Semi-supervised Time Series Classification By Temporal Relation Prediction

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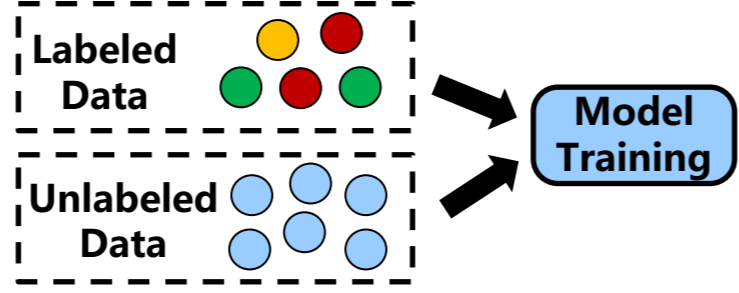
SemiTime: Semi-supervised learning on time series

Semi-supervised learning (SSL) aims at using both labeled and unlabeled data during model training to boost the performance of model.

Notations

$t_i = (t_{(i,1)}, \ldots t_{(i,T)})$: time series

$\mathcal{D}_L$: Labeled training set

$\mathcal{D}_U$: Unlabeled training set

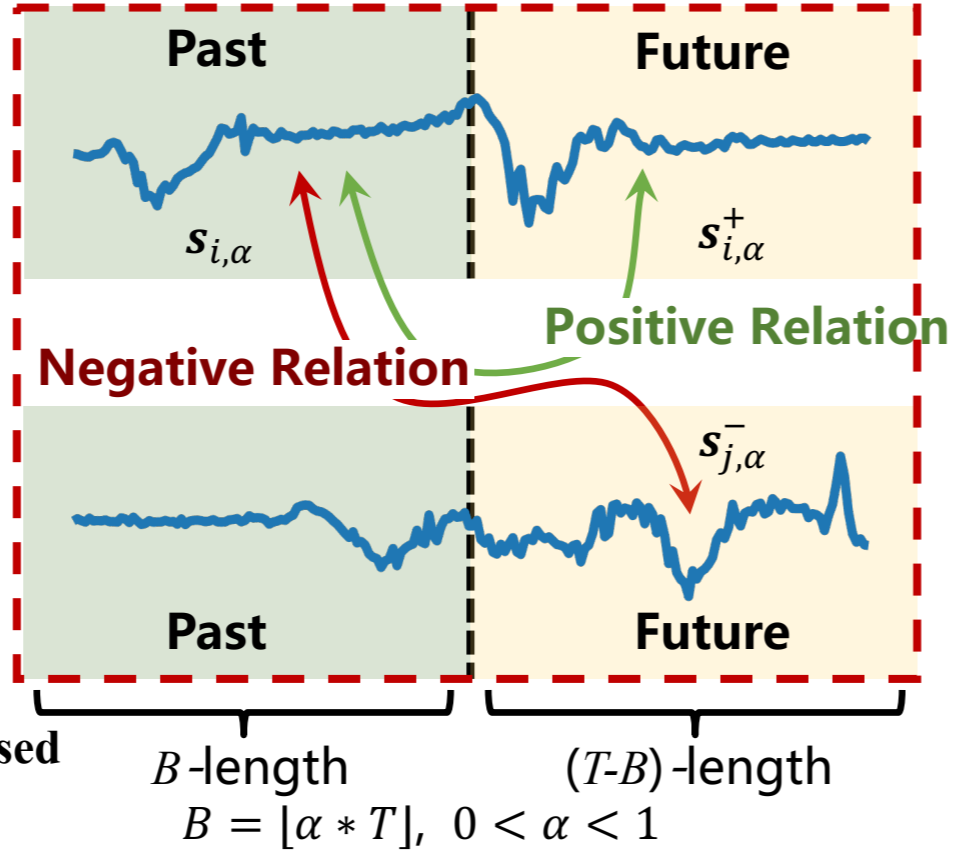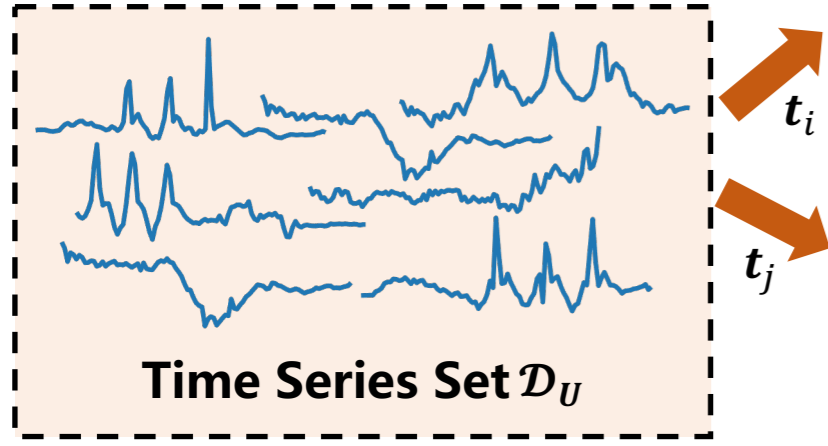α: Past-future segment split ratio

Fig. 1. Schematic illustration of the proposed temporal relational segment sampling.
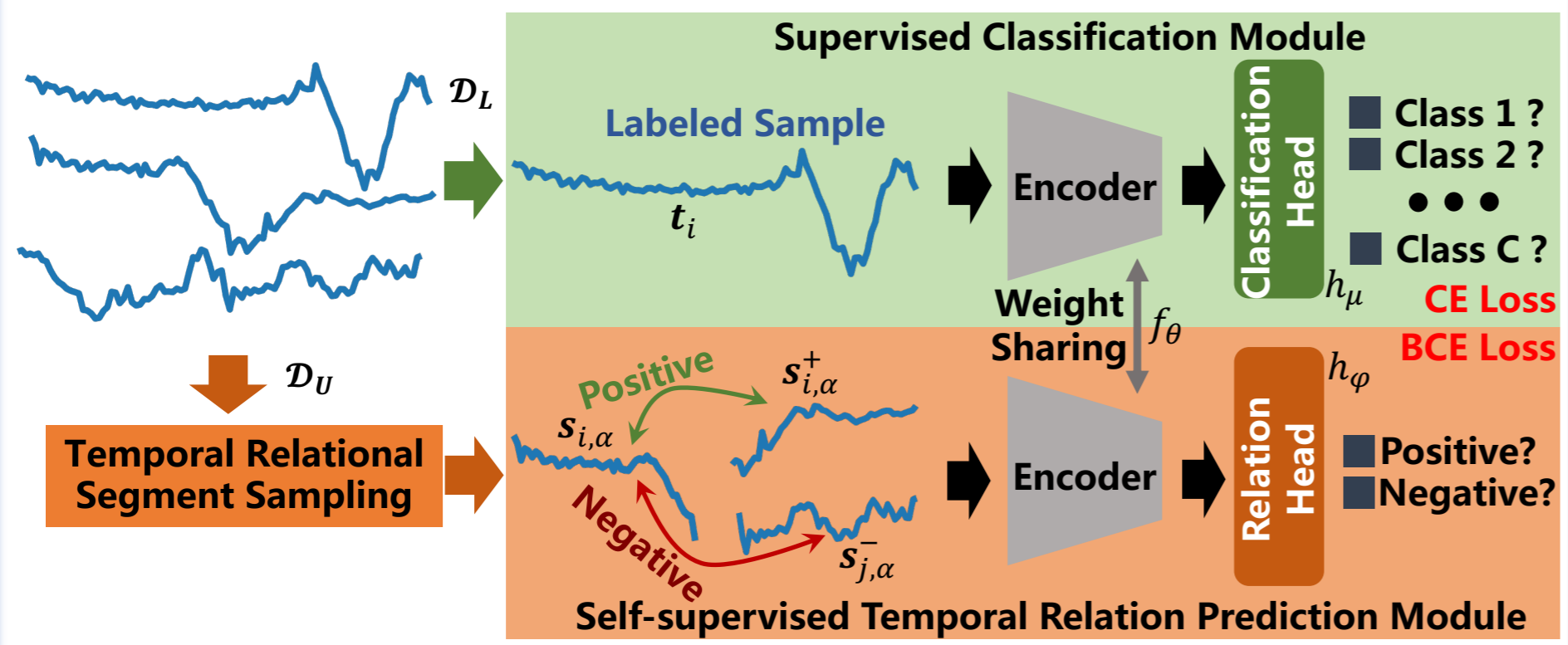
B-length $(T\text{-}B)$-length

$B = \lfloor \alpha * T \rfloor, \ 0 < \alpha < 1$

Fig. 2. Architecture of SemiTime.

Experimental results

Table 1. Statistics of Datasets.

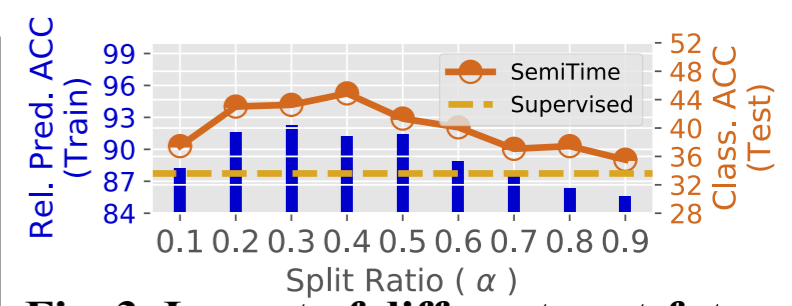| Dataset	Sample	Length	Class
CricketX	780	300	12
XJTU	1920	1024	15
InsectWingbeatSound	2200	256	11
MFPT	2574	1024	15
UWaveGestureLibraryAll	4478	945	8
EpilepticSeizure	11500	178	5

Fig. 3. Impact of different past-future segment split ratios on CricketX.

Table 2. Test classification accuracy (%, averages of 10 runs) for supervised baseline and semi-supervised learning on different datasets. All methods use the same 4-layer convolutional backbone. Best results are marked in red and the second-best in blue.

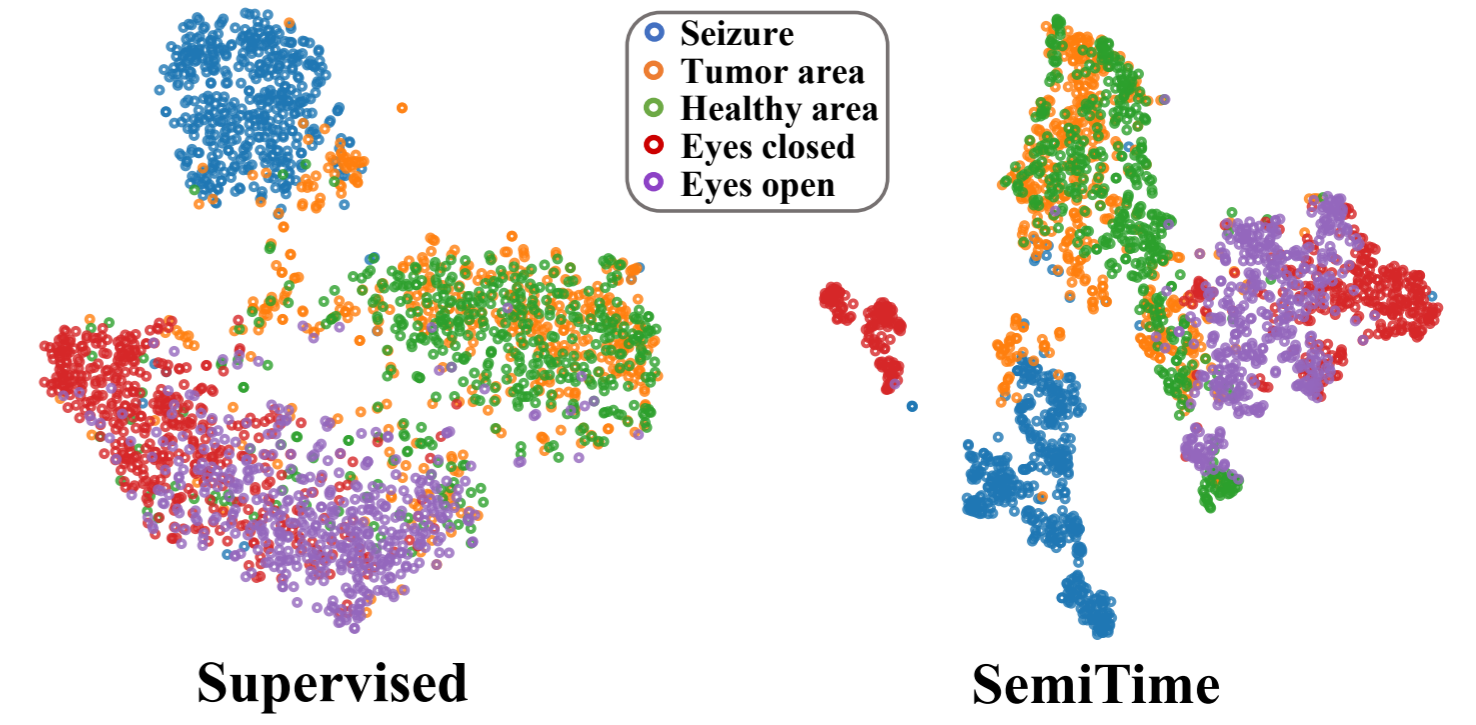| Label Ratio	10%	20%	40%	100%	10%	20%	40%	100%
Dataset	CricketX				XJTU			
Supervised	33.62±0.95	38.79±2.08	52.64±2.53	62.98±2.01	69.71±1.96	83.32±1.59	94.03±1.56	97.92±0.61
Pseudo-Label	38.87±2.26	44.44±2.91	53.39±2.18	-	74.88±2.78	85.19±1.82	93.97±2.79	-
Π-Model	38.61±2.29	48.18±2.07	54.73±1.04	-	75.96±0.52	85.93±0.91	95.03±1.34	-
MTL	40.94±1.97	50.12±1.22	55.10±1.12	63.58±1.72	73.22±1.86	86.64±1.78	94.02±1.65	98.15±1.04
Ours	44.88±3.13	51.61±0.66	58.71±2.78	65.66±1.58	84.61±1.39	93.93±0.49	97.79±0.33	98.46±0.25
Dataset	MFPT				UWaveGestureLibraryAll			
Supervised	50.88±0.32	57.14±0.54	69.76±0.48	81.63±0.15	75.81±0.84	81.53±0.54	85.81±0.66	89.5±0.68
Pseudo-Label	63.90±2.62	65.39±1.70	69.60±2.27	-	75.72±1.85	81.66±0.74	86.45±1.20	-
Π-Model	55.41±0.65	59.68±0.43	70.15±0.88	-	77.26±0.31	82.87±0.64	86.17±0.91	-
MTL	56.11±1.25	66.20±1.18	74.25±1.01	82.81±1.06	76.35±0.56	81.77±0.94	86.01±0.68	89.76±0.96
Ours	64.16±0.85	69.84±0.94	76.49±0.54	84.33±0.50	81.46±0.60	84.57±0.49	86.91±0.47	90.29±0.32
Dataset	InsectWingbeatSound				EpilepticSeizure			
Supervised	50.96±1.58	55.95±0.76	61.41±0.96	66.27±1.30	68.40±0.43	70.77±0.70	73.49±0.60	77.77±1.13
Pseudo-Label	43.16±3.20	48.35±1.81	55.32±2.04	-	68.57±0.50	72.92±0.48	74.60±0.65	-
Π-Model	51.47±0.36	56.14±1.32	62.20±0.53	-	69.60±0.34	71.58±0.64	74.54±0.55	-
MTL	50.45±1.01	56.43±0.88	60.90±0.87	64.14±1.08	68.71±0.94	73.17±0.81	74.77±0.75	78.53±0.62
Ours	54.96±1.61	59.01±1.56	62.38±0.76	66.57±0.67	74.86±0.42	75.54±0.63	77.01±0.79	79.26±1.20

Seizure, Tumor area, Healthy area, Eyes closed, Eyes open

Supervised **SemiTime**

Fig. 4. t-SNE visualization of the learned embedding on EpilepticSeizure dataset. Different colors indicate different labels.

Code and data are publicly available at https://haoyfan.github.io/