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Digital Twin Definition for Detecting Abnormal Perspiration Patterns in High-Stress Professions

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Perspiration is a physiological response in high-stress situations, that also plays a key role in thermoregulation and stress management. Understanding perspiration patterns is used for assessing physiological responses and optimizing human performance especially in professions such as emergency medical services and military operations, as well as for individuals exposed to Isolated Confined Extreme (ICE) environments such as astronauts and space analog mission participants. This paper defines a Digital Twin (DT) model, that will be integrated with an existing physical sweat gland module (SGM) prototype. Its goal is to simulate human perspiration under high-stress conditions by integrating environmental, physiological, and psychological data. The system architecture is developed via Model-Based Systems Engineering (MBSE). The scope of the designed virtual model is to accurately reflect physical perspiration, detect abnormal perspiration patterns, and generate recommendations regarding stress countermeasures. The goal is to influence the behavioral and/or physiological state of the physical twin, thereby creating a dynamic, responsive system. Machine learning (ML) models will be used to identify patterns in the environmental, physiological, and psychological inputs and predict sweat volume, chemical composition, and regional sweat distributions across the body. ML will also be used to detect abnormal perspiration patterns based on input data. The application of generative AI for creating test data from simulation templates is anticipated to facilitate the comparative analysis of two to three distinct profiles, such as astronauts, soldiers, and paramedics or firefighters, using simulated values. The SGM, with its integrated sensors, will serve the dual purpose of validating the model and providing realistic physical simulation.

Author: Mr VIZITIU, Cristian (The Space Applications and Technologies Laboratory, Institute of Space Science – Subsidiary of INFLPR (National Institute for Laser, Plasma and Radiation Physics), Magurele, Romania; Department of Automatics and Information Technology, Faculty of Electrical Engineering and Computer Science, Transilvania University of Brasov, Brasov, Romania)

Co-authors: Dr TURCIN, Ioan (CAMPUS 02 University of Applied Sciences / Department Automation Technology, Graz, Austria); Mr DOMINEY, Kevin Alexander (The Space Applications and Technologies Laboratory, Institute of Space Science –Subsidiary of INFLPR (National Institute for Laser, Plasma and Radiation Physics), Magurele, Romania); Prof. SOFTIC, Selver (CAMPUS 02 University of Applied Sciences / Department IT & Business Informatics, Graz, Austria); Mr DINCULESCU, Adrian Cătălin (The Space Applications and Technologies Laboratory, Institute of Space Science –Subsidiary of INFLPR (National Institute for Laser, Plasma and Radiation Physics), Magurele, Romania); Mr BOCĂNEȚ, Vlad I. (Department of Manufacturing Engineering, Faculty of Industrial Engineering, Robotics and Production Management, Technical University of Cluj-Napoca); Dr DUGAN, Cosmin (Bucharest University Emergency Hospital, Romania); Prof. MORARU, Sorin-Aurel (Department of Automatics and Information Technology, Faculty of Electrical Engineering and Computer Science, Transilvania University of Brasov, Brasov, Romania)

Presenter: Mr VIZITIU, Cristian (The Space Applications and Technologies Laboratory, Institute of Space Science –Subsidiary of INFLPR (National Institute for Laser, Plasma and Radiation Physics), Magurele, Romania; Department of Automatics and Information Technology, Faculty of Electrical Engineering and Computer Science, Transilvania University of Brasov, Brasov, Romania)

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