Autonomous Interactive Physical Caring by Flexible Data Flow Management

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Abstract. Being able to monitor the body condition and health condition of the user telemetrically is a very important for caring the user. User's danger occurring from unconscious body stress can be consisted by vital signs and body postures. These vital signs and body postures can be estimated by data fusion of variety of body parameters. System with fluent flow to estimate body condition and advices should be made. These data can be controlled by user’s oral commands. This paper describes the construction and flow of the autonomous caring system and it’s data control by user.

1. Introduction
Recently, Quality of life (QOL) is becoming an important concern for us in our daily life. Human health is one of the aspect that would influence the QOL. Daily attention to the body condition and health evaluation of your vital sign beforehand will prevent any disorder, deterioration of body condition that may decrease your QOL. The body area network field is an interdisciplinary area which could allow inexpensive and continuous health monitoring with real-time updates of medical records through internet. The system will even enable the user caring by the remote observer which could be used for caring elders living at estranged countryside. Although the system operates autonomously, user will be able to control the data flow through voice command voluntarily. With this system, User and the remote observer will be able to realize user’s body condition without disturbing daily life. This health caring will lead to increase of QOL.

2. System Construction
2.1 System Flow
The system is constructed by two main system; by Local Wearable Sensing Node Network(LWSNN), Host system (HS). LWSNN and HS is connected by internet bidirectional. LWSNN is constructed by 3 sub-systems; HUB system (HUB), Wireless Sensing Nodes (WSNs) and Audio Visual Human Interface (AVHI). Fig.1 shows the connection of each System. The parameters taken at the WSNs are collected to the HUB where it processes the advice and does the estimation. The advice and estimation are transmitted to Host system for monitoring telemetrically, and to AVHI for feedback to the users. Advice will lead to user’s behaviour improvement. Fig.2 shows such interactive close loop system.
2.2 WSNs

Wireless Sensing Nodes (WSNs) is the main aspect of constructing the Local sensing system. WSNs obtains the information of body condition and user’s habits using the sensors contained inside the modules. Series of sensors such as Temperature, Acceleration, Heart rate (HR) and Spo2 are included in each module. Shown inside LWSNN of the Fig.1, seven modules exist as the WSNs such as head, ankle and ankle. Each modules are required to be light and compact not to interrupt user’s daily life.

2.3 Data fusion of heterogeneous data

The HUB system will be the core of the local sensing system which collects the parameters, estimates, construct advice and communicates with other system. HUB is constructed by two main parts, HUB transceiver and smartphone. As same as modules in WSNs, HUB transceiver carries the ZigBee as a communication unit and PIC microcontroller (32bit, 40MHz) for data processing. HUB transceiver receives the parameter data from WSNs and store it inside the connected smartphone through the USB communication. Inside the Smartphone, varieties of applications and data box exists to organize the received data. In Fig.3 it is composed of seven applications and four buffering folders. Received data stored at the databox are used for fusing to usable parameter, such as body swing, walking pitch and average HR. Theses fusion are done by various applications.

2.4 AVHI

To improve the user’s unconscious behavior during the activity, AVHI is used to feedback the advice made in HUB to the user. Feedback is done by the smart glass made by Vuzix M100, head mount gear will give advice visually and also by audio. The example of visual feedback is shown at Fig.4. This feedback will be done by the advice data stored at databox; Postbox to AVHI. This feedback is effective when doing a jogging exercise for it helps keep the aimed walking pace. This is judged by the HR compared with the aimed exercise intensity (EI) on Head module.

![Fig.1 Construction of Telemetric Body Area Network System (TBAN)](image1)
![Fig.2 Interactive Close loop System](image2)
![Fig.3 Application Flow and Data Box of HUB System](image3)
![Fig.4 Visual Feedback on AVHI](image4)
2.5 Remote Caring System

Monitoring HS can confirm current user’s body condition ubiquitously. HS displays the information collected and sent from the HUB for the observer in remote area. This communication is done by drop box of the cloud system. By using data box, it will prevent the lack of data during the communication. Received data is distributed in suitable data form such as Graphs, Picture, and Animation for User Interface (UI). HS also can create command to the WSN or AVHI for not only specific data request but also control the threshold range of WSN. In other words HS can not only monitor from the remote, it can remote control as well.

3. Voice command control

Conventional system allowed the user to view the current body condition and activity advices. Training advice sent from remote observer was distributed autonomously on user’s AVHI as well. With voice recognition function on AVHI, it will enable user to achieve necessary body parameter at their voluntary timing. Body parameter the user command is shown visually through the smart glass on AVHI. User’s request voice is converted to voice command data using voice recognition function. Voice command will be sent to HUB module as command is processed. Hub module will identify the voice command and achieve the required data from data box; Data Collection. Achieved data will soon be transmitted to AVHI to distribute to wearing user. As well as parameter achieving, user will be able to change their exercise threshold range which was conventionally only controlled by host system. This reciprocity function constructs interactive system between the user.

4. Command Control during Jog Training

4.1 Management of Physical Exercise Intensity

The application of WBAN enables the user to perform exercise at their targeted level of intensities. This exercise coaching is one of the function in the system to care the user’s daily life. The relationship between HR variability and EI is defined by Karvonen Formula (Eq.1, 2), which is employed in order to determine HR threshold range and trends of HR indexes in generating advice commands.

\[ EI[\%] = \frac{HR - HR_{min}}{HR_{max} - HR_{min}} \times 100 \]  
\[ HR_{max} = 220 - Age \]

EI is classified into four groups as Table 1. Threshold values are determined by the value of the lowest and the highest heart rate during targeted exercise intensity. Table 2 shows the relation between the trend HR, threshold range and types of advice feedback. The effectiveness of this system is evaluated in a percentage of heartrate settled in the range of the threshold as shown in Eq.3. The higher percentage indicates high quality exercise.

\[ R_{exist}[\%] = \frac{Num_{exist}}{Num_{total}} \times 100 \]

| ZONE | LEVEL OF INTENSITY | EXERCISE INTENSITY [%] |
|------|-------------------|------------------------|
| 1    | Light             | 20-30                  |
|      |                   | 30-40                  |
| 2    | Moderate          | 40-50                  |
|      |                   | 50-60                  |
| 3    | Intense           | 60-70                  |
| 4    | Heavy             | 70 and above           |

![Table 2. Classification of Advice](image-url)
4.2 Experimental condition

The experiment was conducted to prove the reliability and effectiveness of advice generated through system. Also the accuracy of the oral command. The user wore AVHI and all 7 devices of LWSNN and had jog training. Host system act as an observer of the exercising user. User conducted experiment as shown on the schedule of Fig.5. Exercise intensity is changed every 5minutes by the user.

| Rest pace | EI: 20-30% | EI: 30-40% | EI: 40-50% | EI: 50-60% | EI: 60-70% | EI: 70-80% | EI: 80-90% | EI: 90-100% |
|-----------|------------|------------|------------|------------|------------|------------|------------|------------|
| 0         | 5          | 10         | 15         | 20         | 25         | 30         | 35         | 40         |
| 45        | 50         | 55         |            |            |            |            |            |            |

Fig.5 Exercise Intensity Schedule during Experiment

4.3 Experimental Results

Fig.6 shows the graph of HR during the experimental schedule. We can see that User’s HR is gradually increasing and decreasing which matches the user’s aiming EI. Transition of EI after each command was successful and from the advice, user’s HR was kept in range for each threshold. Rate of HR kept under range was maximum of 95% during the highest EI. For almost all other threshold ranges, HR existence percentage was kept above 50%. The lowest HR existence was 24.4% of last threshold level 20-30[\%]. This is considered a cause of High EI jogging and short interval to decrease the intensity. From the two reasons, difficulty occurred for HR to stabilize in certain range.

![HR transition graph during the jogging exercise](image)

5. Discussion

Results indicates a positive improvement as the higher HR existence was achieved by using advices. This proves that advices from the system can drive the HR into targeted range of intensities, giving users the consciousness towards their running behaviour. By user commanding EI the system orally, it will avoid lopsided flow. This will enable more real coaching system where user can communicate with the system as if the observer is there for you. This command was executed instantly which led to advice construction with new EI threshold autonomously. Advice performed efficaciously as existence rate was mostly high for all threshold. In other words, this autonomous interactive close loop system is able to help users in ensuring a better quality of life.

6. Conclusion

From the result we were able to observe the efficiency of the system. Advice made from commanded EI effected the user activity, which showed dynamic response of HR during the exercise. This request from the user makes the system interactive. With the feedback, user will change their activity which would be evaluated again for the new advice estimation. This reverse loop is another essence to call the system interactive. The system provides healthcare assistance in jog training and sport coaching to prevent health problem.

7. Reference

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