Context based physiological signal analysis in a ubiquitous VR environment

Ahyoung Choi, and Woontack Woo

***Abstract*— With the advent of smart sensing technology, environmental context and user context is widely deployed by the context awareness middleware developers and application developers. This environment leverages to utilize the abundant resources of information. In this paper, we present the principles of context based physiological signal analysis in a ubiquitous VR environment. Ultimate goal of this work is building the principles of physiological signal analysis with the knowledge of unknown control variables such as environmental condition and user characteristics.**

***Index Terms*— physiological signal analysis, context awareness, and personalization**

I. INTRODUCTION

WEARABLE or mobile physiological sensors have been commercially sold in common with the development of a next generation healthcare applications. One of the most serious problems in wearable physiological sensing system is low reliability because of low SNR ratio in physiological signal. There are some limitations when we analyze the physiological signal with wearable or mobile sensors due to the sensing noises and changes of sensing condition. In addition, it is hard to obtain the same results obtained from distinct products with respect to the same measurements. To solve this problem, we are able to be aid from heterogeneous sensors and services in the ubiquitous VR environments. There are huge amount of sensors and services which allow us to understand the current situation and context. With this regards, we conclude that sensor fusion techniques are extremely essential part in analyzing physiological signal.

In this paper, we describe the way of analyzing the physiological signal indicator with multiple contexts. This analyzer has a role to integrate multiple physiological signals for reducing measurement error which occurs in wearable computing environment and to combine user-centric context into physiological states for reliable analysis of physiological signal. Knowing the previous condition before measuring the physiological signal gives us clues to understand the user status precisely and reliably. Finally we derive the stress level concerning about user characteristics such as sensitive or non-sensitive against the stimulus, pessimist or optimist, and healthy or non-healthy and the environmental condition such as outdoor temperature, weather, sensing time and noise.

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All is with GIST U-VR Lab, Gwangju, Korea (e-mail: {achoi, wwoo}@gist.ac.kr).

II. RELATED WORKS

In previous work, there are some researches about context fusion and sensory data fusion, or health information fusion. Subrata Das et al indicated the life status estimation with the Bayesian network with history node [1]. It combines the heart related factors such as certainty, previous measurements and current measurements. However, it is not concerned about sensing condition and noise, but physiological signal analysis itself. In the field of wearable sensing technology, they also have been concerned about tiny and light-weight wearable sensors and its integration. Armband type wearable sensor was released from Bodymedia Company [2]. The sensor measure multiple signals, which are galvanic skin response, skin-near body temperature, two axis accelerometer and heat flux through the wireless network. They concerned motion artifacts in physiological signal analysis. However, motion artifact filtering is just for the help of heart related signal analysis and the system works after collecting the data in a offline manner. ubiMon project [3] also indicates the sensory information integration with multiple wearable physiological sensing nodes. However, it just collects the multiple contexts.

III. PROPOSED MNETHOD

Context based physiological analysis with multiple context information is enabling to make personalization and adaptation to the user and the environment. In order to build the context based analysis, we model the relationship among the environmental context and physiological signal from the previous literature and exploratory experiments for checking the relationship as a first step. The relationship is modeled with the Bayesian belief network as Fig. 1 illustrated. The conditional probability table (CPT) is set with the previous literature and the experiments with the process analysis or CNX analysis. As a results, we found that the injected stimulus, body constitution, outdoor temperature, gender, clinical history, age cause the increase of hear rate, and the radical changes of skin response and body temperature.

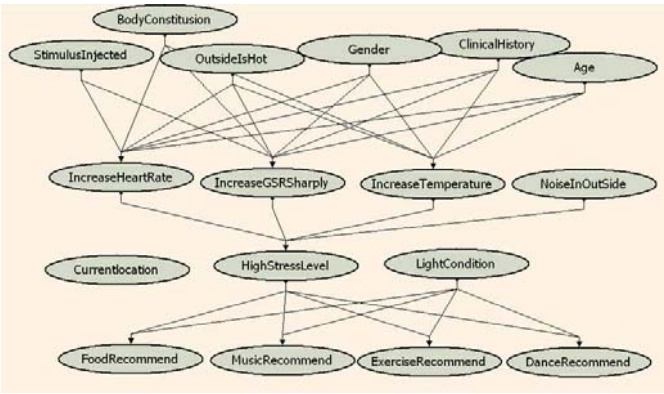

Fig. 1 Conditional probability table

Secondly, we analyze the stress level based on the decision making process. The stress levels and contextual information are combined with the context inference module. After the relationship is set, we select some of the states which have strong relationship from Bayesian belief network model. In the decision making step, we determine the type of process and the input factor. There are two kinds of decision making process. First one is decision in final stage. It means that all feature variables in the sensing step is obtained and the features directly combines with weighted sum, which is illustrated in Fig. 3.

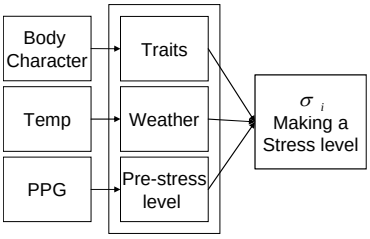

Fig. 2 Decision making process A

Second processing type is multiple threshold based decision, as depicted in Fig. 4. Classified the traits and weather condition is inputted into decision threshold making step and these are combined with each other. In this process, we can express the inter-relationship such as body character and temperature if it is said that higher temperature has more influence on the people who is sensitive against the stimulus. In this step, basic idea is derived from the previous literature about sasang category in oriental medicine which depicted the person into four types such as tae-yang, tae-um, so-yang and so-eum [4]. This theory complies with the personal distinction from the body shape, characteristics, skin type and color and walking patterns. And each person has different response in terms of the outdoor condition, stress and so on.

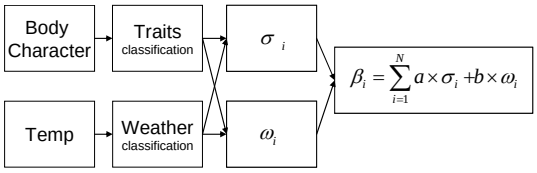

Fig. 3 Decision making process B

IV. EXPERIMENTAL ANALYSIS

In order to get the proper parameter for building relationship model and decision making parameters, we did preliminary experiments. In this experiment, we utilize the wrist type physiological sensor which includes a 3-axis accelerometer sensor and a PPG sensor and commercial sensing equipment-BIOPAC. This experiment consisted of two phase. At first, we should understand the human itself. With this expectation, we observed the physiological signal from distinct user with same measurement devise. Secondly, we verified the fact that the environmental condition such as temperature or humidity levels which may cause the certain stressful or uncomfortable condition is used for setting the basic offset. Some items were control variables when the experiments were conducted and others were added by the theory referenced in this works. Table 1 and Table 2 illustrate the measurements from different user and different sensing condition. From these experiments, we observed that the different user and conditions are influenced on the different situation.

Table 1 Measurements of different users (User A, B, C)

	PPG					GSR	
	pp	min	max	stddev	Med.	mean	slope
A	1.415	-0.331	0.952	0.330	-0.033	5.743	0.000
	1.014	-0.534	0.683	0.232	-0.189	5.557	-0.003
B	3.179	-0.462	2.000	0.605	-0.026	14.202	0.008
	1.495	-1.179	0.986	0.390	-0.161	10.752	-0.010
C	3.311	-0.835	1.740	0.685	0.011	4.566	-0.006
	1.848	-1.801	1.013	0.423	-0.053	2.473	-0.013

Table 2 Measurements in distinct conditions (PPG sensor)

Conditions	pp	Mean	stddev	Median
Basic	1.546	12.242	0.111	-0.099
Noisy	2.829	14.298	1.155	-1.113
Humid and hot	1.009	15.221	2.000	0.008

V. DISCUSSIONS

In this paper, we indicate the context based physiological signal analysis method. After checking all the control parameters which we concern about, we conclude that the higher temperature is derived from the anger of the subject with higher stress level. Therefore, we conjectured that we need at least two axes for supporting reliable analysis in order to allow the reliable analysis. As a future work, we have a plan to investigate whether the selected sensing parameters and decision parameters is appropriate.

REFERENCES

[1] Das, S. K., Introne, J., Lawless, D., Hoyt, R. and Muza, S, "Probabilistic Unit Life Status Estimation (PULSE)," Proceedings of the 7th International Conference on Information Fusion, pp. 959-966, 2004

[2] BodyMedia. Healthwear armband, bodybugg. http://www.bodymedia.com

[3] Kristof Van Laerhoven et al, "Medical Healthcare Monitoring with Wearable and Implantable Sensors," UbiHealth ,2004

[4] Chae H et al, "Alternative way to individualized medicine: psychological and physical traits of Sasang typology," Journal of Alternative and Complementary Medicine, vol 9, 2003