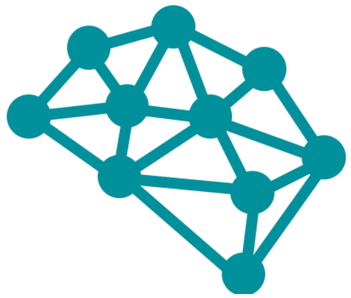
Classification of Cognitive Load and Expertise for Adaptive Simulation using Deep Multitask Learning

Authors
Pritam Sarkar, Kyle Ross, Aaron J. Ruberto, Dirk Rodenburg, Paul Hungler, Ali Etemad



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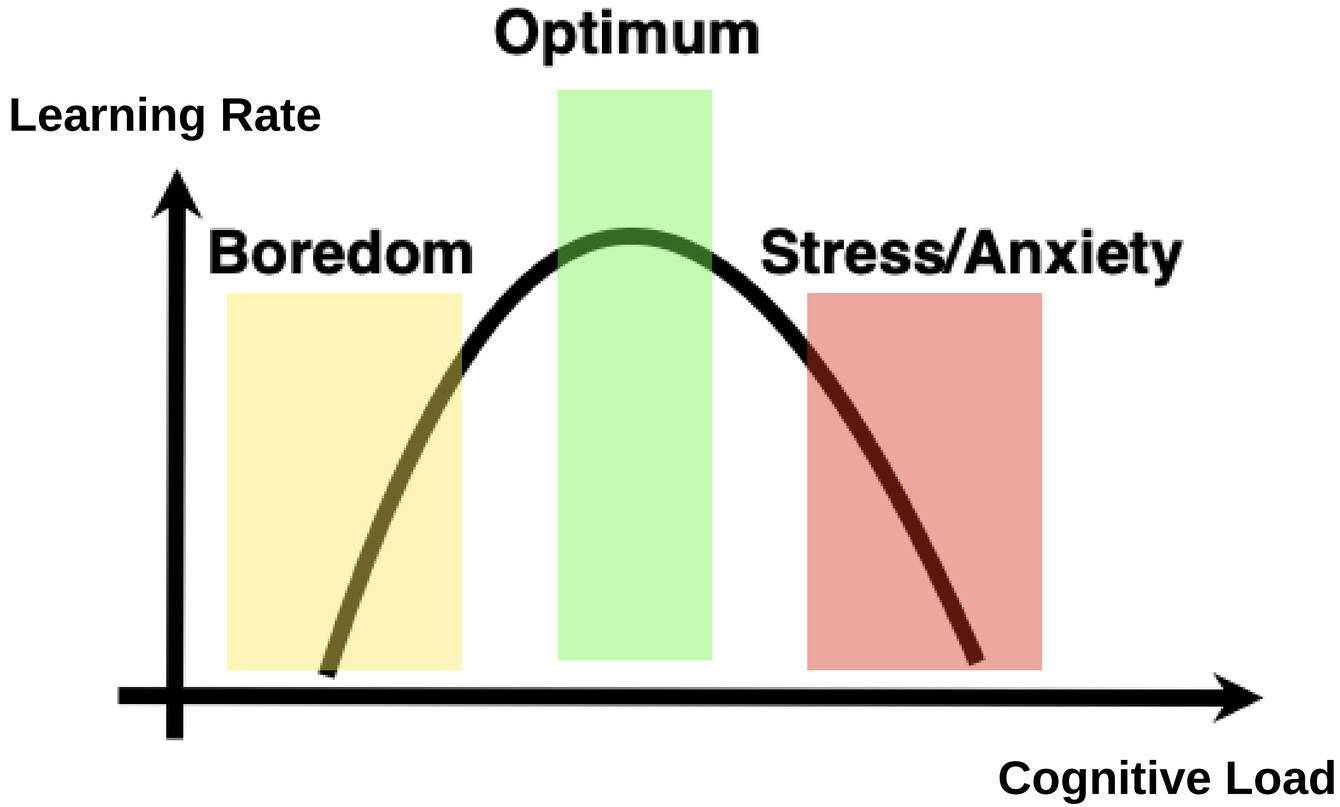
Motivation


Optimum
Learning Rate
Boredom
Stress/Anxiety
Cognitive Load

Problem Statement

- Current learning systems like simulations are ***one size fits all***

- Different people learn at ***different rates*** and showing different learning patterns.

- ***Goal*****:** to develop a system that personalizes training plans based on individuals

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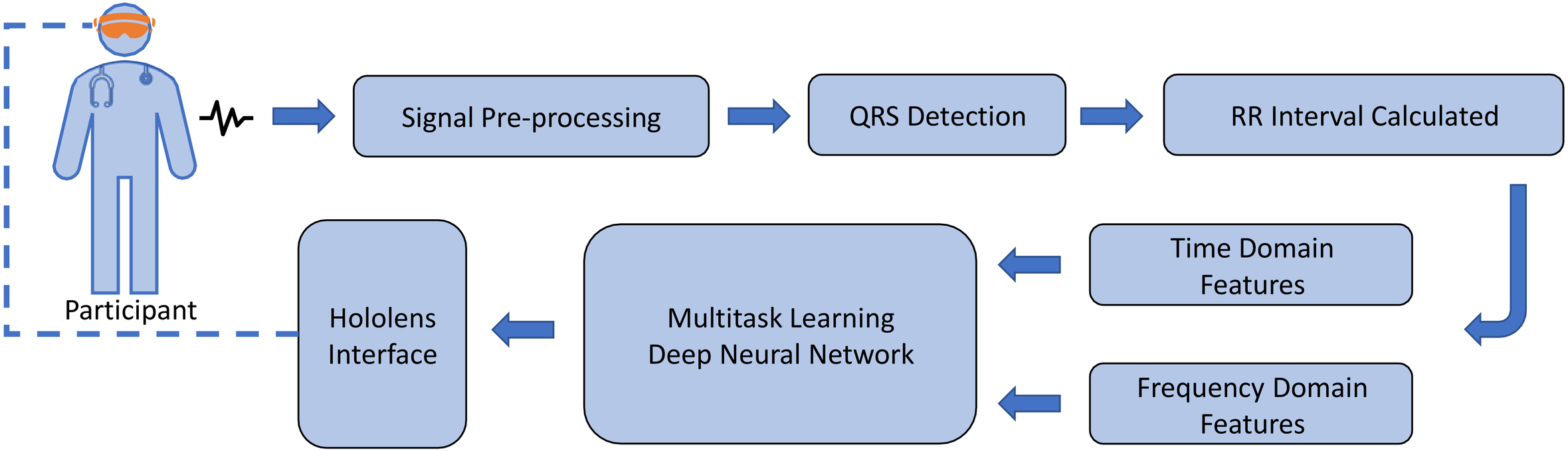

Our Proposed Framework

Experiment Setup

Experiment Setup


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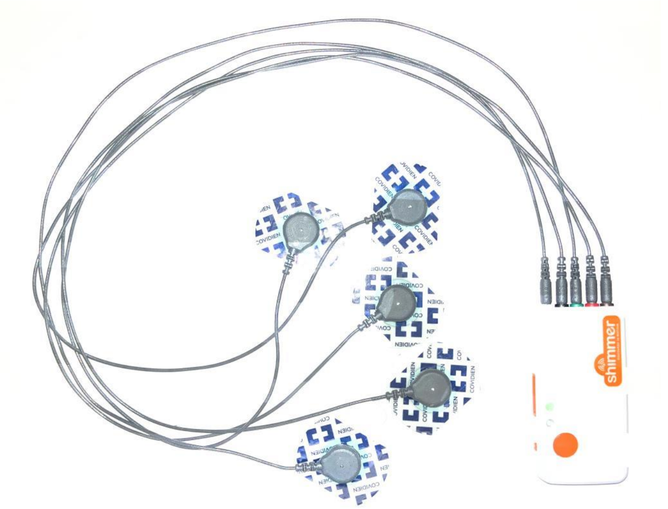
Data Collection

Microsoft HoloLens for placing augmented reality objects and capturing first person video.



Shimmer Sensor for collecting ECG

Total Participants	**9**
Expert (Physicians)	**5**
Novice (4th Year medical students)	**4**

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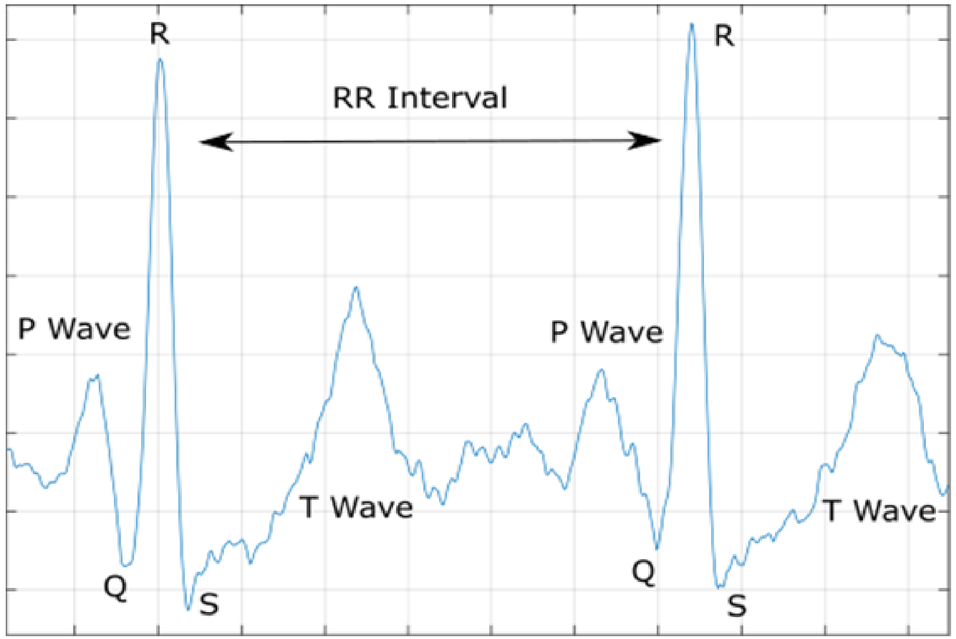
Data Collection

There are three stages of data collection:

1. Baseline Data
2. Simulation Data
3. Ground Truth

Data Pre-processing & Feature Extraction



1. Filter ECG signals
2. Segment into 10 seconds window with 50% overlap
3. Used Pan Tompkins algorithm for R-R peaks detection
4. RR intervals were calculated.
5. Time domain and Frequency domain features extracted.
6. Features were normalized using baseline data

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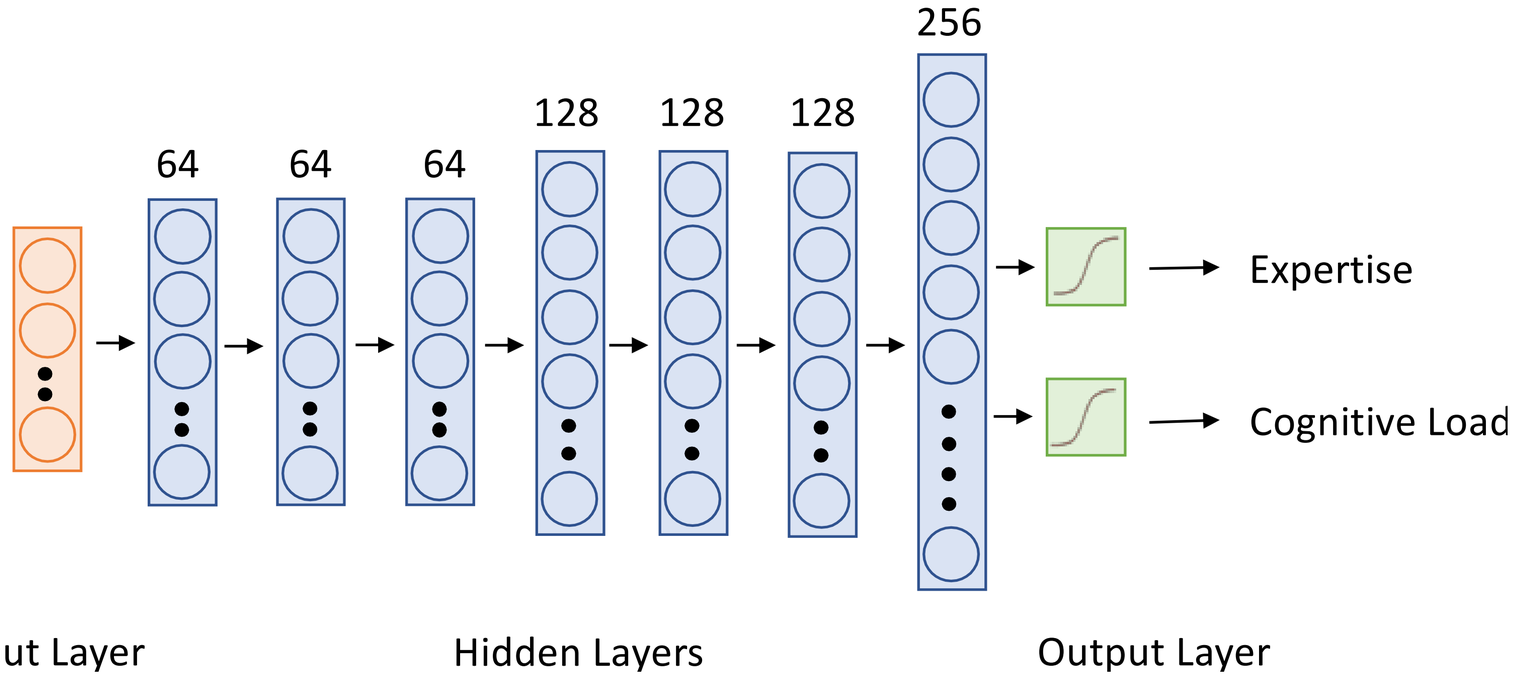
Deep Multitask Learning



Cross entropy loss: $L = -\frac{1}{N}\sum_{i=1}^{N}[y_i \log P(y_i) + (1 - y_i) \log (1-P(y_i))]$

Final Loss $L_{total} = L_{expertise} + L_{cognitive\ load}$

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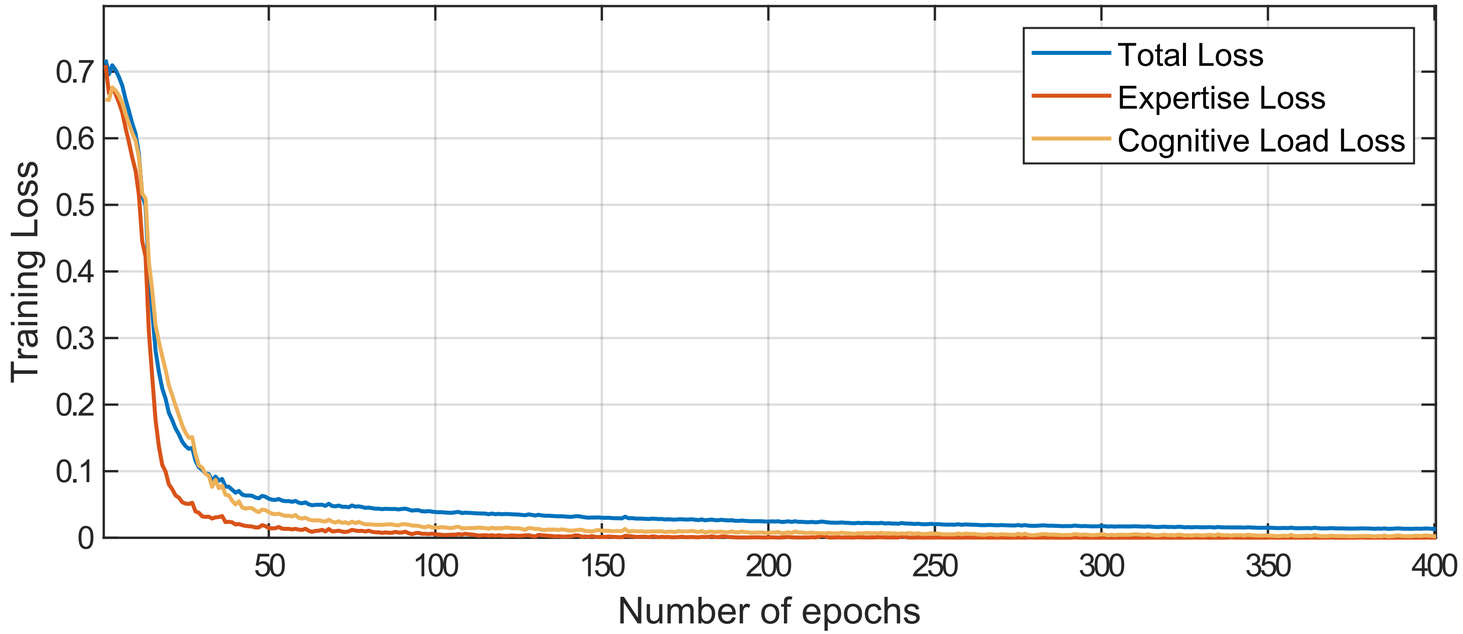
Result



	Accuracy	Precision	Recall	NPV	F1-score
Expertise	96.6	97.7	95.4	95.6	0.965
Cog. Load	89.4	95.7	81.8	85.0	0.882

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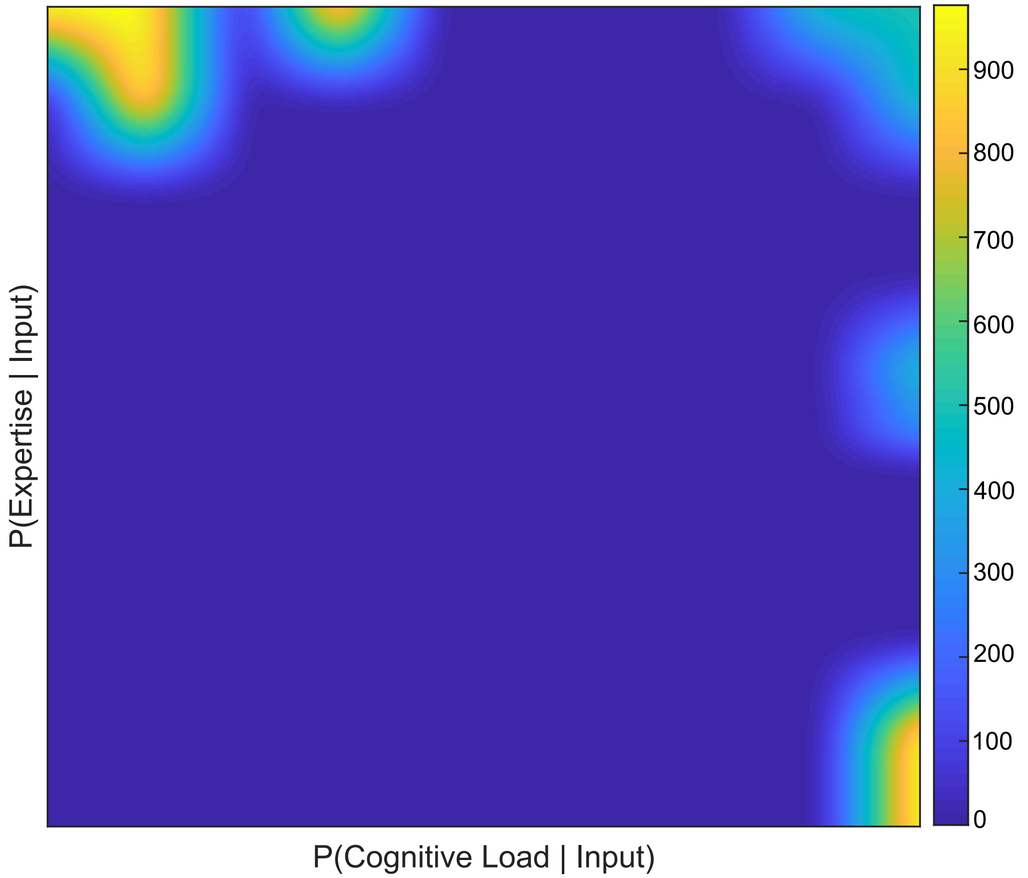
Result Comparison

Ref.	Task	Attribute	Signals	Method	Acc.
[30]	Mental Task	Cog. Load	ECG, EMG, GSR, Temp	kNN	50.4%
				NB	56.3%
				RF	57.8%
[18]	Computer Game	Anxiety	ECG, GSR, Temp	kNN	80.4%
				BN	80.6%
				RT	80.4%
				SVM	88.9%
[17]	Driving task	Stress	ECG, EMG, GSR	LDA	97.3%
[44]	Arithmetic Task	Stress	GSR	SVM	81.3%
				LDA	82.8%
Ours	Training Simulation	Expertise Cog. Load	ECG	DMNN	96.6% 89.4%

Note: All the references are same as original manuscript.

Analysis



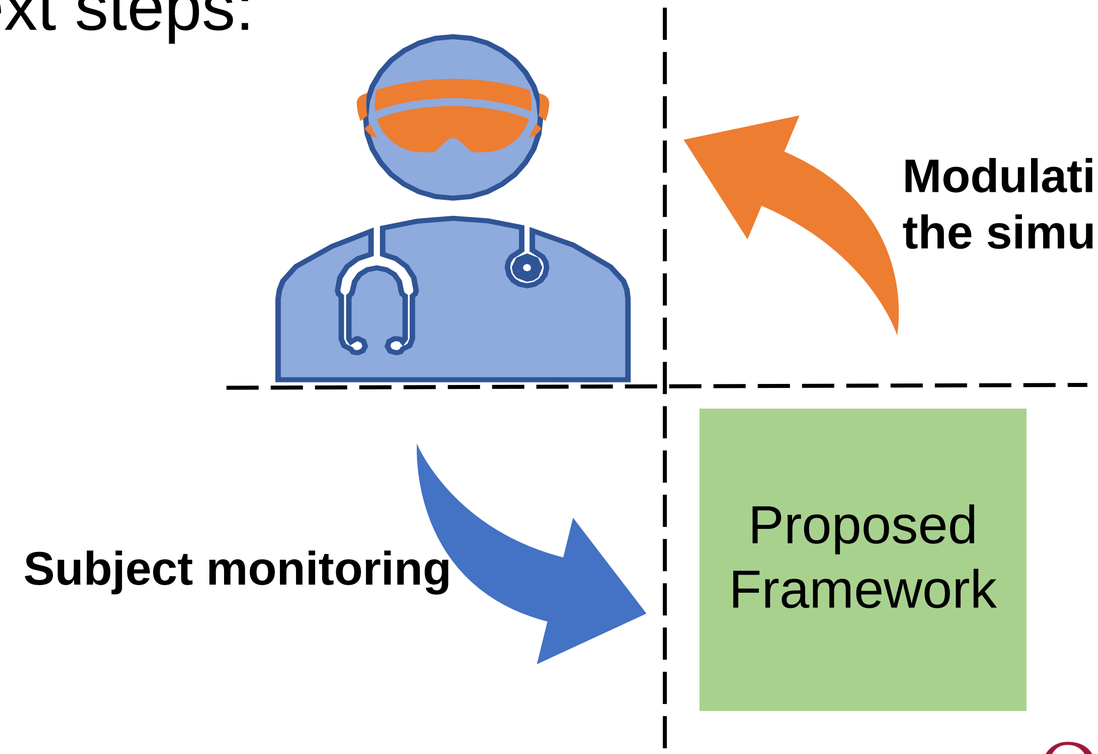
Brighter areas indicate larger number of produced outputs. A relatively inverse relationship is observed. The color bar indicates the concentration of the data points.

Conclusion and Future Work

- We proposed a framework for adaptive simulation.

- We were able to accurately estimate cognitive load and expertise.

- Next steps:



Thank you!

Question?

Contact:

Pritam Sarkar

pritam.sarkar@queensu.ca

www.pritamsarkar.com

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