Personal Health Assistant, an Intelligent User Interface for Healthcare Services Users

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Abstract
This work introduces the road map of a wide project that is aimed to inform and assist healthcare system users of the local healthcare area ASUR Zona Territoriale 7 of Ancona. The system offers several services which are designed to improve the information capabilities of the actual healthcare portal. An intelligent user interface simplifies the interactions between the citizens and the applications offered by the system. The developed information service offers personalized contents and a management system of electronic clinical folders and healthcare processes.

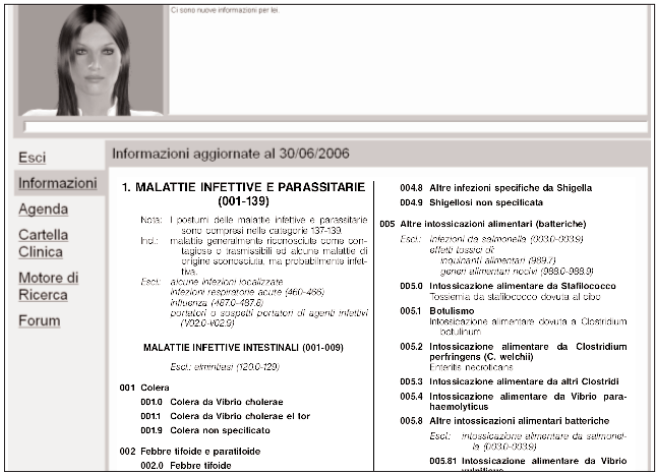
1. Introduction

The introduction of informatic technologies in every human activity is leading informatics to be a discipline oriented to support the communication among users. In the last twenty years has grown the necessity to design the interaction of informatic systems to make them easier to use. The Human Computer Interaction (HCI) is the discipline that studies methoda and techniques for the design and develop of interactive systems which are usable and reliable in order to support and facilitate human activities (Nielsen, 1994). The ever more frequent employment of informatic applications needs a design that considers all the possible contexts of use and objectives of the users. HCI comes up with the increasing necessity of the healthcare system to improve the quality of the information given to the citizens.
Intelligent User Interfaces (IUI) are a subfield of HCI aimed at improving the interaction of humans with computerized machines like television, refrigerator, mobile phones and computer (Maybury, 1998). The main purposes of IUI are the creation of personalized systems which know the user and can use this knowledge to improve their interactions, the reduction of information overload by filtering out irrelevant information, the creation of personalized support systems, the automatic recognition of users' goals and the definition of new ways of interactions like speech and gestures. In this way IUI can adapt themselves to their context of use i.e. the environment and the users, determining their needs and increasing the efficiency of the communication (Ehlert, 2003).
Actually the informative services provided by the healthcare system are not completebly usable by citizens. Even if the contents are fairly complete and updated, they do not adapt themselves to the knowledge and the real need of the citizens that is to their models. Actually the use of the healthcare portal is discouraged by the information overload problem. Every day new sections with new contents are created and users ignore their presence. Informative services should be designed to filter new contents prompting the interested users when they log in.
The Personal Health Assistant (PHA) project designed by ARCHI for the healthcare agency ASUR Zona Territoriale 7 of Ancona (Italy) has been designed to satisfy the needs of citizens who want to establish a direct and personalized contact with the healthcare system. This need is particularly felt by disabled and not completely self-sufficient people who have difficulty in explaining their problems and need continuous assistance.
Actual information and communication technologies allow to create intelligent interfaces which can simplify and improve the dialogue between the healthcare system and its users, providing information services which can help them to prevent and treat their illnesses or disorders.
Our solution has a twofold objective. To improve both the health state and the lifestyle of the citizen and to inform the healthcare user about the new structures and competencies provided by the healthcare system. The development of this new information technology will led to the definition of new services which will complete the general practictioner (GP) activity. Healthcare users will be able to get detailed and exhaustive information through the interaction with an adaptive virtual assistant. In case of need the personal assistant will also contact specialists providing them with the updated clinical folders of the user or a personalized perspective of their content.

2. The User Interface

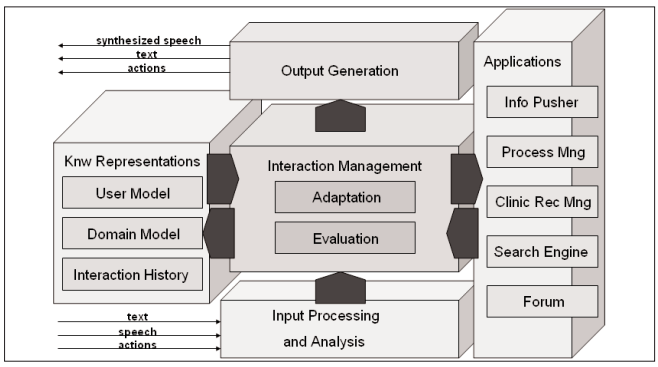
The user interface (UI) displayed in figure 1 is structured into two main panels. In the upper one a chatterbot is loaded. The lower panel is structured like a classic UI with tabs and buttons. The user and the bot can use both the speech and the written text to communicate. The recognized user's requests are mapped within a system of production rules. These rules can fire answers and/or actions performed by the bot. For example the bot can visualize directly the information requested by the user in the lower panel and guide him in the procedure to follow in order to achieve a certain objective. The applications offered by the system are an information pushing service, a process management service, an electronic clinical folder management system, an adaptive search engine and a service for the automatic annotation of forum messages.

Figure 1. User interface.



The personal assistant has to comprehend also imprecise, ambiguous and/or partial multimodal input. In order to achieve this objective we have choosen to consider also passive input modes like the history of the interactions of the user with the interface and we have adopted an architecture similar to the one suggested by Maybury and Wahlster (1998). As represented in figure 2, inputs coming from all the different channels (text, speech, actions) are recognized and fused.

Figure 2. IUI architecture.



This fusion occurs at a semantic level, that is after that each input has been interpreted separately. The IUI makes use of user models, of a domain model and keeps track of users interaction history. The system processes all the inputs and adapts the output generation to the profile of the users (Bui, 2006).

Text and speech are processed directly by a predefined set of production rules. We have choosen a simple finite state model to develop the dialogue management system. In these kind of solutions the dialogue control is system-driven and all the answers given by the IUI are predetermined.

The actions performed by the users (that is the started applications) togheter with their anamnesys data and the interaction history are used to infer the objective of the user by a probabilistic model. These states are mapped in the same system of production rules used by the system to choice the answers and the actions to perform.

The probabilistic model is a bayesian network, which is updated in batch mode with data extracted from previous interactions with the users. We use the WEKA workbench (Witten and Frank, 1995) that is a collection of machine learning algorithms and data preprocessing tools. It provides extensive support for the whole process of experimental data mining, including preparing input data, evaluating learning schemes statistically and visualizing input data and learnign results. Obviously the predictive capabilities of the IUI improve in time, the parameters and the structure of the bayesian network have to be modelled considering a sample of several cases. So at the beginning the actions and the answers of the IUI will be conditioned only by the active input modes.

The production rules generate text, speech and actions. The Mycrosoft Agent compatible platform that we use for the chatterbot () allows to convert directly the produced text in spoken utterances and facial expressions. The output of the rules can also launch C# scripts for the memorization of the state of the user. This state can be recovered by a javascript code to define or modify the contents of the lower panel.

3. Informative contents and usability evaluation

The requirements of the system have been explicitated through a series of interviews involving the medical and paramedical personnel which belongs to ASUR Zona Territoriale 7. In these interviews we have tried to understand the real needs of citizens and patients, paying particular attention to communication and information problems and trying to find possible solutions.

The analysis of the answers have lead to the definition of strategies which could allow to intensify and improve the interaction of the citizens with the healthcare system, without augmenting the

practictioners commitments. In fact we have tried to introduce services which could be able to support the practictioners' activities, simplifying the communication processes with their patients. The designed lower panel comprehends five main sections.
The Information section contains the information selected by the GP and/or the practictioners who (have been contacted by) take care of the user togheter with generic information about his local healthcare area. The information section of the interface also automatically organizes the information provided by heathcare information channels. The information filtering and organization is made according to a model of the user. This model is structured as an associative network of words which is kept updated with the content of the resources considered interesting by the user. The processing modalities of the analysis have been presented in other conferences and I invite the interested ones to read the articles we have published on the topic.
The Agenda section displays all the tasks and procedures that the users have to follow in order to udergo a medical examination or to obtain a certificate. The system memorize the current states of the started processes. In this way the system can prompt the users reminding them of all the tasks that have to be still accomplished. For example an old person could need assistance. The system could inform him that the G.P. authorization is needed, the CUP (the healthcare reservation center) must be contacted and it is necessary to make an appointment with a practictioner for an home visit. Some of these tasks can be automatically executed by the system, but other ones, like the last one in the example, should be executed only by the user. The system could remind the user to contact a certain practictioner until a day hasn't been fixed.
These healthcare processes are healthcare workflow chains which involve healthcare system users and practictioners, and the workflow management system has to organize the activities of the different actors.
The Clinical Folder section contains a perspective of the clinical records of the patient that is kept updated by the GP or authorized front office practictioners. Adaptive perspectives are provided. Irregular values can be highlighted. The system can provide information and make some questions to completely understand the state of health of the user. A printable version of the records can be generated by the system.
The Forum section presents all the available forums where users can post their requests and obtain responses. This service has been presented in other conferences and it allows to find immediately all the messages pertaining to the posted request, without waiting for the direct answers of the phisicians. The domain knowledge of the active forums are modelled by the use of an associative network of words.
The SearchEngine section allows to search files in the web according to users requests and models. This web application has been presented in in other conferences and it is designed to promote the generation of discussion groups made of users with similar profiles. After each search users can select all the results which interest them. Their profile is updated with the content of the selected resources and compared with the profiles of practictioners. In this way the system can return a list of specialist which can be contacted.
From the front office side of the interface practictioners and specialists can attend to the forums answering to not satisfied requests. They can make personalized searches, look for new patients in the Agenda section and select the list of resources which can be consulted by the patients. The domain knowledge, the selected resources and the patients' data are represented through a semantic network. In this way the practictioner can retrieve knowledge about past treated cases in an efficient and effective way. For example the practictioners could select all the resources pertaining to the possible diseases catchable in caribean countries. The system could retrieve all the resources about tetanus-diphteria, hepatitis A+B, typhoid fever, polyomelitis and dengue which have been assigned to past treated cases.
The usability of the system will be evaluated through methods and measures studied in HCI (Benyon, 1993). There are several definitions of usability. The most accepted is the ISO 9241 standard where usability is defined ad the measure by which a product can be used by specific users to achieve specific objectives with effectiveness, efficiency and satisfaction within a specific context of use. The effectiveness is the accuracy and completeness of the reached goals; the efficiency is the set of emploied resources compared with the the accuracy and completeness of the achieved objectives; satisfaction is the comfort and acceptability of the system for the users and other actors influenced by its use. In public informative services like the one presented above, usability is important to reduce errors and to improve the security in the interaction with applications and informative services. Furthermore the need of support is reduced, leading the users to accept more willingly the utilization of the system.
According to the definition provided by the ISO 9241-11 standard (Ergonomic requirements for office work with visual display terminals - Guidance on usability), the usability of the IUI will be evaluated with respect to its three main facets. The effectiveness and the efficiency will be eva-

luated automatically by the system through the computation of quantitative measures as the number of objectives accomplished by the users in a session, the completion time of the relative tasks, the ratio between the correct interactions and the errors, the number of users who chose the best way to reach their objectives and the other ones. This remote usability evaluation will be enabled by the creation of suitable log files with all the session data. The satisfaction of the users will also be evaluated by a short questionnaire designed to evaluate the comfort, the acceptability and most of all the accessibility of the interface. This feedback-based usability evaluation is the best way to know the effective reaction of the users. In order to be accessible the system should be used also by disabled people without the need of training or experts support. The W3C Consortium has defined guidelines for the accessibility but not for the usability. Accessibility is just a precondition for usability, but it is not sufficient to grant it. For example even if a system is accessible for disabled people, this could be not still sufficiently usable for them. So it is important to integrate these different aspects to obtain informative systems for all the possible users.

Conclusions

Healthcare system customers need innovative solutions to find immediately the information and the support they need. The PHA system satisfies customers demands providing adaptive information services. To simplify the interaction with the IUI it is possible to communicate with the system in a multimodal way.
This is an on-going project that will undergo some modifications. Transactional services will be added to the system. It will be possible to make an appointment with practictioners or to perform the payment of the tickets. It will be also possible to access to PHA by UMTS cellular telephones, PDAs and other portable devices.
Finally models of motivations and emotions will be integrated into the PHA agent to make the interaction with the users more natural (Chen, Bechkoum and Clapworthy, 2001).

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