

Proposal for a universal access solution to care in rural areas: case of Senegal

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Abstract— This article proposes a system of universal access to quality and low cost care based on sensors for the continuous monitoring of physiological parameters. Surveillance is essential for patients with chronic diseases such as high blood pressure (hbp) with a mortality rate of 24% in the country and diabetes in rural areas of Senegal lacking medical specialists.

A micro-computer system based on raspberry pi is used. Nurses in rural areas can use to collect biometric information captured by sensors such as high blood pressure, blood sugar, electrocardiogram (ECG) and body temperature of the patient. If one of the patient's biometric parameters exceeds normal, the nurse sends a message to a specialist physician in their area.

Keywords— ECG, hbp, Raspberry Pi, ADIE, e-Health.

I. INTRODUCTION

In Africa, particularly in Senegal, rural populations have difficulty accessing health services in the case of vital diseases such as high blood pressure, diabetes, kidney disease, liver disease, lung disease and so on. These vital diseases are those in which the patient needs continuous monitoring. In these areas, the reference structures are located in Dakar and at the level of regional capitals. The cost of the already high costs is increased by travel and accommodation costs, which makes it unbearable for most patients. Democratizing access to healthcare is thus a major challenge.

Many patients die in rural areas due to lack of care by doctors and lack of financial resources. A portable sensor-based system for the continuous monitoring of physiological parameters is essential for patients with chronic diseases in rural areas without specialist physicians.

Recent research in e-Health has concluded that several vital parameters can be monitored using Arduino, raspberry pi and biometric sensors [1] [2] [3].

To achieve universal access to quality and affordable care in rural areas, a portable monitoring solution is proposed in this paper. The system allows the nurse to choose a specialist if an abnormal value is detected from the physiological parameters of chronic diseases ie high blood pressure, diabetes. It also allows specialists to have an idea about the body temperature and the patient's electrocardiogram, indicated by the biometric sensors. This helps to take appropriate instantaneous measures, and to anticipate the possible risks of diseases that can occur in the future. Such a system can help

reduce hospital bills resulting from patient admission to the hospital and access to quality care while remaining in the community.

The rest of the article is articulated as follows: in II we decline our motivation, in III we will present the components of the system, in IV we will emphasize the experimental parameters of the system and at the end V the conclusion and the perspectives.

II. MOTIVATION

A. Senegalese State Fiber Optic Network

The State of Senegal through the State Information Technology Agency (ADIE) has built since 2002 a network of fiber optic interconnecting 12 of the 14 regional capitals of the country in order to allow the various structures of the State of Exchange of information as shown in Figure 1 below [4].



Figure 1. ADIE TF Network

B. Patient Monitoring System

It is a system in which various vital patient parameters are monitored. The results are displayed on the respective patient monitoring screen and are observed by physicians.

In developing countries, health problems are serious. The number of people suffering from various chronic diseases is quite high. The main cause is the large population, the limited number of health facilities and the lack of medical specialists

in the health facilities in rural areas. Some chronic diseases require regular follow-up.

- Diabetes
- High blood pressure
- Renal Diseases
- cardiac disease
- kidney disease
- liver disease
- Pulmonary Disease

The system proposed in this paper is based on client-server architecture. The application server is responsible for storing patient data, processing data and sending it to the server dedicated to doctors.

C. Basic physiological parameter

1) Blood pressure: Blood pressure results from the force created by the pumping action of the heart that leads the blood into the arteries and then into the circulatory system. As blood flows through the arteries, they offer some resistance to the flow of blood.

Almost twenty-four percent (24%) of deaths in Senegal are caused by hypertension. Early detection and control of hypertension may reduce the risk of heart disease and kidney failure [5].

Normal blood pressure for a healthy person is 120/80 mmHg. If blood pressure is higher than 140/90, it is called hypertension [6].

Daily monitoring of blood pressure would help to control it and take necessary action once the value of this blood pressure is abnormal.

2) Blood sugar levels: Despite very variable intervals between meals or occasional meal consumption with a high carbohydrate load, human blood glucose levels tend to stay within the normal range. However, shortly after eating, blood glucose levels in non-diabetics may increase temporarily to or slightly above 7.8 mmol / L (140 mg / dL) [6].

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3) Heartbeat rate: The pulse is the pulsation of the arteries resulting from the heartbeat. The pulse can usually be felt at the neck, wrists, behind the knee, inside the elbow. The heartbeat frequency (beats per minute) is normally indicated by the pulse rate. At rest for a healthy adult, the normal pulse varies between 60-100bpm. But during sleep, its value is at 40 bpm and during a physical exercise it rises to a value between 200-220 bpm [6] [7] [8].

An irregular or rapid heartbeat shows a cardiac abnormality. Dizziness, fainting, chest pain or shortness of breath can be correlated with the affected pulse. The reduced pulse rate may also indicate a blocked blood vessel.

4) Body temperature: The normal body temperature of a human being is about 98.6 ° F or 37.0 ° C. On the other hand, a temperature above 37.8 ° C (100 ° F) is considered as that of fever [9].

III. PROPOSED SYSTEM FOR MONITORING THE PATIENT IN RURAL AREAS

In this article, blood pressure (systolic and diastolic BP), heart rate, body temperature, and blood sugar detection are measured using biometric sensors interconnected with raspberry pi.

The proposed system is structured around 5 entities that are:

- The sensors
- The Pi Raspberry and e-Heath Kit
- The database
- Application

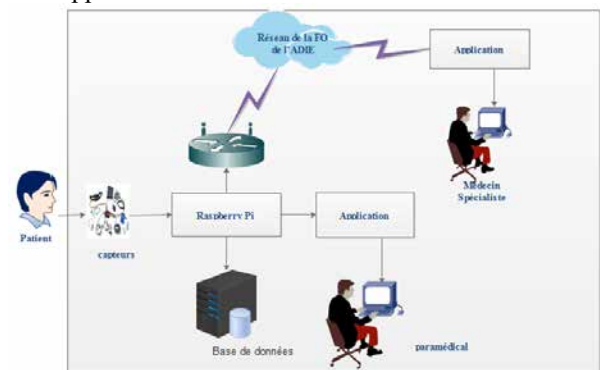


Figure 2. Proposed system architecture

A. The sensors

The system of universal access to care in rural areas of Senegal is based on the forms of acquisition of vital signals from patients. Various sensors are used for this purpose. On the e-Heath V2.0 [10] kit, which is a card that allows users of Arduino and Raspberry Pi to perform medical monitoring and biometric applications using 10 different sensors. For the proposed system the following sensors are used: glucose meter, electrocardiogram, body temperature and blood pressure.



Figure 3. E-Heath Platform

B. The Pi Raspberry and e-Heath Kit

Raspberry Pi is used to receive and analyze signals from different sensors and send them to healthcare workers.

A Raspberry card is actually a microcomputer that has nothing to envy its big brothers. Unlike so-called "programmable" cards such as Arduino cards, Raspberry have all the components of a conventional computer: audio and video outputs, USB ports, SD card reader, Internet connection, and so on. These cards have the advantages of being very compact to be used in many fields (handheld, small server, home automation, etc.), while being very economical. The choice of the operating system of the card is made among a wide choice of Linux distributions specially developed for the Raspberry. Optimization is thus pushed to its maximum on the manufacturer's side [11].



Figure 4. Basic component used to acquire data

C. Database

A Relational Database (RDB) is set up to store biometric data for patients, specialists and general practitioners. Paramedics and nursing staff can access this data. The prescribed treatment and advice of the general practitioner or the specialist physician is also available in the database. Nurses and physicians can access information whenever needed.

D. Application

The web-based application using PHP and HTML is responsible for the client-server architecture allowing communication between paramedics and specialist physicians [12, 13].

Customer: The customer side allows interaction between nurses and doctors. Nurses are actors in the acquisition of biometric data from the body of patients using different sensors.

These signals are transmitted over the ADIE fiber optic network via a WIFI access point via Ethernet or GPRS to specialist or generalist physicians in the region polarizing the health post. A web application is used to visualize biometric signals such as hypertension, blood sugar in real-time patients [14].

Patient information is then entered physiological data as well (Name, First name, Age, sex, size, etc.). When the nurse registers patient information with a signal, a unique code is sent to the nurse to uniquely identify the patient in the network. The Id will allow him to log into his account later.

The data are not only monitored but also compared to the normal values already defined. The specialist physician accesses all information with the image of the signals captured by the patient's sensors. Therefore, the doctor once he has the

patient's information, he treats them and lavishes treatments and advice to the nurse and patient.

Side servers: It is used to make available and store patient data. The server also has a database to store all patient and physician information.

If the doctor, nurse and patient want to communicate, the system is able to provide them with communication via WebRTC. To do this, a camera must be connected to the raspberry Pi and the specialist physician must have a device that supports the webrtc.

IV. EXPERIMENTAL PARAMETERS

The proposed model is based essentially on Raspberry pi to acquire the signals of the different biometric sensors of the patient and the access network of the ADIE.

A web application is developed to send these signals with the required information to the specialist doctor in order to obtain a better treatment if the captured value exceeds normal. The essential users of the system are nurses, specialists and the patient. Figure 5 shows the scenario of the proposed system.

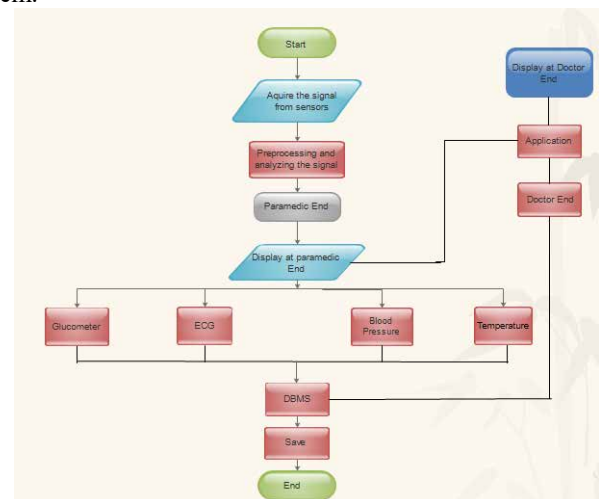


Figure 5. Organigram of the proposed model

The paramedic fills out patient information such as: Name, First Name, Address, Age, Sex, Phone Number Area of Illness. It also attaches all the vital data captured by the sensors, high blood pressure, glucose meter, ECG, body temperature.

Once this information is collected, the set is transmitted in the database and accessible throughout the ADIE network. After completing all the information about the patient, he will be able to assign the patient, a specialist doctor.

To get better treatment in a short time, a specialist physician connects to the network to access this data. Once the data is received, the physician analyzes and gives treatment and advises the patient. The paramedic can now retrieve the file which can be downloaded in PDF, doc or xls.

The proposed system implements as described above. On the client and server side a php and html application are used. This proposed system is designed to work between physician and paramedic. The primary task will be to monitor and

collect the patient's condition. Specialist physicians may prescribe treatment and counseling by videoconference or chat. The nurse downloads the processing file in the desired PDF or other format. Data evaluation is an important issue in patient monitoring systems. The data are not only monitored but also compared to the normal values already defined.

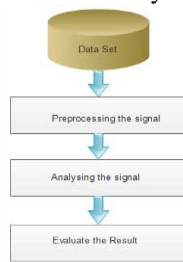


Figure 6. Data processing and evaluation of results

If the data is outside the normal range of predefined values, the nurse sends an alert to the disease specialist. The latter can receive a message on its inbox and in SMS via a GSM module incorporated in the system.

V. CONCLUSION

In this article, we propose a universal access surveillance system in remote rural patients. Since most people in rural areas of Senegal do not have access to quality care, the proposed patient monitoring system can be used by paramedics in health centers.

Medical specialists, once received the biometric data of the patient, make a decision and prescribes a suitable treatment to him remotely anywhere using the fiber optic network of the country. Our system greatly reduces spending and increases the quality of life of patients. As modern life becomes more intense and serious illnesses appear, sustained treatment becomes more necessary. Our system proposal meets the security requirements for patients, paramedics and medical specialists.

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