Advancing Human-AI Configurations Using Physiological Data to Trigger Adaptive Automation

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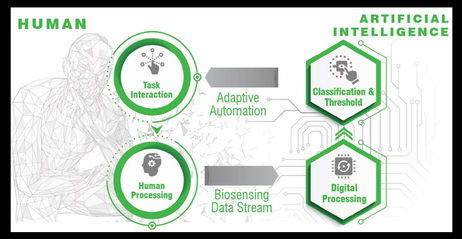
INTRODUCTION

Need: Automatic AI Triggering to Support Human-System Configurations

Adaptive automation supports human-AI collaboration by improving performance through varying levels of task automation, specifically when users need help (Cassenti, 2018). This approach provides AI assistance when human performance drops but keeps AI from interfering when performance is high.

Bi-directional communication between humans and AI automation is critical for effective collaboration and mission outcomes, and a sensitive triggering system is needed to provide varied support based on individual user needs. Research and development must:



Operational Impact:

- Promoting individual interventions to ensure service members function at maximum performance providing increased readiness and lethality.
- Maintaining operational readiness by alleviating severe cognitive overload, stress, and distraction and allowing service members to sustain work.

- Provide objective and quantifiable measures of user states
- Identify decrements and provide appropriate support only when needed
- Streamline workload and performance with seamless automation support driven by individualized, real-time physiological responses

Concept Overview

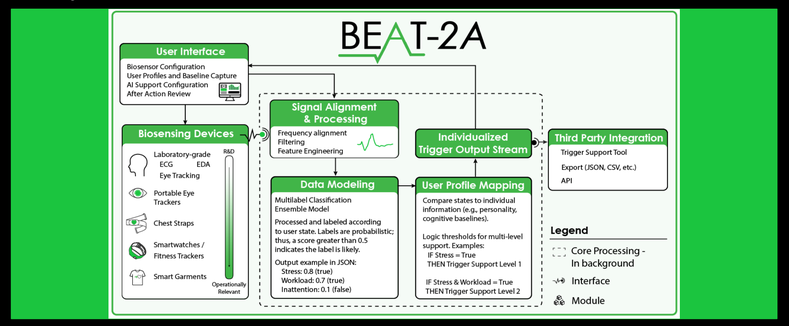
BEAT-2A

Biosignature Evaluation and Analytics Toolkit for Adaptive Automation (BEAT-2A)

- Integration of physiological sensors
- Transmit data in real-time.
- Streamlined development which speeds new sensor integration.

- Data transformed to higher level features to infer user states.
- Apply optimal and individualized thresholds for AI automation.

- Individualized thresholds for automation triggering of AI tools.
- Integration with Army and DoD programs.



Example Use Case

An Army Geospatial Intelligence Imagery Analyst is regularly tasked with analyzing hours of video footage and hundreds of images

This trigger turns on AI aided imagery scanning to detect new changes

This frees the analyst's mental capacity to focus on new areas and improves overall task efficiency.

BEAT-2A is implemented to continually monitor physiological status and infer cognitive states in real-time.

BEAT-2A recognizes increased stress and cognitive workload and sends a trigger to the workstation

With BEAT-2A's support, intelligence reports provide the coalition with rapid situation awareness

Research & Development Strategy

Scientific Foundation

The following methodology aims to quantify real-time user states such as workload, stress, and attention to trigger adaptive automation support at the point of need.

Initial User State Targets

Workload: Amount of processing resources required by a given task. Cognitive workload for a specific individual may rapidly increase leading to decreased performance and risks to operational readiness.

Stress: High mental and sometimes physical stress placed on individuals undergoing highly demanding conditions. Stress is exceedingly prevalent in high-stakes military environments and can influence performance.

Attention: A person's ability to sustain focus and notice changes in their environment. Reduced attention can result from unsustainable multi-tasking, burnout, and mental fatigue which are increasingly common in military environments.

Top 5 Physiological Methods from Literature

- Electrocardiogram (ECG)
- Eye Tracking
- Electrodermal Activity (EDA)
- Respirometry
- Electroencephalogram (EEG)

Initial High-target Data for Research

ECG: Heart rate, heart rate variability
Eye Tracking: Blink rate, fixations, time off-screen
EDA: Phasic and tonic changes
Respiration: Rate
Skin Temperature
PPG: Pulse rate, pulse rate variability
Accelerometry: Movement in x, y, and z
Task Performance: Event types and times, response times, accuracy
Survey Data

Data will be leveraged to conduct modeling with two aims 1) Create an ensemble model of user workload, stress, and attention with highest accuracy, and 2) Examine alternative model inputs to offer direct comparison of data types.

Approved for Public Release

Data Collection

Surveys & Subjective Assessments

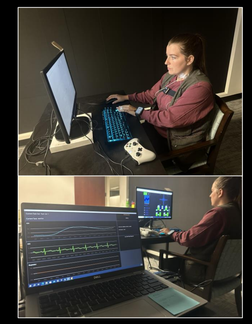
- Big 5 Personality
- State Trait Anxiety Scale
- Lifestyle Questionnaire
- Perceived Stress Scale
- cSWAG during MATB-II
- NASA-TLX after MATB-II

Equipment

- Biopac electrophysiology suite, including ECG, PPG, EDA, respiration, skin temperature, and accelerometry
- Empatica wrist-worn device, including PPG and EDA
- Tobii nano screen mounted eye tracker and Tobii pro glasses (for a subset of participants)
- Custom task testbed

Tasks

- MATB-II (low, medium, high)
- Sing-a-song
- Trier Math
- Driving, distraction



RESULTS

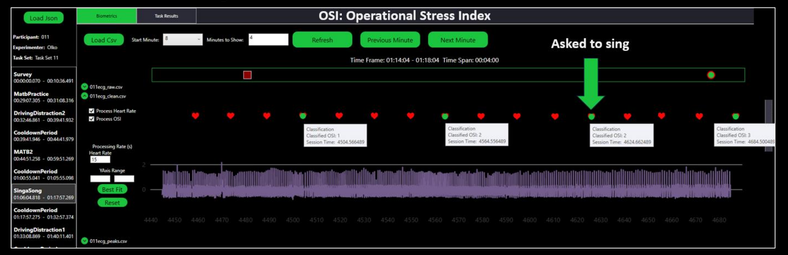
Data Collection Results

- 62 complete
- 7 incomplete (study ended early)
- 1 cancel on-site
- 28.99% cancellations/no show

Data Processing Path

1. Cleaning data
2. Extracting metrics (time-series)
3. Integrating with larger code base
4. Running on participant data
5. Generating ensemble model

Preliminary Data Processing



CONCLUSIONS

This effort represents an innovative approach to support the rapid advancement of human-AI configurations in the military. The resulting model and BEAT-2A system will be widely applicable to a broad range of DoD and commercial domains, including combat vehicles, imagery analysts, mission control, and air traffic control.

Optimize Performance
Individualized triggering of automated aids at optimal times will improve and sustain performance.

Increase Readiness
Reduce fatigue and maintain readiness by alleviating cognitive overload.

DoD Leads Human-AI Collaboration
Users will benefit from early adoption and leadership in advanced human-AI collaboration.

References

Cassenti DN, Veksler VD. Using cognitive modeling for adaptive automation triggering. In: Cassenti DN, ed. Advances in Human Factors in Simulation and Modeling. Vol 591. Advances in Intelligent Systems and Computing. Springer International Publishing; 2018:378-390. doi:10.1007/978-3-319-60591-3_34

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