Design and Implementation of a Voice-Based Medical Alert System for Medication Adherence

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Abstract

Non-adherence to prescribed medical treatment is a major health problem especially with chronic diseases such as HIV/AIDS, Diabetes, Tuberculosis and Malaria for which medication adherence is very critical especially in outpatient setting. This paper presents a voice-based mobile medical alert system (Voice MedAlert) for outpatient adherence. The system runs on client server architecture responsible for data processing. The client (front end) gets user input and gives or shows the result, while the server (back end) does storage, security and major data processing. The front-end makes use of Hypertext Markup Language and PHP, while the back-end uses MYSQL database and PHP (Hypertext Pre-processor). The voice API (Application Program Interface) used is TWILIO REST API. The adoption of voice-based applications could greatly reduce non-adherence of patients to treatment regimen because they allow appointments and prescription information to be captured and heard through voice response rather than in the physician’s handwriting.

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Selection and/or peer-review under responsibility of SCIKA – Association for Promotion and Dissemination of Scientific Knowledge

Keywords: non-adherence; healthcare; voice-based; outpatient; mobile technology; nigeria.

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1. Introduction

The need to improve and provide efficient health services has resulted in the increased use of information and communication technology-based solutions in the healthcare sector. Although the Internet has received significant attention in recent years, voice is still the most convenient and natural way of communicating between human to human or human to computer. The use of voice in health has garnered increasing attention as a means to track disease outbreaks, monitor patient treatment, diagnose patients, educate patients, collect and transmit data through basic mobile phones. With mobile voice technologies, medical practitioners are able to instantly update and retrieve patients’ records from anywhere within a telephone network coverage. This ensures that the patients’ medical records are always current. Physicians with up to date information are likely to make better prescription decisions. The adoption of voice-based application could eliminate redundant paperwork, thereby facilitating more efficient and effective delivery of patient care. Many projects have applied the features of mobile technology in designing interventions for medication adherence. Such projects include: the Mobile MedAlert, a mobile medical alert system that sends SMS to patients, prompting them to take their drugs [1]; WelTel Kenyan project, a randomized trial of mobile (cell) phone text messaging to improve patients’ adherence to antiretroviral therapy [2]; Disease Management Assistance System (DMAS), a programmable electronic device that provides verbal reminder messages at dosing times [3]; Computerized Automated Reminder Diabetes System (CARDS), an e-mail and SMS cell phone text messaging reminders to support Diabetes management [4]. In Norway, SMS messages are sent to educate parents with Type 1 diabetic children. These messages included definitions, facts and tips for managing diabetes [5]. In India, South Africa and Uganda, SMS message campaigns have been used to create awareness of HIV/AIDS. They have also been notified of the centres where they can receive counselling, testing and treatment (Vital Wave Consulting, 2009). Information about communicable diseases and reproductive health are also disseminated via SMS. Project Masilukeke in South Africa takes advantage of the 120 spare characters on free “please call me” SMS messages to provide HIV/AIDS education and awareness [6]. In Norway, SMS messages are sent to educate parents with Type 1 diabetic children. These messages included definitions, facts and tips for managing diabetes [5]. Text to Change (South Africa) project employs an SMS-based quiz to test users’ knowledge of HIV/AIDS and encourage testing and counselling [6]. Other projects include: TRICKs (Text Reminders for Immunization Compliance in Kids) which sends out text messages of immunization reminders prior to immunization dates [7]; Text messaging to motivate walking in older African-Americans [8]; Text4baby, the first free national health text messaging service in the United States that aims to provide timely information to pregnant women and new mothers to help them improve their health and the health of their babies [9]; a mobile phone text message program to measure oral antibiotic use and provide feedback on adherence to patients discharged from the emergency department [10] and the use of text messaging to increase the receipt of influenza vaccine among low-income urban children [11]. Studies have also been carried out to measure the effectiveness of electronic reminders, SMS, and phone calls in improving patient adherence [3, 12, and 13].

The objective of this paper is to design and develop a voice-based mobile medical alert system (Voice MedAlert) to assist patients in keeping track of their doctor’s appointments, and medication.

1.1 Structure

This paper is organized as follows: in section 1 we present the background of study, in section 2 we also present related work of study, in section 3 we give the design architecture of the paper and in section 4, 5 and 6 respectively we give the system implementation, future work and conclusion of the paper respectively.
2. Related Work

Azeta et al., [14] presented a framework for an intelligent voice-enabled e-Education application and an adaptation of the framework for the development of a prototype Course Registration and Examination (CourseRegExamOnline) module. The CourseRegExamOnline module was developed using VoiceXML for the voice user interface (VUI), PHP for the web user interface (WUI), Apache as the middle-ware and MySQL database as back-end. The system would offer dual access modes using the VUI and WUI. The framework would serve as a reference model for developing voice-based e-Education applications. The e-education system when fully developed would meet the needs of students who are normal users and those with certain forms of disabilities such as visual impairment, repetitive strain injury (RSI), etc, that make reading and writing difficult. O'Donnabhain et al., [15] defined a much-needed framework to ease the existing burden of manually testing the quality of voice over IP systems. After years of natural research into IP phone replacement technologies, we argue the emulation of 802.11b. Here, a peer-to-peer tool for constructing IP networks (ORGAL) was presented, which was used to validate that RPCs and lambda calculus can be applied to create better, more automated tests for Voice-over IP. Piette [16] implemented an interactive response assessment system in the treatment of patients with chronic health problems such as heart failure, diabetes, hypertension, and mental health disorders. The information patients report during IVR assessments is at least as reliable as information obtained via structured clinical interviews or medical record reviews. Patients often are more inclined to report health problems to an IVR system than directly to a clinician. The few outcome evaluations of IVR-supported chronic illness management services indicate that they can have moderate impacts on some health and health behavior outcomes. Ikhu-Omoregbe and Azeta [17] presented a framework for the design and implementation of a Voice-based Mobile Prescription Application (VBMOPA) to improve health care services. The application can be accessed through a mobile phone by dialing an appropriate number.

3. Design Architecture

The Voice MedAlert system consists of the voice user interface (VUI) design and modeled with Unified Modelling Language (UML). It was developed using tools such as HTML (Hypertext Markup Language), hypertext preprocessor (PHP), MySQL and the integration of the TWILIO REST API. Its main features includes: it can send voice calls to patients about potential drug intake at a scheduled time; it also send calls to patient about appointments some hours before the scheduled appointment. The system administrator enters information about prescription and appointments to be taken by the patients. The CRON job checks the database every minute and if the prescription or appointment time conforms to the current system time, it then calls the scheduler which initiates the Twilio Rest API in sending voice calls.

3.1. VUI Design

The VUI used for this system is the TWILIO Rest Web Service Interface. It is a voice application program interface (API) that allows you to query meta-data about your phone numbers, calls, text messages, and recordings. Since the API is based on REST principles, it's very easy to write and test applications. Twilio can convert text to speech and play audio files, record calls and store them. It also enables you to create conference calls with up to 40 people in any one conference. In addition Twilio rest has a speech to text engine that converts spoken words into text. Figure 1 presents the deployment architecture of the Voice MedAlert System.
3.2. System Architecture

The Voice MedAlert system is 3-tier client and server architecture for the Voice MedAlert system. It contains client devices, servers and a backend running MySQL database. The client systems include VUI devices such as mobile phones (Personal Digital Assistant (PDA), cell phone and smart phone and other handheld communication devices). The server contains the Voice (TWILIO Rest Web Service Interface) and web server. The Twilio Rest contains the speech server (gateway) which has text-to-speech (TTS) and voice browser. The web/application server stores the voice-based health-care content information. It uses HTTP to maintain Internet connectivity with the voice gateway. The database used is MySQL. It stores the information about appointments and prescriptions. MySQL is a server application (for database) able to carry out a great number of SQL commands. Figure 2 presents the Framework for the Voice MedAlert System.
4. System Implementation

The prototype Voice MedAlert was developed using TWILIO REST for the voice user interface (VUI), PHP for web user interface (WUI), Apache as middle-ware, and MySQL database as backend. The choice for these tools is because of their advantage as free and open source software [18]. Its main features includes: it can send voice calls to patients about potential drug in take at a scheduled time; it also send calls to patient about appointments some hours before the scheduled appointment. The system administrator enters information about prescription and appointments to be taken by the patients. The cron job checks the database every minute and if the prescription or appointment time conforms to the current system time, it then calls the scheduler which initiates the Twilio Rest API in sending voice calls. Figure 3 and 4 presents the “Book Appointment” and “Prescribe Drugs” module of the Voice MedAlert System respectively.
Fig. 3. “Book Appointment” Module for the Voice MedAlert System

Fig. 4. “Prescribe Drugs” Module for the Voice MedAlert System
5. Future Work

Currently this paper is at the development stage and further work will be to measure and evaluate the rate and level of adherence among patients with and without this service, with similar conditions, medications, treatments, and then assess the effectiveness of the system. Also, the system can be accessed from the end-user point of view to check if end-users could confirm medication adherence through their client devices.

6. Conclusion

The Voice MedAlert system discussed in this paper, allows patients receive voice alerts for appointments and medications. It is useful to a medical institution because of its ability to place a voice call to mobile phones which is the fastest way to supply someone with crucial and detailed information which require immediate follow up by alerting them on their medications and appointments. The Voice MedAlert will reasonably reduce human-to-human (H2H) contact (such as doctor to patient) by replacing it with human-to-system (H2S) interactivity. It can also be effective for patients with visual impairment [19].

This system will lead to costs and life savings in healthcare centers’ in developing countries’ where to ensure adherence to treatment, patients must walk many miles to clinics to receive and take medication and this is often not possible because of distance, lack of transportation, bad weather or a worsening condition that prevents them from leaving home.

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