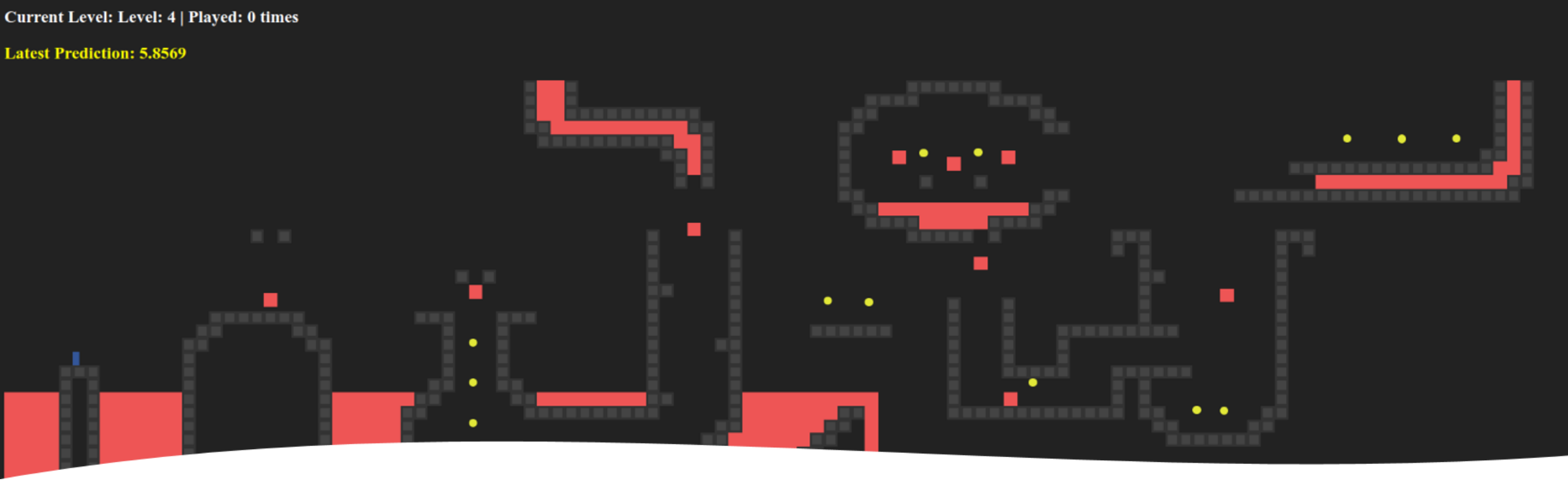


A Game-Based Emo-Arousal Recognition System

GROUP 3

Members: Xiangqi Li, Hongbo Li, Qu Zewen, Wang Yukai, Bai Yuze, Zhang Xiaojing

COMP0053 (2024-25)

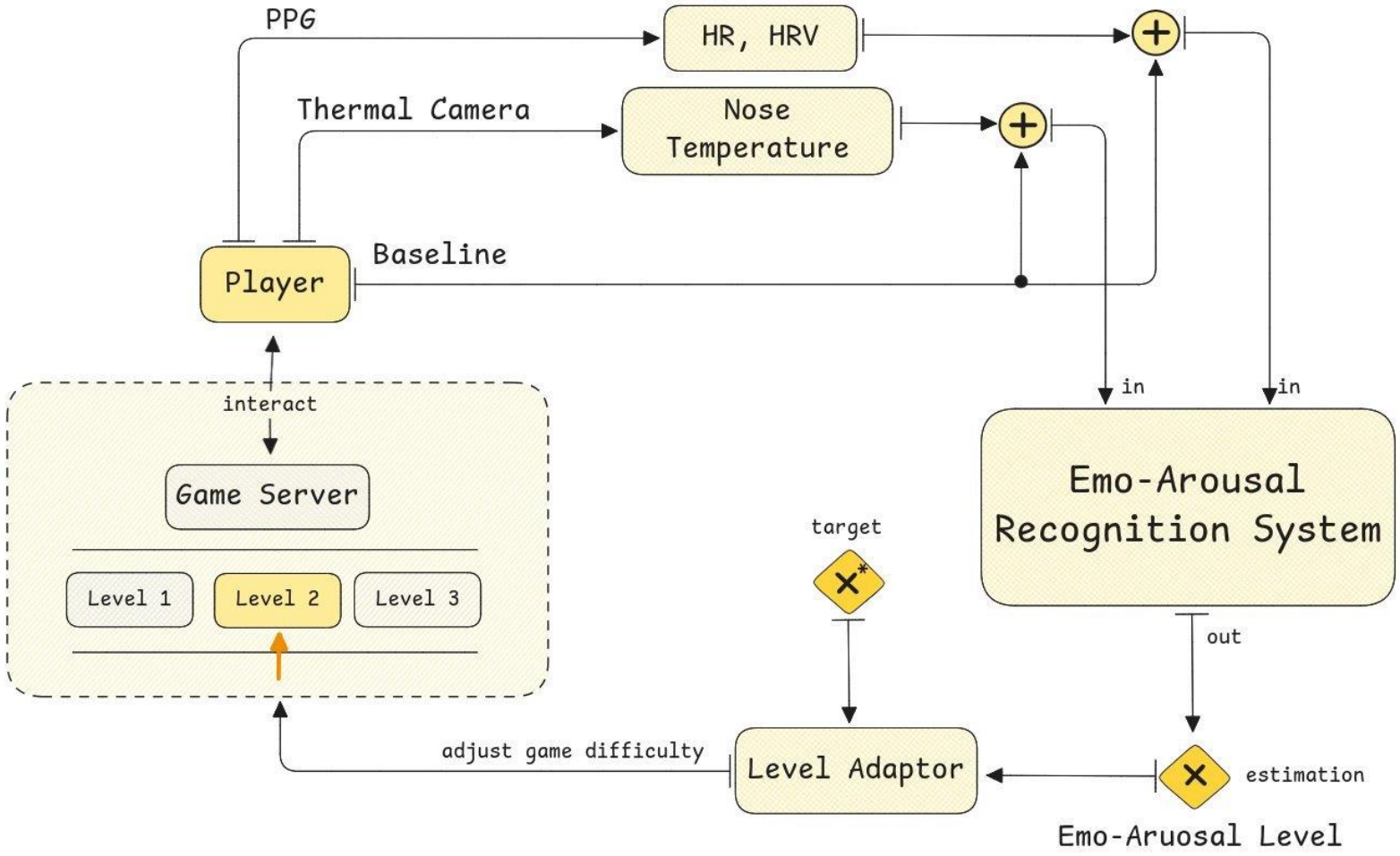
General Idea

We designed an **Emo-Arousal Recognition System**

- estimate user emo-arousal level
- a game-based scenario

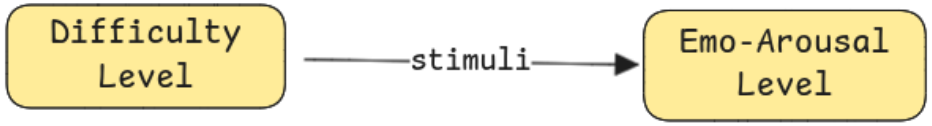
The ultimate goal

- maintain player's emotional arousal level to a target state -- **"focused, active yet not over-stimulated"**
- Proven to be benefitial for gaming experience [1]

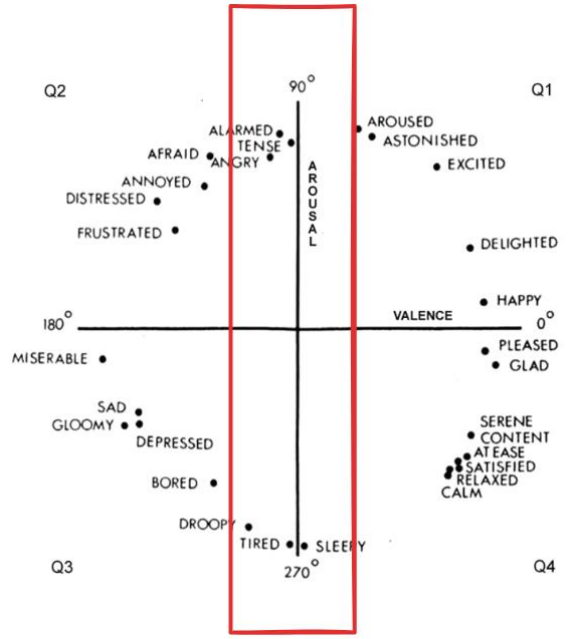


[1] Ninaus, M., Tsarava, K., Moeller, K. (2019). A Pilot Study on the Feasibility of Dynamic Difficulty Adjustment in Game-Based Learning Using Heart-Rate. In: Liapis, A., Yannakakis, G., Gentile, M., Ninaus, M. (eds) Games and Learning Alliance. GALA 2019

Definition of "Emo-Arousal"



- The extend of excitement
  - Proven to be highly relevant with game difficulty [1]
- We referred to the continuous emotion model by James [2]
- We quantified them into ten levels (1~10) and formed a scale
  - Based on work by Bradley et al (1994) [3]



1 - 😑 **Serenity**: Extremely calm, no emotional fluctuations.

2 - 😌 **Calm**: Slightly relaxed, comfortable, and focused.

3 - ☺️ **Relaxed**: Mildly aroused, peaceful mood.

4 - ✍️ **Focused**: Attentive, slight heart rate increase, engaged.

5 - 🔄 **Neutrality**: Active but emotionally neutral.

6 - 🥰 **Active**: Noticeable emotional activation, increased heartbeat.

7 - 😠 **Excited**: Slight excitement, frustration, or mild anger.

8 - 🔥 **Agitated**: Strong externalized emotions, adrenaline increase.

9 - 🚀 **Overstimulated**: On the edge of losing control, strong arousal.

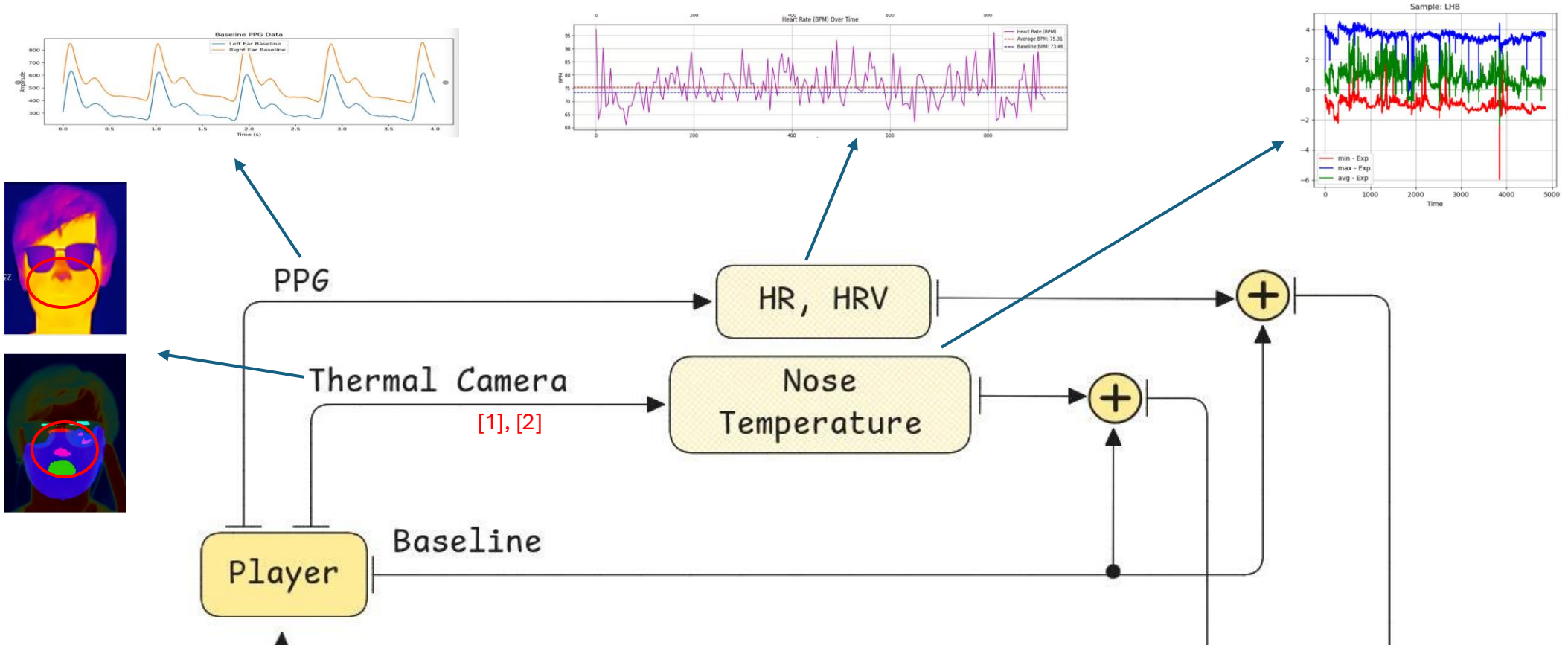
10 - 💣 **Explosive**: Complete emotional outburst, extreme arousal.

Emo-Arousal Rating Scale (EARS)

[1] Larche CJ, Dixon MJ. The relationship between the skill-challenge balance, game expertise, flow and the urge to keep playing complex mobile games. J Behav Addict. 2020 Oct
[2] Russell, James A. "A circumplex model of affect." Journal of personality and social psychology 39.6 (1980):
[3] Margaret M. Bradley, Peter J. Lang, Measuring emotion: The self-assessment manikin and the semantic differential, Journal of Behavior Therapy and Experimental Psychiatry, Volume 25, Issue 1, 1994

Data Collection

- **Sensors & Modalities**: PPG (heart rate, HRV, etc.), thermal camera (nose temperature)
- **Collection Plan**: baseline data (1 min), during the game (15 min)



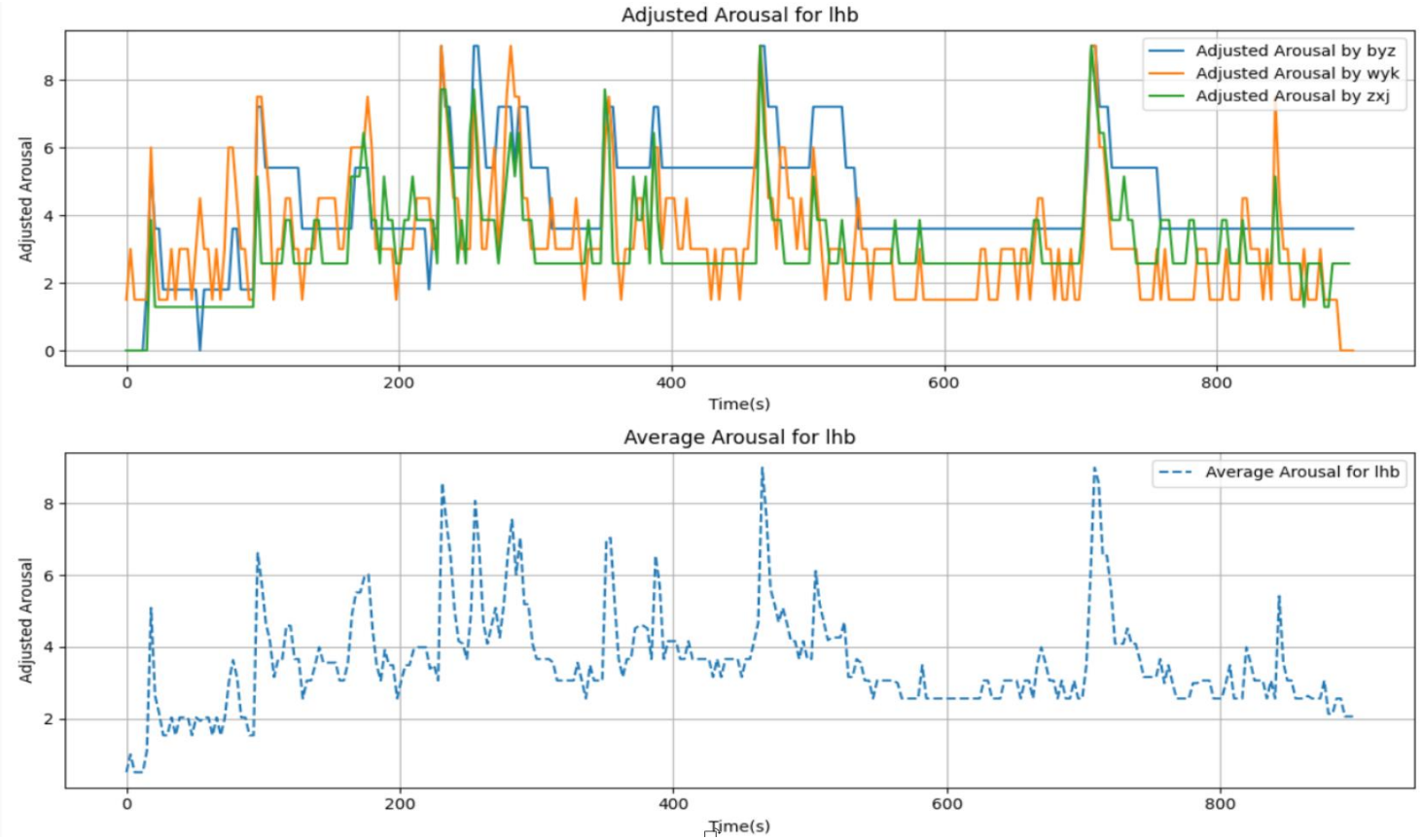
[1] Jitesh N Joshi, Nadia Berthouze, & Youngjun Cho (2022). Self-adversarial Multi-scale Contrastive Learning for Semantic Segmentation of Thermal Facial Images. In *33rd British Machine Vision Conference 2022, BMVC 2022, London, UK, November 21-24, 2022*. BMVA Press.

[2] GitHub: https://github.com/PhysiologicAILab/TC001_SAMCL

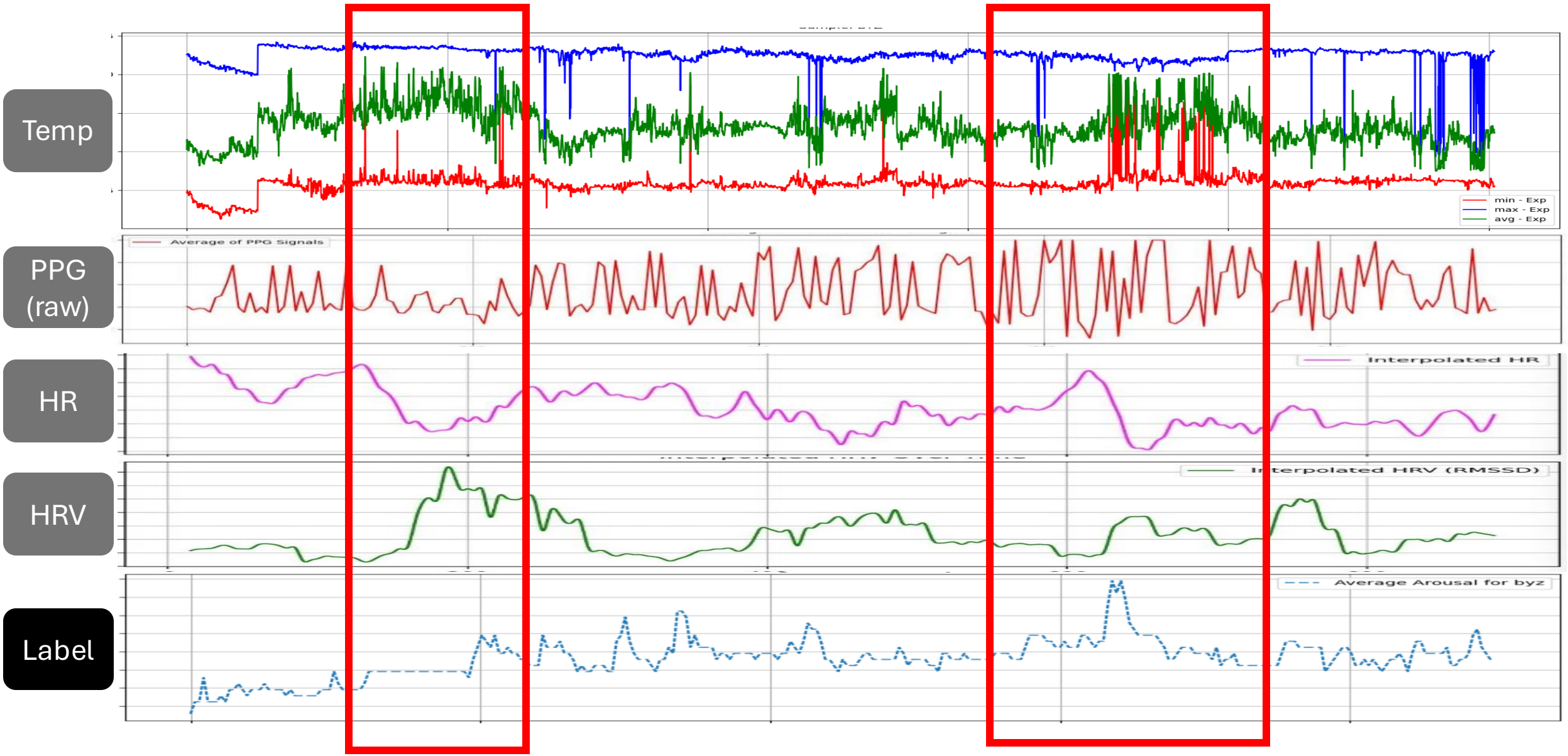
Labelling

- **Rating Material: RGB video of player's facial expression**
- **Rating Scale: EARS**
- **Rating Rule:** Three raters for each player, then take the average
  - 3 sec per label, interpolate into 1 sec

Rater 1	3	6	9
Rater 2	3	5	10
Rater 3	4	7	9



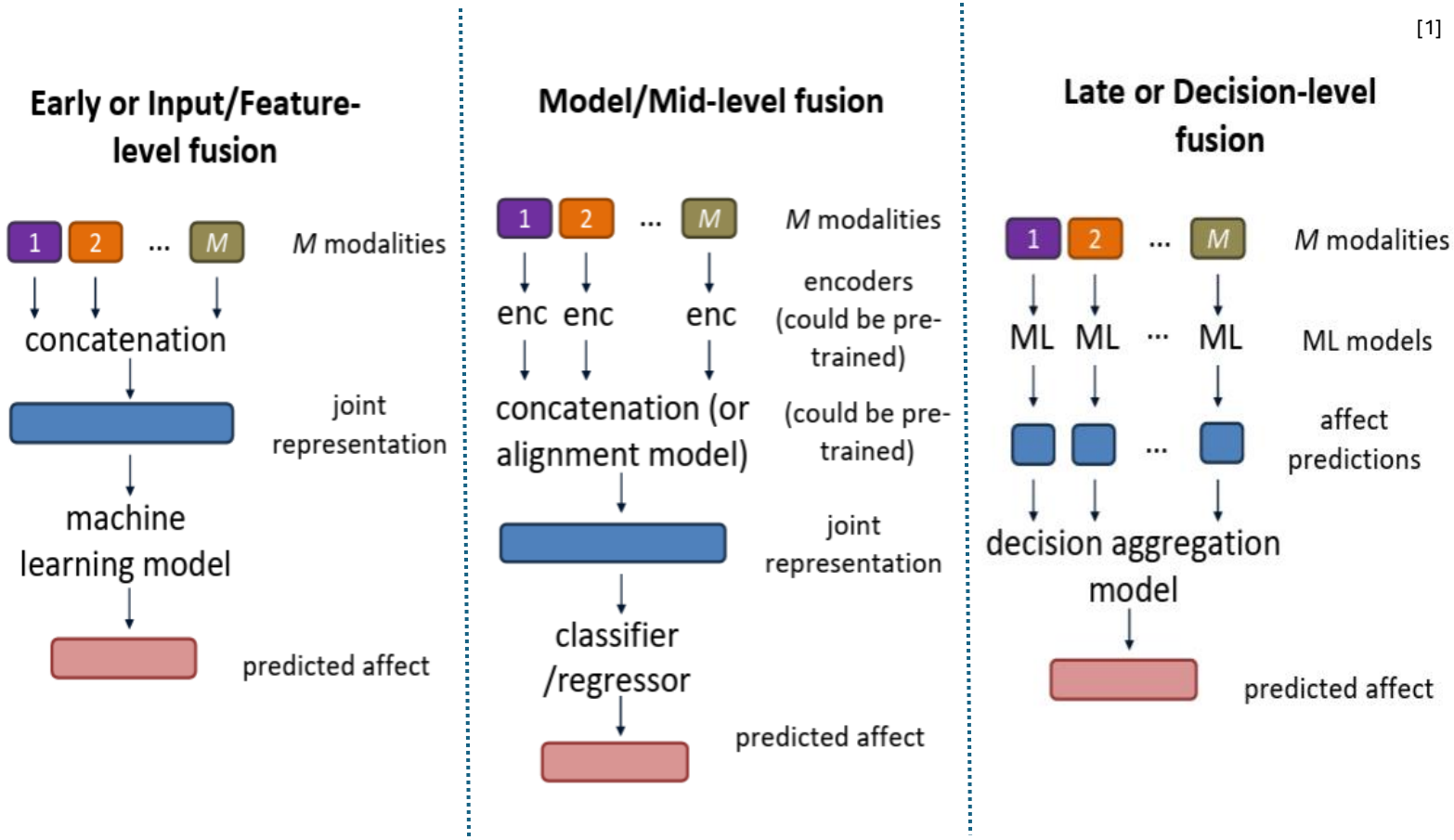
Sensed data vs Labels analysis



Data modelling

- used our own dataset
- three pipeline for early, mid and late fusion.
- The aim is to use the **ML-based models** to estimate the player's emo-arousal level (from 1~10).

[1]



[1] Lecture 7 Slides

Data Structures

Early Fusion – 31 [2][3]

PPG RAW Data → Neurokit2 Extraction[1] → Heart Rate Data

PPG RAW Data: A0, A1

Heart Rate Data: HR, HRV

A0 / A1:
- Min
- Max
- Average
- Std Dev
- Median
- Peak-to-Peak
- Frequency Domain
- Skewness
- Kurtosis

2 x 9=18

HR / HRV:
- Min
- Max
- Average
- Std Dev
- Changing Rate

2 x 5=10

Temperature Data:
- Average
- Std Dev
- Changing Rate

3

Mid & Late Fusion

PPG RAW Data → Neurokit2 extraction → Heart Rate Data

PPG RAW Data: A0, A1

Raw Data **[250,2]**

Heart Rate Data: HR, HRV

Raw Data **[50,2]**

Temperature Data:
- Min
- Max
- Avg
- Min Changing Rate
- Max Changing Rate
- Avg Changing Rate

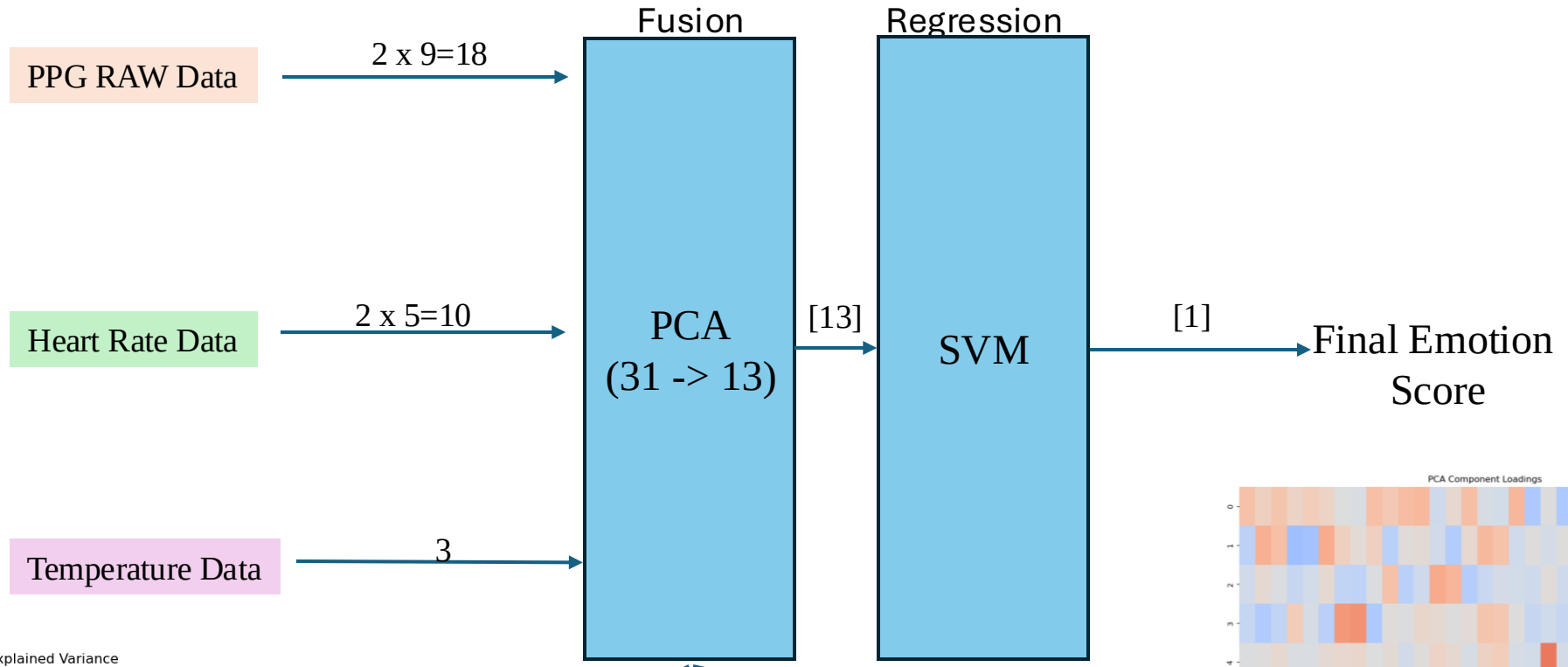
[6,6]

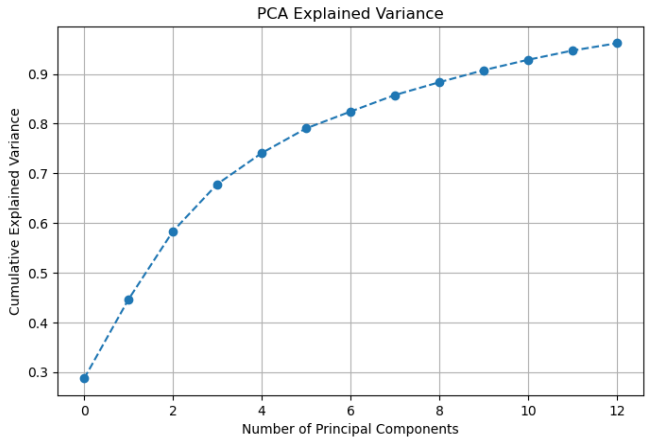
[1] https://neuropsychology.github.io/NeuroKit/examples/ecg_heartbeats/ecg_heartbeats.htm‘

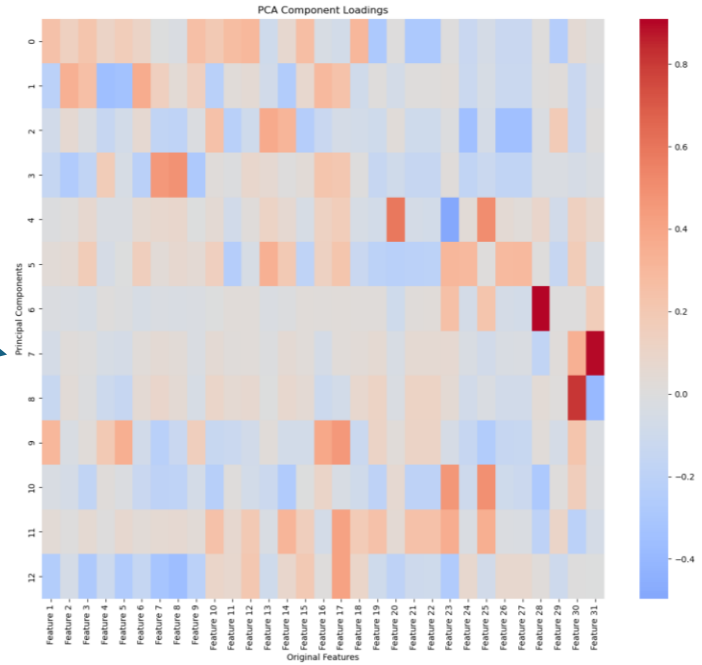
{2l Zhu X, He Z, Wang C, Dai Z, Zhao L. A Learning Emotion Recognition Model Based on Feature Fusion of Photoplethysmography and Video Signal. *Applied Sciences*. 2024; 14(24):11594. https://doi.org/10.3390/app142411594

[3] Ma G, Zhang J, Liu J, Wang L, Yu Y. A Multi-Parameter Fusion Method for Cuffless Continuous Blood Pressure Estimation Based on Electrocardiogram and Photoplethysmogram. Micromachines (Basel). 2023;14(4):804. Published 2023 Mar 31. doi:10.3390/mi14040804

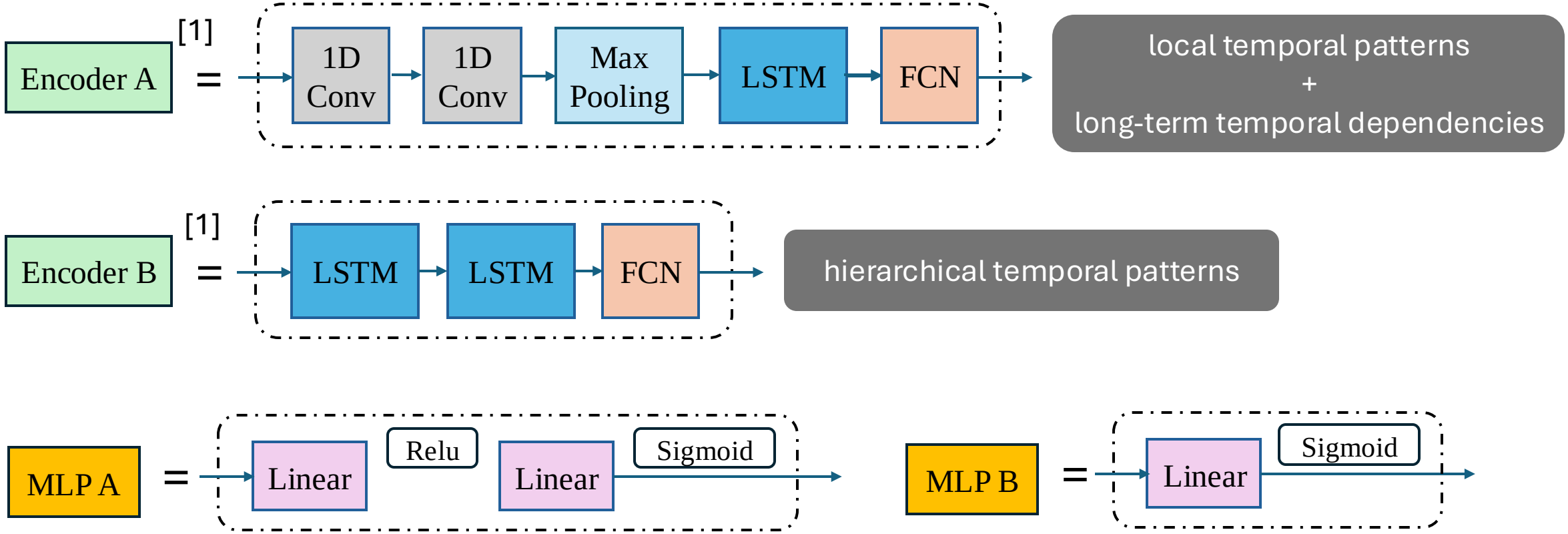
Early Fusion





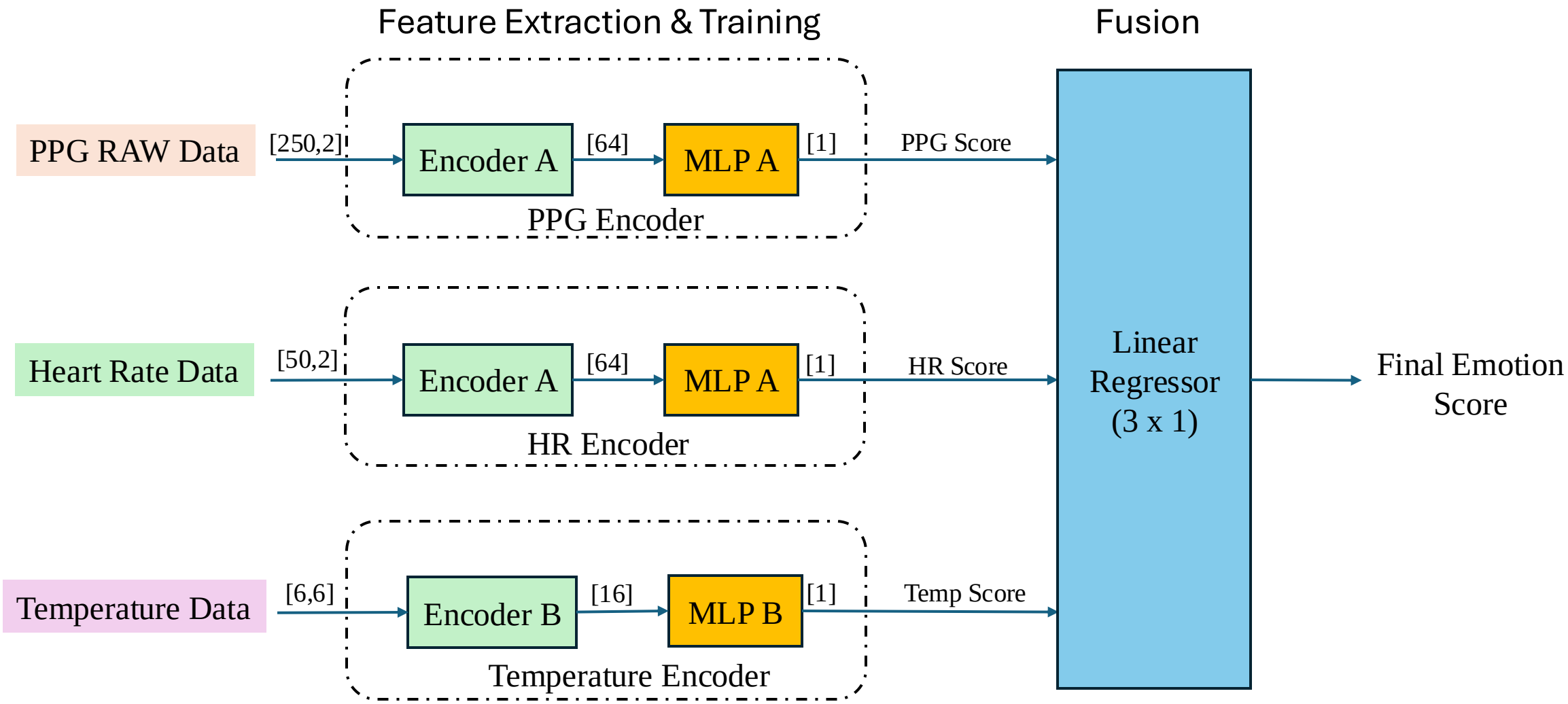


Key Components

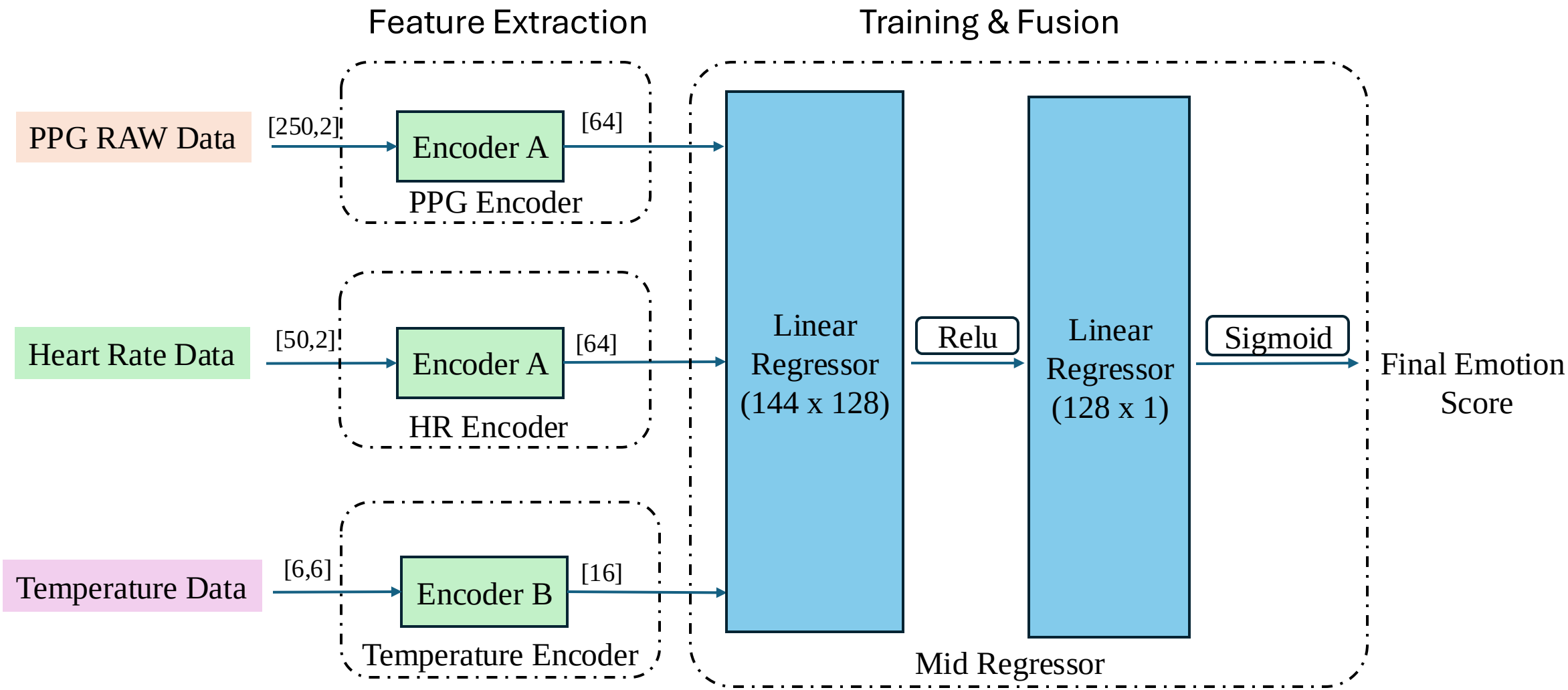


[1] Singh H, Warnecke JM, Picker A, Ganapathy N, Deserno TM. Multimodal Signal Fusion for Heartbeat Monitoring on eScooters. Stud Health Technol Inform. 2024;316:973-977.
doi:10.3233/SHTI240573

Late Fusion


Feature Extraction & Training
Fusion
PPG RAW Data
[250,2]
Encoder A
[64]
MLP A
[1]
PPG Score
PPG Encoder
Heart Rate Data
[50,2]
Encoder A
[64]
MLP A
[1]
HR Score
HR Encoder
Linear Regressor (3 x 1)
Final Emotion Score
Temperature Data
[6,6]
Encoder B
[16]
MLP B
[1]
Temp Score
Temperature Encoder

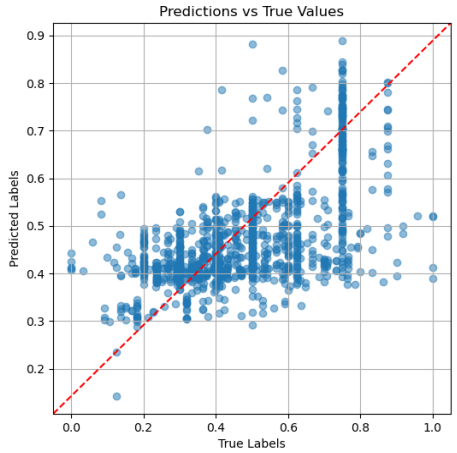
Mid Fusion


Feature Extraction
Training & Fusion
PPG RAW Data
[250,2]
Encoder A
[64]
PPG Encoder
Heart Rate Data
[50,2]
Encoder A
[64]
HR Encoder
Temperature Data
[6,6]
Encoder B
[16]
Temperature Encoder
Linear Regressor (144 x 128)
Relu
Linear Regressor (128 x 1)
Sigmoid
Final Emotion Score
Mid Regressor

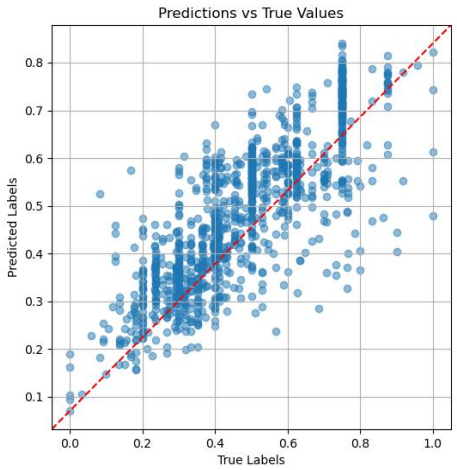
Results: Different Fusion Comparison

Early

Test MSE	0.0248
Test RMSE	0.1574
Test MAE	0.1221
Test R-Square	**0.3333**

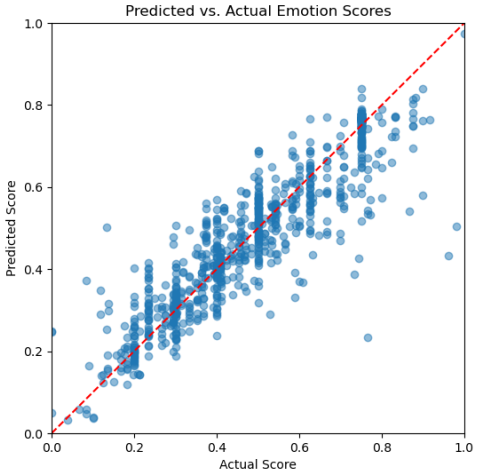


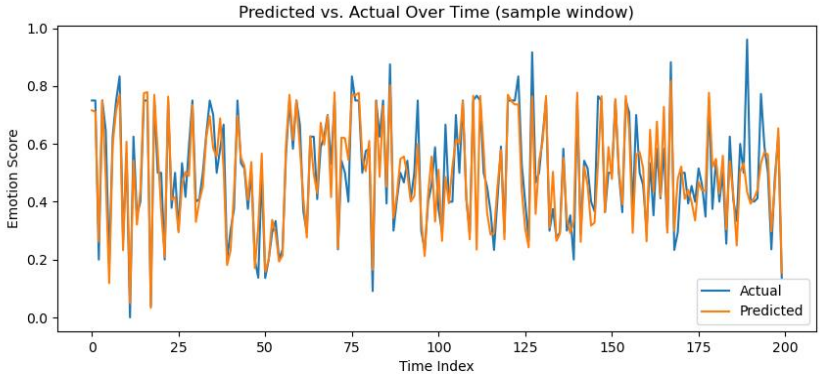
Test MSE	0.0132
Test RMSE	0.1148
Test MAE	0.0851
Test R-Square	**0.6453**



Middle

Test MSE	0.0071
Test RMSE	0.0841
Test MAE	0.0571
Test R-Square	**0.8206**





Late

Test MSE	0.0094
Test RMSE	0.0967
Test MAE	0.0685
Test R-Square	**0.7569**