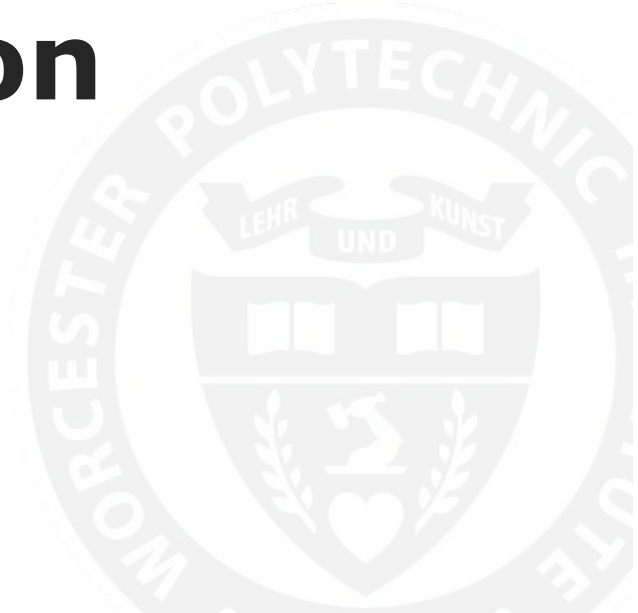
WPI

ECG Classification

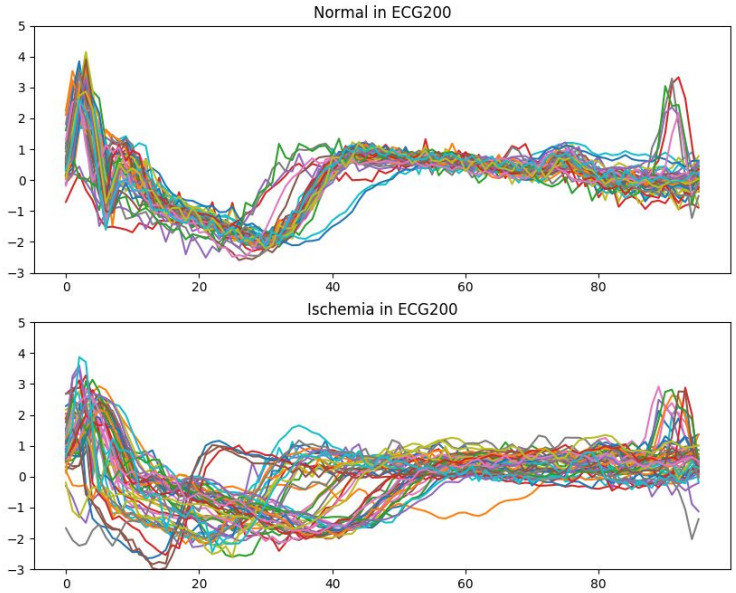
Yudong Yu

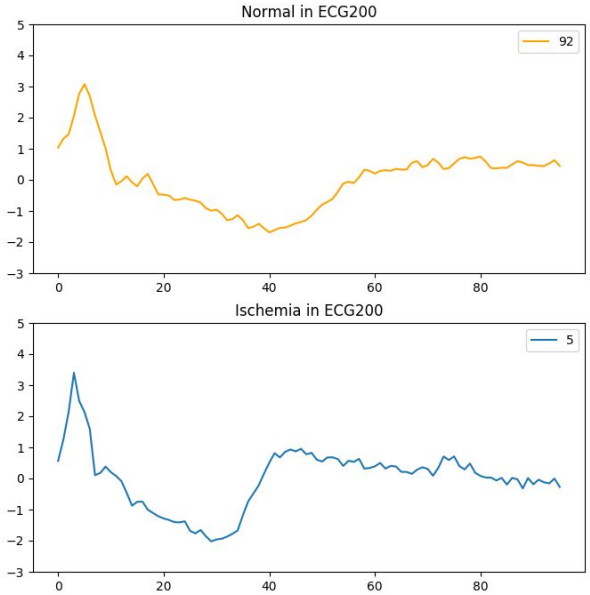


- **Background**
- **Methodology**
- **Analysis**

Background

- The electrocardiogram (ECG) is a diagnostic tool that is routinely used to assess the electrical and muscular functions of the heart.





Training set:
69 / 31

Test set:
64 / 36

Methodology

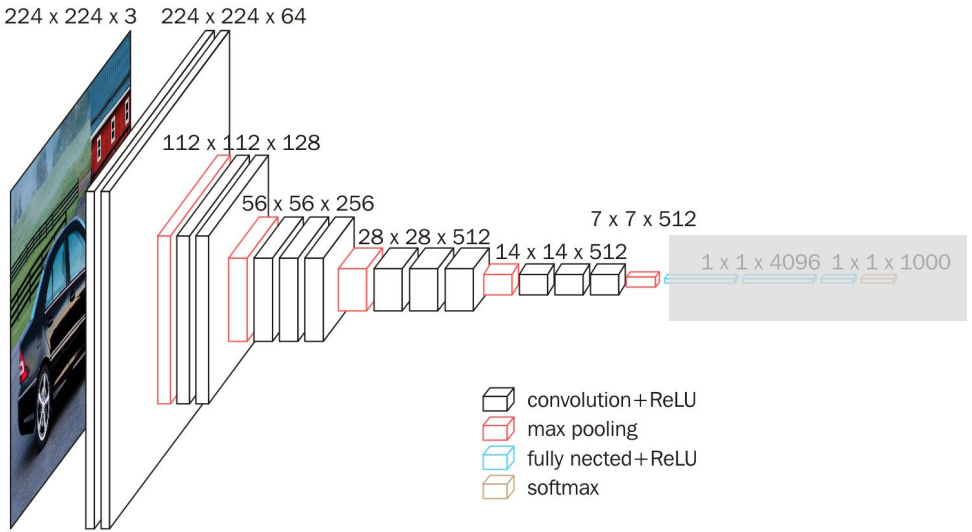
VGG16 + SVM

Fine-tuning VGG16

1. Feature Extractor

VGG16

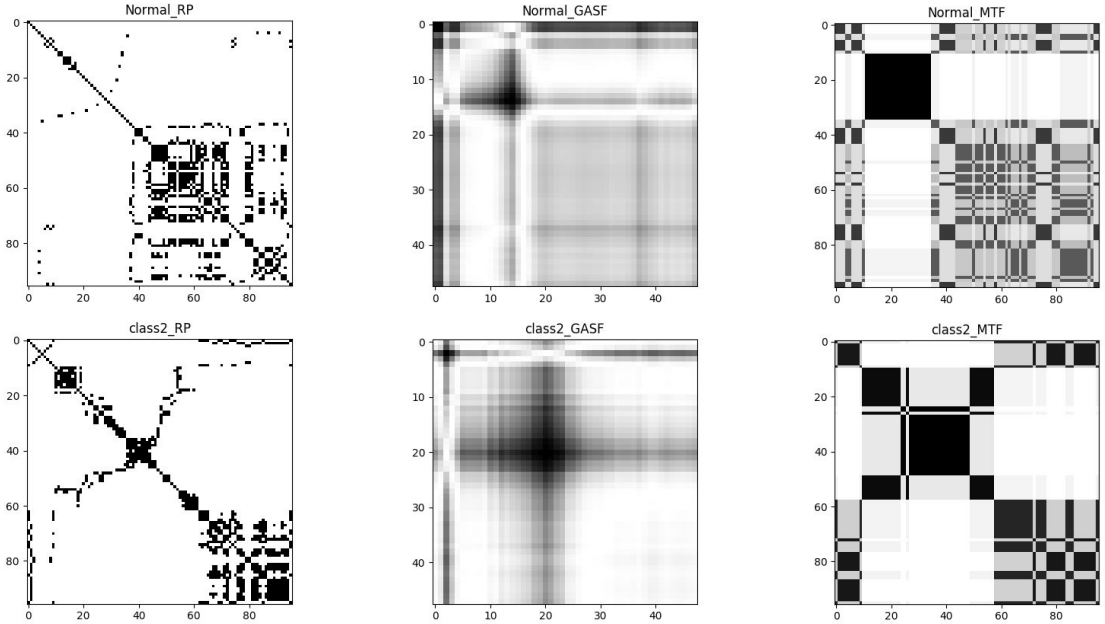
a. VGG16(include_top=False) + Fully-connected layer(128)



1. Feature Extractor

a. VGG16(include_top=False) + Fully-connected layer(128)

b. **Transform** time series signal to **image** (*RP + GASF + MTF*)



Recurrence plots; Gramian Angular Summation Field; Markov transition fields;

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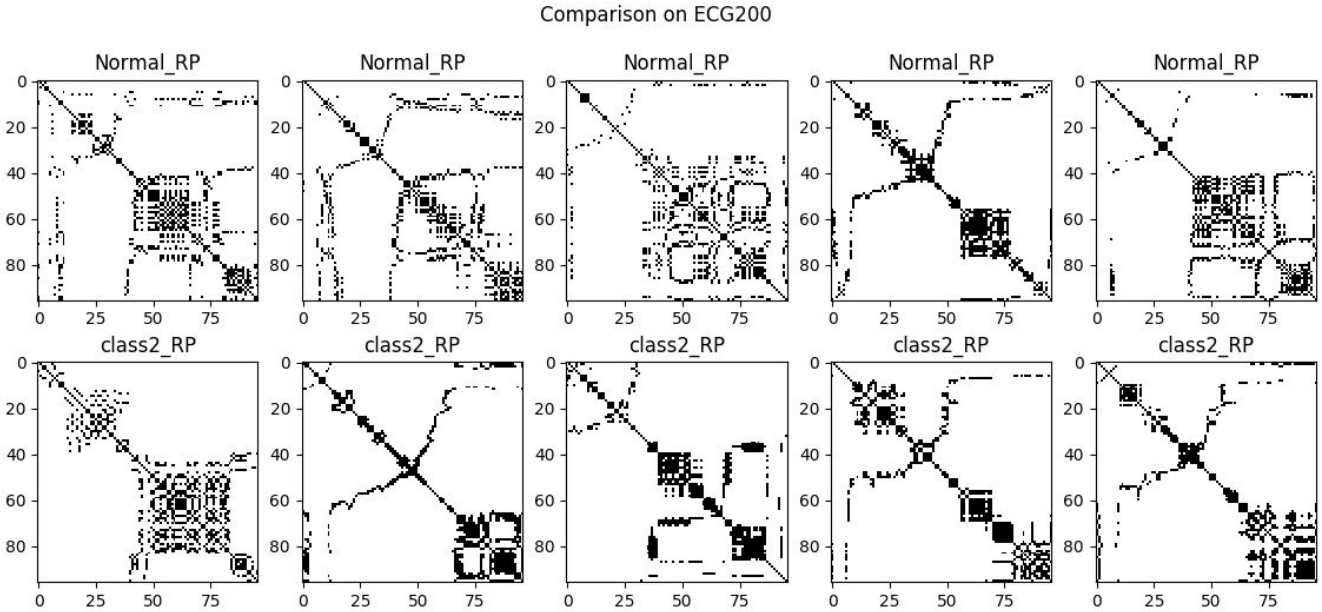
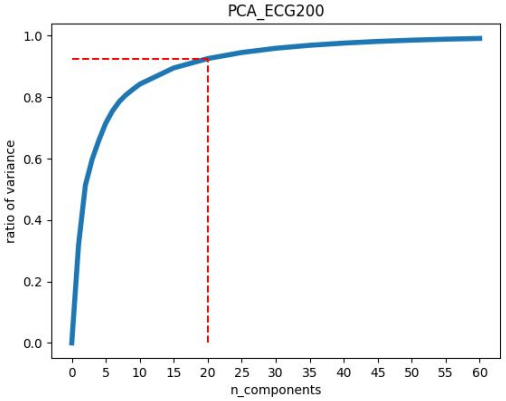
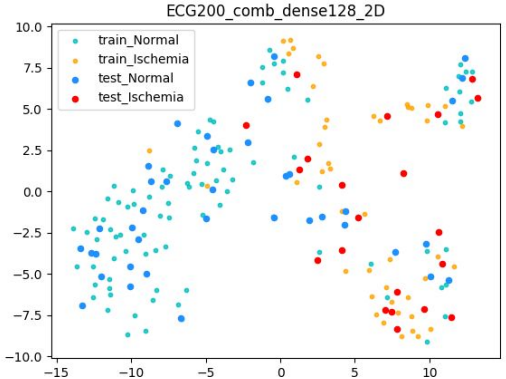
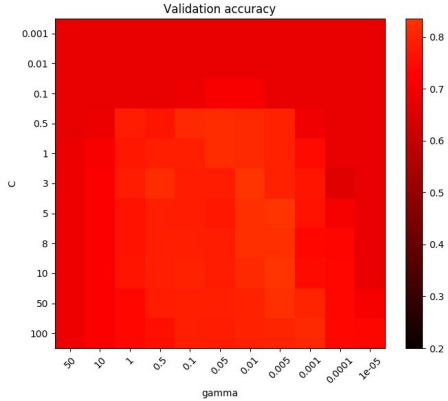


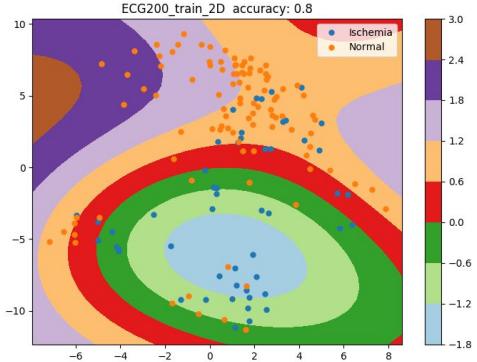
Recurrence plots; Gramian Angular Summation Field; Markov transition fields;

2. Dimensionality Reduction



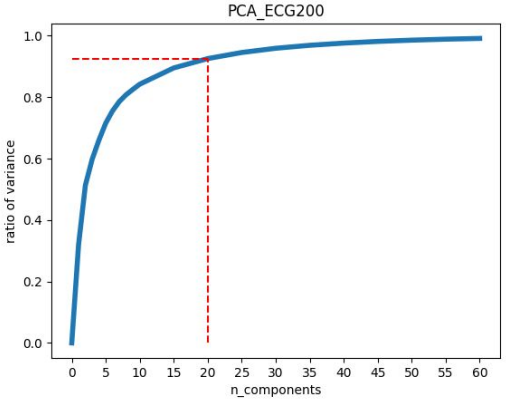


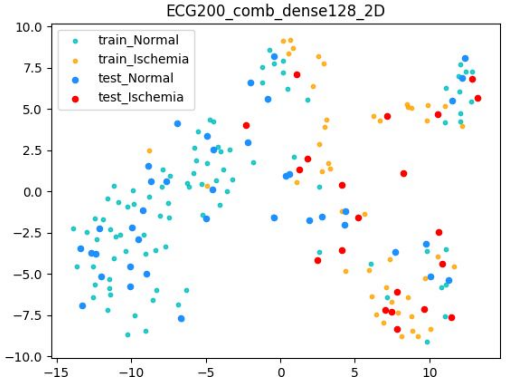


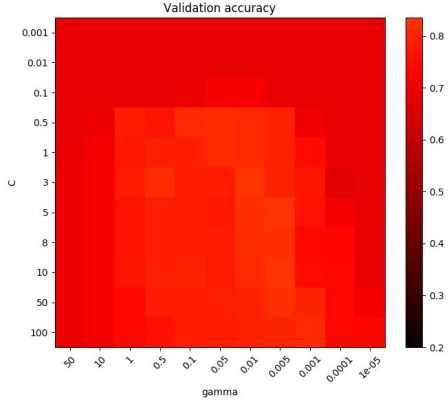


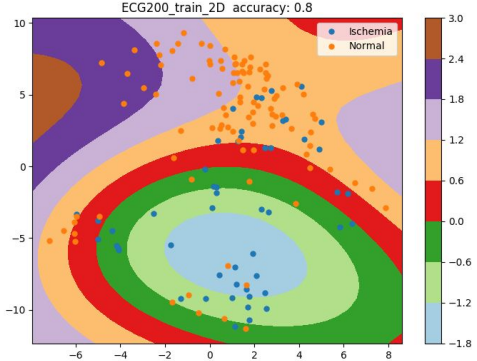
- PCA:
- n components: 20
- t-SNE: 2

3. Train SVM





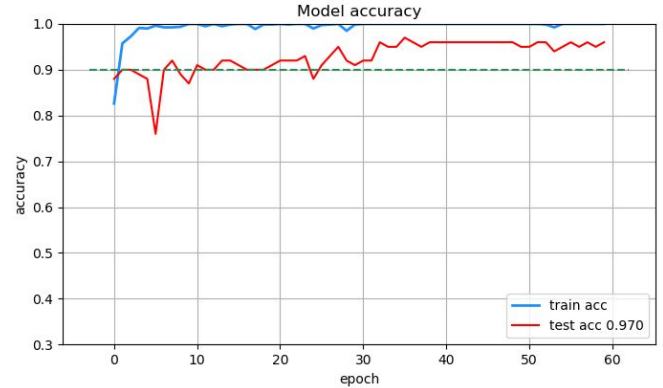


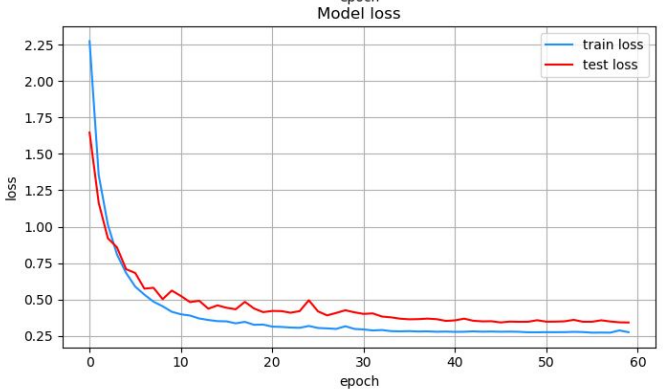


- Grid search
- C: 3, Gamma: 0.01
- Best acc: 0.84

- Training ...
- Test acc: 0.80

Fine-tuning VGG16





VGG16(include_top=False)+Dense(128)+Dense(2)

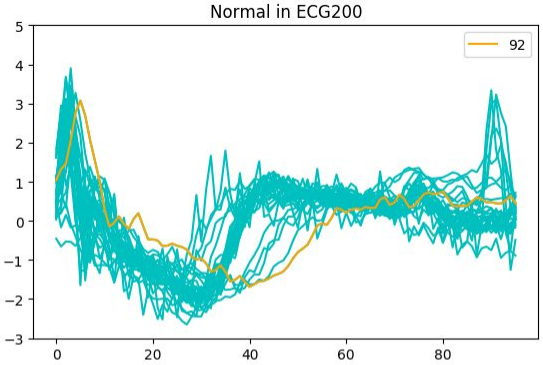
L2 regularization, 0.01
BatchNormalization()
Dropout(0.5) for dense_1

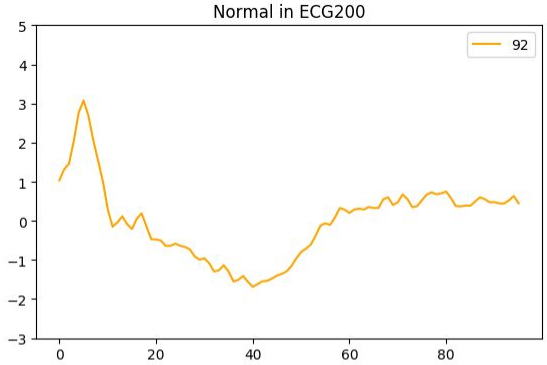
Learning Rate Scheduler()
0.0002 → 0.5*LR → 0.2*LR

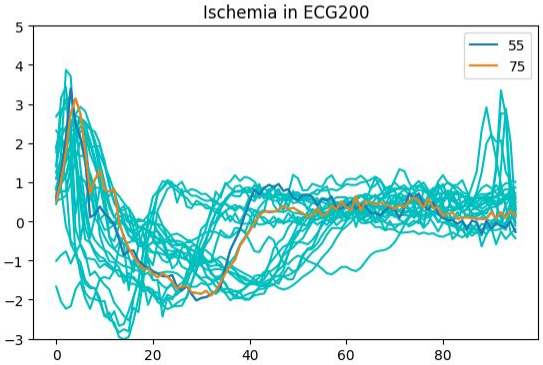
Freeze parameters in first three blocks

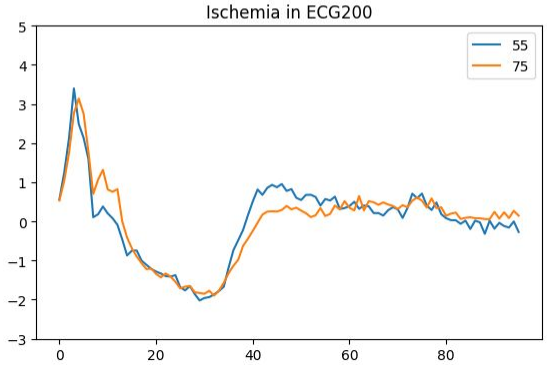
Training set(Augmented): 800($100*2^3$)
Test set: 100

Analysis(1)









FN: 92

FP: 55, 75

* these numbers are the indexes of samples in test set (100 samples)

Analysis(1)

Predictions	model 1	model 2	model 3	model 4	model 5	model 6
FN	[0, 15, 54]	[54]	[]	[]	[]	[]
FP	[9, 41]	[4, 9, 19, 22, 37]	[9, 19, 57]	[9]	[9, 19]	[9, 19]
False in total	5	6	3	1	2	2
Test Acc.	0.92	0.91	0.93	0.95	0.93	0.94

* these number are the indexes of samples in test set(60 samples)

Analysis(1)

Predictions	model 1	model 2	model 3	model 4	model 5	model 6
FN	[0, 15, 54]	[54]	[]	[]	[]	[]
FP	[9, 41]	[4, 9, 19, 22, 37]	[9, 19, 57]	[9]	[9, 19]	[9, 19]
False in total	5	6	3	1	2	2
Test Acc.	0.92	0.91	0.93	0.95	0.93	0.94

Analysis(2)

Table 1. Accuracy comparison with traditional classification algorithm(The method/s with the highest accuracy in each database are shown in bold)

(a)

Data	C4.5	C4.5(S)	1NN	1NN(S)	NaB	NaB(S)
Adiac	53.19	49.36	59.34	56.27	56.52	57.54
Beef	56.67	40	60	53.33	50	60
Chlorine	64.3	56.82	68.52	58.59	34.61	45.52
Coffee	57.14	92.86	75	**100**	67.86	92.86
Diatom	71.24	67.65	93.46	**94.44**	87.91	78.76
ECG200	72	79	**89**	78	77	80

2016

Table 2 Error rates of the methods for a subset of UCR dataset

Dataset	DTW	ST	TSBF	HOG1D	CovNN	CovSVM
50 Words	0.242	0.281	0.209	0.402	0.222	**0.200**
Adiac	0.391	0.435	0.245	0.320	0.217	**0.164**
Beef	0.467	0.167	0.287	0.367	0.100	**0.067**
CBF	0.004	0.003	0.009	**0.000**	**0.000**	**0.000**
ChlorineCon	0.350	0.300	0.336	0.307	0.294	**0.255**
CinCECGT	0.070	0.154	0.262	0.249	0.003	**0.000**
Coffee	0.179	**0.000**	0.004	**0.000**	**0.000**	**0.000**
CricketX	0.236	0.218	0.278	**0.195**	0.244	0.236
CricketY	**0.197**	0.236	0.259	0.205	0.210	0.251
CricketZ	**0.180**	0.228	0.263	0.185	0.239	0.215
DiatomSizeR	0.065	0.124	0.126	**0.016**	0.052	0.043
ECG200	0.310		0.145	**0.060**	0.080	0.070

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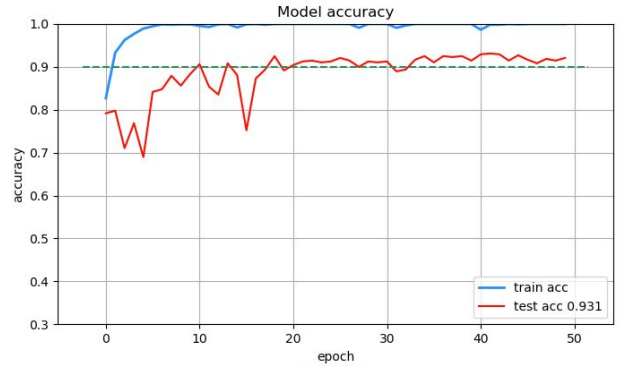
Table 5. Overall classification accuracies of *k*-NN alignment with six scenarios: NONE, DTW, CDTW, SAGA, PTW and CTW.

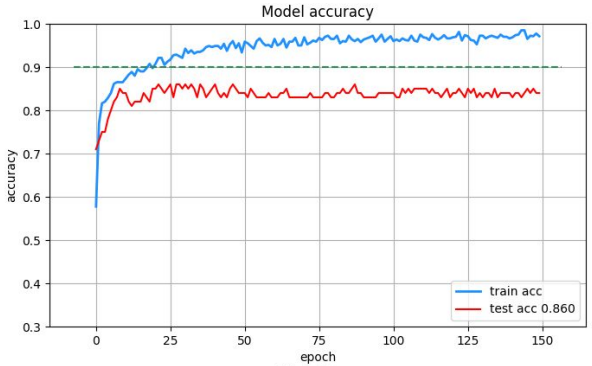
Dataset	NONE	DTW	CDTW	SAGA	PTW	CTW
Synthetic Control	88.0	99.3	98.7	90.3	94.3	98.7
Trace	76.0	100.0	99.0	99.0	99.0	100.0
Sony AIBO Robot Surface II	85.9	83.1	85.9	86.5	85.0	84.3
Sony AIBO Robot Surface	69.6	72.5	69.6	73.5	74.7	73.0
Symbols	89.9	95.0	93.8	94.9	95.3	90.1
Two Lead ECG	74.7	90.4	86.8	86.7	98.4	90.3
Olive Oil	86.7	86.7	83.3	83.3	86.7	80.0
Mote Strain	87.9	83.5	87.9	89.9	86.6	84.0
Lighting 7	57.5	72.6	71.2	79.5	64.4	68.5
Lighting 2	75.4	86.9	86.9	85.2	80.3	85.2
Italy Power Demand	95.5	95.0	95.5	96.4	94.5	95.0
Gun Point	91.3	90.7	91.3	98.7	98.7	88.0
Face Four	78.4	83.0	88.6	77.3	87.5	85.2
ECG Five Days	79.7	76.8	79.7	96.9	90.5	75.3
ECG 200	88.0	77.0	88.0	87.0	85.0	79.0

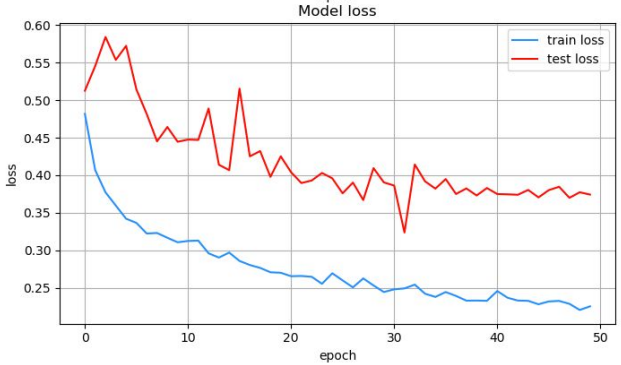
2015

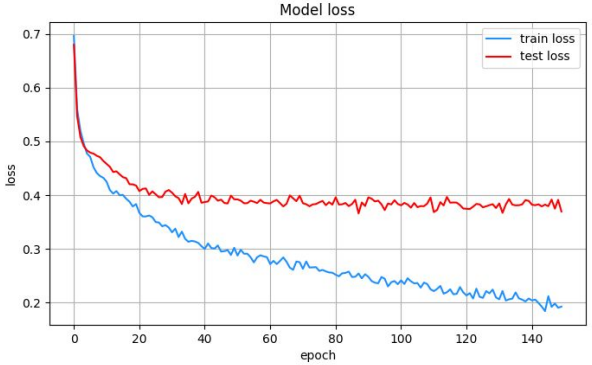
Analysis(3)

RP + GASF + MTF





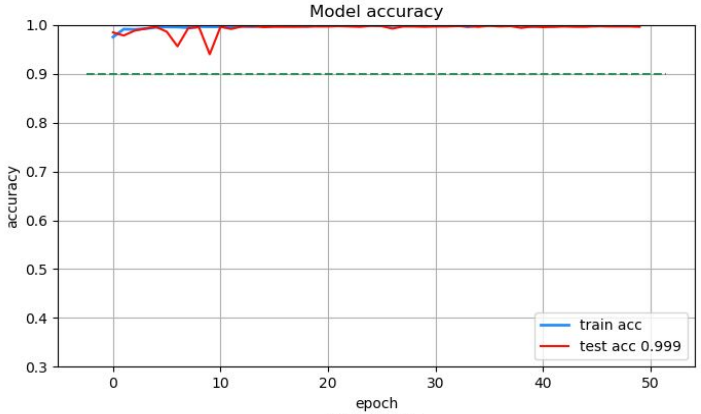


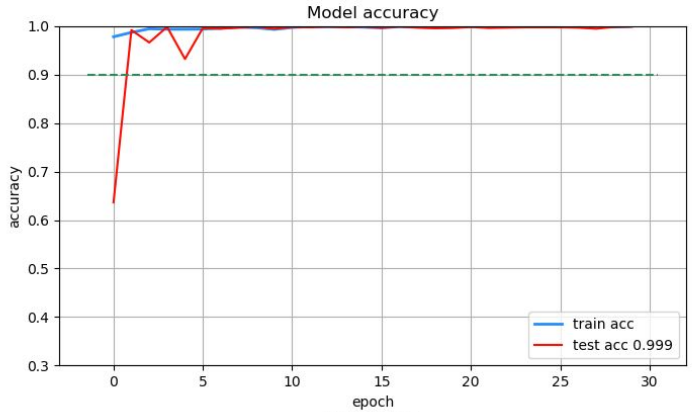


Processing
1D time series signal with **transformation methods** or not

With a simple NN
dense(50)+dense(2)

ECG5000


Model accuracy
accuracy
epoch
train acc
test acc 0.999


Model accuracy
accuracy
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train acc
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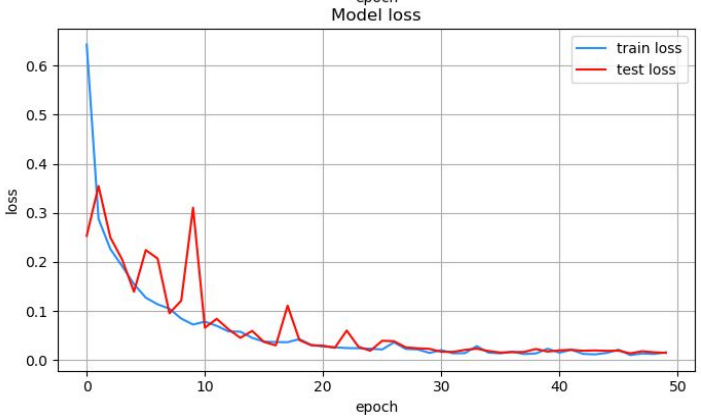
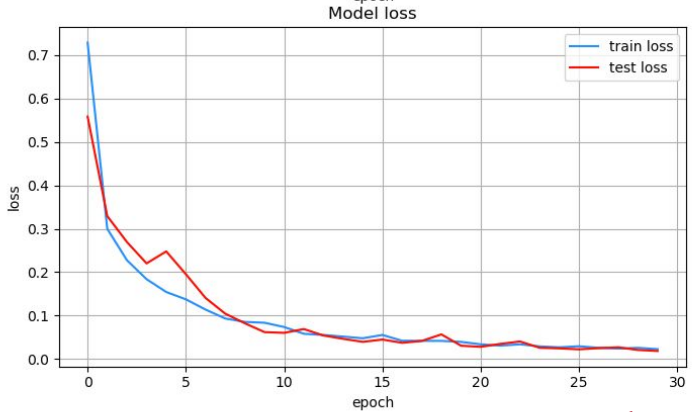
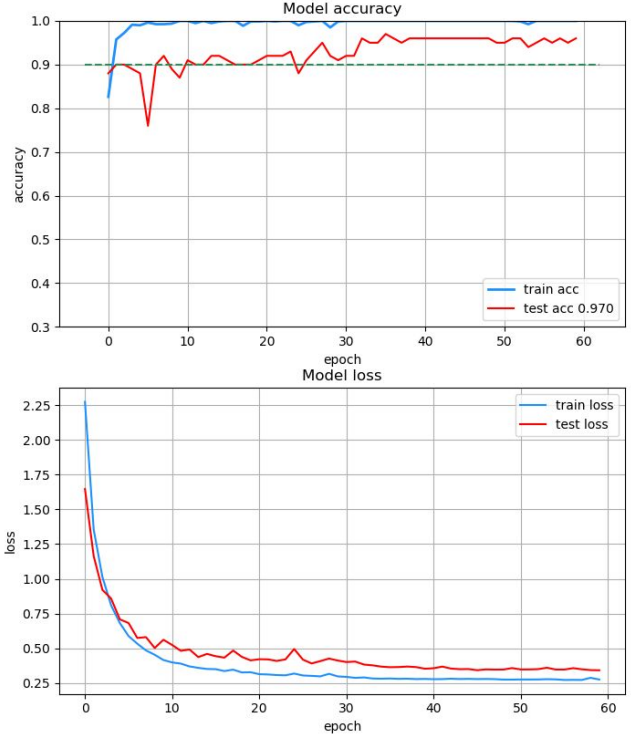

Model loss
loss
epoch
train loss
test loss


Model loss
loss
epoch
train loss
test loss

Question?

ECG200



ECG5000