

User Pattern Learning Algorithm based MDSS (Medical Decision Support System) Framework under Ubiquitous

Insung Jung, and Gi-Nam Wang

Abstract—In this paper, we present user pattern learning algorithm based MDSS (Medical Decision support system) under ubiquitous. Most of researches are focus on hardware system, hospital management and whole concept of ubiquitous environment even though it is hard to implement. Our objective of this paper is to design a MDSS framework. It helps to patient for medical treatment and prevention of the high risk patient (COPD, heart disease, Diabetes). This framework consist database, CAD (Computer Aided diagnosis support system) and CAP (computer aided user vital sign prediction system). It can be applied to develop user pattern learning algorithm based MDSS for homecare and silver town service. Especially this CAD has wise decision making competency. It compares current vital sign with user's normal condition pattern data. In addition, the CAP computes user vital sign prediction using past data of the patient. The novel approach is using neural network method, wireless vital sign acquisition devices and personal computer DB system. An intelligent agent based MDSS will help elder people and high risk patients to prevent sudden death and disease, the physician to get the online access to patients' data, the plan of medication service priority (e.g. emergency case).

Keywords—Neural network, U-healthcare, MDSS, CAP, DSS.

I. INTRODUCTION

THERE have been attempts to develop agent based MDSS (Medical Decision support system) for e-physician to minimize the diagnosis error rate and to conduct effective diagnosis on the basis of real-time data of the patient. Nowadays all segments of the healthcare market place (Physician, Patient and pharmacy) are challenged with providing effective diagnosis support system by proving computer aided diagnosis and statistical analysis. The effort to rectify that any of these issues will help to cut into time that can be better utilize for caring the patient and customers. Thus most of researches are focus on hardware system.

The objective of this paper is to design a framework of the user pattern learning based MDSS with ubiquitous artifacts. This framework consist database, CAD (Computer Aided diagnosis support system) and CAP (computer aided user vital sign prediction system). It helps to patient for medical

treatment and self prevention and sudden death prevention of the high risk patient (COPD, heart disease, Diabetes). It is one of the important points because when those disease patients have got a shock or acute situation fast emergency medical treatments can prevent their sudden death [1]. Other advantages are to help to the physician to get the online access to patients' data, the plan of medication service priority (e.g. emergency case).

An attempt is given to supervise the dynamic situation by using agent based ubiquitous artifacts and to find out the appropriate solution for emergency circumstances providing correct diagnosis and appropriate treatment in time. As per the reference [2], the reason for using the RL (Reinforcement Learning) agent based on MDP (Markov Decision Process) model is that it needs less number of parameters and it also gives approximation method to make tradeoff between accuracy and speed, in turn, solving the complex number of cases in less time compare to the existing system. In this paper we are using input vector(SaO₂, CO₂, Peak flow, HR(Heart Rate), BP(Blood Pressure), temperature and BR(Breathe Rate)) to CAD(computer aided diagnosis) system of Reinforcement Learning Process based on Back Propagation, focused on High Risk patient especially COPD disease at home.

Organization of paper is as follows. Section 2 is a review of the related work; Section 3 to 4 are high risk patient system service scenarios and high risk patient System Framework and Methodology.

II. RELATED WORK

Anton P. has done a research to diagnosis COPD patients using peak Expiratory Flow meter system (PEF) for self management purposes. However, this work is lacking in measuring the effect on the diagnosis and therapy where thermal sensors always imply a spot measurements [3]. Newandee D. has studied COPD severity classification using principal component and cluster analysis on HRV parameters using heart rate, blood pressure and respiration signals [4]. However, it is lack of adaptive monitoring to patients each person and needs decision (expert) system to suggest emergency measurement each cluster's severity.

The concept of ubiquitous healthcare system using agent technology has studied in reference [5]. All of the existing works have focused on the exploitation of ubiquitous system for the betterment of healthcare system. Little attention is given to develop integrated emergency system using agent based approach. The main objective of this paper is to design agent

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based decision support system using reinforcement learning to reduce the time lag between the onset of the attack and the time that care is administered, when the patient is away from the hospital premises. Ubiquitous devices blend with agent technology can reduce the time latency as well as they can provide suitable on-time treatment.

III. SCENARIOS

In this paper, we designed medical homecare system framework in ubiquitous environment. Therefore, we defined assumption of this scenario and ubiquitous environment because of limitation of hardware such as medical sensor device and wireless communication system

A. Assumption of this Scenario

Currently, ubiquitous research has got many open ended problems especially in the form of the limitations of environments such as:

1. Wireless communication
2. Security (personal information)
3. Hardware device (size, wireless communication, reliability of measurement device, collision, security; lack of vital signal sensor etc.)

The following scenario is based on some assumptions such that all of the above mentioned technological problems will be solved out in the future. Therefore we only model medical decision support system framework here.

B. Medical Homecare Station and Technology

Healthcare is becoming increasingly dependent on computer technology. The quality of the interaction between user (patient, elder person) and computers is at the heart of the effective use of technology in medicine. The study of patient diagnosis support system is based on the smart medical home station (Fig. 1).

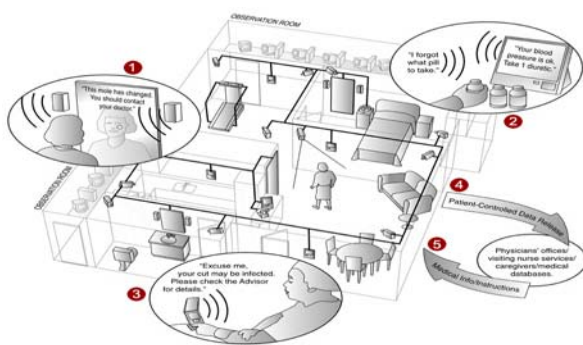


Fig. 1 Smart medical home; source Rochester (NY/USA)

C. Definitions of Patient and Principal Data

This paper mainly focus on high risk patient (Chronic Obstructive Pulmonary Disease (COPD), Hypertension) etc. Given below are the input data and the level of risk standard to measure the severity of the disease.

TABLE I
 HIGH RISK PATIENT'S RISK MEASUREMENT STANDARD

Data	Standard
SaO ₂	Normal : > 90% Lack of oxygen : mild 90 ~ 94% moderate 75-90% severe <75%
HR (Heart Rate)	Normal : 60-100/min Tachycardia : >100/min Paroxysmal Tachycardia: 150-250/min Flutter: 250-350/min Fibrillation: 350-450/min
BP (Blood Pressure)	Normal : 120/80mmHG Hypertension : > 140/90mmHG Danger Hypertension : > 200/140mmHG Hypotonic : > 100/60mmHG Danger Hypotonic : <80/60mmHG
BR (Breathe Rate)	Normal : 12-20 /min (adult) Tachypnea : >20/min
temperature	Normal : 36.5-37° Slight fever: morning : >37.2 afternoon : > 37.7 High fever: > 38.3

Those type of data (e.g heart rate (HR), blood pressure (BP), breath rate (BR) and SPO₂) will be acquired by a watch type of bio-signal acquiring devices.



Fig. 2 Biological Signal Acquiring (source medic4all device)

D. System Service Scenarios

Health monitoring and Computer Aided diagnosis will be useful for high risk patients for prevention of sudden death. As a specific example, the doctors at Ajou University define four clusters of patient level (regular, careful, serious and dangerous) using vital signal data (Fig. 3).

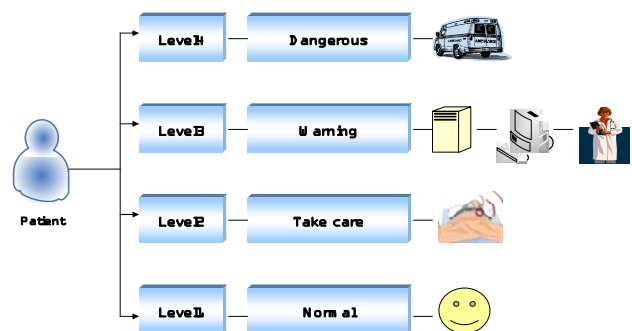


Fig. 3 Patient risk information scenario

Regular and careful level situation patients don't need to go to the hospital. They just need to take some medicines and follow prescriptions at home. However, serious situation patients need to be given first aid and readily be in contact with their private doctor. This system will automatically make a

phone call to emergency call center and send the data. When patient's level is dangerous, the agent computes the location for the nearest hospital to call an ambulance. As a result, we are setting up 3 kinds of health care modules which are called home care module, emergency call center module and an ambulance module system as follow Fig. 4.

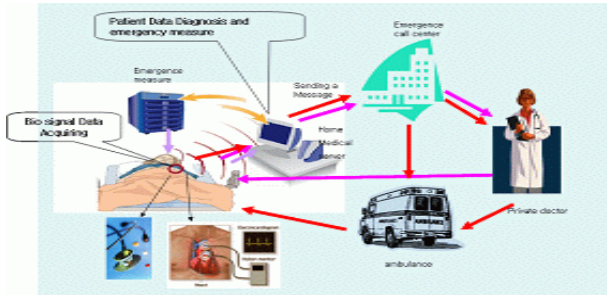


Fig. 4 Interaction of measurement

The working is executed as the following. First, we acquire a bio signal data by electronic peak flow-meter, spirometer or other devices from the patient. Home network protocols such as IEEE 802.11b will be used for wireless communication between sensors and home medical server. Subsequently, the processed information will be sent to the reinforcement learning agent for decision making and to measure the patient's risk level and then suggest an emergency treatment.

Second, if the patient status is not good it will autonomously send a message to emergency call center and private doctor. Final service is connecting to ambulance when the patient result is menace. The home medical server will send the data to emergency call center, private doctor, their family and ambulance (Fig. 5).

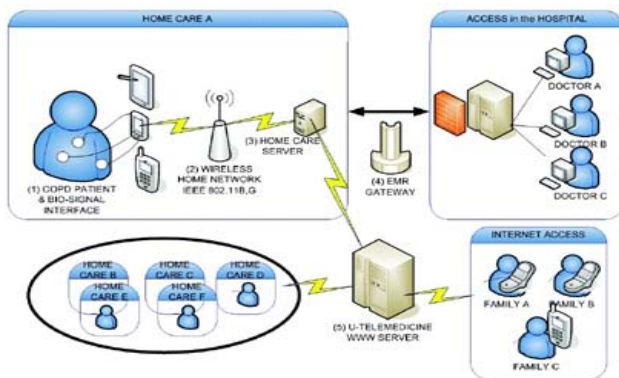


Fig. 5 High risk patient system service scenario

IV. BACKGROUND METHOD & SYSTEM FRAMEWORK

A. Background Method Neural

1) Neural network model

Standard multilayer perceptron (MLP) architecture consists more than 2 layers; A MLP can have any number of layers, units per layer, network inputs, and network outputs such as fig 3 models.

This network has 3 Layers; first layer is called input layer

and last layer is called output layer; in between first and last layers which are called hidden layers. Finally, this network has three network inputs, one network output and hidden layer network.

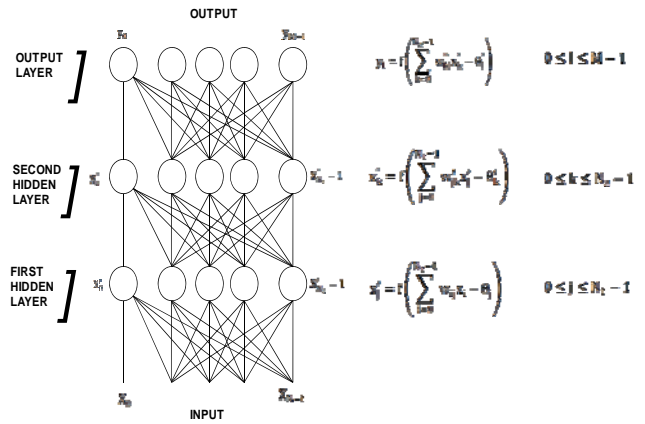


Fig. 6 CAP Standard Multi layer perceptron architecture

However, this research is compared with Back-propagation (BP) model. This model is the most popular in the supervised learning architecture because of the weight error correct rules. It is considered a generalization of the delta rule for nonlinear activation functions and multilayer networks.

The neural network prediction model is between input and output. Inputs are time-series data, and outputs are time-series estimate data with vital signs such as blood pressure, heart rate, SPO₂ and breath rate, and others.

This prediction model could be designed as follows. \hat{y}_t is the estimated output, and \hat{e}_t is the corresponding residual

$$\hat{y}_t = O_t = NN(X_t) + \hat{e}_t \quad (1)$$

According to the Richard P. Lippmann [6], he represents step of the back-propagation training algorithm and explanation.

The back-propagation training algorithm is an iterative gradient designed to minimize the mean square error between the actual output of multi-layer feed forward perceptron and the desired output. It requires continuous differentiable non-linearity. The following assumes a sigmoid logistic non-linearity.

Step1: Initialize weights and offsets

Set all weights and node offsets to small random values.

Step2: Present input and desired outputs

Present a continuous valued input vector X_0, X_1, \dots, X_{N-1} and specify the desired output d_0, d_1, \dots, d_{M-1} . If the net is used as a classifier then all desired outputs are typically set to zero except for that corresponding to the class the input is from. That desired output is 1. The input could be new on each trial or samples from a training set could be presented cyclically until stabilize.

Step 3: Calculate Actual Output

Use the sigmoid non linearity from above and formulas as in fig 3 to calculate output y_0, y_1, \dots, y_{M-1} .

Step 4: Adapt weights

Use a recursive algorithm starting at the output nodes and working back to the first hidden layer. Adjust weights by

$$w_{ij}(t+1) = w_{ij}(t) + \eta \delta_j x_i' \quad (3)$$

In this equation $w_{ij}(t)$ is the weight from hidden node i or from an input to node j at time t , w_j' , is either the output of node i or is an input, η is a gain term, and δ_j , is an error term for node j , if node j is an output node, then

$$\delta_j = y_j(1 - y_j)(d_j - y_j) \quad (4)$$

where d_j is the desired output of node j and y_j is the actual output.

If node j is an internal hidden node, then

$$\delta_j = x_j'(1 - x_j') \sum_k \delta_j^m w_{jk} \quad (5)$$

where k is over all nodes in the layers above node j . Internal node thresholds are adapted in a similar manner by assuming they are connection weights on links from auxiliary constant-valued inputs. Convergence is sometimes faster if a momentum term is added and weight change are smoothed by

$$w_{ij}(t+1) = w_{ij}(t) + \eta \delta_j x_i' + \alpha (w_{ij}(t) - w_{ij}(t-1)) \quad \text{where } 0 < \alpha < 1. \quad (6)$$

Step 5: Repeat by going to step 2

B. System Framework

Our home healthcare system framework (Fig. 7) is consisting of 4 systems and one knowledge database (Fig. 8).

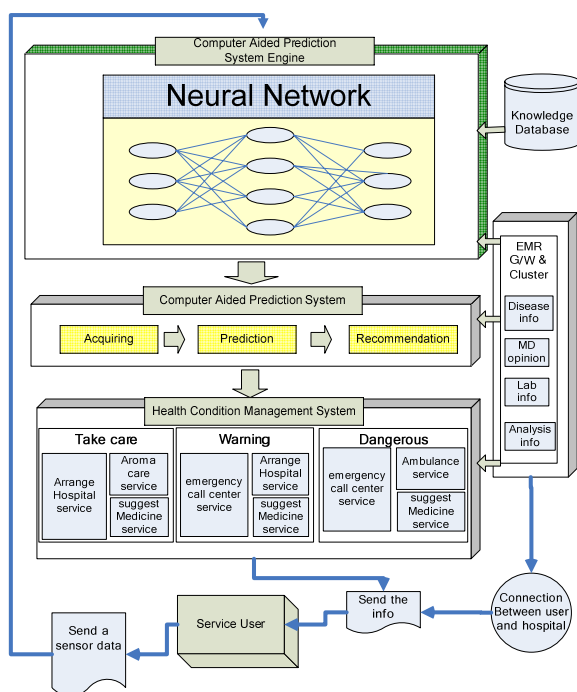


Fig. 7 User pattern learning algorithm based MDSS (Medical Decision support system) framework under ubiquitous

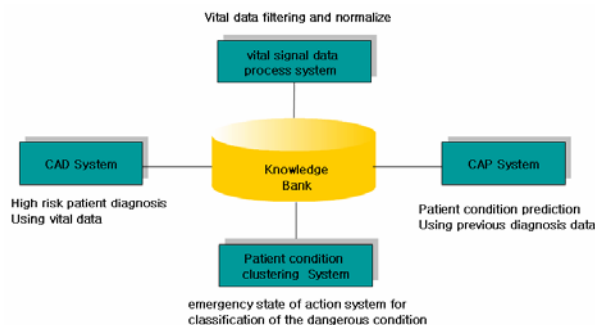


Fig. 8 System function

The database support hospital diagnosis knowledge to CAD system. First system is called vital signal data processing it will be used for noise filtering and data normalization, after detecting the vital data. These filtered signals will be used as input data to the neural network based CAD system. With the help of this information regular monitoring of patient will be possible. It can measure the level of risk by applying regular monitoring and prediction techniques like time series. CAP (computer Aided Prediction) system is possible to predict vital data and the level of the disease. Finally, we are using emergency state of action system for classification of the patient's precarious condition level. However, if the patient's condition is not normal, the system will be suggest and react emergency measurement.

In this paper, we describe CAD and CAP to the patient's precarious condition level framework.

1) CAD (Computer Aided Diagnosis) Framework

In this section, we propose a Computer Aided Diagnosis system (Fig. 9) that is used for the diagnosis of the high risk disease. One of the popular neural network algorithms, Multi Layer Process has been used in this framework. It acquires its input data from patient database. In this framework the problem related to high risk patient, COPD has been studied. Generally, pulmonary disease patient need to check, SaO₂, Co₂, HP, BP etc. which should be passed as an input data to the multilayer neural network process. The target used by this process is based on previous doctor's experience and the output is the result of CAD diagnosis. In addition, the outputs and learning weight results are automatically saved in the database and a message is sent to the server. Then the system waits for database update message to the learning process.

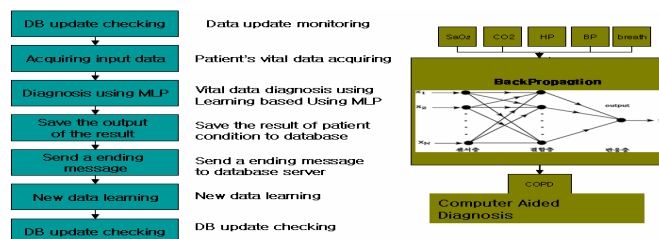


Fig. 9 Computer Aided Diagnosis framework

2) CAP (Computer Aided Prediction) Framework

The method of the Computer Aided Prediction (CAP) system framework (Fig. 10) is almost the same as the Computer Aided diagnosis system. However, this system acquires input vector about patient's previous and current data ($Y_{t-1} \sim Y_{t-n}$) for the prediction of level of risk in the future. The steps of Computer Aided Prediction (CAP) system are described as in figure 10. First, CAP system checks server for updated database to monitor the patient status. Second, it finishes the result of prediction and set the new learning weight, finally, it saves those vital data in the database.

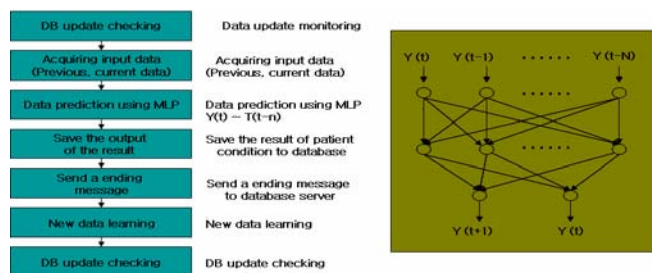


Fig. 10 Computer Aided Prediction framework

V. CONCLUSION

Actually, current medical service systems are lacking in terms of offering real-time patient monitoring, diagnosis, and early detection of disease symptoms and problems in patient's health state. However, ubiquitous system is getting accession to the throne of solution for real time monitoring of data. One of the best utilization of this technology can be in the field of healthcare system especially homecare service using wireless sensor device.

The objective of this paper is to define a framework for the computer aided diagnosis and computer aided prediction of the high risk patients. The inside of the algorithm is using neural network learning model so it is available to learn patient's personalized living body signal pattern.

It will help the medical system to do early detection of high risk diseases, reduce diagnosis error and prevent sudden death situation. Also it can predict and preempt the symptoms of a disease. It means that the most important factor is their individual experience of diagnosis.

The research suggests the best medical treatment for prevention of diseases related to high risk disease in the U-hospital, home healthcare system, PERS (Personal Emergency Response System), and silver town healthcare for elder people and patients.

Our future work aims to further research on developing a numerical model for diagnosis. Especially, we are going to develop CAD, CAP system using neural network for testing with pilot project and checking the reliability of the system. A parallel research and implementation activity is underway concomitant to the research presented in this paper.

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