

A Multi-Sensor Fusion Method For Stress Recognition

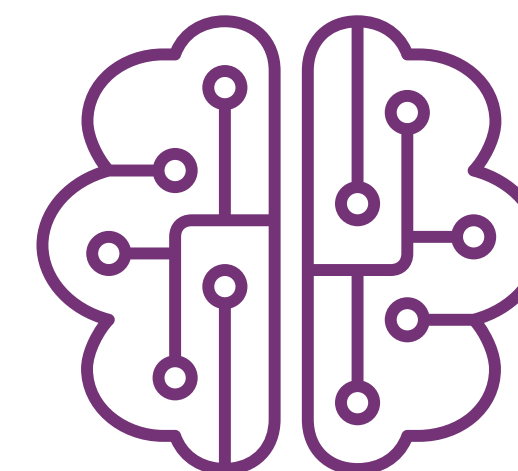
**EMBC 2022 Workshop & Challenge on Detection of Stress and
Mental Health Using Wearable Sensors**

Stress

Justification & Approach

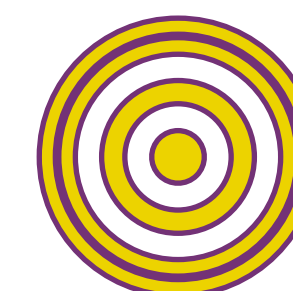


- Negative Life Impact
- Low Mental Physical Health^[2]

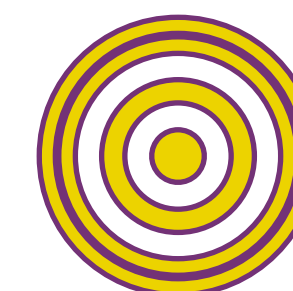


Multi-sensor **Machine Learning**

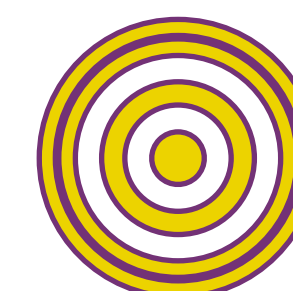
- Physiological Signals **correlated**^[2,4]



Stress Detection



Simple



Explainable



Dataset

SMILE

Momentary Stress Labels w/ ECG, SC & ACC^[10]



45 people

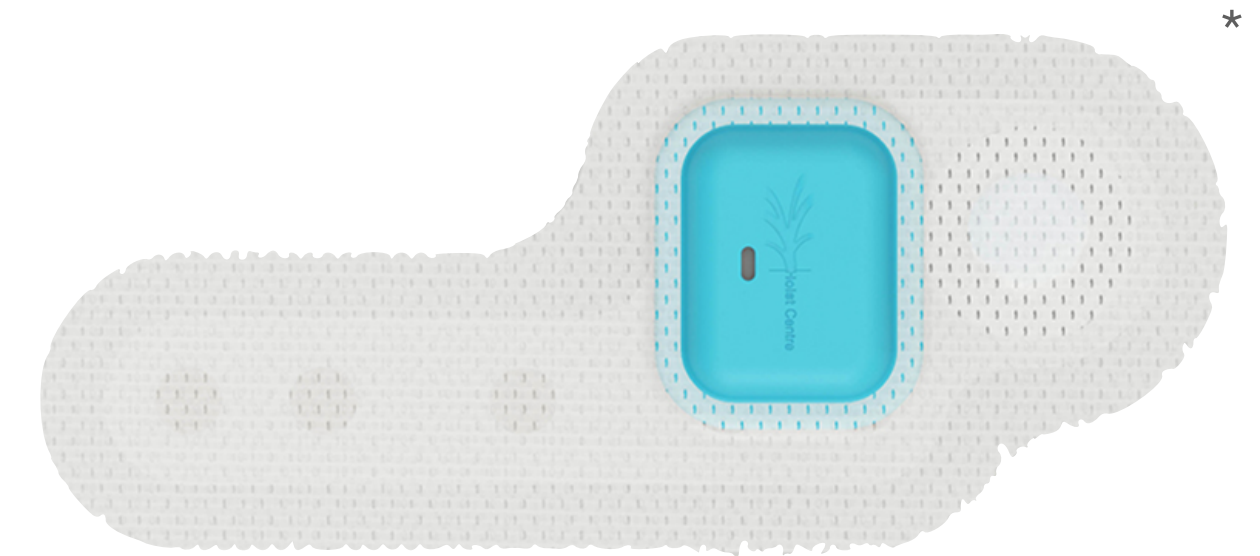
14% ♂

86% ♀



Chillband[©]

- Skin Conductance (SC)
- Skin Temperature (ST)
- Accelerometer (ACC)



Health Patch[©]

- ElectroCardioGram (ECG)
- Accelerometer (ACC)



8.7 days per person



Stress Assessment

SMILE

Features Given



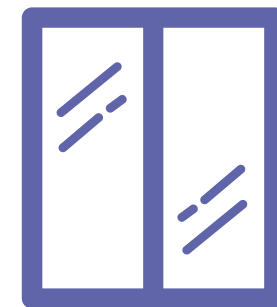
Hand Crafted

- 8 for ECG
- 8 for GSR¹
- 4 for ST



2070 Labels

- 1-7 stress scores
 - Binarized
 - 50-50 distribution



Data Window

- 60min window
- 5 Minute-aggregation



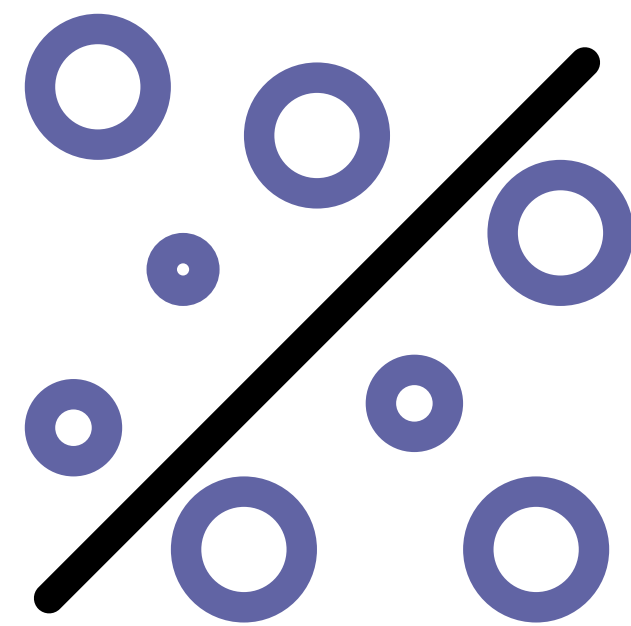
Deep Features

- Encoder-Decoder Unsupervised Learning
- **ECG** only
 - Conv1D (256)
 - LSTM (64)

¹ Galvanic Skin Response, related to Skin Conductance

SMILE

Data Exploration

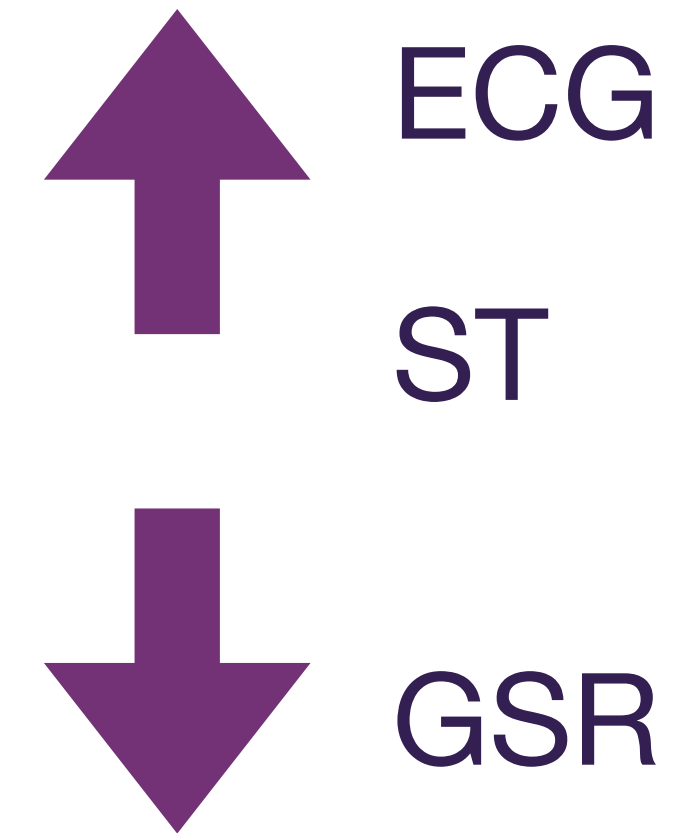


Missing Data

- 27.25% flatlines

Correlation^[13]

- Pearson's ρ
- Spearman's ρ
- Kendall's τ



Pearson's Correlation Coefficient per Feature



Classification Procedure

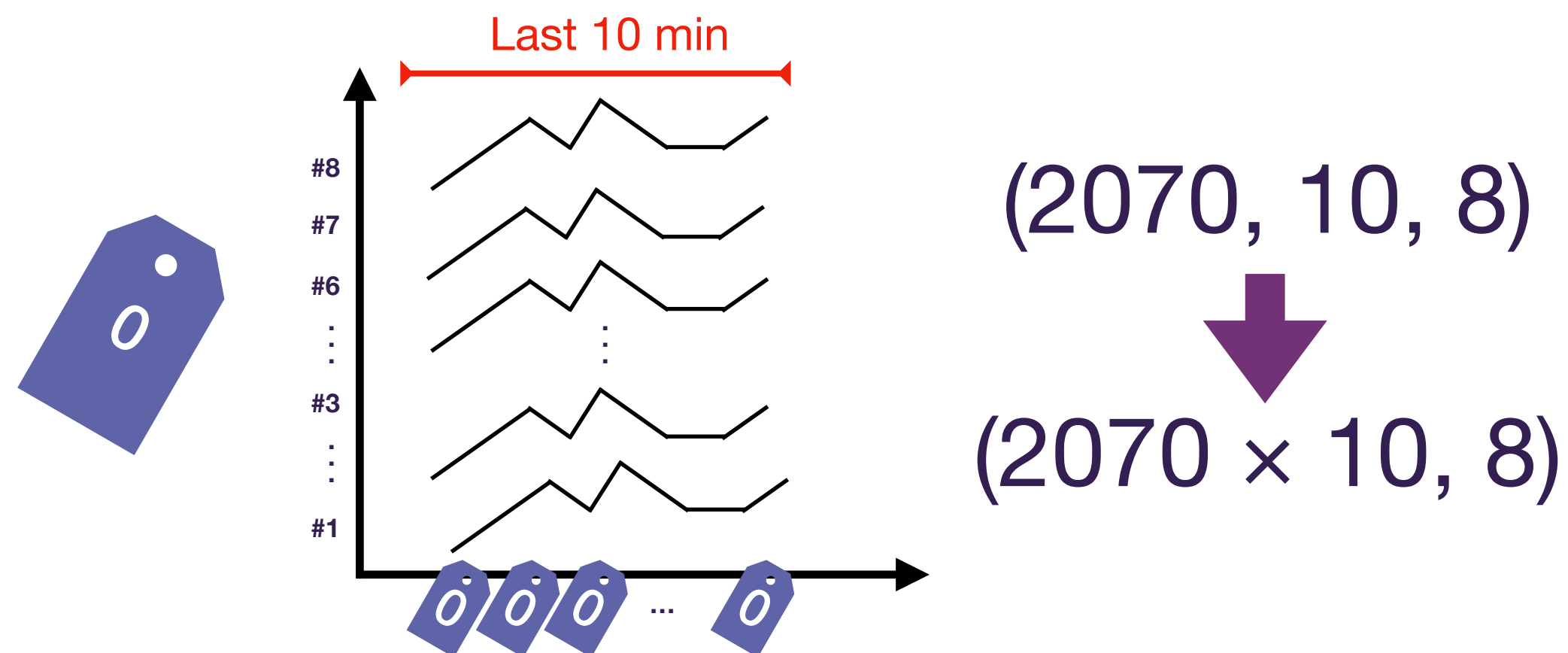
Data Preparation

Preparation & Methods

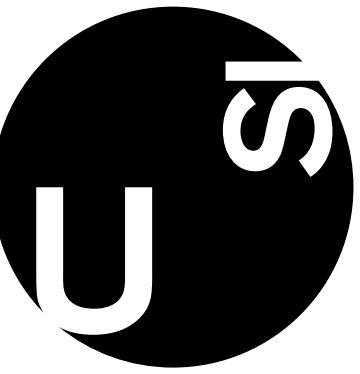
Reduced Timestep



Dimensionality Problem



pythonTM

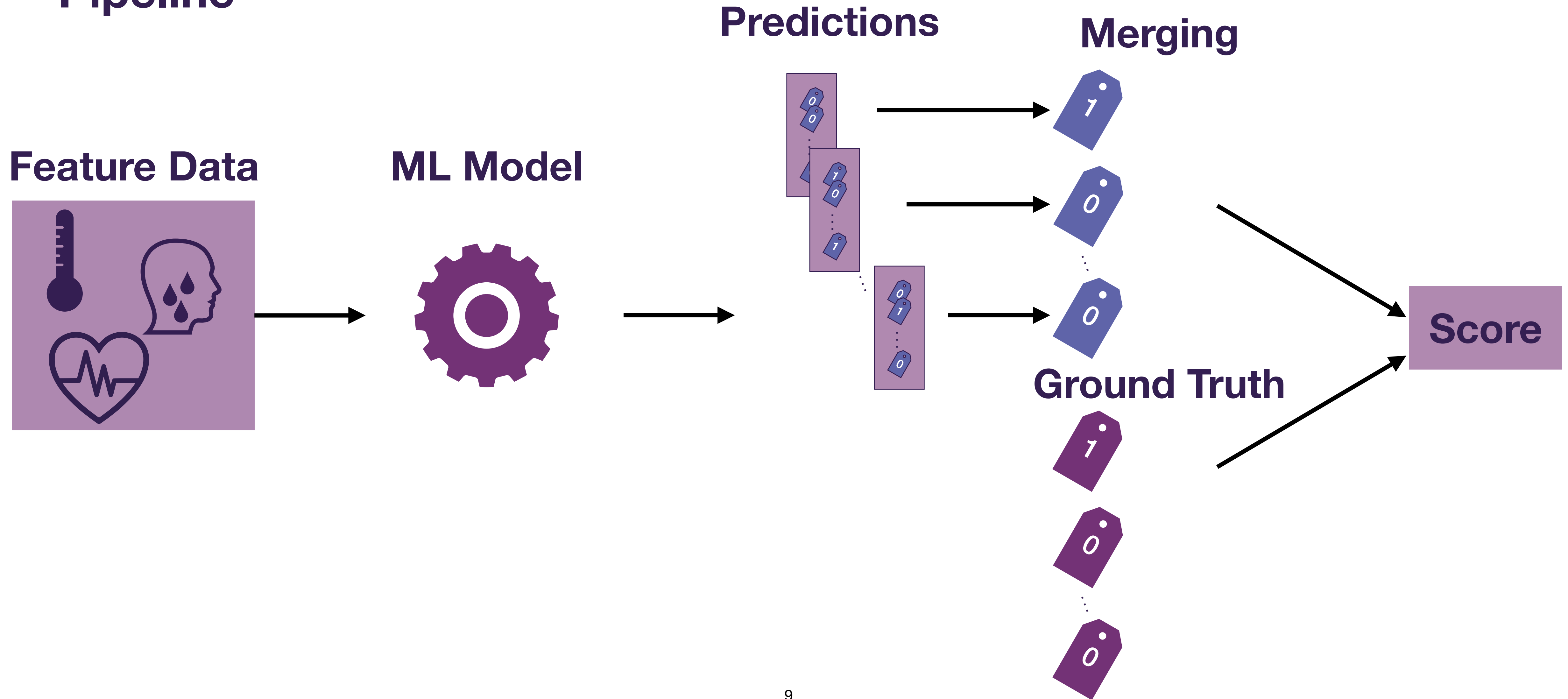


ML Classifiers

- Gaussian Process
- QDA
- SVM
- Gaussian NB
- KNN
- Decision Tree
- XGBoosted Tree
- AdaBoosted Tree
- Random Forest

Single-sensor models

Pipeline

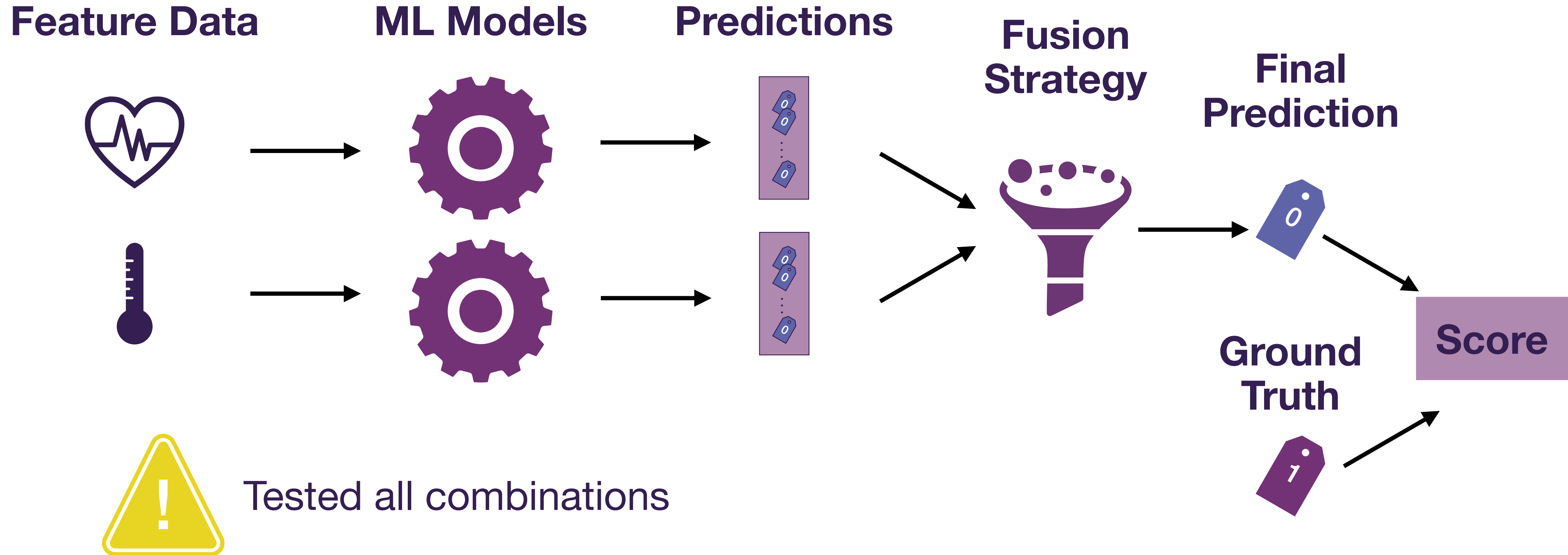


Multi-sensor models

Pipeline



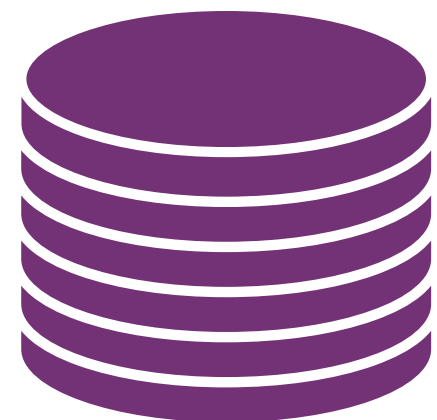
ML fusion strategy



Evaluation

How to confront results

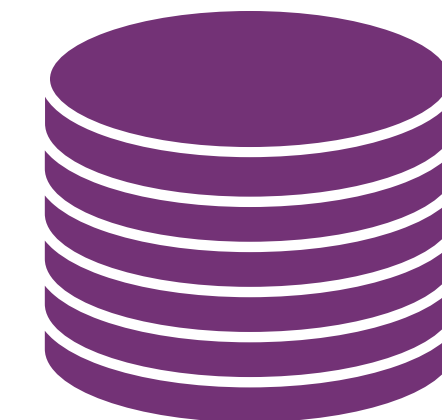
Train Set



10-fold Cross Validation

Accuracy \pm standard error

Test Set



Accuracy

F1-score



Explain Results

Most important features?

Most important timestep?

Results

Single-sensor models

Results

ML Model \ Sensor	ECG	GSR	ST
Gaussian Process	58 ± 3	40 ± 3	60 ± 3
SVM	58 ± 3	44 ± 4	59 ± 4
Naïve Bayes	54 ± 3	49 ± 6	57 ± 5
AdaBoost	54 ± 3	50 ± 3	56 ± 3
KNN	50 ± 2	49 ± 1	51 ± 2
QDA	51 ± 2	48 ± 6	59 ± 4
<i>Uniform Random Baseline</i>	<i>50 ± 2</i>		
<i>Biased Random Baseline</i>	<i>52.75 ± 0.06</i>		

Multi-sensor models

Results



ST



ECG

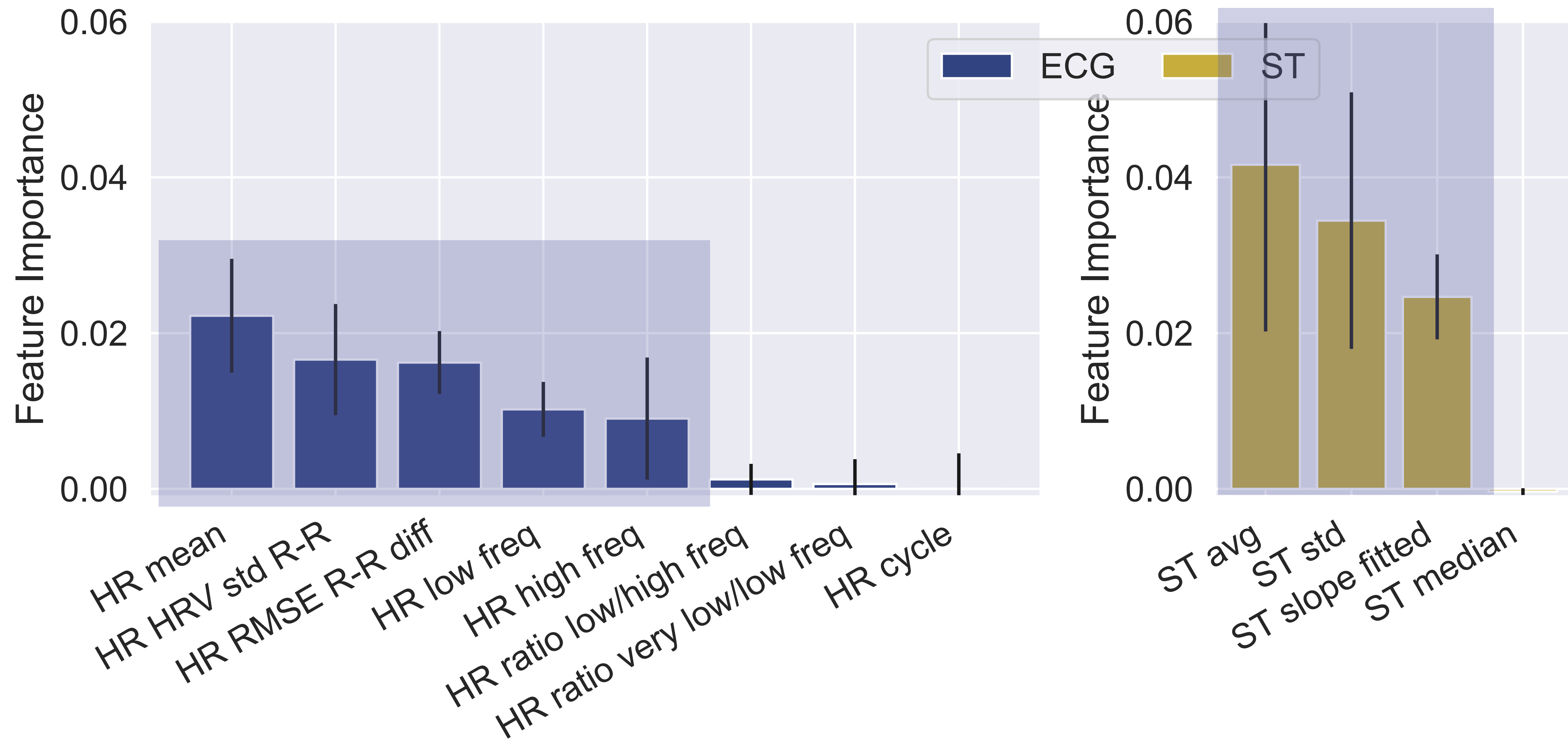


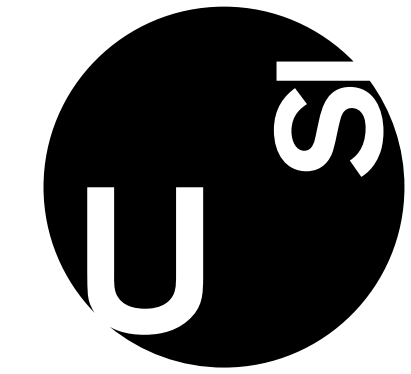
SR

Single-Sensor Model	SVM		GP	
Fusion Technique	CV	Test	CV	Test
Average	59 ± 3	51.52	60 ± 3	54.67
Gaussian Process	60 ± 3	52.74	61 ± 3	52.33
SVM	60 ± 3	53.14	59 ± 3	51.42
AdaBoost	59 ± 3	54.56	60 ± 3	51.72
QDA	55 ± 3	54.16	57 ± 5	56.19
<i>Uniform Random Baseline</i>	<i>50 ± 2</i>			
<i>Biased Random Baseline</i>	<i>52.75 ± 0.06</i>			

Explain

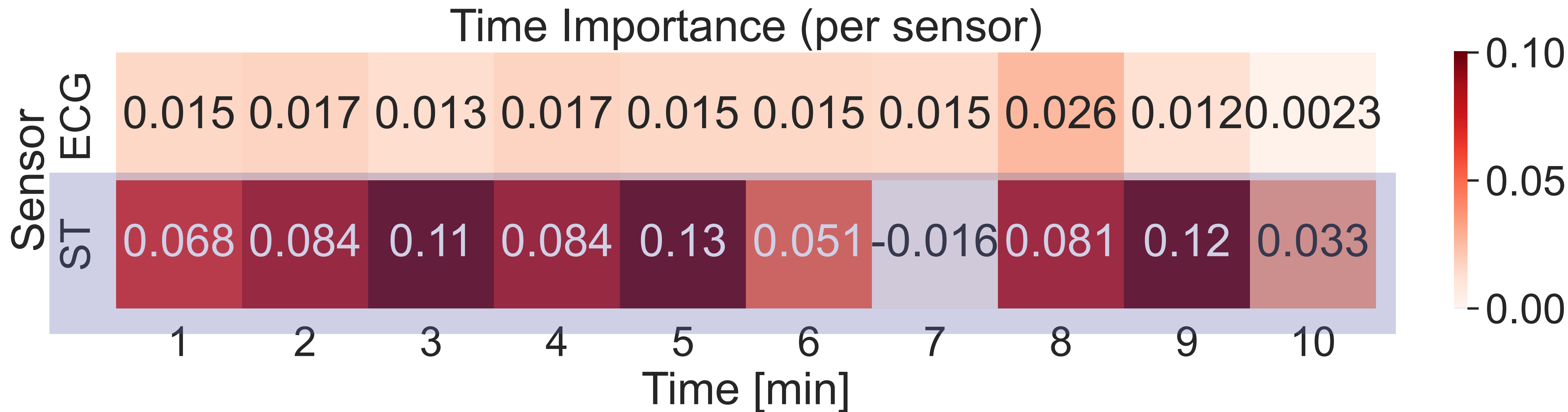
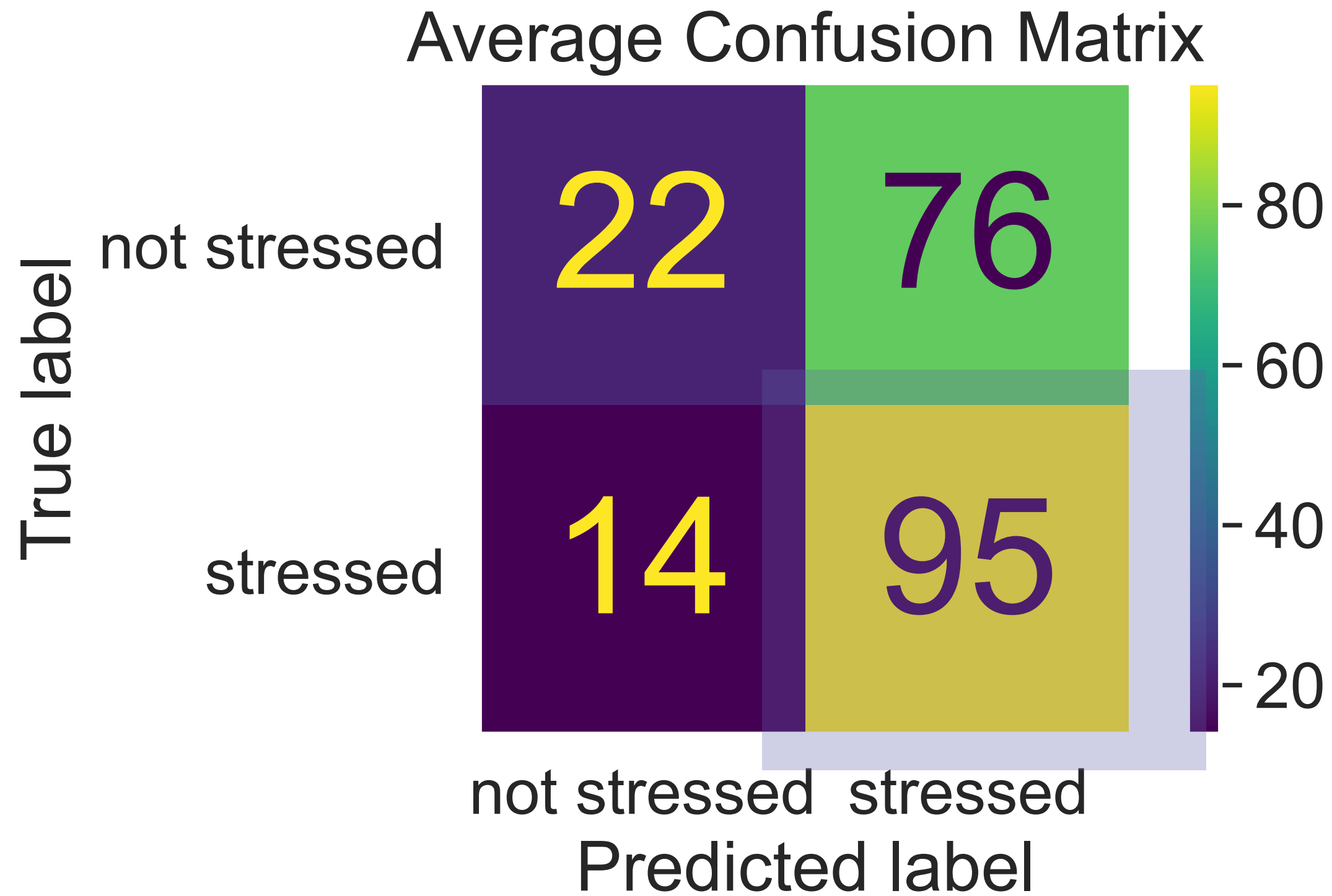
Feature Permutation





Explain

Feature Permutation



Conclusions

- Classical ML can predict stress
- Multi-sensor might be better
- Best model: ECG + ST
acc: 56.19% f1: 61.85%
- No Deep Features here



Thank you!

REFERENCES

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- [20] L. Breiman, "Random forests," *Machine learning*, vol. 45, no. 1, 2001.