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RESEARCH ARTICLE

PATIENT MONITORING SYSTEM USING ANDROID TECHNOLOGY

Prema Sundaram[1]

[1]Biomedical Engineering & P.S.N.A College of Engineering and Technology, India

[1] *premas@psnacet.edu.in*

Abstract— Telemedicine is a rapidly developing application of clinic medicine where medical information is transferred through the phone or internet or other networks for the purpose of consulting and performing remote medical procedures or examinations. Telemedicine can be applied to a greater extend in the field of cardiology where ECG serves as the major tool. This project elaborates the experience; a methodology adopted and highlights various design aspects to be considered for making telemedicine in patient monitoring system effective. In this method, the patient's vital signs like ECG, heart rate, breathing rate, temperature, SpO_2 are captured and the values are entered into the database. It is then uploaded into the web based server and sent to the doctor's phone using ANDROID technology. It also enables the doctors to instantly send back their feedback to the nurse station.

Key Terms: - telemedicine; android; cardiology; database

I. INTRODUCTION

The modern visionary of healthcare industry is to provide better healthcare to people anytime and anywhere in the world in a more economic and patient friendly manner. Therefore for increasing the patient care efficiency, there arises a need to improve the patient monitoring devices and make them more mobile. The medical world today faces two basic problems when it comes to patient monitoring. Firstly, the needs of health care's provider's presence near the bedside of the patient and secondly, the patient is restricted to bed and wired to large machines. In order to achieve better quality patient care, the above cited problems have to be solved.

As the bio instrumentation, computers and telecommunications technologies are advancing, it has become feasible to design more portal vital sign tele monitoring systems to acquire, record, display and to transmit the physiological signal from the human body to any location. Recent works in communication technologies have inspired the development of telemedicine to a large extent. Telemedicine benefits not only the customers who are able to receive health care more efficiently; it also benefits the doctors who can streamline their efforts to assist more patients.

A. Tele-Health Care

Tele-healthcare is the use of information technology to provide healthcare services at a distance. It includes anything from medical services at the inpatient or at the outpatient stage. It could even include when a doctor in one hospital supports surgery with a doctor in another hospital somewhere on another continent. What the doctors actually would like to see is constant monitoring of those parameters so they always know what the history is and how big the change from yesterday to today be and when you have these findings and have these data points available, then a much earlier intervention can take place for a patient.

Telemedicine can be extremely beneficial for people living in isolated communities and remote regions and is currently being applied in virtually all medical domains. Patients who live in such areas can be seen by a doctor or specialist, who can provide an accurate and complete examination, while the patient may not have to travel or

wait the normal distances or times like those from conventional hospital or general practitioner visits. Recent developments in mobile collaboration technology with the use of hand-held mobile devices allow healthcare professionals in multiple locations the ability to view, discuss and access patient issues as if they were in the same room.

B. Telemedicine

Telemedicine is the use of electronic information and telecommunication technologies to support long distance health care, patient and professional health care, patient and professional health related education, public health and health administration. Telemedicine can be used as a teaching tool, by which experienced medical staff can observe, show and instruct medical staff in another location by more effective or faster examination techniques. It has been shown to reduce the cost of healthcare and increase efficiency through better management of chronic diseases, shared health professional staffing, reduced travel times, and fewer or shorter hospital stays.

C. Telemonitoring

Telemonitoring is a medical practice that involves remotely monitoring patients who are not at the same location as the health care provider. In general, a patient will have a number of monitoring devices at home, and the results of these devices will be transmitted via telephone to the health care provider. Telemonitoring is a convenient way for patients to avoid travel and to perform some of the more basic work of healthcare for themselves. In addition to objective technological monitoring, most telemonitoring programs include subjective questioning regarding the patient's health and comfort. This questioning can take place automatically over the phone, or telemonitoring software can help to keep the patient in touch with the health care provider. The provider can then make decisions about the patient's treatment based on a combination of subjective and objective information similar to what would be revealed during an on-site appointment.

Some of the more common things that telemonitoring devices keep track of include blood pressure, heart rate, weight, blood glucose, and hemoglobin. Depending on the severity of the patient's condition, the provider may check these statistics on a daily or weekly basis to determine the best course of treatment. Monitoring a patient at home using known devices like blood pressure monitors and transferring the information to a caregiver is a fast growing emerging service. These remote monitoring solutions have a focus on current high morbidity chronic diseases and are mainly deployed for the first world.

The Telemedicine system consists of customized hardware and software at both the patient and specialist doctor ends with some of the diagnostic equipments like ECG, X-ray or pathology microscope/camera provided at the patient end. Through a telemedicine system consisting of simple computer with communication systems, the medical images and other information pertaining to the patients can be sent to the specialist doctors, either in advance or on a real time basis through the satellite link in the form of digital data packets. These packets are received at the specialist centre, the images and other information are reconstructed so that the specialist doctor can study the data, perform diagnosis, interact with the patient and suggest the appropriate treatment during a video conference with the patient end. Telemedicine facility thus enables the specialist doctor and the patient separated by thousands of kilometers to see visually and talk to each other. This enables the specialist doctor to assess the physical and psychological state of the patient and suggest treatment. In this way, the systematic application of information and communication technologies to the practice of healthcare rapidly expands the outreach of the healthcare system.

D. Remote Patient Telemonitoring

Remote patient monitoring (RPM) is a technology to enable monitoring of patients outside of conventional clinical settings (e.g. in the home), which may increase access to care and decrease healthcare delivery costs.

Incorporating RPM in chronic disease management can significantly improve an individual’s quality of life. It allows patients to maintain independence, prevent complications, and minimize personal costs. RPM facilitates these goals by delivering care right to the home. In addition, patients and their family members feel comfort knowing that they are being monitored and will be supported if a problem arises. This is particularly important when patients are managing complex self-care processes such as home haemodialysis. Key features of RPM, like remote monitoring and trend analysis of physiological parameters, enable early detection of deterioration; thereby, reducing number of emergency department visits, hospitalizations, and duration of hospital stays. The need for wireless mobility in healthcare facilitates the adoption of RPM both in community and institutional settings. The time saved as a result of RPM implementation increases efficiency, and allows healthcare providers to allocate more time to remotely educate and communicate with patients.

E. Remote Patient Telemonitoring Using Android Technology

Remote patient telemonitoring system using Java enabled 3G mobile phone enables doctors to monitor the vital bio signal such as *ECG*, Respiration rate, heart rate SpO_2 and temperature, of patients in ICU/CCU using

the real time waveform and data monitoring function of installed Java based application on the mobile phone. This project discusses the benefits of patient monitoring using android technology. It discusses the technology to collect data from a patient monitoring system, to feed the same to two separate interfaces displaying the patient parameters and details and sync the important information to a web based server. This can in turn accessed by the doctor remotely using an application installed in his android phone, which he analyses and sent feedback in order to take preventive measures before he reaches the hospital. The physiological parameters like temperature, heart rate, ECG, breathing rate and SpO_2 are acquired from the patient monitoring system. Values such as R-wave amplitude and QRS complex width are also acquired in order to simulate an ECG waveform in the android application, which enable the doctors to get a clear scenario of the patient condition.

II. MATERIALS AND METHODS

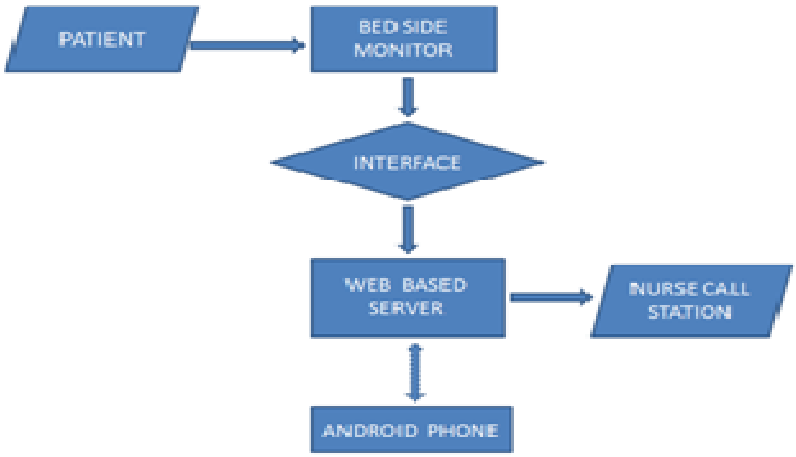

Fig. 1 Block Diagram

A. *Sofwares Used*

- *Java*

Java is used in a wide variety of computing platforms from embedded devices and mobile phones on the low end, to enterprise servers and supercomputers on the high end. While less common, Java applets are sometimes used to provide improved and secure functions while browsing the World Wide Web on desktop computers.

- *Android*

Android is a Linux-based operating system for mobile devices such as smart phones and tablet computers. It is developed by the Open Handset Alliance led by Google. Google releases the Android code as open-source, under the Apache License. The Android Open Source Project (AOSP) is tasked with the maintenance and further development of Android. The version used here is Android 2.2 Froyo was released, based on Linux kernel 2.6.32 is used to carry out out our project work.

- *ECLIPSE*

Eclipse is an open source community, whose projects are focused on building an open development platform comprised of extensible frameworks, tools and runtimes for building, deploying and managing software across the lifecycle. The Eclipse SDK consists of the Eclipse Platform, Java development tools and the Plug-in Development Environment.

- *XAMPP*

This is intended for use only as a development tool, to allow website designers and programmers to test their work on their own computers without any access to the Internet. XAMPP 1.8.1 for Windows, including:

1. *Apache 2.4.3*
   - The Apache HTTP Server is a web server software program notable for playing a key role in the initial growth of the World Wide Web.
2. *MySQL 5.5.27*
   - The mobile phone stores the recorded data in a SQLite database. This is needed because it is not necessary that there will always be a network available to forward the biomedical data to the server. MySQL was chosen over SQLite as database management system.

B. Patient Parameters

ECG

Electrocardiography is a trans thoracic (across the thorax or chest) interpretation of the electrical activity of the heart over a period of time, as detected by electrodes attached to the surface of the skin and recorded by a device external to the body.

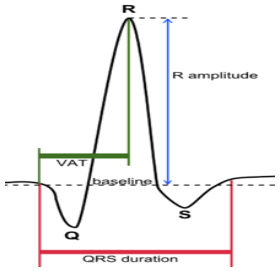

Fig. 2 Wave description

The recording produced by this non-invasive procedure is termed an electrocardiogram (also ECG or EKG).An ECG is used to measure the rate and regularity of heartbeats, as well as the size and position of the chambers, the presence of any damage to the heart, and the effects of drugs or devices used to regulate the heart, such as a pacemaker.

Most ECGs are performed for diagnostic or research purposes on human hearts, but may also be performed on animals, usually for diagnosis of heart abnormalities or research.

Table 1

ECG Parameters

Feature	Description	Duration
RR interval	The interval between an R wave and the next R wave: Normal resting heart rate is between 60 and 100 bpm.	0.6 to 1.2s
P wave	During normal atrial depolarization, the main electrical vector is directed from the SA node towards the AV node, and spreads from the right atrium to the left atrium. This turns into the P wave on the ECG.	80 ms
PR interval	The PR interval is measured from the beginning of the P wave to the beginning of the QRS complex. The PR interval reflects the time the electrical impulse takes to travel from the sinus node through the AV node and entering the ventricles. The PR interval is, therefore, a good estimate of AV node function.	120 to 200 ms
PR segment	The PR segment connects the P wave and the QRS complex. The impulse vector is from the AV node to the bundle of His to the bundle branches and then to the Purkinje fibers. This electrical activity does not produce a contraction directly and is merely traveling down towards the ventricles, and this shows up flat on the ECG. The PR interval is more clinically relevant.	50 to 120 ms
QRS complex	The QRS complex reflects the rapid depolarization of the right and left ventricles. They have a large muscle mass compared to the atria, so the QRS complex usually has much larger amplitude than the P-wave.	80 to 120 ms
J-point	The point at which the QRS complex finishes and the ST segment begins, it is used to measure the degree of ST elevation or depression present.	N/A
ST segment	The ST segment connects the QRS complex and the T wave. The ST segment represents the period when the ventricles are depolarized. It is isoelectric.	80 to 120 ms
T wave	The T wave represents the repolarization (or recovery) of the ventricles. The interval from the beginning of the QRS complex to the apex of the T wave is referred to as the absolute refractory period. The last half of the T wave is referred to as the relative refractory period (or vulnerable period).	160 ms
ST interval	The ST interval is measured from the J point to the end of the T wave.	320 ms
QT interval	The QT interval is measured from the beginning of the QRS complex to the end of the T wave. A prolonged QT interval is a risk factor for ventricular tachyarrhythmias and sudden death. It varies with heart rate and for clinical relevance requires a correction for this, giving the QTc.	Up to 420 ms in heart rate of 60 bpm

U wave	The U wave is hypothesized to be caused by the repolarization of the interventricular septum. They normally have a low amplitude, and even more often completely absent. They always follow the T wave and also follow the same direction in amplitude. If they are too prominent, suspect hypokalemia, hypercalcemia or hyperthyroidism usually.	
J wave	The J wave elevated J-point or Osborn wave appears as a late delta wave following the QRS or as a small secondary R wave. It is considered pathognomonic of hypothermia or hypocalcaemia.	

The following table mentions some pathological patterns that can be seen on electrocardiography, followed by possible causes.

Table 2
Pathological variations in ECG

Shortened QT interval	Hyperkalaemia, some drugs, certain genetic abnormalities, hyperkalaemia
Prolonged QT interval	Hypocalcaemia, some drugs, certain genetic abnormalities
Flattened or inverted T waves	Coronary ischemia, hypokalaemia, left ventricular hypertrophy, digoxin effect, some drugs
Hyper acute T waves	Possibly the first manifestation of acute myocardial infarction, where T waves become more prominent, symmetrical, and pointed
Peaked T wave, QRS wide, prolonged PR, QT short	Hyperkalemia, treat with calcium chloride, glucose and insulin or dialysis
Prominent U waves	Hypokalemia

Heart Rate

A normal resting heart rate for adult's ranges from 60 to 100 beats a minute. Generally, a lower heart rate at rest implies more efficient heart function and better cardiovascular fitness. There are many ways in which the Heart Rate speeds up or slows down. Normal resting heart rates range from 60-100 bpm. Bradycardia is defined as a resting heart rate below 60 bpm. However, heart rate from 50 to 60 bpm are common among healthy people and do not necessarily require special attention. Tachycardia is defined as a resting heart rate above 100 bpm, though persistent rest rates between 80-100 bpm, mainly if they are present during sleep, may be signs of hyperthyroidism or anemia.

Pulse Rate

The pulse rate can be used to check overall heart health and fitness level. In medicine, one's pulse represents the tactile arterial palpation of the heartbeat by trained fingertips. Pulse (or the count of arterial pulse per minute) is equivalent to measuring the heart rate.

Several pulse patterns can be of clinical significance. These include:

- Pulsus alternans
- Pulsus bigemnus
- Pulsus bisferiens
- Pulsus tardus et parvus
- Pulsus paradoxus
- Tachycardia

Temperature

Body temperature is a measure of the body's ability to generate and get rid of heat. The body is very good at keeping its temperature within a narrow, safe range in spite of large variations in temperatures outside the body. Normal human body temperature, also known as normothermia or euthermia, depends upon the place in the body at which the measurement is made, and the time of day and level of activity of the person.

Different parts of the body have different temperatures. Rectal and vaginal measurements, or measurements taken directly inside the body cavity, are typically slightly higher than oral measurements, and oral measurements are somewhat higher than skin temperature. The commonly accepted average core body temperature (taken internally) is 37.0 °C (98.6 °F).

SpO2

Usually, levels of SpO_2 range from 96 to 99% in healthy individuals. However, when patients have pulmonary or cardiovascular chronic diseases at the same time as a common cold or pneumonia, the level of SpO_2 may drop rapidly. SpO_2 lower than 90% is defined as acute respiratory failure. When SpO_2 drops by 3 to 4% from its usual level, even if it is not less than 90%, an acute disease may be suspected. In some patients, usual levels of SpO_2 may be below 90%. Most other individuals will have fluctuations of 3 to 4%.

Depending on individual pulmonary or cardiovascular conditions, the level of SpO_2 may be relatively higher at rest, even though the level drops considerably during exercise or sleep. As with "normal" body temperature,

the level of SpO_2 varies from person to person. Therefore, it is best to record the individual's level of SpO_2 over a long period, and determine their typical range at rest and at various levels of activity so that abnormal decreases can be detected.

C. Database Creation
Control Panel

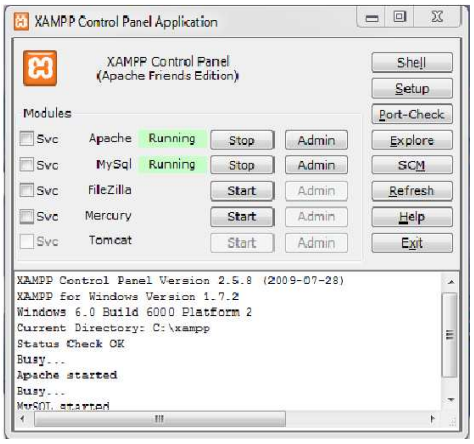

Fig. 3 Control panel

The Control panel is used to create the database .The main software used for this is XAMPP. It mainly consists of Apache, MySQL, FileZilla, and Mercury Tomcat. In this project, Apache and MySQL are used to create the database. The options Apache and MySQL are started. Later the admin of MySQL opens to another window. On opening the database ICU Biomedical and the option patient details will lead us to the patient details window.

Patient Details

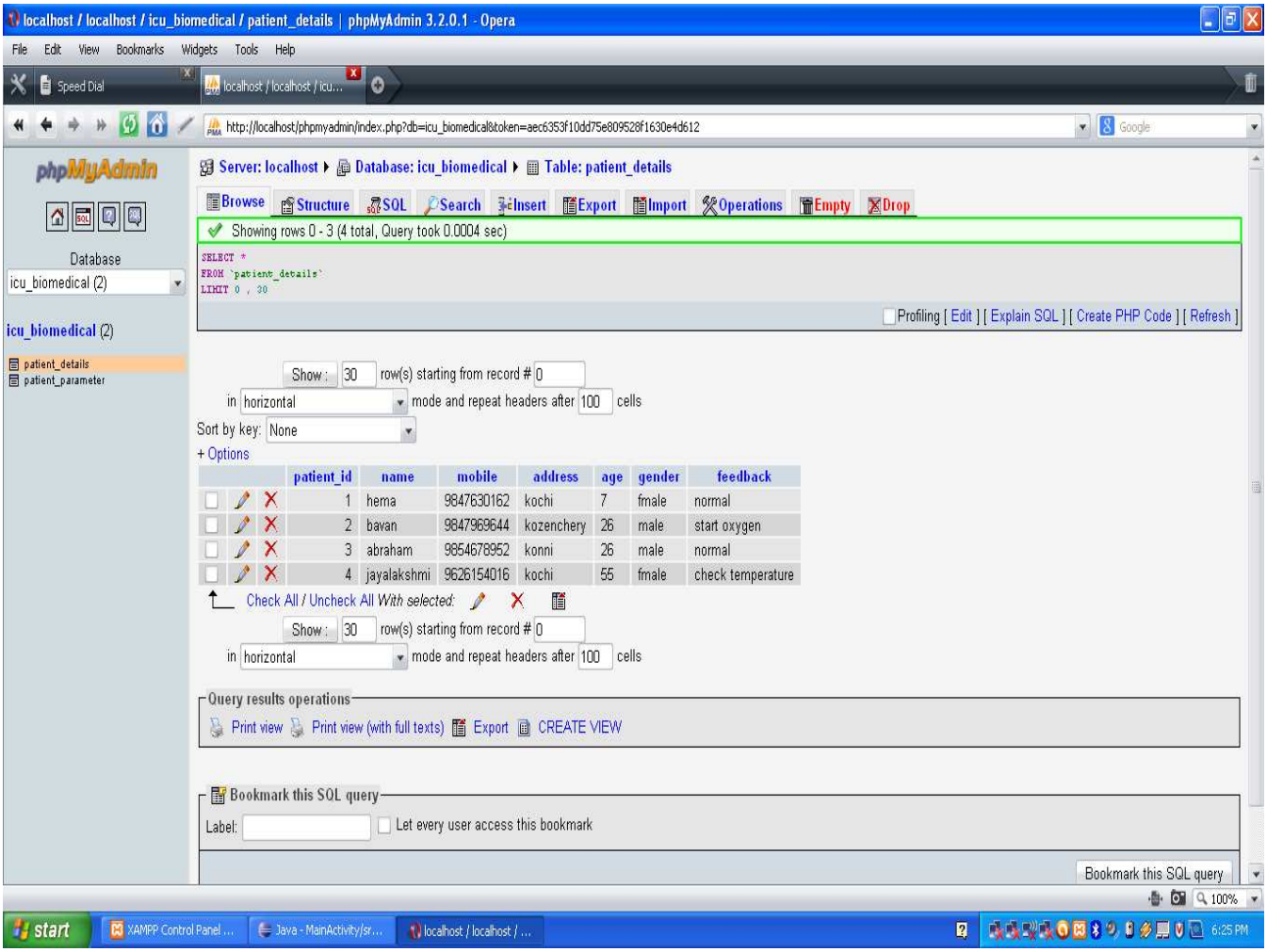

Fig.4 Patient details

The 'patient details window' is used to create a database on patient details containing the necessary information of the patients which includes patient ID, name, mobile number, address, age, gender and feedback. There are separate options to edit and create the database so that the data can be updated on time.

Patient Parameters

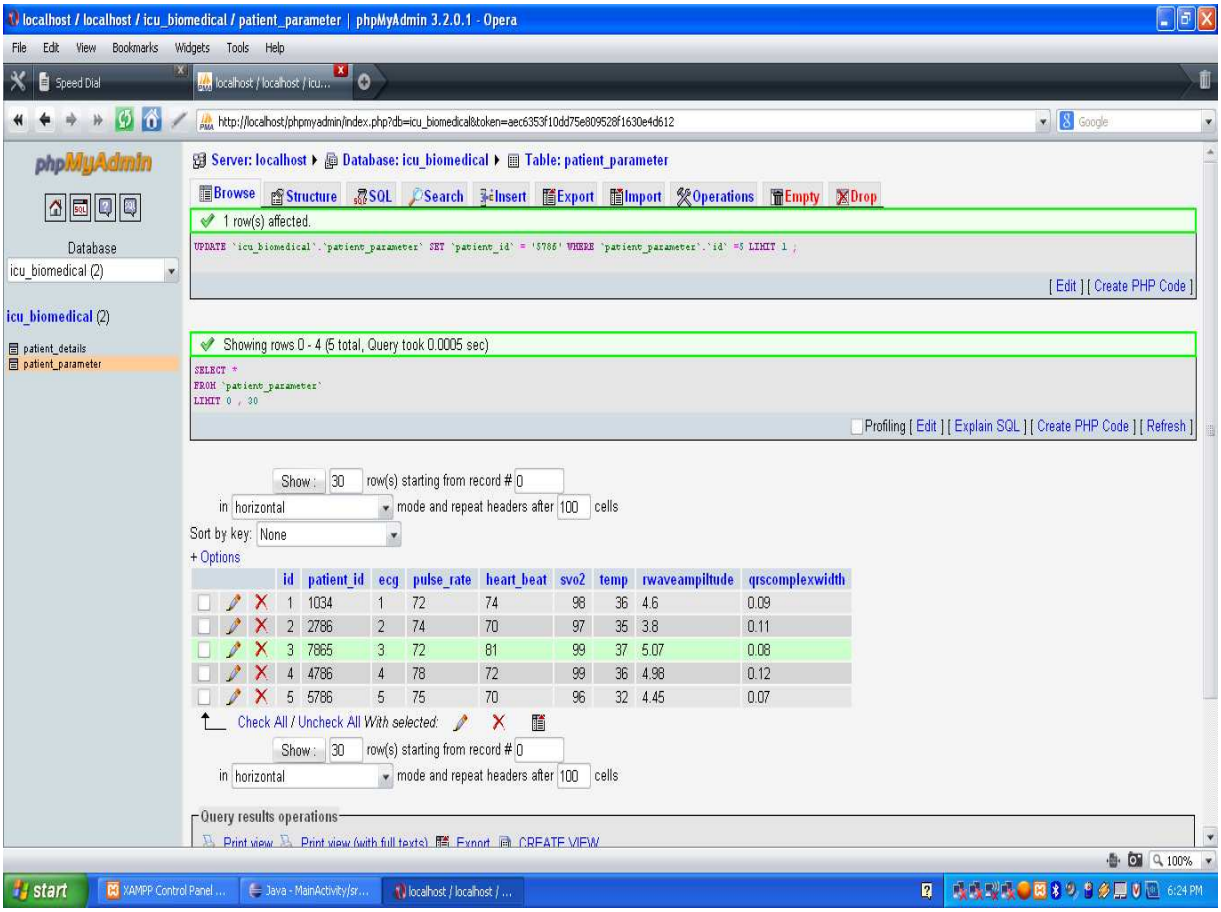

Fig.5 Patient Parameters

The patient parameters window helps in including a database containing the patient parameters such as patient ID, ECG, pulse rate, heart rate, SpO_2, temperature, R wave amplitude and QRS complex width. There are separate options to edit and create the database so that the data can be updated on time

D. Android Emulator

Fig.6 Android emulator

The Android SDK includes a mobile device emulator — a virtual mobile device that runs on our computer. The emulator lets us develop and test Android applications without using a physical device. This document is a reference to the available command line options and the keyboard mapping to device keys.

III. RESULTS AND DISCUSSION

Remote patient monitoring system enables the doctor who is not in the hospital to know about the details of his patient. The values of the bedside monitor in the ICU device are obtained and are uploaded to a server. Then it is made available to the doctor. Notification is send in case of abnormality.

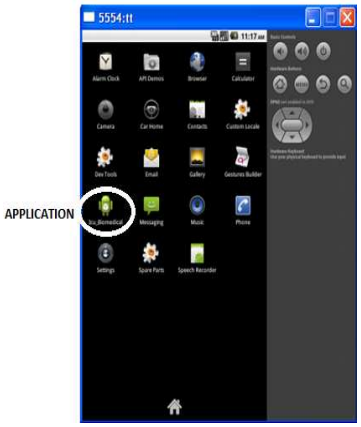

Fig. 7 Mobile application

In this screen the patient parameters like ECG signal, pulse rate, heart rate, temperature and SpO_2 are displayed simultaneously along with the corresponding patient's name. When a patient detail is selected it gets displayed on a separate window.

Fig.8 Application as seen in doctor's phone

In this window each patient's details is particularly viewed. Here two buttons, 'save changes' and ECG are included. When a description is added to the field provided and the save changes button is clicked, the feedback is automatically updated to the feedback. When the ECG is clicked the corresponding waveform is obtained.

Fig.9 Doctor's feedback screen

In this window the corresponding ECG wave pattern is viewed.

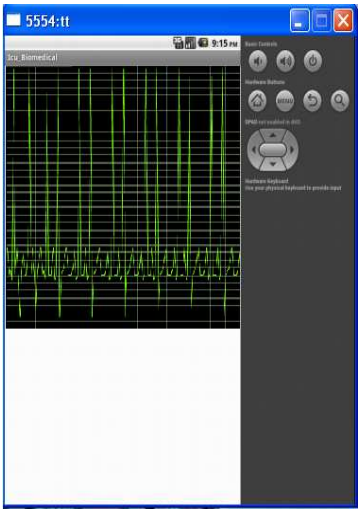

Fig.10 Patient ECG waveform viewed in the doctor's phone

IV. CONCLUSION

This project shows the patient's vital parameters such as ECG, heart rate, SpO2, pulse rate and temperature are measured using a patient monitoring system. These values are entered into a database and are uploaded into a web based server manually; there is scope of entering the database automatically in the future. Also, the entire details of the patient suffering from various chronic diseases like cancer, Alzheimer's etc can be sent to a doctor sitting abroad in order to analyze and recommend the type of treatment and medicines for the diagnosis of the disease.

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