Application of wearable electronics and sensors in professional and leisure wear

Michal Martinka[1], Antonín Havelka[2]

[1] *Technical University of Liberec, e-mail:* michal.martinka@tul.cz.
[2] *Technical University of Liberec, e-mail:* antonin.havelka@tul.cz

Abstract: *This This paper focuses on the use of wearable electronics integrated into clothing for monitoring breathing rate and its subsequent evaluation in the context of emerging body fatigue.Wearable electronics open up new possibilities in monitoring vital signs such as blood pressure, heart rate, skin temperature, skin moisture and breathing rate. This paper specifically focuses on respiratory rate, as its changes are closely related to fatigue*

Keywords: *Breathing rate, wearable electronics, vital signs, fatigue, microsleep*

1 INTRODUCTION

Wearable electronics are becoming an integral part of smart clothing and represent the direction the apparel industry will take in the future. This technology opens the door to new clothing functions that go far beyond common understanding. In addition to comfort and protection from the weather, smart clothing offers: health and environmental monitoring: it monitors temperature, humidity, movement, location, vital signs, lighting, airflow and other parameters.Increase safety: Helps prevent micro-sleep, a serious risk in traffic and the workplace.Microsleep is a brief, unwanted sleep that usually lasts only a few seconds but can have fatal consequences. Drivers and workers in demanding professions are most at risk.Increased fatigue and drowsiness, concentration problems, Drooping eyelids, Slowed breathing rate, Loss of contact with reality, Slowed reactions to external stimuli [1]

Prevention of microsleep: Sufficient sleep duration and quality, Treatment of sleep disorders, Proper sleep hygiene, Limited use of stimulants (caffeine)

Microsleep occurs most often in the early morning hours (2:00-5:00 a.m.), but can also occur during the day (1:00-3:00 p.m.). Four hours of driving without a break increases a driver's reaction time by 50%. After six hours of driving without a break, the risk of an accident increases up to eight times.Up to 20% of all accidents are caused by fatigue and microsleep.Wearable electronics in smart clothing play a key role in preventing microsleep and can save lives[2].

2 EVALUATION OF RESULTS AND CONCLUSION

The aim of this work was to design a system for breathing rate monitoring with the possibility of early prediction of the onset of fatigue and microsleep. Fatigue and microsleep are the most common causes of serious accidents and injuries. For professional drivers, this danger lies in momentary blackouts, where the driver may drive into oncoming traffic or off the road. In order for this system to be usable in normal operation (professional activity, leisure activities), it must meet certain criteria:

- low purchase price of the sensor
- reliability of the sensor
- easy maintenance of the smart garment
- small size of the sensor
- comfort of wearing the smart garment

The idea that fatigue and microsleep can be predicted by changes in breathing rate has been validated both in the laboratory and in simulated driving.
In all cases tested, the change in breathing rate preceded fatigue and microsleep. The change in breathing rate with the onset of fatigue is clearly visible in Fig. The same result was obtained in experiments conducted in collaboration with Shinshu University, Japan, where FBG sensors were used to measure

3 REFERENCES

[1] OSA in Professional Transport Operations: Safety, Regulatory, and Economic Impact CHESTVol. 158 Issue 5p2172–2183Published online: June 12, 2020 Indira Gurubhagavatula,Miranda Tan,Aesha M. Jobanputra

[2] Microsleep, 2023. *Sleep Foundation* [online]. Seattle: OneCare Media [cit. 2023-07-25]. Dostupné z: https://www.sleepfoundation.org/how-sleep-works/microsleep

[3] Kurasawa, S.; Koyama, S.; Ishizawa, H.; Fujimoto, K.; Chino, S. Verification of Non-Invasive Blood Glucose Measurement Method Based on Pulse Wave Signal Detected by FBG Sensor System. *Sensors* 2017, *17*, 2702. https://doi.org/10.3390/s17122702

[4] Koyama, S.; Ishizawa, H.; Fujimoto, K.; Chino, S.; Kobayashi, Y. Influence of Individual Differences on the Calculation Method for FBG-Type Blood Pressure Sensors. *Sensors* 2017, *17*, 48. https://doi.org/10.3390/s17010048

[5] S. Koyama, T. Yoda, M. Yamamoto, S. Shiokawa, K. Kane and M. Martinka, "Verification of optimal installation point of FBG sensor for pulsation strain measurement," in *IEEE Sensors Journal*, doi: 10.1109/JSEN.2023.3289966