Talking Telemedicine:
Is the Interactive Voice-Logbook Evolving into the Cornerstone of Diabetes Healthcare?

Black, L.[1], McTear, M.[1], Black N.[1], Harper, R.[2], and Lemon, M.[2]

[1]Faculty of Engineering,University of Ulster, Jordanstown, Belfast, Northern Ireland.
[2]Diabetes Clinic, Ulster Hospital, Dundonald, Northern Ireland
e-mail: la.black@ulster.ac.uk

Abstract

This paper presents DI@L-log, a telemedicine prototype solution under development in Northern Ireland which is being designed to extend meaningful contact with the hospital and improve care for a mature cohort of Type 2 hypertensive patients. The recent surge in telecommunications technology can help prompt patients to adhere to self-care regimens using asynchronous, automated communication via their telephone. The system proposed aims to extend care to accommodate the shifting paradigm of care into the home environment, provide feedback and timely intervention to the patient, and decision support for health professionals. The Internet and Spoken Dialogue Technology (SDT) provides healthcare with a tool for effective telemedicine delivery. We argue the potential basis for our system is to provide pro-active motivation and incentive over the stagnant paper logbook currently used to document home-monitored patient data.

Introduction

Doctors often make decisions on incomplete information. The adoption of telemedicine technology has been slowly embraced by heath care, however, trends are highlighting the potential improvements these systems can have for both the recipients and the providers of health care (Carpenter, 2003). Telemedicine is fundamentally a communication mechanism for sharing and exchanging medical resources at a distance. These systems are designed to share heterogeneous components, manage data and to integrate/interface with legacy systems.

Our health service is currently overstretched with financial, human and medical resources, and needs improved mechanisms to contain and acquire accurate, complete patient information. In particular, Type 2 diabetes mellitus (T2DM) poses a difficult and serious chronic condition for patients and health providers to manage. According to the World Health Organisation (1999), T2 diabetes is '*a global epidemic*'. Without effective intervention, the prevalence of T2 diabetes in all populations is likely to rise. Currently, worldwide, 151 million adults have been clinically diagnosed with diabetes. These patients are particularly at risk of excessive morbidity and mortality from cardiovascular, cerebrovascular and peripheral vascular disease leading to myocardial infarction, strokes, and amputations.

Telemedicine and Diabetes

Many telemedicine systems have been proposed for diabetes management. Examples include the IDEA-Tel (Informatics for Diabetes Education and Telemedicine) project, which was established as a disease management program in rural and urban underserved areas (Starren, et al. 2002). Patients received a home telemedicine unit (palmtop computer) facilitating blood glucose downloading and videoconferencing. Likewise, the DIACRONO system (Gomez, et al. 1987) combined a portable device (palmtop computer) for home monitoring, with data collection through PC based software located in the clinic. More recently, the M^{2}DM (European Multi-Access Services for Managing Diabetes) project goal is to develop 24-hour telemedicine support via multi-access services (MAS) (Bellazzi, et al. 2002). The concept is to collect data on central database server which can be accessed through Internet, telephone or dedicated software for downloading data directly from reflectometers.

Other telephony solutions have been proposed including GLUCONET (France Telecom R&D partnership), who have collaborated with Grenoble and Toulouse University hospitals to permit a cohort of Type 1 diabetes patients to send blood glucose monitoring data to physician via text messages on their cell phones. To facilitate the transmission of data, France Telecom uses the Orange GSM cellular network to send glucose data to a secure server containing patient files. Several examples of prototype diabetes applications using WAP (Hung, and Zhuang, 2003), and mobile communications have also been proposed (Woodward, Istepanian, and Richard, 2001, Durso, et al. 2003). However, there seems to be a lack of pervasive, inexpensive and user-friendly technologies in medical practice that extend to the majority of the diabetes

population and serve as a platform to enable better care delivery.

Care and Communication

Diabetes care delivery relies on effective patient-physician communication, and involves both parties having an understanding and agreed agenda of monitoring, periodic review and therapeutic intervention. It has been frequently documented that clinic visits are both inadequate and ineffective for long-term diabetes management. This is further compounded by patients who do not realise the seriousness of their condition, and who are not well educated in appropriate disease management. The majority of T2DM patients frequently monitor blood sugar at home. Recent trials have emphasised the need to extend blood glucose coupled with blood pressure monitoring (Clarke, Gray, Briggs and Holman, 2003) to provide health professionals with important and frequent patient states (White, and Schick, 2004).

Our system has been discussed elsewhere (Black, McTear, et al. 2004), and is specifically designed for Type 2 diabetes patients with co-morbid hypertension. These patients are at higher risk of macrovascular complications and need frequent interaction with the point of care. As a practical and potentially cost effective intervention, DI@L-log aims to replace the paper logbook by recording medically determined data (namely weight, blood sugar and blood pressure) on a weekly basis using the latest spoken dialogue technologies and artificial intelligent methods. Moreover, to enable patients to document recent health experiences via the paper logbook has been shown to be unreliable (Stone et al. 2002). Patients often voice apathy a resulting from a lack of support from the healthcare provider regarding changes in behavioural or treatment regimens. As discussed by Fulmer (1999), education without follow-up does not result in improved outcomes. However trials conducted assessing whether nurse follow-up using the telephone improved patients glycaemic control and promoted better self-care (Piette, Weinberger, Kraemer, and McPhee, 2001). Therefore, our system promotes an interactive strategy for patients to regularly give, and receive feedback on their health data. These methods must be designed and implemented to improve the current communication chasm and fractured nature of diabetes health care delivery.

Voice Solutions for Healthcare

The recent convergence of voice technologies with the web have enabled a plethora of services from tele-banking to voice activated e-mail. As the technology permeates the industrial realm, new voice solutions are being proposed as potentially useful tools in order for doctors to obtain important patient information for chronic patients in an ambulatory or remote setting. Several PSTN (Public Switched Telephone Network) systems have been highlighted to augment patient care. Early developments such as TLC (Telephone-Linked Care), proposed as a successful alternative to supplement a home visit by a physician (Friedman et al. 1997), and more recently, the EU-funded HOMEY project which is creating an intelligent, adaptive dialogue system (Azzini et al. 2002).

Benefits and Challenges

Undoubtedly, the telephone is a practical and a user-friendly device for the majority of older T2DM patients. We have emphasised that our patients should use a fixed rather than mobile telephone line, so that there is no reception degradation in data quality received. Furthermore, mobile telephones are not an appropriate modality for a patient population who are most likely to be elderly, infirm and disabled. In terms of usability, the mobile keypad is limited, and forces the user to move the telephone from their ear to the hand when entering DTMF data. This is potentially frustrating for the user when speech recognition errors happen. Likewise, buttons are not easily manipulated, and most of our patients are not familiar with this type of phone. Unlike other studies, a fixed telephone is not an expensive or daunting device. DI@L-log allows patients to communicate remotely with the clinic with greater flexibility and convenience, with little or no technical training or know-how. Furthermore, if deemed successful, hospital visits can be reduced, therefore saving doctors valuable time, giving them more time to focus on caring for patients. Patient profiles can be generated over time, visualised at the touch of a button, and shared if transmitted securely in XML format. Advantages of such a system afford doctors a second expert opinion promptly.

System Specification

DI@L-log is in its preliminary stages of development. The DI@L-log architecture consists of a voice user interface (VUI) and voice browser, a web server, and a backend database and graphical user interface (GUI). The initial modelling of the system was based on interviews, focus group sessions and questionnaires given to both Type 2 patients (n=32) and consultants (n=5) at the UCHT (Ulster Community Hospitals Trust) in Northern Ireland. Prerequisites for the study involved recruiting 20 Type 2 diabetes patients who were over 55 years old, with co-morbid hypertension. Early discussions enabled designers to generate a user profile and make analyses on task completion in order to create a system that lets users build a virtual model of system interaction.

The system has been designed as an application-directed rather than mixed–initiative service, but we plan to

develop more techniques for patients to enter data and in whichever order they prefer, or indeed, all in one sentence. The systems' dialogues and sub dialogues were initially graphically represented as a state transition network using the CSLU toolkit. The script was written in VoiceXML, endorsed by the W3C (World Wide Web Consortium) and has been rigorously tested by peers and patients using WOZ (Wizard of OZ) scripts. Variables of PIN, password, weight, blood sugar and blood pressure are written using VoiceXML as integers and/or characters. Log files were collected and analysed for error recovery and identification. Certain design trade-offs have been established to accommodate users preferences, for example, a female anthropomorphic system persona was preferred. In addition, it is noteworthy to add that early findings reveal our target audience are more reserved, and hence prefer communicating using DTMF (Dual Tone Multi Frequency) over speech input.

The patient has been given a special number in which to contact the system. When contact is made as an IVR (Interactive Voice Response) reply welcomes the user. The file *login.vxml* prompts the patient for a PIN number and a password. This is checked via "post" method in the database against patient id. Once the user is identified, the status of the patient is encoded by a state vector. The dialogue manager controls the flow and content of the script based on user inputs. Once the patient enters their data (either using DTMF or spoken input), information is relayed in real-time to the point of care via an ODBC DBI. A data repository created in MS Access2000 enabled developers to test the efficacy and accuracy of the data acquired, and how it could be effectively and dynamically updated with each new interaction. The voice browser acts as a gateway to the backend system where it sends data as SQL queries. Data is dynamically updated by an Apache Tomcat 4.0 Web server, using JSP technology and is modelled against production rules or arguments, which performs operations and returns a value by comparing data with previous call and clinic readings for validation.

Discussion

The service aims to accommodate two very diverse user populations and provide sound feedback to both, without jeopardising the doctor-patient relationship. From a health carer perspective, DI@L-log serves as a tool for decision support and evidence based practice. Authorised health professionals can view the latest patient readings and decide on medical intervention based on clinical protocols, if required.

Due to the sensitive nature of this type of communication exchange, positive feedback is given to the patient to encourage them and motivate them on how well, or how much difference there is in their readings since the last call. No medication advice is given, due to ethical reasons, however the system encouragingly prompts the user regarding simple lifestyle and behavioural modifications.

Further testing will be necessary to assess DI@L-log's integration and effectiveness in the clinical environment. Performance and user satisfaction also play a vital part in the assessment objectives of the study. Moreover, the technology will only be effective if its target audience are willing to embrace it. We are proposing to integrate our home monitoring system with the current DIAMOND diabetes EPR used by over 40 health institutions in the UK, to make it easier for doctors to track and create patient profiles remotely. Of course, another important aspect of this research will be tackling issues concerning security, privacy and legalities of acquiring confidential, context sensitive data over PSTN lines.

Conclusion

Telemedicine coupled with automated dialogue systems can potentially provide and important link to enhance care and ultimate communication between patients and their providers. Our DI@L-log system aims to provide empowerment and a voice and choice for patients to become active partners in their care. This innovative solution to the static paper logbook will be a matter of trial and error before it can be successfully implemented in practice. The refreshed advancements in the speech domain promise interesting and hopeful new solutions to facilitate the struggling demands chronic care delivery faces in the future.

Acknowledgments

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