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Telemedicine Setup using Wireless Body Area Network over Cloud

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Abstract

Healthcare has been grown into a new paradigm because of Telemedicine. Hence patients get easy access of teleconsultations for diagnosis and treatments. Patients get numerous benefits in practicing telemedicine when there is a need of an immediate consultation, being anywhere. In this paper, through wireless body area network, telemedicine has been investigated and practiced for remote patients constantly being monitored. The medical records of patients are stored very carefully in the cloud. The doctors create a network who can respond to emergency conditions of patients. Here, three different parameters viz., blood viscosity, blood pressure and blood sugar level are measured, constantly monitored, and sent to cloud for storage and analysis. Then, for emergency condition, on the spot treatment is given after teleconsultation, by the doctor near the patient's locality; otherwise teleconsultation alone is given. The healthcare professionals at the care centers have remote monitoring capability as well as registers patients for storing and monitoring health information anytime, anywhere. Security during teleconsultation is also possible as the data are stored in cloud. Cloud gives dynamic, scalable and portable infrastructure. This is achieved through the use of trusted software, compliance understanding, lifecycle management, portability, continuous monitoring, and choice of right people. It is possible through secure log-in access, risk tolerance, cost-benefit analysis giving protection to data, applications and infrastructure. There is high-level security like avoiding attack, no unauthorized leaks and exposure of data and no weak access of control. This is achieved through data-centric approach where the data is encrypted and strengthened through the authorization process of requiring strong passwords and two factor authentication.

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1. Introduction

1.1. Telemedicine

In recent years, patients experience consultations remotely through Telemedicine. Here, diagnosis, treatment and healthcare services can be done effectively. It helps in solving health related issues globally. The delivery of health services must be of high-quality and immediate response. It increases care by accessing medical data remotely. It evolves through new health advancements and health needs. It improves outcomes of health and support clinically. It is used by military, space, television for teleconsultations and healthcare delivery services. Telemedicine applications can be from healthcare professionals and patients or from patients to healthcare professionals or between healthcare professionals. Hence the healthcare service delivery can be migrated from clinics to homes.

1.2. Cloud

The health data are stored in cloud, so that whenever the healthcare professionals need them, they can be easily retrieved and shared making cloud storage reliable. The cloud gives the comfort of security, data collection, data management, data accessibility and data analysis. It give many benefits like no hardware to purchase, very quick execution and powerful data management. It must be available at any time, safe and there should be no data loss. It must also ensure compliance and data protection. There are different types of cloud storage like mobile, public, private and hybrid. Mobile cloud stores only individual data and has increased data accessibility. Public cloud manages an enterprise's storage. Private cloud offers performance and security.

2. Literature survey

Telemedicine is made possible through information and communication technology (ICT). It provides quick healthcare service delivery by managing patients and healthcare professionals [1]. Telehealth system offers teleconsultation through healthcare centers for analyzing patients at home or hospital. This saves time and also provides secure access of health records by patients and doctors. So patients easily access their results. The health records stores health information of the patient and shares only to the authenticated persons [2]. Profile of patients and doctors, patient history, lab test results, prescriptions given to patients are also maintained in health records. Interoperability and security should also be taken care when maintaining health. Medical monitoring tracks the activities of patients, by giving assistive care. Whenever the health condition of patient is abnormal, it alerts doctors. Healthcare centers are growing rapidly with telehealth systems for easy delivery and security [3]. Telehealth supports digital healthcare and multiple healthcare services are handled uniquely while servicing patients. Next-generation healthcare is patient-friendly having numerous benefits for patients. Telemedicine offers precise medical consultations with prompt data access and authentication [4]. Doctors easily access the health data of rural patients in urban hospitals. Telemedicine application optimizes the care of delivery in liver disease [5], it also explains the support of evaluation, management and remote monitoring interventions for liver disease patients. Technology acceptance model (TAM) used in [6] is useful, easy and acceptable for healthcare providers. It has questionnaire for consultations. Health care providers give tele psychiatry [7] for children. This can be implemented in schools for the betterment of children at schools. These services are considered to be more efficient and effective for school children. For managing disasters, multinational telemedicine system was implemented in [8] where communication protocols, web based tools are developed for patient recovery. Its evaluation is based on deployment capabilities. Neonatal care [9] is also possible through telemedicine. This system assures safety and also extends intensive care even in medically underserved areas. Acceptability of text messages [10] was feasible with descriptive statistics and bivariate analyses for real-time data collection which optimizes the response rates. It has advantages like less delay,

low cost and highly scalable architectures [11]. For data analytics, telemedicine helps in deriving innovative information medically [12].

3. Proposed Wireless Body Area Network Based Telemedicine through Cloud

The proposed WBAN network helps the patients to know their blood viscosity levels, blood pressure level and blood sugar level through telemedicine. For finding the blood viscosity of a patient, similar to a prototype model of measuring the viscosity of Newtonian fluids [1] can be made which finds the viscosity through the load sensor connected to arduino and then power amplifier for measuring the feeble voltage. This sends the viscosity values to the cloud for further analysis and storage. Similarly, the blood pressure and blood sugar levels are also measured accordingly and stored in cloud for further processing and analysis. A tree model which records the desired activity is used for analysing as shown in Fig. 1. Decision trees with nodes, branches graphically represent the possible outcomes. The square decision node denotes the choice that must be taken. The circle random node does not depend on the decision maker's control and it denotes events that are with influence of chance. The triangle terminal nodes denotes the decisions' outcome. First, the problem is defined and the probabilities are identified with health outcomes.

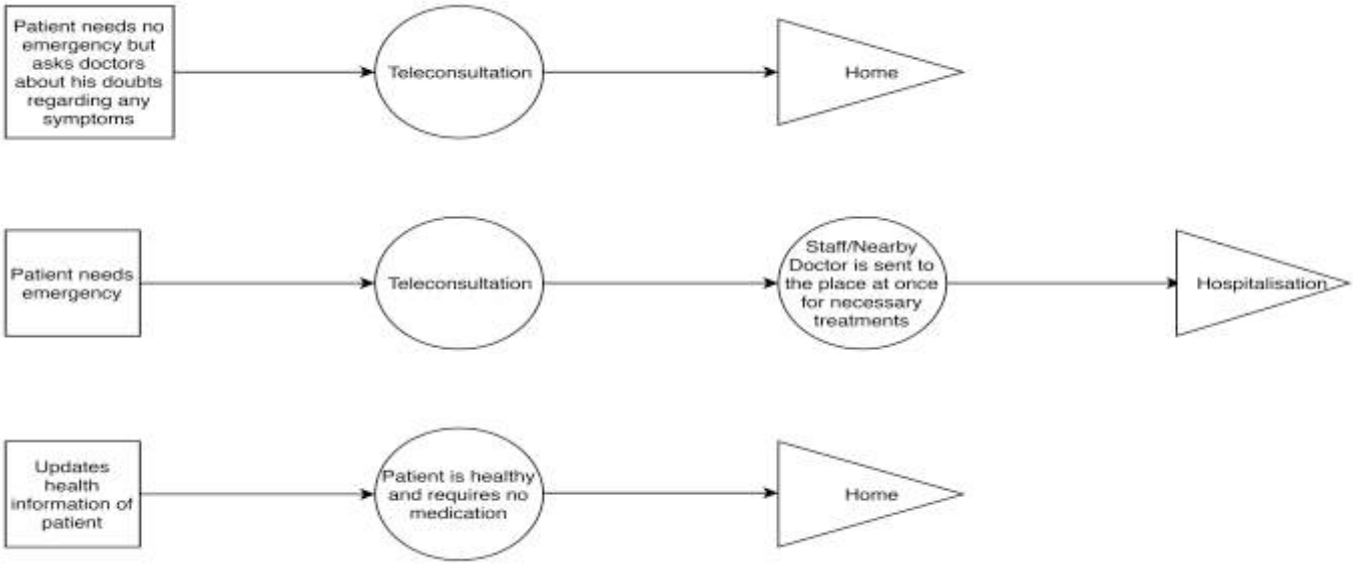
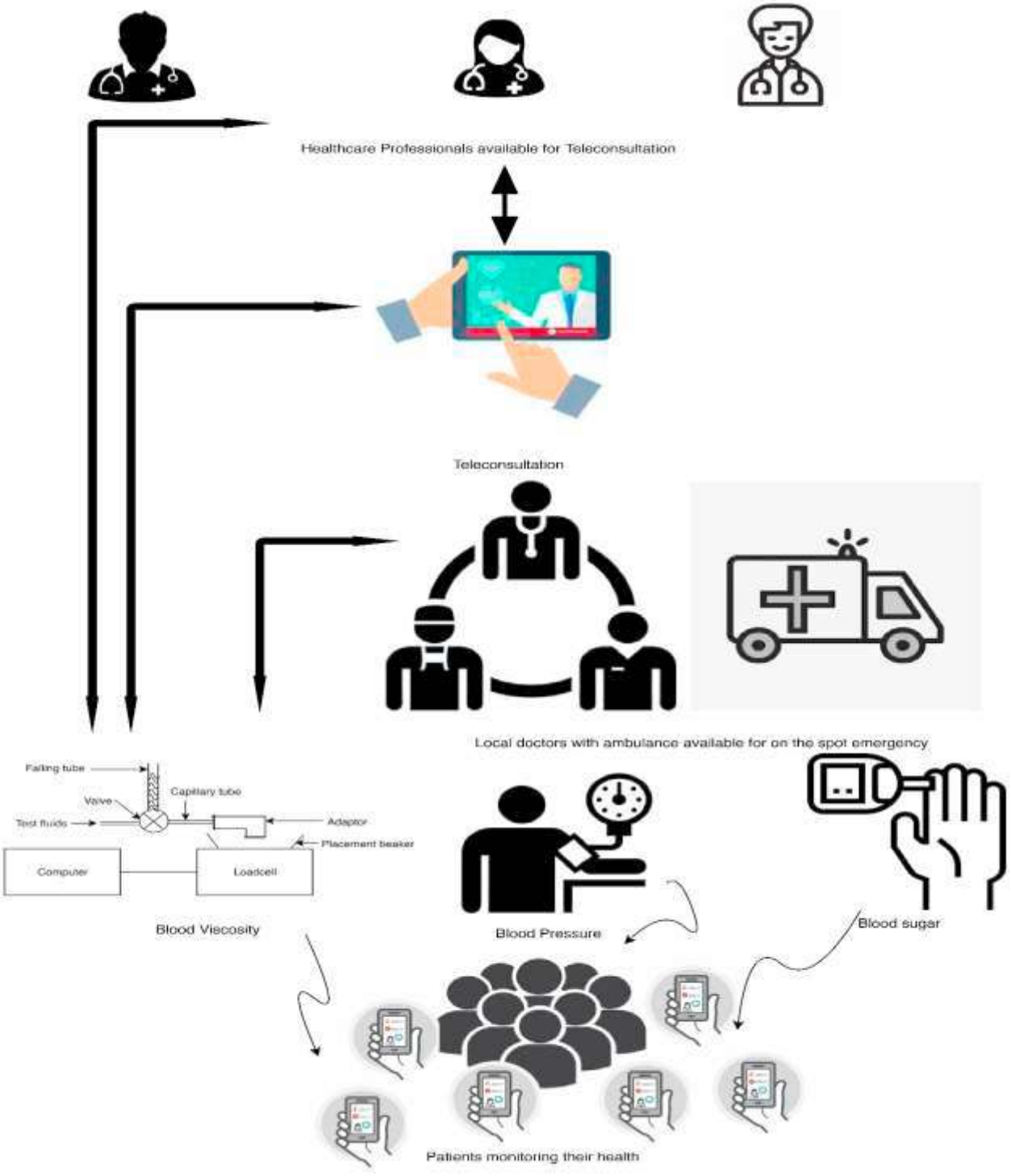


Fig.1. Decision tree model for Telemedicine.

The patient's involvement for remote monitoring also plays a key role in telecare. By telecare, the patient becomes responsible, concerned and respect values. The patient experiences multiple telecare objects of healthcare team. This develops remote relationship of telecare with humanity and technical care. The waiting time of patient is reduced drastically through mobile computing. Clinically, point of care delivery is the utmost concern in healthcare. The medical information is shared and validated remotely. Doctors' network is created which constitutes of doctors from different hospitals who are capable for giving initial diagnosis and treatment thus minimizing consultation time. The managing protocols are implemented by doctors.

The proposed method takes care of the patients by analysing the decision tree. Fig. 2 shows the proposed remote monitoring system for Telemedicine. Teleconsultation patients are handled easily, but if there is an emergency case, a doctor will be sent to the spot in ambulance. The percentage of probability defined, the disease and symptoms

finally decides the doctor according to his specialization. After consulting, the doctor analyse the condition of the



patient and decides whether he must be admitted locally or treated remotely.

Fig. 2. Proposed remote monitoring system for Telemedicine.

Cloud security requires secure log-in which can be achieved through strong password authentication. Hybrid clouds are very safe because of the placement of workloads and data which are based completely on compliance, security, policy and audit requirements, which protects sensitive data in private cloud and other data in public cloud. It manages security by preventing unauthorized access. The data can be more secured in datacentres which require compliance for storing the health information. Some important cloud features needed for security are (i) ubiquitous i.e. the cloud must be reachable; (ii) scalable i.e. any number of features and users can be added without any complication; (iii) integrated i.e. services must recognize and talk to each other; (iv) comprehensive i.e. cloud must scan all bytes received as well as transmitted; (v) intelligent i.e. the cloud learns all users, their connections such that all threats are blocked.

4. Results and Discussions

Telemedicine helps the patients and healthcare professionals through remote monitoring. The doctor can detect emergency condition when the patient is even at home. Patients, healthcare professionals and remote healthcare centers constantly keep in touch and are aware of the possible outcomes. Sensor nodes measure the patients' signs and through a mobile app. For measuring the patients' vital signs like blood viscosity, blood pressure, blood sugar, many sensors can be attached non-invasively. The patient and also the doctors at remote care centers can view them; and if any condition is abnormal, then an automatic call is made to the care centre and the doctor alerts the locally available ambulance and doctor for on the spot critical situations. The healthcare professionals monitor through teleconsultation. In teleconsultation, the patient is remotely monitored and his vital signs are analyzed by expert doctors through cloud application. The health data of all patients are stored in the cloud for analysis. From the cloud, the patients' profile, health professionals' availability, anomalies from health data, identification of diseases and symptoms are carried out effectively. In the same way, the anomalies in the data are identified for faster and precise teleconsultation. The patients' health data are recorded and updated in the computer whenever patient comes for teleconsultation. It is used for keeping electronic health records updated.

Table 1. Finding anomalies from health data

Data	Q1	Q3	IQR	Upper bound	Lower bound	Outlier
110	105	120	15	142.5	82.5	False
100	103.75	120	16.25	144.375	79.375	False
120	111.5	120	8.5	132.75	98.75	False
99	108.25	120	11.75	132.625	90.625	False
150	118	120	2	123	115	True
96	118.75	122.5	3.75	128.125	113.125	True
130	119.5	125	5.5	133.25	111.25	False
145	119.25	120	0.75	121.125	118.125	True
120	119	120	1	121.5	117.5	False
118	118.75	120	1.25	121.875	116.875	False
119	119.5	120	0.5	120.75	118.75	False
120	120	120	0	120	120	False
120	120	120	0	120	120	False

One case study for finding anomalies from blood pressure data is shown in the Table 1. Data analysis can be improved by applying the statistical properties. The abnormal data can be easily identified with the help of outliers, which can be clearly identified through quartiles. This helps in identifying the high pressure values which are above normal values of blood pressure. Anomalies are figured out when a new data is checked against the other data in the

same range. The first step is the calculation of quartiles. Secondly, the upper and lower boundaries are calculated. Finally the results are evaluated and identified whether they are normal values or abnormal values. The patient data is analyzed with the previously stored data and the outliers are found easily. The data is checked whether it is in first half of dataset & again it is checked whether it is in the second half of dataset with quartile function. Then interquartile range is found by finding the difference between them. Finally outliers are calculated with the help of upper bound (greater than Q3 by 1.5 times) and lower bound (lesser than Q1 by 1.5 times) and evaluated as true or false. The Eq. (1) – (5) finds the anomalies of the blood pressure data.

$$Q1=QUARTILE\ (array,\ 1) \tag{1}$$

$$Q3=QUARTILE\ (array,\ 3) \tag{2}$$

$$IQR = Q3 - Q1 \tag{3}$$

$$Upper\ bound = Q3 + (1.5 * IQR) \tag{4}$$

$$Lower\ bound = Q1 + (1.5 * IQR) \tag{5}$$

$$Outlier = OR\ (Data>Upper\ bound,\ Data<Lower\ bound) \tag{6}$$

The blood pressure of a patient is dependent on the age of that person which is easily read by the blood pressure chart [13]. From this chart, the relationship between them is found using correlation and the predicted response is found through regression. Correlation analysis is obtained by finding the degree of association i.e. correlation coefficient. From the data analysis toolbox, the coefficient is found out. If it is nearer to 1, then the variables are related closely which describes associated strength between them. Regression finds the dependency of a variable to the independent variable. It can be obtained through the regression equation which specifies that average of dependent value is a function of independent value. The R^2 gives the variation of blood pressure is explained by the age of the patient. The value closer to 1, fits with better regression. Significance F and P-value must always be lesser than 0.05. If it is greater than 0.05, then P-value must be deleted. The coefficients m and a are found and substituted in Eq. (7). Residual help in calculating the predicted data point from Eq. (7). Regression gives the functional relation between the variables, thus making future predictions on events. The blood pressure data with the age from 1-100 is taken in excel, and correlation is found as 0.905, which says that the variables are highly associated. Then R^2 and regression coefficients m and a are found to be 0.826 and -329.77 and 3.018 respectively as shown in Table 2. The residual data for age (1 -100) is also found, which gives the predicted data point.

$$y = f\ (x) + a \tag{7}$$

Table 2. Finding R^2 from health data and Regression coefficients from health data

Regression Statistics	
Multiple R	0.908885118
R Square	0.826072158
Adjusted R Square	0.824279087
Standard Error	12.04033857
Observations	99

	Coefficients
Intercept	-329.7745769
	3.018390833

Because of cloud storage, there is reliable information processing which is very fast and cheap. Hence the emergency situations are handled with ease, secure and efficient providing assistance quickly. This helps in managing health information, accessing services of cloud and also minimizes healthcare professionals' work. Patients and doctors involved in teleconsultation can be distinguished easily. Prediction is performed from the stored data, availability of healthcare professionals and critical alert messages that are sent to local doctor.

5. Conclusions

By telemedicine setup, the patients get quick consultation even in emergency situations. The storage of health data is in cloud for securing the system. Proper health management is taken care because of secure authorization and access. The healthcare providers take an additional step for providing secure access and storage of health data. Hence through telemedicine secure transmission of health data and reception of health data becomes possible with cloud security. Elderly care of remote patients who are unable to visit doctors frequently can make their doctors visit through teleconsultation with the help of WBAN.

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