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Health Track

Health Monitoring and Prognosis System using Wearable Sensors

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***Abstract* — The latest generation of smartphones are increasingly viewed as handheld computers rather than as phones, due to their powerful on-board computing capability, capacious memories, large screens and open operating systems that encourage application development. This paper provides a brief state-of-the-art overview of 'Health Track' smartphone app which is used with wearable biosensors for health monitoring and prognosis. In this paper, we present a system using an Android smartphone that collects, displays sensor data on the screen and streams to the central server simultaneously. Our system has Doctor, Nurse, Caretaker, User and Administrator as actors who are completely connected to each other via our Health Track modules. Raw sensor data collected from body area network are interpreted to either graphical or text notations to be presented on the smartphone and the central server. Furthermore, a PHP-based central server application is used to demonstrate communication with the Android system for data storage and analysis. Analysis section includes our prognosis algorithm, which helps to detect medical condition of user. Prognosis algorithm works on vital sign classification. Our system has classification which is based on context based health monitoring, trigger based and past records. Emergency conditions are handled by evaluating prognosis report. System provides location based emergency services.**

Keywords - prognosis, body area network, biosensors, context based health monitoring

I. INTRODUCTION

Mobile communication devices are designed to achieve multiple purposes but mostly are focused on voice and short messaging services [9]. Wireless technology has the benefit of improving data mobility, using different protocols such as Wi-Fi and Bluetooth [15]. In the medical field, many studies introduced body sensor networks [7] (BSN) for healthcare applications. BSN improves the patient's monitoring system [8] with the help of the modern technology. This can be done by various wearable sensors equipped with wireless capabilities [11]. Different types of sensors can be used for monitoring movements, temperature changes, heart-beat, blood pressure, respiration rate, ECG data and more to establish a patient monitoring system [19]. In this paper, we introduce a Health Track system that communicates with sensors via smartphone for data collections, and streams data simultaneously to the central server for data storage and analysis via the Internet. Analysis is deals with prognosis [17] where we are searching effect of vital sign on one another. Through this interdependency check [6] we are able to find early signs of disease or illness. Our system's main goal is to achieve prognosis based report generation which is unique facility. HealthTrack categorizes user according to risk factor calculation algorithm at the time of registration. Risk factor calculation algorithm includes BMI, Framingham Heart Study, and Metabolic Syndrome. Our Classification algorithm gives label to values provided by sensors. These labels are input to prognosis system. Through medical domain analysis it generates different prognosis which are summarized into the report. Report is helpful for pre-diagnosis of different disease and illnesses.

II. RELATED WORK

The design and development of wearable biosensor systems for health monitoring has garnered lots of attention in the scientific community and the industry during the last years. In our system sensors have very important role as they are going to equipped us with statistics.

Alexandro's Angelopoulos[11] has attempted to comprehensively review the current research and development on wearable biosensor systems for health monitoring. A variety of system implementations are compared in an approach to identify the technological shortcomings of the current state-of-the-art in wearable biosensor solutions. An emphasis is given to multipara meter physiological sensing system designs, providing reliable vital signs measurements and incorporating real-time decision support for early detection of symptoms or context awareness.

Presented pervasive healthcare [19], wireless networking solutions and several important and interesting research problems. The pervasive health care applications include pervasive health monitoring, intelligent emergency management sys-tem, pervasive healthcare data access, and ubiquitous mobile telemedicine.

We choose different types of vital sign for prognosis. Out of them ECG is most researched

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physiological sign which provides minute change in our body. Jaipur Pan [10] have de-eloped a real time algorithm for detection of QRS complexes in ECG analysis. Through this analysis we can calculate R-R interval, PQ duration and ST voltage which is used in prognosis algorithm.ECG representation is unique for each disability or disease which is studied through book published by Lippincott Williams and Wilkins [5] ECG interpretation made incredibly easy!!

Ralph B. D'Agostino [5] General Cardiovascular Risk Profile for Use in Primary Care: The Framingham Heart Study widely known as The Framingham Heart Study. Reynolds Risk score [14] is also notable part in risk percentage calculation. These risk score helps us to categorize the user. As aforementioned detailed prognosis report [4] generation is unique facility of this system. Report contains graphical representation of each vital sign change with time pain etc. As shown in figure 1, we divide physical conditions into two groups: 1. measurable 2. Non measurable, same is true for the symptoms group. Measurable conditions can be easily captured through sensors and classify through our central processing unit. But to capture non measurable conditions we develop interactive GUI which will run on handheld devices. It will help to establish a communication with user to track signs.

Some vital sign can change with surrounding parameters, It is called as [18] context based health parameters. For example Change in surrounding temperature affects the blood pressure. Lower the temperature, Higher the blood pressure. Sleeping, Running are modes of user which indicates current activity. Context based monitoring includes modes as parameter.

Our system categorizes patients on basis of the risk score. Risk score is calculated using three equations 1) Framingham Heart Study 2) BMI Index Risk 3) Metabolic Syndrome Score these risk percentage is evaluated by doctor. Doctor decides the number evaluations required for patients to determine vital signs status in one day. All data related to vital sign is gathered in centralized server periodically, where we run our two algorithm i.e. Classification and prognosis algorithm. Through analysis of medical domain detailed prognosis report is generated.

III. PROPOSED SYSTEM ARCHITECTURE

Our system employing a variety of bio sensors is thus capable of collecting real-time measurements of vital signs and other physiological signals. By applying proper signal processing on the measured data, important diagnostic features can be extracted from every individual signal. [22][12]

However sheer, [21] Vital signs cannot predict the medical condition of the user. For accuracy we need some other non-measurable conditions such as consciousness level, cough.

IV. CLASSIFICATION AND PROGNOSIS ALGORITHM

Sensors are sending a numeric data for each vital sign.

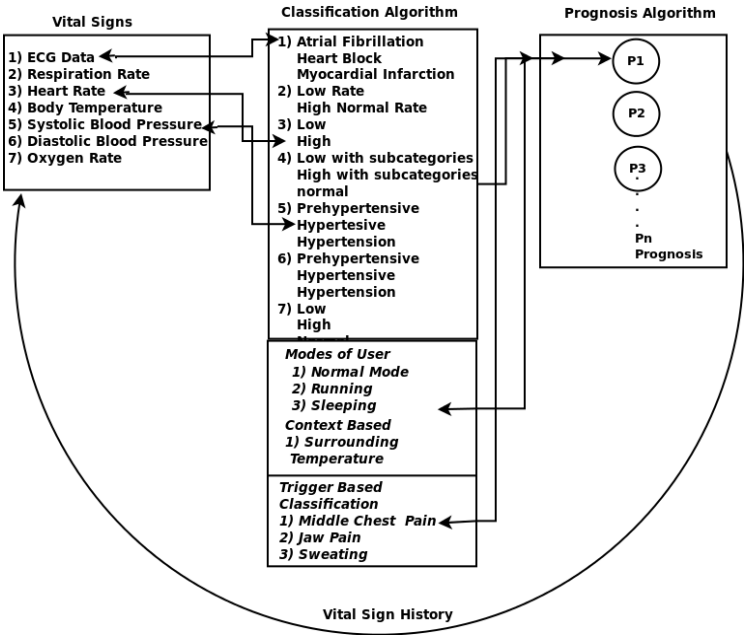

Figure 1 Prognosis: Measurable and Non Measurable Vital Signs

But proper classification of those numeric values is important. We classify each vital sign as 'High', 'Low', 'Normal'. ECG classification is different from these values. It has voltage and time analysis. ECG gives three label [16] 1) Atrial Fibrillation 2) Myocardial Infarction 3) Heart Block after analysis.

We register each entity user, caretaker, doctor and nurse in system for authentication. They will authorized by the admin of our hospital information system. Registration fields contain some information such as total cholesterol, HDL. If user is not aware about that then user can schedule appointment with our pathology lab. After registration we need to categorize the user. This is done by using three risk calculators.

A. *Framingham Heart Risk Calculator*

As suggested by Framingham Heart Study [1], we calculate 10 years heart risk of the user. To calculate a risk they have given this formula *:*

$$\hat{p} = 1 - S_0\,(t)^{exp} \sum_{i=1}^{\rho} \beta_i \chi_i \; - \; \sum_{i=1}^{\rho} \beta_i\, \bar{\chi}_i$$

p = Number of parameters, represents regression coefficients and is our risk factor. We take logarithmic value of our parameters and multiply them with coefficients. We have total six parameters age, gender, blood pressure, systolic blood pressure, total cholesterol, HDL, smoking habit, diabetes etc. Our

system helps to calculate our own regression coefficients. As aforementioned, we have our own registered population, so we are able to calculate regression coefficients for them. This improves accuracy of risk factor.

B. BMI Risk

BMI stands for Body Mass Index [7]. It is simple calculation which takes division of square of height in meters with weight in Kilograms. It provides us value, which has four categories underweight, normal, overweight, obesity. This category helps us to decide next risk factor i.e. Metabolic Syndrome.

C. Metabolic Syndrome

It checks abdominal obesity [25], High body glucose, HDL, total cholesterol as metabolic syndromes. If we find three or more symptoms in user, He is prone to heart disease.

Each labeled vital sign and ECG data pass [3]to prognosis algorithm which checks different cases of medical domain to find diseases , abnormalities , prediction of heart stroke risk[2] etc. Each vital sign pass through different cases of prognosis[20] , where they are checked under medical domain for different prognosis results[13] as shown in Fig.1.Cases are predefined as age and genders. If our system finds problem in any vital sign it generates alert label. More than three alert labeled vital signs indicates attention. If patient suffers from jaw pain, middle chest pain, sweating then he can start our trigger mode. In trigger mode prognosis for heart stroke is carried out.

Emergency Help Module: If User is suffering heart stroke [22] [13] according to prognosis then his current location is stored in database. We have registered ambulance with Hospital information System person can dial ambulance number and get the help at that location. Doctor checks users medical report so if he finds any critical condition, he can prescribe, suggest, schedule appointment for the user. This enhances the communication between user and doctor. Caretaker also inform at the time of emergency. Hershel can check report of concern user.

Detailed Registration of user, categorization on the basis of standard risk factor, classification algorithm of vital sign, and prognosis of classified vital signs, full printable report generation makes Health Track unique in itself.

D. Illustrative Examples

Android Application and PHP server works in coordination to generate a prognosis report. Now we see a brief illustrative example for classification and prognosis algorithm. Here we are considering a user.

Case 1 — Women. A 61-year-old woman treated for low blood pressure has a total cholesterol of 180 mg/ld., HDL of 47 mg/ld., and systolic blood pressure of 85 mm Hg and diastolic blood pressure as 55 mm Hg is a current smoker but is not diabetic. According to current sensor values she has pulse rate 120, oxygen rate 97 percentage, Body temperature as 37 degree Celsius and respiration rate as 22 and current activity is in normal mode. As aforementioned in section 3, we have different algorithms for each parameter, here we are illustrating BP and Pulse rate for classification and prognosis.

We pass SBP = 85 mm Hg, DBP = 55 mm Hg and Pulse Rate = 120 to classification algorithm. These values will be pass through conditional structure.

After executing this algorithm we get classified labels for BP parameter as well as for pulse rate. Here BP has label “Low BP” and Pulse Rate as “High” label. Above algorithm is just a sample for BP and Pulse rate. Similarly we have algorithm for each vital sign which runs parallel. They give us labels as follows Respiration Rate =”Normal”, Oxygen Rate

= ”Normal” , Body Temperature = ”Normal , Mode of User

= ”Normal”. These classified values are passed to prognosis algorithm.

As aforementioned, prognosis algorithm accepts pulse rate label, BP label and mode of User. It invokes following conditional structure. Through conditional structure we get status of user as “bleeding internally and require immediate attention” for BP and PR signs. In similar way we get different status for different cases. We named those Prognosis as P1, P2 up to Pn as shown in Fig. 1. These P1 to Pan are passed through medical domain analysis. Where detailed report is generated

E. Discussion

Our BMI, Framingham and Metabolic Syndromes help us to categorize between the register users. In above algorithms inform at the time of emergency. Hershel can check report of concern user. Detailed Registration of user, categorization on the basis of standard risk factor, classification algorithm of vital sign, and prognosis of classified vital signs, full printable report generation makes Health Track unique in itself.

Values for comparison of vital sign are fixed. For example Low BP indicates SBP 90 and DBP 60. But this may differ according to category of user. User may be senior citizen, pregnant woman or person suffering from diabetic who usually have different ranges for blood pressure. Age and gender affects the standard readings. So we should take above situations under consideration.

As mentioned earlier, our ECG analysis currently generates three labels only. ECG gives us exact information about medical condition of user. So we can add detail analysis and separate report generation of

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ECG. Electrocardiogram storage facility can be included in system.

We are generating P1 to Pn Prognosis of vital sign (Fig.1). These P1 to Pan vital signs may be further related to each other. Detail study should be performed considering medical domain which will give us exact and accurate knowledge of illness, disease.

Framingham Heart Risk Calculator considering their own regression points. We can calculate our own regression points through proper evaluation of the data of registered users. This requires continuous assessment, calculation on available statistics. Now Availability of proper sensor kit which captures all vital sign is cup of tea for researchers.

Classification Algorithm

```
Input: A Blood Pressure SBP and DBP, Pulse
       Rate Value
Output: Classified Labels for BP, PR
User is at normal mode (not running, jogging etc.)
if ((sbp => 121 & sbp <= 139) & (dbp =>80&dbp
<= 89)) then
     label =”PreHypertensiveness”
else if ((sbp >=140 & sbp <= 159)& (dbp>= 90 &
dbp <= 99))
     bplabel =”Stage 1 Hypertension”
eles if ((sbp>= 160 & sbp<= 170) & (dbp
>=100 & dbp<= 110))
     bplabel =”Stage 2 Hypertension”
else if ((sbp  >= 90 & (dbp  <= 60))
     bplabel =”Low BP”
else if ((sbp == 120) & (dbp == 80))
     bplabel =”Normal”

Pulse Rate Classification
if (pr ==  60) then
     prlabel = ”Low”
else if (pr ==  110)
     prlabel = ”High”
else
    prlabel = Normal
```

Prognosis Algorithm

```
Input: A Blood Pressure with Label, Pulse Rate with
label , Mode of User
Output: Prognosis “Pn”

User is at normal mode (not running , jogging etc)
if (pr   == 120) & (sbp > 90) & (dbp < 60) then
Status : bleeding internally and require immediate
attention
if (pr ==50) & (mode == normal) then
     status :
          Low Oxygen Rate , increase in carbon
          Dioxide and other waste in blood lose
          consciousness because the brain is not
          receiving enough oxygen Sleep/Rest
          ,Organic Heart Disease,
          Hypothyroidism, Medications diabetes
          kidney disease, infection, ingestion of
          certain poisons, drug overdosing
          starvation, diarrhoea, sickle cell
          anaemia carbon dioxide and other
          waste in blood
if (pr ==150) & (mode == normal) then
     status :
          Body temperature ,Anxiety, Pain,
          Exercise, Hyperthyroidism, Anaemia,
          Medications
```

V. CONCLUSION

In this paper, we have discussed the prognosis of user using biosensors. The vital signs are measurements which are easily recognized and interpreted by our prognosis algorithm. They provide a quick assessment of how sick someone is and how urgently they need medical care. This is especially useful in the emergency room where patients are treated according to who is in need of the most urgent care and not on a first come, first-serve basis. For example, someone with a very high heart rate and a very low blood pressure could be bleeding internally and require immediate attention.

The advantages are that tracking the vital signs is quick, painless and cheap. The major disadvantage is that the in-formation obtained is often very general and rarely gives the specific cause of the problem[6]. In other words, the vital signs are good at telling if something serious is going on, but usually not too good at telling exactly what is wrong. To be specific in medical decision making future work should be conducted in innovation of biosensors capturing specific values.

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