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Smart Health Record for ECG Data and Its Classification for Atrial Fibrillation using NFC card

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***Abstract*— As population is increasing ,it has lead to increase in number of patients & hospitals .Currently biggest task for the doctors in hospital is to maintain & retrieve the patient's data. The data maintaining is a crucial task all over the world . Various methods or technologies are implied to maintain data. Thus understanding the current problem this system is proposed to retrieve data at faster rate in an easy way by using NFC card. The system is introducing smart health record for patient's data(normal , pvc ,heart patient,etc) & based on reports classification is processed. ECG results are shown on graph. For precision results random forest algorithm is used . System also detects Atrial fibrillation atuomatically from signals recorded using an unobtrusivebed-mounted vibration sensor. Mainly system is focused to provide accurate data detection & also maintains accurate patient history. System also retrieves data at faster rate whenever doctor needs patients data , as only patient has to carry NFC card .**

***Index Terms*—NFC , patient ,health , data.**

I. Introduction

As recently there is increase in usage of mobile devices especially in developing countries, they can be used for an efficient healthcare management[1]. In this work, we have proposed a novel architecture for improving health care system with the help of Android based mobile devices with NFC interfaces, smartcard technology on tamper resistant secure element (SE) for storing credentials and secure data, and a HealthSecure service on a Server for security and health record management along with classification of heart disease which can be identified by knowing the classification of heartbeats using Random Forest classifier.

The main contribution of this paper is proposal of applications for i) Secure Medical Tags for reducing medical errors and ii) Secure Healthcard for storing Electronic Health Record (EHR) based on Secure NFC Tags, mobile device using NFC P2P Mode or Card Emulation Mode. Iii) Datamining for Patients ECG feature classification. The electrocardiogram (ECG) is a non-invasive diagnostic and monitoring tool that records the electrical activity of the heart at the body surface [2] . It provides very accurate information about the performance of the heart and cardiovascular system. Any deviation from the norm in a particular ECG measurement is an indication of possible heart disease or abnormality. Early detection of heart diseases enables patients to enhance the quality of their life through more effective treatments. Therefore, numerous researches have been conducted in an attempt to analyze and classify the ECG signal. A heart disease can be identified by knowing the classification of heartbeats. However, this is very tedious task, because some heart diseases appear infrequently, and very long ECG measurements are needed to capture them. The recognition and categorization of the ECG beats is an extremely significant task in the coronary intensive unit, where the classification of the ECG beats is essential tool for the diagnosis. ECG offers cardiologists with useful information about the rhythm and functioning of the heart. Therefore, its analysis illustrates an efficient way to detect and treat unusual kinds of cardiac diseases until now, many algorithms have been expanded for the recognition and classification of ECG signal. Some of them use time and some use frequency domain for depiction. Analysis of a large number of data is very time consuming, thus automated analysis and classification can be very helpful. Automated classification provides inestimable aid for long-term electrocardiography [5], which is a commonplace in patient monitoring, both in bedside and in ambulatory settings. Indeed, a large number of approaches using a variety of techniques have been proposed for this task, easing the diagnosis of arrhythmic changes as well as further inspection, e.g., heart rate variability or heart rate turbulence analysis. However, due to the huge amount of data and the need for classification present in these situations, additional requirements arise concerning the complexity of classification algorithms. Therefore, suited methods are required to enable high performance classification even in unfavorable environments. The Proposed System provides a reliable, simple and fast method for qualitative features selection and determining the heart beat cases from ECG signals.Automatic assessment of Cardiac Vascular Diseases(CVD) [6] for patients has been a long time research; the cardio vascular disease is one of the leading causes of death around the world. The causes of CVD are due to the variations in the heart rate or irregularities and are characterized by the Electrocardiogram (ECG) beats or patterns [1],[2]. The ECG signal is a representation of the bioelectrical activity of the heart representing the cyclical contraction and relaxation of the human heart muscles. To acquire the signal, ECG devices with varying number of electrodes (3– 12) can be used. The Electrocardiogram (ECG) is a vital sign signal for heart functional investigation. This electric signal is generated from human heart to create the cardiac cycle, which generates the blood circulation.

II. TECHNOLOGY

The system uses network & cloud technologies combine using mobile device as a media to detect NFC (Near Field Communication) card & retrieve data . Also the system

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creates its own server to store & retrieve data whenever required. The data can be retrieved either using mobile or machine (Laptop, PC,etc). NFC is the wireless media which is an easy media to exchange the data. Mobile device that has NFC enabled can operate in three modes: i) Reader mode: in which device can read and write to NFC based passive tags. ii) Peer to Peer (P2P) mode in which NFC devices can interact and exchange information with each other iii) Card emulation mode: in which NFC device can operate as a contactless card. Data is secured using RSA Framework. Data is stored on server . The data handled in the Server system is very vital. The server should always be confirmed to run properly and the data are saved to the database at consecutive intervals. Power is a significant feature and the power supply should be always taken care of. An Uninterrupted Power Supply is always recommended.

III. PROPOSED SYSTEM

Following is the proposed system architecture

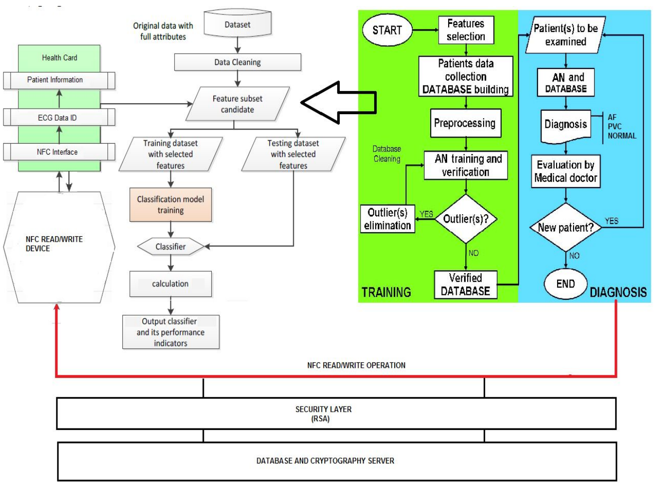

Fig 1 Proposed Architecture

System mainly focuses on patients history data retrieval at faster rate using NFC card .The system is introducing smart health record for ECG data & based on reports classification is processed. Results are shown on graph. Likewise for other diseases also smartly record can be maintained. The Datamining Framework as follows

A. Pre-Processing

I) Filter

The Data collected by the sensor is filtered using High Pass and Low Pass Filter. The filtered data is further given for Pre Process

II) Preprocess

The Filtered data is normalized using the below feature extraction methods

a) Standard deviation of the NN

The simplest variable to calculate is the SDNN that is the square root of variance. Since variance is mathematically equal to total power of spectral analysis, SDNN reflects all the cyclic components responsible for variability in the period of recording. In many studies, SDNN is calculated over a 24 hours period and thus encompasses both short-term high frequency variation, as well as the lowest frequency components seen in a 24-hours period, as the period of monitoring decreases, SDNN estimates shorter and shorter cycle lengths. It should also be noted that the total variance increases with the length of analyzed recording. Thus SDNN is not a well defined statically quantity because of its dependence on the length of recording period. Thus, in practice, it is inappropriate to compare SDNN measures obtained from recordings of different durations. A short-term recording are used in this work. Calculation of standard deviation is below shown in equation.

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2},$$

Where x1,x2..xn are sample & $\overline{x}$ is mean of sample.

b) Standard deviation of differences between adjacent NN intervals

The most commonly used measures derived from interval differences include the standard deviation of differences between adjacent NN intervals. Calculation of standard deviation is show in above equation.

c) Root mean square successive difference of intervals

The most commonly used measures derived from interval differences include the square root of the mean squared differences of successive NN intervals. Calculation of root mean square is show in equation

$$x_{\text{rms}} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}x_i^2} = \sqrt{\frac{x_1^2 + x_2^2 + \cdots + x_n^2}{n}}$$

d) Proportion- pNN50

The number of interval differences of successive NN intervals greater than 50ms (NN50) is calculated. It is used for the proportion derived by dividing NN50 by the total number of NN intervals (pNN50).

IV. ALGORITHMS

The classification of data is based on patient's disease , it may be related to heart , normal , etc. These diseases are classified using algorithm for precision results ,considering patients health as the most important factor. For accurate results for classification of disease especially heart we use two algorithms ,random forest & k-means clustering.

A. Random Forest

Ensemble method is a popular machine learning technique which has been interested in data mining communities. It is widely accepted that the accuracy from the ensemble of several weak classifiers is usuallybetter than a single classifier given the same amount of training information.

Random Forests is an ensemble classifier proposed by Breiman. It constructs a series of classification trees which will be used to classify a new example. The idea used to create a classifier model is constructing multiple decision trees, each of which uses a subset of attributes randomly selected from the whole original set of attributes. However, the rules generated by existing ensemble techniques sometimesconflict with the rules generated from another classifier. This may lead to a problem when we want to combine all rule set into a single rule set. Therefore, several works intend to increase the accuracy of theclassifiers.
The Random Forests [2] [5] is an effective prediction tool in data mining. It employs the Bagging method to produce a randomly sampled set of training data for each of the trees. This Random Forests method also semi-randomly selects splitting features; a random subset of a given size is produced from the space of possible splitting features. The best splitting is feature deterministically selected from that subset. A pseudocode of random forest construction is shown below

To generate *c* classifiers:
for $i = 1$ to c **do**
Randomly sample the training data *D*with replacement to produce D_i
Create a root node, $N_i$containing *i*
Call BuildTree(N_i)
end for
BuildTree(N):
if*N* contains instances of only one class **then**
return
else
Randomly select x% of the possible splitting features in *N*
Select the feature *F* with the highest information gain to split on
Create f child nodes of *N*, 1*N*,...,*f* *N*, where *F* has *f* possible values (1*F*, …..,*f* *F*)
for $i = 1$ to f **do**
Set the contents of $N_i$to *Di*, where *Di*is all instances in *N* that match F_i
Call BuildTree(N_i)
end for
end if

To classify a test instance, the Random Forests classifies the instance by simply combining all the results from each of the trees in the forest. The method used to combine the results can be as simple as predicting the class obtained from the highest number of trees.

B) K-Meansclustering Algorithm

K-means is one of the simplest unsupervised learning algorithms that solve the well-known clustering problem. The procedure follows a simple and easy way to classify a given data set through a certain number of clusters (assume k clusters) fixed apriori. The main idea is to define k centers, one for each cluster. These centers should be placed in a cunning way because of different location causes different result. So, the better choice is to place them as much as possible far away from each other. The next step is to take each point belonging to a given data set and associate it to the nearest center. When no point is pending, the first step is completed and an early group age is done. At this point we need to re-calculate k new centroids as barycenter of the clusters resulting from the previous step. After we have these k new centroids, a new binding has to be done between the same data set points and the nearest new center. A loop has been generated. As a result of this loop we may notice that the k centers change their location step by step until no more changes are done or in other words centers do not move any more. Finally, this algorithm aims at minimizing and objective function known as squared error function given by:

$$J(c, \mu) = \sum_{i=1}^{m} ||x^{(i)} - \mu_{c(i)}||^2$$

Where,

'$||x_i - v_j||$' is the Euclidean distance between x_i and v_j.

'c_i' is the number of data points in i^{th} cluster.

'c' is the number of cluster centers.

Algorithmic steps for k-means clustering

Let $X = \{x_1,x_2,x_3,\ldots\ldots..,x_n\}$ be the set of data points and $V = \{v_1,v_2,\ldots\ldots.,v_c\}$ be the set of centers.

1) Randomly select 'c' cluster centers.
2) Calculate the distance between each data point and cluster centers.
3) Assign the data point to the cluster center whose distance from the cluster center is the minimum of all the cluster centers.
4) Recalculate the new cluster center using:

$$v_i = (1/c_i) \sum_{j=1}^{c_i} x_i$$

Where, 'c_i' represents the number of data points in i^{th} cluster.
5) Recalculate the distance between each data point and new obtained cluster centers.
6) If no data point was reassigned then stop, otherwise repeat from step 3).

V. SECURITY FRAMEWORK REQUIREMENT

Robust healthcare is a requirement for both developed countries, where the cost of healthcare is high and security and privacy are critical issues and developing countries like India, where there is a mass population to handle in hospitals and robust healthcare procedures are required. An efficient, reliable, robust and secure health flow is important to manage patients, their health records smoothly and for the right care to reach to the patient at the right time. Identification of objects for secure medical procedures is very essential for a secure workflow. For example, secure identifiers on the medicines can help healthcare professional to administer correct medication to a patient to reduce errors. Along with this issue the Patient Health Record management [7] is important both for patients as well as hospital management.

In developing countries like India, there is no centralized management of health records and records are mostly retained by patients in a paper format OPD (Out Patient Department) card, which is both cumbersome to maintain along with the paper based reports and also unreliable. Work is still being done for a secure, electronic patient record management as a Health card on a Smartcard in developing countries like India [3] and other nations [4]. Most of the public health care services issue a Health card on a Smartcard, which retains just the primary information of the patient. All other records are stored on a centralized medical storage server. In developing countries like India, there are challenges like costly infrastructure, connectivity problem for accessing centralized medical records and acceptability of the Health card uniformly across different hospitals. With the recent advancements in mobile devices involving secure credential storage, larger storage capability, wireless communication interfaces and computational power, they can be used in healthcare for not only gathering vital health parameters, as in the Body Area Networks, but also for healthcare management. Privacy and security is a very important aspect of health care. We propose that the patient should retain all or major patient's EHR electronically, on a Health card that is either on a external Smartcard accessible by a mobile device or on the mobile device retained by a patient.

A Health card retained on a mobile device can retain the entire EHR including reports and tests. Permitted portion can be accessed securely by an authorized medical provider by a simple tap of mobile device. Due to the computational capabilities the records can be summarized and organized for a quicker action to be taken. Healthcard on a mobile device can be helpful in developed countries also, where health care cost is high and privacy and security are critical. The patient can retain all records and can manage the privacy concerns of which portion of the records are to be accessible. The records can occasionally be synced to the central server for backup or storing past history. EHR on Health cards retained by people can also help in providing the right care in an emergency situation when the patient is unconscious. It can also help determine location of the patient in case of emergency through location service on recent mobile devices. The business logic of using Health card on mobile devices can be beneficial to a medical professional since it can securely identify patients using simple portable mobile devices and also get a concise health report. A simple tap of NFC enabled mobile device [7] will not only improve the workflow of medical professionals but also prove to be beneficial in emergency and chaotic conditions like mass populated hospitals. Simplified workflows will result in faster and more efficient patient-doctor interaction.

The main contribution of this paper is proposal of a robust secure healthcare architecture using Android based mobile device with Near Field Communication (NFC) and Bluetooth interfaces and smartcard technology on Secure Element (SE) for retaining security credentials and EHR. NFC is already being used for applications related to financial payments and ticketing. We propose a novel usage of NFC enabled mobile devices to access secure external medical tags for identifying medical objects like medicines and patient Health cards. The Health card could be on an external tag or retained on the patient mobile device using NFC P2P or card emulation modes. This can provide greater control of sharing personal records with any authorized doctor by a simple tap of mobile devices. Bluetooth can be used along with NFC to provide faster access of bulky data from mobile device. There is a strong cryptographic framework required for healthcare data. The mobile devices and Health cards can be authorized by a Health Secure service on a Amazon cloud, to provide services for enhanced security and extended storage for health records. We also present a study on the feasibility of the automatic detection of atrial fibrillation (AF) from cardiac vibration signals as a part of the EHR. The proposed system is intended as a screening and monitoring tool in home-healthcare applications and not as a replacement for ECG-based methods used in clinical environments. Based on the ECG data recorded in a study with ten AF patients, we evaluate and rank popular machine learning algorithms (naive Bayes, support vector machines, random forests) for their performance into one of three classes: sinus rhythm, AF, and artifact. For each algorithm, feature subsets of a set of statistical time-frequency-domain and time-domain features were selected based on the mutual information between features and class labels as well as the first- and second-order interactions among features. The overall project defines NFC Card as Heath Record, Security Framework using Amazon Cloud Service and RSA for securing data over network and classification of AF [12].

VI. Conclusion

In this work, we have proposed applications based on NFC enabled Android mobile devices for improving healthcare process for secure medical object identification and patient Healthcard on an external tag. The applications are simple to use with a simple touch of NFC for secure communication. This will improve the health flow in crowded hospitals of developing countries like India as well as of developed nations. We have also evaluated and discussed algorithms for the automatic detection of AF epochs from signals recorded using samples dataset download from MIT BH. Based on the results RF classifiers seem to be the most suitable algorithms for the task of separating the three classes: normal, arrhythmia, and artifact. The proposed architecture can be used for applications other than healthcare with secure identifiers and secure transfer of large data between devices and classification of AF.

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