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Is it time for passive Brain Computer Interfaces in UAV Operations ?

Unmanned Aerial Vehicles (UAVs, drones) are steadily rising in popularity for both military and civilian use, but as these systems become capable to operate for extended periods of time operator mental fatigue is growing into a serious issue [3,4,7].

Mental Fatigue affects a multitude of cognitive processes, that are critical to the safe operation of UAVs. Research has shown effects of mental fatigue on attention [6], cognitive flexibility [15], decision making [2], rule adaptation [12], planning [14] and situational awareness [13]. These problems are well studied in the domain of Aviation [11]. However, UAV operations are often characterized by long, monotonous and fatigue-inducing phases of surveillance, intermittently interrupted by unpredictable periods of high mental workload. This renders traditional methods of fatigue mitigation, such as crew-rest as not viable.

Passive Brain Computer Interfaces (pBCIs) are one of the most promising technologies that could ensure safety for prolonged UAV operations. EEG based pBCIs have been shown to reliably detect mental fatigue, as elicited by time-on-task (TOT). A recent meta-analysis of 21 studies, found that mental fatigue resulted in reliable increases of both alpha and theta activity [9]. Power features have been successfully used as biomarkers for single-trial fatigue classification [8,10].

Yet knowing about the state of an operator is only half of the solution, as the altered mental state needs to be accounted for within the operations. State-based adaptive automation (AA) and adaptive interfaces (AI) are promising tools to fulfill this duty. By taking over certain tasks for the operator or by changing the interaction between the operator and the control surfaces, AA and AI have been proven to be capable to accommodate the needs of operators' mental state [1,5]. Hence, we suggest that combining pBCIs with AI or AA offers a significant opportunity to support UAV operators in situations of prolonged use.

References

1. Aricò, P., Borghini, G., Di Flumeri, G., Colosimo, A., Bonelli, S., Golfetti, A., Pozzi, S., Imbert, J.-P., Granger, G., Benhacene, R., & Babiloni, F. (2016). Adaptive Automation Triggered by EEG-Based Mental Workload Index: A Passive Brain-Computer Interface Application in Realistic Air Traffic Control Environment. *Frontiers in Human Neuroscience*, 10, 539. <https://doi.org/10.3389/fnhum.2016.00539>
2. Boksem, M. A., & Tops, M. (2008). Mental fatigue: Costs and benefits. *Brain Research Reviews*, 59 (1), 125–139. <https://doi.org/10.1016/j.brainresrev.2008.07.001>
3. Caid, S., Hauret, D., Wolff, M., & Mollard, R. (2016). Fatigue study and discourse analysis of french uninhabited aerial vehicle (UAV) operators to understand operational issues. *Proceedings of the 15th Ergo'IA "Ergonomie Et Informatique Avancé" Conference on - Ergo'IA '16*, 1–8. <https://doi.org/10.1145/3050385.3050399>
4. Chappelle, W., Scheiman, T., & Sanford, E. (2018). U.S. Air Force Special Operations Command Remotely Piloted Aircraft Operator Fatigue Levels and Compensatory Strategies (tech. rep.) [Section: Technical Reports]. USAFSAM/FHO Wright-Patterson AFB United States. Retrieved January 29, 2022, from <https://apps.dtic.mil/sti/citations/AD1057349>

5. Dehais, F. D., Saint-Lot, J. S.-L., & Imbert, J.-P. I. (2020). Red Alert: A cognitive countermeasure to mitigate attentional tunneling. 2020. <https://doi.org/10.1145/3313831.3376709>
6. Holtzer, R., Shuman, M., Mahoney, J. R., Lipton, R., & Verghese, J. (2010). Cognitive Fatigue Defined in the Context of Attention Networks [Publisher: Routledge _eprint: <https://doi.org/10.1080/13825585.2010.517826>]. *Aging, Neuropsychology, and Cognition*, 18 (1), 108–128. <https://doi.org/10.1080/13825585.2010.517826>
7. Jahanpour, E. S., Berberian, B., Imbert, J.-P., & Roy, R. N. (2020). Cognitive fatigue assessment in operational settings: A review and UAS implications *IFAC-PapersOnLine*, 53 (5), 330–337. <https://doi.org/10.1016/j.ifacol.2021.04.188>
8. Roy, R. N., Charbonnier, S., & Bonnet, S. (2014). Detection of mental fatigue using an active BCI inspired signal processing chain. *IFAC Proceedings Volumes*, 47(3), 2963-2968.
9. Tran, Y., Craig, A., Craig, R., Chai, R., & Nguyen, H. (2020). The influence of mental fatigue on brain activity: Evidence from a systematic review with meta-analyses [_eprint: <https://onlinelibrary.wiley.com/doi/pdf/10.1111/psyp.13554>]. *Psychophysiology*, 57 (5), e13554. <https://doi.org/10.1111/psyp.13554>
10. Trejo, L. J., Kubitz, K., Rosipal, R., Kochavi, R. L., & Montgomery, L. D. (2015). EEG-Based Estimation and Classification of Mental Fatigue [Number: 5 Publisher: Scientific Research Publishing]. *Psychology*, 6 (5), 572–589. <https://doi.org/10.4236/psych.2015.65055>
11. Tvaryanas, A. P., & Thompson, W. T. (2006). Fatigue in Military Aviation Shift Workers: Survey Results for Selected Occupational Groups. *Aviation, Space, and Environmental Medicine*, 77 (11), 1166–1170.
12. van der Linden, D., Frese, M., & Meijman, T. F. (2003). Mental fatigue and the control of cognitive processes: Effects on perseveration and planning. *Acta Psychologica*, 113 (1), 45–65. [https://doi.org/10.1016/S0001-6918\(02\)00150-6](https://doi.org/10.1016/S0001-6918(02)00150-6)
13. van der Linden, D., Frese, M., & Sonnentag, S. (2003). The Impact of Mental Fatigue on Exploration in a Complex Computer Task: Rigidity and Loss of Systematic Strategies. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 45 (3), 483–494. <https://doi.org/10.1518/hfes.45.3.483.27256>
14. Vijaya K, K., Deepika, D., & Lei, D. (2014). EEG Correlates of Fluctuation in Cognitive Performance in an Air Traffic Control Task, 30.
15. Yu, S., Mückschel, M., & Beste, C. (2021). Event-related synchronization/desynchronization and functional neuroanatomical regions associated with fatigue effects on cognitive flexibility. *Journal of Neurophysiology*, 126 (2), 383–397. <https://doi.org/10.1152/jn.00228.2021>