Self-supervised learning for time series

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Motivation

- Time series everywhere
 - Medical data such as: ECG, EMG, EEG
 - Stock market
 - Boring and drill failure
- ► A lot of data (mostly unlabeled)
- Self-supervised learning
- Foundation model for time-series

Introduction

- Zhang et al: Pre-training method for time series datasets
- ► Merging multiple dataset for pre-train failed
- ▶ Investigate the reasons behind this phenomena

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Thank you for your

Time-Frequency Consistency framework [2]

- Zhang et al: Pre-training method for time series datasets
- Uses Fourier-transform
- Method:
 - ► Embedding from Time-series: Time domain
 - ▶ Embedding from Fourier transform: Frequency domain
 - Cast both into a common domain: Time-Frequency domain

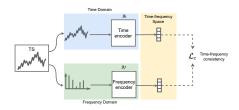


Figure: TFC contrastive learning [2]

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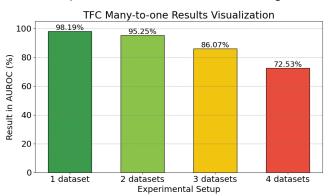
TFC results

- ► Testing embedding quality:
 - 1. Pre-train on one dataset
 - 2. Fine-tune on a different dataset
- Results:

One-to-one: successOne-to-many: success

► Many-to-one: fail

► More pre-train dataset → Worse fine-tuning



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► Why does combining multiple pre-training datasets hurt performance in TFC fine-tuning?

- ▶ Unusal in machine learning (more data is better)
- Interesting implications for time-series domain
- ▶ It this specific for dataset composition?

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Methodology

- Mixup augmentation
 - For data points x_i , x_j and their respective labels y_i , y_j
 - Augmented data point (\hat{x}, \hat{y}) :

$$\hat{x} = \lambda \cdot x_i + (1 - \lambda) \cdot x_j$$
$$\hat{x} = \lambda \cdot y_i + (1 - \lambda) \cdot y_i,$$

where $\lambda \in Beta(\alpha)$, and α is a fixed.

- Adding fine-tuning dataset to pre-train dataset
- (Never Train from Scratch: Fair Comparison of Long-Sequence Models Requires Data-Driven Priors, ICLR 2024) [1]

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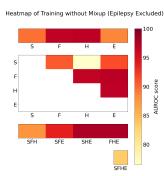
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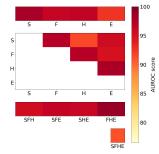
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Experiments and results 1.



Heatmap of Training with Mixup (Epilepsy Excluded)



Dataset abbreviations: S = SleepEEG; F = FD_A; H = HAR; E = ECG

(a) No mixup, Epilepsy excluded from pre-train

Dataset abbreviations: S = SleepEEG; $F = FD_A$; H = HAR; E = ECG

(b) Using mixup, Epilepsy excluded from pre-train

Figure: No matter the pre-train dataset composition, using mixup yields success.

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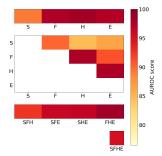
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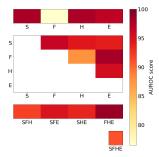
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Experiments and results 2.





Heatmap of Training with Mixup (Epilepsy Included)



Dataset abbreviations: S = SleepEEG; $F = FD_A$; H = HAR; E = ECG

Dataset abbreviations: S = SleepEEG; F = FD_A; H = HAR; E = ECG

(a) No mixup, Epilepsy included in pre-train

(b) Using mixup, Epilepsy included in pre-train

Figure: Adding the target dataset to pre-training.

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Thank you for your

- Mixup achieves improvement
- Adding fine-tune to pre-train: doesn't achieve considerable improvement
- Future research:
 - Repeat the experiment
 - Other augmentation techniques
 - ► A plot comparing dataset similarity and fine-tune AUC
 - Loss function expansion
 - New networks

Thank you for your attention!

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