eDiab: A System for Monitoring, Assisting and Educating People with Diabetes

L. Fernández-Luque[1], J.L. Sevillano[1,*], F.J. Hurtado-Núñez[2], F.J. Moriana-García[3], F. Díaz del Río[1], and D. Cascado[1]

[1] Robotics & Computer Technology for Rehabilitation Laboratory.- University of Sevilla, Spain
[2] Clinical Psychologist - Specialist in Diabetic Education. Spanish Society of Diabetes (SED) - Diabetes Education Study Group
[3] MSc Computer Science - eHealth Consultant
[*] Corresponding author: ETS Ingeniería Informática. University of Sevilla, Spain. Avda. Reina Mercedes s/n. 41012, Sevilla
jlsevillano@us.es

Abstract. In this paper, a system developed for monitoring, assisting and educating people with diabetes, named eDiab, is described. A central node (PDA or mobile phone) is used at the patient's side for the transmission of medical information, health advices, alarms, reminders, etc. The software is adapted to blind users by using a screen reader called Mobile Speak Pocket/Phone. The glucose sensor is connected to the central node through wireless links (Zigbee/Bluetooth) and the communication between the central node and the server is established with a GPRS/GSM connection. Finally, a subsystem for health education (which sends medical information and advice like treatment reminder), still under development, is briefly described.

1 Introduction

The Diabetes Mellitus is one of the most common chronic diseases worldwide, characterised by a state of chronic hyperglycaemia (raised blood sugar). Diabetes Mellitus affects almost 6% of the population in Europe [1,2]. It is also one of the main causes of mortality in the world [3] and responsible for serious health complications [4,5,6,7] such as cardiac and renal diseases, depressions, blindness, etc. The Diabetes has a very deep impact in patient's life: glucose controls, insulin, dietetic restrictions, fears, etc. The management of the disease needs a lot of discipline and self-care by the patient, because only healthy habits could break down its progression and reduce the risk of these complications [8]. A good diabetic control is affected by lifestyle factors (diet, exercise, etc.) and self-care (treatment compliance, self-monitoring, etc.). The key component in empowering patients to manage their own diabetes is education.

The objective of a diabetes education program is to provide people with diabetes the knowledge, skills and tools to manage their disease and avoid the complications associated with the diabetes. Nowadays, educational programs include personal meetings and lessons provided by diabetes educators (nurses, dieticians, doctors, psychologists, etc.).

Over the last years there has been an explosion of web pages with information for diabetic people. However, the inclusion of new technologies in educational programs is very low; a systematic review [9] of diabetes education has found that only 6% of the time in educational programs is spent in Computer-assisted instruction. Systematic reviews of computer-assisted education programs [10,11,12,13] have found evidences that emerging IT may improve diabetes care.

The use of new information and communication technologies in diabetes care has been focused on telemedicine projects. There are many telemedicine projects for diabetic people [14,15,16,17,18,19]. The aims of most of these projects were telemonitoring the patient's glucose [15,16,17,18] and tele-ophthalmology for the prevention of diabetic retinopathy, one of the main causes of blindness [19]. The first goal of this monitoring is the adjustment of the insulin treatment. One example of these projects is the M2DM project [16], in which a system has been developed for telemonitoring, alarms, decision support, electronic clinical record, SMS reminders, etc. Another interesting project is IDEATEL [15], focused on telemonitoring and education. In this project a complete system has been developed to control the patients. The system of IDEATEL includes: glucometers, blood pressure sensors, video conference, emails, educational resources via web, etc. The use of new technologies to improve the methods for delivering diabetes education is encouraged by the International Federation of Diabetes.

In our analysis of the state-of-art in telemedicine for diabetes, no works have been found that include blind people as users. This is a very important problem, since the diabetes Mellitus is the second cause of blindness in elderly people and the first one in young and adult people [5]. However, despite the high number of assistive products developed for the visually impaired [20,21], we have not found any work merging telemonitoring diabetes and assistance to visually impaired people. Unfortunately, this is a usual lack in telemedicine, although we think that there are no reasons to separate Assistive Technologies from Telemedicine. Furthermore, in telemedicine projects for diabetic people new technologies like mobile phones and PDAs are only used for the transmission of glucose measures or retina images and communication between doctors and patients. As far as we are concerned, these systems could also be used for the education of people suffering from diabetes. For instance, SMS and MMS could be used to improve the healthy habits of the patients by sending them personalized educational information.

In this paper, we propose a system that merges monitoring and educating people with diabetes, as well as assisting those users that are also visually impaired, probably due to diabetes complications.

2 Description

In the project eDiab an Information System for the Management of Diabetic People is being developed. This project has been designed with a multidisciplinary view: assistive technologies, telemedicine and diabetic education. The project has been divided into two subsystems: Subsystem for Monitoring and Controlling of Diabetes and Subsystem for Health Education.

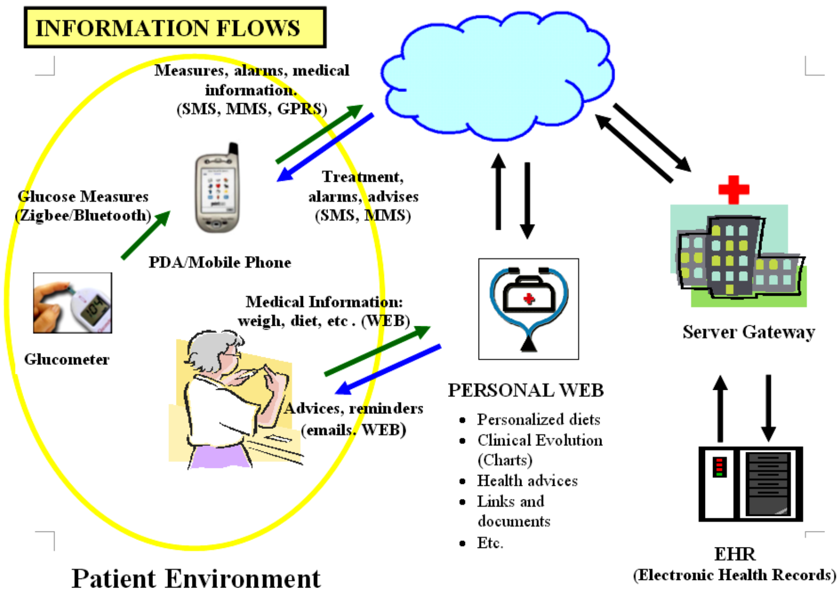

Fig. 1. Information flow of eDiab

2.1 Subsystem for Monitoring and Controlling

The subsystem for monitoring and controlling of Diabetes is the responsible for the transmission and storage of measures of glucose levels and other data from the patient such as information about diet, weight, etc. At the patient side there is a central node, PDA (for young users) or a mobile phone (for elder users). These devices are designed for the transmission of medical information, health advices, alarms, reminders, access to medical information, etc. The software of both devices is adapted to blind users by using an application called Mobile Speak Pocket/Phone [22], a screen reader solution for mobile phones that allows the access to most of the device functionality. The PDA has more features than a mobile phone, but its complexity is higher, so this device is mainly developed for young users. The design of the system for the PDA includes note reminders, a data base of glucose measures, generation of charts, etc.; these applications have been developed using .NET technology in a Pocket PC O.S. The PDA uses Zigbee/802.15.4 on the connection between the glucose sensor and the PDA, since this relatively new wireless sensor technology is the best option for battery saving and low cost [25]. This connection has been developed using Zigbee-RS232 modules of Telegesis Inc. [23], with the communication established by AT-commands. The first prototype had been developed with the Telegesis development board, but this development board was not a good choice because it is not battery powered and it needs to be powered with an adaptor. In order to overcome this drawback a new board with a small size and battery powered has been developed using Zigbee-RS232.

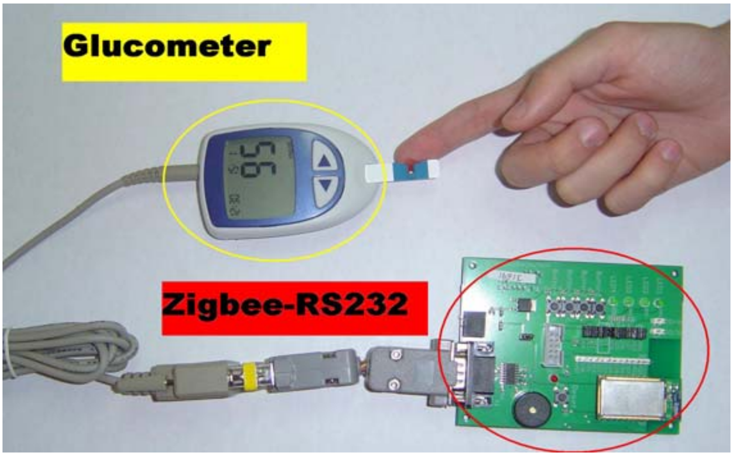

Fig. 2. Sensor connection with the Zigbee module

The communication between the patient and the server is established with a GPRS/GSM connection, using a Nokia 6630 connected to the PDA. Our current prototype is working in a HP iPAQ device; this PDA has a GPRS connection using a mobile phone connected via Bluetooth. However, the next prototypes will be developed in a Pocket PC with GPRS connection.

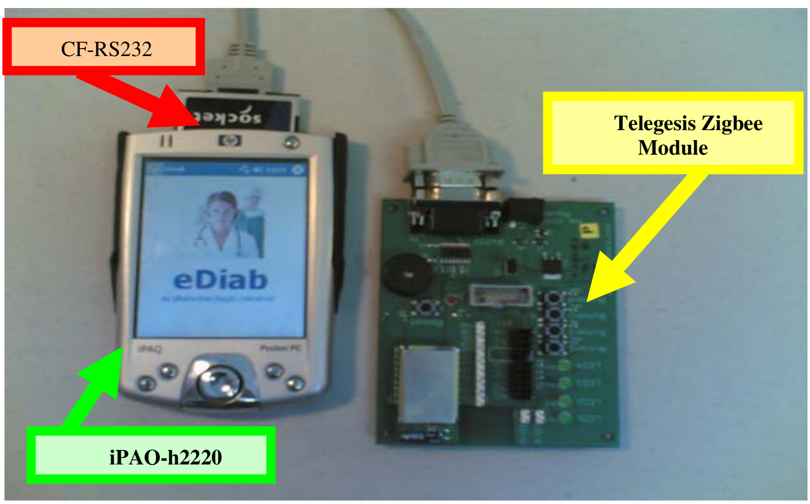

Fig. 3. PDA monitoring system

As described above, the mobile device used in the first prototype is a Nokia 6630 [24] with UMTS and Symbian O.S. The application software for this mobile has been developed using Java technology, J2ME. This device works as a gateway between the servers and the user. This bidirectional communication is based on GPRS/GSM, although the following prototypes could use UMTS. We have also used Bluetooth for the communication between the sensor and the mobile phone; in this case, the system uses a serial port-Bluetooth adapter.

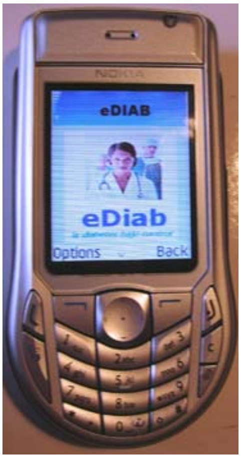

Fig. 4. eDIAB Application for Pocket PC

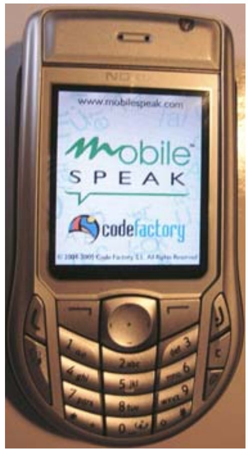

Fig. 5. Mobile Speak, Screen Reader Application

2.2 Subsystem for Health Education

The subsystem for Health Education has two components: one personal web for the patient (currently under development) and one system to send SMS and MMS with medical information and advice. The web allows the patient to access to the medical information (charts, analysis, etc.) and to send emails to the doctors and professionals. The web also shows advice for the patient, which are personalized and generated automatically. A smart system studies the information about the patient and provides customized information and tailored view of it in the personal web; for example, if the patient doesn't practise sports, the web will show information about the benefits of sports. This system also provides SMS/MMS features for health education. The server could send SMS/MMS to remind about the treatments and to give advice. This feature is being developed for improving the healthy habits of the patients. Two main target groups are considered: children, who are very receptive to this kind of system, and people with type II diabetes (the most common form of diabetes), who may need more advice in healthy living because most of them have been diagnosed with diabetes when they are adults.

3 Future Work and Challenges

Currently, the Subsystem for Monitoring and Controlling is being tested with end users in order to test the usability and to improve the system in the next prototype. The subsystem of Health Education has been designed and is currently being developed; we hope that it will be fully developed during the academic course 2006-2007. After this, the system will be tested on diabetic patients, including blind people, and diabetic educators.

There are several interesting areas for further research related to Information Technologies in Diabetic Care, especially in the educational area. For example, we have found projects [26] where animated agents were used to educate patients who had suffered brain stroke. We think that this approach has a high potential of applicability to the education of patients with chronic diseases. Another interesting area is the use of Artificial Intelligence techniques to personalize the presentation of documents [27,28] according to the patient's characteristics and interests.

Probably the more interesting challenge is the integration of eDiab into an Ambient Intelligent System. Ambient Intelligence has an enormous potential through the creation of "intelligent" environments able to proactively adapt to humans, as well as to serve their needs and goals. In this case, the autonomy and quality of life of diabetic people would be enhanced through a proactive education, monitoring and self-care system providing an integral care of this very important chronic disease. The use of wireless links guarantees ubiquitous access to medical data (e.g. sensors) and advice and/or medical information. Also, the ubiquitous access to electronic clinical records and the application of smart techniques would allow personalizing and adapting advice and medical information to the user's characteristics (age, abilities, etc.). Future work will address the improvement of the system described in this paper in order to allow *interoperability* with other devices. For instance, a person using eDiab and entering a hospital or school may be interested in interchanging services and/or information. We are currently considering the use of one of the available architectures (like UPnP or Jini) for dynamic service discovering, service description and service control.

4 Conclusions

In this paper, we describe a system named eDiab, developed for monitoring, assisting and educating people with diabetes. The main contribution of this system is that it is (to the best of our knowledge) the first one in merging monitoring and education of diabetic people with assistance to visually impaired people. This feature is especially useful considering that the Diabetes Mellitus is the second cause of blindness in the elderly and the first one in young and adult people. Although the system is still under development, several interesting characteristics can already be presented.

Acknowledgements

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