Personal Assistants for Healthcare Treatment at Home

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ABSTRACT

This paper describes the research plans in the SuperAssist project, introducing personal assistants in the care of diabetes patients, assisting the patients themselves, the medical specialists looking after the patients' healthcare, and the technical specialists responsible for maintaining the health of the devices involved. The paper discusses the issues of trust and cooperation as the critical success factors within this multi-user multi-agent (MUMA) project and within the future of agent-based healthcare attempting to increase the self-help abilities of individual patients.

Keywords

Human-computer interaction, personalization, agent technology, supervision, health care, personal assistants, cooperative problem-solving.

THE SuperAssist PROJECT

TNO Human Factors (TNO), Delft University of Technology - Man-Machine Interaction group (TUDelft) and Leiden University Medical Centre - Medical Informatics (LUMC) are developing guidelines, models and methods for joint user-"electronic assistant" supervision of critical equipment and information.

The aim is to establish effective and efficient distributed supervision of networked information compilations and technical equipment, which is trustworthy for the user and takes place in a socially approved manner. Specific innovative project results are: communication and interaction model for these assistants; methods for joint human-computer supervision; improved test methods, tools and criteria for systematic assessment of user experience; "best practice" implementation-method and guidelines; and a "proof of concept" in the transmural health care domain (e.g. diabetes).

For the medical application domain, the SuperAssist framework aims to reduce the costs by improving the local, self-care capacity of people by efficient employment of remote, distributed expertise. Figure 1 provides a possible setting for the SuperAssist framework in which both, a patient, the medical specialists who treat the patient, and a technical specialist who looks after the proper functioning of the medical equipment involved are all provided with personal assistants to facilitate their own tasks as well as to support cooperative tasks which might occur, for instance, with the introduction of new drugs and therapies or with the inevitable malfunctioning or erroneous use of the medical equipment.

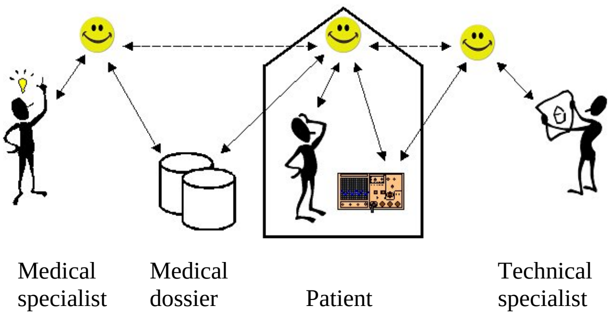

Figure 1. Situation with users and personal assistants

The project's business partners - Science & Technology, Philips Research, Pemstar and Sigmax PDA Solutions - bring in their technology and contribute to the development and validation of SuperAssist elements. The joint activities are included in cognitive engineering cycles, in which the foundation, specification and demos of the SuperAssist concept are being refined and extended. The SuperAssist research takes place in the medical domain, but it aims at a generic solution for the distributed supervision of complex environments.

DIABETES TYPE II

Diabetes type II or "old-age diabetes", occurs when the body doesn't use the available insulin effectively. Because of the low insulin level, the blood glucose level may build up, causing a sick feeling. Type II diabetes is generally caused by a life-long combination of a bad diet, lack of exercise and overweight. The treatment of diabetes II is focused on keeping a healthy blood-glucose level, which should neither be too high not too low. If the glucose level drops too low, there is the possibility of passing out, coma and eventually death. A minority of diabetes II patients has to inject themselves with insulin (about 15%) but for most patients the treatment consists of a diet, in combination with medicines to boost the production and the effectiveness of insulin.

Diabetes II is not deadly by itself but its symptoms, in the form of a deterioration of small blood vessels may lead to blindness, numbness, inflammations, etc. which may eventually cause death. In principle, diabetes II is not difficult to treat. However, because of the life-long bad eating habits and the much increased feeling of wellbeing by medication, it is often difficult to get sufficient cooperation from the patients well before the point when the bodily condition really deteriorates.

Since most diabetes II patients are elderly - though starting from their forties - feeling secure about the illness and the care they receive tends to be more important then in other diseases. As such, patients should not just be told how to live, what to eat, and which medicines to take how often, but they should also receive specific reassurance about the fact that one may grow old with diabetes.

A USER SCENARIO

Ms. Brown is a vital 72 year old who, after loosing her husband several years ago, refound her balance and takes a keen interest in bicycling and reading. Two years ago she was diagnosed with type II diabetes for which a diet and medication were prescribed. Although she is sincere in following up the medical directions, sometimes her memory fails her and she simply forgets things like when she has last taken her pills or that she should only buy low glucose products. Like many of her friends she is enjoying life but every now and then coping with the restrictions of old-age takes the form of a struggle. Although she accepts having an incurable disease, she is definitely not going to live her life like a sick person.

Since Ms. Brown is well overweight, she has been asked to participate in a therapeutic program whose purpose is to attempt to let participants lose some of that weight in a responsible yet playful manner. As a result, every day before breakfast and before bedtime Ms. Brown consults her personal diabetes assistant, provided to her as part of the program, to check her blood glucose levels and to help her remind whether she has taken her pills or not. She can also fill in a questionnaire regarding food intake, exercise, and stress in order to help her manage her food intake in relation to her activities. Since ms. Brown does not to be her illness she has kindly refused to carry the assistant all day as a portable dietary advisor. Because the diabetes assistant is not used as a portable and to address her deteriorating eyesight, the assistant is equipped with an extra-large extra-bright screen, a few large and clearly labelled buttons. In addition, the form and content of the dialogue have been adapted for Ms. Brown according to her preferences and to the way she uses the diabetes assistant.

On three consecutive days, Ms. Brown's blood glucose level has been slightly higher than normal and today it is rather high. An abnormal reading is not necessarily a cause for alarm. One possibility is that there is nothing wrong with Ms. Brown but rather that the technique let her down. The reading of the blood glucose level is derived from the light passing through the finger that ms. Brown offered for testing, which is much more comfortable but also less reliable then blood sampling. Ms. Brown may call the district-nurse to do blood tests but she prefers not to, because he is busy enough with the "really sick people". Finally, the measurement might be genuine. It may be that ms. Brown has forgotten to take her night time pills. However, the display of the assistant clearly shows that she has confirmed taking her pills until this morning and besides, the compartments of her pill-box are empty. It may be - again- that she has accidentally taken a regular instead of a low sugar desert.

A little alarmed, Ms. Brown at first doesn't know what to do but then she sees the help-button on the diabetes assistant and remembers from the instruction session that "if you would like to ask a question, first try the help-button". This she does and a friendly voice assures her that there is only a little worry but not an acute problem. Furthermore, the assistant suggests her to redo the measurement, this time using the little finger of her other hand. Using her other little finger, ms. Brown now learns that her blood glucose level is only slightly higher than normal and her assistant asks her to take her pills, including an extra TZD "you know, the big blue one" just to be on the safe side.

HIDDEN SCENARIO ASPECTS

By this time, also behind the scenes some activity has taken place. Because of the measurement error, a maintenance module inside the assistant increased the problem count of the measurement module, reset it and performed a self evaluation test in order to exclude a range of technical problems. Also a temporary wireless network is set-up for a number of routine and problem reports. When the assistants' problem count exceeds a certain level of serious measurement or transmission problems, a technical expert is informed for further maintenance or for a replacement of the device.

In addition, with serious problems the district nurse will be informed of the existence of a possibly faulty device, so that he can check out to take over or provide a replacement diabetes assistant. Because in this case, the measurements remained within the safety boundaries, there was no need to alarm the specialist diabetes team, although, as a matter of routine, both blood glucose readings and the measurement problem are fed into ms. Browns medical dossier.

Finally, because there has been a change in Ms. Brown's otherwise rock stable blood glucose level which deviated from normal over a number of days, a reminder is send to the district nurse. The personal patient-visiting assistant agent will remind the nurse the next time he goes on a periodical visit to Ms. Brown. Even though the diabetes assistant is "allowed" within certain boundaries to change a patient's medication, only medical specialists (or in their place the district nurses) are allowed to make any enduring or substantial changes.

CRITICAL FACTORS IN TELEMEDICINE

Even though the project targets at a novel type of application in a new area of multi-user multi-agent (MUMA) interaction, it does not start from scratch. Apart from being concerned with software agents (aka personal assistants) which assist human beings in the area of ubiquitous computing (Maes, 1998; Weiser, 1991), SuperAssist attempts to build further upon the PALS project, a Dutch project investigating the requirements to meet changing user needs and usage contexts with respect to web-services (see:. PALS, Herder, 2003; Neerincx and Streefkerk, 2003). From this and other projects, two factors turned out to be of critical importance for the success of human-agent interaction: trust and cooperation. Trust in the sense that people need a basic level of trust in a system or personal assistant to "do business" with them, and cooperation in the sense that, like in human-human cooperation, participants rely on images, models or ideas about the communication and cooperation abilities of their discussion partners in order to set appropriate expectations.

Trust

The trust of a patient, a medical specialist or a nurse in their personal assistant is a prerequisite to delegate part of their responsibilities to the electronic device. To enable trust and delegation between people and electronic assistants, it is a first necessity that the form and content of the interaction dialogue are acceptable to the human user, including a possibly frightened patient or an excessively busy medical worker. Here, it may be possible to adapt the dialogue to the current context of use including aspects like fear and stress (Herder, 2003). Apart from a humanly usable dialogue for solving problems, it is necessary that there is a shared view on the problem domain. This may be achieved by creating a representation of the problem space in which rules exist or may be derived to guide the behaviour of the assistants. Note that, even in a well-delimited problem domain as diabetes, this is a major undertaking due to influences from outside the system, such as the nurses' other responsibilities or the complex (side) effects between things like medication, stress and diet.

Cooperation

Cooperation for problem solving between people and their assistants and the cooperation between assistants among themselves requires some kind of model which at least describes 'what to expect from whom' in terms of questions, actions, etc. In (software) multi-agent architectures like e.g. FIPA (see: FIPA) the question 'what to expect from whom' is specified in agent-communication models, either by way of static models, specified beforehand, or in on-request models, used in dynamically changing environments. FIPA is a proposal mainly aimed at enabling communication between software agents but for heterogeneous networks with human agents, it is similarly required that some model exists to specify what other participants may contribute and how to ask them; either directly or by means of some user-agent. In the scenario this is exemplified by Ms. Brown's diabetes assistant asking her (on behalf of some supervision agent) to redo the measurement of her blood glucose. Also here, personalisation and adaptation come into play, for instance in deciding whether is appropriate to ask the patient to do something or to alarm the nurse. In addition to this it is probably even more important to utilise inter-agent communication to prevent the human participants from becoming overloaded with questions from their software counterparts.

RESEARCH PERSPECTIVES

The overall perspective of the project is to focus on a combination of relevant research areas: ubiquitous computing and ambient intelligence, personalisation and adaptation, cooperative problem solving (involving multiple users and agents), and finally, the combination of medicine and informatics. In this area, most research has taken place on how to support the medical staff in the treatment of patients. Relatively new in this area is the shift towards programmes for patient self-healthcare, using the internet, for instance (cf. Alpay et al., 2004), and the increased use of information appliances for both, patient-specialist cooperation as well as patient self-healthcare. In the Oxford-Diabetes project at the University of Oxford (Tarassenko et al., 2004) for example, diabetes patients do not merely monitor their blood glucose level to treat themselves, but also phone-in the measurement results to a diabetes treatment centre, where it is stored in a database and used for expert advice. From these and related investigations, a general "lesson learned" is that patients are generally able and willing to take participate in such mutual medical specialist-patient cooperation project, but only if the personal benefits to the patient are clear; that is: when advice and treatment are personalised to the patients' context and circumstances.

Inspired by such research efforts, a main research idea in the SuperAssist project is to use a PDA-like device to present diabetes patients with an existing paper "diabetes manual" (Stewart, 2004), to be translated in Dutch) in a personalised, adaptable and context-sensitive way to help them cope with their disease and with the often associated overweight. In this context, it is interesting to note that since diabetes patients are somewhat notorious in not being able to change to a healthier lifestyle and diet. As such, the treatment of diabetes in the SuperAssist project should be regarded as a very conservative test which, if it succeeds, should also provide a rather robust solution for other self-healthcare treatments.

Cognitive Engineering and Scenario-based Design

Research and design in the SuperAssist project will make use of cognitive engineering cycles, an engineering approach to HCI design with a focus on the human abilities and limitations as the most critical of all design aspects (Lindenberg et al., 2003). In relation to other HCI design approaches this means that design is user-centred, involves user participation and takes the need for design iterations for granted. This is not all too different from the common HCI approach to design, except perhaps that an engineering stance is taken in that both, a particular problem has to be solved and that the solution should be systematically applicable to a whole class of similar problems. In contrast to, for example, Dourish (2004) who argues that it makes little sense to try to specify beforehand what is relevant in the context of a particular ubiquitous computing applications because context is an emergent property of human-computer systems, a cognitive engineering approach would argue that Dourish may very well be right, in principle but that, in practice, it is may very well be possible to find a solution that satisfies all stakeholders.

The research plan is organized around three main experiments or rather three series of experiments to investigate the main research questions in the project: task allocation among agents and men, the organization of joint anomaly management or problem solving, and finally, the "look & feel" of the assistants, respectively. In addition, a number of flanking experiments and scenario exercises is planned, intended to delimit the design space for the main experiments by excluding in an early stage the less- or irrelevant factors and to find solutions for design details for which a full-size experimental setup is overkill.

Apart from empirical validation of models and theories, the three experiments also serve to validate and improve the design of the prototypes which are designed to run these experiments. The prototypes are used as vehicles to develop both the required knowledge about human-agent cooperation as well as drive the actual design of the specific solution to the problem at hand. As such, in the course of the project, the design of the prototypes being tested changes and becomes more refined and detailed. Whereas the initial experiments will take place using mock-ups, at the end of the project the aim is to present and test a demonstrator in the form of a hafiz prototype. It should be noted, however, that the primary aim of SuperAssist is to acquire and validate knowledge to design MUMA applications.

ENVISIONED RESULTS AND OUTLOOK

The SuperAssist project attempts to set up an integrated healthcare service in the area of diabetes treatment, assisted by electronic devices and software agents. From this research we expect to be able to derive models, architectures, guidelines and general design knowledge to introduce human-agent systems that enable people to help themselves to a greater extend than they are able to do, now. As such, the SuperAssist case is intended as a test case for a range or healthcare and other services and not just as yet another smart solution for a particular problem. Only by introducing, testing and validating general tools, we will be able to help keep future healthcare costs within the boundaries of affordability and manageability - at the very least for individual patients like Ms. Brown.

Furthermore, SuperAssist employs diabetes as a first vehicle to learn general lessons about how to introduce trustworthy and cooperative electronic or software assistants into the everyday life of real people. Until recently, human-agent interaction has been studied in settings where a single agent assisted a single user, as in supporting searching, information filtering, and critiquing systems.

Finlly, in the SuperAssist project, research and development are extended to MUMA or multi-user multi-agent communication and cooperative problem solving. This novel research area does not only introduce new types of questions and new types of problems but it is also a starting point for the integration of separate intelligent applications into intelligent overall services.

ACKNOWLEDGEMENT

The work reported in this paper was performed while the first author was a member of the MMI group, Faculty EWI, Delft University of Technology. I (GdH) wish to thank my former colleagues and project members for their support and contribution.

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