FW-HTF: Collaborative Research: Augmenting and Advancing Cognitive Performance of Control Room Operators for Power Grid Resiliency

Submitted by vonmeier on Tue, 05/07/2019 - 12:32pm

Project Details

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Performance Period:	10/01/18 - 09/30/23
Institution(s):	University of California-Berkeley
Sponsor(s):	National Science Foundation
Award Number:	1840083

Abstract: The Future of Work at the Human-Technology Frontier (FW-HTF) is one of 10 new Big Ideas for Future Investment announced by the National Science Foundation. The FW-HTF cross-directorate program aims to respond to the challenges and opportunities of the changing landscape of jobs and work by supporting convergent research. This award fulfills part of that aim. Effective decision making by power grid operators in extreme events (e.g., Hurricane Maria in Puerto Rico, the Ukraine cyber attack) depends on two factors: operator knowledge acquired through training and experience, and appropriate decision support tools. Decision making in electric grid operation during extreme adverse events directly impacts the life of citizens. This project will augment the cognitive performance of human operators with new, human-focused decision support tools and better, data-driven training for managing the grid especially under highly disruptive conditions. The development of new generation of tools for online knowledge fusion, event detection, cyber-physical-human analysis in operational environment can be applied during extreme events and provide energy to critical facilities like hospitals, city halls and essential infrastructure to keep citizens safe and avoid economic loss for the Nation. Higher performance of operators will improve worker quality of life and will enhance the economic and social well-being of the country. The project's training objectives will leverage existing educational efforts and outreach activities and we will publicize the multidisciplinary outcomes through multiple venues. The proposed project will integrate principles from cognitive neuroscience, artificial intelligence, machine learning, data science, cybersecurity, and power engineering to augment power grid operators for better performance. Two key parameters influencing human performance from the dynamic attentional

control (DAC) framework are working memory (WM) capacity, the ability to maintain information in the focus of attention, and cognitive flexibility (CF), the ability to use feedback to redirect decision making given fast changing system scenarios. The project will achieve its goals through analyzing WM and CF and performance of power grid operators during extreme events; augmenting cognitive performance through advanced machine learning based decision support tools and adaptive human-machine system; and developing theory-driven training simulators for advancing cognitive performance of human operators for enhanced grid resilience. A new set of algorithms have been proposed for data-driven event detection, anomaly flag processing, root cause analysis and decision support using Tree Augmented naive Bayesian Net (TAN) structure, Minimum Weighted Spanning Tree (MWST) using the Mutual Information (MI) metric, and unsupervised learning improved for online learning and decision making. Additionally, visualization tools have been proposed using cognitive factor analysis and human error analysis. We propose a training process driven by cognitive and physiometric analysis and inspired by our experience in operators training in multiple domain: the power grid, aircraft and spacecraft flight simulators. A systematic approach for human operator decision making is proposed using quantifiable human and engineering analysis indices for power grid resiliency.