

## e-Health System for Stress Management Based on Heart Rate Variability

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## 1. Introduction

With the development of information and communication technology, all kinds of work have been streamlined and shifted to computer processing. As a result, the software business and the communication industry have continued to increase. In recent years, the Fifth Science and Technology Basic Plan proposed the Society 5.0, a sophisticated fusion of cyber and physical space, as the society that Japan aims to become. In this society, vast amounts of big data will be collected in cyberspace, analyzed by artificial intelligence, and fed back to physical space in various forms.

Elementary school students and older people alike own smartphones, and the Internet is constantly being used somewhere, for example, to complete governmental procedures through online applications. In other words, the convenient Internet will continue to evolve to become even easier to use and more efficient, and the shift to online will increase. It is easy to predict that IT businesses will make great strides in the future, and the term “IoT” will become more familiar and more commonplace.

In addition, since last year, as a countermeasure against infection, many people have been forced to work remotely, refrained from going out, work at home, remote meetings, online classes, and delivery-type events. Though such policies were implemented only in the last year due to infection control, many of those activities will probably continue to be carried in such a manner for the sake of efficiency.

In job hunting, many companies plan to continue to hold information sessions and first interviews online. In addition, there were many cases of positive impressions of increased efficiency compared to before the infection control measures, such as take-out at restaurants, touch panel order, and online business trips at work. This countermeasure against infection has led to changes in social systems and increased opportunities to feel stress.

This study measures the low frequency/high frequency (LF/HF) value, a general stress indicator, using a heart rate sensor, one of the biometric sensors. The LF/HF value is then incorporated into a part of the lifelog data for analysis and processing. After that, we extract the life data of the current time from the lifelog and apply it to a system that determines appropriate coping contents based on biometric data and behavior. Coping requires measuring stress using biometric sensors, identify behaviors, and calculate the elapsed time of similar behaviors using behavior identification.

To collect lifelog data, we use a Raspberry Pi 3 (Model B) and an Arduino UNO with various sensors attached and use cluster analysis of the lifelog data. The current behavior, elapsed time of behavior, stress state, and so forth are identified from the analysis results. We developed a system where the user can follow coping commands and automatically take measures against stress by making the HTML available to the public to be viewed with smart glasses.

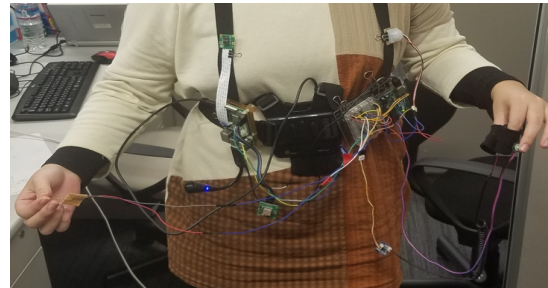


Figure 1. Equipment used for data collection

## 2. Lifelog Data Collection

Several methods deal with lifelogging, a data set of transactions platform human life information. Many of them use the location information in the device to record behavior. The lifelog can be used for recording and automatic health management and daily life management by including biometric data such as body temperature and weight. In addition to recording, the lifelog can automatically manage health and improve daily [1].

Existing research using lifelog data includes behavioral feature extraction and event detection from lifelogging data using tweets. By analyzing the acquired lifelog data, we can utilize it for users' health management and learning and targeted advertising as a business. Hence, the analysis of lifelog data can be used for individuals and society.

However, in the current situation, users have to take photos and record their moods by hand. There are many different applications for lifelogging, such as the purpose of use, required data, and output interface. In addition, there are various applications for lifelogging, such as the purpose of use, required data, and output interface. To prevent some of the drawbacks, it is vital to use a single application to collect lifelog data.

We are developing a wearable device that uses a microcontroller with Arduino UNO from Arduino LLC and Raspberry Pi 3 (Model B) developed by the Raspberry Pi Foundation, a biometric sensor that can measure body temperature and heart rate, and an environmental sensor that can measure GPS and acceleration. This research will also utilize this developed device (see Fig. 1) and the behavior identification method.

## 3. Measuring Stress

Stress in this study refers to the degree of tension and balance between the sympathetic and parasympathetic nervous systems. It is referred to as the ‘stress state’ when the sympathetic nervous system is tense and the ‘relaxed state’ when the parasympathetic nervous system is tense. Studies on stress measurement include those using self-administered questionnaires.

However, self-assessment has the disadvantage that it requires the subject to reflect on his/her state and answer a questionnaire

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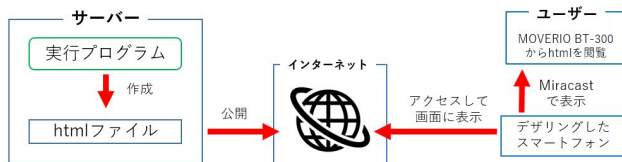


Figure 2. The flow of the collected data and its analysis

and that there is a discrepancy between physical sensation and the body, so the actual stress state cannot be determined.

In this context, existing research on biometric sensors related to stress includes methods using saliva, skin temperature, and galvanic skin response. The saliva method [1] uses biochemicals that are considered stress markers. Salivary amylase activity is used to measure stress because it is highly correlated with norepinephrine concentration, a neurotransmitter involved in sympathetic nervous system signaling. Methods such as saliva and blood are often used, although they require collecting samples because they can handle more than ten biochemical substances related to stress. In addition, research is underway to develop a tool to measure stress within 10 minutes using a small micro electrophoresis chip.

The skin temperature of the trunk (the torso excluding the left and right limbs) does not change significantly with stress. On the other hand, peripheral skin temperature decreased by environmental temperature changes and psychological factors such as anxiety, tension, and mental load such as task execution [2], and is a significant indicator of physical fatigue in stress measurement. The galvanic skin electrical response is a skin electrical resistance (skin potential change) generated by the activity of sweat glands due to sympathetic nervous system excitation, and the excitation of the sympathetic nervous system is obtained from the resistance value by passing an electric current through the area prone to psychogenic sweating. HF and LF, which estimate the balance of the autonomic nervous system, are indicators of stress values among biological information and are used in many stress-related studies [3].

#### 4. Proposed Method and Experimental Results

To make the system work as ambient computing, we need to publish HTML and let users recognize it naturally. In this system, we use MOVERIO BT-300. This glass is connected to the Internet and can be accessed through a browser so that the HTML can be viewed in real-time by accessing it through Google Chrome (see Fig. 2). Since the HTML file is stored on the server by the executable program, we use HTTPS communication to make it accessible from the outside. In other words, since the file can be viewed from any device as long as the address is known, the only information that does not violate privacy is presented (e.g., the location is not the name of a building but a desk).

Usually, browsers need to be refreshed manually. Google Chrome has a feature called Easy Auto Refresh that automatically refreshes the browser at a specified time. However, Android devices do not have this feature, so installing the Auto Refresh application on the device and automatically refreshing the HTML accessed by Chrome will eliminate the need for manual refreshing. Additionally, it has a cast function to be shared with the screen of the device. Thus, the HTML is automatically updated on the phone

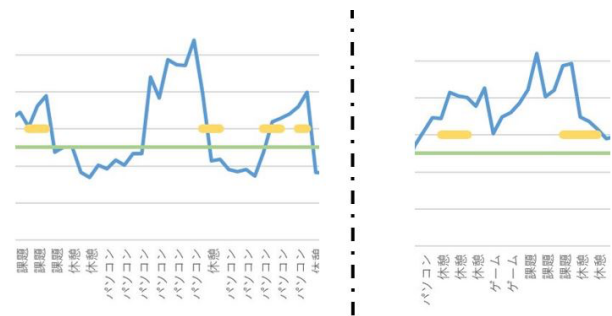


Figure 3. Changes in stress values (left: PC work, right: game)

and cast on the glass so that the user can recognize the HTML content naturally. The MOVERIO series does not allow the installation of applications other than those specified. The MOVERIO BT-300 is equipped with a Miracast function to share the screen with the device's screen. The HTML is automatically refreshed on the smartphone and cast on the glasses, allowing the user to recognize the HTML content naturally.

Figure 3 compares the stress values from the stress logs before and after a computer work and game. Yellow indicates the time when the coping was performed. If one looks at the left task (typing) and computer work in Figure 3, one can see that the LF/HF value increases when the computer work is continued. When the coping was triggered during the experiment, the subject took a short break to rest their eyes or stand up. As a result, the LF/HF value tended to decrease. On the other hand, if the coping was ignored, the LF/HF value did not fall below the standard value but remained higher than the expected value. Therefore, it suggests that computer work causes stress even for a short time and becomes undesirable if continued for a long time.

#### 5. Concluding Remarks

This study analyzed heart rate variability in time series data using a heart rate sensor in a wearable sensor that acquires biological and environmental data and calculated LF/HF values, which are stress indicators. The sensor data was then sent to a server using socket communication, and behavior identification was performed from the lifelog created based on the sensor data. Appropriate coping was set based on the identification and stress state. Finally, we developed an ambient computing system that presents the coping contents to the user in HTML displayed on smart glasses. Various behaviors were analyzed to determine the significance of the proposed system, and the coping results were verified by the change of LF/HF between coping and no coping. It was confirmed that the stress tended to decrease more when coping was performed.

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