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Design of a Particle Swarm Optimization-based Classification System in a WBAN Environment

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Abstract: Many medical application services in a WBAN(Wireless Body Area Network) require a close diagnosis from a doctor after monitoring or storing data from medical sensors. In a WBAN environment, the amount of data is huge because the data is created in real time. When we analyze a large amount of data, there are some drawbacks in terms of time performance and space. Thus, a study of analysis methods for detecting new information from vital signals is needed. In this paper, we design a blood pressure classification system in the WBAN environment to aim at predicting cardiac disorder that is one of the highest mortality risks in Korea these recent years. To analyze stored blood pressure data in a database, we need to create classification rules of existing data and figure out the best rule based on accuracy. And then, this rule is applied to real data that needs to be classified. Accordingly, we suggest a design of a Particle Swarm Optimization (PSO) Classification System in the Wireless Body Area Network environment to analyze a large amount of blood pressure data efficiently.

Key words: classification, medical sensors, Particle Swarm Optimization, WBAN.

INTRODUCTION

Recently, WBAN is getting famous due to its wide range of features. WBAN offers data exchange and combination between sensors around a human's body[1]. u-Healthcare service has the highest number of users in WBAN applications. u-Healthcare services can evaluate the status of patients after analyzing the data from various medical sensors. Blood pressure evaluation sensors are the most used among the various medical sensors in Korea. Disorder of blood pressure has influence on various diseases. For instance, the top three mortality risks are malignantneoplasm, cerebrovascular disease and cardiac disorder for the last three years in Korea[2]. Cerebrovascular disease and cardiac disorder are related to hypertension so it is possible to reduce a death rate from cardiovascular disease and apoplexy by curing hypertension. About 35%~40% death rate of apoplexy and 20~25% death rate of myocardial infarction could be reduced by controlling blood pressure of hypertension patients. If systolic blood pressure of hypertension patients could be lowered by5mmHg, it could lower 14% for the death rate of apoplexy, 9% death rate for the coronary arteriosclerosis disease, and 7% death rate for the whole death rate. Additionally, hypertension is related to dementia so it is possible to reduce the occurrence of dementia by controlling blood pressure.

Otherwise, if hypertension is not controlled, then the pressure in blood vessels would be increased so and apoplexy(cerebral infarction, cerebral hemorrhage), angina pectoris, myocardial infarction, hypertrophy of the heart, cardiac insufficiency and retinopathy[3] could happen. Accordingly, increasing blood pressure has a bad effect to the death rate and develops complication. In this paper, we suggest the system design for classifying blood pressure data automatically. This system evaluates blood pressure in a WBAN environment in real time then stores it into the Database for analysis. To analyze a huge amount of data efficiently, PSO Classification algorithm is used in this system. In many local and foreign research and development of u-Healthcare applications, the functions are only limited to simple monitoring of data that includes vital signs or providing diagnosis of doctors about data stored in the Database. Therefore, analysis methods to find out complicated relations and new information reflecting various vital sign features are needed. In this paper, we design a classification system based on the Particle Swarm Optimization algorithm to classify blood pressure data that is stored in a database in a real-time fashion. This enables evaluating blood pressure in a WBAN environment so that it could be possible to medically examine and find chronic feeble people and prospective patients.

RELATED RESEARCH

A. Wireless Body Area Network(WBAN)

Recent advanced developments have enabled wireless sensors to tiny, lightweight, and low power consumption. These wireless sensors have been used in the medical area with a wide range of capability. It enables clinicians to monitor patients remotely and give them timely health information and support. Also clinicians could give diagnosis to patients efficiently.

The mobile communication infrastructure which enables communication between implanted bio sensors in or on the body and portable devices such as Personal Digital Assistants(PDA) is called the Wireless Body Area Network(WBAN). A broad spectrum of requirements exist in the WBAN application area. Standardization of WBAN

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is the first step which is getting important recently[1].The representative WBAN application is the medical service, like medical examination and treatment in a hospital. WBAN with sensors are used to monitor patients' condition inside the hospital and also transmit patients' vital signs to doctors over the internet in real time outside the hospital. Fig 1 shows the WBAN service structure in a medical environment[4].

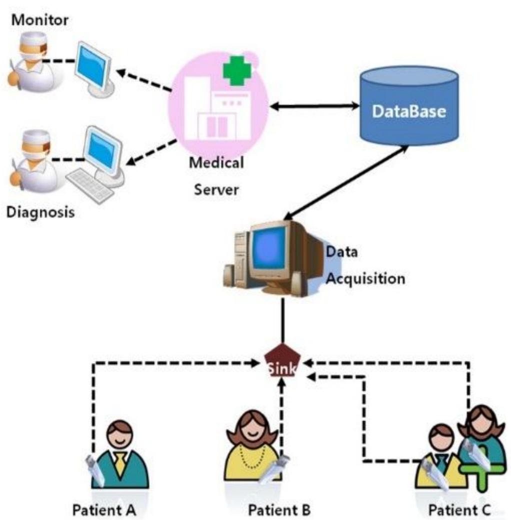

Fig 1: WBAN service structure in medical environment

There are several related research projects such as the MobiHealth project of EU[5], Personal Care Connect(PCC) Open System Platform of IBM[6] and CareNet of Univ. Texas, Dallas for analysis of patient's status from collecting vital signs[7]. In Korea, also a lot of research and development is going on. For instance, there are KT Healthcare Center[8], technology of 24 hours health screening using somatometry of Univ. Seoul, the Samsung Advanced Institute of Technology, and telemedicine service of EsuUbiCare[9].

```
Input : training data

iteration number

Generate initial particles
(= classification rule) randomly

for iteration number do
  for each particle do
    calculate the fitness value using training data
    find the pbest
  end for

  find the gbest

  for each particle do
    calculate velocity
    update particle
  endfor
endfor

output : rule corresponding to gBest
```

Fig 2:PSO Classification algorithm pseudo code

B. Particle Swarm Optimization Classification

Particle Swarm Optimization(PSO) algorithm is based on swarm intelligence such as birds and fishes. PSO algorithm is a stochastic, population-based computer problem-solving algorithm[10], [11]. It has plural search points and seeks the globally best value by probabilistically changing search points using particle's best value. The "best" simply means the position with the smallest objective value. The Particle Swarm Optimization Classification algorithm is developed by applying the PSO algorithm to the Classification problem. Fig 2 shows the PSO Classification algorithm[12],[13].

SYSTEM DEVELOPMENT

In the WBAN environment, a huge amount of data is stored into the Database in real time so that users could get more accurate analysis results than other applications. But there are some drawbacks such as time performance and space caused from analyzing the huge amount of real sensing data. Due to this most existing applications provide simple limited diagnosis to users after the data is stored and manually analyzed by the doctors.

To overcome these drawbacks, we suggest a system that can analyze the blood pressure data automatically. In this system, the blood pressure data is stored into the database in real time and it can classify normal and abnormal cases using the PSO algorithm. PSO is a kind of evolution algorithm. It is applicable to huge amounts of data and has very good time performance, and therefore it fits the purpose of blood pressure data analysis in a WBAN environment. To measure blood pressure, we use DuoCare blood pressure sensor which is made by GENEXEL-MEDICAL and T-mote is used for wireless communication. An example of blood pressure data in WBAN is shown in Fig 3.

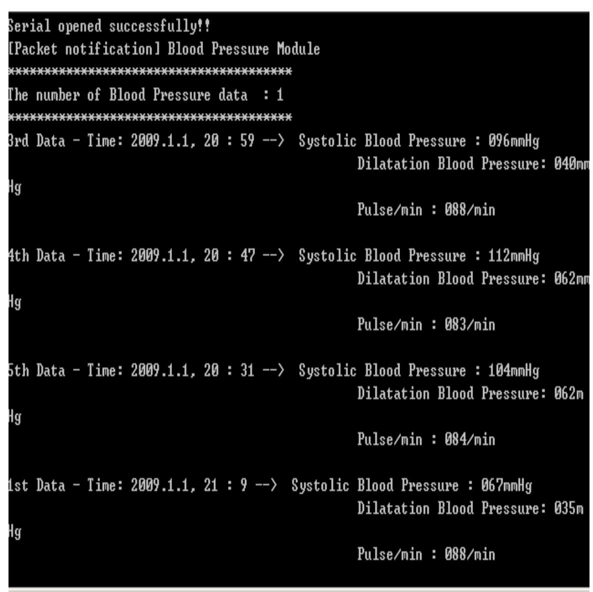

Fig 3: Blood pressure data from WBAN

Before performing the actual classification, an aggregation process is needed to reduce the amount of blood pressure data. The aggregation is done by calculating the average of each hour and divided into the Activity

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period(day-time) and rest period(night-time) by circadian rhythm. Also, in order to analyse the blood pressure data for a day, the average of blood pressure data for each day is calculated. Following "The Body Clock Guide to Better health", activity period is from the sharpest rise in blood pressure(6:45am) to the highest blood pressure(6:30pm) and rest period is from getting decrease in blood pressure(6:31pm) to just before the sharpest rise in blood pressure(6:44am)[14]. Table 1 shows the data after the aggregation process.

Table 1: Example of the aggregated data

Name	**7am**	**8am**	**…**	**7pm**	**Rest period**	**24 hour**	**Class**
M.B.Y	135 /85	131 /81	…	121 77	120 /70	130 /80	Norma l
C.O.K	131 /81	129/ 85	…	113 /80	92 /65	135 /90	Ab-normal
…	…	…	…	…	…	…	…

Aggregated data is stored to a DataMart, and the data in the DataMart is divided into a training data set and test data set. The training data set is used for making rules and the test data set is used for evaluating the accuracy of the rules. Fig 4 shows an overview of the system performing the analysis on the blood pressure data.

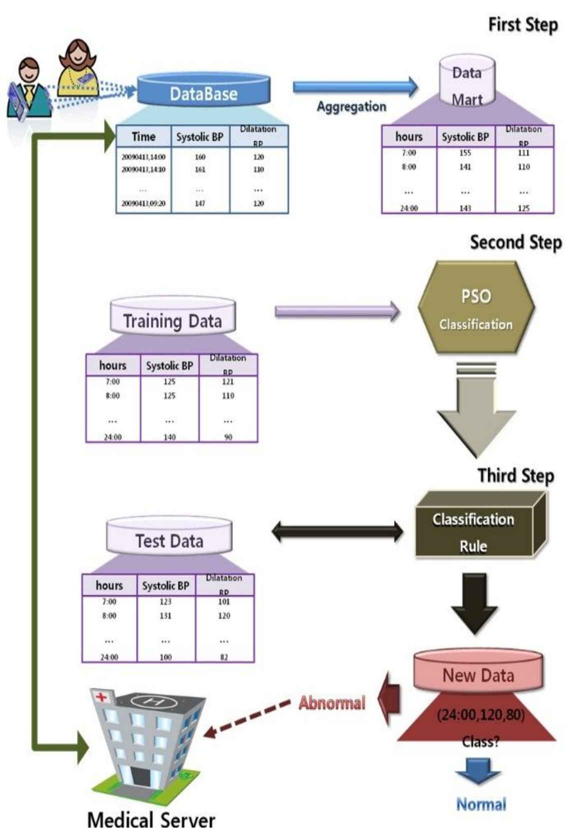

Fig 4: Blood pressure data analysis system

In this paper, the suggested blood pressure analysis system has three steps. In the first step, the blood pressure data is stored into the Database in real time and then, to reduce the amount of data, an aggregation process is performed. Aggregated data is stored into the DataMart and initial classification rules are randomly generated. In the second step, training data is applied to the PSO Classification algorithm and rules are constructed. The PSO Classification algorithm is executed iteratively and evaluates the accuracy of rules. Table 2 shows the confusion matrix to evaluate the accuracy.

Table 2: Confusion matrix

		Predicted Class	
		Class = 1	Class = 0
Actual Class	Class = 1	f11	f10
	Class = 0	f01	f00

fij represents the number of records of class iwhich are predicted to be class j. According to the confusion matrix, the number of correctly predicted records is f11+f00 and the number of inaccurate predictions is f10+f01, so the formula to evaluate the accuracy is shown in Fig 5 [15].

$$\text{Accurate} = \frac{f11+f10}{f11+f10+f01+f00}$$

Fig 5: The formula to evaluate accuracy

These steps are iteratively performed until the iteration number is met and selection of the best rule is done by selecting the rule with the best accuracy. The new data which needs to be classified by these rules could get results such as normal and abnormal. In the third step, if the new data is classified as abnormal, the data will be sent to the Medical Server in real time for monitoring and a second diagnosis from clinicians would be obtained.

CONCLUSION AND FUTURE WORK

The number of doctors is small compared with the data ofpatients to be handled so we suggest a system to automatically analyze blood pressure data in a WBAN environment. To reduce the amount of blood pressure data in the WBAN environment, an aggregation process is performed based on the Circadian rhythm and aggregated data is stored in a DataMart. In this paper, the PSO Classification algorithm is suggested for applying classification rules to improve the time performance. We suggest applying the confusion matrix for evaluation of the rules. This system architecture is proposed to automatically classify normal and abnormal blood pressure data as the first diagnosis before clinicians actually analyze the patients' data. If patients' data is classified as abnormal, the data will be sent to clinicians for monitoring and get a second diagnosis. Thus, Clinicians could give diagnosis to patients in a timely and efficient manner. In the future, further verification of the system that we suggested will be carried out. We may compare the time performance and accuracy of the blood pressure classification system with other classification systems.

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