Supplementary Material: Temporal-Frequency Co-training for Time Series Semi-supervised Learning

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A Experimental Setup

A.1 Datasets

The UCR time series archive (Dau et al. 2019) contains a large number of time series datasets from different domains and is widely employed for time series classification studies (Ismail Fawaz et al. 2019). For the datasets that contain missing values, we utilize the mean imputation method for processing. Following (Ismail Fawaz et al. 2019), we employ z-score to normalize the series for each dataset. In particular, to avoid information leakage in the test set, we use the mean imputation method to fill the training set, validation set, and test set separately. In addition, some datasets in the UCR archive contain a relatively small number of samples, leading to large classification bias in the semi-supervised classification performance after five-fold cross-validation. For example, the Beef dataset contains 60 samples, with each category containing an average of 12 samples. The PigCVP dataset contains 312 samples, but each category contains 6 samples on average. After a five-fold cross-validation partition, the above datasets are likely to result in some categories having no samples in the training set to participate in the model training, leading to a large random bias in the classification performance. To address the above issues, we constrain the average number of samples included in each category to be no less than 30. Hence, we employ 106 datasets from the original 128 UCR datasets for experiments, as shown in Table 1.

A.2 Baselines

The baselines used in the main text are described in detail as follows:

Supervised: We train the model using existing labeled samples and then obtain the classification results on the test set.

Pseudo-Label (Lee et al. 2013): Obtaining pseudo-labels of unlabeled samples using the classifier prediction results and performing supervised classification learning in combination with labeled samples. We use the open source code from https://github.com/iBelieveCJM/pseudo_label-pytorch for experimental analysis.

Temporal Ensembling (Laine and Aila 2017): The consensus prediction results of the classifier are used as pseudo-labels for the unlabeled samples, which are then combined with the labeled samples for semi-supervised learning. We use the open source code from https://github.com/ferretj/temporal-ensembling for experimental analysis.

LPDeepSSL (Iscen et al. 2019): Label propagation is utilized to construct the nearest neighbor graph using embedddings of all samples, thus obtaining pseudo-labels of unlabeled samples for semi- supervised learning. We use the open source code from https://github.com/ahmetius/LP-DeepSSL for experimental analysis.

TS-TCC (Eldele et al. 2021): Unsupervised representation learning is performed on the encoder using the temporal contrasting and contextual contrasting modules, and then the encoder and classifier are fine-tuned using the labeled samples. For the hyperparameters of TS-TCC for the UCR time series datasets, we follow the setting of the HAR dataset in the original article. We use the open source code from https://github.com/emadeldeen24/TS-TCC for experimental analysis.

MTL (Jawed, Grabocka, and Schmidt-Thieme 2020): The authors employ the time series forecasting task for all time series samples and combine it with a supervised classification task with labeled time series samples for joint learning. We use the open source code from https://github.com/super-shayan/semi-super-ts-clf for experimental analysis.

SemiTime (Fan et al. 2021): The authors utilize a self-supervised relation prediction training loss for unlabeled time series samples and learn it jointly with a classification task with labeled time series samples. We use the open source code from https://github.com/haoyfan/SemiTime for experimental analysis.

TS-T: We remove the co-training mechanism of TS-TFC, and use only time-domain view data for semi-supervised learning.

TS-F: We remove the co-training mechanism of TS-TFC, and use only frequency-domain view data for semi-supervised learning.

In addition, to ensure a fair comparison, we allow all baselines to utilize FCN (Wang, Yan, and Oates 2017) as the encoder and a linear classifier for classification, and adopt a uniform random seed for network initialization. Since the training epoch is set to 1000 for each dataset, we employ a

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Algorithm 1: The proposed TS-TFC framework.

Input: Labeled and unlabeled time series set D^L and D^U, temporal encoder $\mathbf{w}_{tem}$, frequency encoder $\mathbf{w}_{feq}$, temporal classifier $\mathbf{c}_{tem}$, frequency classifier $\mathbf{c}_{feq}$, warm-up epoch $warm_{max}$, hyperparameters λ and μ

Output: $\mathbf{w}_{tem}$, $\mathbf{w}_{feq}$, $\mathbf{c}_{tem}$, and $\mathbf{c}_{feq}$

Obtain temporal training set $\mathcal{D}$ from D^L and D^U;
Obtain frequency training set $\mathcal{D}'$ via Fast Fourier Transform to convert $\mathcal{D}$;
for $epoch = 1$ to $warm_{max}$ **do**
  Warm-up training using only the labeled time series;
  Fetch mini-batch $\mathcal{D}_m^L, \mathcal{D'}_m^L$ from $\mathcal{D}$ and $\mathcal{D}'$,
  $\mathcal{D}_m^L = \{\mathcal{X}_m^L, \mathcal{Y}_m^L\}$ and $\mathcal{D'}_m^L = \{\mathcal{S}_m^L, \mathcal{Y}_m^L\}$; // $\mathcal{D}_m^L$ and $\mathcal{D'}_m^L$ denote labeled time series set;
  Update $\mathbf{w}_{tem}, \mathbf{c}_{tem} = \nabla_\theta\{\mathcal{L}_{cls}\left(\mathcal{X}_m^L, \mathcal{Y}_m^L\right) + \lambda\mathcal{L}_{tem}^{sup}\left(\mathcal{X}_m^L, \mathcal{Y}_m^L\right)\}$;
  Update $\mathbf{w}_{feq}, \mathbf{c}_{feq} = \nabla_\theta\{\mathcal{L}_{cls}\left(\mathcal{S}_m^L, \mathcal{Y}_m^L\right) + \mu\mathcal{L}_{feq}^{sup}\left(\mathcal{S}_m^L, \mathcal{Y}_m^L\right)\}$;
end for
for $epoch = warm_{max}$ to $epoch_{max}$ **do**
  Fetch mini-batch $\mathcal{D}_m, \mathcal{D}'_m$ from $\mathcal{D}$ and $\mathcal{D}'$,
  $\mathcal{D}_m = \{\mathcal{X}_m, \mathcal{Y}_m\}$ and $\mathcal{D}'_m = \{\mathcal{S}_m, \mathcal{Y}_m\}$; // $\mathcal{Y}_m$ contains labeled and unlabeled information;
  Obtain representations r_{tem} and r_{feq},
  $r_{tem} = MLP(\mathbf{w}_{tem}(\mathcal{X}_m))$, $r_{feq} = MLP(\mathbf{w}_{feq}(\mathcal{S}_m))$;
  Update r_{tem}, r_{feq} by contrastive loss $\mathcal{L}_{tem}^{\text{sup}}$ and $\mathcal{L}_{feq}^{\text{sup}}$;
  Generate pesudo-labels $\mathcal{F}_{tem}$, $\mathcal{F}_{feq}$ by Label Propagation (LP),
  $\mathcal{F}_{tem} = LP(r_{tem}, \mathcal{Y}_m)$ and $\mathcal{F}_{feq} = LP(r_{feq}, \mathcal{Y}_m)$; // Using labeled information in $\mathcal{Y}_m$ to obtain pesudo-labels;
  Obtain curriculum pesudo-labels Z^{tem}, Z^{feq} by Equation (6);
  Update $\mathbf{w}_{tem}, \mathbf{c}_{tem} = \nabla_\theta\{\mathcal{L}_{cls}\left(\mathcal{X}_m, Z^{feq}\right) + \lambda\mathcal{L}_{tem}^{sup}\left(\mathcal{X}_m^L, \mathcal{Y}_m^L\right)\}$; // Using pesudo-labels provided by r_{feq};
  Update $\mathbf{w}_{feq}, \mathbf{c}_{feq} = \nabla_\theta\{\mathcal{L}_{cls}\left(\mathcal{S}_m, Z^{tem}\right) + \mu\mathcal{L}_{feq}^{sup}\left(\mathcal{S}_m^L, \mathcal{Y}_m^L\right)\}$; // Using pesudo-labels provided by r_{tem};
end for

uniform early-stop training pattern for all baselines via the loss variation on the validation set, thus reducing the training time of the model.

B Full Results

B.1 Comparison with the State-of-the-art Methods

Tables 2, 3, and 4 give the test classification accuracy results for TS-TCC and different baselines for 106 UCR time series datasets with the labeling ratio of 10%, 20%, and 40%, respectively. To facilitate the layout and reading of the test classification results, the standard deviation of the classification accuracy for each dataset is not given again in Tables 2, 3, and 4. Still, the average standard deviations of the classification accuracy on the UCR 106 time series datasets have been given in the main text.

B.2 Ablation Study

We conduct ablation studies for TST and TSF respectively, and the detailed test classification accuracy on the 106 UCR time series dataset with 10% labeling ratio are shown in Tables 5 and 6 Also, for the convenience of layout and reading of the test classification results, the standard deviations of the classification performance evaluated for each dataset are not given in Tables 5 and 6. Still, the main text has given the average standard deviations of the classification accuracy on the UCR 106 time series datasets.

B.3 Hyperparameter Analysis

We analyze the test classification accuracy of hyperparameters λ, μ, τ, and top k on 18 UCR time series datasets. Tables 7 and 8 represent the detailed test classification accuracies of the contrastive loss weights λ and μ on the temporal and frequency encoders. Tables 9 and 10 represent the detailed test classification accuracies of the temperature coefficient τ on the temporal and frequency encoders. Tables 11 and 12 represent the detailed test classification accuracies of the hyperparameter top k on the temporal and frequency encoders. Additionally, for the convenience of layout and reading of the test classification results, the standard deviations of the classification performance for each dataset are not given in Tables 7- 12.

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ID	Dataset	Numbers	Length	Classes	Average number of samples in one class
1	AllGestureWiimoteX	1000	385	10	100
2	AllGestureWiimoteY	1000	385	10	100
3	AllGestureWiimoteZ	1000	385	10	100
4	ArrowHead	211	251	3	70
5	BME	180	128	3	60
6	Car	120	577	4	30
7	CBF	930	128	3	310
8	Chinatown	365	24	2	183
9	ChlorineConcentration	4307	166	3	1436
10	CinCECGTorso	1420	1639	4	355
11	Computers	500	720	2	250
12	CricketX	780	300	12	65
13	CricketY	780	300	12	65
14	CricketZ	780	300	12	65
15	Crop	24000	46	24	1000
16	DiatomSizeReduction	322	345	4	81
17	DistalPhalanxOutlineAgeGroup	539	80	3	180
18	DistalPhalanxOutlineCorrect	876	80	2	438
19	DistalPhalanxTW	539	80	6	90
20	DodgerLoopGame	158	288	2	79
21	DodgerLoopWeekend	158	288	2	79
22	Earthquakes	461	512	2	231
23	ECG200	200	96	2	100
24	ECG5000	5000	140	5	1000
25	ECGFiveDays	884	136	2	442
26	ElectricDevices	16637	96	7	2377
27	EOGHorizontalSignal	724	1250	12	60
28	EOGVerticalSignal	724	1250	12	60
29	EthanolLevel	1004	1751	4	251
30	FaceAll	2250	131	14	161
31	FacesUCR	2250	131	14	161
32	Fish	350	463	7	50
33	FordA	4921	500	2	2461
34	FordB	4446	500	2	2223
35	FreezerRegularTrain	3000	301	2	1500
36	FreezerSmallTrain	2878	301	2	1439
37	GesturePebbleZ1	304	455	6	51
38	GesturePebbleZ2	304	455	6	51
39	GunPoint	200	150	2	100
40	GunPointAgeSpan	451	150	2	226
41	GunPointMaleVersusFemale	451	150	2	226
42	GunPointOldVersusYoung	451	150	2	226
43	Ham	214	431	2	107
44	HandOutlines	1370	2709	2	685
45	Haptics	463	1092	5	93
46	Herring	128	512	2	64
47	HouseTwenty	159	2000	2	80
48	InlineSkate	650	1882	7	93
49	InsectEPGRegularTrain	311	601	3	104
50	InsectEPGSmallTrain	266	601	3	89
51	InsectWingbeatSound	2200	256	11	200
52	ItalyPowerDemand	1096	24	2	548
53	LargeKitchenAppliances	750	720	3	250
54	Lightning2	121	637	2	61
55	Mallat	2400	1024	8	300
56	Meat	120	448	3	40
57	MedicalImages	1141	99	10	114
58	MelbournePedestrian	3650	24	10	365
59	MiddlePhalanxOutlineAgeGroup	554	80	3	185
60	MiddlePhalanxOutlineCorrect	891	80	2	446
61	MiddlePhalanxTW	553	80	6	92
62	MixedShapesRegularTrain	2925	1024	5	585
63	MixedShapesSmallTrain	2525	1024	5	505
64	MoteStrain	1272	84	2	636
65	NonInvasiveFetalECGThorax1	3765	750	42	90
66	NonInvasiveFetalECGThorax2	3765	750	42	90
67	OSULeaf	442	427	6	74
68	PhalangesOutlinesCorrect	2658	80	2	1329
69	Phoneme	2110	1024	39	54
70	PLAID	1074	1344	11	98
71	Plane	210	144	7	30
72	PowerCons	360	144	2	180
73	ProximalPhalanxOutlineAgeGroup	605	80	3	202
74	ProximalPhalanxOutlineCorrect	891	80	2	446
75	ProximalPhalanxTW	605	80	6	101
76	RefrigerationDevices	750	720	3	250
77	ScreenType	750	720	3	250
78	SemgHandGenderCh2	900	1500	2	450
79	SemgHandMovementCh2	900	1500	6	150
80	SemgHandSubjectCh2	900	1500	5	180
81	ShapeletSim	200	500	2	100
82	SmallKitchenAppliances	750	720	3	250
83	SmoothSubspace	300	15	3	100
84	SonyAIBORobotSurface1	621	70	2	311
85	SonyAIBORobotSurface2	980	65	2	490
86	StarLightCurves	9236	1024	3	3079
87	Strawberry	983	235	2	492
88	SwedishLeaf	1125	128	15	75
89	Symbols	1020	398	6	170
90	SyntheticControl	600	60	6	100
91	ToeSegmentation1	268	277	2	134
92	ToeSegmentation2	166	343	2	83
93	Trace	200	275	4	50
94	TwoLeadECG	1162	82	2	581
95	TwoPatterns	5000	128	4	1250
96	UMD	180	150	3	60
97	UWaveGestureLibraryAll	4478	945	8	560
98	UWaveGestureLibraryX	4478	315	8	560
99	UWaveGestureLibraryY	4478	315	8	560
100	UWaveGestureLibraryZ	4478	315	8	560
101	Wafer	7164	152	2	3582
102	Wine	111	234	2	56
103	WordSynonyms	905	270	25	36
104	Worms	258	900	5	52
105	WormsTwoClass	258	900	2	129
106	Yoga	3300	426	2	1650

Table 1: Description of 106 UCR time series datasets, where Numbers denotes the number of all samples contained in the dataset, and Length indicates the length of the series.

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ID	Dataset	Supervised	Pseudo-Label	Temporal Ensembling	LPDeepSSL	TS-TCC	MTL	SemiTime	TS-T	TS-F	TS-TFC
1	AllGestureWiimoteX	0.518	**0.559**	0.538	0.424	0.156	0.422	0.496	0.420	0.365	0.547
2	AllGestureWiimoteY	0.580	0.562	0.589	0.578	0.181	0.436	0.555	0.607	0.420	**0.619**
3	AllGestureWiimoteZ	0.537	0.537	0.540	0.375	0.209	0.346	0.503	0.511	0.425	**0.543**
4	ArrowHead	0.687	0.758	0.744	0.725	0.308	0.565	**0.765**	0.693	0.702	0.711
5	BME	0.633	0.672	**0.694**	0.661	0.550	0.667	0.678	0.656	0.661	**0.694**
6	Car	0.658	0.592	**0.667**	0.467	0.250	0.558	0.662	0.608	0.433	0.520
7	CBF	0.998	0.998	0.994	0.997	0.975	0.975	0.993	0.998	0.871	**0.999**
8	Chinatown	0.970	0.961	0.970	0.973	0.712	0.419	0.970	**0.978**	0.885	0.973
9	ChlorineConcentration	0.604	0.722	0.733	0.737	0.537	0.607	0.719	0.630	0.712	**0.744**
10	CinCECGTorso	0.911	0.940	0.925	0.927	0.702	0.881	0.915	0.957	**0.998**	**0.998**
11	Computers	0.658	0.736	0.742	0.722	0.646	0.756	0.761	0.752	0.682	**0.764**
12	CricketX	0.535	0.535	0.515	0.505	0.126	0.492	0.524	0.589	0.490	**0.590**
13	CricketY	0.527	0.541	0.531	0.451	0.146	0.367	0.524	**0.544**	0.392	0.540
14	CricketZ	0.537	0.567	0.560	0.550	0.156	0.459	0.563	0.572	0.472	**0.619**
15	Crop	0.674	0.667	0.667	0.656	0.410	0.624	0.628	0.676	0.611	**0.685**
16	DiatomSizeReduction	0.876	0.923	0.920	0.929	0.350	0.731	0.885	0.894	0.954	**0.975**
17	DistalPhalanxOutlineAgeGroup	0.822	0.821	0.824	0.820	0.753	0.764	0.790	0.818	0.781	**0.826**
18	DistalPhalanxOutlineCorrect	0.787	0.765	0.791	0.775	0.629	0.713	0.791	**0.805**	0.774	**0.805**
19	DistalPhalanxTW	0.746	0.732	0.741	0.699	0.691	0.731	**0.751**	0.744	0.735	0.742
20	DodgerLoopGame	0.651	0.676	0.708	0.632	0.481	0.576	0.683	0.791	0.817	**0.842**
21	DodgerLoopWeekend	0.810	0.778	0.760	0.815	0.797	0.703	0.852	**0.860**	0.759	0.849
22	Earthquakes	0.795	0.775	0.796	**0.825**	0.602	0.595	0.741	0.760	0.745	0.790
23	ECG200	0.946	0.942	0.941	0.936	0.896	0.939	0.942	0.946	0.941	**0.950**
24	ECG5000	0.991	0.995	0.997	0.996	0.794	0.899	0.992	0.998	**1.000**	0.996
25	ECGFiveDays	0.327	0.345	0.378	0.318	0.192	0.328	0.424	0.427	0.403	**0.459**
26	ElectricDevices	0.318	0.318	0.313	0.337	0.166	0.293	0.379	0.344	0.351	**0.443**
27	EOGHorizontalSignal	0.798	0.792	0.798	0.798	0.798	0.798	0.770	0.777	0.798	**0.801**
28	EOGVerticalSignal	0.852	0.838	0.838	0.832	0.663	0.809	0.844	0.855	0.729	**0.857**
29	EthanolLevel	0.547	0.389	0.427	0.292	0.249	0.263	0.554	**0.582**	0.320	0.580
30	FaceAll	0.864	0.942	0.942	0.919	0.246	0.806	0.921	**0.944**	0.816	0.933
31	FacesUCR	0.854	**0.935**	0.926	0.886	0.214	0.862	0.901	0.918	0.830	0.912
32	Fish	**0.829**	0.589	0.569	0.389	0.143	0.446	0.757	0.800	0.326	0.354
33	FordA	0.891	0.900	0.906	0.899	0.800	0.890	0.905	0.900	0.866	**0.907**
34	FordB	0.881	0.877	0.884	0.882	0.805	0.872	**0.892**	0.885	0.808	0.873
35	FreezerRegularTrain	0.998	0.994	0.997	**0.998**	0.761	0.638	0.992	0.997	0.986	0.997
36	FreezerSmallTrain	**0.999**	0.998	**0.999**	0.998	0.760	0.848	0.997	**0.999**	0.985	**0.999**
37	GesturePebbleZ1	0.651	0.586	0.593	0.563	0.187	0.591	**0.677**	0.424	0.378	0.434
38	GesturePebbleZ2	0.622	**0.691**	0.671	0.538	0.208	0.577	0.629	0.480	0.293	0.460
39	GunPoint	0.735	0.955	0.945	0.910	0.545	0.765	**0.957**	0.920	0.740	0.910
40	GunPointAgeSpan	0.858	0.949	0.920	0.942	0.774	0.882	0.969	0.978	0.758	**0.982**
41	GunPointMaleVersusFemale	0.967	0.992	0.993	0.991	0.956	0.989	0.991	0.993	0.973	**0.998**
42	GunPointOldVersusYoung	0.927	0.820	0.845	0.891	0.601	0.765	0.938	0.942	0.843	**0.985**
43	Ham	0.603	0.575	0.622	0.593	0.481	0.547	**0.654**	0.650	0.542	0.636
44	HandOutlines	0.800	0.811	0.832	0.777	0.639	0.643	0.805	0.829	0.830	**0.875**
45	Haptics	**0.382**	0.344	0.363	0.305	0.203	0.290	0.319	0.359	0.380	0.370
46	Herring	0.617	0.579	0.549	0.579	0.562	0.601	0.616	0.578	0.593	**0.618**
47	HouseTwenty	0.905	0.899	0.931	0.872	0.578	0.899	**0.932**	0.925	0.906	0.928
48	InlineSkate	0.239	0.294	0.362	0.360	0.161	0.257	0.215	0.363	0.286	**0.428**
49	InsectEPGRegularTrain	0.910	0.917	0.930	0.894	0.654	0.911	0.871	0.952	0.737	**0.962**
50	InsectEPGSmallTrain	0.922	0.888	0.888	0.888	0.631	0.853	0.884	0.925	0.820	**0.944**
51	InsectWingbeatSound	0.296	0.358	0.361	0.349	0.121	0.292	0.355	0.376	**0.576**	0.547
52	ItalyPowerDemand	0.947	0.964	0.955	**0.971**	0.886	0.875	0.960	0.964	0.949	0.965
53	LargeKitchenAppliances	0.857	0.857	0.832	0.835	0.603	0.756	0.868	**0.873**	0.671	0.843
54	Lightning2	0.637	0.744	0.654	0.627	0.612	0.628	0.666	0.620	0.554	**0.746**
55	Mallat	0.960	0.982	0.980	0.958	0.159	0.437	0.940	0.941	**0.989**	0.988
56	Meat	0.767	0.667	0.750	0.617	0.333	0.617	0.817	0.852	0.767	**0.867**
57	MedicalImages	0.619	**0.674**	0.653	0.639	0.521	0.562	0.608	0.600	0.614	0.637
58	MelbournePedestrian	0.854	0.842	0.846	0.847	0.501	0.525	0.847	0.864	0.781	**0.864**
59	MiddlePhalanxOutlineAgeGroup	**0.753**	0.744	0.737	0.728	0.582	0.608	0.725	0.736	0.715	0.731
60	MiddlePhalanxOutlineCorrect	0.772	0.764	0.744	0.741	0.622	0.654	0.764	0.773	0.708	**0.817**
61	MiddlePhalanxTW	**0.595**	0.590	0.585	0.579	0.551	0.528	0.586	0.579	0.588	0.579
62	MixedShapesRegularTrain	0.927	0.935	0.927	0.923	0.453	0.772	0.940	0.936	0.945	**0.959**
63	MixedShapesSmallTrain	0.914	0.921	0.926	0.913	0.454	0.795	0.924	0.949	0.941	**0.962**
64	MoteStrain	0.953	0.951	0.947	0.951	0.911	0.956	0.962	0.962	0.800	**0.963**
65	NonInvasiveFetalECGThorax1	0.247	0.342	0.316	0.255	0.028	0.082	0.316	0.278	**0.379**	0.327
66	NonInvasiveFetalECGThorax2	0.271	0.358	0.410	0.205	0.027	0.077	0.333	0.230	**0.464**	0.457
67	OSULeaf	0.862	0.766	0.808	0.815	0.347	0.769	0.849	0.876	0.679	**0.899**
68	PhalangesOutlinesCorrect	0.328	0.304	**0.342**	0.339	0.191	0.282	0.335	0.303	0.319	0.332
69	Phoneme	0.778	0.781	0.779	0.781	0.639	0.708	**0.806**	0.783	0.748	0.799
70	PLAID	0.289	0.292	0.294	0.291	0.168	0.298	**0.303**	0.292	0.262	0.290
71	Plane	0.852	0.886	0.886	0.886	0.248	0.781	**0.892**	0.857	0.786	0.817
72	PowerCons	0.811	0.822	0.828	0.764	0.778	0.786	**0.832**	0.803	0.714	0.811
73	ProximalPhalanxOutlineAgeGroup	0.822	**0.848**	0.828	0.845	0.783	0.668	0.817	0.831	0.826	0.826
74	ProximalPhalanxOutlineCorrect	0.825	0.785	0.811	0.814	0.681	0.689	0.833	0.839	0.758	**0.842**
75	ProximalPhalanxTW	0.770	0.785	0.772	**0.790**	0.724	0.676	0.762	0.780	0.752	0.775
76	RefrigerationDevices	0.563	0.489	0.512	0.533	0.547	0.551	0.487	**0.581**	0.465	0.567
77	ScreenType	0.532	0.551	**0.581**	0.545	0.395	0.552	0.505	0.503	0.472	0.521
78	SemgHandGenderCh2	0.701	0.742	0.772	0.728	0.659	0.646	0.777	0.700	0.756	**0.804**
79	SemgHandMovementCh2	0.390	0.414	0.417	0.389	0.211	0.303	0.400	0.393	0.387	**0.423**
80	SemgHandSubjectCh2	0.662	0.601	0.610	0.580	0.437	0.567	0.664	0.672	0.687	**0.691**
81	ShapeletSim	0.970	0.965	0.960	**0.995**	0.500	0.730	0.820	0.970	0.685	**0.995**
82	SmallKitchenAppliances	0.724	0.744	0.743	0.741	0.593	0.707	0.733	**0.753**	0.620	0.740
83	SmoothSubspace	0.840	0.827	0.843	0.873	0.543	0.637	0.870	**0.907**	0.567	0.897
84	SonyAIBORobotSurface1	0.990	**0.994**	0.992	**0.994**	0.971	0.973	0.992	0.989	0.973	**0.994**
85	SonyAIBORobotSurface2	0.986	0.989	0.984	0.984	0.964	0.971	0.989	0.990	0.924	**0.991**
86	StarLightCurves	0.951	0.976	0.976	0.976	0.847	0.516	0.977	0.941	0.975	**0.978**
87	Strawberry	0.698	0.927	0.932	0.930	0.643	0.755	0.928	0.936	0.885	**0.939**
88	SwedishLeaf	0.701	0.876	**0.891**	0.877	0.145	0.725	0.727	0.876	0.807	0.877
89	Symbols	0.989	0.988	0.990	0.992	0.759	0.766	0.993	**0.995**	0.935	0.989
90	SyntheticControl	0.955	0.950	0.942	0.930	0.917	0.947	0.965	**0.990**	0.895	0.980
91	ToeSegmentation1	0.888	0.855	0.870	0.840	0.713	0.866	0.892	0.881	0.777	**0.896**
92	ToeSegmentation2	0.855	**0.856**	0.830	0.855	0.752	0.759	0.850	0.819	0.820	0.777
93	Trace	0.875	0.830	0.805	0.885	0.485	0.830	0.860	0.930	**0.990**	0.935
94	TwoLeadECG	**1.000**	**1.000**	**1.000**	**1.000**	0.787	**1.000**	**1.000**	**1.000**	0.992	**1.000**
95	TwoPatterns	0.878	0.878	0.878	0.876	0.683	0.842	0.878	0.874	0.634	**0.883**
96	UMD	0.844	0.833	0.872	0.828	0.583	0.739	0.889	0.897	0.683	**0.900**
97	UWaveGestureLibraryAll	0.773	0.714	0.714	0.690	0.233	0.694	0.788	0.808	0.871	**0.892**
98	UWaveGestureLibraryX	0.727	0.728	0.723	0.710	0.310	0.552	0.733	0.746	0.625	**0.757**
99	UWaveGestureLibraryY	0.602	0.625	0.623	0.596	0.312	0.515	0.606	0.632	0.563	**0.647**
100	UWaveGestureLibraryZ	0.692	0.690	0.684	0.677	0.299	0.569	0.673	0.696	0.597	**0.700**
101	Wafer	0.977	0.933	0.952	0.972	0.894	0.909	0.913	0.957	0.998	**0.998**
102	Wine	0.583	0.576	0.540	**0.667**	0.504	0.578	0.667	0.638	0.523	0.583
103	WordSynonyms	0.348	0.319	0.296	0.274	0.214	0.306	0.371	0.365	0.364	**0.372**
104	Worms	0.550	0.535	0.570	0.504	0.437	0.523	**0.579**	0.574	0.431	0.574
105	WormsTwoClass	0.658	0.737	0.710	0.694	0.547	0.667	**0.740**	0.682	0.613	0.686
106	Yoga	0.848	0.856	0.859	0.839	0.529	0.701	0.880	0.827	0.814	**0.899**
	Avg Acc	0.738	0.745	0.749	0.729	0.513	0.650	0.751	0.754	0.694	0.769
	Avg Rank	5.06	4.56	4.27	5.43	9.64	7.81	4.30	3.74	6.85	**2.44**
	Training Time (hours)	**1.12**	8.03	12.26	11.37	3.46	41.35	123.32	5.69	3.00	9.17
	P-value	1.16E-04	1.71E-04	4.94E-04	6.55E-09	2.05E-27	5.78E-18	8.53E-03	9.01E-03	1.47E-17	-

Table 2: Detailed test classification accuracy compared to baselines on 106 UCR datasets with 10% labeling ratio.

ID	Dataset	Supervised	Pseudo-Label	Temporal Ensembling	LPDeepSSL	TS-TCC	MTL	SemiTime	TS-T	TS-F	TS-TFC
1	AllGestureWiimoteX	0.597	0.534	0.540	0.369	0.191	0.530	**0.622**	0.606	0.474	0.606
2	AllGestureWiimoteY	0.654	0.661	0.656	0.563	0.287	0.534	0.686	0.696	0.515	**0.702**
3	AllGestureWiimoteZ	0.608	0.534	0.575	0.504	0.250	0.346	0.633	0.645	0.529	**0.649**
4	ArrowHead	0.825	0.810	0.805	0.796	0.451	0.797	0.881	0.834	0.787	**0.910**
5	BME	0.683	0.794	0.739	0.722	0.556	0.633	0.728	0.811	**0.933**	0.806
6	Car	0.775	0.692	0.750	0.542	0.258	0.458	0.775	**0.783**	0.533	0.767
7	CBF	**0.999**	**0.999**	**0.999**	0.998	0.979	0.987	0.996	**0.999**	0.948	**0.999**
8	Chinatown	0.978	0.975	0.973	0.953	0.858	0.288	0.962	0.981	0.844	**0.986**
9	ChlorineConcentration	0.858	0.875	0.871	0.874	0.550	0.662	0.882	0.865	0.809	**0.892**
10	CinCECGTorso	0.976	0.988	0.985	0.955	0.675	0.854	0.989	0.991	0.999	**1.000**
11	Computers	0.794	**0.830**	0.792	0.776	0.650	0.798	0.802	0.770	0.674	0.796
12	CricketX	0.685	0.701	0.696	0.686	0.249	0.609	0.671	0.687	0.563	**0.709**
13	CricketY	0.635	0.683	0.687	0.654	0.191	0.541	0.667	0.696	0.581	**0.714**
14	CricketZ	0.639	0.691	0.672	0.671	0.185	0.581	0.621	0.669	0.581	**0.700**
15	Crop	0.716	0.710	0.716	0.711	0.462	0.664	0.716	0.721	0.671	**0.726**
16	DiatomSizeReduction	0.950	0.942	0.938	0.953	0.411	0.695	0.898	0.978	0.975	**0.991**
17	DistalPhalanxOutlineAgeGroup	0.827	0.818	**0.831**	**0.831**	0.772	0.764	0.818	0.814	0.794	0.800
18	DistalPhalanxOutlineCorrect	0.821	0.791	0.809	0.750	0.615	0.727	0.819	0.695	0.779	**0.833**
19	DistalPhalanxTW	0.777	0.754	**0.787**	0.767	0.698	0.733	0.753	0.737	0.740	0.774
20	DodgerLoopGame	0.723	0.793	0.820	0.765	0.519	0.581	0.786	0.855	0.804	**0.863**
21	DodgerLoopWeekend	0.937	0.943	0.906	0.912	0.759	0.673	0.881	0.937	0.918	**0.949**
22	Earthquakes	0.785	0.816	0.836	0.760	0.670	0.680	0.806	0.820	0.785	**0.845**
23	ECG200	0.947	0.944	0.943	0.940	0.899	0.942	**0.952**	0.945	0.945	0.946
24	ECG5000	0.999	0.997	0.998	0.993	0.840	0.983	0.998	**1.000**	**1.000**	**1.000**
25	ECGFiveDays	0.550	0.557	0.547	0.454	0.213	0.460	0.572	0.547	0.539	**0.584**
26	ElectricDevices	0.439	0.414	0.424	0.363	0.174	0.399	0.435	0.479	0.514	**0.559**
27	EOGHorizontalSignal	0.790	0.790	0.796	0.805	0.798	0.794	0.807	0.790	0.798	**0.817**
28	EOGVerticalSignal	0.860	0.863	0.862	0.858	0.769	0.836	0.862	**0.867**	0.767	0.865
29	EthanolLevel	0.663	0.636	0.625	0.539	0.253	0.244	0.640	**0.713**	0.383	0.686
30	FaceAll	0.952	0.966	0.963	0.937	0.425	0.856	0.958	0.972	0.909	**0.972**
31	FacesUCR	0.940	0.963	0.961	0.931	0.376	0.918	0.950	0.962	0.906	**0.968**
32	Fish	0.820	0.831	0.849	0.583	0.143	0.471	0.789	0.840	0.671	**0.906**
33	FordA	0.909	0.912	0.913	0.907	0.866	0.907	**0.931**	0.915	0.888	0.914
34	FordB	0.890	0.895	0.891	0.893	0.829	0.883	0.892	0.891	0.853	**0.896**
35	FreezerRegularTrain	0.997	0.997	0.997	0.898	0.758	0.681	0.995	**0.998**	0.994	**0.998**
36	FreezerSmallTrain	**0.999**	**0.999**	0.998	0.999	0.759	0.719	**0.999**	0.999	0.996	**0.999**
37	GesturePebbleZ1	0.829	0.751	0.760	0.711	0.250	0.760	0.793	**0.842**	0.487	0.796
38	GesturePebbleZ2	0.799	**0.858**	0.827	0.740	0.309	0.713	0.810	0.839	0.536	0.826
39	GunPoint	0.985	0.820	0.985	0.940	0.630	0.660	0.985	0.985	0.865	**0.990**
40	GunPointAgeSpan	0.987	0.991	0.978	0.989	0.857	0.767	**0.996**	0.993	0.836	0.987
41	GunPointMaleVersusFemale	0.987	0.993	0.991	0.892	0.982	0.993	0.996	0.996	0.985	**0.998**
42	GunPointOldVersusYoung	0.968	**0.985**	0.978	0.894	0.650	0.902	0.973	0.980	0.874	**0.985**
43	Ham	0.622	0.691	0.620	0.690	0.625	0.695	0.628	0.715	**0.724**	0.682
44	HandOutlines	0.868	0.868	0.848	0.834	0.639	0.682	0.833	0.882	0.870	**0.897**
45	Haptics	0.456	0.359	0.354	0.334	0.210	0.302	0.411	0.402	**0.478**	0.465
46	Herring	0.617	0.610	0.579	0.580	0.602	0.610	0.587	0.602	**0.649**	0.601
47	HouseTwenty	0.944	0.962	**0.975**	0.943	0.906	0.962	0.975	0.931	0.842	0.924
48	InlineSkate	0.366	0.412	0.408	0.441	0.163	0.299	0.346	0.466	0.488	**0.528**
49	InsectEPGRegularTrain	0.936	0.961	0.961	0.923	0.870	0.939	0.952	0.961	0.872	**0.962**
50	InsectEPGSmallTrain	0.959	0.981	0.981	0.785	0.830	0.970	**0.989**	0.970	0.895	0.963
51	InsectWingbeatSound	0.446	0.431	0.441	0.388	0.149	0.339	0.465	0.392	0.616	**0.645**
52	ItalyPowerDemand	0.961	0.967	0.964	**0.973**	0.929	0.830	0.962	0.966	0.953	0.970
53	LargeKitchenAppliances	0.912	0.915	0.901	0.883	0.620	0.892	0.883	**0.940**	0.729	0.913
54	Lightning2	0.612	0.669	0.678	0.686	0.636	0.627	0.712	0.687	**0.753**	0.712
55	Mallat	0.987	0.988	0.990	0.816	0.263	0.545	0.990	0.988	0.987	**0.991**
56	Meat	0.900	0.925	0.933	0.900	0.333	0.575	0.933	0.950	0.842	**0.967**
57	MedicalImages	0.664	**0.708**	0.708	0.704	0.521	0.557	0.615	0.681	0.667	0.696
58	MelbournePedestrian	0.893	0.869	0.872	0.869	0.629	0.664	0.893	**0.901**	0.823	0.899
59	MiddlePhalanxOutlineAgeGroup	0.756	0.757	0.762	0.751	0.724	0.497	0.734	0.733	0.704	**0.764**
60	MiddlePhalanxOutlineCorrect	0.797	0.759	0.774	0.773	0.622	0.660	0.802	0.784	0.736	**0.821**
61	MiddlePhalanxTW	0.591	0.612	0.622	0.612	0.540	0.420	0.613	0.609	0.620	**0.629**
62	MixedShapesRegularTrain	0.958	0.945	0.952	0.944	0.561	0.812	0.961	0.964	0.964	**0.972**
63	MixedShapesSmallTrain	0.949	0.947	0.953	0.942	0.583	0.716	0.960	0.962	0.955	**0.972**
64	MoteStrain	0.963	0.965	0.958	0.954	0.921	0.962	0.966	0.970	0.861	**0.971**
65	NonInvasiveFetalECGThorax1	0.460	0.426	0.454	0.382	0.033	0.084	**0.523**	0.280	0.386	0.386
66	NonInvasiveFetalECGThorax2	0.490	0.460	0.452	0.090	0.036	0.120	0.503	0.395	0.506	**0.515**
67	OSULeaf	0.930	0.923	0.928	0.886	0.410	0.840	0.942	**0.957**	0.758	0.935
68	PhalangesOutlinesCorrect	0.337	0.339	0.379	0.308	0.192	0.295	**0.388**	0.318	0.385	0.338
69	Phoneme	0.821	0.823	0.817	0.806	0.632	0.694	0.827	0.833	0.785	**0.838**
70	PLAID	0.357	0.337	0.347	0.312	0.194	**0.365**	0.342	0.345	0.315	0.317
71	Plane	**1.000**	**1.000**	**1.000**	**1.000**	0.486	0.929	**1.000**	**1.000**	0.986	**1.000**
72	PowerCons	0.814	0.844	0.831	0.822	0.761	0.786	**0.851**	0.800	0.803	0.814
73	ProximalPhalanxOutlineAgeGroup	0.825	0.840	0.831	0.848	0.783	0.783	0.850	0.851	0.828	**0.856**
74	ProximalPhalanxOutlineCorrect	0.861	0.850	0.864	0.870	0.703	0.469	**0.871**	0.856	0.822	0.859
75	ProximalPhalanxTW	0.769	0.789	0.789	0.786	0.727	0.693	0.790	0.784	0.765	**0.793**
76	RefrigerationDevices	0.576	0.639	0.627	0.572	0.564	0.583	0.596	0.601	0.521	**0.655**
77	ScreenType	0.601	0.648	**0.656**	0.640	0.409	0.601	0.591	0.619	0.503	0.639
78	SemgHandGenderCh2	0.856	0.788	0.804	0.793	0.662	0.724	0.836	0.828	0.818	**0.879**
79	SemgHandMovementCh2	0.501	0.449	0.493	0.431	0.258	0.331	0.477	**0.524**	0.489	0.516
80	SemgHandSubjectCh2	0.759	0.651	0.711	0.673	0.464	0.590	0.778	0.789	0.759	**0.796**
81	ShapeletSim	0.970	**1.000**	0.995	0.995	0.695	0.735	0.975	**1.000**	0.820	**1.000**
82	SmallKitchenAppliances	0.759	0.764	0.781	0.763	0.585	0.739	0.747	0.784	0.652	**0.797**
83	SmoothSubspace	0.893	0.927	0.903	0.933	0.867	0.790	**0.937**	**0.937**	0.583	0.883
84	SonyAIBORobotSurface1	**0.997**	0.990	0.989	0.990	0.974	0.990	0.992	0.994	0.987	**0.997**
85	SonyAIBORobotSurface2	0.990	0.995	**0.996**	0.987	0.979	0.981	0.989	0.993	0.977	**0.996**
86	StarLightCurves	0.977	0.978	0.977	0.837	0.849	0.613	0.979	0.963	0.978	**0.980**
87	Strawberry	0.894	0.947	0.952	0.942	0.643	0.646	0.949	**0.958**	0.930	0.949
88	SwedishLeaf	0.765	0.942	0.932	0.907	0.203	0.703	0.836	0.941	0.886	**0.954**
89	Symbols	0.994	0.991	0.989	0.990	0.896	0.835	0.991	0.994	0.864	**0.996**
90	SyntheticControl	0.985	0.988	0.985	0.983	0.885	0.978	0.988	0.988	0.930	**0.995**
91	ToeSegmentation1	0.953	0.955	0.963	0.952	0.899	0.955	0.963	0.940	0.829	**0.963**
92	ToeSegmentation2	0.795	**0.886**	0.880	0.848	0.789	0.807	0.875	0.492	0.843	0.530
93	Trace	0.995	0.995	0.995	0.990	0.590	0.975	**1.000**	**1.000**	**1.000**	**1.000**
94	TwoLeadECG	**1.000**	**1.000**	**1.000**	**1.000**	0.898	**1.000**	**1.000**	**1.000**	0.998	**1.000**
95	TwoPatterns	0.890	0.876	0.878	0.876	0.795	0.868	0.892	0.890	0.700	**0.899**
96	UMD	0.883	0.917	0.944	0.872	0.783	0.900	0.956	0.982	0.667	**0.983**
97	UWaveGestureLibraryAll	0.832	0.814	0.803	0.748	0.313	0.653	0.844	0.828	0.918	**0.935**
98	UWaveGestureLibraryX	0.768	0.743	0.737	0.730	0.446	0.520	0.761	0.773	0.654	**0.779**
99	UWaveGestureLibraryY	0.664	0.654	0.659	0.650	0.420	0.523	0.666	0.668	0.617	**0.680**
100	UWaveGestureLibraryZ	0.732	0.720	0.723	0.705	0.433	0.615	0.720	**0.752**	0.641	0.727
101	Wafer	0.998	0.914	0.997	0.996	0.894	0.913	0.998	1.000	0.998	**1.000**
102	Wine	0.738	0.673	0.699	0.638	0.487	0.450	0.749	**0.802**	0.726	0.738
103	WordSynonyms	0.411	0.393	0.400	0.366	0.230	0.350	0.456	0.433	**0.494**	0.448
104	Worms	0.531	0.512	0.492	0.567	0.481	**0.602**	0.575	0.500	0.493	0.469
105	WormsTwoClass	0.671	0.683	0.667	0.647	0.566	**0.768**	0.702	0.701	0.667	0.732
106	Yoga	0.888	0.901	0.899	0.893	0.562	0.763	0.910	0.908	0.851	**0.927**
	Avg Acc	0.798	0.800	0.803	0.769	0.569	0.681	0.807	0.808	0.756	0.822
	Avg Rank	4.86	4.36	4.50	6.37	9.51	7.98	3.84	3.49	6.67	**2.19**
	Training Time (hours)	**1.65**	10.16	15.32	17.29	3.51	91.62	130.57	5.89	3.02	9.18
	P-value	4.68E-06	6.28E-05	1.76E-04	1.54E-09	1.58E-24	8.94E-18	3.48E-03	1.12E-04	1.04E-11	-

Table 3: Detailed test classification accuracy compared to baselines on 106 UCR datasets with 20% labeling ratio.

ID	Dataset	Supervised	Pseudo-Label	Temporal Ensembling	LPDeepSSL	TS-TCC	MTL	SemiTime	TS-T	TS-F	TS-TFC
1	AllGestureWiimoteX	0.676	0.674	**0.702**	0.557	0.195	0.556	0.670	0.685	0.566	0.685
2	AllGestureWiimoteY	0.766	0.677	0.743	0.685	0.272	0.587	0.763	**0.788**	0.629	0.786
3	AllGestureWiimoteZ	**0.725**	0.666	0.696	0.605	0.323	0.376	0.673	0.687	0.597	0.708
4	ArrowHead	0.886	0.891	0.853	0.867	0.589	0.801	0.896	0.891	0.863	**0.914**
5	BME	0.867	0.867	0.889	0.894	0.567	0.817	0.917	0.917	0.961	**0.972**
6	Car	0.817	0.815	0.833	0.783	0.250	0.633	0.758	0.825	0.775	**0.892**
7	CBF	**1.000**	**1.000**	0.999	0.999	0.985	0.984	0.999	0.999	0.979	**1.000**
8	Chinatown	0.984	**0.986**	0.982	**0.986**	0.910	0.288	0.982	0.984	0.934	**0.986**
9	ChlorineConcentration	0.961	0.972	0.975	0.962	0.555	0.658	0.964	0.970	0.944	**0.976**
10	CinCECGTorso	0.994	0.998	0.996	0.992	0.755	0.890	0.997	0.997	**1.000**	**1.000**
11	Computers	0.876	0.856	0.860	0.860	0.656	0.846	**0.888**	0.870	0.796	0.874
12	CricketX	0.819	0.813	0.814	0.780	0.301	0.722	0.790	0.822	0.712	**0.824**
13	CricketY	0.729	0.790	0.765	0.787	0.203	0.715	0.791	0.797	0.712	**0.808**
14	CricketZ	0.789	0.815	0.804	0.808	0.228	0.674	0.797	0.803	0.730	**0.833**
15	Crop	0.780	0.766	0.766	0.764	0.554	0.725	0.778	**0.781**	0.760	0.771
16	DiatomSizeReduction	0.994	0.978	0.967	0.988	0.351	0.833	0.957	**0.997**	**0.997**	**0.997**
17	DistalPhalanxOutlineAgeGroup	0.811	0.813	0.837	0.824	0.751	0.774	0.827	0.829	0.827	**0.848**
18	DistalPhalanxOutlineCorrect	0.822	0.837	0.832	0.816	0.615	0.708	**0.842**	0.824	0.812	0.834
19	DistalPhalanxTW	0.752	0.766	0.794	0.763	0.698	0.708	0.794	0.776	0.783	**0.805**
20	DodgerLoopGame	0.861	0.869	0.850	0.862	0.481	0.612	0.818	0.874	**0.918**	0.899
21	DodgerLoopWeekend	0.930	0.956	0.924	0.968	0.854	0.748	0.962	0.943	**0.987**	0.975
22	Earthquakes	0.885	0.891	0.890	0.910	0.670	0.773	**0.915**	0.865	0.915	0.885
23	ECG200	0.932	0.955	0.953	0.952	0.910	0.947	0.950	0.954	0.955	**0.957**
24	ECG5000	**1.000**	0.999	0.999	0.999	0.847	0.987	**1.000**	**1.000**	**1.000**	**1.000**
25	ECGFiveDays	0.645	0.631	0.633	0.577	0.231	0.603	0.650	0.673	0.627	**0.724**
26	ElectricDevices	0.577	0.563	0.510	0.425	0.276	0.462	0.460	0.593	0.627	**0.695**
27	EOGHorizontalSignal	0.798	0.781	0.787	0.798	0.798	0.814	0.796	0.807	0.814	**0.827**
28	EOGVerticalSignal	0.881	0.881	0.882	0.878	0.775	0.864	0.876	**0.884**	0.809	0.883
29	EthanolLevel	0.712	0.674	0.708	0.665	0.249	0.263	0.709	0.690	0.500	**0.713**
30	FaceAll	0.983	0.985	0.984	0.974	0.559	0.899	0.984	**0.990**	0.942	0.988
31	FacesUCR	0.987	0.978	0.978	0.973	0.550	0.942	0.978	**0.989**	0.948	0.986
32	Fish	0.923	0.919	0.917	0.880	0.143	0.477	0.943	0.946	0.891	**0.951**
33	FordA	0.928	0.927	0.928	0.922	0.898	0.918	**0.936**	0.925	0.901	0.927
34	FordB	0.903	0.900	0.898	0.895	0.878	0.887	0.900	0.900	0.879	**0.905**
35	FreezerRegularTrain	0.998	0.999	0.999	0.997	0.763	0.774	0.992	0.998	0.996	**0.999**
36	FreezerSmallTrain	0.992	0.998	0.998	0.998	0.762	0.710	0.998	**0.999**	0.996	**0.999**
37	GesturePebbleZ1	0.865	0.875	0.866	0.869	0.420	0.816	0.875	0.878	0.662	**0.885**
38	GesturePebbleZ2	0.872	0.905	0.878	0.852	0.475	0.844	0.876	0.879	0.727	**0.908**
39	GunPoint	0.995	**1.000**	**1.000**	0.990	0.775	0.940	**1.000**	0.995	0.955	**1.000**
40	GunPointAgeSpan	0.836	0.985	0.985	0.989	0.978	0.919	0.992	0.989	0.931	**0.993**
41	GunPointMaleVersusFemale	0.998	0.996	0.998	0.996	0.980	0.989	**1.000**	**1.000**	0.991	**1.000**
42	GunPointOldVersusYoung	0.972	0.927	0.907	0.922	0.758	0.842	0.983	0.978	0.949	**0.987**
43	Ham	0.678	0.701	**0.794**	0.743	0.519	0.678	0.682	0.743	0.790	0.725
44	HandOutlines	0.887	0.892	0.892	0.876	0.639	0.713	0.875	0.909	0.901	**0.931**
45	Haptics	0.467	0.465	0.475	0.437	0.214	0.322	0.504	0.443	**0.577**	0.531
46	Herring	0.540	0.650	0.656	0.625	0.602	0.563	**0.691**	0.546	0.641	0.587
47	HouseTwenty	0.956	**0.994**	**0.994**	**0.994**	0.906	0.956	0.988	0.944	0.868	0.963
48	InlineSkate	0.462	0.565	0.557	0.518	0.168	0.389	0.526	0.469	0.589	**0.705**
49	InsectEPGRegularTrain	0.974	0.994	0.994	**0.997**	0.961	**0.997**	0.990	**0.997**	0.923	0.987
50	InsectEPGSmallTrain	0.974	0.970	0.974	0.959	0.778	0.966	0.993	**0.996**	0.929	**0.996**
51	InsectWingbeatSound	0.546	0.544	0.491	0.439	0.272	0.355	0.574	0.551	0.690	**0.746**
52	ItalyPowerDemand	0.972	0.973	0.975	0.976	0.958	0.789	0.974	0.973	0.960	**0.979**
53	LargeKitchenAppliances	0.919	0.936	0.939	0.919	0.624	0.937	0.931	**0.953**	0.792	**0.953**
54	Lightning2	0.794	0.726	0.605	0.713	0.661	0.636	0.754	0.636	0.777	**0.835**
55	Mallat	0.991	0.990	0.992	0.990	0.321	0.340	0.993	0.993	0.990	**0.995**
56	Meat	0.967	0.658	**0.975**	0.858	0.333	0.617	0.965	0.967	**0.975**	**0.975**
57	MedicalImages	0.763	0.777	0.787	0.753	0.521	0.589	0.790	0.795	0.742	**0.798**
58	MelbournePedestrian	0.912	0.903	0.904	0.903	0.738	0.564	0.921	0.920	0.854	**0.921**
59	MiddlePhalanxOutlineAgeGroup	0.742	0.753	0.740	0.758	0.729	0.671	0.746	0.746	0.760	**0.798**
60	MiddlePhalanxOutlineCorrect	0.837	0.798	0.804	0.721	0.622	0.682	0.845	0.835	0.806	**0.853**
61	MiddlePhalanxTW	0.609	0.615	0.626	0.612	0.597	0.584	0.621	0.642	0.611	**0.657**
62	MixedShapesRegularTrain	0.969	0.968	0.962	0.966	0.683	0.744	0.972	0.969	0.963	**0.974**
63	MixedShapesSmallTrain	0.962	0.966	0.969	0.955	0.742	0.587	0.972	0.969	0.965	**0.977**
64	MoteStrain	0.969	0.973	0.971	0.969	0.943	0.967	0.970	**0.974**	0.877	0.970
65	NonInvasiveFetalECGThorax1	0.299	0.395	0.403	0.081	0.052	0.109	0.491	0.200	**0.501**	0.444
66	NonInvasiveFetalECGThorax2	0.351	0.440	0.460	0.179	0.048	0.109	**0.632**	0.292	0.475	0.520
67	OSULeaf	0.973	0.959	0.955	0.881	0.479	0.880	0.975	0.975	0.831	**0.982**
68	PhalangesOutlinesCorrect	0.420	0.445	0.457	0.437	0.219	0.330	0.443	0.454	0.453	**0.477**
69	Phoneme	0.852	0.858	0.846	0.847	0.640	0.661	**0.873**	0.853	0.826	0.853
70	PLAID	0.367	0.407	0.405	0.398	0.212	**0.449**	0.435	0.396	0.392	0.396
71	Plane	**1.000**	**1.000**	**1.000**	**1.000**	0.514	0.914	**1.000**	**1.000**	**1.000**	**1.000**
72	PowerCons	0.867	0.881	0.869	0.856	0.800	0.853	**0.908**	0.869	0.847	0.889
73	ProximalPhalanxOutlineAgeGroup	0.850	0.843	0.840	0.841	0.787	0.700	0.845	0.845	0.817	**0.865**
74	ProximalPhalanxOutlineCorrect	0.887	0.877	**0.897**	0.884	0.690	0.668	0.894	0.889	0.856	0.873
75	ProximalPhalanxTW	0.759	0.804	0.807	0.804	0.728	0.640	0.814	0.810	0.831	**0.840**
76	RefrigerationDevices	0.603	0.689	0.720	0.693	0.544	0.731	0.700	0.703	0.620	**0.779**
77	ScreenType	0.693	0.717	0.724	0.720	0.431	0.625	0.687	**0.737**	0.597	0.720
78	SemgHandGenderCh2	0.891	0.848	0.853	0.859	0.678	0.792	0.890	0.898	0.874	**0.912**
79	SemgHandMovementCh2	0.623	0.586	0.600	0.548	0.271	0.409	0.614	0.627	0.648	**0.662**
80	SemgHandSubjectCh2	0.828	0.798	0.799	0.732	0.537	0.582	0.846	0.848	0.857	**0.858**
81	ShapeletSim	0.995	0.985	0.995	0.995	0.800	0.975	0.990	**1.000**	0.865	**1.000**
82	SmallKitchenAppliances	0.779	0.797	0.789	0.800	0.589	0.728	0.805	0.791	0.691	**0.827**
83	SmoothSubspace	0.967	0.960	0.967	0.957	0.913	0.723	0.977	**0.980**	0.740	0.970
84	SonyAIBORobotSurface1	0.995	0.997	0.995	0.995	0.978	**0.998**	**0.998**	0.997	0.995	**0.998**
85	SonyAIBORobotSurface2	**0.998**	0.994	0.995	0.995	0.981	0.992	0.989	0.997	0.980	0.996
86	StarLightCurves	0.978	0.979	0.978	0.979	0.850	0.979	0.977	**0.980**	**0.980**	0.979
87	Strawberry	0.963	0.959	0.954	0.954	0.700	0.686	0.967	0.968	0.952	**0.977**
88	SwedishLeaf	0.968	0.956	0.948	0.941	0.553	0.814	0.953	0.971	0.940	**0.979**
89	Symbols	0.995	0.994	**0.996**	0.935	0.929	0.830	0.994	0.995	0.966	0.992
90	SyntheticControl	0.987	**0.995**	0.990	0.992	0.988	0.987	0.985	0.990	0.955	0.988
91	ToeSegmentation1	0.971	0.951	0.940	0.952	0.951	**0.978**	0.974	0.974	0.892	**0.978**
92	ToeSegmentation2	0.910	0.885	0.855	0.861	0.807	0.880	0.921	0.918	0.910	**0.922**
93	Trace	**1.000**	**1.000**	**1.000**	**1.000**	0.635	0.990	**1.000**	**1.000**	**1.000**	**1.000**
94	TwoLeadECG	**1.000**	**1.000**	**1.000**	**1.000**	0.995	**1.000**	**1.000**	**1.000**	0.998	**1.000**
95	TwoPatterns	0.905	0.906	0.901	0.909	0.833	0.886	0.915	0.899	0.815	**0.918**
96	UMD	0.983	0.983	0.983	0.972	0.750	0.911	0.978	**0.994**	0.744	**0.994**
97	UWaveGestureLibraryAll	0.874	0.880	0.874	0.860	0.478	0.668	0.879	0.897	**0.944**	0.923
98	UWaveGestureLibraryX	0.806	0.760	0.769	0.745	0.564	0.437	0.793	**0.809**	0.720	0.795
99	UWaveGestureLibraryY	0.707	0.721	0.722	0.657	0.503	0.530	**0.729**	0.708	0.677	0.717
100	UWaveGestureLibraryZ	0.788	0.784	0.781	0.765	0.534	0.480	0.784	**0.795**	0.717	0.794
101	Wafer	0.999	0.999	0.999	0.999	0.894	0.913	0.999	**1.000**	0.999	1.000
102	Wine	**0.892**	0.797	0.813	0.783	0.495	0.514	0.788	0.838	0.755	0.829
103	WordSynonyms	0.467	0.465	0.427	0.387	0.223	0.401	0.487	0.467	**0.576**	0.505
104	Worms	0.721	0.632	0.636	0.648	0.508	0.675	**0.750**	0.732	0.609	0.658
105	WormsTwoClass	0.760	0.761	0.768	0.760	0.670	0.756	**0.783**	0.764	0.714	0.728
106	Yoga	0.906	0.923	0.924	0.928	0.596	0.792	0.935	0.926	0.896	**0.947**
	Avg Acc	0.839	0.840	0.842	0.823	0.610	0.716	0.852	0.847	0.818	**0.867**
	Avg Rank	4.97	4.68	4.61	5.84	9.55	8.19	3.82	3.23	6.21	**2.00**
	Training Time (hours)	**2.78**	11.07	20.15	22.56	3.62	128.78	136.62	6.00	3.48	9.81
	P-value	1.12E-08	7.48E-09	7.73E-08	8.57E-10	1.57E-26	2.55E-19	4.09E-04	2.17E-05	2.71E-13	-

Table 4: Detailed test classification accuracy compared to baselines on 106 UCR datasets with 40% labeling ratio.

ID	Dataset	TS-TFC	TS-T	w/o warmup	w/o queue	w/o contrasting	w/o curriculum
1	AllGestureWiimoteX	0.547	0.420	0.253	**0.565**	0.528	0.513
2	AllGestureWiimoteY	0.619	0.607	0.459	0.609	0.573	**0.624**
3	AllGestureWiimoteZ	0.543	0.511	0.467	0.508	0.508	**0.543**
4	ArrowHead	0.711	0.693	0.398	**0.749**	0.702	0.664
5	BME	0.694	0.656	0.667	0.634	0.661	**0.700**
6	Car	0.520	0.608	0.358	0.578	**0.708**	0.500
7	CBF	**0.999**	0.998	**0.999**	0.998	**0.999**	0.998
8	Chinatown	0.973	0.978	0.975	0.959	**0.978**	0.964
9	ChlorineConcentration	**0.744**	0.630	0.627	0.651	0.665	0.635
10	CinCECGTorso	**0.998**	0.957	0.992	0.946	0.911	0.940
11	Computers	**0.764**	0.752	0.642	0.750	0.708	0.694
12	CricketX	**0.590**	0.589	0.467	0.571	0.568	0.569
13	CricketY	0.540	0.544	0.387	**0.549**	0.537	0.537
14	CricketZ	**0.619**	0.572	0.396	0.568	0.592	0.566
15	Crop	**0.685**	0.676	0.651	0.668	0.667	0.655
16	DiatomSizeReduction	**0.975**	0.894	0.951	0.885	0.885	0.879
17	DistalPhalanxOutlineAgeGroup	**0.826**	0.818	0.801	0.796	0.813	0.796
18	DistalPhalanxOutlineCorrect	0.805	0.805	**0.812**	0.796	0.809	0.781
19	DistalPhalanxTW	0.742	**0.744**	0.731	0.731	0.742	**0.744**
20	DodgerLoopGame	**0.842**	0.791	0.733	0.781	0.715	0.783
21	DodgerLoopWeekend	0.849	0.860	**0.905**	0.830	0.817	0.834
22	Earthquakes	**0.790**	0.760	0.665	0.775	0.705	0.715
23	ECG200	**0.950**	0.946	0.935	0.947	0.944	0.936
24	ECG5000	0.996	0.998	**1.000**	0.993	0.998	0.997
25	ECGFiveDays	**0.459**	0.427	0.206	0.434	0.365	0.417
26	ElectricDevices	**0.443**	0.344	0.280	0.329	0.320	0.271
27	EOGHorizontalSignal	**0.801**	0.777	0.798	0.765	0.796	0.756
28	EOGVerticalSignal	**0.857**	0.855	0.776	0.855	0.845	0.837
29	EthanolLevel	0.580	0.582	0.251	0.588	0.527	**0.601**
30	FaceAll	0.933	**0.944**	0.662	0.936	0.912	0.938
31	FacesUCR	0.912	0.918	0.790	**0.929**	0.888	0.903
32	Fish	0.354	0.800	0.583	0.269	0.794	**0.806**
33	FordA	**0.907**	0.900	0.906	0.897	0.894	0.888
34	FordB	0.873	0.885	**0.890**	0.886	0.878	0.867
35	FreezerRegularTrain	0.997	0.997	0.998	0.998	**0.999**	0.988
36	FreezerSmallTrain	0.999	0.999	0.959	0.999	**0.999**	0.998
37	GesturePebbleZ1	0.434	0.424	0.397	0.455	**0.668**	0.631
38	GesturePebbleZ2	0.460	0.480	0.437	0.463	**0.629**	0.463
39	GunPoint	0.910	0.920	0.915	0.920	**0.970**	0.925
40	GunPointAgeSpan	**0.982**	0.978	0.889	0.888	0.796	0.829
41	GunPointMaleVersusFemale	**0.998**	0.993	**0.998**	0.983	0.976	0.987
42	GunPointOldVersusYoung	**0.985**	0.942	0.690	0.792	0.809	0.782
43	Ham	0.636	**0.650**	0.583	0.622	0.637	0.602
44	HandOutlines	**0.875**	0.829	0.777	0.820	0.794	0.819
45	Haptics	**0.370**	0.359	0.285	0.342	0.354	0.339
46	Herring	**0.618**	0.578	0.555	0.567	0.611	0.561
47	HouseTwenty	0.928	0.925	0.931	0.914	0.835	**0.937**
48	InlineSkate	**0.428**	0.363	0.331	0.339	0.305	0.326
49	InsectEPGRegularTrain	**0.962**	0.952	0.958	0.955	0.904	0.943
50	InsectEPGSmallTrain	**0.944**	0.925	0.922	0.923	0.937	0.918
51	InsectWingbeatSound	**0.547**	0.376	0.289	0.354	0.346	0.372
52	ItalyPowerDemand	**0.965**	0.964	0.961	0.957	0.937	0.959
53	LargeKitchenAppliances	0.843	0.873	0.891	**0.899**	0.852	0.888
54	Lightning2	**0.746**	0.620	0.637	0.607	0.611	0.634
55	Mallat	**0.988**	0.941	0.983	0.982	0.985	0.950
56	Meat	0.867	0.852	**0.933**	0.827	0.833	0.850
57	MedicalImages	0.637	0.600	0.571	0.594	**0.652**	0.594
58	MelbournePedestrian	0.864	0.864	0.826	**0.864**	0.850	0.862
59	MiddlePhalanxOutlineAgeGroup	0.731	**0.736**	0.735	0.722	0.713	0.731
60	MiddlePhalanxOutlineCorrect	**0.817**	0.773	0.618	0.752	0.774	0.764
61	MiddlePhalanxTW	0.579	0.579	**0.606**	0.566	0.553	0.583
62	MixedShapesRegularTrain	**0.959**	0.936	0.949	0.940	0.936	0.929
63	MixedShapesSmallTrain	**0.962**	0.949	0.955	0.933	0.927	0.949
64	MoteStrain	0.963	0.962	0.959	**0.969**	0.963	0.968
65	NonInvasiveFetalECGThorax1	**0.327**	0.278	0.133	0.213	0.326	0.272
66	NonInvasiveFetalECGThorax2	**0.457**	0.230	0.082	0.178	0.260	0.250
67	OSULeaf	**0.899**	0.876	0.831	0.852	0.853	0.874
68	PhalangesOutlinesCorrect	**0.332**	0.303	0.281	0.260	0.316	0.274
69	Phoneme	**0.799**	0.783	0.721	0.796	0.776	0.776
70	PLAID	0.290	**0.292**	0.172	0.278	0.276	0.284
71	Plane	0.817	0.857	0.657	0.857	**0.886**	0.852
72	PowerCons	0.811	0.803	0.775	0.808	0.797	**0.819**
73	ProximalPhalanxOutlineAgeGroup	0.826	**0.831**	0.826	0.820	0.822	0.830
74	ProximalPhalanxOutlineCorrect	0.842	0.839	**0.855**	0.824	0.778	0.822
75	ProximalPhalanxTW	0.775	**0.780**	0.722	0.775	0.754	0.770
76	RefrigerationDevices	0.567	**0.581**	0.559	0.575	0.547	0.563
77	ScreenType	0.521	0.503	0.464	**0.575**	0.515	0.459
78	SemgHandGenderCh2	**0.804**	0.700	0.791	0.692	0.764	0.798
79	SemgHandMovementCh2	0.423	0.393	0.306	0.385	0.349	**0.436**
80	SemgHandSubjectCh2	**0.691**	0.672	0.584	0.673	0.566	0.678
81	ShapeletSim	0.995	0.970	**1.000**	**1.000**	**1.000**	0.975
82	SmallKitchenAppliances	0.740	**0.753**	0.745	0.743	0.707	0.744
83	SmoothSubspace	0.897	0.907	**0.943**	0.903	0.890	0.897
84	SonyAIBORobotSurface1	0.994	0.989	**0.997**	0.984	0.994	0.992
85	SonyAIBORobotSurface2	0.991	0.990	0.988	0.986	**0.992**	0.985
86	StarLightCurves	**0.978**	0.941	0.902	0.905	0.976	0.937
87	Strawberry	**0.939**	0.936	0.928	0.932	0.919	0.922
88	SwedishLeaf	**0.877**	0.876	0.618	0.853	0.809	0.852
89	Symbols	0.989	0.995	**0.997**	0.995	0.988	**0.997**
90	SyntheticControl	0.980	**0.990**	**0.990**	0.985	0.987	**0.990**
91	ToeSegmentation1	0.896	0.881	0.851	0.878	0.871	**0.925**
92	ToeSegmentation2	0.777	0.819	0.795	0.812	**0.880**	0.831
93	Trace	0.935	0.930	0.995	**1.000**	**1.000**	0.935
94	TwoLeadECG	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
95	TwoPatterns	**0.883**	0.874	0.872	0.872	0.864	0.868
96	UMD	0.900	0.897	0.811	**0.936**	0.789	0.896
97	UWaveGestureLibraryAll	**0.892**	0.808	0.701	0.809	0.763	0.784
98	UWaveGestureLibraryX	**0.757**	0.746	0.592	0.744	0.727	0.749
99	UWaveGestureLibraryY	**0.647**	0.632	0.550	0.623	0.608	0.630
100	UWaveGestureLibraryZ	0.700	0.696	0.595	**0.715**	0.671	0.679
101	Wafer	**0.998**	0.957	0.894	0.947	0.967	0.947
102	Wine	0.583	**0.638**	0.487	0.626	0.571	0.610
103	WordSynonyms	**0.372**	0.365	0.258	0.357	0.357	0.339
104	Worms	0.574	**0.574**	0.362	0.562	0.558	0.538
105	WormsTwoClass	**0.686**	0.682	0.643	0.671	0.655	0.677
106	Yoga	**0.899**	0.827	0.598	0.814	0.820	0.812
	Avg Acc	**0.769**	0.754	0.696	0.744	0.746	0.747
	Avg Rank	**2.17**	2.79	4.34	3.56	3.85	3.78
	P-value	-	9.01E-03	2.66E-10	3.77E-02	4.10E-02	8.57E-04

Table 5: Detailed test classification accuracy of ablation study on 106 UCR time series datasets with 10% labeling ratio in time-domain view.

ID	Dataset	TS-TFC	TS-F	w/o contrasting	w/o curriculum	only amplitude	only phase
1	AllGestureWiimoteX	**0.547**	0.365	0.393	0.385	0.399	0.256
2	AllGestureWiimoteY	**0.619**	0.420	0.417	0.403	0.416	0.256
3	AllGestureWiimoteZ	**0.543**	0.425	0.398	0.410	0.454	0.240
4	ArrowHead	0.711	0.702	0.706	0.721	**0.728**	0.493
5	BME	0.694	0.661	0.656	0.633	0.628	**0.783**
6	Car	**0.520**	0.433	0.428	0.417	0.308	0.392
7	CBF	**0.999**	0.871	0.859	0.851	0.665	0.793
8	Chinatown	**0.973**	0.885	0.852	0.890	0.918	0.778
9	ChlorineConcentration	**0.744**	0.712	0.632	0.660	0.709	0.636
10	CinCECGTorso	0.998	0.998	0.988	**0.999**	0.990	0.994
11	Computers	**0.764**	0.682	0.662	0.634	0.674	0.566
12	CricketX	**0.590**	0.490	0.474	0.494	0.476	0.260
13	CricketY	**0.540**	0.392	0.453	0.378	0.444	0.228
14	CricketZ	**0.619**	0.472	0.465	0.447	0.472	0.236
15	Crop	**0.685**	0.611	0.591	0.609	0.509	0.546
16	DiatomSizeReduction	**0.975**	0.954	0.923	0.938	0.945	0.845
17	DistalPhalanxOutlineAgeGroup	**0.826**	0.781	0.779	0.774	0.772	0.789
18	DistalPhalanxOutlineCorrect	**0.805**	0.774	0.766	0.753	0.776	0.711
19	DistalPhalanxTW	**0.742**	0.735	0.716	0.726	0.718	0.696
20	DodgerLoopGame	0.842	0.817	0.805	0.854	**0.861**	0.689
21	DodgerLoopWeekend	**0.849**	0.759	0.764	**0.849**	0.758	0.785
22	Earthquakes	**0.790**	0.745	0.715	0.700	0.750	0.630
23	ECG200	**0.950**	0.941	0.940	0.946	0.938	0.925
24	ECG5000	0.996	**1.000**	0.997	**1.000**	**1.000**	0.907
25	ECGFiveDays	**0.459**	0.403	0.402	0.428	0.388	0.278
26	ElectricDevices	**0.443**	0.351	0.351	0.337	0.340	0.293
27	EOGHorizontalSignal	**0.801**	0.798	0.790	0.798	0.783	0.787
28	EOGVerticalSignal	**0.857**	0.729	0.718	0.723	0.727	0.546
29	EthanolLevel	**0.580**	0.320	0.327	0.328	0.346	0.312
30	FaceAll	**0.933**	0.816	0.735	0.799	0.829	0.572
31	FacesUCR	**0.912**	0.830	0.791	0.772	0.785	0.611
32	Fish	0.354	0.326	0.326	0.514	**0.559**	0.466
33	FordA	**0.907**	0.866	0.861	0.869	0.868	0.651
34	FordB	**0.873**	0.808	0.804	0.844	0.823	0.635
35	FreezerRegularTrain	**0.997**	0.986	0.978	0.986	0.995	0.816
36	FreezerSmallTrain	**0.999**	0.985	0.977	0.987	0.978	0.825
37	GesturePebbleZ1	**0.434**	0.378	0.378	0.253	0.266	0.204
38	GesturePebbleZ2	**0.460**	0.293	0.289	0.289	0.368	0.243
39	GunPoint	**0.910**	0.740	0.600	0.765	0.780	0.655
40	GunPointAgeSpan	**0.982**	0.758	0.570	0.776	0.820	0.632
41	GunPointMaleVersusFemale	**0.998**	0.973	0.962	0.971	0.960	0.829
42	GunPointOldVersusYoung	**0.985**	0.843	0.834	0.840	0.922	0.690
43	Ham	**0.636**	0.542	0.513	0.523	0.535	0.532
44	HandOutlines	**0.875**	0.830	0.818	0.837	0.839	0.738
45	Haptics	0.370	0.380	**0.410**	0.365	0.410	0.259
46	Herring	0.618	0.593	0.617	0.577	**0.627**	0.555
47	HouseTwenty	**0.928**	0.906	0.748	0.862	0.787	0.616
48	InlineSkate	**0.428**	0.286	0.337	0.279	0.279	0.228
49	InsectEPGRegularTrain	**0.962**	0.737	0.785	0.792	0.708	0.727
50	InsectEPGSmallTrain	**0.944**	0.820	0.820	0.839	0.805	0.767
51	InsectWingbeatSound	0.547	**0.576**	0.545	0.546	0.547	0.482
52	ItalyPowerDemand	**0.965**	0.949	0.938	0.938	0.938	0.912
53	LargeKitchenAppliances	**0.843**	0.671	0.689	0.671	0.669	0.412
54	Lightning2	**0.746**	0.554	0.620	0.613	0.537	0.628
55	Mallat	0.988	0.989	0.980	**0.991**	0.974	0.958
56	Meat	**0.867**	0.767	0.742	0.767	0.813	0.742
57	MedicalImages	**0.637**	0.614	0.608	0.636	0.586	0.558
58	MelbournePedestrian	**0.864**	0.781	0.760	0.764	0.737	0.637
59	MiddlePhalanxOutlineAgeGroup	**0.731**	0.715	0.702	0.713	0.692	0.653
60	MiddlePhalanxOutlineCorrect	**0.817**	0.708	0.706	0.707	0.709	0.682
61	MiddlePhalanxTW	0.579	**0.588**	0.557	0.568	0.569	0.515
62	MixedShapesRegularTrain	**0.959**	0.945	0.942	0.952	0.888	0.802
63	MixedShapesSmallTrain	**0.962**	0.941	0.929	0.942	0.887	0.773
64	MoteStrain	**0.963**	0.800	0.784	0.807	0.793	0.806
65	NonInvasiveFetalECGThorax1	0.327	0.379	0.537	0.342	**0.555**	0.132
66	NonInvasiveFetalECGThorax2	0.457	0.464	**0.603**	0.451	0.583	0.163
67	OSULeaf	**0.899**	0.679	0.677	0.659	0.683	0.315
68	PhalangesOutlinesCorrect	0.332	0.319	**0.366**	0.317	0.287	0.320
69	Phoneme	**0.799**	0.748	0.752	0.740	0.738	0.696
70	PLAID	**0.290**	0.262	0.248	0.255	0.243	0.195
71	Plane	0.817	0.786	0.738	0.767	**0.862**	0.257
72	PowerCons	**0.811**	0.714	0.728	0.731	0.736	0.619
73	ProximalPhalanxOutlineAgeGroup	**0.826**	**0.826**	0.822	**0.826**	0.793	0.820
74	ProximalPhalanxOutlineCorrect	**0.842**	0.758	0.758	0.760	0.825	0.734
75	ProximalPhalanxTW	**0.775**	0.752	0.741	0.757	0.762	0.722
76	RefrigerationDevices	**0.567**	0.465	0.505	0.459	0.477	0.397
77	ScreenType	**0.521**	0.472	0.471	0.463	0.472	0.345
78	SemgHandGenderCh2	**0.804**	0.756	0.738	0.619	0.733	0.747
79	SemgHandMovementCh2	**0.423**	0.387	0.396	0.398	0.378	0.376
80	SemgHandSubjectCh2	**0.691**	0.687	0.670	0.682	0.666	0.642
81	ShapeletSim	**0.995**	0.685	0.735	0.695	0.680	0.505
82	SmallKitchenAppliances	**0.740**	0.620	0.609	0.627	0.611	0.561
83	SmoothSubspace	**0.897**	0.567	0.640	0.597	0.413	0.597
84	SonyAIBORobotSurface1	**0.994**	0.973	0.968	0.984	0.971	0.839
85	SonyAIBORobotSurface2	**0.991**	0.924	0.932	0.926	0.920	0.852
86	StarLightCurves	**0.978**	0.975	0.975	0.879	0.967	0.823
87	Strawberry	**0.939**	0.885	0.888	0.902	0.923	0.897
88	SwedishLeaf	**0.877**	0.807	0.716	0.745	0.806	0.356
89	Symbols	**0.989**	0.935	0.930	0.878	0.934	0.823
90	SyntheticControl	**0.980**	0.895	0.868	0.872	0.642	0.585
91	ToeSegmentation1	**0.896**	0.777	0.761	0.773	0.769	0.538
92	ToeSegmentation2	0.777	0.820	0.802	0.808	**0.823**	0.585
93	Trace	0.935	**0.990**	0.875	0.980	0.985	0.560
94	TwoLeadECG	**1.000**	0.992	0.995	0.990	0.987	0.708
95	TwoPatterns	**0.883**	0.634	0.627	0.615	0.517	0.392
96	UMD	**0.900**	0.683	0.650	0.661	0.672	0.522
97	UWaveGestureLibraryAll	**0.892**	0.871	0.823	0.860	0.726	0.741
98	UWaveGestureLibraryX	**0.757**	0.625	0.604	0.615	0.453	0.529
99	UWaveGestureLibraryY	**0.647**	0.563	0.558	0.569	0.465	0.496
100	UWaveGestureLibraryZ	**0.700**	0.597	0.592	0.605	0.486	0.487
101	Wafer	**0.998**	0.998	0.997	0.998	0.996	0.989
102	Wine	**0.583**	0.523	0.495	0.468	0.468	0.459
103	WordSynonyms	**0.372**	0.364	0.360	0.361	0.350	0.305
104	Worms	**0.574**	0.431	0.425	0.396	0.427	0.388
105	WormsTwoClass	**0.686**	0.613	0.593	0.508	0.578	0.504
106	Yoga	**0.899**	0.814	0.794	0.802	0.797	0.635
	Avg Acc	**0.769**	0.694	0.685	0.687	0.682	0.581
	Avg Rank	**1.35**	2.88	3.98	3.41	3.69	5.52
	P-value	-	1.47E-17	2.57E-17	1.33E-18	9.78E-14	2.51E-27

Table 6: Detailed test classification accuracy of ablation study on 106 UCR time series datasets with 10% labeling ratio in frequency-domain view.

ID	Dataset	Numbers	Length	Classes	Contrastive loss weight in temporal encoder									
					0.0001	0.001	0.005	0.01	0.05	0.1	0.5	1	10	20
1	GunPoint	200	150	2	0.740	0.820	0.855	0.895	0.910	**0.930**	0.920	0.905	0.880	0.710
2	Trace	200	275	4	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	0.770	0.730
3	ArrowHead	211	251	3	0.692	0.683	0.706	0.688	0.683	**0.726**	0.711	0.726	0.711	0.564
4	Fish	350	463	7	0.831	**0.834**	0.257	0.369	0.789	0.794	0.383	0.371	0.194	0.177
5	OSULeaf	442	427	6	0.887	0.885	0.883	0.876	**0.894**	0.851	0.883	0.856	0.727	0.639
6	DistalPhalanxOutlineAgeGroup	539	80	3	0.798	0.827	0.813	0.803	0.803	0.805	**0.829**	0.764	0.772	0.770
7	MiddlePhalanxTW	553	80	6	0.584	0.581	**0.597**	0.582	0.577	0.595	0.593	0.597	0.499	0.449
8	EOGVerticalSignal	724	1250	12	0.247	0.224	0.257	0.290	**0.367**	0.314	0.272	0.272	0.218	0.217
9	CricketX	780	300	12	0.581	0.563	**0.590**	0.571	0.580	0.565	0.414	0.396	0.328	0.290
10	DistalPhalanxOutlineCorrect	876	80	2	0.783	**0.804**	0.784	0.800	0.789	0.800	0.787	0.774	0.782	0.767
11	WordSynonyms	905	270	25	**0.362**	0.361	0.351	0.353	0.347	0.336	0.274	0.269	0.204	0.206
12	CBF	930	128	3	0.999	0.999	0.999	**1.000**	0.998	0.998	0.999	0.998	0.997	0.996
13	EthanolLevel	1004	1751	4	0.522	0.527	0.519	0.615	**0.621**	0.256	0.262	0.248	0.250	0.255
14	ItalyPowerDemand	1096	24	2	**0.965**	0.964	0.964	0.964	0.960	0.959	0.958	0.958	0.957	0.955
15	InsectWingbeatSound	2200	256	11	0.377	0.375	0.375	0.382	**0.383**	0.371	0.282	0.254	0.211	0.189
16	MixedShapesRegularTrain	2925	1024	5	0.935	0.940	0.939	0.941	0.942	0.938	0.941	**0.945**	0.819	0.801
17	MelbournePedestrian	3650	24	10	0.866	0.870	0.862	0.866	0.872	**0.872**	0.868	0.866	0.799	0.694
18	ECG5000	5000	140	5	**0.948**	0.946	0.946	0.946	0.945	0.947	0.944	0.941	0.933	0.932
AVG Acc					0.729	0.733	0.705	0.719	**0.748**	0.725	0.684	0.674	0.614	0.574
AVG Rank					4.06	4.06	4.22	3.94	**3.72**	3.94	4.44	6.00	8.50	9.78

Table 7: The influence of the contrastive loss weights λ on the classification performance of the time series datasets with a 10% labeling ratio in the temporal encoder. Among them, the temperature coefficient τ is set to 50, the hyperparameter top k is set to 10.

ID	Dataset	Numbers	Length	Classes	Contrastive loss weight in frequency encoder									
					0.0001	0.001	0.005	0.01	0.05	0.1	0.5	1	10	20
1	GunPoint	200	150	2	0.770	0.780	0.710	0.725	**0.785**	0.745	0.705	0.725	0.740	0.710
2	Trace	200	275	4	0.935	**1.000**	**1.000**	**1.000**	0.940	0.990	0.985	0.995	0.570	0.900
3	ArrowHead	211	251	3	0.697	0.745	0.730	**0.749**	0.730	0.716	0.692	0.744	0.716	0.731
4	Fish	350	463	7	0.523	0.257	0.283	0.574	0.543	**0.580**	0.537	0.486	0.403	0.283
5	OSULeaf	442	427	6	0.681	0.681	0.708	0.663	0.708	0.699	0.684	**0.736**	0.661	0.679
6	DistalPhalanxOutlineAgeGroup	539	80	3	**0.789**	0.783	0.783	0.764	0.783	0.783	0.750	0.765	0.774	0.766
7	MiddlePhalanxTW	553	80	6	0.577	0.591	0.591	0.577	0.590	0.579	0.579	0.590	**0.602**	0.566
8	EOGVerticalSignal	724	1250	12	0.373	0.350	0.318	**0.384**	0.351	0.304	0.271	0.224	0.155	0.169
9	CricketX	780	300	12	0.472	0.458	0.465	0.480	**0.505**	0.487	0.476	0.473	0.228	0.218
10	DistalPhalanxOutlineCorrect	876	80	2	0.749	0.738	0.756	0.724	0.745	0.752	0.767	0.772	0.772	**0.775**
11	WordSynonyms	905	270	25	0.358	0.343	0.360	**0.374**	0.357	0.368	0.311	0.283	0.290	0.213
12	CBF	930	128	3	0.858	0.847	0.868	0.848	0.861	0.861	**0.897**	0.896	0.874	0.874
13	EthanolLevel	1004	1751	4	0.302	0.314	0.305	0.322	**0.323**	0.313	0.297	0.265	0.257	0.250
14	ItalyPowerDemand	1096	24	2	0.949	0.947	0.945	0.950	0.950	0.948	**0.956**	0.944	0.948	0.950
15	InsectWingbeatSound	2200	256	11	0.550	0.535	0.546	**0.567**	0.561	0.567	0.533	0.441	0.238	0.197
16	MixedShapesRegularTrain	2925	1024	5	0.947	0.942	**0.948**	0.946	0.945	0.942	0.942	0.935	0.918	0.911
17	MelbournePedestrian	3650	24	10	0.770	0.778	0.778	**0.783**	0.774	0.777	0.777	0.773	0.749	0.740
18	ECG5000	5000	140	5	0.940	0.939	0.941	**0.944**	0.941	0.940	0.943	0.941	0.931	0.930
AVG Acc					0.680	0.668	0.669	0.687	**0.688**	0.686	0.672	0.666	0.601	0.603
AVG Rank					5.50	5.28	4.50	3.89	**3.78**	4.50	5.61	5.78	7.17	7.72

Table 8: The influence of the contrastive loss weights μ on the classification performance of the time series datasets with a 10% labeling ratio in the frequency encoder. Among them, the temperature coefficient τ is set to 50, and the hyperparameter top k is set to 10.

ID	Dataset	Numbers	Length	Classes	Temperature coefficient in temporal encoder									
					0.01	0.1	0.5	1	5	10	20	50	100	1000
1	GunPoint	200	150	2	0.755	0.865	0.875	0.915	0.920	0.910	0.910	**0.925**	0.845	0.895
2	Trace	200	275	4	0.435	0.950	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	0.980	**1.000**
3	ArrowHead	211	251	3	0.607	0.559	0.716	0.702	0.521	0.478	0.697	0.659	**0.725**	0.711
4	Fish	350	463	7	0.143	0.143	0.220	0.226	0.263	0.249	0.774	0.797	**0.811**	0.591
5	OSULeaf	442	427	6	0.382	0.371	0.505	**0.899**	0.887	0.892	0.894	0.876	0.883	0.835
6	DistalPhalanxOutlineAgeGroup	539	80	3	0.796	0.796	**0.829**	0.814	0.805	0.787	0.816	0.807	0.820	0.805
7	MiddlePhalanxTW	553	80	6	0.374	0.568	0.591	0.575	0.593	0.595	0.595	0.586	0.570	**0.602**
8	EOGVerticalSignal	724	1250	12	0.176	0.222	0.225	0.322	0.231	0.239	0.313	**0.325**	0.284	0.171
9	CricketX	780	300	12	0.176	0.235	0.563	0.555	**0.565**	0.562	0.560	0.564	0.559	0.265
10	DistalPhalanxOutlineCorrect	876	80	2	0.802	0.795	0.804	0.796	**0.808**	0.789	0.790	0.806	0.788	0.798
11	WordSynonyms	905	270	25	0.202	0.273	0.287	0.318	0.346	0.333	0.338	0.317	**0.348**	0.313
12	CBF	930	128	3	0.951	0.998	**1.000**	**1.000**	**1.000**	**1.000**	0.999	0.998	0.999	0.998
13	EthanolLevel	1004	1751	4	0.249	0.257	0.259	0.255	0.335	0.433	0.272	0.590	0.604	**0.626**
14	ItalyPowerDemand	1096	24	2	0.964	**0.968**	0.964	0.962	0.959	0.965	0.960	0.963	0.958	0.963
15	InsectWingbeatSound	2200	256	11	0.171	0.288	0.359	0.322	**0.389**	0.370	0.345	0.368	0.380	0.318
16	MixedShapesRegularTrain	2925	1024	5	0.851	0.940	0.943	0.941	0.941	0.941	0.946	**0.948**	0.944	0.936
17	MelbournePedestrian	3650	24	10	0.783	0.864	0.869	0.866	0.868	0.869	**0.875**	0.868	0.863	0.844
18	ECG5000	5000	140	5	0.924	0.940	0.945	0.944	0.946	0.944	**0.948**	0.945	0.945	0.945
AVG Acc					0.541	0.613	0.664	0.690	0.688	0.686	0.724	**0.741**	0.739	0.701
AVG Rank					8.83	7.94	4.50	4.94	3.89	4.61	**3.78**	**3.78**	4.89	5.61

Table 9: The influence of the temperature coefficient τ on the classification performance of the time series datasets with a 10% labeling ratio in the temporal encoder. Among them, the contrastive loss weight λ is set to 0.05, and the hyperparameter top k is set to 10.

ID	Dataset	Numbers	Length	Classes	Temperature coefficient in frequency encoder									
					0.01	0.1	0.5	1	5	10	20	50	100	1000
1	GunPoint	200	150	2	0.640	0.720	0.780	0.780	0.660	0.785	**0.800**	0.745	0.770	0.760
2	Trace	200	275	4	0.550	**1.000**	**1.000**	0.995	0.990	**1.000**	**1.000**	**1.000**	0.890	0.830
3	ArrowHead	211	251	3	0.555	0.526	0.673	**0.797**	0.782	0.783	0.763	0.749	0.744	0.706
4	Fish	350	463	7	0.169	0.237	0.251	0.223	0.317	0.314	0.537	0.494	0.494	**0.600**
5	OSULeaf	442	427	6	0.362	0.364	0.670	0.665	0.683	0.686	0.686	**0.695**	0.695	0.588
6	DistalPhalanxOutlineAgeGroup	539	80	3	0.696	0.788	0.768	0.783	**0.792**	0.774	0.777	0.759	0.783	0.768
7	MiddlePhalanxTW	553	80	6	0.502	**0.602**	0.590	0.588	0.579	0.600	0.597	0.575	0.597	0.575
8	EOGVerticalSignal	724	1250	12	0.193	0.123	0.157	0.340	0.351	**0.384**	0.349	0.343	0.358	0.275
9	CricketX	780	300	12	0.178	0.309	0.477	0.381	0.458	0.459	0.467	**0.485**	0.439	0.237
10	DistalPhalanxOutlineCorrect	876	80	2	0.763	0.754	0.756	**0.777**	0.750	0.761	0.755	0.772	0.748	0.740
11	WordSynonyms	905	270	25	0.202	0.250	0.343	0.362	0.362	0.339	0.340	0.359	**0.399**	0.392
12	CBF	930	128	3	0.655	**0.882**	0.844	0.867	0.859	0.856	0.848	0.867	0.869	0.857
13	EthanolLevel	1004	1751	4	0.277	0.298	0.302	0.308	0.317	0.315	0.293	0.317	0.312	**0.336**
14	ItalyPowerDemand	1096	24	2	0.952	**0.954**	0.951	**0.954**	0.951	0.951	**0.954**	0.953	0.953	0.944
15	InsectWingbeatSound	2200	256	11	0.095	0.562	0.560	0.560	0.571	0.565	0.551	**0.573**	**0.573**	0.456
16	MixedShapesRegularTrain	2925	1024	5	0.551	0.947	0.946	0.936	**0.950**	0.947	0.948	0.947	0.941	0.936
17	MelbournePedestrian	3650	24	10	0.513	0.771	0.774	0.771	0.771	0.779	0.763	**0.780**	0.772	0.757
18	ECG5000	5000	140	5	0.937	0.939	0.940	**0.942**	0.939	0.941	0.941	0.939	0.942	0.940
AVG Acc					0.488	0.612	0.654	0.668	0.671	0.680	**0.687**	0.686	0.682	0.650
AVG Rank					9.22	5.94	5.83	4.67	4.83	**3.94**	4.39	**3.94**	4.06	6.83

Table 10: The influence of the temperature coefficient τ on the classification performance of the time series datasets with a 10% labeling ratio in the frequency encoder. Among them, the contrastive loss weight λ is set to 0.05, and the hyperparameter top k is set to 10.

ID	Dataset	Numbers	Length	Classes	Top k in temporal embeddings								
					2	5	10	15	20	30	40	50	80
1	GunPoint	200	150	2	0.895	**0.925**	0.910	0.920	0.905	**0.925**	0.910	0.710	**0.925**
1.000	0.975	0.920	0.985	0.920	**1.000**	0.935	0.915						
3	ArrowHead	211	251	3	0.659	0.674	0.692	**0.730**	0.702	0.650	0.697	0.693	0.721
4	Fish	350	463	7	0.343	0.754	0.803	0.760	0.754	0.791	0.774	**0.823**	0.771
5	OSULeaf	442	427	6	0.548	**0.892**	0.876	0.883	0.885	0.878	0.883	0.824	0.871
6	DistalPhalanxOutlineAgeGroup	539	80	3	**0.816**	0.811	0.800	0.809	0.809	0.779	**0.816**	0.768	0.798
7	MiddlePhalanxTW	553	80	6	0.595	0.593	0.561	**0.604**	0.590	0.573	0.568	0.588	0.588
8	EOGVerticalSignal	724	1250	12	0.162	0.358	**0.361**	0.253	0.327	0.316	0.330	0.343	0.214
9	CricketX	780	300	12	0.551	0.556	**0.581**	0.563	0.569	0.560	0.567	0.567	0.568
10	DistalPhalanxOutlineCorrect	876	80	2	0.806	0.807	**0.814**	0.797	0.789	0.791	0.798	0.787	0.797
11	WordSynonyms	905	270	25	0.327	0.340	0.327	0.339	**0.369**	0.354	0.341	0.326	0.344
12	CBF	930	128	3	0.994	**0.999**	0.998	0.998	0.998	0.998	**0.999**	0.998	0.998
13	EthanolLevel	1004	1751	4	0.423	0.602	0.610	0.568	**0.622**	0.574	0.593	0.600	0.585
14	ItalyPowerDemand	1096	24	2	0.964	0.956	0.963	0.956	**0.964**	0.956	0.963	0.962	0.959
15	InsectWingbeatSound	2200	256	11	0.328	0.372	0.374	0.388	0.372	**0.389**	0.382	0.368	0.373
16	MixedShapesRegularTrain	2925	1024	5	0.925	0.935	0.941	0.942	0.934	0.939	0.936	**0.945**	0.935
17	MelbournePedestrian	3650	24	10	0.833	**0.873**	0.869	0.863	0.866	0.869	0.871	0.867	0.866
18	ECG5000	5000	140	5	0.935	0.945	0.945	**0.947**	0.946	0.946	0.946	0.946	0.946
AVG Acc					0.672	0.744	**0.744**	0.735	0.744	0.734	0.743	0.725	0.732
AVG Rank					6.89	4.00	4.11	4.56	4.11	5.17	**3.56**	5.39	5.06

Table 11: The influence of the hyperparameter top k on the classification performance of the time series datasets with a 10% labeling ratio in the temporal encoder. Among them, the contrastive loss weight λ is set to 0.05, and the temperature coefficient τ is set to 50.

ID	Dataset	Numbers	Length	Classes	Top k in frequency embeddings								
					2	5	10	15	20	30	40	50	80
1	GunPoint	200	150	2	0.765	0.775	0.765	0.735	**0.835**	0.755	0.825	0.745	0.750
2	Trace	200	275	4	0.940	0.935	**0.990**	0.935	**0.990**	0.935	**0.990**	0.950	**0.990**
3	ArrowHead	211	251	3	0.754	0.749	0.759	0.764	0.730	0.764	0.731	0.730	**0.769**
4	Fish	350	463	7	**0.577**	0.540	0.554	0.543	0.551	0.551	0.566	0.514	0.451
5	OSULeaf	442	427	6	0.643	0.674	0.672	**0.731**	0.677	0.706	0.647	0.711	0.684
6	DistalPhalanxOutlineAgeGroup	539	80	3	0.789	0.757	0.789	0.774	0.770	0.764	0.794	**0.803**	0.770
7	MiddlePhalanxTW	553	80	6	0.390	**0.608**	0.535	**0.608**	0.599	0.608	0.588	0.597	0.584
8	EOGVerticalSignal	724	1250	12	**0.355**	0.327	0.351	0.344	0.343	0.339	0.351	0.352	0.352
9	CricketX	780	300	12	0.428	0.476	0.471	0.490	0.490	0.494	0.478	**0.500**	0.494
10	DistalPhalanxOutlineCorrect	876	80	2	0.776	0.765	0.761	0.760	0.771	0.773	0.740	**0.785**	0.774
11	WordSynonyms	905	270	25	0.361	0.367	0.327	0.333	0.369	0.355	**0.386**	0.376	0.358
12	CBF	930	128	3	0.824	0.872	0.881	0.866	0.856	0.887	0.865	0.875	**0.895**
13	EthanolLevel	1004	1751	4	0.331	0.311	0.304	0.317	0.324	**0.336**	0.332	0.299	0.302
14	ItalyPowerDemand	1096	24	2	0.947	0.951	0.945	0.946	0.950	0.953	0.948	**0.954**	0.948
15	InsectWingbeatSound	2200	256	11	0.538	0.566	0.561	0.559	0.570	0.569	**0.580**	0.560	0.568
16	MixedShapesRegularTrain	2925	1024	5	0.924	0.945	0.945	0.948	0.948	0.946	**0.952**	0.945	0.947
17	MelbournePedestrian	3650	24	10	0.760	0.775	0.781	0.780	**0.784**	0.781	0.780	0.778	0.780
18	ECG5000	5000	140	5	0.933	0.942	0.941	0.942	0.939	**0.943**	0.943	0.938	0.942
AVG Acc					0.669	0.685	0.685	0.687	**0.694**	0.692	0.694	0.690	0.687
AVG Rank					6.11	5.67	5.56	5.39	4.28	**3.89**	4.00	4.78	4.28

Table 12: The influence of the hyperparameter top k on the classification performance of the time series datasets with a 10% labeling ratio in the frequency encoder. Among them, the contrastive loss weight λ is set to 0.05, and the temperature coefficient τ is set to 50.