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Real Time Healthcare System for Patients with Chronic Diseases in Home and Hospital Environments

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Abstract— **Devices like ECG monitors or pulse monitors are available in the market today that can be easily operated by healthcare personnel or the patient himself. The monitors record the vital statistics of the patient, including heart rate, blood pressure, blood sugar levels etc periodically. The data is stored in the central database and processed extensively. The system will contain the patient's medical history, his current statistics, and a database of chronic diseases, their symptoms and treatment mechanism. The major idea being implemented here is the classification system (PSCM) which compares the patient data with the disease records and medical history to group the patient into tiers based on the severity of the disease. If the patient is classified into a higher tier, it means the patient needs urgent care and the healthcare personnel are notified by the system by sending them an SMS. The system administrator may place a call to the doctor's cell phone, if needed. Another SMS may be sent, or system administrator can make a call to the patient's mobile phone to advise him of emergency first aid or to call for help.**

This system is applicable in both home and hospital environment as the connection to the central database is made using devices like laptops or mobile phones which are so commonly used these days that most people will have either of these at all times with them and hence their vital data can always be monitored effectively.

Index Terms— **Association rule, Healthcare, PSCM (Patient Status Classification Method), Sensors, SMOP (Surface Measure of Overall Performance), Wireless**

I. INTRODUCTION

The business of healthcare, whether at a doctor's office, hospital, outpatient facility or long-term care facility, is often a delicate balancing act of urgency, accuracy, privacy, regulations and technology. This balancing act can make solving issues in the healthcare industry seem like a daunting task, but with the right wireless solution, many improvements can be seen quickly and easily. [1]

Arguably, two of the largest issues facing the healthcare industry today are worker productivity and error rates. While computers and networks have been used for some time in healthcare settings, they are still often tied to a specific, physical location, requiring the presence of the clinician to be used. Communication among healthcare workers in different areas often takes place via fixed telephones, because most hospital regulations prohibit the use of cell phones in many areas of the facility. For clinical professionals such as nurses and physicians every moment they are tethered to a desktop computer or a fixed-wall phone is one moment they aren't spending at the bedside with their patients or on the move to their next task. Increased mobility for these professionals means increased productivity. A more pressing issue than productivity, however, is the need to reduce the number of errors that take place every day errors that are measured not just in dollars, but also in harm to patients [1].

Clearly, few industries have a greater or more compelling need for computing mobility than the healthcare industry. After all, immediate access to patient data from anywhere in the facility can significantly reduce potentially life-threatening errors while increasing healthcare workers' productivity. This, in turn, improves the quality of patient care and reduces costs [1].

The hospitals of today, are trying to become more highly intensive in terms of their care environments. With less-acute patients, the more they can be kept out of an institutional setting, that's better for care and it's a more effective use of resources

II. A FUNCTIONAL ARCHITECTURE

Integrated healthcare systems mainly focus on monitoring patients' health status, detecting and managing potential daily life. Extending health monitoring from the hospital to the home environment should not be seen as a replication of the same monitoring procedures and methods of the home environment, because the home environment has characteristics that are very different from those of the hospital in terms of medical facility, human resources, the medical knowledge of operator, and other factors. Thus, the approach for simply building the same monitoring architecture as the hospital will dramatically increase the time and human resources necessary for healthcare services delivery. [2]

It may also be unacceptable for patients due to its obtrusive and stressing nature. Within the scope of continuity of healthcare, the need to move beyond passive monitoring to efficient mechanisms for personalized healthcare is becoming more and more evident.[3] To overcome the challenges of developing healthcare systems for home environments, it is desirable to support industrial information integration methods such as service-oriented architecture, and multi-tenancy patterns in chronic disease services so that patient-specific healthcare services can easily be integrated into the healthcare system.[4]

A . System Framework

In the proposed integrated healthcare system, classify at-home services into three levels according to the target patients: serious patients, potential patients, and normal patients. Each patient class is determined based on the proposed PSCM. The serious patent service class is mapped with the TIER (4), and the patient whose statistics are normal is classified into the TIER (1). [2]

The system provides separate user interfaces according to the user types, i.e., the patient and the physician. The patient's interface displays an abstract and simplified view of the health monitoring results, whereas the physician's interface shows detailed information, such as patient's profile and medical history.

The architecture of the system is given in the Figure 2. There are three main modules to the system; the

- Sensor Networks,
- Home Healthcare System,
- Data Mining System.

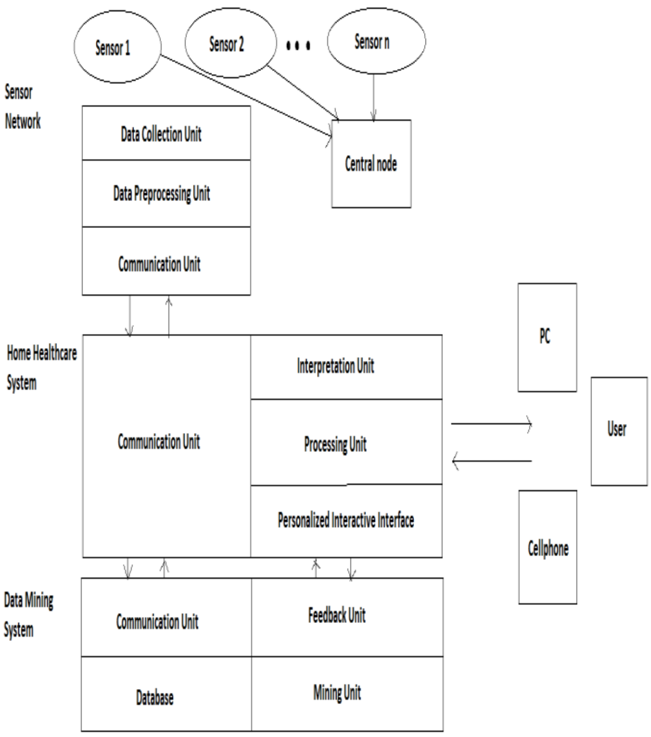

Fig 2: System Architecture

The service-oriented architecture is an appropriate solution for improving integrated healthcare systems, as it is known that the service-oriented architecture can provide a unified platform for managing various services, such as data federation, temporal order filtering, and image processing.[4] Also, a service-oriented architecture can offer a reduction in the system complexity, an increase of service extensibility, and good replaceability to overcome the challenges of developing healthcare systems for home environments, it is desirable to support industrial information integration methods such as service-oriented architecture, and multi-tenancy patterns in chronic disease services so that patient-specific healthcare services can easily be integrated into the healthcare system. The features of the system include

- In the proposed system, the central system is equipped with a messaging service that informs the carer about the patient needing medical help and advises the patient of first aid. The system administrator is also notified about the condition and is asked to make a call to ambulance services or patients relatives.
- There will be a system that coordinates information from all the physicians if the patient chooses to consult multiple physicians.
- Security features using encryption methods are also incorporates.[5]

As shown in Figure 1,

SN stands for Sensor Networks. The data collection is done by the Sensor Networks. They form the set of wireless sensors that record the patient's data and transmit them to the Bluetooth enabled device. As shown, the sensors collect the data; pre-process the recorded data with highly intelligent technology like motion analysis, taking the effect of these into consideration. The recorded data is then sent to a central node from which it is sent via Bluetooth to a mobile device. The sensors used must be small, robust and use as little electricity as possible. It needs to be unobtrusive and blend into the patient's environment without any disturbance. It may be a bio-watch, injected into the blood stream, attached to the body etc [6].

HHS is the Home Healthcare System that acts as the communication interface. Recordings are simply monitored until the system realises a critical condition in the patient, in which case it sends the information to the DMS or Data Mining System for further processing. It receives the output from the DMS and displays it in a patient-friendly format. The data displayed to the user varies depending on their role as patient, doctor or admin. The admin will have full control over all data. The information given to the patient will be on a need-to-know basis. Only the essential details will be shown. All the technical information about the patient's health will be given to the doctor. [6]

DMS is the Data Mining System that uses the recorded data to make accurate diagnoses and predict future medical data and events. The reading are received and stored in the central database until its need arrives. If and when a critical situation is identified, it considers the mining information and decides whether to consult the doctor. If not, an automated feedback that contains standard information is sent back, else, the caregiver/specialist is consulted, and their response is sent over to the HHS. The assignment of values for different attributes, their analysis etc is done here. [6]

The flowchart for the proposed system is shown below. As mentioned above, the Sensor Network is the data collection and pre-processing section. It simply passes on the data to the Healthcare System. The analysis is done in the Data mining System and results are displayed to the user depending on their role as patient, doctor or admin

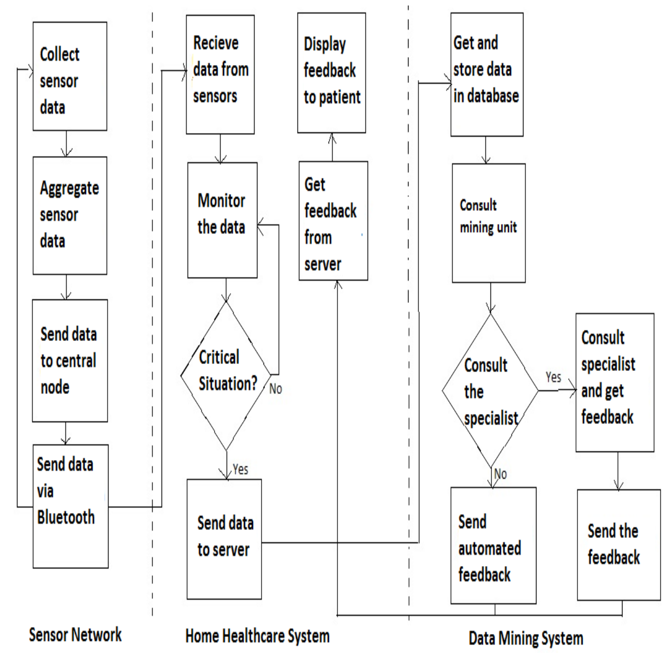

Fig 1: Flowchart of Proposed System

Integrated healthcare systems mainly focus on monitoring patients' health status, detecting and managing potential diseases in the early stage, and managing health problems in daily life. The system developed in this research consists of three major components: a personalized user interface, an integrated healthcare server, and chronic disease care services. [7]

For real time monitoring of patients to be effective, their health related data needs to be monitored at regular intervals. Pertinent information related to the overall health of the patient, like heart rate, temperature, blood sugar levels, blood pressure etc are recorded using wireless sensors. [6]

We use the SMOP method [2] to generate a radar chart for identifying the disease. Because the data of the disease set is normalized by the different criteria in the different ranges from *T (1)* to *T (5)*, the statistical classifications fall within five tiers. According to the theory [2], *SMOP* can be expressed as follows:

SMOP=(P1*P2)+(P2*P3)+(P3*P4)+(P4*P5)+(P5*P6)+....+(Pn*P1)) * sin(360/n)/2,

Where P is the data point on the axis of the radar chart.

N denotes the number of medical tests for a patient examined. P_n represents in which range the medical test *N* falls. In this section, we defined five ranges, from *T (1)* to *T (5)*; thus, the value of P_i is determined as follows:

0.2, if i_{th} test result is within *T (1)*
0.4, if i_{th} test result is within *T (2)*
0.6, if i_{th} test result is within *T (3)* (2)
0.8, if i_{th} test result is within *T (4)*
1.0, if i_{th} test result is within *T (5)*

The three main advantages of the radar chart approach are,

1. It enables self-evident descriptive analysis
2. It yields an effective and illustrative description of selective performance in only one synthetic indicator (by means of SMOP).[2]
3. The change over time of the SMOP can indicate performance, independently from countervailing effects that possibly could have taken place.[3]

The main weaknesses of this method are that it does not take in account the input factors and thus cannot say anything about the efficiency of the used policies. The second weakness is the weighting problem: all indicators have the same weight and it is impossible to assign different weights to the different dimensions without a clear normative idea of differences in the desirability of the goals. In this thesis we explicitly assign the same weight to every dimension, but we will display the values of all separate dimensions, so anyone with a different normative idea can recalculate the overall scores with different weights. [2]

B . Association Rule Discovery

Association rules represent a promising technique to improve heart disease prediction. The major idea behind using association rule mining in the healthcare scenario is to identify the risk factors involved in the disease, follow their impact on health and to analyse the relationship of these risk factors with disease complication and mortality

When association rules are applied on a medical data set, they produce an extremely large number of rules. Most of such rules are medically irrelevant and the time required to find them can be impractical [8]. A more important issue is that, in general, association rules are mined on the entire data set without validation on an independent sample. Four constraints were proposed to reduce the number of rules: item filtering, attribute grouping, maximum item set size, and antecedent/ consequent rule filtering. An algorithm that uses search constraints to reduce the number of rules, searches for association rules on a training set, and finally validates them on an independent test set. Instead of using only Support and confidence, one more parameter i.e. lift have been used as the metrics to evaluate the medical significance and reliability of association rules [7]. Medical doctors use sensitivity and specificity as two basic statistics to validate results. Sensitivity is defined as the probability of correctly identifying sick patients, whereas specificity is defined as the probability of correctly identifying healthy individuals. Lift was used together with confidence to understand sensitivity and specificity. To find predictive association rules in a medical data set the algorithm has three major steps. [6]

First, a medical data set with categorical and numeric attributes is transformed into a transaction data set. Second, four constraints mentioned above are incorporated into the search process to find predictive association rules with medically relevant attribute combinations. Third, a train and test approach is used to validate association rules. [7]

Weighted Associative Classifiers is the concept that assigns different weights to different features and can get more accuracy in predictive modeling system like medical field etc. [6] In any prediction model all attributes do not have same importance in predicting the class label. So different weights can be assigned to different attributes according to their predicting capability. Weighted associative classifiers consist of training dataset T= {r1, r2, r3…. ri…} with set of weight associated with each {attribute, attribute value} pair. Each i^{th} record ri is a set of attribute value and a weight wi attached to each attribute of ri tuple / record. In a weighted framework each record is set of triple {ai, vi, wi} where attribute ai is having value vi and weight wi, 0<wj<=1. [7]

Weight is used to show the importance of the item. Using Weighted Associative Classifiers, weighted rules like "Medium Income-Young Age", "{(Age,">50"), (BMI, "45"), (Blood pressure, "95-135")}, Heart Disease, (Income [20,000-30,000] Age [20-30]) can be used for classification.

Table 1 shows different attributes and their weights. If the patient's age is less than 35, the chance of this patient being severely ill or even having a chronic disease is very low. Hence the weight given to that attribute is comparatively lower. If the patient is a smoker, or has a higher Body Mass Index (BMI), the possibility of them having a chronic disease is higher and accordingly, the weight given these attributes is greater.

Sl No	Attributes	Weights
1	Age<35	0.1
2	35<Age<50	0.2
3	Age>50	0.3
4	Smoker?= YES	0.8
5	Smoker?=NO	0.7
6	Hypertension?=YES	0.6
7	Hypertension?=NO	0.5
8	BMI<25	0.1
9	26<BMI<30	0.3
10	31<BMI<40	0.5
11	BMI>40	0.8

Table 1: Weight Distribution for Attributes

New formulae of support and confidence for classification rule X, where X is a set of weighted items, is as follows:

Weighted Support: Weighted support WSP of rule Xl, where X is set of non empty subsets of attribute value set, is fraction of weight of the record that contain above attribute-value set relative to the weight of all transactions.[8]

Weighted Confidence: Weighted Confidence of a rule XUY where Y represents the Class label can be defined as the ratio of Weighted Support of (XUY) and the Weighted Support of (X).[8]

SL.no	Age	Smoker?	Hyper tension	BMI	Weight
1	42	Yes	Yes	40	(0.2+0.8+0.6+0.8) /4=0.60
2	62	Yes	No	28	(0.3+0.8+0.5+0.3) /4=0.42
3	55	No	Yes	40	(0.2+0.8+0.6+0.5) /4=0.52
4	62	Yes	Yes	28	(0.3+0.8+0.6+0.8) /4=0.67
5	45	No	Yes	30	(0.2+0.7+0.6+0.3) /4=0.45

Table 2: Weights of Association Rules

Consider a rule R (Hypertension="yes") Heart Disease="yes" then Weighted Support of R is calculated as:

WSP(R) =Sum of Record Weight having the condition Hypertension='yes" true and also given class label Heart Disease/Sum of Weight of all transactions

WSP(R)

= (0.42+0.40+0.50)/(0.42+0.38+0.40+0.50+0.34)
= 0.640

WC(R) =Sum of Record Weight having the condition Hypertension="yes" true and also the class label Heart Disease/Sum of Record Weight having the condition Hypertension="yes" true

WC(R)

= (0.42+0.40+0.50)/(0.42+0.40+0.50+0.34)
= 0.795

If all the generated rules are used in the classifier then the accuracy of the classifier would be high but the process of classification will be slow and time-consuming. So in the next stage, generated rules are ranked based on several parameters and interestingness measures such as confidence, support etc. Then only the high-ranking rules are chosen to build a classifier and the rest are pruned. [6]

III. PERFORMANCE ANALYSIS

The results, as shown in Figure 3 and Figure 4 represent a comparison of the processing time to identify disease according to different patient classification systems used, namely SMOP method and using weighted association classifiers. The horizontal axis represents the number of concurrent processes for patients with a chronic disease which are running in our integrated healthcare system. The vertical axis denotes the elapsed time to finish the execution of the disease detection service.

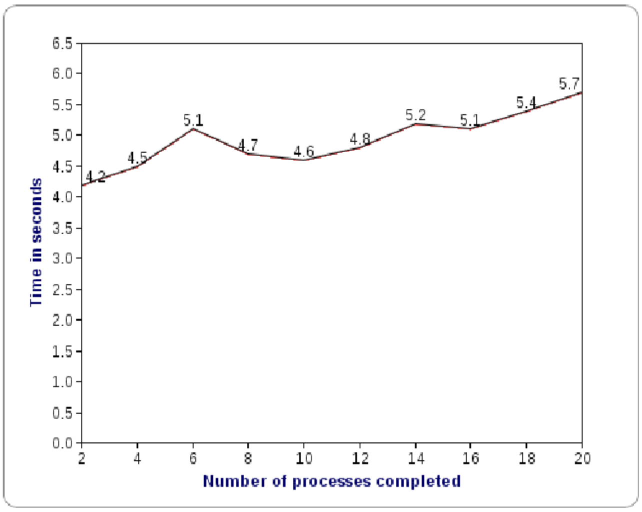

Figure 3: Processing time to identify disease in the integrated healthcare system using SMOP method

Accuracy measures the ability of the classifier to correctly classify unlabeled data. It is the ratio of the number of correctly classified data over the total number of given transactions in the test dataset. [7]

Accuracy = Total number of objects in the testset/ Number of objects correctly classified

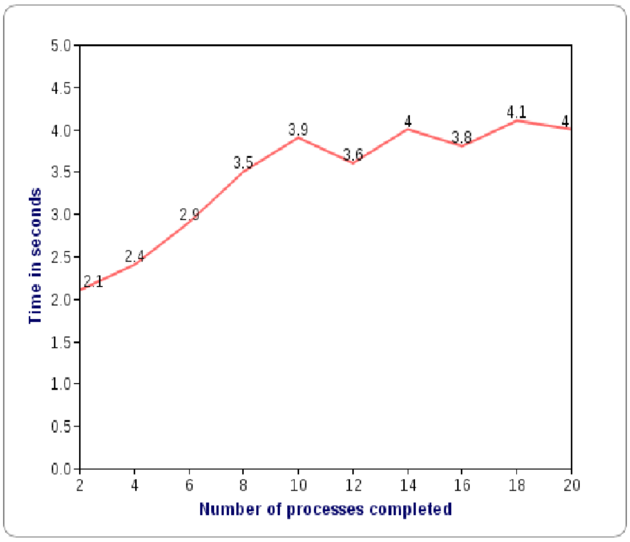

Figure 4: Processing time to identify disease in the integrated healthcare system using Weighted association classifiers

As seen from the graphs, the Weighted Association classifiers use less time to complete equal number of processes. The proposed system generates lesser number of rules, on the same time it improves the accuracy of the system. So it is very easy to construct the classifier and to predict the new labels.

IV. CONCLUSION

According to the proposed medical information services, patients' status can be monitored in a real-time manner even if the patient or the doctors are moving or engaged in another task. By doing this, there are more opportunities for early diagnoses for patients and a more flexible treatment compared to reacting to a patient's urgent situation. [2] In addition, the main function of the integrated visualization system can display the patients' information according to its priority levels so as to reduce the burden of information reorganization as well as the cost of diagnose. It can provide the patient with chances to see their own health status and determine their own self-health management strategy. In addition, patient's can be provided with emergency help if the diagnosis is that the health of the patient is critical, by sending alerts to the ambulance service. The hospital can also be alerted so that carers can be ready to receive the patient. [1]

Future work will be focused on providing the carer and patient, alarms if the patients need emergency help or if the carer needs to reach the patient. The proposed system will also strive to make the disease detection process and identification process simpler. Advanced concepts of Neural Networks and Genetic Algorithms have been proven to yield better accuracy and improved efficiency. Research must be conducted in these areas. There is also an option for different physicians to communicate with each other and resolve conflicts about diagnosis, thus reducing errors.

V. ACKNOWLEDGEMENT

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