Transactions of the VŠB – Technical University of Ostrava, Mechanical Series
No. 1, 2018, vol. LXIV
article No. 2039

Jan KOHOUT*, Jan MAREŠ**

HUMAN FATIGUE ESTIMATE: USAGE OF SYSTEMS FROM TRAFFIC IN BUILDINGS

ODHAD ÚNAVY ČLOVĚKA: VYUŽITELNOST SYSTÉMŮ Z DOPRAVY VE VNITŘNÍM PROSTŘEDÍ

Abstract

Fatigue monitoring is nowadays domain in traffic and transportation (e.g. system for driver's sleepness monitoring in cars or in trains). People working in offices are affected by fatigue too, but there is no general system that is able to monitor it. The fatigue in offices can cause decreasing work productivity or security risks in the industry. This review article compares the advantages and disadvantages of approaches used in traffic (e.g. an eye-movement tracking, driver activity) in internal environment (in buildings) with focus on people that work in offices with a computer. Because of the greater possibility of movement, it can not be enough. People are in offices longer than in cars and this causes that they are more affected by the quality of the internal environment. It should be useful to include this information in a system for fatigue monitoring. It can result in a system that is able to quantify fatigue level from both biological and environment variables.

Abstrakt

Sledování únavy člověka je dnes hlavně doménou dopravy (systémy pro sledování řidiče v moderních automobilech, systémy pro strojvedoucí, atd.). U lidí pracujících v kancelářích se únava prakticky nesleduje, přestože její vliv může mít negativní dopad nejen na kvalitu a produktivitu práce, ale v případě osob na velínech v průmyslu také možná bezpečností rizika. Tato rešeršní práce se zabývá možnostmi aplikace systémů pro monitoring únavy řidiče automobilu (např. z pohybu očí, aktivit při řízení) na osoby pracující v kancelářských prostorách. To se vzhledem k možnostem pohybu po kanceláři jeví jako nedostatečné. Protože člověk tráví v kanceláři typicky více času než v automobilu, ovlivňuje jej výrazněji vnitřní prostředí budov, které je vhodné do odhadu únavy také zahrnout. Výsledkem tak může být systém kvantifikující míru únavy zohledněním jak vnitřního prostředí, tak vybraných biologických signálů člověka snímaných na pracovním místě.

Keywords

Fatigue, office, cars, sleepness, buildings.

1 INTRODUCTION

The main domain of fatigue, alertness, exhausting or sleepness monitoring is in traffic and transportation (modern cars, trains). The most simple anti-sleepness system is in trains – a button that a driver has to switch regularly (in Czech it is called “dead man”). In cars, there are more sophisticated systems (most of them based on eye tracking) and many patents. [1, 2]

* Ing., Department of Computing and Control Engineering, University of Chemistry and Technology in Prague, Czech Republic, Technická 1905/5, 166 28 Praha 6, tel. (+420) 220 444 270, e-mail jan.kohout@vscht.cz
** doc., PhD., Ing., Department of Computing and Control Engineering, University of Chemistry and Technology in Prague, Czech Republic, Technická 1905/5, 166 28 Praha 6, tel. (+420) 220 444 270, e-mail jan.mares@vscht.cz

The problem is that sleepness monitoring in a car is more specific than in offices (where people work with a computer). A driver has to react fast, but an office user solves creativity tasks. In a car, there is a lack of the movement out of the place. On the other hand, in offices, a user is longer and is able to move out of the working place. It means that the internal environment affects him significantly. Although users' fatigue is not monitored in offices, it can cause:

1. a greater amount of errors (critical for dispatchers, in medicine, …)
2. health problems (a headache, backache, ...)
3. decreasing work productivity and motivation
4. decreasing life quality

According to some studies, 92% of people working in offices have experiences with a backache. [3]

2 CURRENT STATE IN OFFICES

There is not a general system for monitoring or estimating users' fatigue in offices. A subjective questionnaire approach is mainly used when researchers want to estimate it (e.g. Karolinska sleepiness scale [4]).

Nowadays, internal environment increases an influence on work productivity: it is because of increasing number of open spaces, air conditions and building insulation. Many studies deal with the influence of CO_2, daylight, noise or temperature on user's fatigue or stress level. [4, 5, 6, 7]

Sources of fatigue in offices can be divided into two groups:

a) internal environment: simply measurable (air quality, a concentration of CO_2, humidity, air flow, dust, volatile organic compounds (VOC), light, noise).

b) physiology: very subjective and difficult to measure (hunger, thirst, stress, lack of sleep, body position).

There are techniques like working hours regulation, Pomodoro (work and relax changing) or work scheduling that tries to deal with users' fatigue. [8]

2.1 Goals for fatigue monitoring in offices

Possible goals for fatigue monitoring in offices are (see scheme in Figure 1):

1. Prevention – to eliminate influences that cause exhausting
2. Increasing security – professions where alertness is important (industry, aircraft dispatchers)
3. Increasing work productivity (interesting mainly for programmers, freelancers, corporate companies)
4. Decreasing health problems
5. Using in research, building control systems development

Requirements can be for such a system:

1. minimal user disturbance
2. to be able to estimate fatigue even if a user is not at the same place
3. an estimation for a group of people (open spaces, lecture halls)

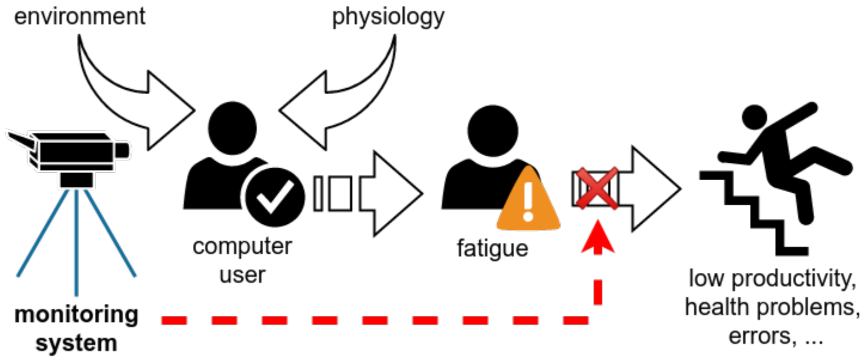

Fig. 1: fatigue monitoring in office – main goals.

3 AN ANALOGY OF THE MONITORING SYSTEM IN CARS

We can now discuss an office analogy of systems from traffic (Table 1). “ dead man” is the most disturbing and a user can push it quickly automatically, so it loose its purpose. Behavior tracking seems to be more useful because it can be estimated from user's interaction with a computer. Eye tracking can be problematic if a user can move out of a working place, but is it the most simple approach because it does not disturb the user and there are many studies about this topic [11, 12]. Wearable devices (e.g. smartwatch) can obtain information about a user, but the measurement can be affected by his age.

Tab. 1: A strategies of fatigue/alertness monitoring in cars and their analogy in offices. (compared systems in cars based on [9, 10])

Strategy of monitoring	**Typical device**	**A system in a car**	**An analogy in an office**
“dead man”	button	+ is driver alive?	- disturbing
Behavior tracking	camera	+ driving style + interaction with devices	+ working hour + mouse movement + changing of the windows + repeating patterns
Eyes tracking	camera	+ user sit statically	- a user can move out of the place + simplicity
Accelerometer	wearable device	- noise from the car	+ monitor only the user + check walking
Heart rate	wearable device	- affected by age	- affected by age
Breath	wired device	- uncomfortable	+ device with headphones and microphone
Skin conductance	wired device	- affected by weather	+ more stable environment
EEG	wired device	- uncomfortable	- uncomfortable

4 CONCLUSIONS

There are advanced systems in traffic and transportation, but not all of them are suitable for offices. The most promising seems to be eye tracking in combination with behavior tracking.

The question is if this is suitable for more people (e.g. in open spaces or university halls). The approach can be to combine biomedical information with a measurement of an inner environment.

REFERENCES

[1] KLEINBERG, Raymond. Driver alertness monitoring system. U.S. Patent No 6,154,123, 2000.

[2] SMITH, Raymond Paul; SHAH, Mubarak; DA VITORIA LOBO, Niels. Algorithm for monitoring head/eye motion for driver alertness with one camera. U.S. Patent No 6,927,694, 2005.

[3] MAHER, C., UNDERWOOD, M., & BUCHBINDER, R. (2017). Non-specific low back pain. *The Lancet*, 389(10070), 736–747. https://doi.org/10.1016/S0140-6736(16)30970-9

[4] CUI, W., CAO, G., PARK, J. H., OUYANG, Q., & ZHU, Y. (2013). Influence of indoor air temperature on human thermal comfort, motivation and performance. *Building and Environment*, 68, 114–122. https://doi.org/10.1016/j.buildenv.2013.06.012

[5] FANG, L., WYON, D. P., CLAUSEN, G., & FANGER, P. O. (2004). Impact of indoor air temperature and humidity in an office on perceived air quality, SBS symptoms and performance. *Indoor Air, Supplement*, 14(SUPPL. 7), 74–81. https://doi.org/10.1111/j.1600-0668.2004.00276.x

[6] VIMALANATHAN, K., & RAMESH BABU, T. (2014). The effect of indoor office environment on the work performance, health and well-being of office workers. *Journal of Environmental Health Science and Engineering*, 12(1), 113. https://doi.org/10.1186/s40201-014-0113-7

[7] MAIEROVA, L., BORISUIT, A., SCARTEZZINI, J.-L., JAEGGI, S. M., SCHMIDT, C., & MÜNCH, M. (2016). Diurnal variations of hormonal secretion, alertness and cognition in extreme chronotypes under different lighting conditions. *Scientific Reports*, 6(1), 33591. https://doi.org/10.1038/srep33591

[8] JONES, Christopher B., et al. Working hours regulations and fatigue in transportation: A comparative analysis. *Safety science*, 2005, 43.4: 225-252.

[9] SAINI, V. (2014). Driver Drowsiness Detection System and Techniques : A Review. *International Journal of Computer Science and Information Technologies*, 5(3), 4245–4249.

[10] CHISTY, & GILL, J. (2015). A Review : Driver Drowsiness Detection System. *International Journal of Computer Science Trends and Technology (IJCST)*, 3(4), 243–252.

[11] GONZÁLEZ-ORTEGA, D., DÍAZ-PERNAS, F. J., ANTÓN-RODRÍGUEZ, M., MARTÍNEZ-ZARZUELA, M., & DÍEZ-HIGUERA, J. F. (2013). Real-time vision-based eye state detection for driver alertness monitoring. *Pattern Analysis and Applications*, 16(3), 285–306. https://doi.org/10.1007/s10044-013-0331-0

[12] HE, J., CHOI, W., YANG, Y., LU, J., WU, X., & PENG, K. (2016). Detection of driver drowsiness using wearable devices: A feasibility study of the proximity sensor. *Applied Ergonomics*, 65, 2–9. https://doi.org/10.1016/j.apergo.2017.02.016

[13] LEE, B. L. G., LEE, B. L. G., & CHUNG, W. Y. (2015). Smartwatch-based driver alertness monitoring with wearable motion and physiological sensor. *In Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, EMBS (Vol. 2015–Novem, pp. 6126–6129). https://doi.org/10.1109/EMBC.2015.7319790