Quantifying Environmental Noise impact on Heart Rate Variability

Conference Paper · January 2016

DOI: 10.4108/eai.30-11-2016.2267063

3 authors:

Faiza Guerrache
Nottingham Trent University

Eman Younis
Minia University

Eiman Kanjo
Nottingham Trent University

Quantifying Environmental Noise impact on Heart Rate Variability

Faiza Guerrache
Computing and Technology, Nottingham Trent University[1]
N0045291@my.ntu.ac.uk

Eman M.G.Younis[1, 2]
Faculty of Computers & Information, Minia University, Egypt[2]
eman.younis@ntu.ac.uk
eman.younas@mu.edu.eg

Eiman Kanjo
Computing and Technology, Nottingham Trent University[1]
eiman.kanjo@ntu.ac.uk

ABSTRACT

The environmental factors in outdoor spaces can have a great influence on how people feel and behave. In this paper, we propose a new method to quantify the environmental noise impact on health and behavior in real-world settings. This is achieved by monitoring physiological signals such as heart rate variability in response to environmental noise. By employing wearable sensors and smart phones, we will be able to quantify and study both environmental noise levels and physiological data simultaneously. The heart rate data can be analyzed and visualized using Heart Rate Variability (HRV) responses to independent variables in real time. As a result, we can establish a better understanding of the inter-relations between human health (in particular heart rate) and personal exposure to environmental pollutants.

CCS Concepts

• Applied computing~Consumer health • *Human-centered computing~Smartphones* • Computing methodologies~Classification and regression trees

Keywords

Heart and noise; environmental monitoring; heart rate variability; environmental noise; physiological signals.

INTRODUCTION

Noise can be defined as undesirable and annoying sounds. Noise pollution can be generated by many sources in our daily life. It can be from household devices, cars on the roads, aircrafts in airports and even social events and celebrations. Noise is not only irritating and disturbing, but also, is now considered a serious health problem. There have been multiple research efforts on studying the effects of noise on people's health [4, 5, 6, 8, and 9]. The effects of noise on the human body are extensive, ranging from hear loss, tinnitus, heart disease, stroke, anxiety, stress, sleep disorders, depression, learning difficulties, job performance, to reduced cognitive abilities [1].

Many external factors affect the body physiologically in response to changes in surrounding environment. The development of the wearable sensors has made it possible to collect environmental data and integrate it with physiological body data to quantify the humans' well-being (Quality of Life) in real-time. This technological advancement enables us to detect physiological and cardiovascular responses, associated with the environmental context and understand their inter-relationships. Previous research addressed the noise exposure effect on health in general. Nonetheless, to the best of our knowledge, there is no studies investigating the use of smart sensors to quantify the cause and effect relationship between heart variability and environmental noise. In this paper, we present an initial experiment and early result around Nottingham City Center showing a clear relationship between noise and heart variability. This provides us with a set of objective measures in relation to human wellbeing. We can then understand and correlate these measures with other environmental factors in specific setting, e.g. traffic noise, busy shopping environments and many more (the concept of the Exposome)

Related Research

Previous research has overlooked the quantification of the relation between noise and heart rate in real-time, hence to understand the ways which people feel, and biologically react to environmental noise; monitoring the physiological state and surrounding noise in the environment should be studied. Heart rate variability methods are well-established and widely used methods in medical research [3]. We believe that using them in monitoring the human body reactions to noise, will give new insights on health and noise relationships. Tzaneva, et al. [4], investigated the use of HRV statistical methods such as mean and standard deviation to measure the impact of human exposure to higher noise level. This study claimed that there is an increase of the sympathetic activity after exposure to high levels of noise. Radadi and Rehimi, [5] studied the impact of noise on humans by developing numerical tools for the estimation of noise levels generated by the flow of traffic and to map sound noise in order to reduce its impact on people's quality of life and the environment. Whereas, Taylor et al. [6] presented a method to use wearable physiological sensors to dynamically detect participant response to increased system delays. Sharma [8] concluded that persons' exposure to a noisy environment for long times may cause a tinnitus in ears. Siskova and Juricka [9] conducted a survey to study the effect of noise on workers' performance in a plastic manufacturing company. The study showed that high noise levels have a negative impact on job performance, where between 30 to 50 % of those who have been surveyed believed that different noise sources in the work area are "very troubling" and "disturbing "and the most annoying sounds were from machines. 75% of respondents stated that if the workplace was better adjusted, their performance would be much higher. Many other research projects [6, 7, 10, 11,12] have used mobile sensing and crowd sourcing to create noise maps around various areas of a city, to show the effect of noise on humans.

MobiCASE 2016, November 30-December 01, Cambridge, Great Britain

DOI 10.4108/eai.30-11-2016.2267063

Heart Rate Variability (HRV)

Heart Rate signal consists of heartbeats along a period of time. HRV involves analysing beat-to-beat variations of the heart signal which is stimulated by the automatic nervous system. Additionally, the time interval between consecutive heart beats are known as RR interval measured over a period of time. Figure 1, shows an episode of a heart rate signal, showing the RR interval. QRS interval is called the peak.

Figure 1: an episode of a heart rate signal.

HRV analysis techniques can be divided into Time Domain methods, Frequency Domain methods and Non-linear methods.

User Study

We have conducted a user study "in the wild" around Nottingham city center. Twenty users (all female with average age of 30) have been recruited to collect data following a specific route, using wearable physiological sensors, connected with smart phone in different locations at different times, with multiple settings. Initial data analysis on users' data indicates a noticeable correlation between noise and Heart Rate (HR). Figure 3 depicts a block diagram of a system architecture showing various wearable sensors used for ubiquities health monitoring while the phone microphone is utilized to monitor noise. Data are layered as a heat-map on a map at city and personal levels.

Environmental noise levels data have been collected using the NoiseSpy application [10]. Figure 2 depicts the relation between HR, and noise signals for multiple users around the specified route. It can be noted that there is a positive correlation between noise levels and heart rate. Although real-time and always-on data capture has been utilized in our system to perform on-sensor processing and event detection, this captured data is also logged and can be analyzed off-line to improve step detection algorithms.

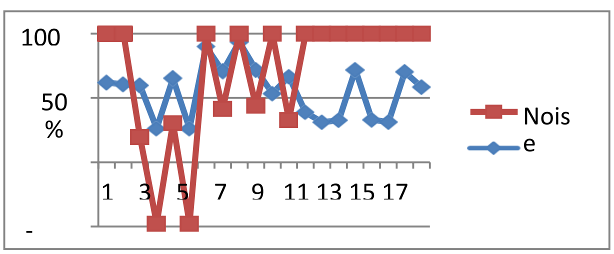

Figure 2: The relation between noise skewness and Heart rate skewness.

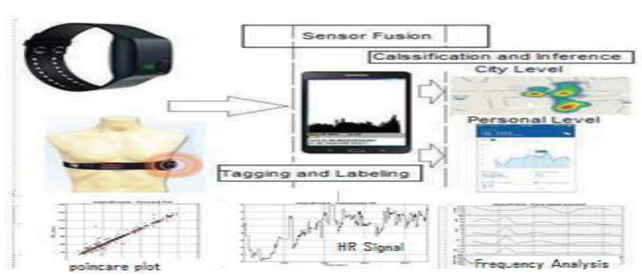

Figure 3: System architecture showing various wearable sensors used for ubiquities health monitoring

Conclusion

In this paper, we proposed an early attempt at modeling the impact of environment on health by utilizing wearable and mobile devices to collect on-body and environmental data at higher granularity and in real-time. We believe this system design architecture will greatly enhance quality of life, health, and wellbeing for those in live in urban environment.

Wearable context aware sensor systems were used in several contexts such as, a wristband type sensor system and a chest belt type sensor system. To show the feasibility of the proposed study, we presented an initial user study with early data analysis results suggesting a noticeable relationship between noise and heart variability. For future research, we will study a more efficient structure for wearable context aware sensors to obtain accurate HRV predication along with other physiological sensors.

REFERENCES

[1] Lusk, S. L., McCullagh, M., Dickson, V. V., & Xu, J. (2016). Position statement: Harmful effects of environmental noise exposures. Nursing Outlook, 64(4), 395-396.

[2] UMEMURA, M., & HONDA, K. (1998). Influence of Music on Heart Rate Variability and Comfort. A Consideration Through Comparison of Music and Noise. Journal of human ergology, 27(1/2), 30-38.

[3] Cygankiewicz, I. W. O. N. A., & Zareba, W. O. J. C. E. C. H. (2013). Heart rate variability. Handb Clin Neurol, 117(3), 379-393.Tavel, P. 2007.

[4] Tzaneva, L., Danev, S., & Nikolova, R. (2001). Investigation of noise exposure effect on heart rate variability parameters. Central European journal of public health, 9(3), 130-132.

[5] Radadi, A., & Rehimi, F. (2013, May). Implementation of a numerical tool for estimating the sound noise caused by road traffic in urban area. In Advanced Logistics and Transport (ICALT), 2013 International Conference on (pp. 211-214). IEEE.

[6] Taylor, B., Dey, A., Siewiorek, D., & Smailagic, A. (2015, September). Using physiological sensors to detect levels of user frustration induced by system delays. In Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing (pp. 517-528). ACM.

[7] Guerrache, F., Aldabbagh, A., & Kanjo, E. (2016, September). Multiple sensor fusion approach to map environmental noise impact on health. InProceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct (pp. 1074-1078). ACM.

[8] Sharma, M. K., & Vig, R. (2014, March). Server noise: Health hazard and its reduction using active noise control. In Engineering and Computational Sciences (RAECS), 2014 Recent Advances in (pp. 1- 5). IEEE.

[9] Siskova, V., & Juricka, M. (2013, December). The effect of sound on job performance. In 2013 IEEE International Conference on Industrial Engineering and Engineering Management (pp. 1679-1683).IEEE.

[10] Kanjo, E. (2010). Noisespy: A real-time mobile phone platform for urban noise monitoring and mapping. Mobile Networks and Applications, 15(4), 562-574.

[11] Kanjo,E, Al-hussain, L, Chamberlain, A., (2015), Emotion in Context: Examining Pervasive Affective sensing systems, applications, and analyses, Personal and Ubiquitous Computing Journal.

[12] Al-Husain, L., Eiman Kanjo, Chamberlain, A, (2013),Sense of space: mapping physiological emotion response in urban space. UbiComp (Adjunct Publication) 2013: 1321-1324