he/she wishes to be picked up by a cybercar. The user also must choose which type of service he/she wants. The system permits two types of service: (1) *Regular* - This service is the more classic one and the cheaper one. The user here states his destination. If there are other users that are close (at the time the user is using the cybercar) and that go on the same direction, the cybercar will stop and pick up these people; (2) *Premium*: The passenger will have his/her own cybercar and the vehicle will take the user directly to the destination by using the shortest path. With this information concerning the user and at the time the passenger is at the place and time that he reserved, the nearest available cybercar will show up to pick him/her up.

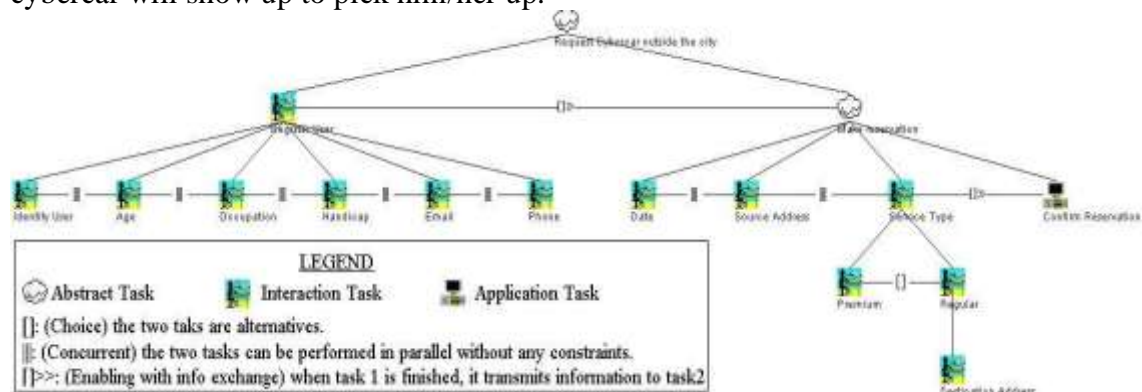


Figure 3. Task “Request Cybercar outside the city”

5.2 Context-aware user interface modelling using UsiXML

To develop a prototype of an interface that is context-aware, we have chosen UsiXML (User Interface Extensible Markup Language) (UsiXML, 2008); this language which is based on XML allows us to describe user interfaces capable of considering different contexts by using different levels of details and abstraction. UsiXML is a declarative language that captures the essence of an interface independent of the physical characteristics of the platform. This is done by using an abstract description of the elements that describe the particular interface. These elements are regrouped in different models (User, transformation, tasks, concepts, and others; for more details, see (UsiXML, 2008)). It is very important that the user identifies himself/herself, so that the adapted user interface is generated, according to the appropriate context. By using UsiXML, a simple first prototype was created; for lack of place in the article, we will only describe the part where we request a cybercar outside the city. Figure 4 shows a small extract on how the simplified interface was modelled. Three languages have been chosen at the moment for the interfaces (English, French and Spanish). By inspecting the code in figure 4, we see that the same interface is created easily for the three different languages (for example, we see the same button called “cancel” in English, “annuler” in French and “cancelar” in Spanish). In this same way, the rest of the interface was created. This is a first prototype and in the future the interface will take

into account other aspects for international users such as time formats, symbols,... (Russo and Boor, 1993). In figure 5, we see the result of the simplified interface on a website for a user who wants to reserve a cybercar. The user can choose his/her language of preference. If the user is registering, he/she must indicate his/her name, age, occupation, handicap, email, telephone. After the user is registered, he/she chooses which type of service he/she wishes for his/her journey. He/she indicates the date, time and place for the reservation of the cybercar. The transportation system will pass the information to the nearest available cybercar at this particular time and the vehicle will arrive at the location of the user. The user's information will be confidential and will not be accessible to external parties as established by the European Community (European, 2007). The interface in figure 5 was generated by using GrafiXML (based in UsiXML) which is a tool to develop interfaces for different interaction platforms (GrafiXML, 2008). This development environment offers also different plugins to export the UsiXML code to XHTML, Java and XUL. By using these plugins, we will be able to test different versions of this interface in PDAs, cell phones, PC, etc.

```
<cioRef cioId="button_component_10">
  <resource content="Annuler" contextId="CyberVal3-context-fr_FR_29"/>
  <resource content="Cancel" contextId="CyberVal3-context-en_US_29"/>
  <resource content="Cancelar" contextId="CyberVal3-context-es_ES_19"/>
</cioRef>
</resourceModel>
</uiModel>
```

Three languages for the button "cancel"

Figure 4. UsiXML code for the button cancel in three languages.

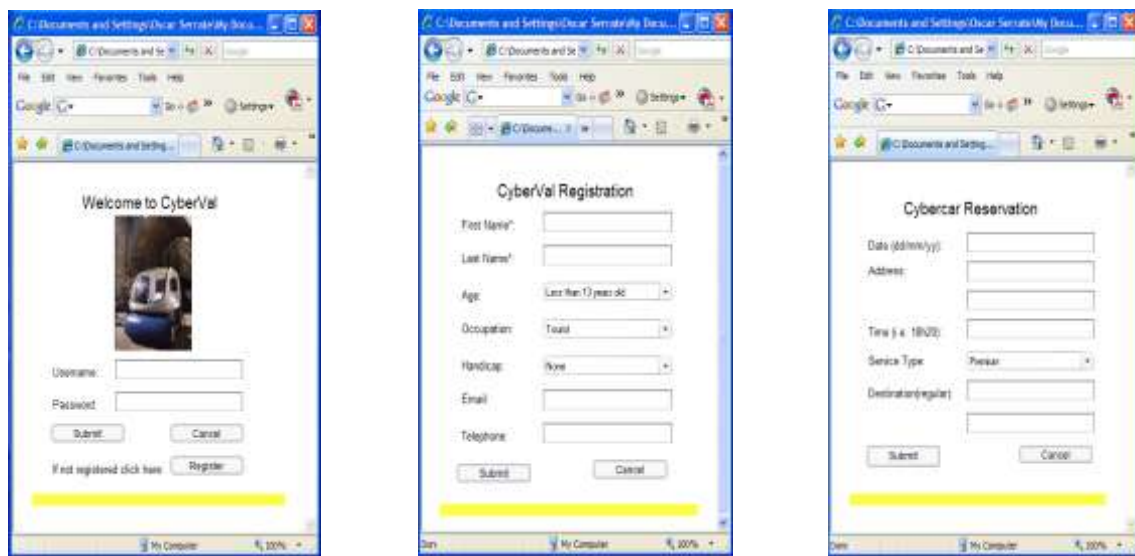


Figure 5. Website to request a cybercar

Figure 6a shows the scenario where the user is using a PDA inside the city to request a cybercar. Figure 6b shows the message that would be sent from the cybercar to the user in the case another regular passenger is going in the same direction as the first regular user.

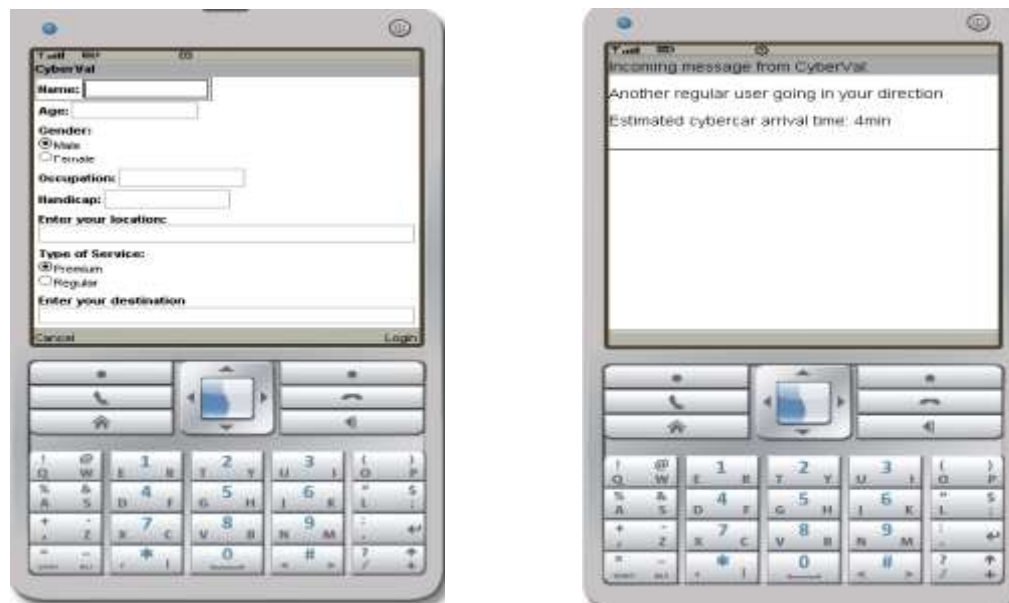


Figure 6 (a) PDA example for requesting a cybercar (b) Alert message indicating to the user that another passenger will be in the cybercar.

6 Conclusion

Cybercars are automated vehicles that intend to improve the quality of life (more flexibility in the transportation, less pollution, less noise, etc.). These cybercars can be integrated with the current public transportation system by using the ACTIF model. The conception of a transportation system composed of cybercars along with the principles of self-organization give the system robustness, flexibility and decentralization (concepts treated in the PPF project which we are a part of). The aspect that interests us the most concerns the interactions between the cybercars and the user, with the aid of a user interface that is context-aware; taking into account the user, the environment and the devices used during these interactions with the vehicles (including if these interactions are between cybercars, or between cybercars and the transportation system). Concerning the passenger, the system intends to integrate different types of users (children, adults, people with sensory handicaps...), that are inside or outside the city. A simplified first prototype was created in UsiXML was developed. In terms of research perspectives, other than the fact of going deeper on the development and testing of the prototype, we wish to integrate other types of human-computer interactions (i.e. vocal, sound) staying sensitive to the context of the user. Links between the cybercars and the other means of transport have to be taken into account also (i.e. information about other means of transport provided by the cybercar).

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