An Augmentative Communication System Based on Adaptive Evolutionary Hypermedia Systems

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Abstract. This paper focuses on improving ACS (Augmentive Communication Systems) by means of an adaptive evolutionary hypermedia. One of the most important features of our approach is the separation of the different aspects involved in the development, use and maintenance of the communication system. Concerning the knowledge representation aspect we use an ontology model that permits specifying the semantic of the represented reality. Regarding the presentation aspect, in order to generate the hypermedia structures we provide a mechanism that allows the creation of different views of the global knowledge model. About the navigation aspect it is important to emphasise its multimodal facet: at the technology level (PC or PDA) and at the interaction level (depending on the access restrictions and the selection units). The user adaptation aspect permits to analyse and to personalise the user navigation using his user profile, his user model and a set of appropriate adaptive methods. In addition, during the whole process we apply an evolutionary mechanism to evolve these aspects in an integral form.

1 Introduction

Augmentive Communication Systems [1] (sign languages, pictorial languages, sign templates and communicators) are part of a technology developed to improve the social integration of people with temporal o permanent communicative difficulties providing useful tools for their rehabilitation.

Each person requires a specific attention and adaptation to fit his profile, which could evolve in time. However these systems don't support mechanisms for their necessary adaptation to each user and situation taking in account his capabilities, skills and progresses at run-time. Therefore, an efficient and suitable approach to design these systems is needed, based on software evolution and adaptability [2,3].

In particular this paper proposes an adaptive evolutionary hypermedia (from a knowledge and an interaction models) that allows to represent control and to adapt the context communication.

2 Features of Adaptive Evolutionary Communication Systems

The elements that this approach manages in order to design adaptive evolutionary communication systems are:

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- **Ontology model**, which represents each conceptual world and describes a specific knowledge domain by means of concepts and relationships between them (a semantic net) [4]. The ontology, in this case, provides the link between the symbols used in the communicator (image, sound or text adapted to each person's knowledge) and the entities of the real world they represent. In addition, ontologies both allow a global vision of each conceptual world based on the concepts employed by the users, and allow to standardize into a single model the knowledge about the people with the communicative difficulties, the knowledge about the people around them (i.e. relatives, tutors, rehabilitators, etc.), and the media used for communication (i.e. templates, agendas, etc.).
- **User model**, which provides knowledge about the people with communication disabilities and consists on the following components:
    - **Knowledge domain** represented by means of ontology. In addition, the educators can define different semantic views of the whole knowledge domain taking into account the user profile. For example, figure 1 shows a partial view of ontology that describes a scenario of shopping.

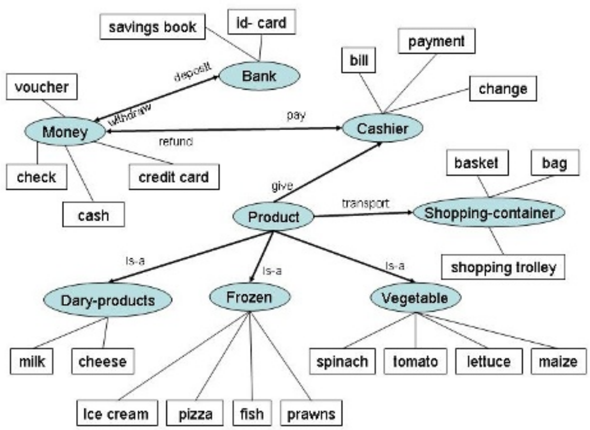

Fig. 1. Shopping scenario

The process followed by the tutor to create a new view consists in hiding in the semantic net the concepts, items and conceptual relations he considers not related to the current view. The system automatically keeps the integrity of the view, for example, if after hiding a relation some concepts get disconnected, they are also automatically hidden. In the same way, when a concept is hidden all the items associated to it and all the relations starting or arriving to the concept are also hidden.

Once the semantic net is built, the system will be able to automatically generate the interaction templates from it. These templates constitute one of the possible media used to establish the communication with the user and are represented in hypermedia format.

- o **User profile** containing the particular characteristics of users (communication habits, training or therapy objectives, and interaction preferences). To construct and select it the user (and relatives or educators) must provide this information. This artefact allows the adaptation and selection of the semantic view that best fits to a particular user.
- o **User interaction** determines how the person must interact with the communicator in order to communicate. We use a format approach to represent the person's interaction. It is cased on direct manipulation style in order to highlight relevant system features and properties [5].

- **Evolution and Adaptation methods.** The evolutionary mechanisms allow the hypermedia model to incorporate the needed changes in an easy, flexible and consistent way. The process of adaptation to the user can be seen as a particular case of evolution where the system changes its behaviour depending on the user utilizing it.

3 Architecture of Adaptive Evolutionary Communication System

The architecture of our adaptive model has two tiers: the system (communicator) and the meta-system [6]. This division allows us to separate on the one hand the interaction, communication and user adaptation and on the other hand its evolution process.

The communicator is used by the user and the meta-system by the educators. The cognitive, interaction, design and adaptation aspects have to be differentiated to avoid the coupling. Thereby, evolution/adaptability can be done more easily and safely because the architecture components are independent.

The system is itself divided in four parts, which allows us to tackle separately the aspects of knowledge representation (memorization system), construction of partial views focused to one o several concrete knowledge subdomains (presentation system), navigation of the built views (navigation system), and personalization of the navigation process (learning system) [2].

3.1 Types of Navigations and Adaptations

The structure offered to navigate is different depending on the used platform. If a personal computer is used the interface has two frames: at the left the semantic net and at the right some information about the element selected in the net (Figure 2). It provides a semantic and contextual mode of navigation.

If it has not been predefined by the educator, the user can choose the navigation mode that he desires. Depending of the chosen mode (free navigation, conceptual navigation, navigation by conceptual relation or navigation by prerequisites), some options in the semantic net are disabled according to the user features and his interests. So, the adaptation is carried out depending on the user, but also on the navigation mode used in that moment.

In the **free navigation**, the conceptual structure is chosen according to the user profile and the user browses the structure without any restriction. While the user visits items, the system gathers information about the navigation strategy. By means of a transition matrix, the system captures the conceptual relationships followed by the person during navigation. The matrix has one row and one column for every concept represented in the knowledge domain. Based on the analysis of the matrix, the system can identify new conceptual relationships that are needed or existing conceptual relations that should be removed in the knowledge domain. Take into account these navigation patterns, the system can suggest changes in the structure and the educator can identify progress or problems in the mental knowledge of the patients (adaptation by feedback).

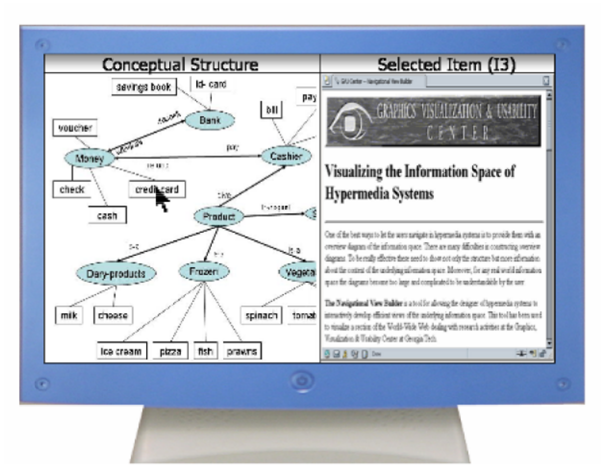

Fig. 2. Shopping with the PC

Conceptual navigation only shows the conceptual structure so, the navigation structure is smaller. When a user visits a concept, the system presents the whole domain information associated to it; a composition of the items order according to a compositional structure specified by the educator.

In the **navigation by conceptual relation** the user must follow the navigational links established among the concepts in the navigation system. Therefore, the user must visit the items in an order that is consistent with the semantic of the relation among them. This type of navigation is suitable for people we need to learn/remember routine tasks (autistic, Alzheimer's disease).

Navigation by prerequisites restricts the items the user can visit depending on some educational or the therapeutic prerequisites. To determinate the accessible items the system checks if the user reaches some achievements. This kind of navigation is the one that permits more adaptation possibilities. For instance, the educator or therapist wants the user works in a particular direction. In this case, the system can personalize the structure and show only those concepts that suit a set of interests or a specify knowledge goal. In addition, the system can provide the optimal route that best matches the preferences of the educator. With this adaptation technique (guides routes) the user loses freedom but in return it increasing the efficiency and quality of the navigational process.

In other case, when a PDA or other embedded system is used, the interface is based in templates. Every template only shows the available options in the current moment, without additional information. Each option is represented by means of an icon which can also have associated text and audio.

Figure 3 shows a possible use of the PDA in a scenario based on figure 1. As it can be seen, in some templates all the options must be selected in a particular sequence, while in others it is enough that the user selects one or several options in any order.

Fig. 3. Shopping with the PDA

3.2 The Evolution Process

The meta-system is in charge of the evolution of the system. It includes the evolution of the complete knowledge domain, of the partial views built from it, and of the navigation and adaptation rules used during the user interaction.

This level of abstraction includes tree evolutionary mechanisms: evolutionary actions, restrictions and change propagation. To perform a change, the educator chooses the appropriate action and run it. The action is only executed if it satisfies a set of restrictions imposed by the model and by the educator. Finally, this change could involve modifications in order to guarantee the consistency of same system and the other systems. For example, when a concept is removed in the knowledge domain, the meta-system removes this concept in all the views that show it. In addition, if after the change, some concept is disconnected in a semantic net, the meta-system performs new modifications in order to guarantee the consistency of the net.

4 Conclusions and Further Work

This work proposes a new way of conceiving Augmentive Communication Systems development based on adaptive evolutionary hypermedia systems. This approach reaches to design adaptive evolutionary communication systems: using an ontological model to define conceptual world, modeling the user's interaction by means of the knowledge model and the user model, and supporting ad hoc communications by an adaptive evolutionary hypermedia system.

This new conception allows: the representation and control of communication with the environment, the generation of different templates and navigation models which are available using a PDA or PC, the selection of the best semantic view take into account the user profile and, finally, the adaptation and evolution of the hypermedia model according to the progress obtained and to the new demands of each user.

Now we are working on creating a tool for educators to allow the design and adaptation of the communicator and to monitor the user behaviour. In next future, we will extend our experience with autistic children (Sc@ut project) to other communities such as people with speech or memory disabilities.

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