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An Improved Expert System for Modeling Controlled Human Blood Pressure

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ABSTRACT: In a bid to promoting the systemhealthcare; itbecomes imperative that the very patient's physiological parameters ought to be monitored regularly in order to effectively control the condition of health of that patient. This dissertationunveils an improved expert system for modelling and simulating controlled human blood pressure "with the capability of physiological parameters monitoringand diagnose the ailment. The proposed system has a coordinator nodeattached to the patient body to acquirethe signals and sent them to a unit called base station through several wireless relay nodes. The coordinator/combination of the relay nodes and that attached on the body of the patient forms a wireless body sensor network (WBSN) which are capable of sensing the patient's physiological parameters. This proposed system can quickly detect abnormal conditions in a patient and instantly issue an alert/alarm to both thephysician and the patient via SMS. The proposed system has a level of accuracy which is high in diagnosis, speed and effective communication coverage which has improved the patient's freedom for quality of life.
Keyword: Expert-system, Base-station (BS), Monitoring, communication coverage and physiological-parameters.

I. INTRODUCTION

Recent development in science and technology has ushered innovation into the healthcare sectors most especially in the developed nations leaving African nations behind. In provision of healthcare services such as medical data access, clinical monitoring, automated disease diagnosis, and being able to communicate with the physicians in emergency situations via SMS or mails. This can be achieved with the aid of a body sensor network system (Mcfadden, &Indulska J., 2014). To improve the detection of patient conditions at emergency situation in a risk patient, a wearable transducers will help achieve this. Also, the monitoring systems will provide useful methods to monitor the physiological signals remotely without interrupting the patient's normal life, thus improving life quality through provision of quality healthcare (Alemdar, &Ersoy 2010). The existing system for monitoring patients vital signs require that the sensors be placed bedside monitor hence limiting the patient to his or her bed. To solve the problem of limiting the coverage to a short distance, wireless devices and wireless networks can help achieve this as there is no relation between the bedside equipment in the hospital and the sensors due to the long range of the wireless devices and wireless networks (Shnayder, et al, 2005). In these systems patient are not limited to their bed but allows them to move around and still the data can be captured.

Furthermore, the technology of data acquisition, access, storage, visualizationand analysis are critical health monitoring systems components and evaluations. Handling data of high dimension like these makes data analysis task a bit frustrating and error prone for persons handling it.

This is because every case is unique and needs a unique approach to avoid colossal damage. The handling of the various medical cases is different and the procedures are carried out differently in every service and treatment according to the patient's condition as may be applied by the physician. The combination of the new multipurpose sensors and intelligent system technique, more precisely fuzzy logic, is being considered here as a most effective approach in addressing these challenges face in developing an improved expert system for modelling a controlled human blood pressure.

1.1 Statement of the Problem

Apparently the issue of health constitutes a major problem to Federal, State and Local governments. Science and technology are advancing as can be evidenced by the ever increasing domination of our everyday life by the computer and the internet. Yet life expectancy is decreasing. A great percentage of the mortality and sudden death are attributable to blood pressure. Hence people leave there homes or go to bed apparently healthy only to end up at the hospital suddenly with stroke or heart attack or in the mortuary without notice. The consequence of this fact is more often than not very fatal and often irreversible. Thus, accurate, very reliable analysis, interpretation, clinical monitoring and diagnosis would go a long way in forestalling and preventing these deadly ailments and attacks. There is therefore a serious need to reduce this ugly trend.

1.2 Scope of the Study

The research will dwell on modelling a clinical sensor that can monitor blood pressure and send an alert when the pressure is above the required range via an expert system. The blood pressure BP monitoring was implemented using MATLAB Tool and visual basic 6.0.

II. LITERATURE SURVEY

AUTHORS	TECHNIQUE ADOPTED	CONTRIBUTION	LIMITATIONS
Alemdar, 2010	wireless networks	systems do not require the patient to be limited to his bed and allow him to move around but requires being within a specific distance from the bedside monitor	Out of this range, it is not possible to collect data
Yuce, 2010	multi-hopping network for a multi-patient system	remote monitoring of physiological parameters	the coverage range by this system is 10 meters, and the patients cannot move around freely
Chung, 2012	multi-patient network intermediate node	patient's physiological signals are acquired by the sensors attached on the patient body	the patient is dominated by signals and it is harmful for body of patients in the long time
Gennaro et. al. 2012	IOT	continuous monitoring features for the patient and the improvement of workflows	Security is a key concern
Capone, 2016	real-time patient monitoring	integrates wearable vital signs sensors, location sensors, ad-hoc networking, electronic patient records	The devices are expensive to produce, cumbersome and often difficult to use

III. MATERIALS AND METHOD

For an improved Expert System for modelling and simulation of a controlled human blood pressure, a specialized GSM modem which operates on mobile subscription likethe mobile phone is required. The connectivity of the modemto a computer allows for communication over the mobile network, thus providing internet connectivity which frequently used for receiving and sending SMS and MMS messages.

This unit is wearable by the patient on the hand or in a pouch. There are two users, the patient and the healthcare provider/doctor. The hardware part of the system consists of a multi parameter sensor unit;some designated mobile handsets, the GSM network and a server.

The sensor unit consists of 6 components: the sensing unit, the signal conditioning device which filters and amplifies the signals. There are also an analogue to digital converter, a buffer memory, a processor and transceivers.

This unit uses zigbee to wirelessly transmit digital recognizable data to the patient's or healthcare provider/doctor's mobile phone. Zigbee is now used in place of Blue tooth and Wi-Fi because of economy in power utilization and signal transmission efficiency.

The processor manages the time and periodic transmission of signals as required. There is an ad hoc

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management of the information's from the sensor which is analyzed and shown real time.
On detecting a problem the model sends an alert message to both the patient, and the doctor. It is also being sent to the Control Part for record keeping of userinformation and for further analysis that will lead to the interim diagnosis.

3.1 Method

In the design of the new system Expert system methodology was adopted. The expert system is a rule-based expert system; it consists of three main phases as shown in Figure. 3.2.

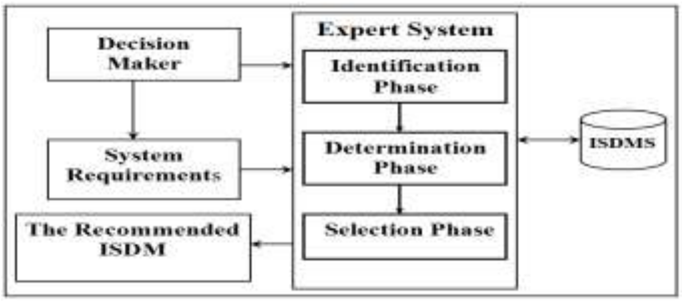

Figure 3.2: Expert System Framework

3.2 Expert System Components

The major components ofexpert systems are mainly the knowledge base of the system and the systems reasoning engine as shown in Figure. 3.3.

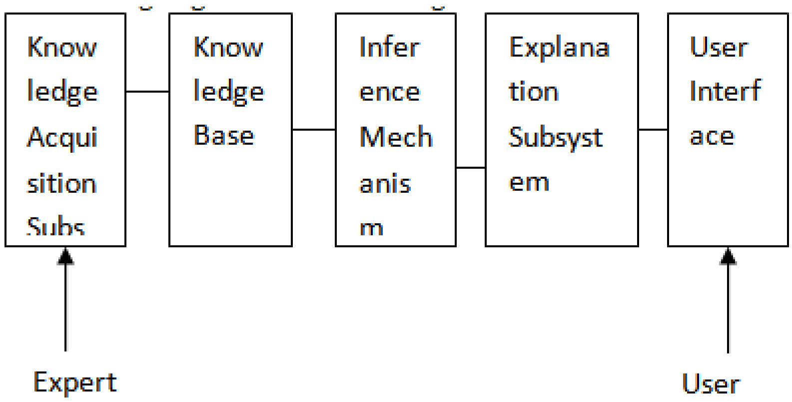

Figure 3.3: Expert System Components.

3.3 Analysis and Treatment of Data

This heart bit or forceful contraction of heart High BP inmost cases lead to problems such as heart attack, stroke, kidney disease etc. High BP usuallyhas no symptoms, so there is this need for one to have his or her blood pressure checked at regular interval.
Monitoring of blood pressure is importantespecially for high BP patients. BP usually fluctuates to meet individual body's needs. It can be affected by the position of the patient's body, emotional state or, breathing,sleep and exercise.Blood pressure are best measure when the patient is very relaxed and sitting or lying down.

3.4 Model Development

We model the cardiovascular system using a compartment model. The components of the system are the heart, arteries and veins enabling systemiccirculation.The oxygen exchange takes placein the aorta (smaller arteries, arterioles and capillaries). The right heart pumps CO_2 rich blood into the lungs, closing the loop.

In our study the model compartment employed the arteries,veins and left ventricle were employed. However, exhibiting adicrotic notch in arterial pressure fluctuation that occurs when the aortic valve closes.asa result of the decrease in pressureacross the valve being negative.
Mathematically, no problem will arise in dividing thecardiovascular system into compartments, as it is done with the finite elementcomputations. However, in giving meaning to this compartment it could be represented as the aortic arch. This model here is being describedby four-compartment system; thus,

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$\tilde{v}_e = Q_{LV} - Q_e$ (3.1)
$\tilde{v}_a = Q_e - Q_a$ (3..2)
$\tilde{v}_v = Q_a - Q_v$ (3.3)
$\tilde{v}_{LV} = Q_V - Q_{LV}$ (3.4)

whereV is representing the volume and Q the rate of blood flow. The subscriptsLV,v,e, anda, representleft ventricle, venous, exit, arterial, and the dots indicates derivative with respectto time. Hence equation (3.1) does indicate the volume rate of change of in the exit regiondepends on the rates at which blood flows in from the left ventricle to the aortic arch.Whilein the second equation, the arterial volume increases due to fluidflowing in from the exit region to the arterial region. The third equation also represents a balance forthe venous system, while the fourth equation is for the material balance for the left ventricle. Theseequationsexpresses conservation of blood volume. Assumption: blood is incompressible, compliance of blood vessels are associated with changes in pressure ratherthan the small bloodcompressibility and conservation in volume of blood is equivalent to the principle of conservation of blood mass.

$$\dot{V}_e = C_e \dot{p}_e \dot{V}_a = C_a \dot{p}_a \dot{V}_v = C_v \dot{p}_v \dot{V}_{LV} = \frac{d}{dt}\left(\frac{p_{LV}}{E_{LV}}\right) \quad (3.5)$$

$$C_e \dot{p}_e = \frac{p_{LV} - p_e}{R_e} - \frac{p_e - p_a}{R_a} \quad (3.6)$$

$$C_a \dot{p}_a = \frac{p_e - p_a}{R_a} - \frac{p_a - p_v}{R_v} \quad (3.7)$$

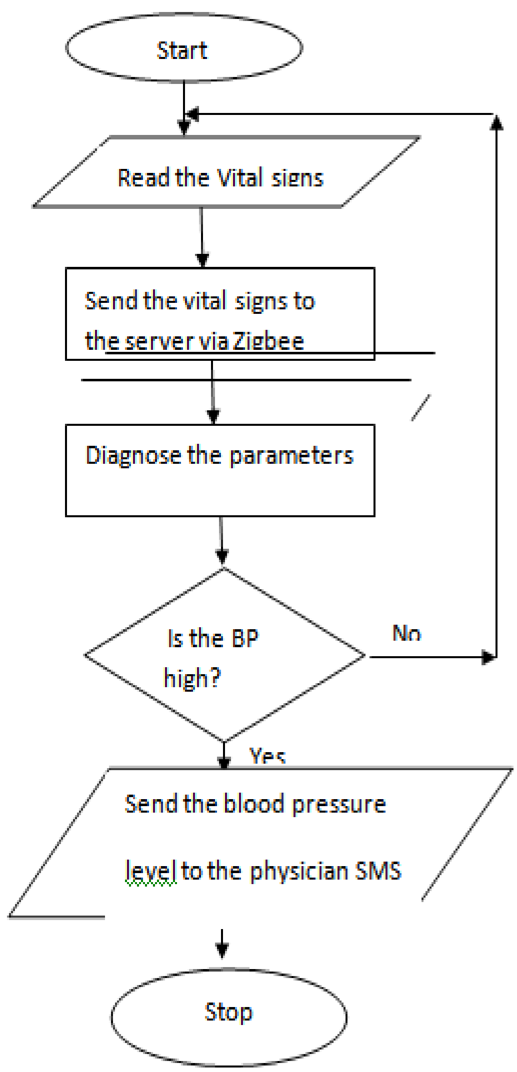
$$C_v \dot{p}_v = \frac{p_a - p_v}{R_v} - \frac{p_v - p_{LV}}{R_{LV}} \quad (3.8)$$

$$\frac{d}{dt}\left(\frac{p_{LV}}{E_{LV}}\right) = \frac{p_v - p_{LV}}{R_{LV}} - \frac{p_{LV} - p_e}{R_e} \quad (3.9)$$

$$C_e \dot{p}_e = \frac{p_{LV} - p_e}{R_e(t)} - \frac{p_e - p_a}{R_a} + f(t) \quad (3.16)$$

$$\frac{d}{dt}\left(\frac{p_{LV}}{E_{LV}(t)}\right) = \frac{p_v - p_{LV}}{R_v} - \frac{p_{LV} - p_e}{R_e(t)} - f(t) \quad (3.17)$$

Program Flowchart



Program Flowchart for the diagnostic system

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IV. SIMULATION RESULT

This part highlights the result obtained as against the expected result. The expected result is the outcome obtainable from the system if everything were to work perfectly. The expected result has been carefully documented as a standard for assessing the performance of the system. This result compared with the expected result is presented in the table below.

Table 4.1: Sample Test Result

S/N	MBP	SBP	DBP	Expected Result	Result Obtained
1	130.3	86	93	Hypertension	Hypertension
2	128	55	96	Hypertension	Hypertension
3	85	65	94	Kidney Disease	Kidney Disease
4	118	78	98	Hypertension	Hypertension
5	145	45	97	Hypertension	Hypertension
6	160	120	78	Heart disease	Heart disease
7	165	77	88	Hypertension	Hypertension
.	.	.	.	.	Hypertension
.	.	.	.	.	Hypertension

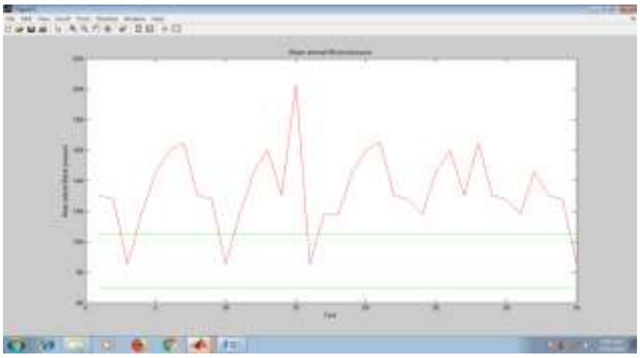

Figure. 4.1: Simulation of Mean arterial Blood pressure for various patients

Out of 35 patients diagnosed, 4 patients have their MABP readings within the specified range while 31 patients have a higher reading with the highest being 203. The green line indicates the lower and upper limit of the parameter which is the normal range.

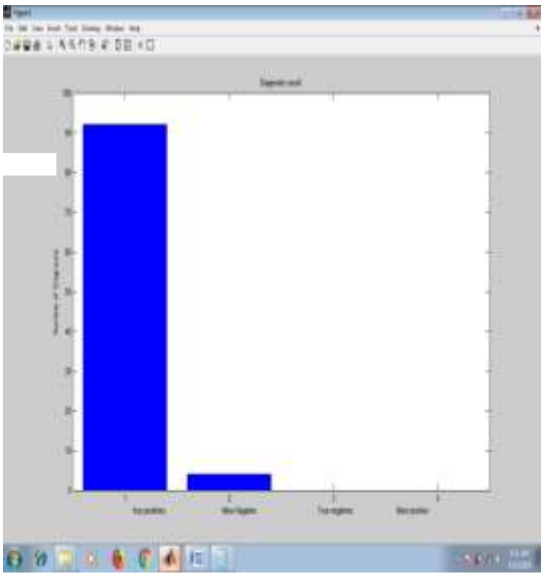

Figure. 4.3: Performance evaluation

4.2 **Discussions**

To evaluate the working of the proposed system the same database is taken in to account. With the help of our proposed system we can identify the diagnostic system for BP, and can diagnose the symptoms in an efficient way at very low cost. For performance evaluation we considered the Accuracy and Sensitivity of the result. Figure 4.3 show that the proposed system has 89% accuracy and 89% sensitivity which mean that the system can correctly detect the disease and generate an early warning to the patients.

Figure 4.1 shows that out of 35patients diagnosed, 4 patients have their MABP readings within the specified range while 31patients have a higher reading with the highest being 203. The green line indicates the lower and upper limit of the parameter which is the normal range.

V. CONCLUSION

In this project/dissertation we proposed an improved expert system for modelling controlled human blood pressure that is capable of a continuous monitoring of a patient's blood pressure and other critical health parameters. In fact, our goal is to characterize the signs for blood pressure status, which has being sufficiently proven in the initial stage.

Thus, the system comprises of nodes (coordinator node) for acquiring the physiological data of a patient, a Wireless Multi-Hop Relay Node (WMHRN) which forwards the acquired data and a Base Station which receives data. The model can perform a long-term monitoring of the condition of health of a patient and is also supported with SMS messaging format rescue mechanism.

In this study, a mobile multi-parameter sensor for measuring vital signs has been successfully implemented. This system was able to demonstrate the feasibility of having an integrated mobile sensor based multi-parameter vital sign monitor that could continuously monitor users' BP status. Having gone this far it demonstrated the feasibility of having a system (intelligent software via fuzzy logic) that could effectively warn users early enough of impending or potential crisis or attacks from BP. The research ably demonstrates and reinforced the knowledge about the utility of the mobile phone as a handy tool for transmission, processing and storage of medical information and could effectively communicate with its user.

Thus, the system comprises of nodes (coordinator node) for acquiring the physiological data of a patient, a Wireless Multi-Hop Relay Node (WMHRN) which forwards the acquired data and a Base Station which receives data. The model can perform a long-term monitoring of the condition of health of a patient and is also supported with SMS messaging format rescue mechanism.

In this research work,BP curve model that tookdicrotic notchinto account resulting from aortic valve being closed. This was important because it didhelp the model in accounting for insufficiency in the work and the pressure changes in vascular tree resulting from the vascular compliance and resistance changes

Contributions to Knowledge

The contribution of this research to knowledge isan automated continuous intelligent health monitor with a fuzzy based life saving device; a model of mobile vital sign monitor that can capture many vital signs continuously not at the instance of the user/patient as had been the case, using only one integrated simple sensor unit.

It could also give a timely alert to users and care provider of health dangers directly through common SMS. Thus the research has also contributed and reinforced the knowledge about the utility of the mobile phone as a handy tool for transmission, processing and storage of medical information.

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