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NECST laboratory

BALANCE

Behavioral and Ambient Learning Across Networked Collaborative Edges

An overview of Methodology and Results of Neural Networks for Sleep Quality Prediction

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Agenda

1. Problem Overview and Task Definition
2. Ex Ante Literature Review
3. Framework Adopted
    - 3.1. Data Engineering
    - 3.2. Network Architecture
4. Results
5. Ex Post Literature Review, Considerations and Future Works

Problem Overview and Task Definition

Sleep quality has been proven through extensive research to be a key element academic performance [1][2] …

[1] Lorenzo Tonetti, Marco Fabbri, Marco Filardi, Monica Martoni, Vincenzo Natale, Effects of sleep timing, sleep quality and sleep duration on school achievement in adolescents, ISSN 1389-9457,
[2] Julia F. Dewald, Anne M. Meijer, Frans J. Oort, Gerard A. Kerkhof, Susan M. Bögels, The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: A meta-analytic review, ISSN 1087-0792
[3] Shin Ji-eun , Kim Jung Ki , How a Good Sleep Predicts Life Satisfaction: The Role of Zero-Sum Beliefs About Happiness, ISSN 1664-1078

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… But also on Happiness and Optimism towards the future! [3]

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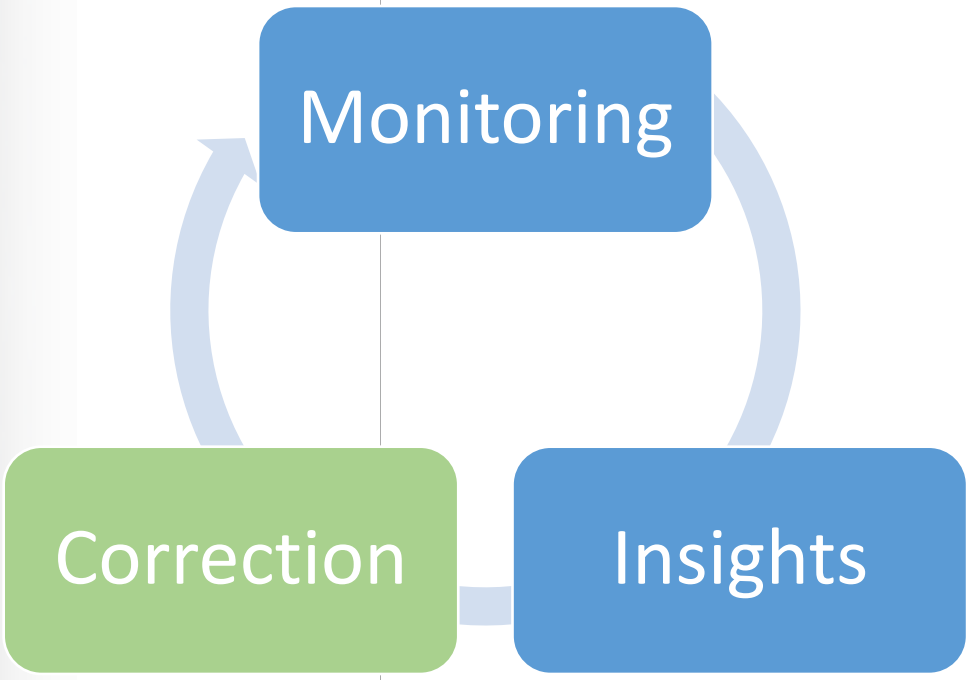
Monitoring
Insights
Correction

Problem Overview and Task Definition

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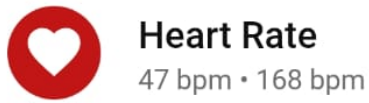

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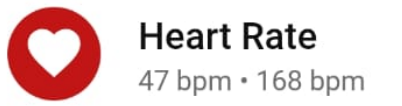

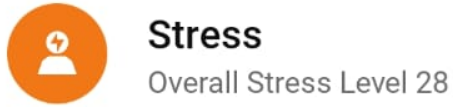

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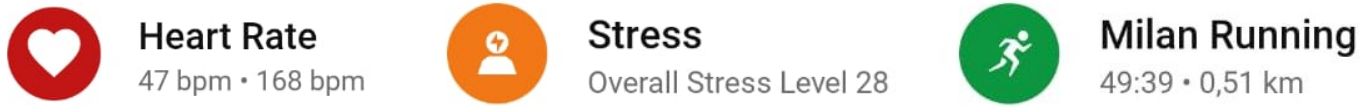

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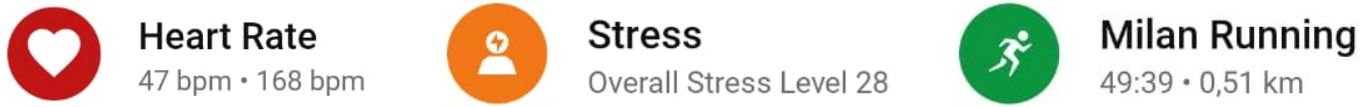


To do so, we use a **Federated Approach**, which allows us to keep the data from different users **separated**, respecting privacy of the users

Ex Ante Literature Review

Relevant Features

- Past Sleep Patterns
- Day Activity

Chosen Architectures

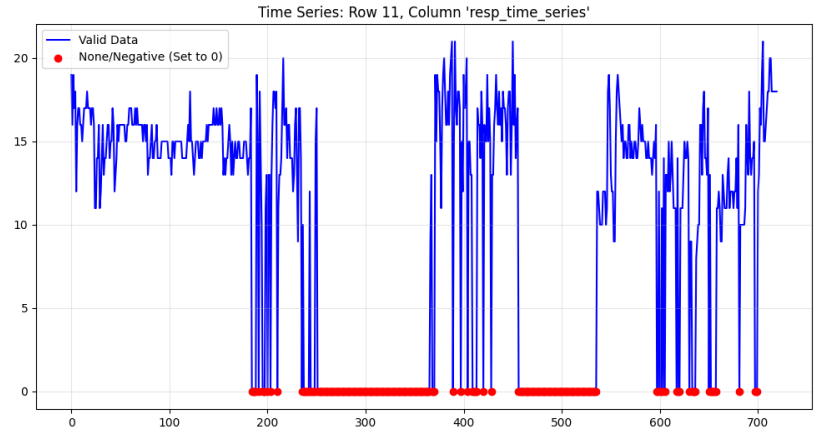
- Neural Networks
  CNNs, MLP, LTSM
- Random Forests, XGBoost

Salgaonkar, Sujal & Ghule, Kishori. (2025). Predicting Sleep Quality Using 24-Hour Physical Activity Data from Wearable's: A Fitness Tracking Approach. International Journal of Scientific Engineering and Research. 13. 27-32. 10.70729/SE25115123316.

Sathyanarayana A, Joty S, Fernandez-Luque L, Ofli F, Srivastava J, Elmagarmid A, Arora T, Taheri S, Sleep Quality Prediction From Wearable Data Using Deep Learning, JMIR Mhealth Uhealth 2016;4(4):e125, DOI: 10.2196/mhealth.6562

Arora, A., Chakraborty, P. & Bhatia, M.P.S. Analysis of Data from Wearable Sensors for Sleep Quality Estimation and Prediction Using Deep Learning . *Arab J Sci Eng* **45**, 10793–10812 (2020). https://doi.org/10.1007/s13369-020-04877-w

Framework Adopted – Data Engineering



- **Resampling to target number of values**
- **Linear Interpolation with Forward Fill**

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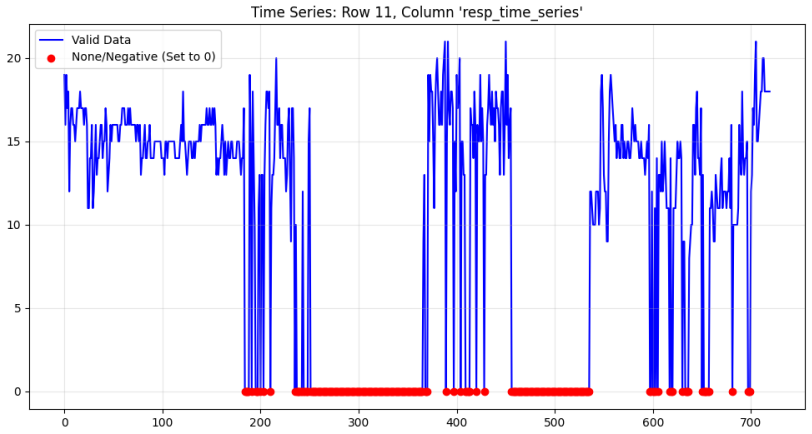

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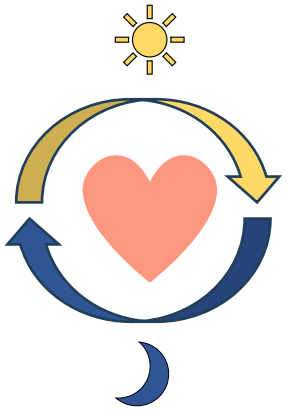
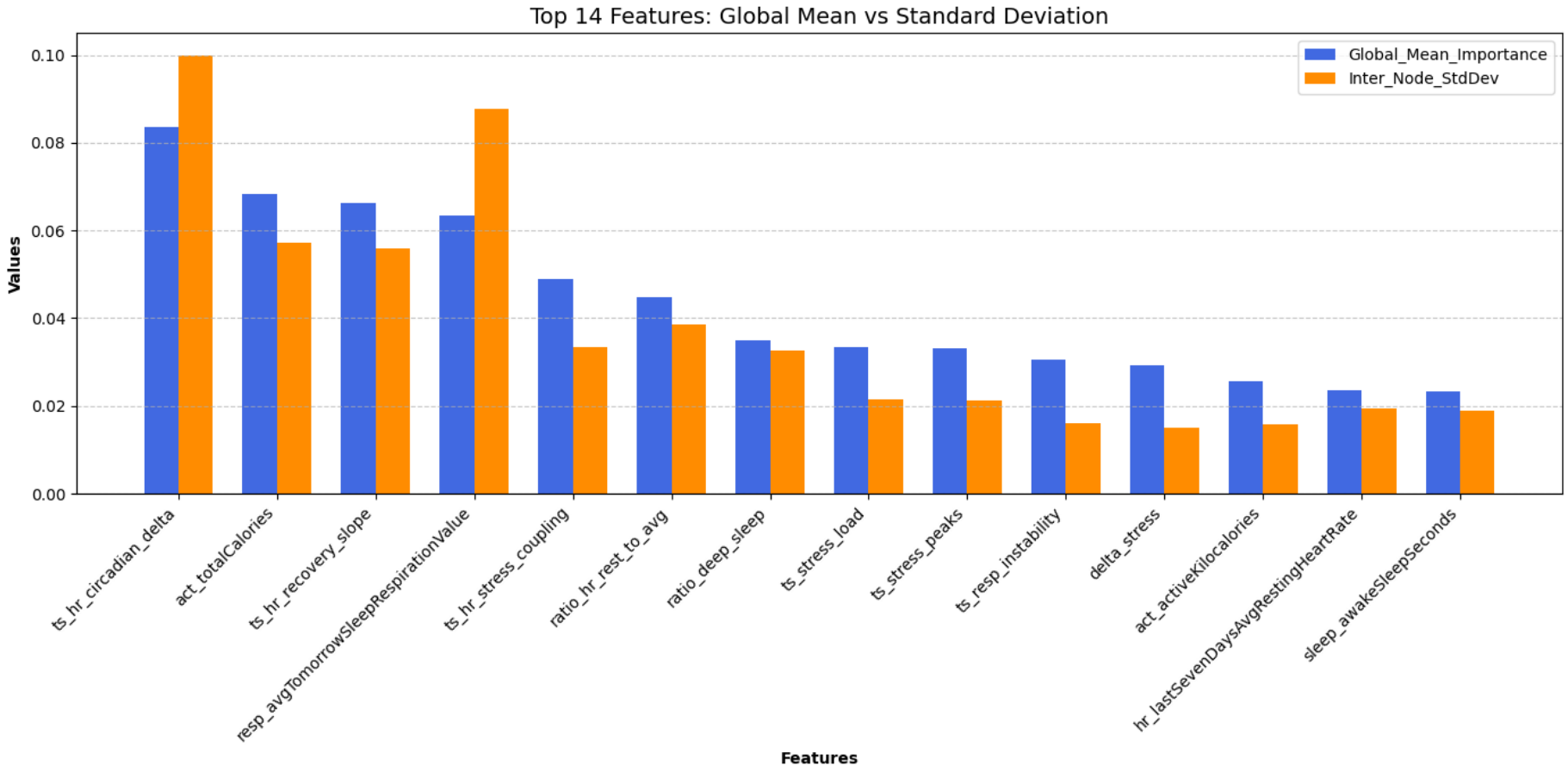


$$\frac{Active\ KCal}{Total\ KCal}$$

Addition of

- **Circardian Features**
- **Early Sleep Quality**
- **LogKCal**
- **Ratios of Existing features**

Random Forest – based Feature Extraction



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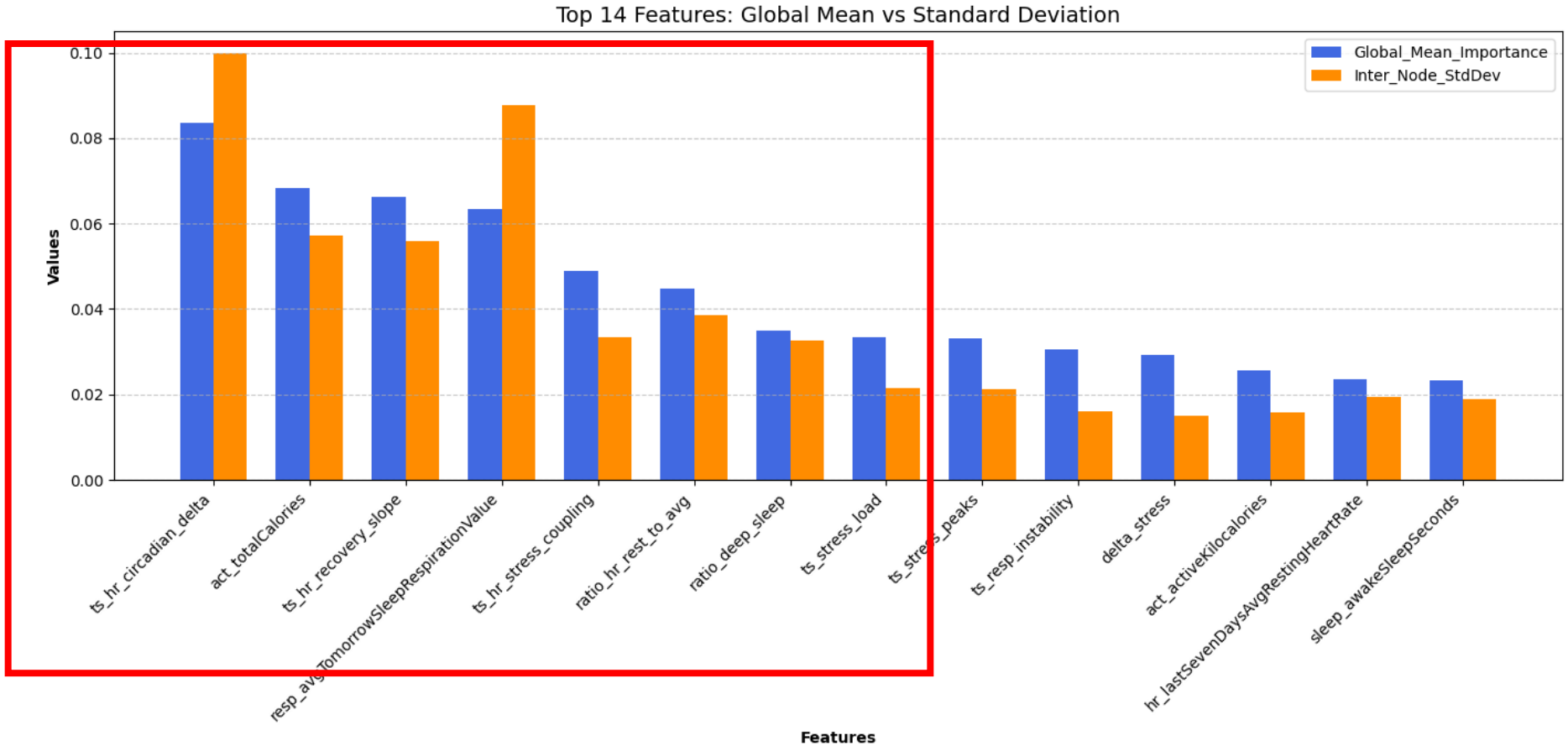
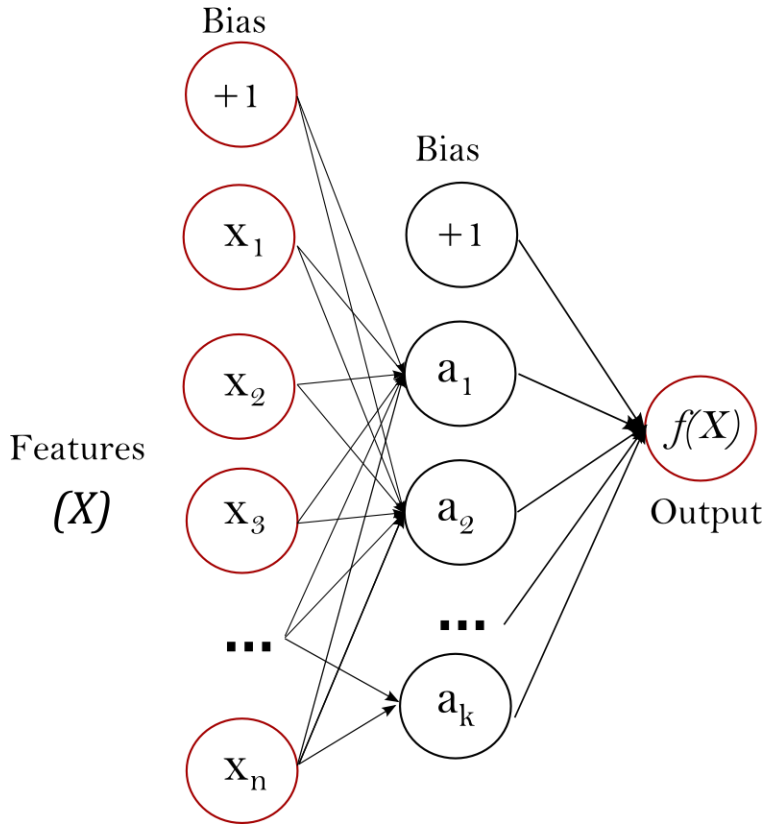


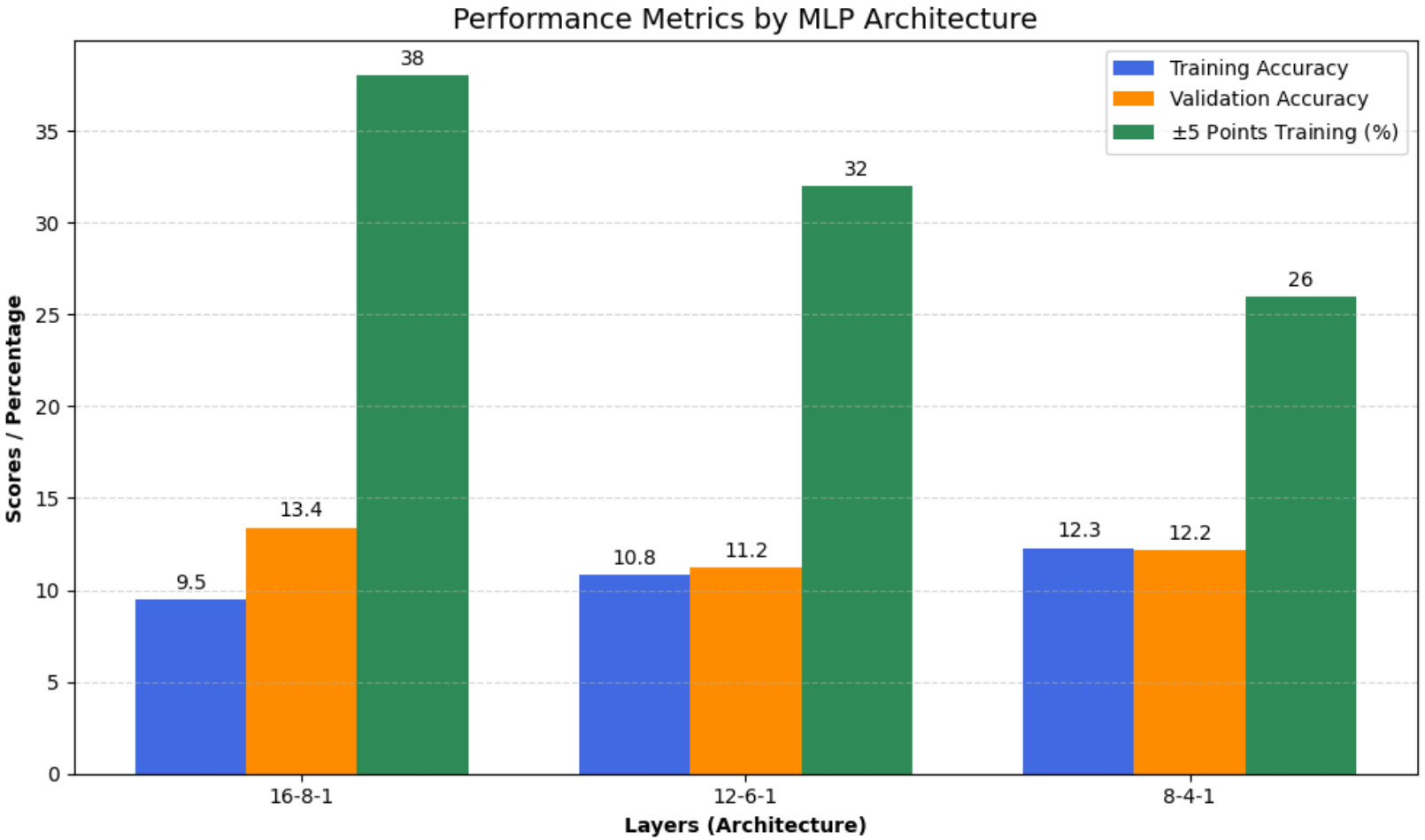
Framework Adopted – Network Architecture

Parameter	Value
Regularization	L2(0.001)
LossFunction	MSE
Batch Size	16
Local Epochs	8
Round	35
Averaging	FedProx



Nodes	**12**	**6**	**1**
Dropout	0.4	0.2	
Activation	Leaky_relu	Leaky_relu	Sigmoid

Results


Performance Metrics by MLP Architecture
Training Accuracy
Validation Accuracy
±5 Points Training (%)
Scores / Percentage
Layers (Architecture)
16-8-1
12-6-1
8-4-1
9.5
13.4
38
10.8
11.2
32
12.3
12.2
26
0
5
10
15
20
25
30
35

Features importance seems to mirror existing literature, with few emerging properties coming from the measurement of stress

Ex Post Literature Review, Considerations and Future Works

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Non IID datasets limits the efficacy of a Model built on all data, pointing to the necessity of user-fine tuning

Variance of Prediction consistently doesn't reflect variance of label in the datasets

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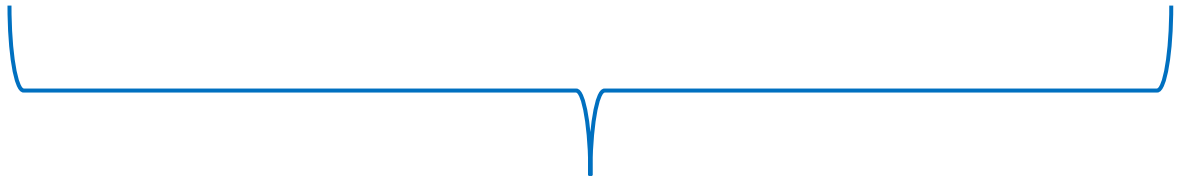

Local / Federated Discrimination to match local / global distribution

Thank You!

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