Availability of Wearable Heart Beat Rate Data on Analyzing Daily Sleeping

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ABSTRACT

In the past few decades, many catastrophic natural disasters have occurred not only in Japan and Korea, but also in other countries in the world, forcing people to live in unfamiliar houses for middle or long range evacuation periods. Residents staying in temporary houses exhibit insomnia, resulting in severe fatigue. In order to investigate sleeping state of residents, measuring vital signals has been performed at examination room of a hospital. To avoid the restriction of residents' movement, we propose to use smartphone and/or wearable devices with various high performance sensors like measuring heart beat rate. We clarify the availability and usefulness of those devices as support for analyzing daily sleeping state of residents.

Keywords : heart beat rate variation, wearable device, smartphone, living in temporary houses for evacuation.

1. Introduction

In the past few decades, many catastrophic natural disasters have occurred not only in Japan and Korea, but also in other countries in the world, forcing people to live in unfamiliar houses for middle or long range evacuation periods. Residents staying in temporary houses exhibit insomnia, resulting in severe fatigue. In order to measure sleeping state of residents at their home, we propose to use smartphone and/or wearable devices implemented with sensing heart beat rates, and show the availability and usefulness for analyzing residents' daily sleeping state during the night-time period.

2. Devices Used for Measurements

The devices that are used for measuring the heart beat rate variability are as follows: Wearable Heart Rate Recording device: Wrist-type MIO-LINK [1], Smartphone (Samsung I9190 Galaxy S4 min (android v.4.4.2 version-up) , Korea, and BLE Heart Rate & HRV Recorder, MUC-InnOvation, D-83564 Soyen Germany[2]. The software for analyzing the data of sensed time series of heart beat rates has been developed by the authors.

3. Analysis of Recorded Data of Daily Heart Beat Rate

The data of heart beat rate from four participants has been obtained since October 2014: three adults (65- and 63-year-old male and 45-year-old female) and one young adult (21-year-old male). In order to ascertain the usefulness of the proposed method, we showed the data of participant A of 63-year-old male who was diagnosed as insomnia

3.1 Case of Mr. A: The sleep data shown in Fig. 1 were recorded during night-time (23:00 to 07:00) at April 3, 2015. He went to bed at 23:15, but it took about 75 minutes to fall in sleep. First and second wake-up time were at 01:30 and at 03:10, respectively, because he used toilet. Third wake-up time was from 04:05 to 05:20, during which he used toilet and followed reading books, hearing music, etc. These were because he could not fall in sleep. At the time of 5:30, he slept in depth again until wake-up at 07:10.

3.2 Analysis of the recorded data: As described in Poincare diagram (see Fig. 2), the distribution of heart beats per minute (BPM) showed asymmetrical curve. Thus, we used the median value, 60 [bpm] in this case, to reduce the artifact effects caused by body movements. Accordingly, we could obtain the accurate characteristics of BPM variation during night-time period.

· The stable state of BPM is defined as the state that last ten successive BPM values are under predefined threshold of BPM. The duration of sleep state is defined as the time interval of more than 60 seconds in stable state. Sleep level i is the state of BPM values under the median-2i (i=0, 1, 2, 3,⋯). For the data of Mr. A, the duration of Sleep level 0 is calculated as 2.56 [hours] and sleep level 3 did not appear at all. Consequently, it means severe lack of sleep for him. The power spectral density of the BPM is shown in Fig. 3.

4. Conclusions

In order to measure BPM variation of residents during night-time period from 23:00-07:00, long measuring interval, at home bedroom, we proposed the useful tools of smartphone/wearable devise combination with software that we have developed. Based on the time-series of BPM, Poincare diagram, and Power spectrum of the data recorded from residents were analyzed. These methods proved to be highly available and useful for residents who were living in the temporal houses for evacuation purposes. We will further clarify the characteristics of gender and age differences in more details.

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6. References

[1] Wrist-type MIO-LINK, available at http://www.mioglobal.com/Default.aspx.
[2] BLE Heart Rate & HRV Recorder, MUC-InnOvation, D - 83564 Soyen Germany, available at http://www.muc-innovation.de/mucbox/NEUE-HP/
[3] Holloway PM, Angelova M, Lombardo S, St Clair Gibson A, Lee D, Ellis J., 2014, "Complexity analysis of sleep and alterations with insomnia based on non-invasive techniques", J. R. Soc. Interface 11: 20131112.,. available at http://dx.doi.org/10.1098/rsif.2013.1112.
[4] Feng-Tso Sun, Cynthia Kuo, Heng-Tze Cheng, S. Buthpitiya, P. Collins, M. Griss, "Activity-aware mental stress detection using physiological sensors", Mobile Computing, Applications, and Services, Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering Volume 76, 2012, pp 211-230.
[5] J.M. Kelly, R.E. Strcker, M.T. Bianchi, "Recent Developments in Home Sleep-Monitoring Devices", International Scholarly Research Network, vol.2012, Article ID 768794, 10 pages.

Sleep Level 0: 2.6 hours, Level 1: 1.7 hours, Level 2: 0.4 hours, Level 3: 0 hours

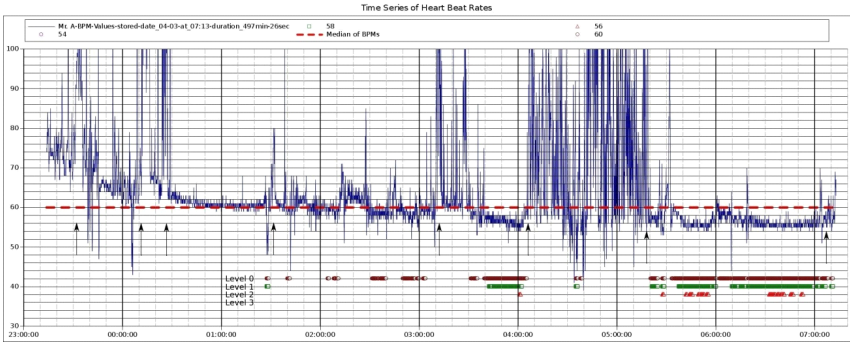

Fig.1 Time series of heart beat rate during night-time (23:00-07:00).

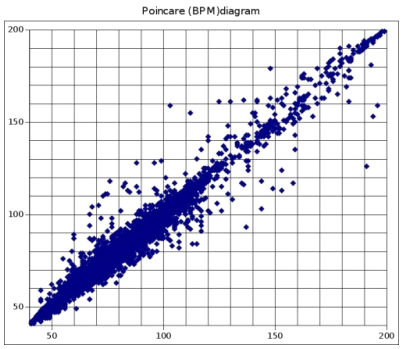

Fig.2 Poincare Diagram.

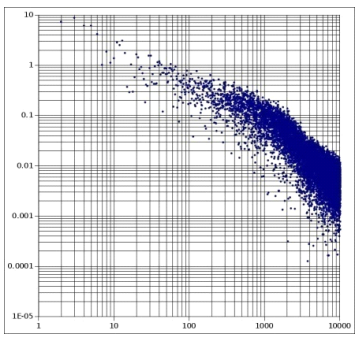

Fig.3 Power Spectrum Diagram