

Hunger and stress monitoring system using galvanic skin response

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ABSTRACT

In the world, roughly more than 3 million people are affected by muscle power loss diseases which cause lack of communication. Further, this lack of communication is a severe problem with hunger and stress, which sometimes proves to be fatal. It is essential to monitor physical parameters such as hunger and mental stress of the patient. To observe hunger and stress, galvanic skin response (GSR) sensor is a most preferred method because it measures the conductance of skin due to sweating. We have designed new hunger and stress monitoring system (HS-MS) that helps patients and their caretakers to monitor stress and hunger level. HS-MS is two electrodes system that attaches to two fingers (index and middle) of the patient and monitors starvation and tension. According to the response of the sensor, caretakers can identify hunger and even the mental stress conditions of the patient. In all, 35 patients were examined using HS-MS system and 20 of them were used as a control. Overall system accuracy was found out to be 86.6% and response time of HS-MS 5 seconds. Sensitivity with respect to hunger and stress was about 99.9% and 73.3% respectively. Thus HS-MS can be identified as a helpful tool to provide comfort to the patient easily and can be used in hospitals or homes with lonely elderly people.

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1. INTRODUCTION

In the hospital, various physiological parameters of the patient are monitored continuously by trained nursing staff and doctors. Vital body parameters such as temperature, heart rate, and pulse rate and blood oxygen level of the patient are to be continuously monitored so that health condition of the patient can be kept under control. Due to certain muscle power loss diseases such as Amyotrophic lateral sclerosis (ALS), Stoke, Tay-Sachs disease, patients become highly dependent on their relatives or care-takers. In many cases, patients even cannot express hunger or demand food. In such cases, the hunger and stress monitoring system (HS-MS) system can help care-takers or hospital attendants in finding out patients hunger. Even HS-MS system can help these care-takers finding any stress on patient, who cannot express feelings like fear or irritation. Mental condition of the patient is also important for fast recovery of a patient. For example, for the heart patient, any stress can lead to a serious condition like the heart attack.

Stress and hunger can be measured with a simple system comprising of a Galvanic Skin Response sensor. It is observed that skin secret more sweat in stressed conditions. Galvanic skin response sensor can be used to identify any such incidences. Physiologists believe in the fact that, in increased stress condition many of the following symptoms are observed in patients, like rapid breathing, increased heart beat rate, excess sweating, drop in body temperature and tension on muscles.

Many researchers have contributed in development of wearable instruments measuring the human stress. They adapted different techniques like computer vision techniques [1] to extract the visual evidences like facial expressions, wearable emotion monitoring using skin temperature, skin conductance, and pulse wave [2]. Also quantifying stress levels based on measures of Heart-Rate Variability (HRV) using reliable, high-precision instrumentation and synchronized measurements [3,4], using wearable instruments like glove containing skin temperature and GSR sensor were reported [5, 6]. Repositionable Chest Straps System for cardiac and respiration recordings are reported recently [7]. Many other researchers used methods to measure any one or a combination of different body parameters like heart rate, respiration rate, blood pressure or skin conductance etc. [8-13]. Most of above mentioned literature work is focused on stress measurement and very few reports on hunger measurement.

All the research work reported in literature was done using more than one sensor or methods and mostly in fully controlled environment. In the literature many kind of hunger are enlisted like physical, emotional etc. which can be detected by psychologists using psychological techniques and therapies. In physiology an attempt of hunger detection is mainly done to control obesity or dementia in literature. They used methods like observing intake patterns, by questioning [14], and suggesting hunger scale [15]. No specific method is suggested to detect hunger for patients or elderly people who are totally dependent on others.

In this paper we have described design and implementation of HS-MS system which is an attempt to detect human stress and hunger using skin conductance. GSR sensor is used to measure skin conductance by attaching sensor to finger tips of a person. GSR signals are collected and send to controller using inbuilt analog to digital converter. Signal is then sent to PC using wireless communication as shown in Figure 1 HSMS architecture. This method is based on the fact that GSR of a person varies in case of any stress and hunger than normal readings, as shown in Figure 2. Our prototype HS-MS system is a wearable and wireless system that can be used by elderly people and patients on their own.

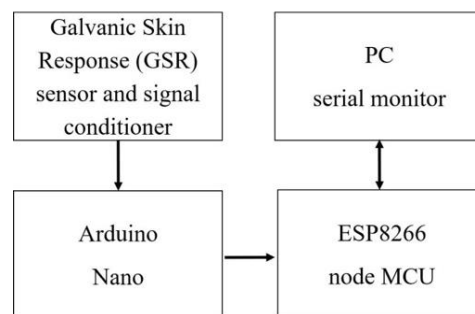


Figure 1. HS-MS system architecture. Readings are acquired using GSR sensor and converted in to digital signal using Arduino Nano on board ADC. ESP 8266 node MCU is the used to transmit the data over Wi-Fi towards PC

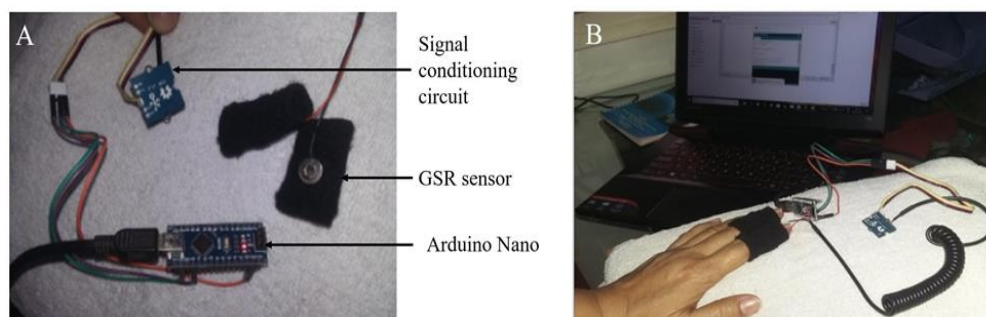


Figure 2 Arduino Nano is used to acquire readings from GSR sensor and send it over WiFi using ESP8266. The signal conditioning circuit is used for interfacing GSR sensor with A to D converter of Arduino Nano. GSR sensor is a sensor for standard readout of the conductance value from the scale. (B) Image of experimental setup

2. RESEARCH METHOD

2.1. System Description

HS-MS system consists of sensors and Arduino board to collect and process data from sensor. The data is then sent to computer system for storage and display using wireless communication. Figure 3 shows the HS-MS system (A) and the experimental setup (B). System consists of GSR sensor which takes skin conductance as sensor input and produces analog voltage signals as sensor output. Signal conditioning circuit consists of an amplifier and voltage divider circuit that shifts voltage level of GSR sensor between 0 to 5V DC. Signal conditioner output is then converted to digital signals using inbuilt A to D converter circuit of Arduino Nano board. Output from Arduino Nano board is then sent to computer using wireless communication module WiFi ESP 8266 node MCU.

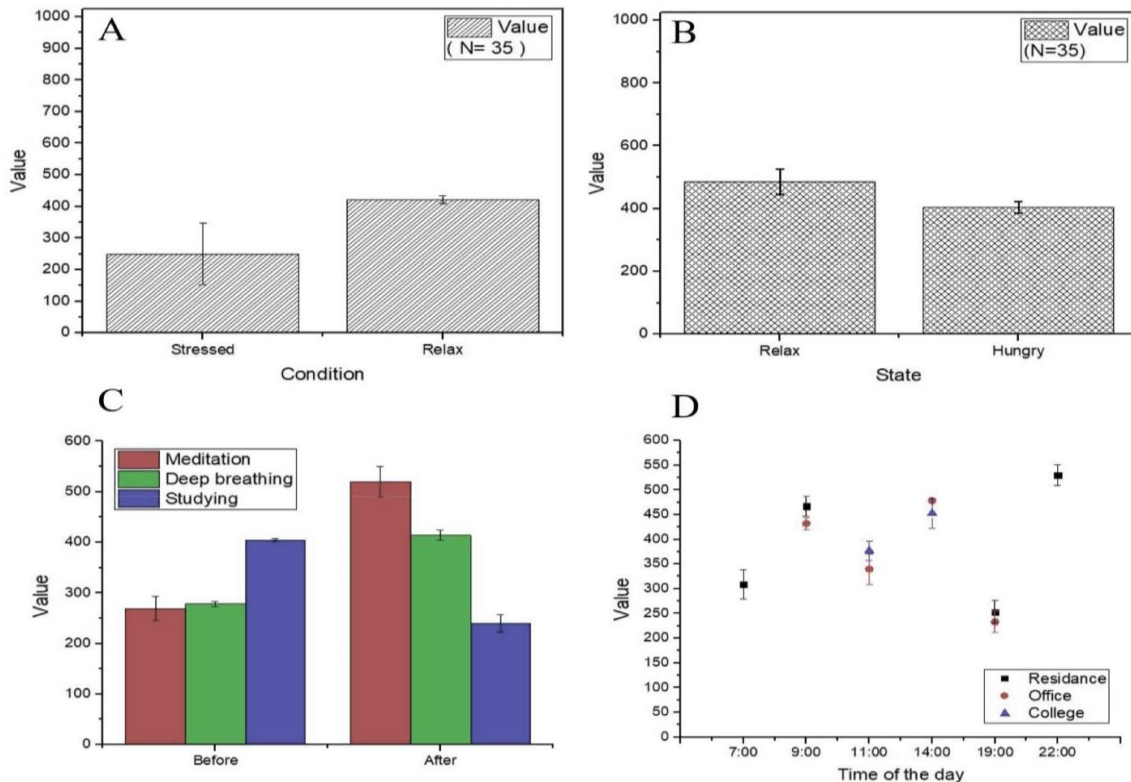


Figure 3. Standard values at the output of GSR sensor

Figure 3(A) Different values obtained with the stressed condition and relax condition. In stressed condition the average value goes below 300 and standard deviation is very high. In relax condition the value is above 400 with negligible standard deviation. Figure 3(B) Indicates Hunger status readouts from HS-MS system. It is always observed that during hunger the value falls below 400 but remains above 300 with slight standard deviation value. Figure 3(C) Stress levels affected by meditation, deep breathing and studying. As per the system readout we found meditation and deep breathing translates stressed to relax state. On the other hand, studying changes relax state to stressed state. Figure 3(D) Effect of time of the day on system readout. At 7 AM and 11 AM most of the subjects were found hungry. At 9.00, 14.00 and 22.00 almost all the readings were found into a relaxed category. At 19.00 PM most of the test cases were stressed and few of them were lying into a hungry state. There was no significant difference as per the place (residence, college, office) concerned.

2.2. Experimental Procedure

The experimentation for stress and hunger measurement is conducted on a group of 35 healthy people (each for hunger and for stress) in regular environment at different locations like residence, office and college campus. Test was carried on people from age group of 18 to 45 and almost equal number of males and females. Out of 35 samples 20 were used and control (Already known as hungry or stressed) and 15

readings were used for blind testing which was then verified from user feedback given prior to the testing. The readings were taken in different conditions such as before and after meditation, deep breathing, while studying difficult subjects at different times like early morning, late night, before and after lunch time and at different places also like college campus and at home.

2.3. Algorithm for Hunger and Stress Detection

- a) Attach sensor input leads to fingers tips of person.
- b) GSR values are collected, converted from analog to digital by Arduino using serial communication.
- c) Processed Arduino output is sent to laptop/computer using wireless communication ASP8266 WiFi.
- d) If GSR value is above 400 then set State= relax, else if GSR value lies in between 300 to 400 then set State= hungry else set State= stressed.

In above algorithm step 4 values were decided after control experiment with 20 readings each for hunger and for stress.

3. RESULTS AND ANALYSIS

We have taken different GSR readings to detect stressed and relaxed conditions similarly to observe hungry and relaxed condition as shown in Figure 3(A) and (B). It is observed that the GSR reading shows high values in relaxed state. In hungry condition readings are found out to be below 400 but above 300. When readings were below 300 and with high variance, we found out the status to be stressed. We can conclude that GSR readings were generally above 400 in relaxed state. We have observed that the state to be relaxed with no hunger and no stress. Figure 3(C) shows the readouts of HSMS system when test subject was under meditation, deep breathing and studying. We found the effect of these conditions on the stress level of participants. From the values recorded after meditation and before meditation and deep breathing exercise, it is found out that stressed state of the subject has changed to relax state.

On other hand readings before studying and after studying shows transformation from relaxed state to stressed state. Figure 3(D), shows the effect of time of the day on system readout. Different state of relaxation at different time was recorded. Most of the subjects found out to be hungry at 7.00 and 11.00 time points. At 9.00, 14.00 and 22.00, almost all the readings were found into a relaxed category. At 19.00 most of the test cases were stressed and few of them were lying into a hungry state. The readings were taken at different places but there was no significant difference as per the place (residence, college, office) concerned. All results could detect hunger. Same participants participated 3 times in detection of hunger on different days. The obtained results were confirmed for repeatability.

In case of some participants GSR value increased even after consuming tea or coffee. HS-MS system will be further modified as wearable system and measuring different body vital parameters like temperature, heart rate, pulse rate and ECG. Using all these parameters or a combination of any one with GSR values more accurate tests for stress can be performed. This model can be used as precautionary measure for giving alerts to caretakers in case of increased stress or uncommon patterns in any vital body parameter. This is useful in case of heart or stroke patients and elderly people staying at home alone.

4. CONCLUSION

In hospitals when patients are in unconscious or semi-conscious state, under treatment with heavy medicine doses found hard to detect actual hunger. Also in case of patients suffering from heart diseases, stroke etc. it is required to keep the patients stress free. HS-MS system is used to detect stress and hunger using GSR sensor. It detects hunger with 86.6% accuracy and 99.9% sensitivity. We have successfully detected stress with 66.66% accuracy and 73.33% sensitivity. Average response time of the system is 5 seconds. It is difficult to identify stress and hunger simultaneously because we found in stressed condition effect of hunger is negligible. We also found that, there was no significant difference on hunger as per the place is concerned; on the other hand, time of the day has significant effect on hunger because of the body cycle.

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REFERENCES

- [1] Liao, W., Zhang, W., Zhu, Z., Ji, Q. *A real-time human stress monitoring system using dynamic Bayesian network*. In: 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR2005)-Workshops, San Diego, CA, USA, pp. 70–80 (2005). doi:10.1109/CVPR.2005.394 9.
- [2] Yoon, Sunghyun, Sim, Jai Kyoung, Cho, Young-Ho, *A Flexible and Wearable Human Stress Monitoring Patch Scientific Reports* 2016/03/23/online 6-23468, <http://dx.doi.org/10.1038/srep23468>, <https://www.nature.com/articles/srep23468#supplementary-information>.
- [3] E. Jovanov, A. O'Donnell Lords, D. Raskovic, P. G. Cox, R. Adhami and F. Andrasik, Stress monitoring using a distributed wireless intelligent sensor system, in *IEEE Engineering in Medicine and Biology Magazine*, vol. 22, no. 3, pp. 49-55, May-June 2003. doi:10.1109/EMEMB.2003.1213626, <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1213626&isnumber=27287>.
- [4] M. Khan, Z. Rizvi, M.Z. Shaikh, W. Kazmi, A. Shaikh, Design and implementation of intelligent human stress monitoring system, *International Journal of Innovation and Scientific Re-search* 10(1), 179-190 (2014).
- [5] M.V. Villarejo, B.G. Zapiain, A.M. Zorrilla, Sensors 12(5), A Stress Sensor Based on Galvanic Skin Response (GSR) Controlled by ZigBee, *Sensors* 2012; 12(5): 6075-6101; <https://doi.org/10.3390/s120506075>.
- [6] T. Huang, J. Xiong, L. Xuan, *Design and Implementation of a Wireless Healthcare System Based on Galvanic Skin Response*, International Conference on Applied Informatics and Communication (Springer, 2011), pp. 337-343.
- [7] J. Ferreira, L. Alvarez, R. Buend a, D. Ayllon, C. Llerena, R. GilPita, F. Seoane, *Bioimpedance-Based Wearable Measurement Instrumentation for Studying the Automatic Nerve System Response to Stressful Working Conditions*, in Journal of Physics: Conference Series, (IOP Publishing, 2013), vol. 434, p. 012015, doi: 10.1088/1742-6596/434/1/012015.
- [8] L. Clifton, D.A. Clifton, M.A. Pimentel, P.J. Watkinson, L. Tarassenko, Predictive Monitoring of Mobile Patients by Combining Clinical Observations with Data from Wearable Sensors, *IEEE journal of biomedical and health informatics* 2014; 18(3), 722: 2168-2194.
- [9] K. Malhi, S. C. Mukhopadhyay, J. Schnepfer, M. Haefke, and H. Ewald, A Zigbee-based wearable physiological parameters monitoring system, *IEEE Sensors J.*, 2012; 12(3): 423-430.
- [10] J. Choi, B. Ahmed, R. Gutierrez-Osuna, Development and evaluation of an ambulatory stress monitor based on wearable sensors., *IEEE transactions on information technology in biomedicine*, 2012; 16(2): 279-86. doi:10.1109/TITB.2011.2169804. Epub 2011 Sep 29.
- [11] S. Saha, P. Nag, M.K. Ray, in Control, *A complete Virtual Instrument for Measuring and ANALYZING Human Stress in Real Time, Instrumentation*, Energy and Communication (CIEC), 2014 International Conference on (IEEE, 2014), pp. 81-85.
- [12] A. Sano, R.W. Picard, *Stress Recognition using Wearable Sensors and Mobile Phones*, in Affective Computing and Intelligent Interaction (ACII), 2013 Humaine Association Conference on (IEEE, 2013), pp. 671-676.
- [13] F.T. Sun, C. Kuo, H.T. Cheng, S. Buthpitiya, P. Collins, M. Griss, *Activity-aware Mental Stress Detection Using Physiological Sensors*, in International Conference on Mobile Computing, Applications, and Services (Springer, 2010), pp.282-301.
- [14] R.E. Kleinman, J. M. Murphy, K.M. Wieneke, M. S. Desmond, A. Schi, J.A. Gapinski, *Use of a Single-Question Screening Tool to Detect Hunger in Families Attending a Neighborhood Health Center*, *Ambulatory Paediatrics*, 2007; 7(4): 278-284.
- [15] R.H. Barnes. *Mind/body integration: Essential readings in biofeedback* (1980).