MOBILE MENTORING FOR DIABETES

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ABSTRACT
Mobile devices offer considerable potential for educational applications, allowing users to learn when and where they want to. Recent health strategy has promoted the concept of the Expert Patient who has developed a high level of knowledge and expertise to enable them to manage their own condition. This requires focused instruction and health professional intervention. In this paper we discuss the development of an Intelligent Tutoring System that mentors diabetics, giving them the ability to develop the necessary expertise, and early evaluation offers encouragement that this approach is successful.

INTRODUCTION
The prediction is that application development for mobile devices will explode (Computer Business Review, 2001), with high growth in social, recreational and educational applications (McManus, 2002). The mobile market offers considerable potential for educational applications (Savill-Smith & Kent, 2003) with an emergent trend in mobile learning for supporting health and leisure activities.

There is growing governmental awareness of the need for patients with chronic or long term health conditions to become Expert Patients (Dept. of Health, 2001) skilled at managing their own condition rather than relying on the intervention of healthcare professionals. Current Expert Patient education entails structured clinic-based learning with regular follow-ups (Dept. of Health, 2003).

A number of alternative approaches to educating patients to manage long-term illness have been implemented, including patient education materials (Blears, 2003; Toobert, Hampson, & Glasgow, 2000) and on-line solutions (McKay, Glasgow, Boles et al, 2002). A potential approach is mentoring (Frijling et al., 2002) where patients are matched with mentors with more experience and expertise in the management of their condition. Ideally a patient should be able to consult with their mentor wherever and whenever needed, but providing such a mentor to each patient would be prohibitively expensive.

In this paper we discuss a mobile mentoring approach, where an Intelligent Tutoring System (ITS) provides a permanently accessible mentor to educate patients with Type 1 diabetes. In the following sections we consider Expert Patients (the intended users of the system), the problems of diabetes, Intelligent Tutoring Systems, and the development of the Diabetes Mentor system.
EXPERT DIABETES PATIENTS

The predominant pattern of disease in most developed countries has shifted from one of acute illness to one of chronic or long term illness. Diabetes is almost a paradigm case among chronic diseases as it can have profound effects on lifestyle as well as health. Around 1.3 million people in England are diagnosed with the disease, of whom 15% have Type 1 diabetes.

Research and practical experience has shown that long term health benefits can be achieved if diabetics are empowered to take responsibility for the management of their condition in partnership with their health and social care providers. By becoming Expert Patients (Dept. of Health, 2001), diabetics develop problem solving, decision making and resource utilization skills that allow them to effectively manage their blood glucose levels. It has been shown that tight control of blood glucose, either by insulin replacement therapy or by diet and exercise, can prevent or delay the onset of complications and increase life expectancy. However, such close control of blood glucose levels requires considerable effort and dedication by both the patient and the healthcare professionals.

Education is considered to be a fundamental part of diabetes care (NHS, 2000), with programmes such as DAFNE (Dose Adjustment for Normal Eating) providing structured education for Type 1 diabetics in the form of five days of intensive training delivered to small groups of patients, and teaches individuals to adjust their insulin dose to match carbohydrate intake and lifestyle on a meal by meal basis.

However, there is evidence that patients who enrol on closely controlled programmes of diabetes management often fail to maintain good control after completion of the programme, suggesting continued reliance on health care professionals. A particular problem occurs with children and young people, who find it particularly difficult to control their disease – young people have significantly increased rates of diabetic emergencies, and their death rates are higher than young people without diabetes.

INTELLIGENT TUTORING SYSTEMS

The development of Intelligent Tutoring Systems has been a focus of applied Artificial Intelligence in education since the early 1970’s (Wenger, 1987) ITSs attempt to undertake the same responsibilities as a human tutor in face-to-face education, for example explaining core knowledge and how it can be applied to solve individual problems, providing examples, giving hints and corrections, analysing student solutions and explaining errors (Cheunga, Hui, Zhang et al, 2003). The behaviour of an ITS is determined by rules that allow the system to determine the selection and ordering of materials that should be presented to the student and allow the generation of appropriate advice and explanations.

ITSs have been developed for a variety of applications, for example learning languages (Cumming, Sussex, & Cropp, 1993), programming languages (Songa, Hahna, Tak et al, 1997), chess (Lazzeri & Heller, 1996), mathematics (Nwana, 1993) and medical training (Mansoura,
Although a number of ITSs exist to aid and train medics, there are relatively few ITSs aimed at patients. A notable exception is Carmen’s Bright Ideas which aims to help parents of children with cancer explore their problems and potential solutions (Marsella, Johnson, & LaBore, 2003). It seems likely that ITSs have potential to train and guide Expert Patients, however, there is currently little research published on this application domain.

An ITS to educate Expert Patients will be of most use if it is constantly available, such as on a mobile device. However, the technologies for implementing ITSs have not yet been adapted for delivery via such devices, largely due to the constraints of processing power and memory size, both of which are typically required for their successful deployment. Mimosa Wireless Ltd. has developed a set of technologies which allow intelligent systems to be deployed on a range of mobile devices, and the following section discusses how an ITS for diabetes self management has been created for deployment on the mobile platform.

**DIABETES MENTOR**

Mimosa Wireless Ltd. is in the process of developing the Diabetes Mentor, an ITS to be run on a mobile device that will help patients with Type 1 diabetes mellitus to manage their condition. The system will complement the education that is currently provided by programmes such as DAFNE, described above. Diabetes Mentor provides the knowledge and skills of such experts as healthcare professionals and experienced diabetes patients. This knowledge will then be made accessible on a mobile device to diabetics who are less able to manage their disease, such as children and young adults, and providing such support via a mobile phone may provide an additional motivational factor for such patients.

Diabetes Mentor monitors and documents adherence to a personalized regimen for maintaining near-normal blood glucose levels in Type 1 diabetics. It helps to educate users to understand and react to their condition by providing tailored information and supporting a range of tasks including a schedule of blood glucose measurements, an exercise plan, meal plans and/or nutritional recommendations, and a schedule of preventative care.

Diabetes Mentor assists the user to determine appropriate basal doses of slow acting insulin, and premeal doses of fast acting insulin in response to activity and nutrition related fluctuations in blood glucose levels. It provides instruction and help to the user using lay terms for all of its recommendations. In order to operate successfully the system will have a model of the dynamics of blood glucose levels relative to nutrition (including dietary aberrations), exercise, medication, stress and acute illness, in relation to the individual patient. It will also take into consideration special circumstances such as travel, driving and operating machinery. The system will also monitor and document complications of diabetes, such as hypoglycaemia, infection (e.g. skin, feet), vascular disease and neuropathy, by periodically interrogating the user.
The DIABETES MENTOR PROTOTYPE

A small Diabetes Mentor prototype has been constructed to illustrate how the ITS might be used to enable a patient to learn how to determine appropriate slow and fast acting insulin doses. The screenshots shown below are taken from a mobile phone device emulator running on a PC, but the system has also been implemented on a number of actual devices. In the scenario below, the patient is a teenage boy whose insulin regimen involves two combined doses of fast and slow acting insulin per day, usually taken at 7am and 6pm. In the screenshots shown, Diabetes Mentor is educating the boy about his morning insulin doses. He has been recording elevated blood glucose levels in the afternoon for several days and Diabetes Mentor seeks to mentor the user in possible reactions to this problem.

Figure 1: Entering Data
Figure 2: Slow Dose Explanation
Figure 3: Fast Dose Explanation

In the above figures, the patient must choose a type of insulin dose to be determined. In the example shown here, it is assumed that “morning slow/fast acting” has been chosen, i.e. the boy is about to take his 7 a.m. combined fast/slow acting insulin dose. Diabetes Mentor then poses the user a set of questions that can be used as a basis for determining the correct dosage. These include the user’s current blood glucose measurement (Figure 1), carbohydrate count of a meal, any exercise planned, special circumstances and so on. For each topic the user can select a help button which provides more information about the task. For example in the exercise section, information is provided about the importance of specifying exercise plans in determining insulin dosage, and helps the user to understand the impact of exercise through discussing factors such as exercise type, duration and strenuousness. The Diabetes Mentor mentors the user on how to perform the task and explains why the
task is relevant. In Figures 2 and 3, the Diabetes Mentor is explaining its recommended insulin dose decisions.

**DISCUSSION**

Developments in wireless communications technologies and the move to hand-held mobile devices is forcing a re-evaluation of existing technology infrastructures within healthcare (Moore, 2001) In this paper we have discussed the potential of ITSs to be deployed on mobile devices to support Expert Patient training. Early evaluation suggests that an intelligent mentoring approach can help diabetics to gain the expertise needed to manage their own condition. Being able to seek expert advice on balancing blood sugar, or confirming personal opinions on the timing and quantity of insulin intake allows the diabetic to live a near-normal lifestyle without endangering their long-term health.

The prototype of Diabetes Mentor illustrated above, which models a small but significant part of the system that we are proposing, uses the software technologies developed by Mimosa Wireless Ltd and has been demonstrated on real hardware devices. However, it contains a minimal knowledge of managing diabetes. Currently, Mimosa is in the process of gaining input from expert healthcare professionals and diabetic Expert Patients and extending the knowledge of Diabetes Mentor. A small scale trial is planned for later this year.

**References**


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