

HOLISTIC SEMI-SUPERVISED APPROACHES FOR EEG REPRESENTATION LEARNING

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Problem Statement

Data:

- Electroencephalogram (EEG)

Challenge:

- Obtaining reliable EEG labels is time demanding and often required experts
- The model's performance often degrades without enough labeled training data

Goal:

- Adapt state-of-the-art semi-supervised learning (SSL) methods for EEG representation learning

Methods:

- MixMatch (NeurIPS 2019), FixMatch (NeurIPS 2020) and AdaMatch (ICLR 2022)

Datasets

SEED dataset:

- Publicly available in <https://bcmi.sjtu.edu.cn/~seed/downloads.html#seed-access-anchor>
- Total of 15 subjects participated in the experiments
- 15 film clips were selected as stimuli
- Three emotion categories: positive, neutral and negative

SEED-IV dataset:

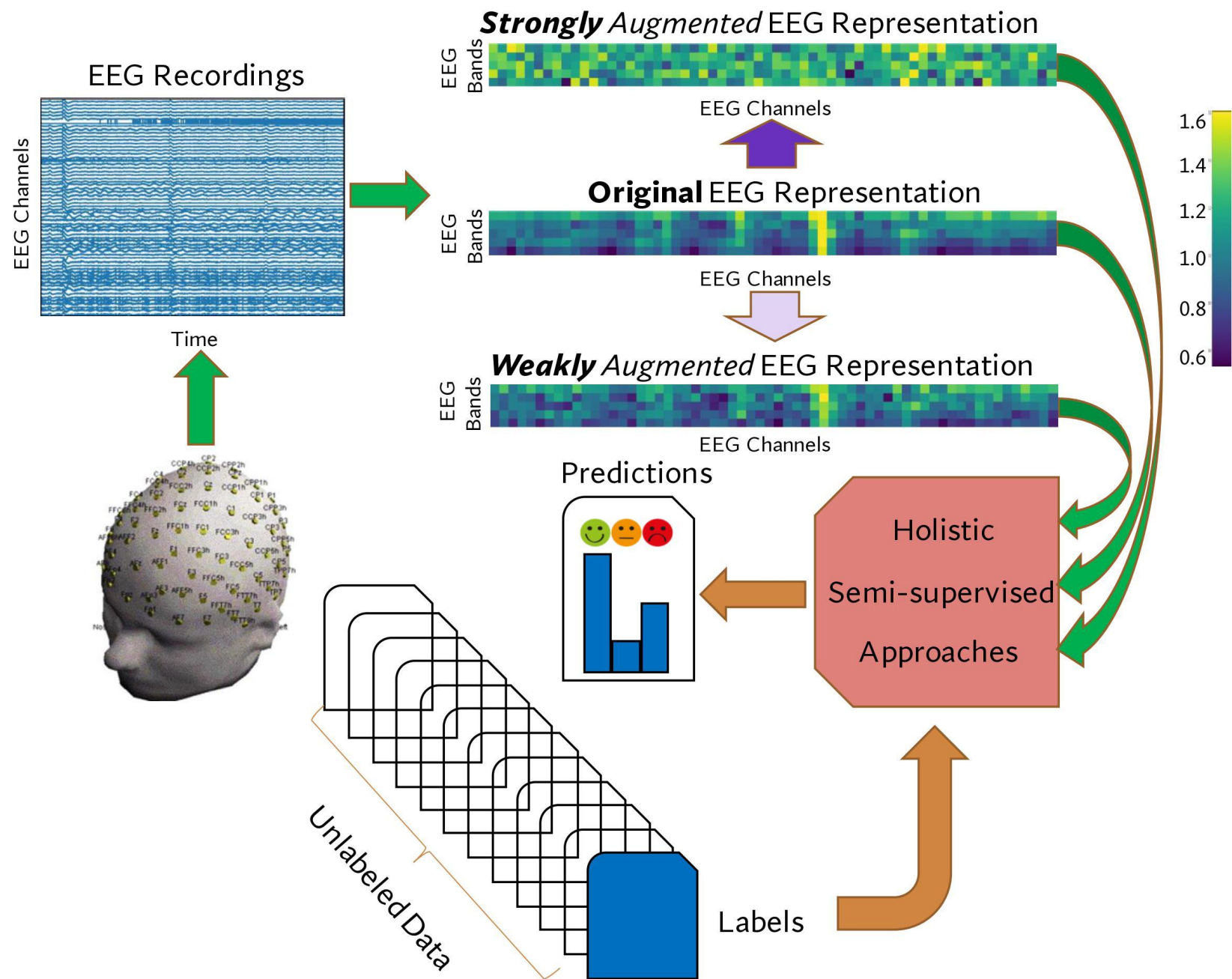
- Publicly available in <https://bcmi.sjtu.edu.cn/~seed/downloads.html#seed-iv-access-anchor>
- Total of 15 subjects participated in the experiments
- 72 film clips were selected as stimuli
- Four emotion categories: happy, sad, neutral and fear

Data Preparation

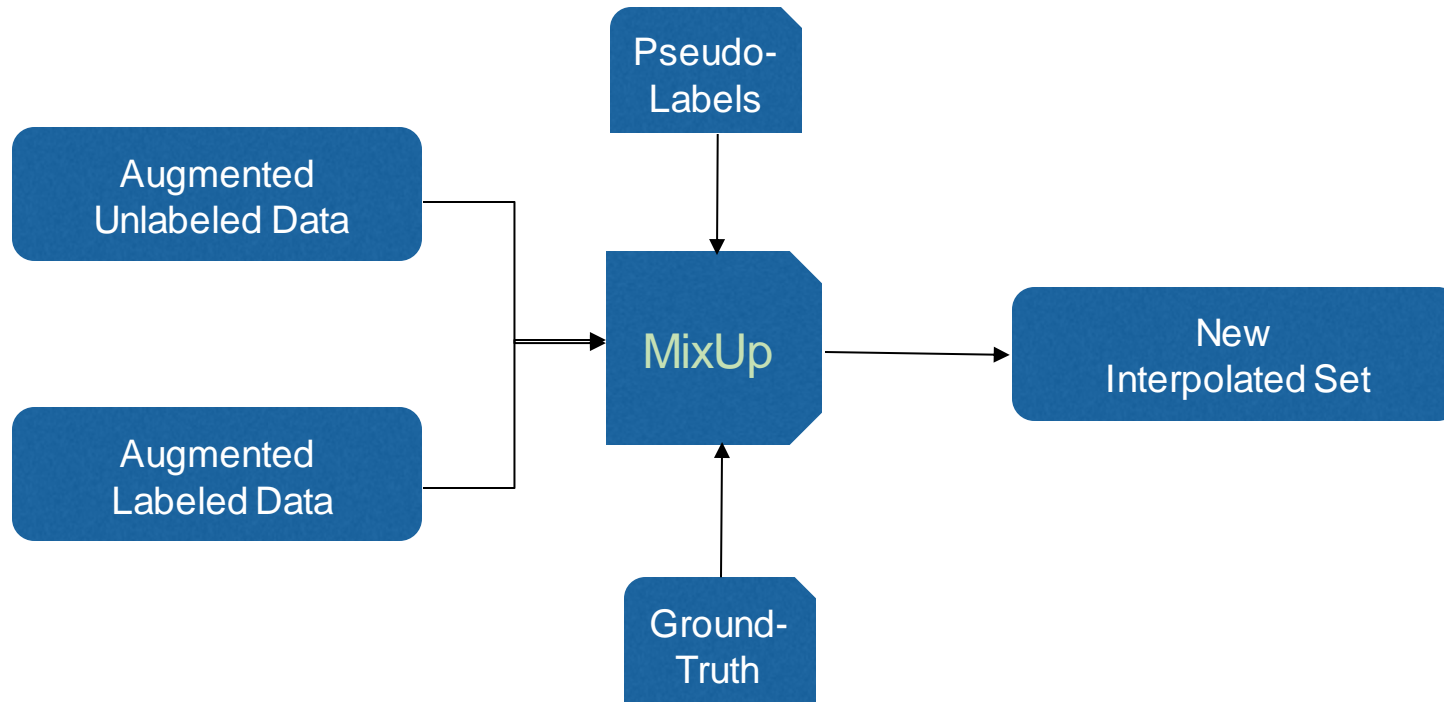
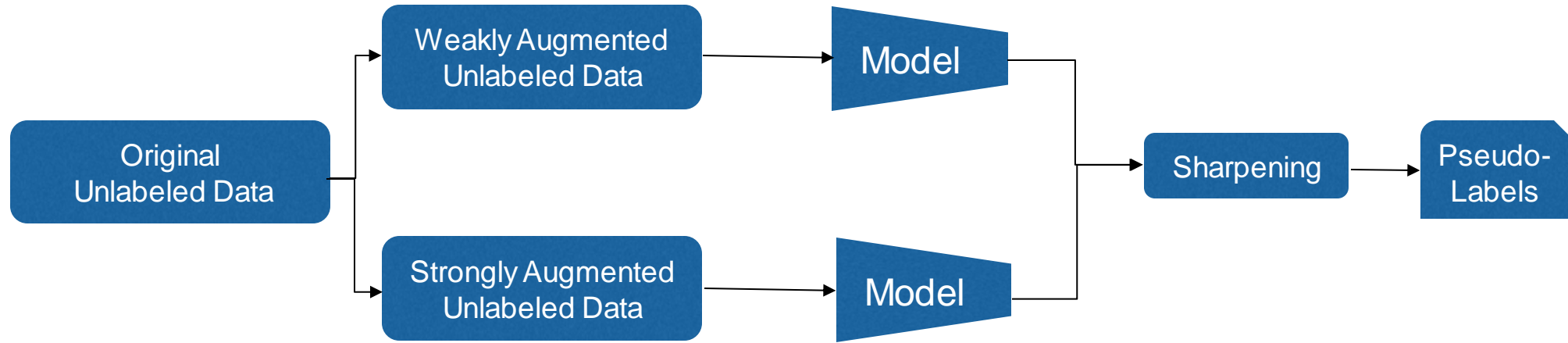
- Preprocessing:
 - Downsample from 1000Hz to 200Hz
 - Reduce noise and artefact by applying band-pass filter within [0.5-70Hz]
 - Minimize power line effect using notch filter at 50Hz
- Feature Extraction:
 - Different Entropy
 - Assume signal obeying Gaussian distribution

$$\mathbf{DE} = - \int_{-\infty}^{\infty} \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right) \ln\left(\frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)\right) dx = \frac{1}{2} \ln 2\pi e\sigma^2$$

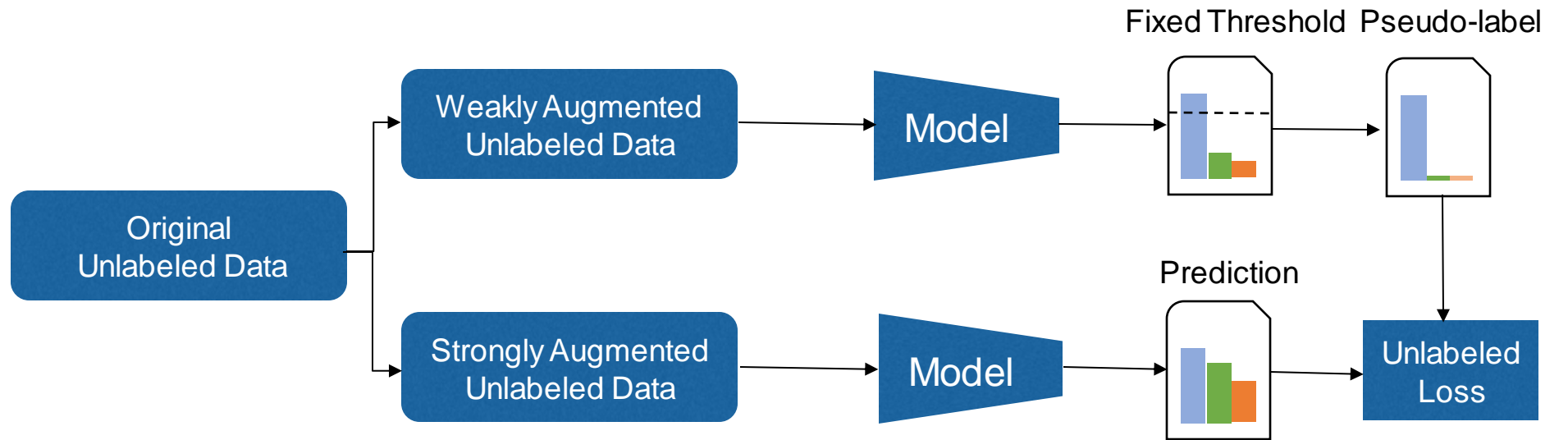
Our SSL Training Phase



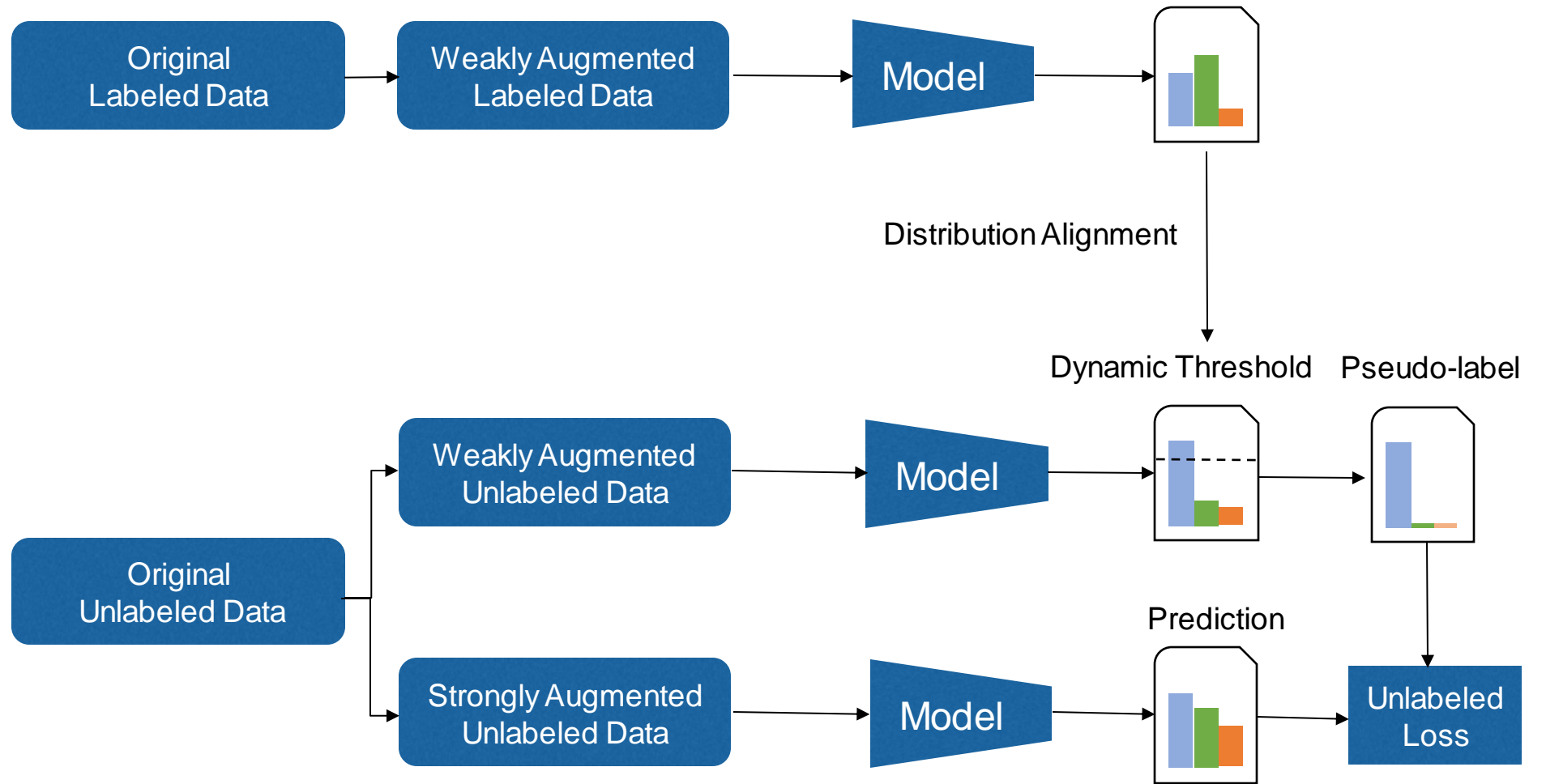
MixMatch



FixMatch



AdaMatch

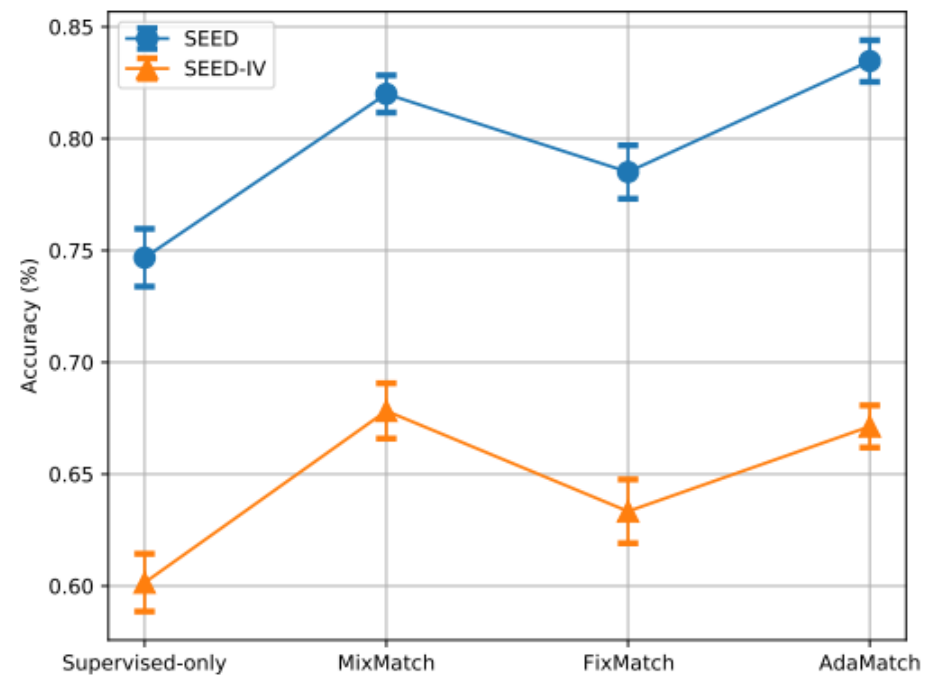


Results

Table 1. The performance of holistic approaches in comparison to other semi-supervised methods on SEED and SEED-IV.



Method / m	SEED						SEED-IV					
	1 label	3 labels	5 labels	7 labels	10 labels	25 labels	1 label	3 labels	5 labels	7 labels	10 labels	25 labels
Π -model	60.25 (9.57)	67.87(10.14)	72.43(11.32)	74.94(10.84)	76.35(10.93)	77.87(10.88)	49.93(12.30)	54.65(14.66)	57.65(14.36)	58.79(14.77)	60.14(15.14)	61.92(15.30)
Temporal Ens.	59.22 (9.02)	69.95 (9.07)	73.80 (9.78)	77.15 (9.57)	79.80 (9.53)	83.83 (8.73)	52.76(13.15)	59.76(14.48)	63.00(14.35)	65.26(14.07)	65.92(13.71)	67.25(13.63)
Mean Teacher	53.97 (8.24)	62.75 (9.98)	66.42 (9.46)	69.90(11.32)	71.48 (8.98)	77.09 (9.66)	47.03(11.84)	51.56(12.35)	55.05(13.27)	56.60(12.91)	56.66(11.78)	57.97(13.00)
Conv. AutoEnc.	71.39(12.20)	80.03(11.69)	82.86(10.89)	84.74 (9.70)	85.46 (9.77)	87.34 (8.96)	53.19(18.58)	59.52(18.13)	63.01(16.74)	64.83(15.75)	66.40(17.26)	65.96(16.62)
Pseudo-Label	68.02(13.20)	78.11(12.02)	79.57(10.78)	82.21(11.03)	84.11 (9.79)	85.32 (9.38)	52.31(17.93)	58.08(16.76)	60.36(17.92)	60.84(17.59)	62.13(19.03)	62.71(18.36)
MixMatch	68.97(13.93)	80.89(12.80)	83.94(10.30)	85.46 (9.64)	85.84 (9.24)	86.88 (8.78)	56.08(15.92)	65.03(15.79)	69.42(16.31)	70.92(16.02)	72.31(16.27)	73.20(15.19)
FixMatch	66.36(13.84)	76.26(11.56)	79.04(10.68)	81.79(10.56)	83.14 (9.98)	84.44 (9.09)	53.37(17.33)	63.57(15.57)	63.43(16.26)	64.62(15.57)	66.50(15.91)	68.54(15.58)
AdaMatch	74.03(11.78)	82.59(10.26)	83.62(10.84)	85.84 (9.69)	86.71 (9.09)	88.02 (8.80)	58.30(15.95)	66.52(16.58)	69.12(16.45)	68.11(15.80)	69.31(16.87)	71.43(16.04)

Analysis



Thank you!

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