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무선 생체신호 처리를 이용한 상황인식

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Context Awareness Using Wireless Biosignal Processing

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요 약

본 논문에서는 상황인식(Context Awareness)에 필수적인 정보인 사용자의 활동을 감지하고 인식하기 위한 무선 생체신호처리 시스템과 퍼지추론에 의한 사용자의 눕기, 앉기, 걷기, 뛰기의 상황을 인식하는 방안을 제안한다. 제안된 방법에서는 지속적인 동작관찰과 사용자의 생체운동량 및 운동패턴을 측정하기 위하여 가속도 센서인 ADXL 202JE를 사용하였다. 측정된 데이터를 RF(Radio Frequency)로 상황인식 서버에 전송하여 퍼지추론 방법으로 사용자의 상황인식(눕기, 앉기, 걷기, 뛰기)을 하였다. 실험결과 Longitudinal Accelometer Average Value의 크기데이터 만으로는 사용자가 뛰고 걷는 행동상태 판단에 어려움이 있었으며, 임의의 블록에 대한 L.A.A의 분산은 걷고 뛰는 행동 판단에 유용하게 이용될 수 있음을 확인하였다.

Abstract

In this paper, it was suggested method to recognize the motion of a person(lying, sitting, walking, running) using fuzzy inference and wireless biological signal processing system. These are to perceive the motion of the person. Furthermore, the information of motion is indispensable parameter for Context Awareness(CA). In the present study, ADXL 202JE accelerometer sensor was used to measure for checking the continuance motion, biological quantity of motion, and motion pattern of a person. The measured data was transmitted to CA server by Radio Frequency(RF). From the present result, we confirmed that it is difficult to decide the motion of walking and running with only the magnitude of the Longitudinal Accelerometer Average Value(LAAV) and moreover the covariance of LAAV in any block is very useful for CA of walking and running.

▸ Keyword : Wireless Communication, Biosignal, Signal Processing, Context Awareness

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Ⅰ. Introduction

Center), Xerox America, has mentioned features of ubiquitous computing in a broad sense through research of essential properties of computer and network.[1] Mark Weiser of PARC referred to ubiquitous computing as "intelligent environment composed of numerous computers offering necessary information timely to the right demander".[2] Since then, there have been a lot of active researches and developments by many researchers. Ubiquitous computing is a complex area combined with human-computer interaction (HCI), embedded-type software agents and AI (artificial intelligent) and it is considered that it will have a great influence on human life. The core technical factor in ubiquitous computing environment is user's context awareness. Dey defined the term of context as "all kinds of information featuring existences (man, place, things, etc.) related to interaction between user and system".[3]

Context means information related when system (equipment, program, etc) provides information for users and the system that sense this information automatically and provides proper services for users according to current situation is context awareness system and it is core technology of ubiquitous computing. According to existent researches on context awareness, Ashbrook researched possibility of user's foot awareness using accelometer sensing function on one-handed keyboard called "Twiddler" which is frequently used as input device of wearable computer,[4] and Lee Tae-Su, et al. suggested technique which applies 2D accelometer sensor made with micro precision machinery technique and high frequency data communication of 916 MHz. senses and classifies motion state of human body.[5] Many researchers investigated how to sense motion activity of users using accelometer sensor and system recognizing users' activities with Multi-Layer Perceptron (MPL)[6] and Self Organizing Map (SOM) was developed.[7] These methods are based on measuring position and thus they are not suitable for continuous motion observation or measurement of momentum and motion pattern. Therefore, this paper suggests methods of context awareness of user's lying, sitting, walking and running by embedded wireless biosignal processing and fuzzy inference for the purpose of sensing and recognizing user's activities which are essential to context awareness. Methods suggested use ADXL 202JE, accelometer sensor, to observe user's continuous motion and measure user's momentum and activity pattern. Measured data are transmitted to context awareness server with RF (radio frequency) and conducts user's context awareness by fuzzy inference. PDA (Personal Digital Assistant) embodies system which data received by RF can be understood by embedded software and system which results processed on context awareness server can be displayed on PDA.

Ⅱ. Suggested Context Awareness Methods

Ubiquitous computing means combination of movable computing and intelligent environment and when intelligent environment is space of place that when situation of a space is expressed by sensor, such behaviors on space can be traced automatically without any command.[11] Understanding user's current context is context awareness with information collected by sensor in intelligent environment and inquiry of information collected.[8] This paper measures user's momentum and motion patterns with ADXL 202JE, accelometer sensor. User's context awareness is performed with fuzzy inference by transmitting measured data into server by RF. User's context is displayed on PDA to observe at any time and any place.

2.1 Wireless Biosignal Acquisition System

This paper makes wireless communication at MTS possible with Mica composed of MIB510 (Programming and Serial interface board), MPR (Processor/Radio Board) and MTS (Sensor Board) shown in (Fig. 1) and it uses accelometer sensor signal of sensor functions used and processes it like algorithm in (Fig. 2).

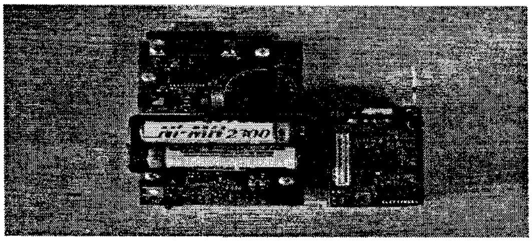


Fig. 1. Mica composed of MIB510, MPR and MTS

MPR to be used as base station is mounted on MIB510 and it is nesC programmed for signal processing of X and Y axes sensed by accelometer sensor.[9] (Fig. 2) indicates relationship between components of nesC .

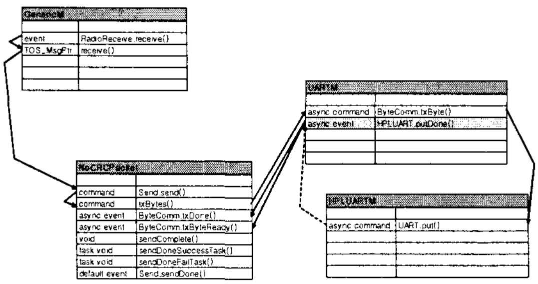


Fig. 2 Relationship between components of nesC

2.1.1 Algorithm of MTS Transmission and MPR Receive

Each component is made of properties of interface and interface embodiment for the definition of basic behaviors. (Figure 3) and (Figure 4) is algorithm of MTS transmission and MPR receive.

```
void SensorDataReceive(data)
{
    while(i<data) {
      packet = makePacket(data);
    }
    RfPut(packet);
    RfPutDone();
}
```

Fig. 3. MTS Send Algorithm

```
void RadioReceive(data)
{
    while(i<data) {
      dataAry = packetParse(data);
    }
    dataByte = txToByte(dataAry);
    UartPut(dataByte);
    UartPutDone();
    txToByteDone();
}
```

Fig. 4. MPR Receive Algorithm

2.1.2 PDA Signal Processing

Data collected from MIB510 are input serially from PDA and signals are analyzed with algorithm shown in (Fig 5).

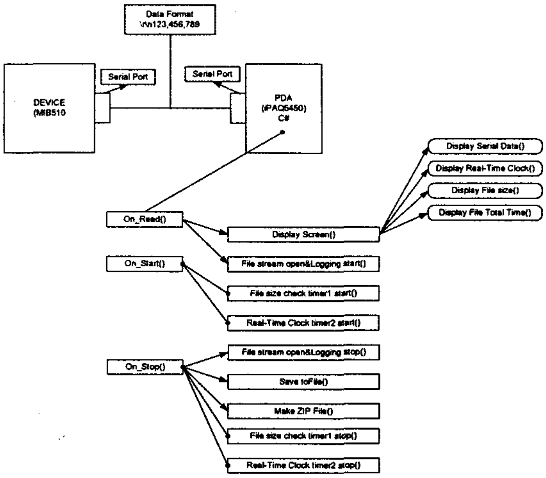


Fig. 5. Signal Processing Algorithm in PDA

Signal of MIB510 is divided into header packet and data packet PDA input and a packet is 37 byte as shown in Table 1.

Table 1. Biosignal Packet Composition

No	Function		Byte
1	Destination Address(7E 42)		2
2	Not use (3F 3F)		2
3	handler ID (0A)		1
4	group ID (7D)		1
5	Not use (5D)		1
6	Message Length(1A)		1
8	PayLoad	Source mote ID(02 00)	2
9		sample counter(50 52)	2
10		ADC channel(01 00)	2
11		ADC data reading	20
12		Other bytes(2F 3F)	2
13		Stop byte(7E)	1
Total			37

Number 1 to 10 in Table 1 is header packet and No. 11 is data packet of X and Y axes of accelometer sensor. If packet is input, header values and data values are displayed on screen at real time. (Fig. 6) shows composition of wireless biosignal acquisition system.

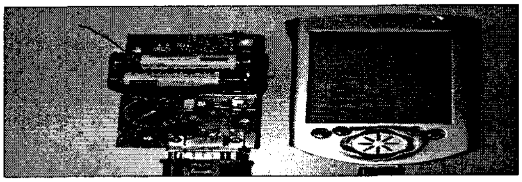


Fig. 6. Composition of Wireless Biosignal Acquisition System

2.2 Context Awareness by Fuzzy Inference

Fuzzy inference system is system that corresponds to input data vector with scala input, has structure like (Fig. 7) and is composed of four factors including fuzzy rule, fuzzifier, inference and defuzzifier.

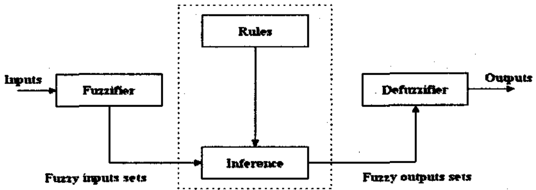


Fig. 7. Composition of Fuzzy Inference System

If a rule is set, fuzzy logic system makes input correspond to output and this correspondence is expressed as $y = f(x)$. Engineering fuzzy rule is a set of propositions expressed by if-then. In (Fig. 10), fuzzifier is needed to activate rules as language variables to make input correspond to fuzzy set and inference is to correspond to fuzzy output set from fuzzy input set according to rules. Defuzzifier makes fuzzy output set correspond to a value.[10]

Fuzzy inference algorithm for user's context awareness is composed of the following steps.

[Step 1] : Divide input and output spaces into fuzzy zone.

Sections having valuables x and y are divided into several areas. Each area is called Lying, Sitting, Walking and Running and fuzzy membership functions are assigned to each area. (Fig. 8) divides x1~x4 into four areas (N=2) and y into four areas.

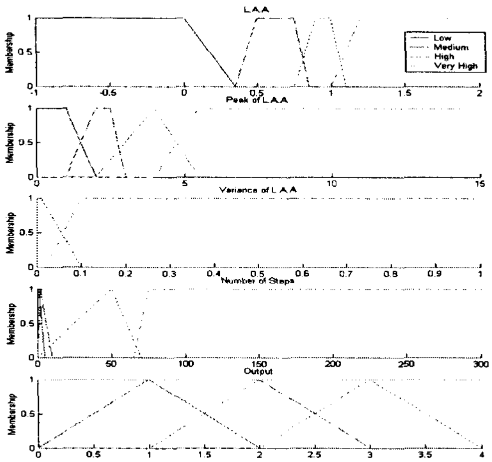


Fig 8. Membership for inputs and output

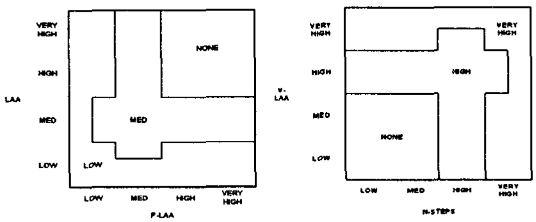
[Step 2] : Fuzzy rules are produced from given data pair.

Production of fuzzy rules is decided with membership degree of input and output data pair from each area, data from specialist and numerical data obtained through experiment. Rules are produced by applying fuzzy operators like AND or OR from secured input and output data pair.

- Rule 1 : IF LAA is LOW or P-LAA is LOW, THEN y is LOW.
- Rule 2 : IF LAA is MED or P-LAA is MED, THEN y is MED.
- Rule 3 : IF V-LAA is HIGH or N-STEPS is HIGH, THEN y is HIGH.
- Rule 4 : IF V-LAA is VERY HIGH or N-STEPS is VERY HIGH, THEN y is VERY HIGH.

[Step 3] : Fuzzy Rule.

Fuzzy rule base has forms like (Fig. 9(a)) and (Fig. 9(b)) and then result from fuzzy rule is assigned to each area.



(a) (b)

(a) Fuzzy rule base for decision (b) Fuzzy rule base for decision of Lying and Sitting of Walking and Running

Fig. 9. Fuzzy Rule

[Step 4] : Deciding output correspondence based on fuzzy rule.

Inputs LAA, P-LAAA, V-LA and N-Steps are received with sensor and inferred by prearranged rule. After inference, patient's conditions are decided through defuzzification.[10] First, find DOF of each state from membership functions of four inputs (x1, x2, x3, x4) and make if part of ith rule expression (1) by using max-min operation to decide degree of input membership. That is,

$$m^{i}_{O^i} = m_{I^i_1}(x_1) \cdot m_{I^i_2}(x_2) \quad \cdots\cdots (1)$$

where, Oi and Iij indicate output area of rule I and input area of jth condition. For instance, in case of rule 1, expression (2) is generated.

$$m^{1}_{LOW} = m_{LOW}(x_1) \cdot m_{LOW}(x_2) \quad \cdots\cdots (2)$$

For deciding output, defuzzification method of center area method is used like Expression (3).

$$y = \frac{\sum_{i=1}^{K=4} m^{i}_{O^i} \bar{y}^{i}}{\sum_{i=1}^{K} m^{i}_{O^i}} \quad \cdots\cdots (3)$$

where K is the number of fuzzy rule base and yi is center of output area Oi.

III. Experiments and Investigations

3.1 Experiment

3.1.1 Wireless Biosignal Acquisition

This paper used Mica (Serial Port Based Programming Device) of Cross Bow Co. as sensor measuring user's motions. Mica uses Atmega128L microprocessor by Atmel Co and is used by attaching multifunctional sensor modules which can sense various analog signals like magnetic field, sound, light, temperature and accelometer to extension slot of main programming board.[8] (Fig. 10) is configuration of development system and equipments for this paper.

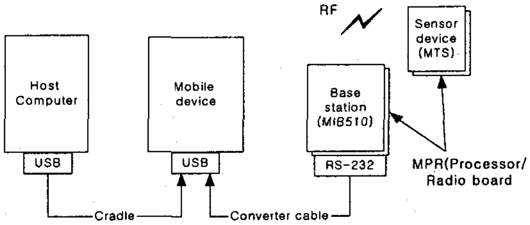


Fig. 10. Configuration of Development System and Equipments

Mica used as sensor is composed of MIB510, MTS and MPR, signal monitoring device is PDA and development system is host computer.[8] MIB510 in (Fig. 13) receives data to RF from MTS and outputs it to serial port. Data between PDA and MIB510 receive signal input by using USB to Serial conversion cable. Host computer uses and links cradle using USB interface for developing and debugging PDA monitoring program. (Fig. 11-A) shows MTS and MPR and (Fig. 11-B) is figure connecting MIB510 and PDA.

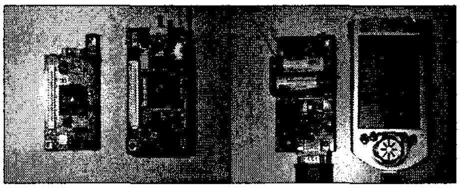


Fig.11-A. MPR, MTS Fig.11-B.MIB510, PDA

(Fig. 12) is displaying data sent to RF on PAD. [start]/[end] button is on/off function of serial port, [Save] button saves collected data to text file and database table simultaneously.

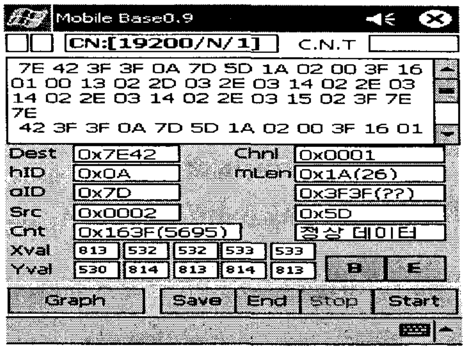
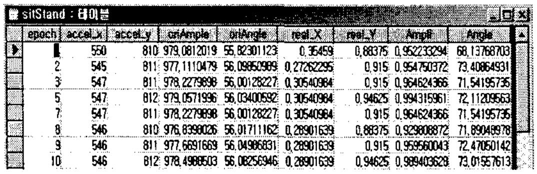


Fig. 12. Header and Data Output



sitStand : 테이블

epoch	accel_x	accel_y	oriAmple	oriAngle	real_X	real_Y	Ampli	Angle
1	550	810	979.0812019	55.82301123	0.35459	0.88375	0.952233294	68.13768703
2	545	811	977.1110479	56.09850989	0.27262295	0.915	0.954750372	73.40864931
3	547	811	978.2279898	56.00128227	0.30540984	0.915	0.964624366	71.54195735
5	547	812	979.0571996	56.03400592	0.30540984	0.94625	0.994315961	72.11209563
7	547	811	978.2279898	56.00128227	0.30540984	0.915	0.964624366	71.54195735
8	546	810	976.8398026	56.01711162	0.28901639	0.88375	0.929808872	71.89048978
9	546	811	977.6691669	56.04986831	0.28901639	0.915	0.959560043	72.47050142
10	546	812	978.4988503	56.08256946	0.28901639	0.94625	0.989403628	73.01557613

Fig. 13 shows structure of saved database table.

[Graph] button in (Fig. 12) is function to show graph like (Fig. 14) with saved database and in experiment, data obtained after user's motion of sitting and standing are displayed on PDA through sensor attached to chest without context awareness of data obtained. User's motion pattern is known as shown in graph, but concrete user's context is not known. Therefore, context awareness is needed by analyzing signals on database.

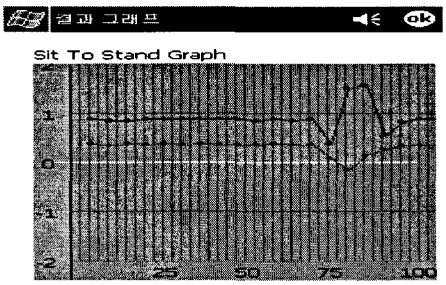


Fig. 14. Sensor Data Output Graph

3.1.2 Context Awareness

Context awareness of received biosignal is conducted with fuzzy inference. Input signals for fuzzy inference include accelometer value, mean of peak of accelometer value, variance of accelometer and number of steps, and name of input variables are shown in Table 2.

Table 2. Input Signal of Fuzzy System

Name of Variable	Meaning
Long.Acc.Avg	1 sample/sec mean value of 5 samples of data obtained
Peak of L.A.A	1 sample/sec mean value of 5 samples of data obtained
Variance of L.A.A	variance value of 10 samples of L.A.A
Number of Steps	30 samples/min mean value of 5 samples of data obtained

(Fig. 15) is results of context analysis by inputting several input variables to system.

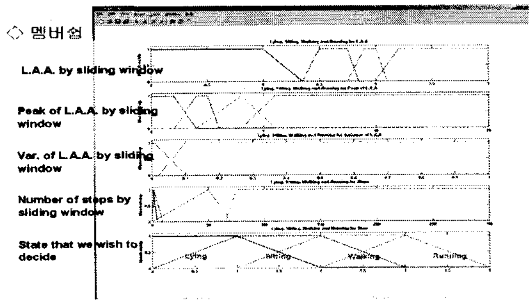


Fig. 15. Context Analysis Using Multi-Inputs

(Fig. 16) is conduced in order of walking (10 min.) - sitting (5 min.) - walking (5 min.) - running (10 min) - walking (10 min.) - sitting (10 min.) - lying (10 min.) and shows L.A.A., Peak of L.A.A., Number of steps, variance of L.A.A, obtained from accelometer sensor and result values of lying (~1), sitting (~2), walking (~3) and running (~4) analyzed by fuzzy inference system.

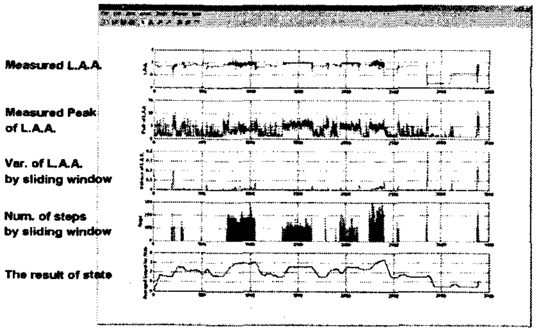


Fig. 16. Input Signal and Context Judgment

(Fig. 17). is vertical direction signal L.A.A of accelometer sensor and divides emergency situation by Running→Fall backward and Walking→Fall backward.

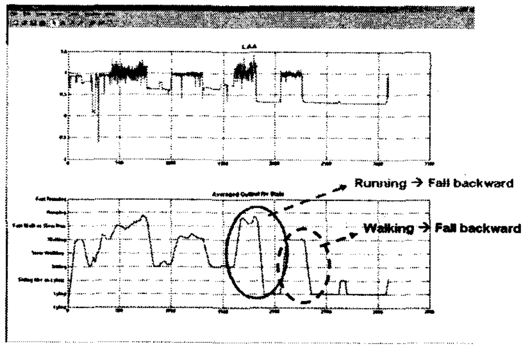


Fig. 17. Condition of Emergency Situation Judged

3.2 Investigation

Ubiquitous computing means combination of moving computing and intelligent environment. Therefore, wireless biosignal acquisition system is absolutely needed to trace acts in environment or space where intelligent environment and situation in space are expressed by sensor and acquired signals are processed by context awareness system to know current state. System for wireless biosignal acquisition lacks its development environment or application system. For building such a system, sensor which can measure biosignal exactly should be equipped and signal of this sensor should be sent and received. This paper embodies systems that motions and data sensed in biosignals send to RF and process them at PDA and context awareness server. Context awareness understands Running, Walking, Sitting and Lying as fuzzy inference methods. Embodied system is available in application system to sense ADL (Activity of Daily Life Index) of patient requiring continuous care as well as context awareness and make observer see them.

VI. Conclusions

The core technical factor in ubiquitous computing environment is user's context awareness. This paper suggested wireless biosignal processing system of embedded type for sensing and recognizing user's activities which are compulsory information in context awareness and methods of context awareness including user's lying, sitting, walking and running by fuzzy inference. Suggested methods used accelometer sensor ADXL202JE for observing continuous motions and measuring user's momentum and motion patterns. User's context awareness (lying, sitting, walking and running) are conducted by means of sending measure data to context awareness server with RF (radio frequency) and using fuzzy inference. Wireless biosignal acquisition system used Mica sensor. Data are received from MIB510 MTS of Mica with RF and output to serial port. Data between PDA and MIB510 have signal input using UBS to Serial conversion cable. Host computer uses and links cradle using USB interface for developing and debugging PDA monitoring program. Obtained data are sent to server with RF and user's context awareness is performed by fuzzy inference method.

User's behaviors can be understood by means of multiple input data at context awareness system. As a result of experiment, it was difficult to judge user's motions like walking or running only with Longitudinal Accelometer Average Value and it was confirmed that variance of L.A.A of random block was available in judging motions of walking and running. Further research tasks are to develop technique acquiring distant biosignal, recognizing user's context automatically using acquired biosignal, providing results of context awareness to observer and observing it at any time and any place.

References

[1] Mark Weiser. "Hot topic: Ubiquitous Computing", IEEE Computer, PP 71~72, October 1993.

[2] Weiser, M. The Computer for 21th Century. Scientific American, September , 1991.

[3] Dey, A.K. "Understanding and Using Context", Personal and Ubiquitous Computing Journal, Vol. 5(1), pp. 4~7, 2001.

[4] D. Ashbrook, "Context sensing with the twiddler key-board", in The Third Int'l Symposium on Wearable Computer, (San Francisco), pp. 197~198, October 1999.

[5] Lee Tae-su, Cha Eun-jong, Hong Ju-hyun, Jin Gey-hwan, Park Gyeong-sun, Cho Myeong-chan, Park Gil-seon, "embedded computing for moving body measurement"

[6] C. Randell and H. Muller, "Context Awareness by analysing accelerometer data", in The Fourth Int'l Symposium on Wearable Computers, (Atlanta, Georgia), pp. 175~176, October 2000.

[7] K. V. Laerhoven and O. Cakmakci, "What shall we teach our pants?", in The Fourth Int'l Symposium on Wearable Computers, (Atlanta, Georgia), pp. 77~83, October 2000.

[8] http://webs.berkeley.edu/tos/media.html

[9] Milena Milenkovic, Jovanov, E, John Chapman, Dejan Raskovic, John Price, An Accelerometer -Based Physical Rehabilitation System, IEEE, 2002.

[10] Jeong Dong-seong, Lee Yong-hak, A study on fuzzy rule function test for predicting service rate of server at ATM network.

[11] Choon-Bo Shim, Yong-Won Shin, Byung-Rae Park, "An Implementation of Context-Awareness Support System based on Voice for Medical Environments", "Journal of The Korea Society of Computer and Information", Vol. 10. No. 4. September. pp 29~36, 2005.

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