Psychophysiological Monitoring of Aerospace Crew State

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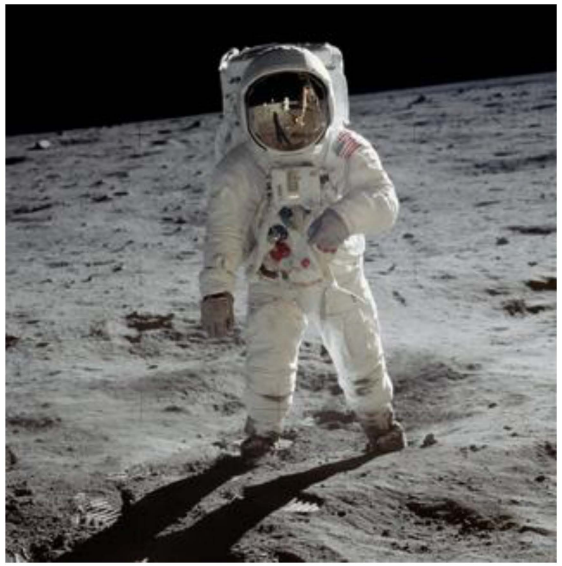
Exploration Extravehicular Activity (EVA)

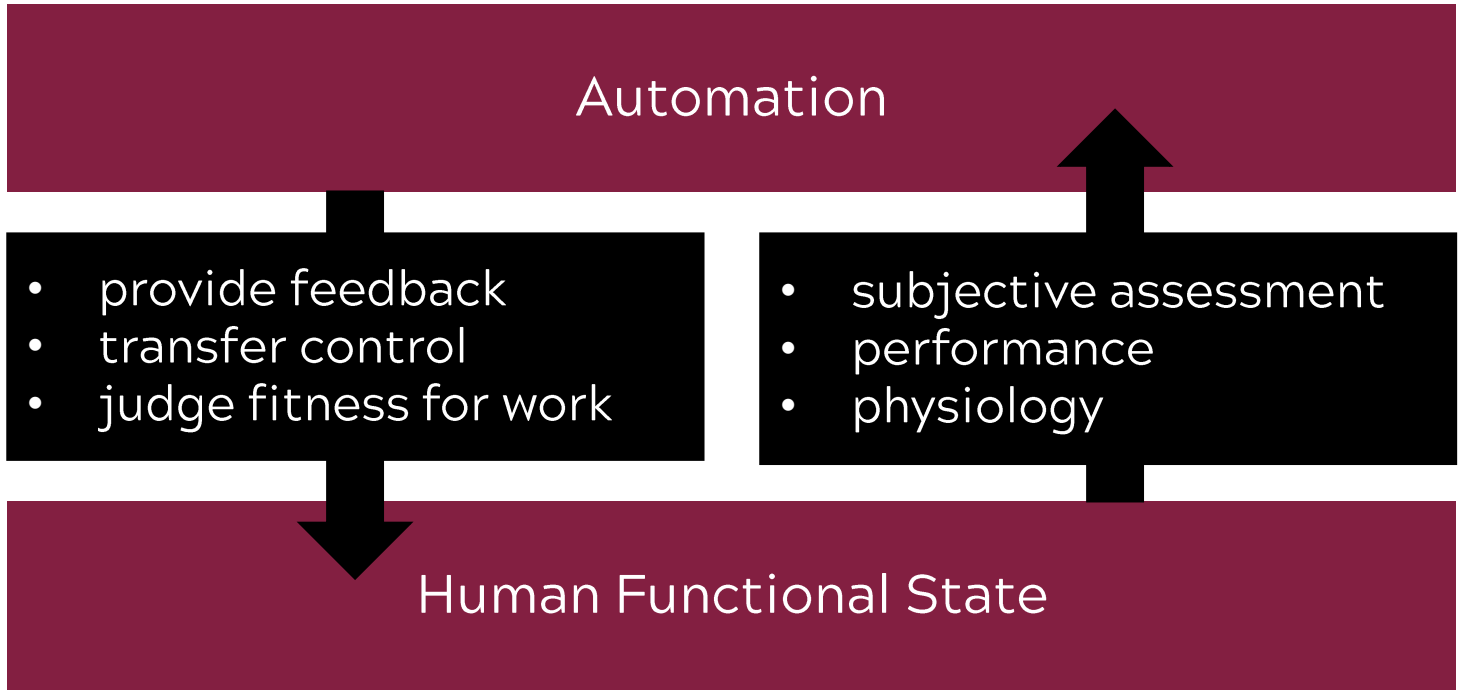
Gemini 4
Ed White
1965



Apollo 11
Buzz Aldrin
1969

International Space Station (ISS)
Anne McClain
2019

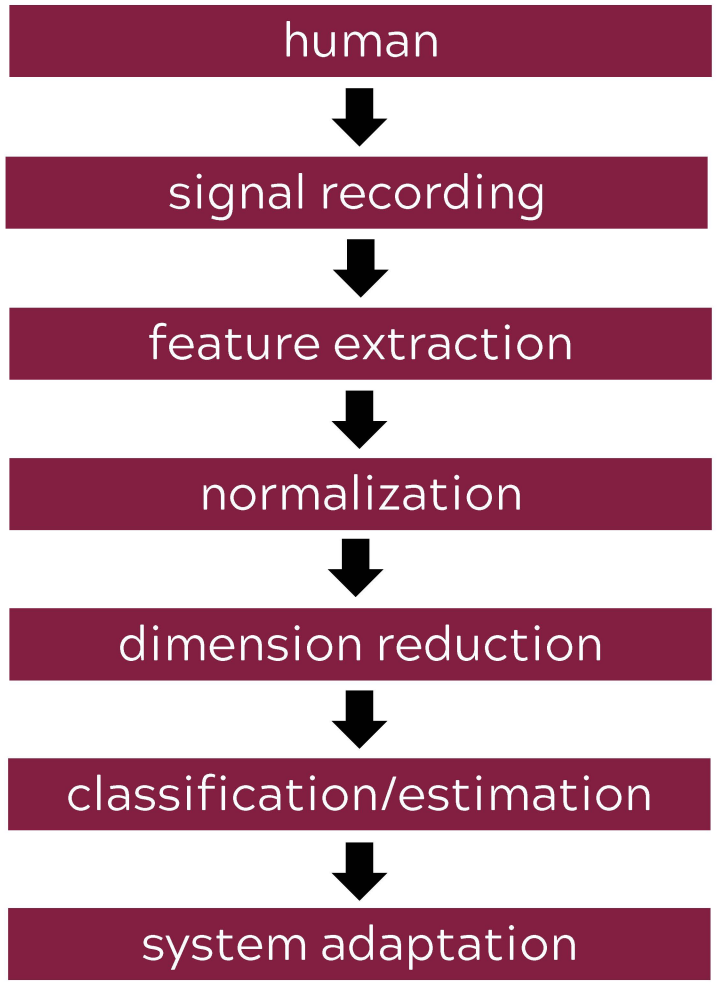
Crew State Monitoring



"the variable capacity of the operator for effective task **performance** in response to task and environmental demands, and under the constraints imposed by cognitive and physiological processes that control and energize behavior"

(Hockey et al., 2013)

Physiological Computing



physiological responses

physiological signals

psychophysiological features

normalized features

smaller feature set

psychological state

(Novak, Mihelji, & Munih, 2011)

Research Objective

Develop a robust prediction model of crew functional state for surface extravehicular activity using multi-modal psychophysiological monitoring.

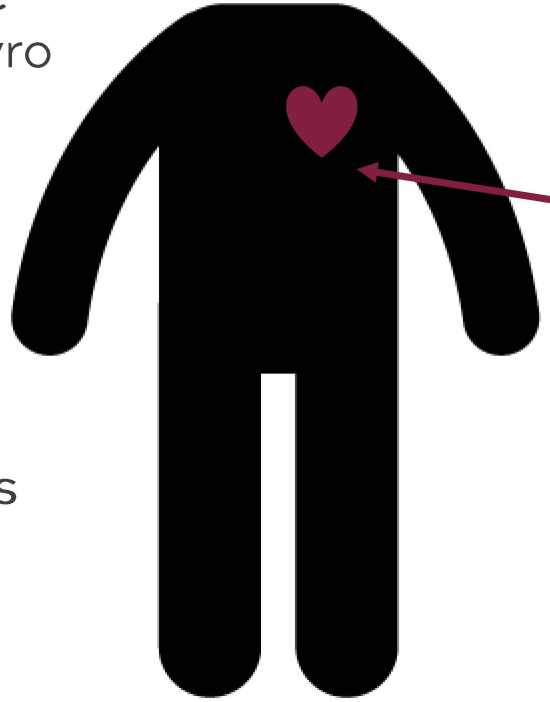
Compile Sensor Suite

Interaxon Muse
EEG, ECG, Acc, Gyro

Vive Pro Eye
Eye tracking

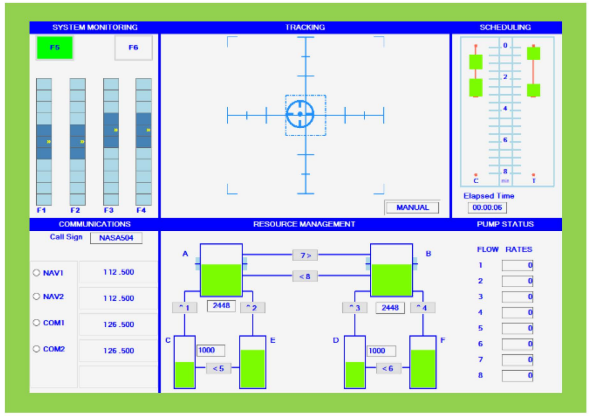
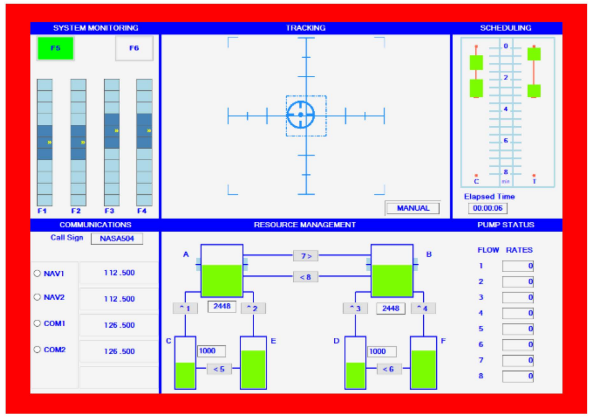
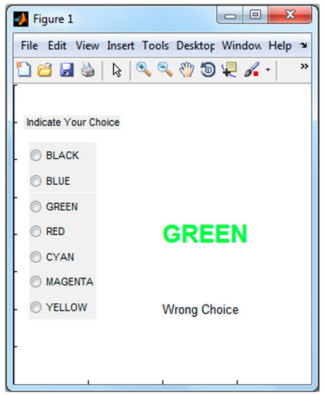
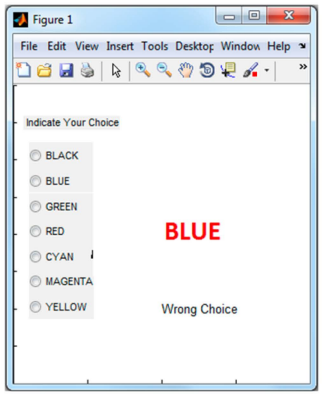
Advanced Brain Monitoring
B-Alert X10
EEG, ECG

Empatica E4 + Finger Electrodes
EDA, PPG, Temp, Acc

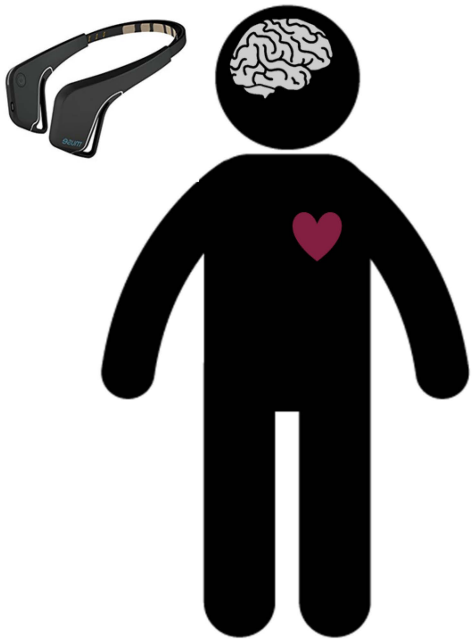


Polar H10
ECG

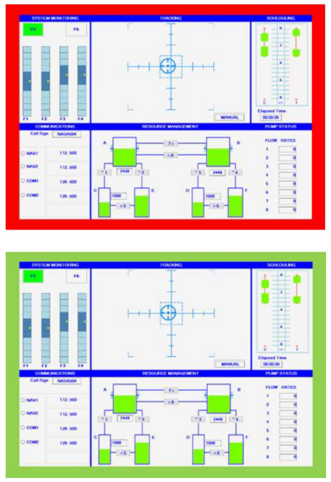
Propose Target Crew States

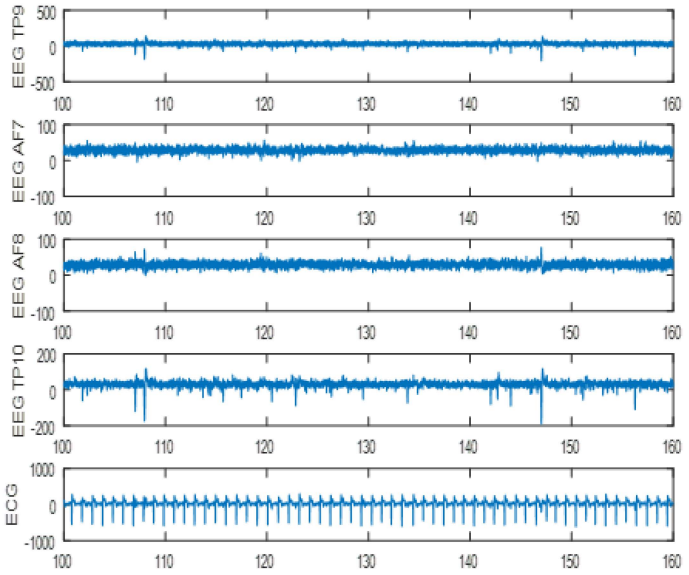
	Low Cognitive Workload	High Cognitive Workload
Multi-Attribute Task Battery (MATB) (Comstock & Arnegard, 1992)		
Paced Stroop Test (PST) (Saha et al., 2015)	 PST-Congruent	 PST-Incongruent

Collect Training Data



N = 9



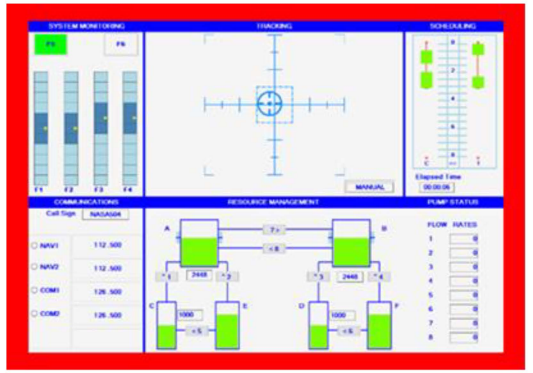


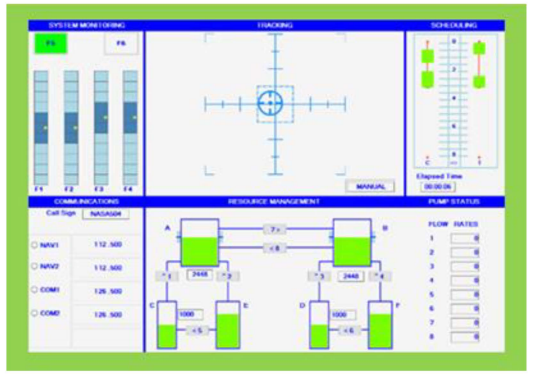
Signal	Features	Count
EEG	Relative bandpowers	5 x 4
ECG	Time-domain HRV	3
	Frequency-domain HRV	3
Total		26

human → signal recording → feature extraction

Validate Crew States

MATB Configuration

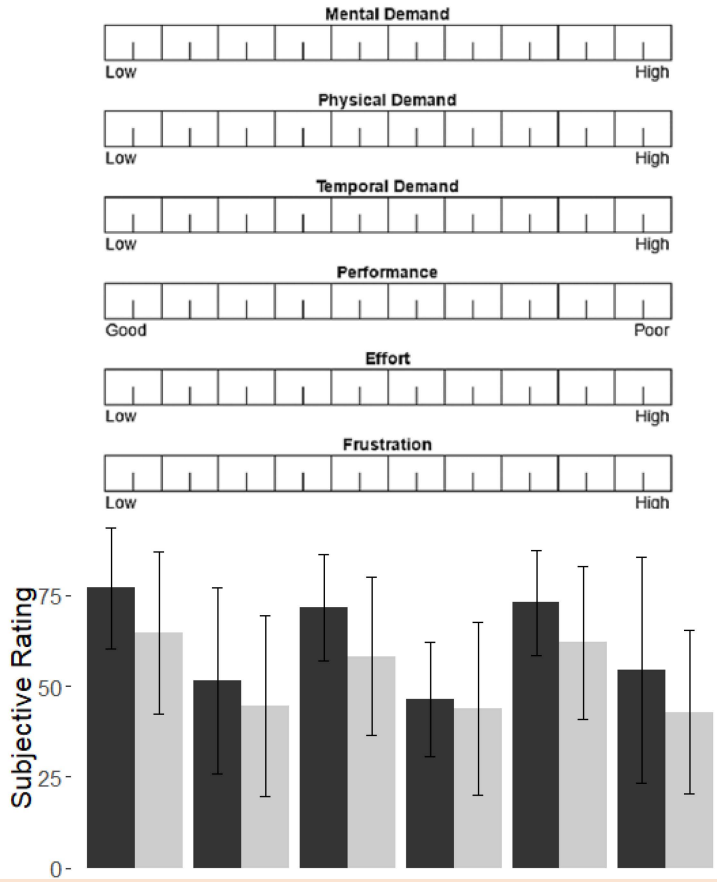




vs

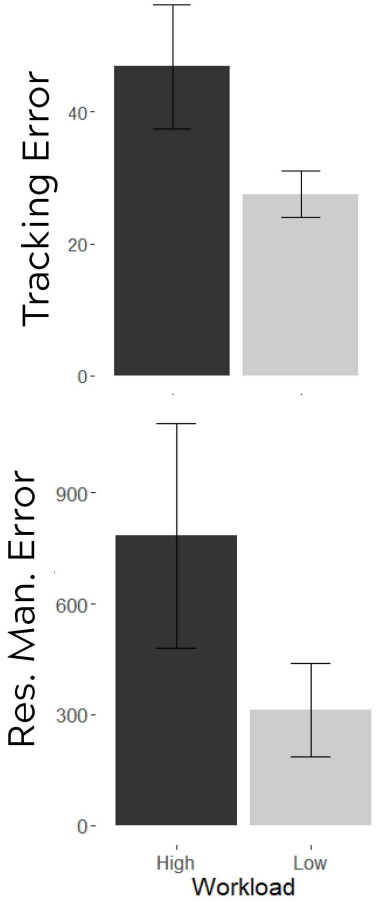
Subjective Assessment

NASA Task Load Index (TLX)



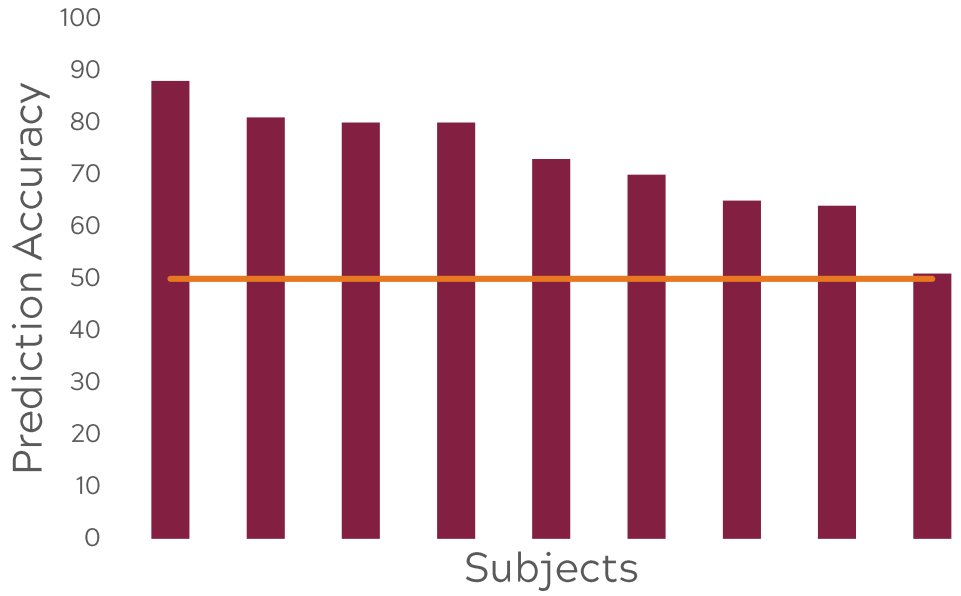
vs

MATB Performance

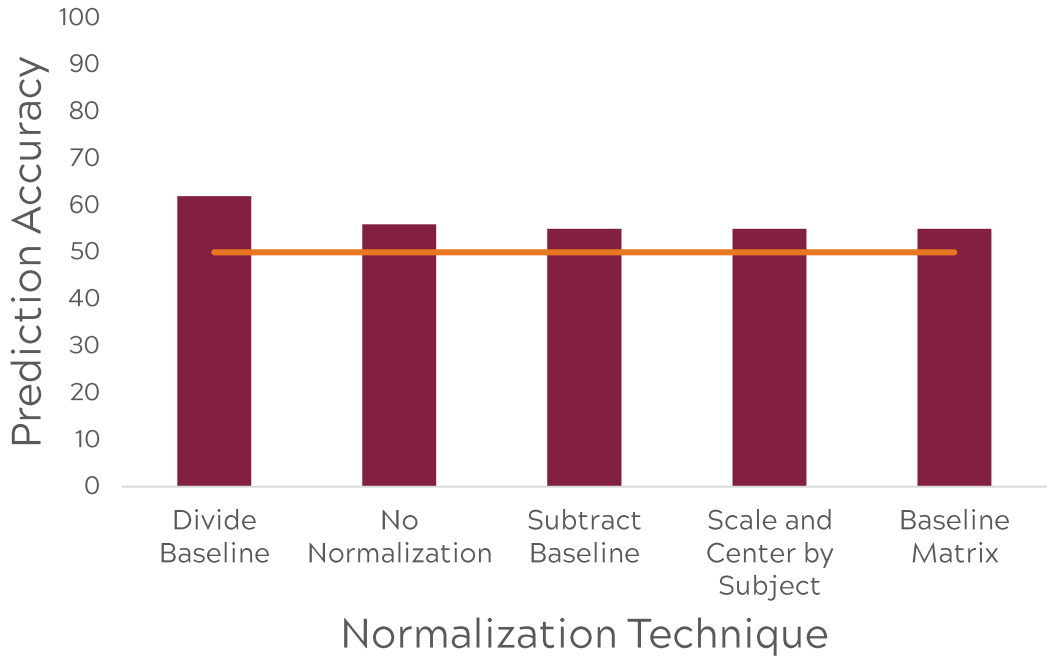


Develop Classifiers - Logistic Regression

- Subject-specific

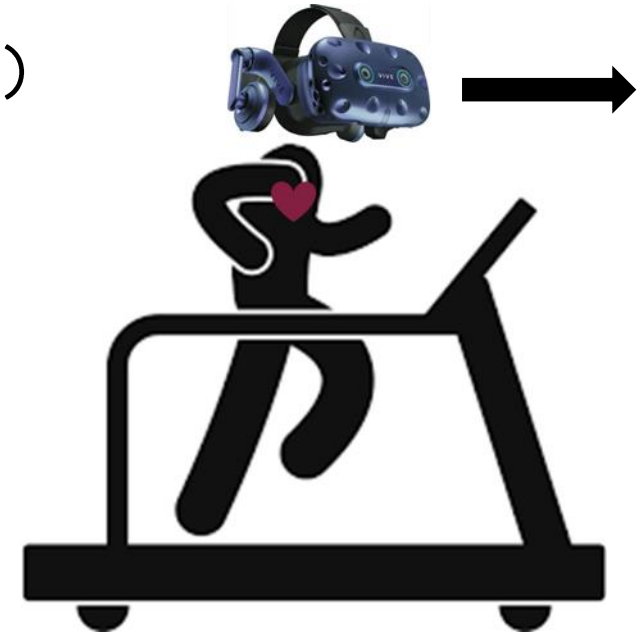


- Population-based

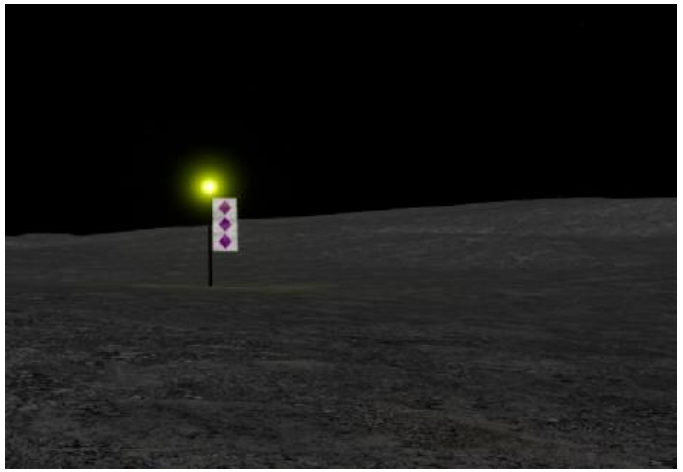


Develop EVA Simulation

- Pacing (time vs consumables)
- Waypoint identification
- Communication



EV Crewmember
(Test Subject)



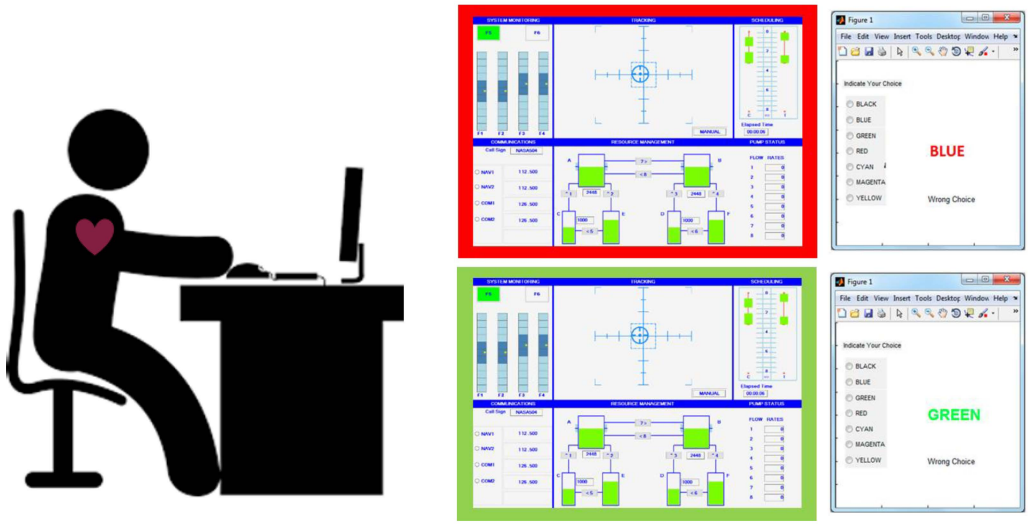
IV Crewmember
(Test Conductor)

Limitations

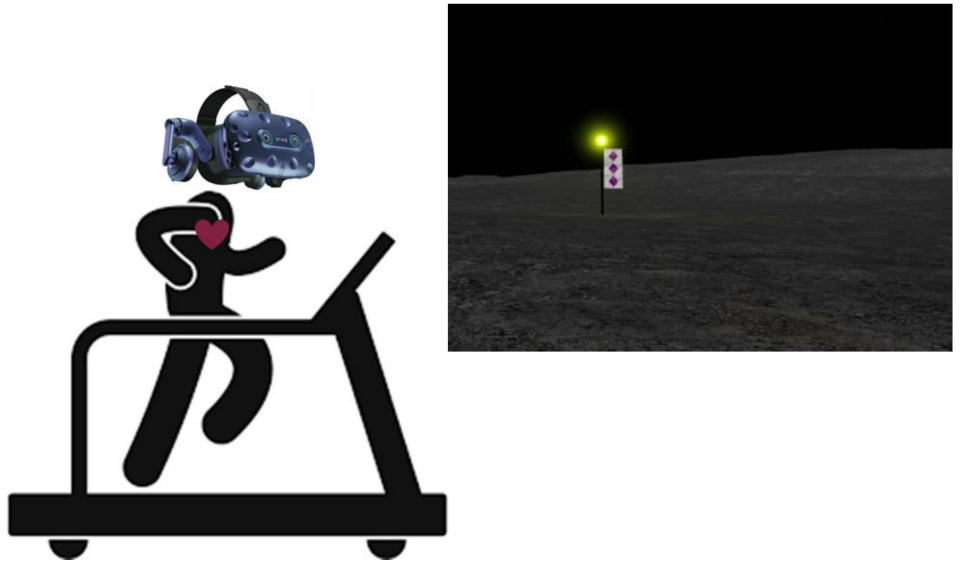
- Data quality from wearable devices
- Subject population ≠ astronaut population
- Classifier dependence on subject, time, and task

Future Work

Train Multi-Modal Classifier



Test Classifier



Acknowledgements

NASA Space Technology and Research Fellowship:
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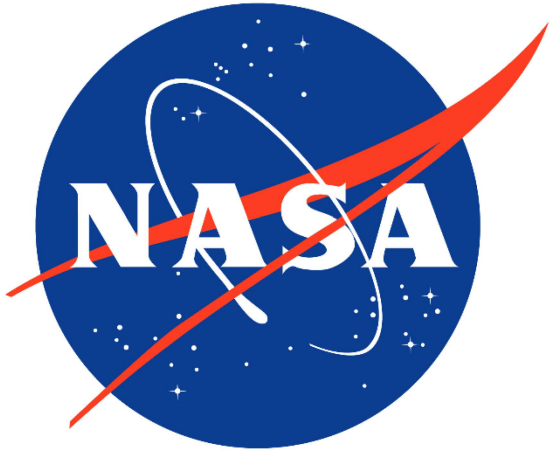

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