Analyzing the Features and Efficacy of Classification Models for Physiological Stress Prediction

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Motivation and Background

Motivation: Accurate stress prediction in law enforcement can serve to better prepare officers for the intensity of their work.

- **27%** of police officers suffer from symptoms of PTSD **[1]**

Concepts in current stress prediction research:

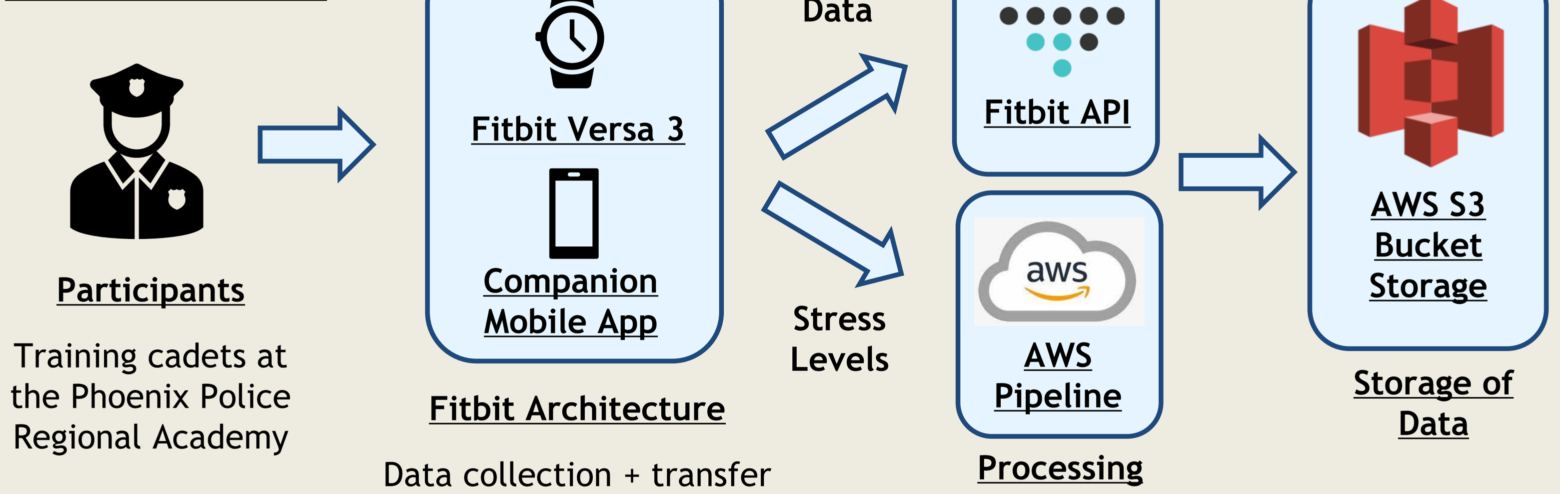
- Healey **[2]** and the *WESAD* dataset **[3]** use physiological data.
- Standard supervised learning models (ex. RF, SVM) are used regularly **[4]**.
- Deep learning in stress prediction has been attempted **[5]**.

Goal:

- Compare conventional models with deep learning and investigates the effect of certain features and time ranges
- Generate results on the ideal algorithms and conditions for stress prediction.

Methodology

Data Collection



Feature Extraction

- Removal of non-responses and other noisy data
- Mapped biometric data to inputted stress levels based on certain time interval of relevance

	Heart Rate	Calories, METs, and Steps
Extracted Features	Mean, Max, Min, Std Dev, Regression Line, RMSSD, Resting Rate	Mean, Max, Min, Std Dev

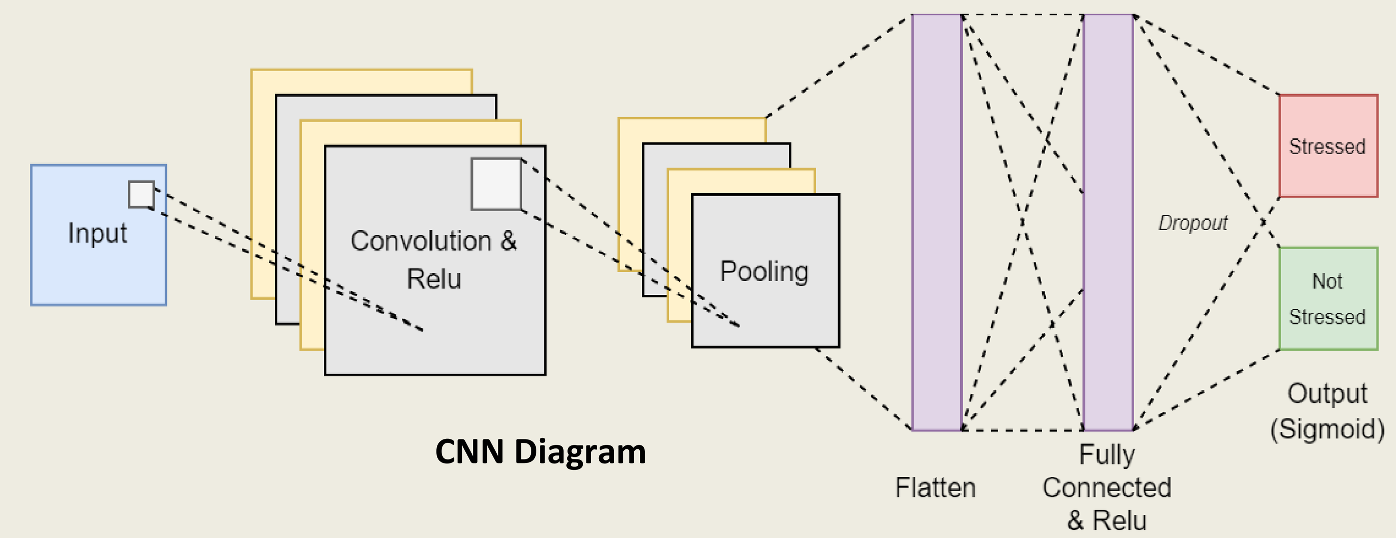
Data Processing

- **Binary classification threshold tuning** down to **0.3** due to unbalanced dataset
- **SMOTE-ENN** for both over-sampling and under-sampling
- **Principal component analysis (PCA)** to reduce components
- Divided dataset into different intervals of time to investigate ROC_AUC
  - Intervals from **1 minute** to **3 hours**

Neural Network Development

Implemented two forms of neural network: **CNN** and **MLP**

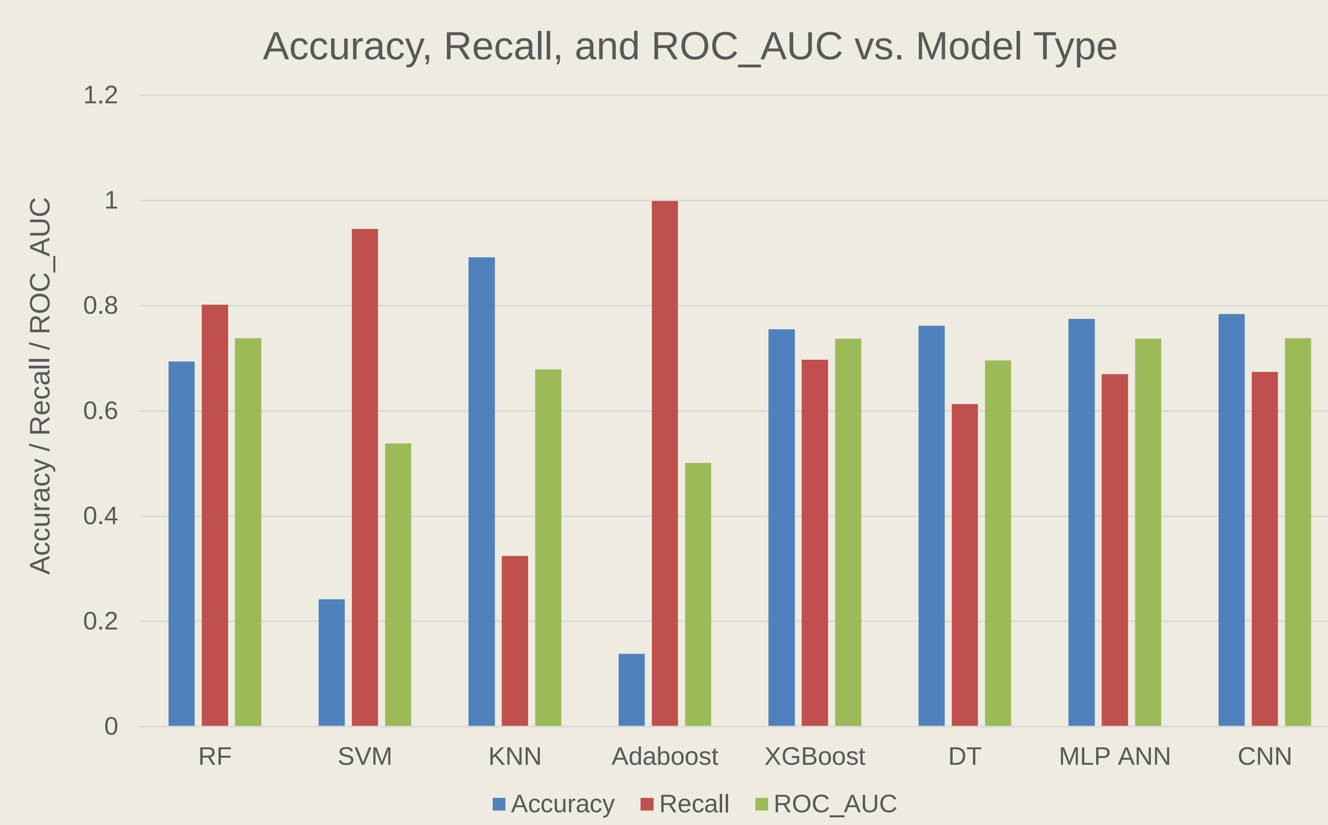
- **Convolutional Neural Network (CNN)**
  - Reshaped dataset to fit Keras 1-Dimensional CNN
  - Implemented network with **convolutions, pooling, flattening,** and **dropout.**
- **Multilayer Perceptron (MLP ANN)**
  - Created **MLP Classifier** with **4 hidden layers**



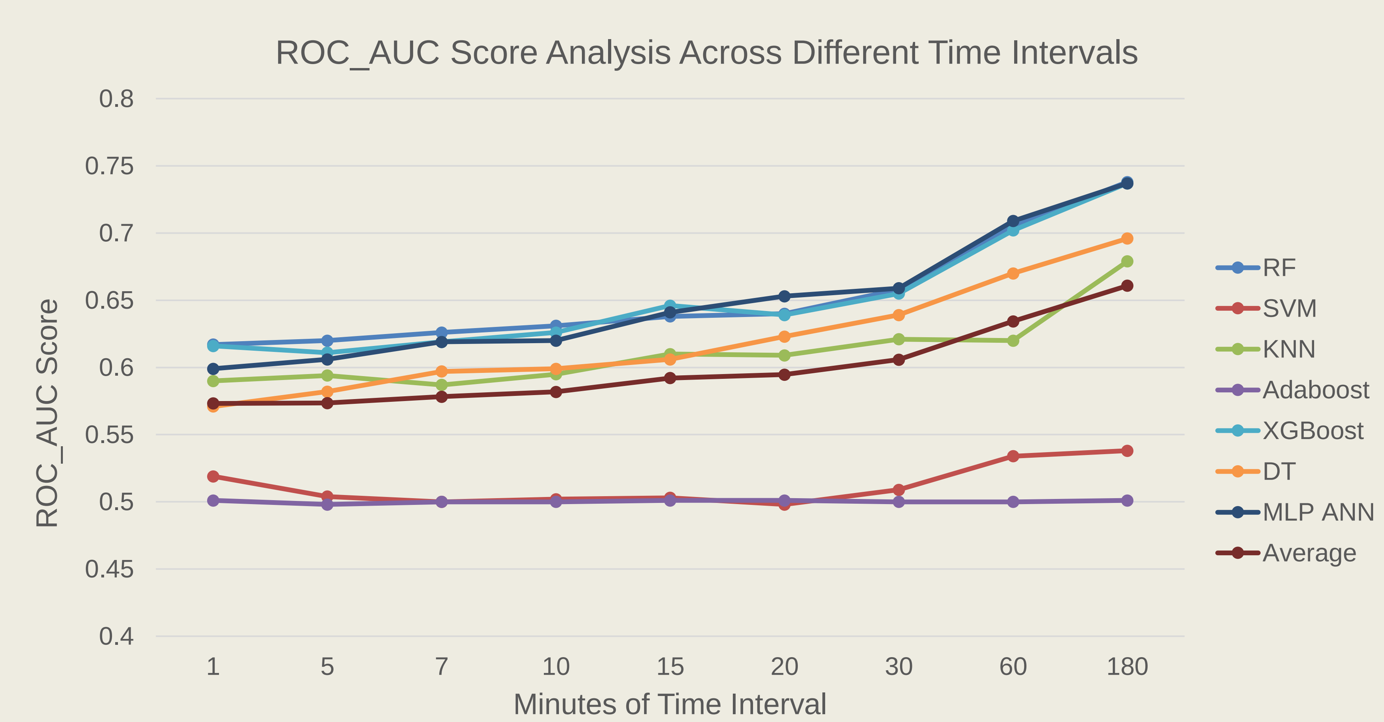
CNN Diagram

Results

Efficacy of Each Model Type



ROC_AUC Score vs Time Frame



Comparison of 5 Strongest Models

Model Type	Accuracy %	Recall %	ROC_AUC %
Random Forest	0.694	0.802	0.738
XG Boost	0.755	0.697	0.737
Decision Tree	0.762	0.613	0.696
MLP ANN	0.775	0.67	0.737
CNN	0.784	0.674	0.738

Feature Importance for 5 Strongest Models

Feature	Model
Resting Heart Rate	Random Forest, XG Boost, Decision Tree
RMSSD (Root Mean Squared of Successive Differences)	Random Forest, XG Boost
Max Steps	Random Forest, Decision Tree
Mean HR	Random Forest, Decision Tree

Conclusions

- **RF, XG Boost, and Decision Tree** are best at stress prediction among common models
  - Consistent with previous studies **[4]**
- **Neural network** models performed **equally well or better** for overall metrics
  - Good potential for further use of deep learning in stress prediction
- **Larger time windows (up to 3 hours)** yielded better accuracies
  - More data outweighs more relevant timeframe
- Strong correlation between **heart related metrics** and **model efficacy**

Future Work

- Test latency of real-time stress prediction on Fitbit **mobile devices**
- Compare efficiencies of larger **deep learning models** on **mobile devices** with efficiencies of standard supervised learning models
- Consider addition of **other features** such as **location contextualization** or **emotional responses**

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References and Related Works

[1] Caterina G. Spinaris, Michael D. Denhof, and Julie A. Kellaway, Posttraumatic Stress Disorder in United States Correctional Professionals: Prevalence and Impact on Health and Functioning (2012).
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