



BAMS

Biometric AI Measurement System

ELECOMP Capstone Design Project 2022-2023

Sponsoring Company:

In-Depth Engineering

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Company Overview:

In-Depth Engineering is a small business provider of combat systems software solutions to the United States Navy. We have a rich combat system development legacy that encompasses designing and delivering real-time mission critical software systems.

Our programs and efforts span the development and deployment lifecycle including applied research, advanced development, engineering development, system integration and test, hardware design and integration, ship integration, system certification, and training.

In-Depth Engineering has Small Business Innovative Research contracts in the following areas:

- Adaptive Training
- Artificial Intelligence and Machine Learning
- Signal Processing
- Spatial Data visualization
- Aquatic life detection

Incorporated in 2006 as a Maryland company, In-Depth is a veteran owned, small, disadvantaged business with headquarters in Fairfax, Virginia.









Technical Directors:

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Project Motivation:

The proliferation of wearable smart devices has led to an explosion of biometric monitoring and analysis applications. Data from these devices has been used for applications like athletic performance optimization and health monitoring. In-Depth engineering is researching whether information from biometric devices can be used to optimize performance of Computer Based Information System (CBIS) operators. The goal of this project is to use Artificial Intelligence to assess CBIS operator performance as a function of biometric data. Understanding and predicting operator performance will help organizations like the Federal Aviation Administration (FAA), US military and power plants optimize their work force. This work will provide keen insight as to when a CBIS operator needs a break, a day off, additional training, or on-line help.

CBIS operator performance will be classified with a machine learning model trained on data from operator interaction (cursor movements, keyboard, screen focus). The biometric data (heartrate, body temperature, sleep score) will be collected concurrently with the performance data to understand the impact on biometric state on operator performance.









Anticipated Best Outcome:

The goal of the project is to develop a system to measure the relationship between operator biometrics and operator performance on a CBIS system. The project will result in a Biometric AI Measurement System (BAMS) prototype that collects and processes data from operator machine interface (OMI) and biometric sensors. The students will use a video game as an analogue CBIS application to determine the feasibility of the approach on a deployed CBIS. The project will result in the following:

- Development of CBIS Operator Interaction data collection system
- Development of a biometric data collection system
- Development of an AI/ML model to classify operator performance based on operator interaction with CBIS
- Development of AI/ML model to predict operator performance based on biometric state

The output of the system can be used to predict and improve performance of operators of CBIS systems for air traffic control, power plant operation, sensor processing and unmanned vehicle control.









Project Details:

Biometric AI Measurement System (BAMS)

This project will develop a prototype system to collect operator machine interaction data and operator biometric data to assess performance versus biometric state. A video game will be used as an analogue for a CBIS as a proof of concept.



Biometric AI Measurement System Block Diagram

The team will design and develop the BAMS data collection capability. Data will be collected from biometric sensors and computer Operator Machine Interfaces (OMI). The biometric sensors will be a commercially available smart device (e.g. Fitbit or Garmin) with an accessible API (Application Programming Interface). The OMI data collection will consist of an eye tracking device synchronized with a keyboard and mouse recorder. The students will specify, and purchase all required equipment within the specified budget. The team will assemble the data collection system and collect data. Once the data is collected the team will use the data to train two machine learning models. The first machine learning model will classify operator performance based on OMI data. The second machine learning model will predict future performance based on current biometric data.









Hardware/Electrical Tasks:

- 1. Specify and purchase devices (Biometric sensors, eye tracker, key logger, data storage)
- 2. Specify and purchase CBIS analogue (Video game)
- 3. Interface devices in Local Area Network (LAN)
- 4. Acquire data from devices
- 5. Time align data from multiple sources
- 6. Analyze, align, and curate data
- 7. Develop and maintain budget for hardware purchases

Firmware/Software/Computer Tasks:

- 1. Develop software to collect biometric data from device
- 2. Develop software to collect data from eye tracking device
- 3. Develop software to capture operator interactions with CBIS analogue (Video game)
- 4. Collect data under various conditions
- 5. Develop machine learning model to classify operator proficiency based on OMI data
- 6. Train, test, and update operator proficiency model
- 7. Develop machine learning to predict operator score based on biometric data
- 8. Train, test, and update operator biometric performance prediction model
- 9. Analyze results

Composition of Team:

1 Electrical Engineers & 2 Computer Engineers

Skills Required:

Electrical Engineering Skills Required:

- Equipment Specification (Biometric wearables, eye tracker, video camera, recorder for mouse and keyboard interactions)
- Networking
- Artificial Intelligence and Machine learning algorithm development
- Neural networks
- Sensor correlation and Data Fusion
- Matlab / Excel / PowerPoint / Python
- Leadership / Presentation skills
- Writing skills









Computer Engineering Skills Required:

- Programming skills Python, java
- Machine Learning architecture knowledge
- Machine learning model training
- Data Acquisition
- Neural networks

Anticipated Best Outcome's Impact on Company's Business, and Economic Impact

In-Depth Engineering competes for Small Business Innovative Research (SBIR) contracts. This project will seed research that In-Depth can apply to future SBIR efforts. We estimate this technology would support winning of two contracts with an estimated value of three million dollars.

Broader Implications of the Best Outcome on the Company's Industry:

The market size of smart wearable devices is estimated at over \$20 billion for 2022. Data from these devices is going to revolutionize the future workforce. Machine learning algorithms working on biometric data are already being used to optimize athletic performance. A key factor in optimizing athletic performance is knowing when an athlete needs to train and when an athlete needs to rest. The same concept can be applied to the broader workforce and specifically CBIS operators. Understanding when an operator needs a break, or a vacation will improve quality of life while increasing overall organization productivity. The best outcome of this project will be a system that assesses biometric factors that relate to stress and fatigue and their impact on productivity.



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