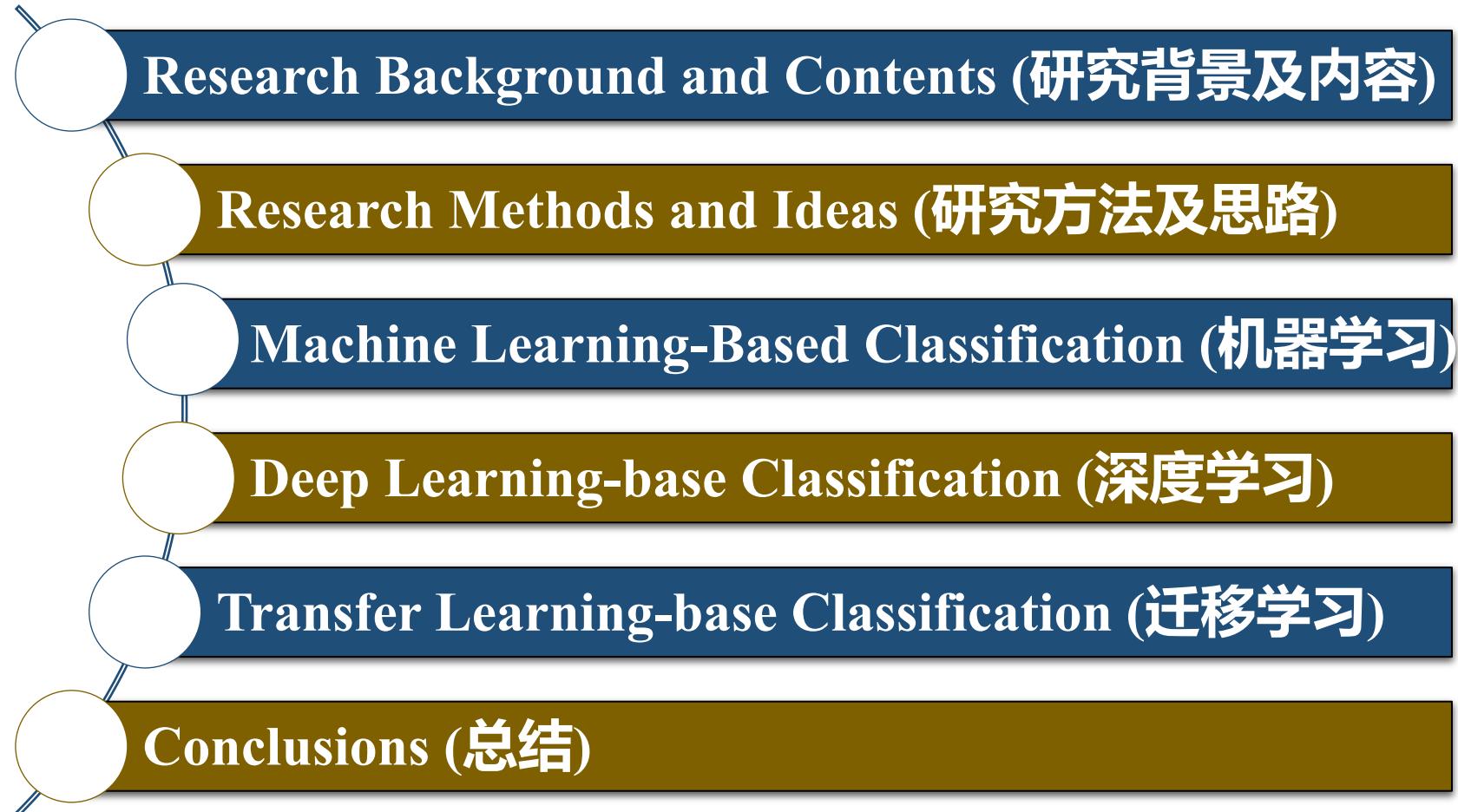




Occupational health monitoring in dangerous manufacturing contexts: Machine Learning-based ECG Signal Classification

危险制造业环境中的职业健康监测：
基于机器学习的心电信号分类

项目负责人：Alessandro Simeone





第一部分

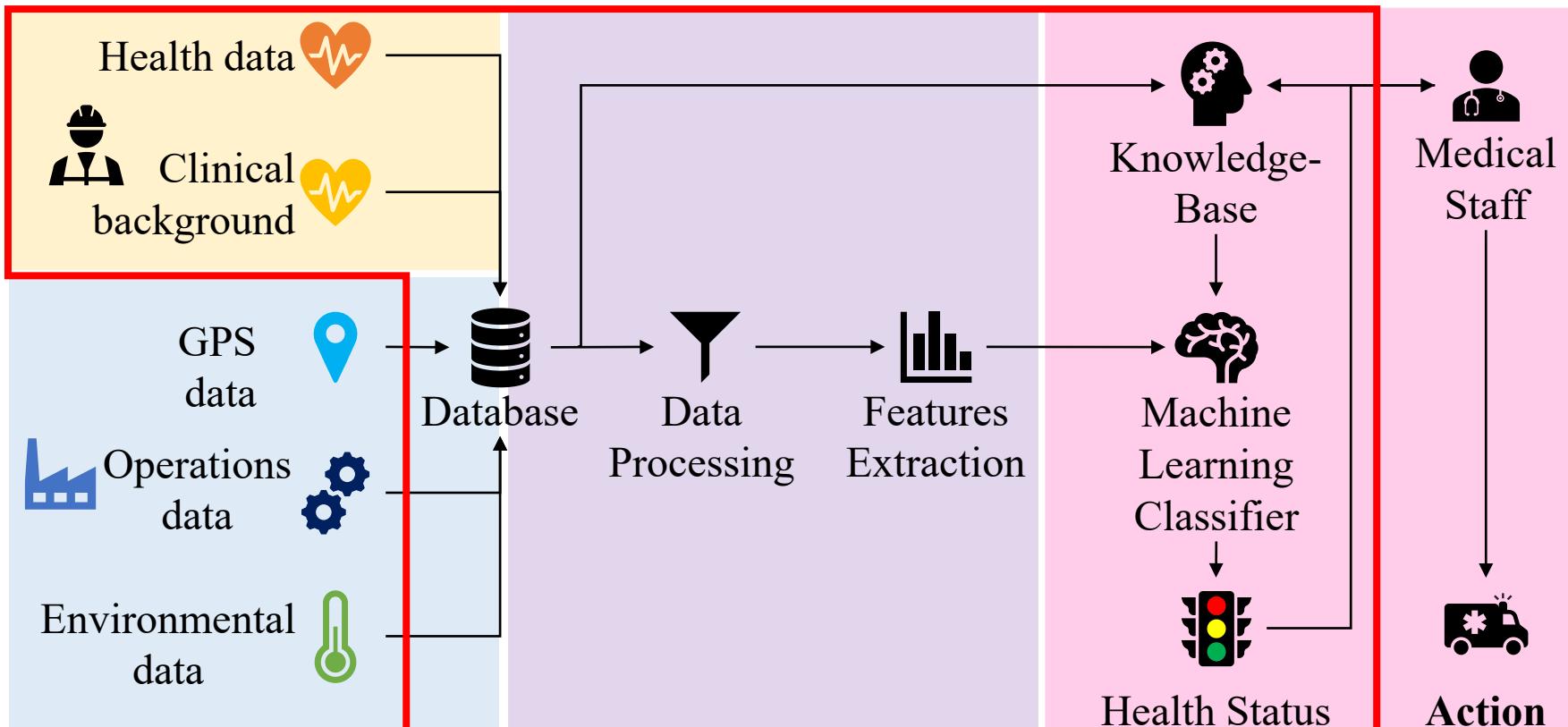
Part 01

Research Background and Contents

(研究背景及內容)

Background and Contents

Research Scope



Project Partners



Alessandro Simeone^a



Alessandra Caggiano^{b,c}



Lev Boun^d



Rebecca Grant^e

^aIntelligent Manufacturing Key Laboratory of Ministry of Education, Shantou University, 515063 Shantou, Guangdong, China

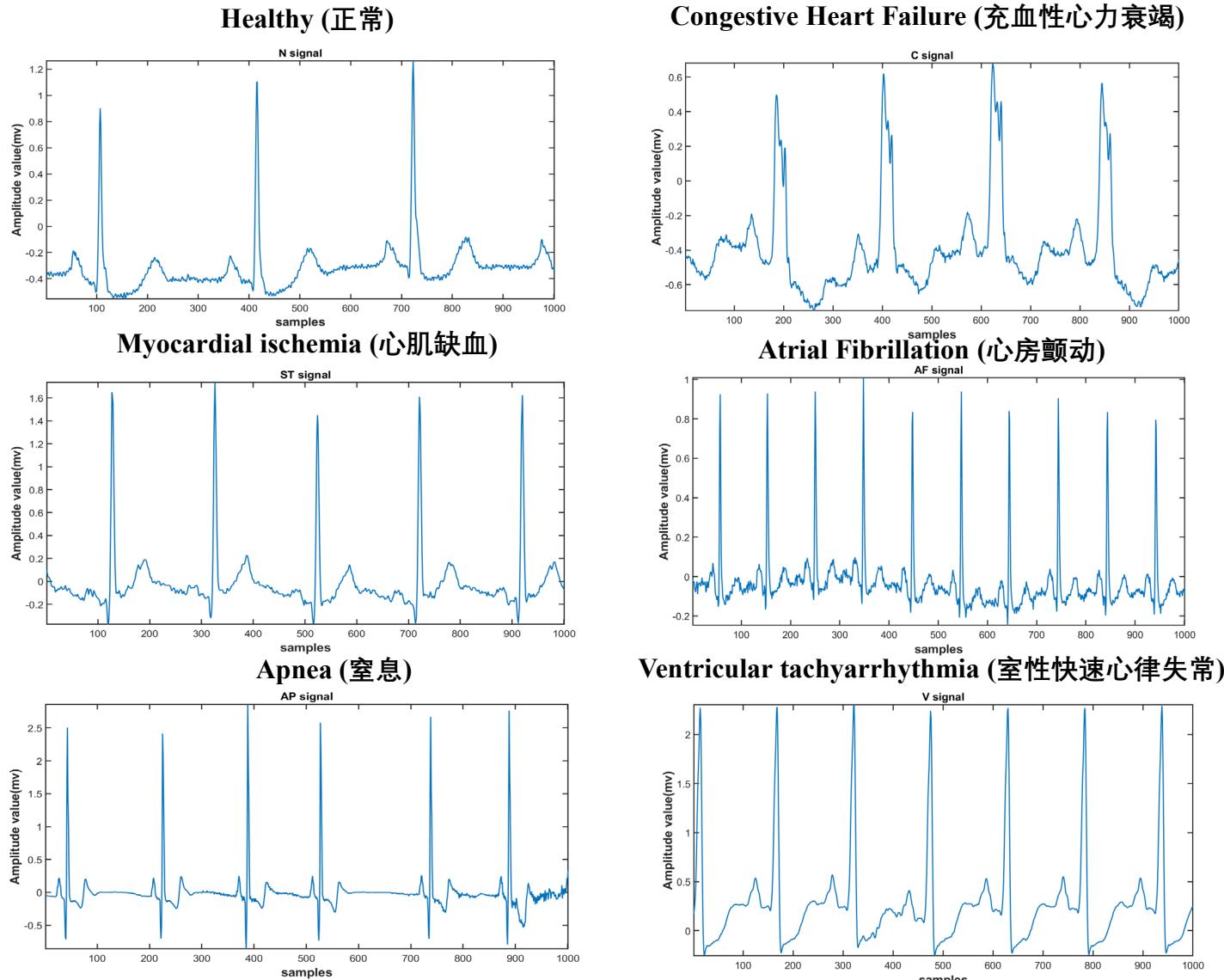
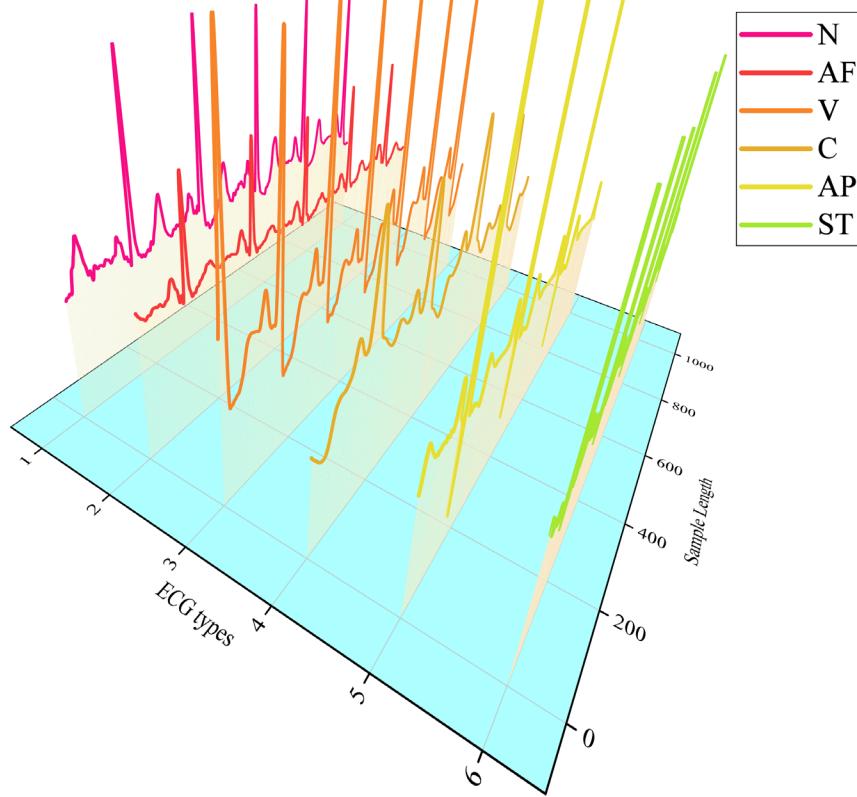
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^eWolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough, LE11 3TU, UK

PhysioNet Database

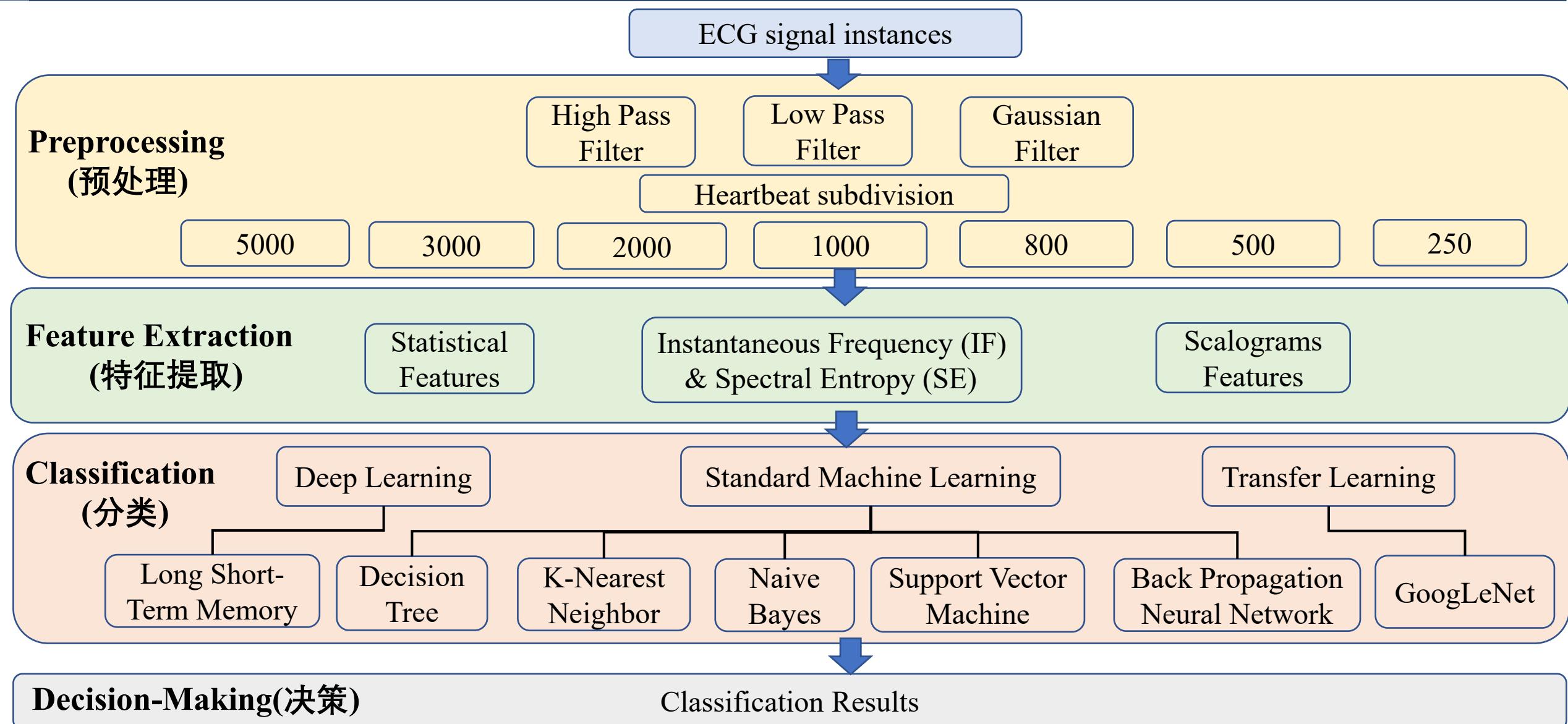




第二部分

Part 02

Research Methods and Ideas (研究方法及思路)



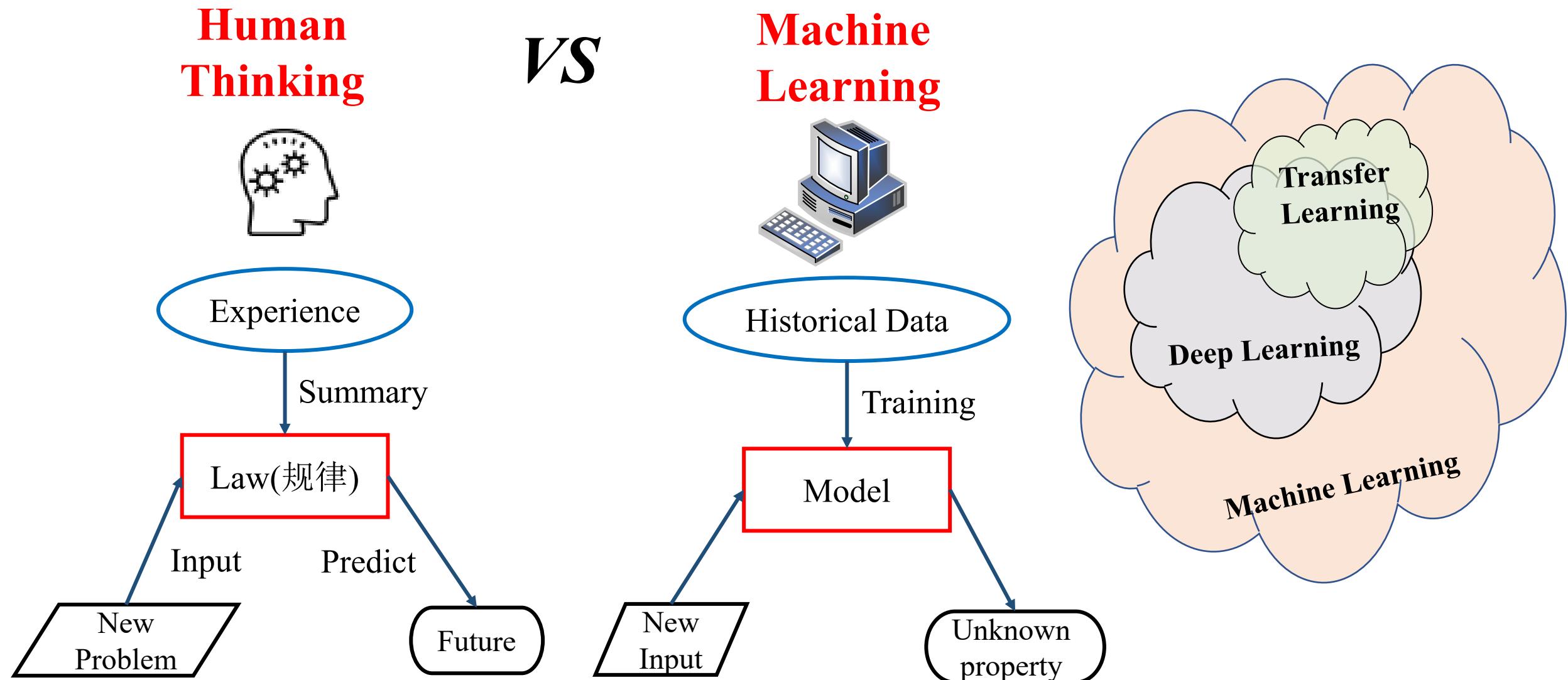
第三部分



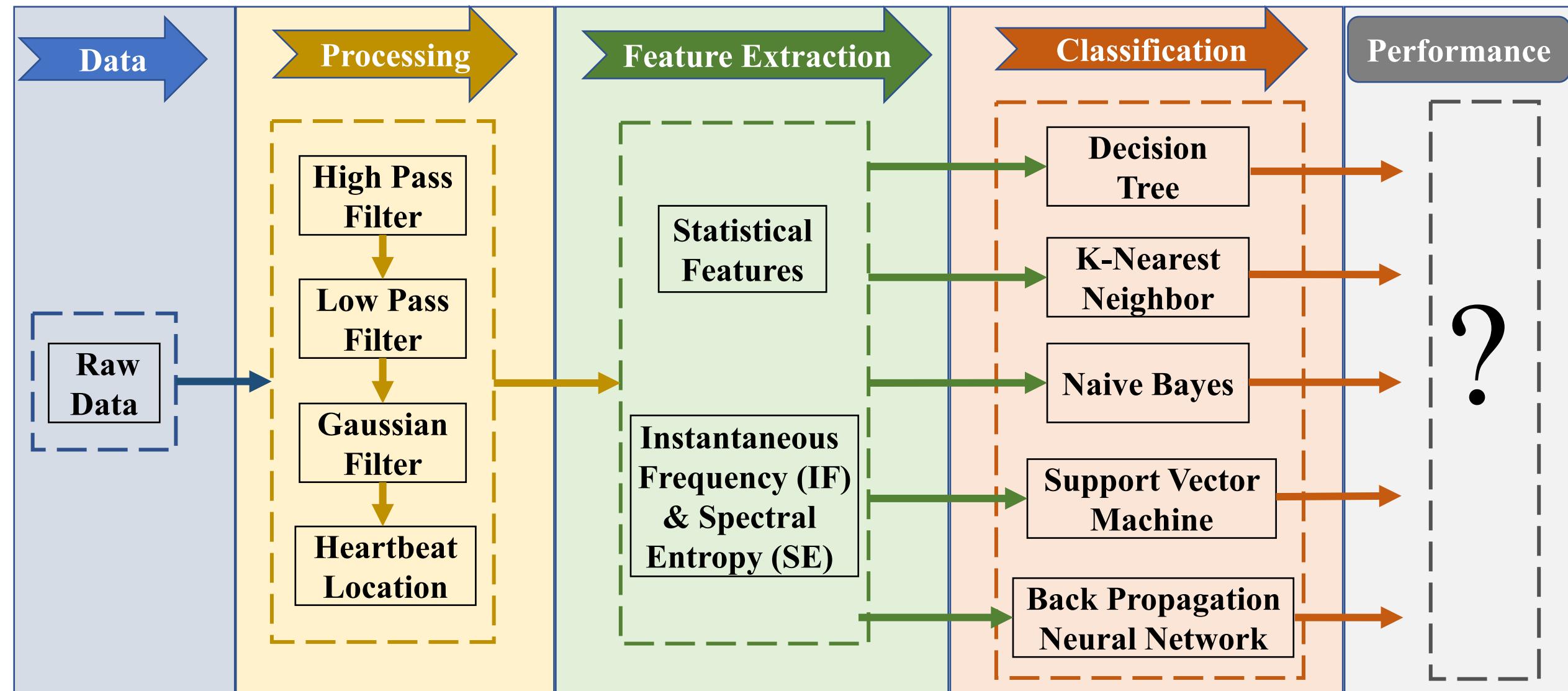
Part 03

Machine Learning-Based Classification

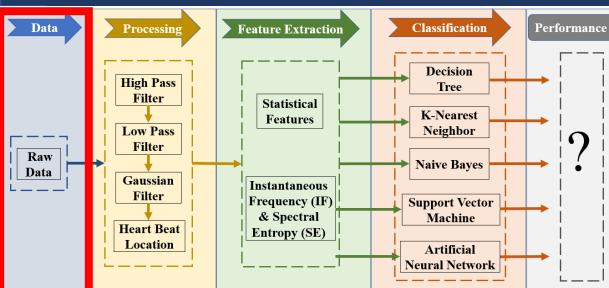
(基于机器学习的分类算法)



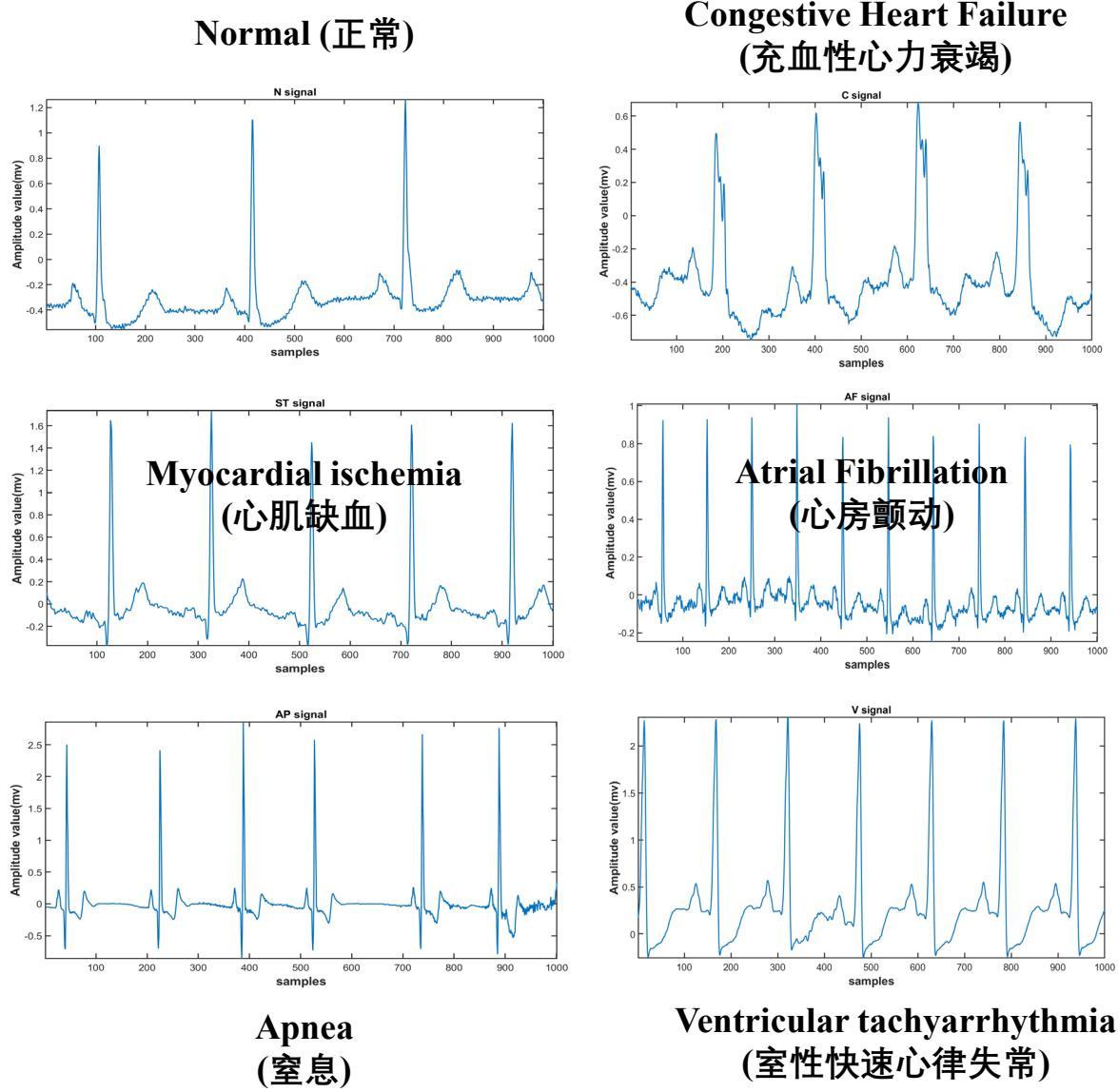
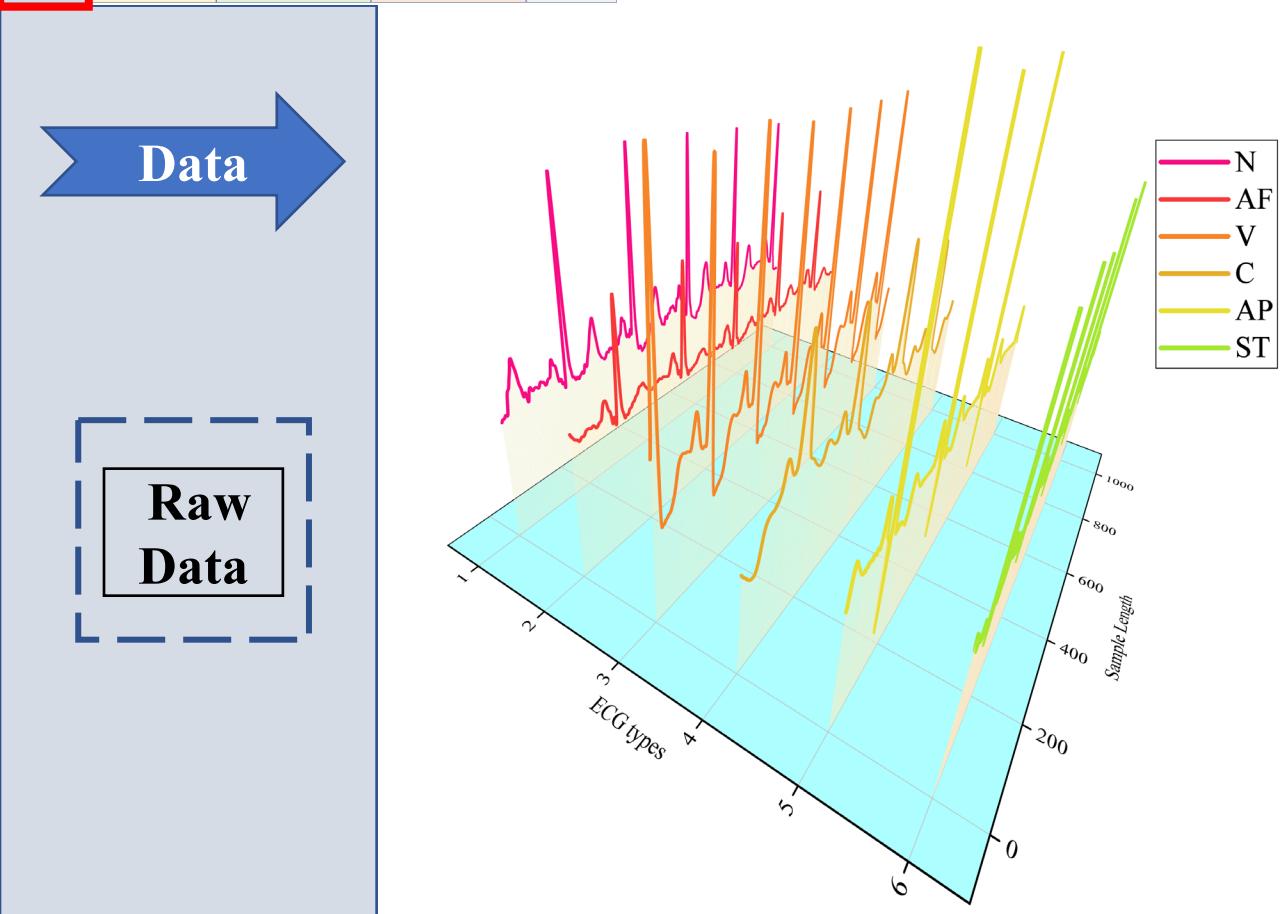
Standard Machine Learning



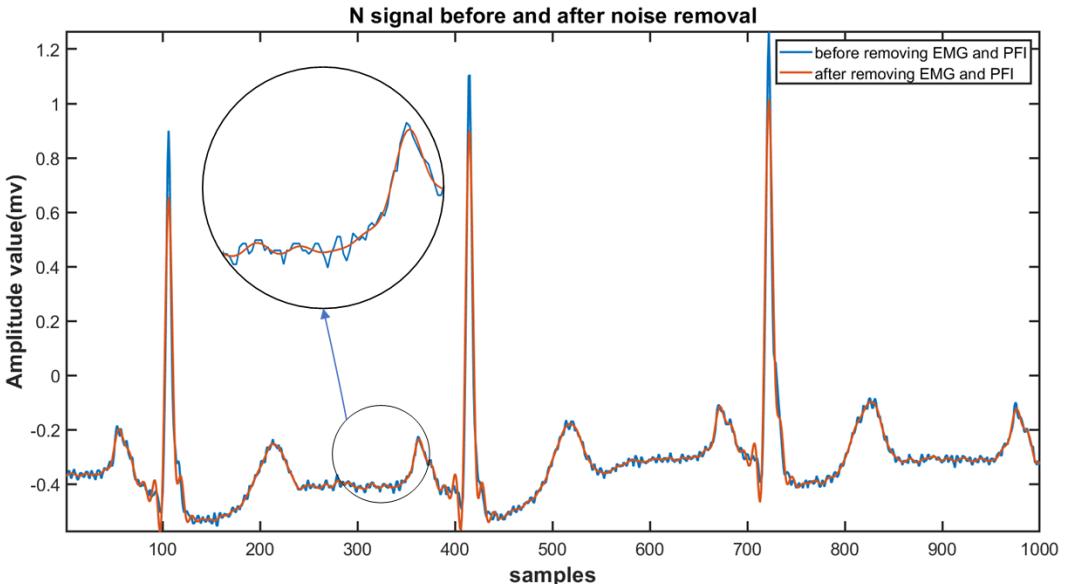
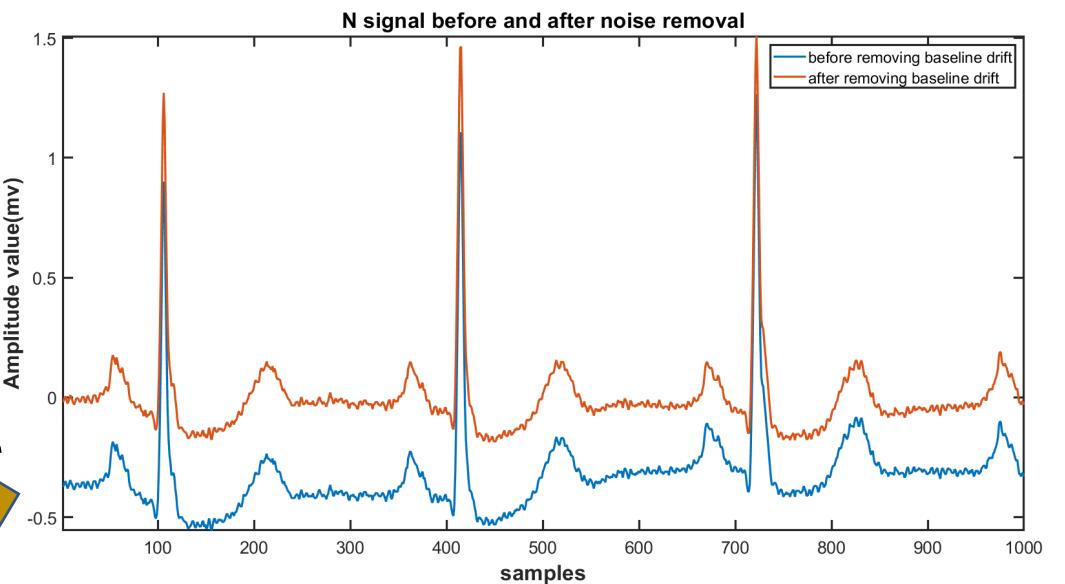
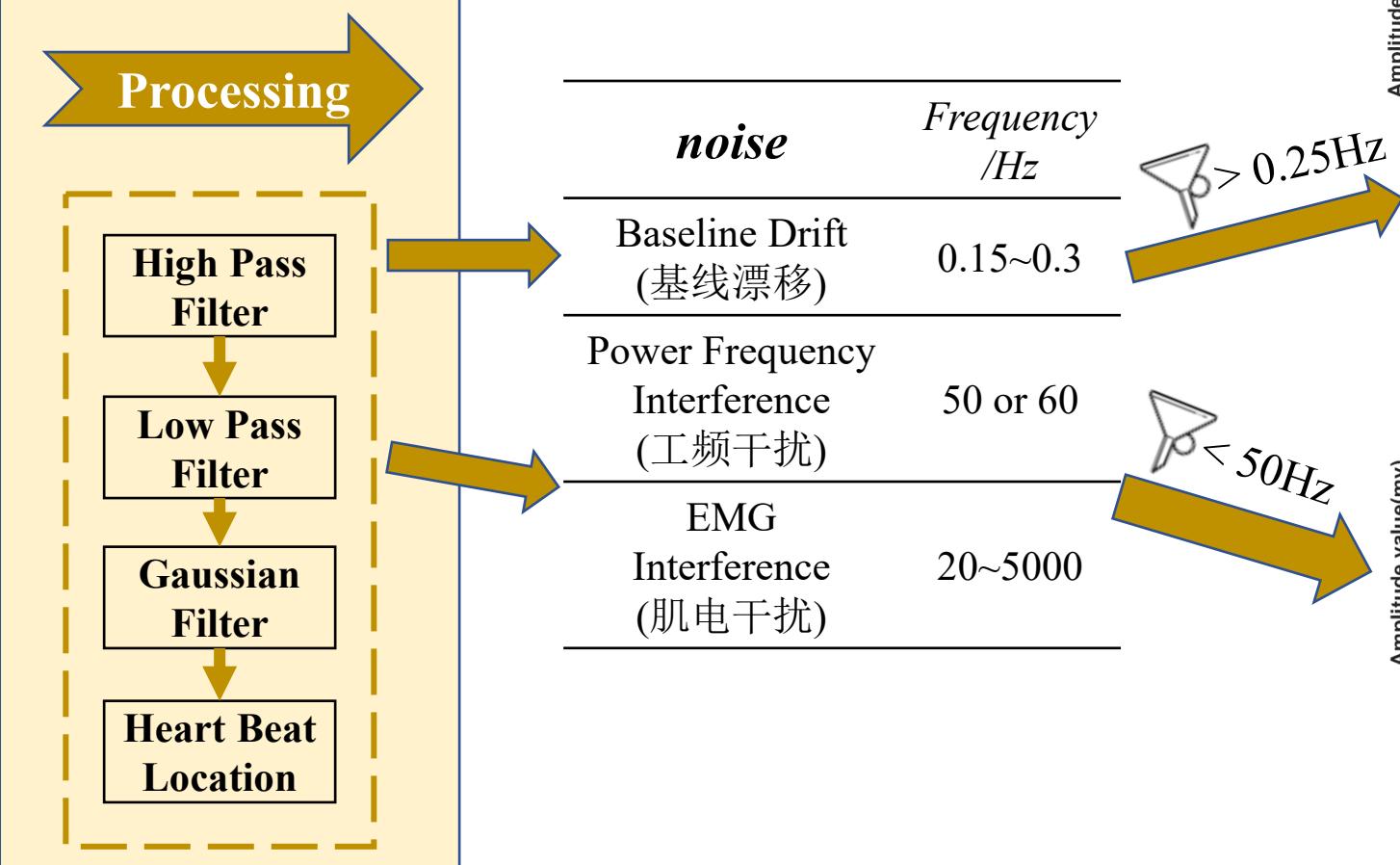
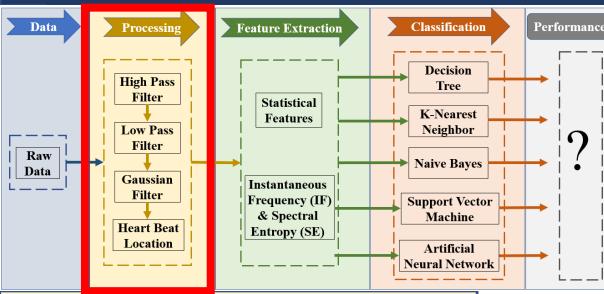
Standard Machine Learning

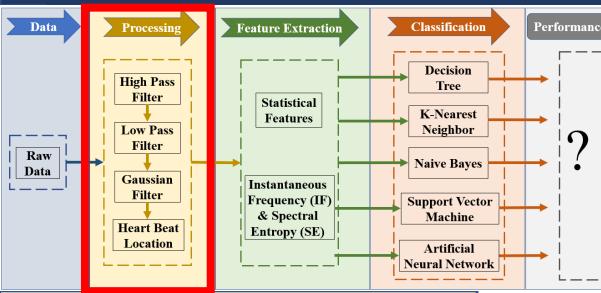


PhysioNet

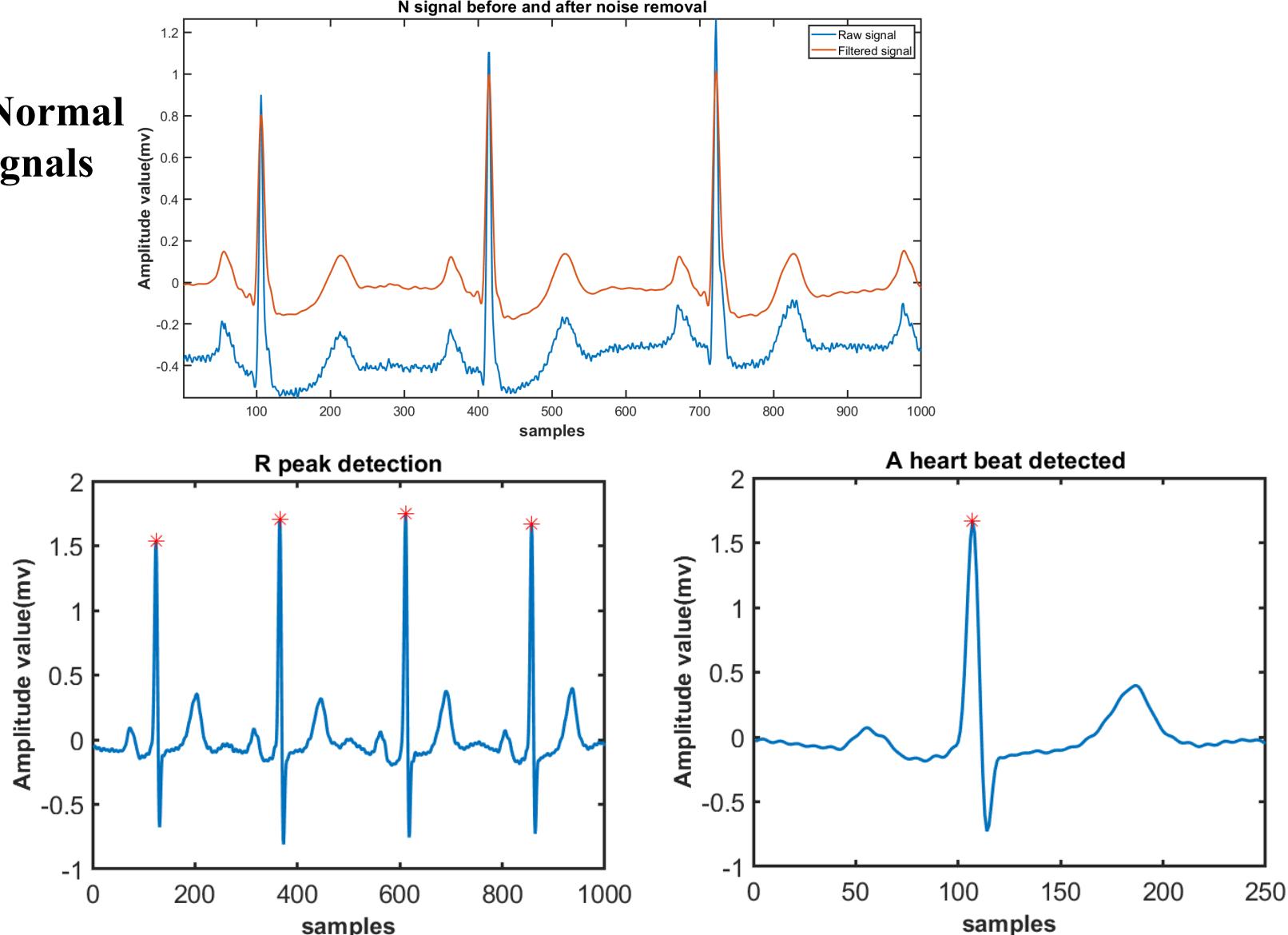
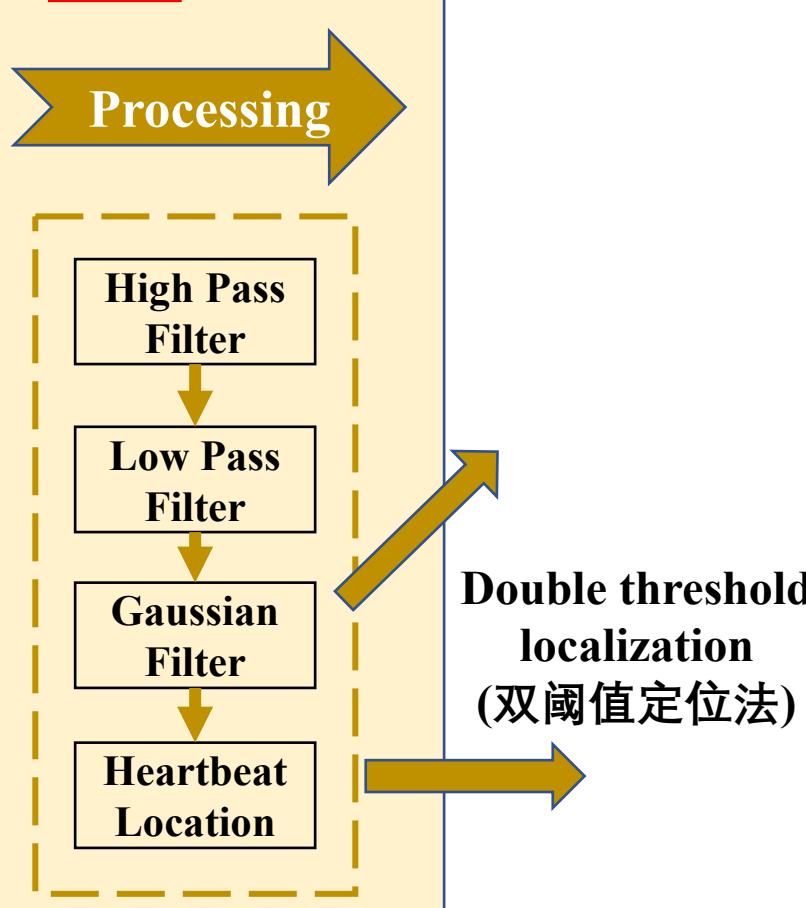


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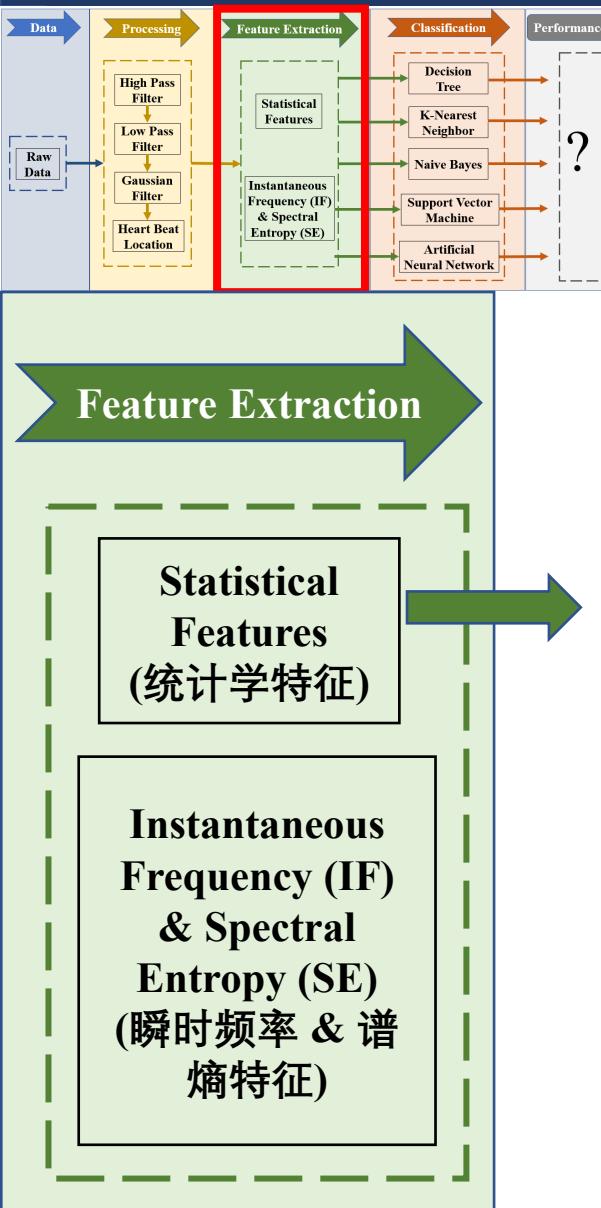




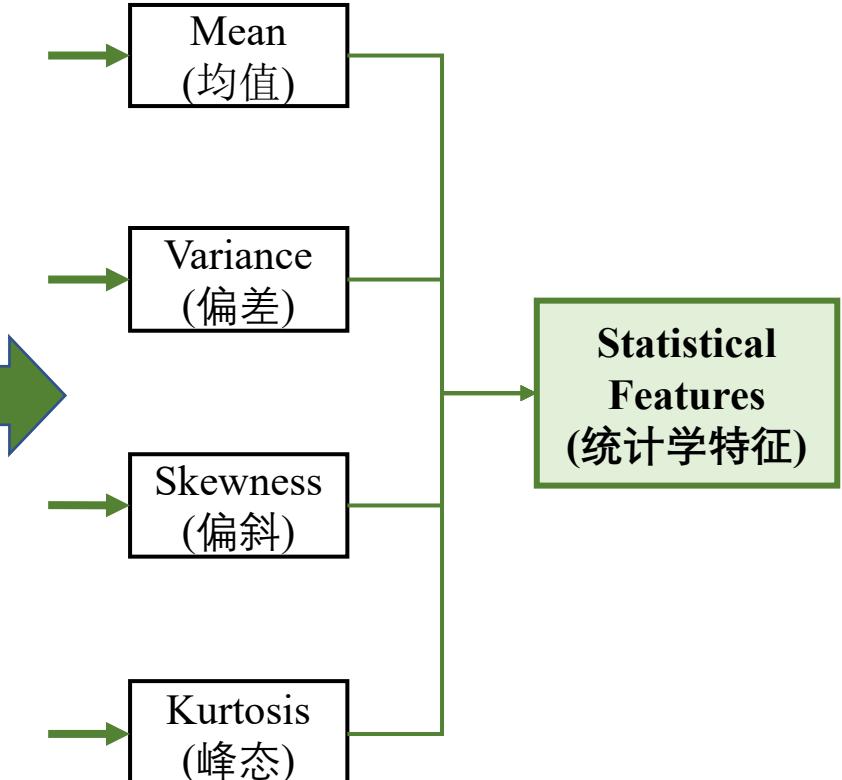
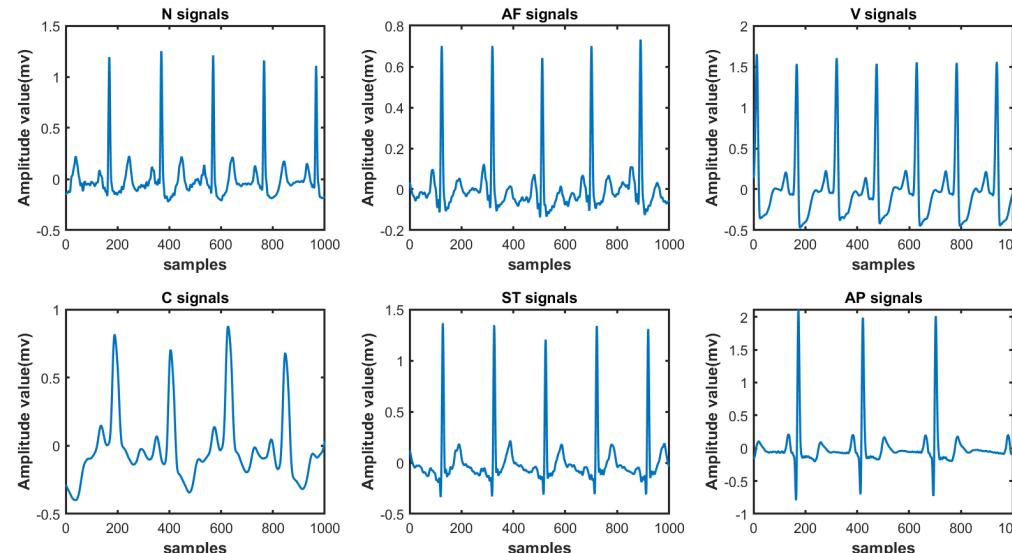
Filtered Normal ECG Signals



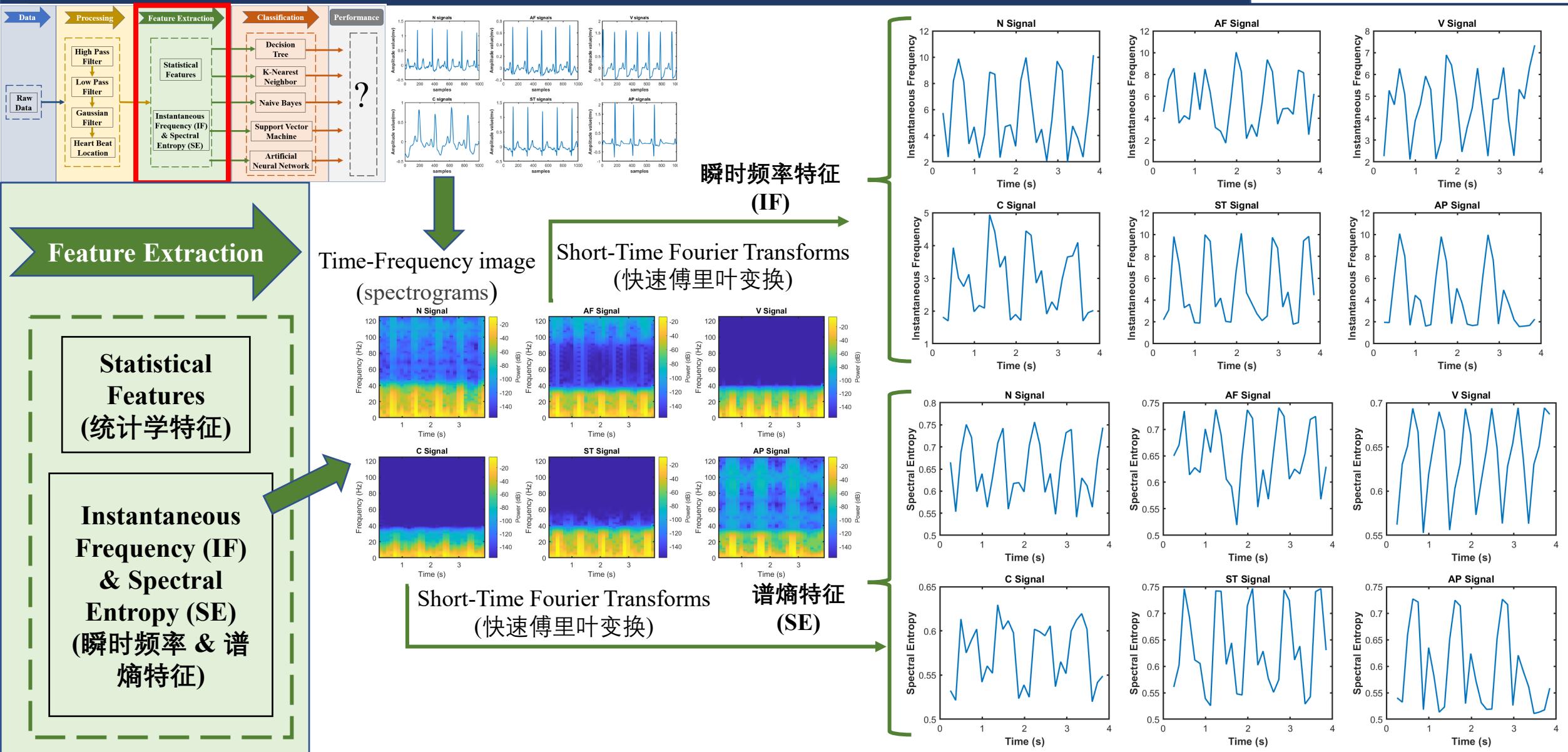
Standard Machine Learning



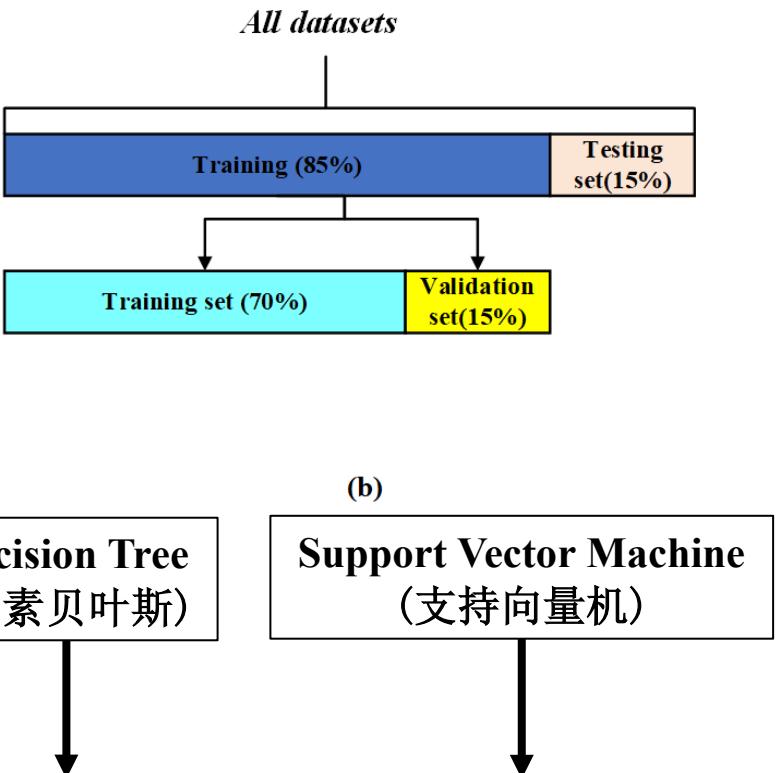
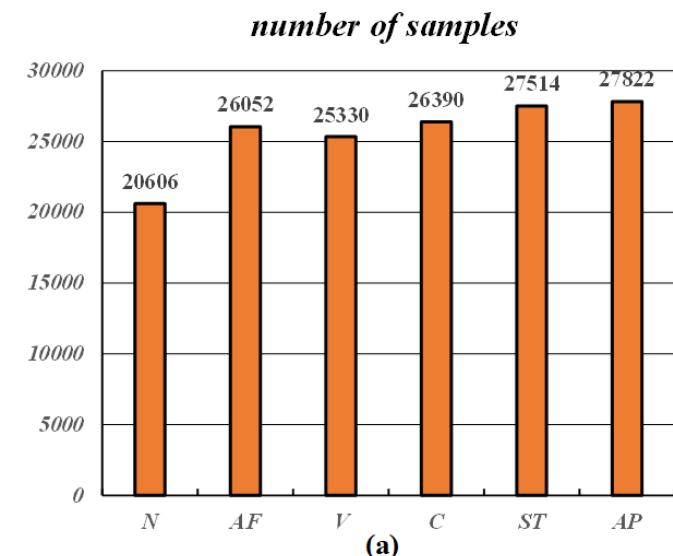
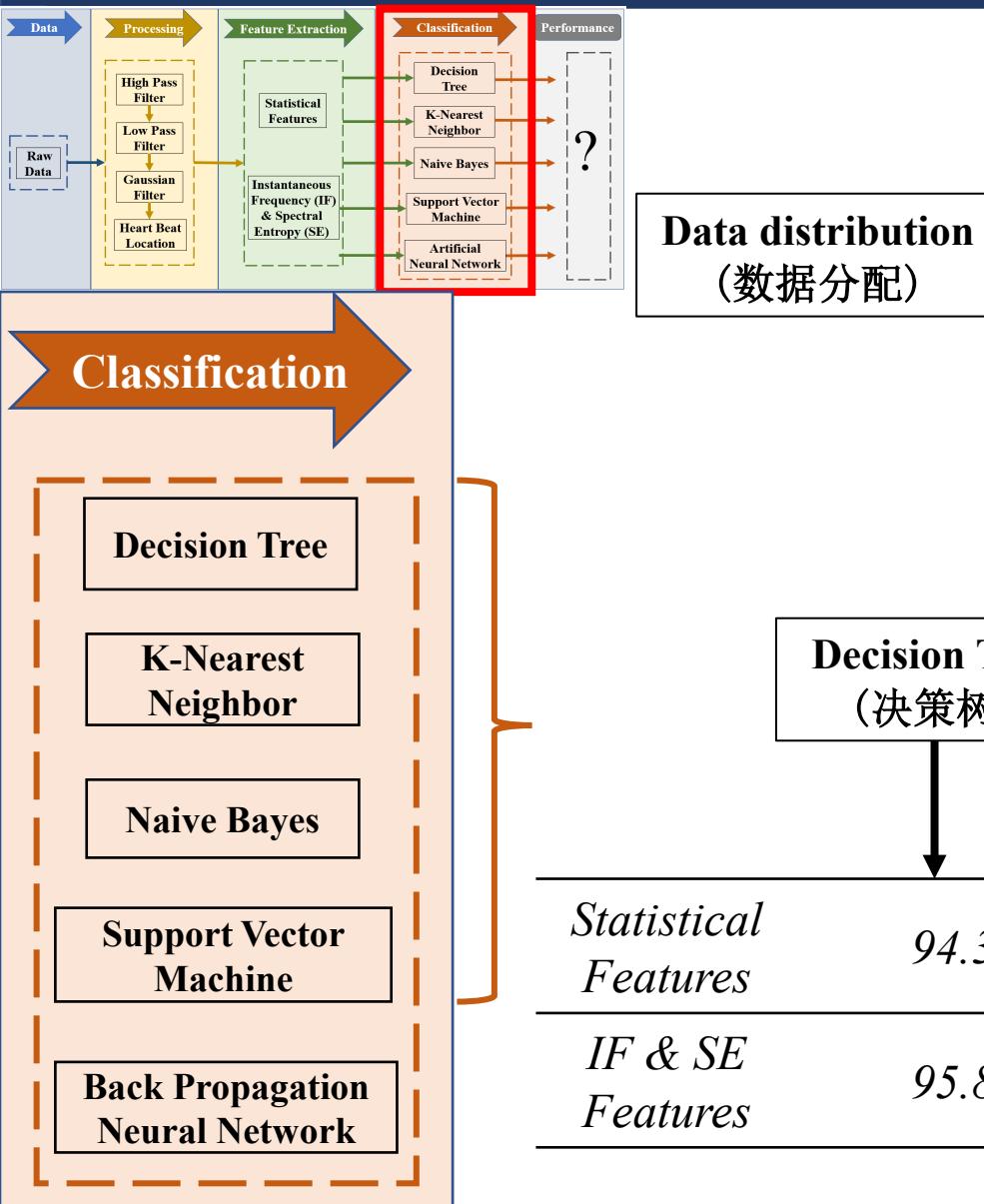
Filtered ECG Signals



Standard Machine Learning

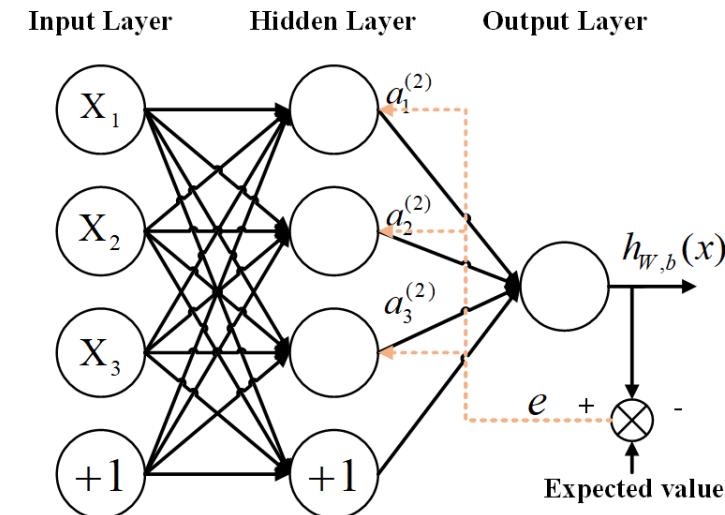
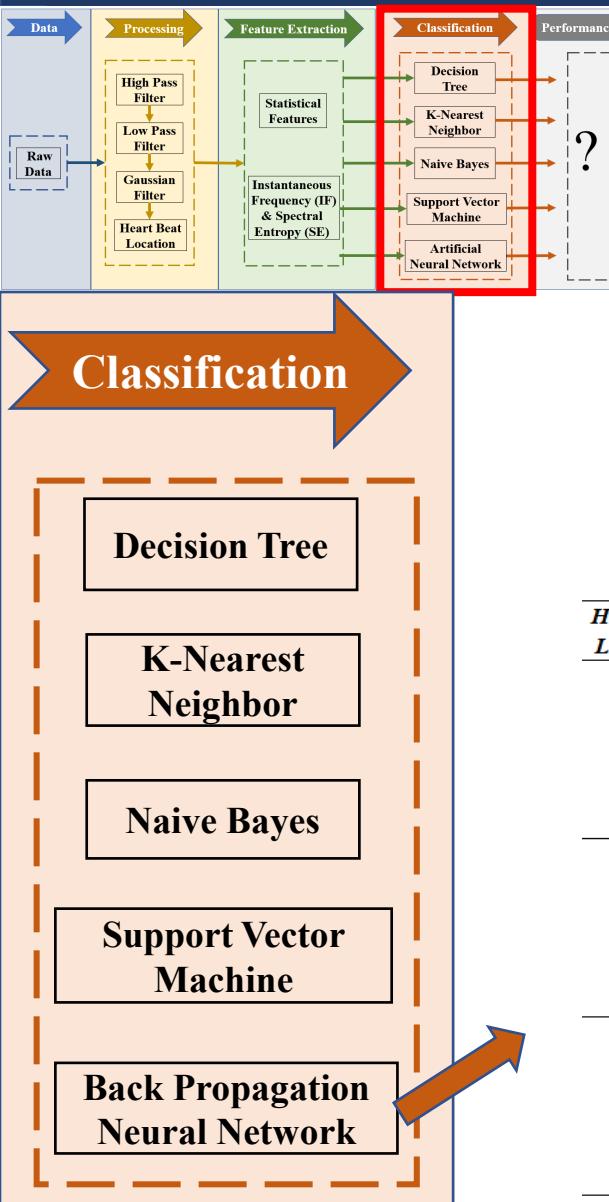


Standard Machine Learning



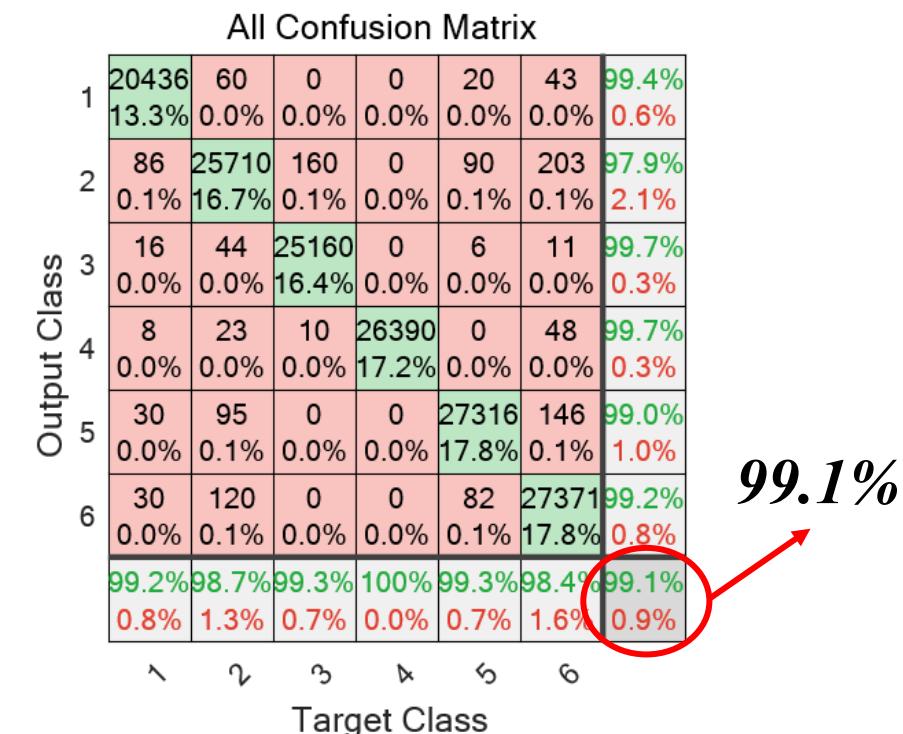
<i>Statistical Features</i>	94.3%	96.2%	85.4%	83.8%
<i>IF & SE Features</i>	95.8%	95.7%	96.1%	96.5%

Standard Machine Learning



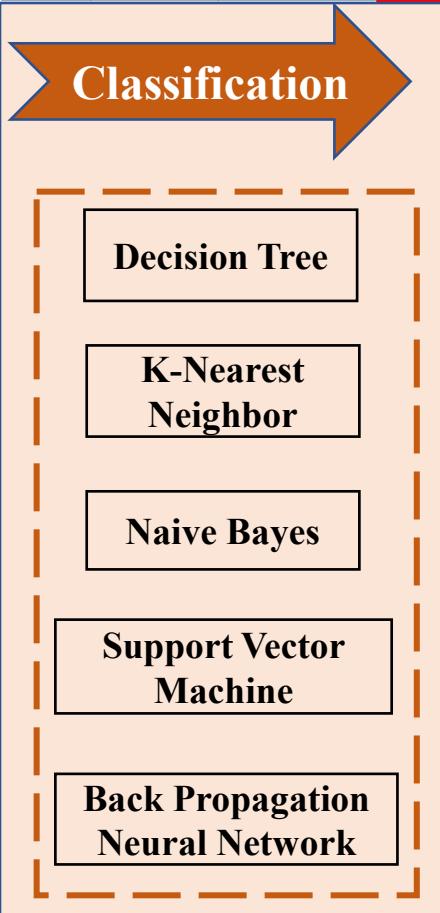
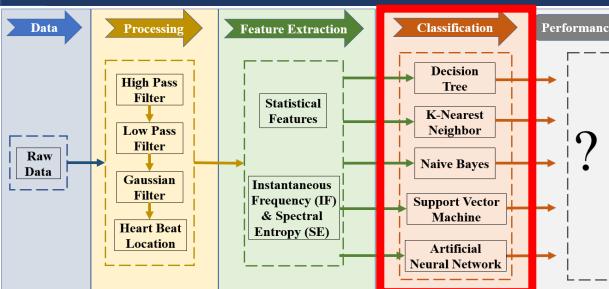
Classification performance with Statistical Features

Hidden Layers	Hidden Neurons	Performance			
		Training Acc(%)	Validation Acc(%)	Testing Acc(%)	Total Acc(%)
1	5	92.5	92.7	92.6	92.6
	10	94.8	94.8	94.8	94.8
	15	93.5	93.3	93.4	93.5
	20	94.6	94.6	94.6	94.6
	25	94.3	94.7	94.4	94.4
	30	95.5	95.7	95.5	95.5
2	5,5	86.7	86.7	86.8	86.7
	10,10	83.3	83.5	83.9	83.4
	15,15	96.1	96.1	95.8	96.0
	20,20	97.2	97.0	97.1	97.2
	25,25	96.9	96.8	97.0	96.9
	30,30	97.1	97.2	97.1	97.1
3	5,5,5	85.5	85.4	85.5	85.5
	10,10,10	96.1	96.2	96.2	96.2
	15,15,15	96.3	96.2	96.4	96.3
	20,15,10	96.9	96.8	96.8	96.8
	25,20,10	96.2	96.2	96.2	96.2
	30,20,10	96.6	96.6	96.6	96.6

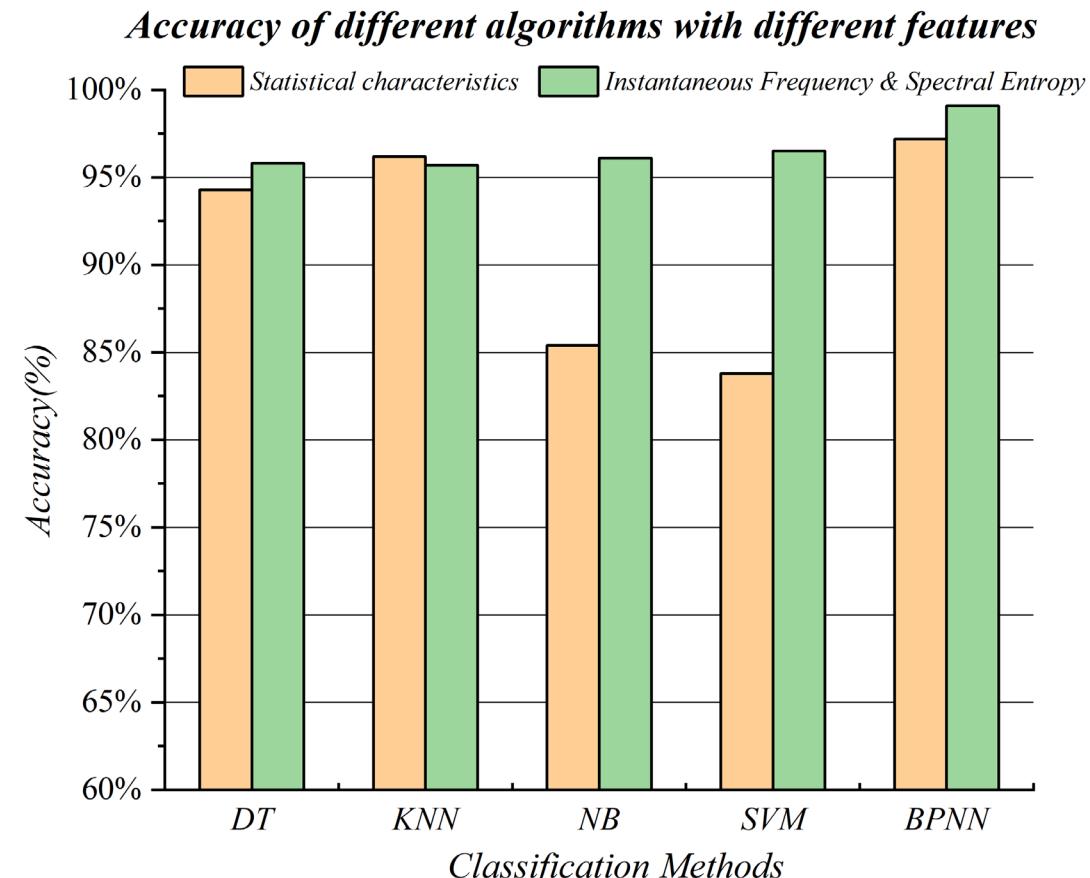


Classification performance with IF & SE Features

Hidden Layers	Hidden Neurons	Performance			
		Training Acc(%)	Validation	Testing	Total Acc(%)
1	5	96.7	96.4	96.6	96.6
	10	97.6	97.4	97.4	97.5
	15	99.2	99	98.9	99.1
2	5,5	96.3	96.4	96.5	96.4
	10,10	98.7	98.6	98.6	98.7
	15,15	99.2	99	99.1	99.1
3	5,5,5	96.4	96.4	96.4	96.4
	10,10,10	98.7	98.7	98.7	98.7
	15,15,15	98.9	98.8	98.7	98.8



Visualize Classification Performance



Summary:

1. IF & SE feature **performs better than** Statistical feature in ECG signal classification.
2. Neural network **performs better than** other classical machine learning algorithms.

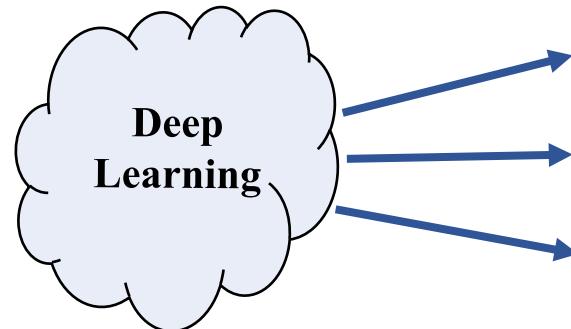


第四部分

Part 04

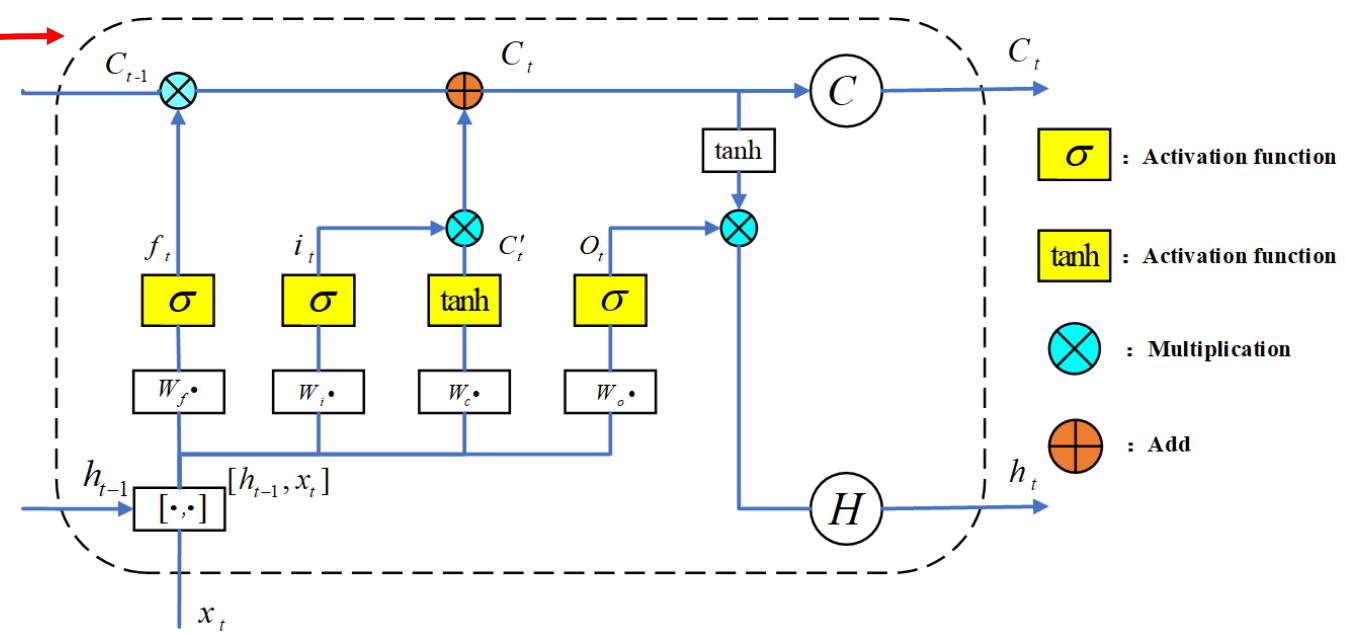
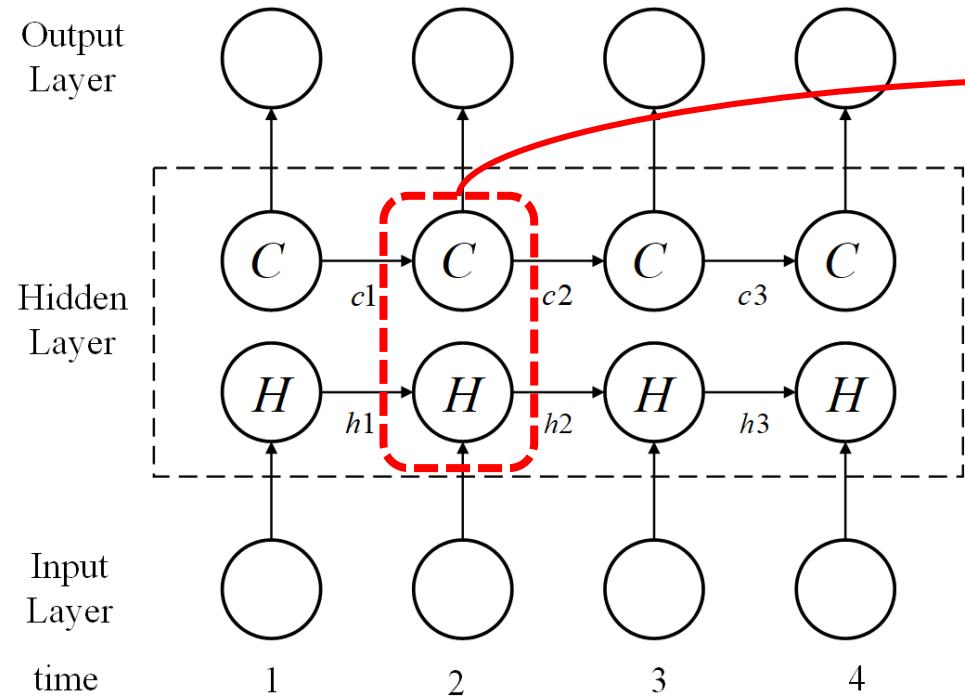
Deep Learning-Based Classification

(基于深度学习的分类算法)

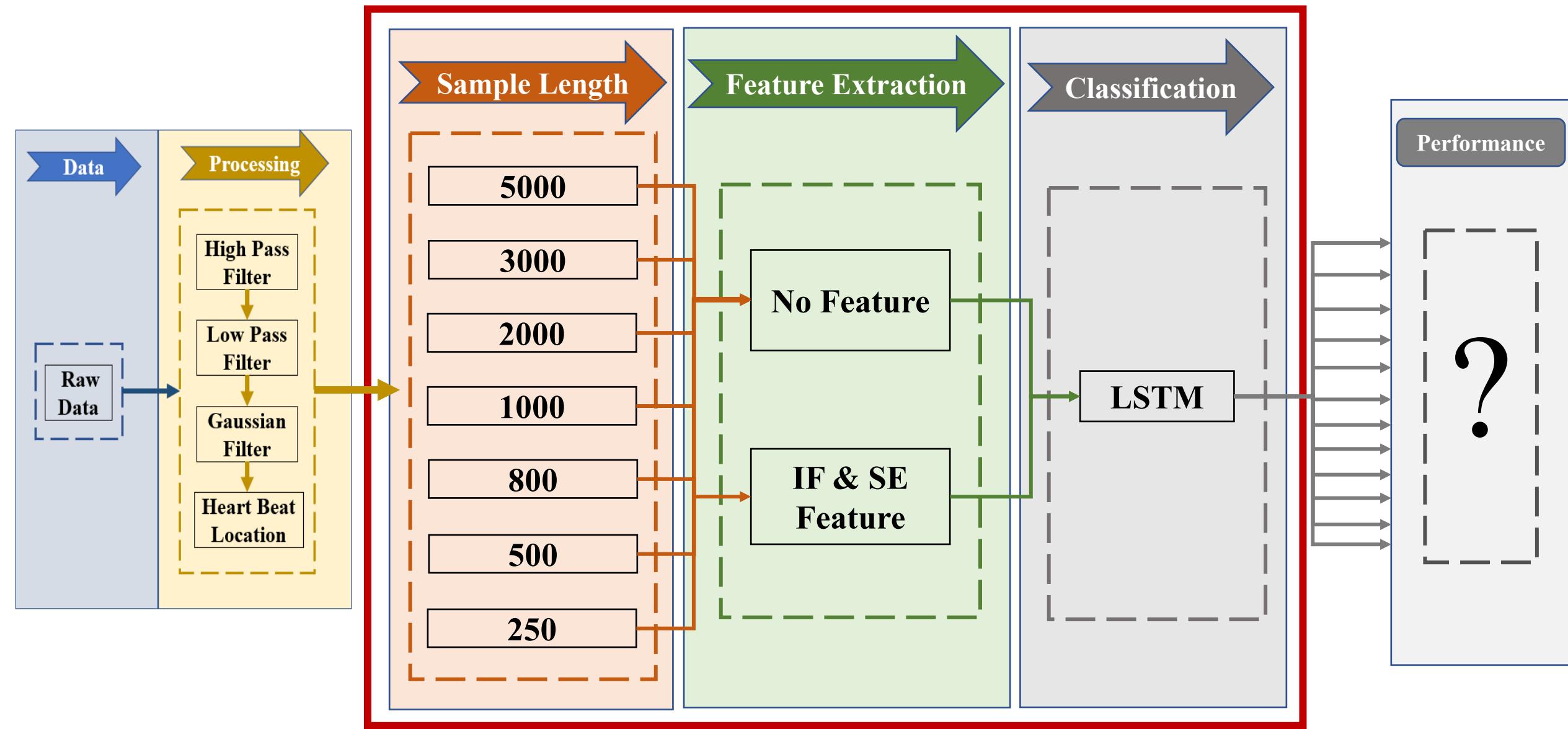


- Recurrent Neural Network (RNN) (循环神经网络)
- Convolutional Neural Network (CNN) (卷积神经网络)
- Deep Belief Neural Network (DBNN) (深度置信神经网络)

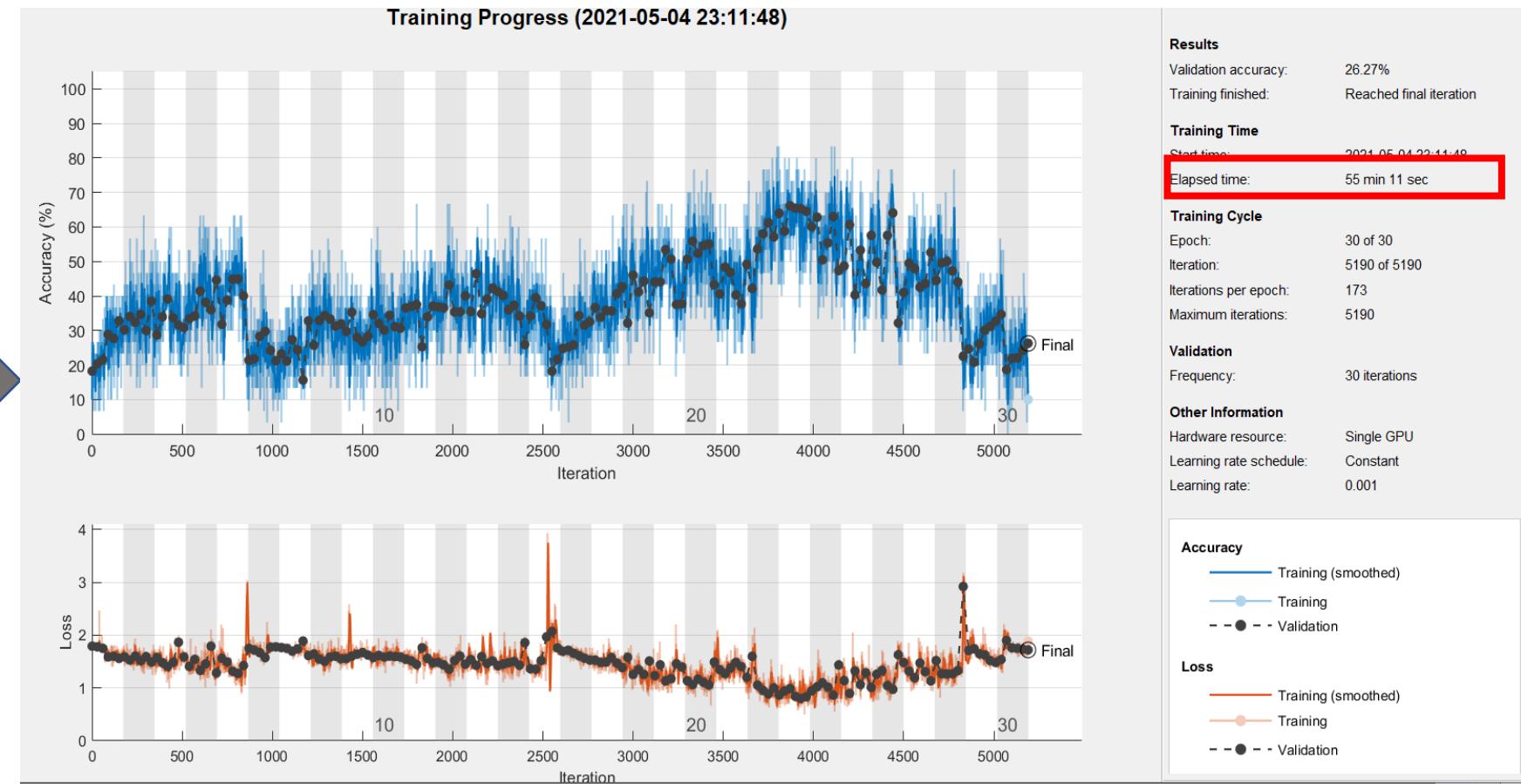
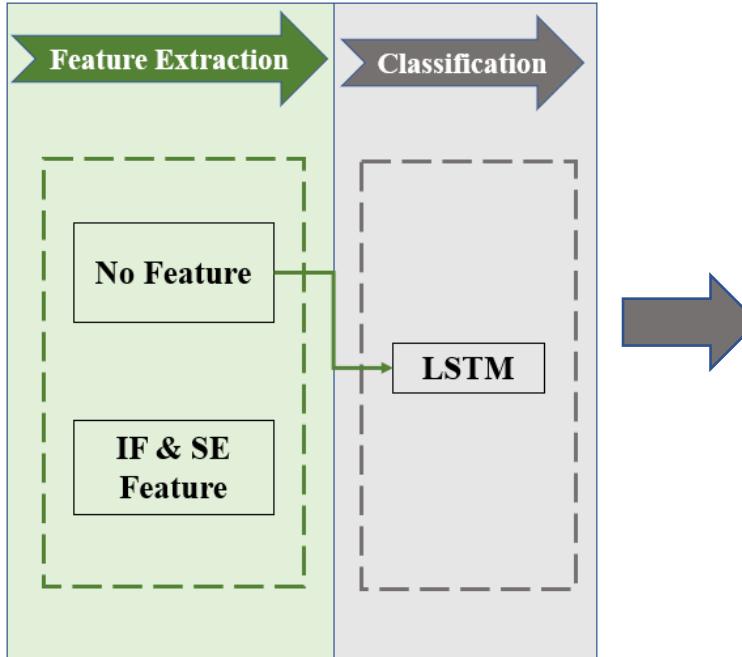
**Long Short-Term Memory
(LSTM)(长短记忆法)**



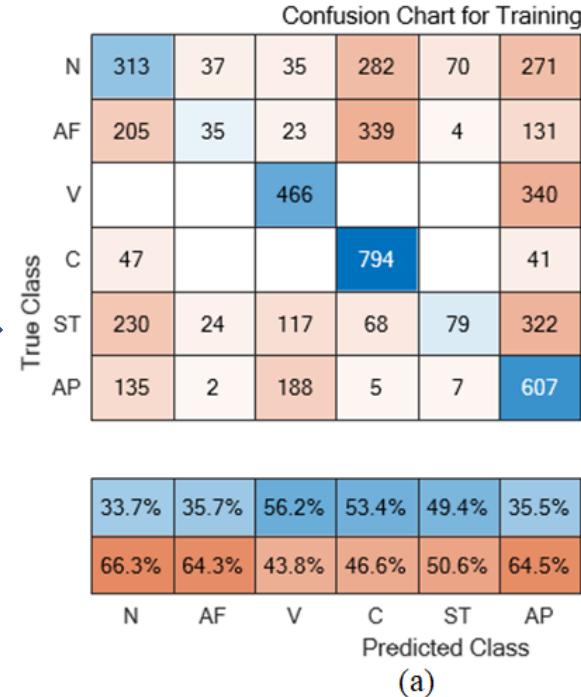
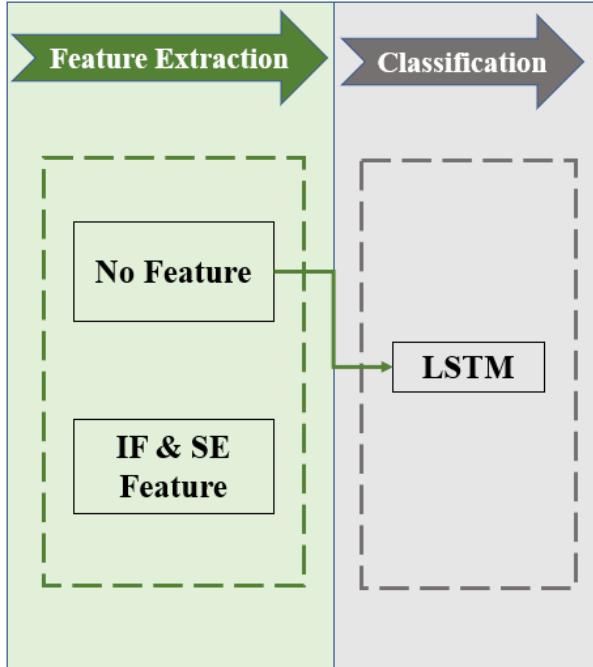
Deep Learning——LSTM Network



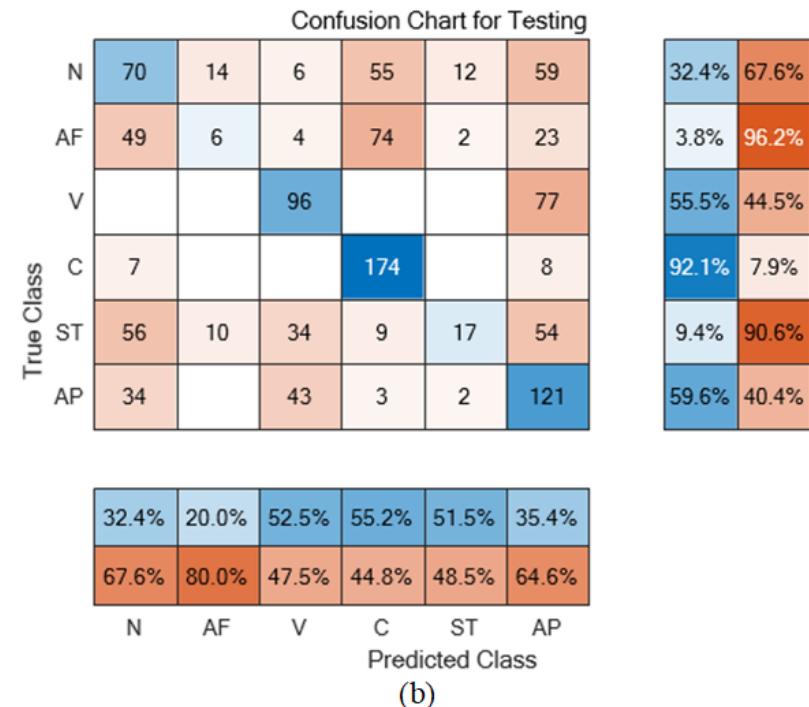
Deep Learning——LSTM Network



Deep Learning——LSTM Network



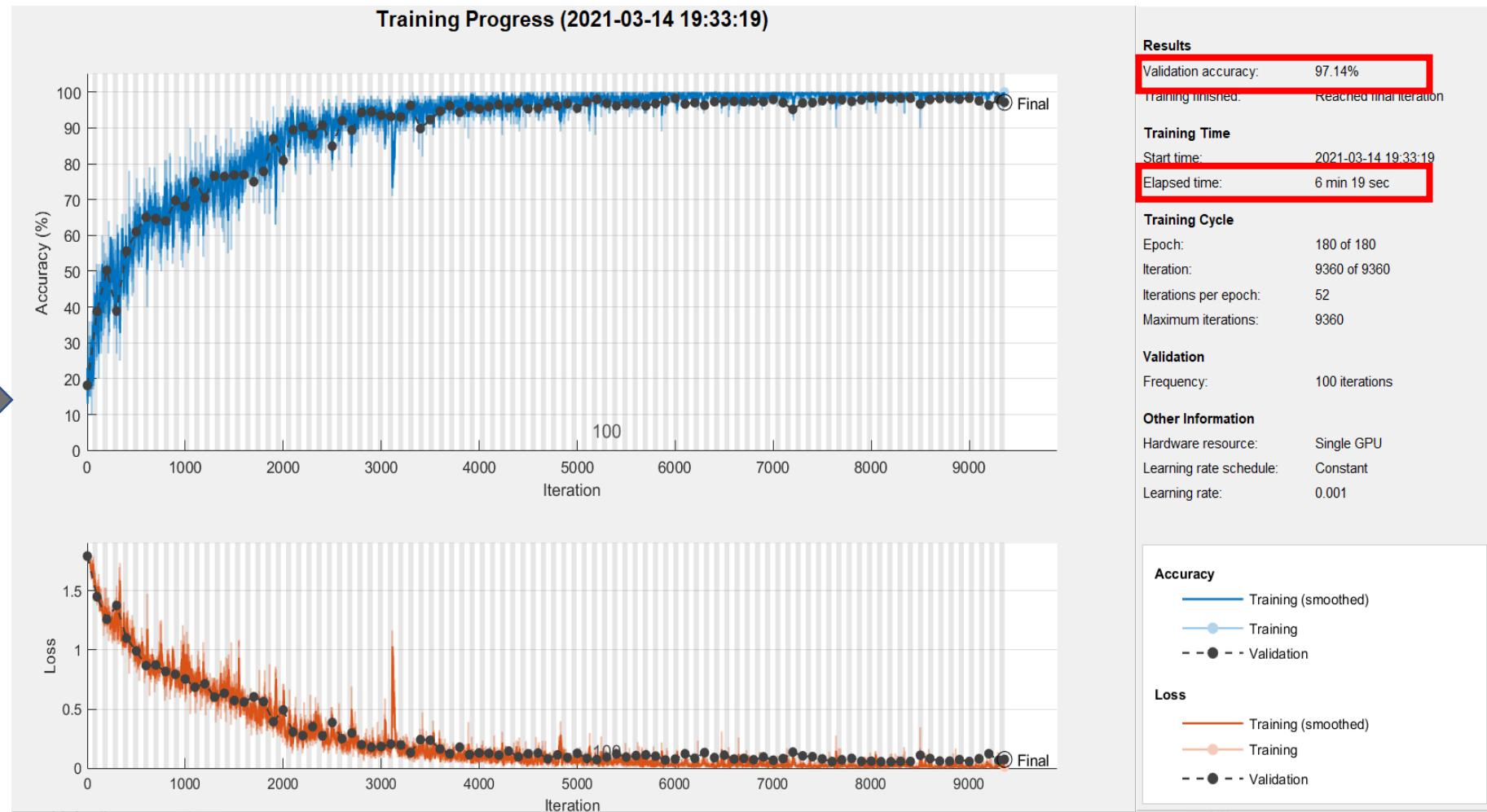
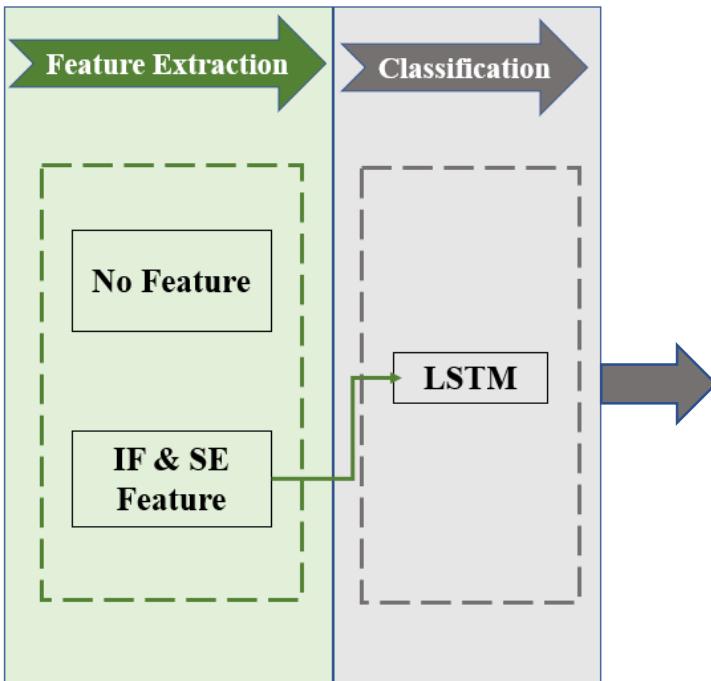
31.1%	68.9%
4.7%	95.3%
57.8%	42.2%
90.0%	10.0%
9.4%	90.6%
64.3%	35.7%



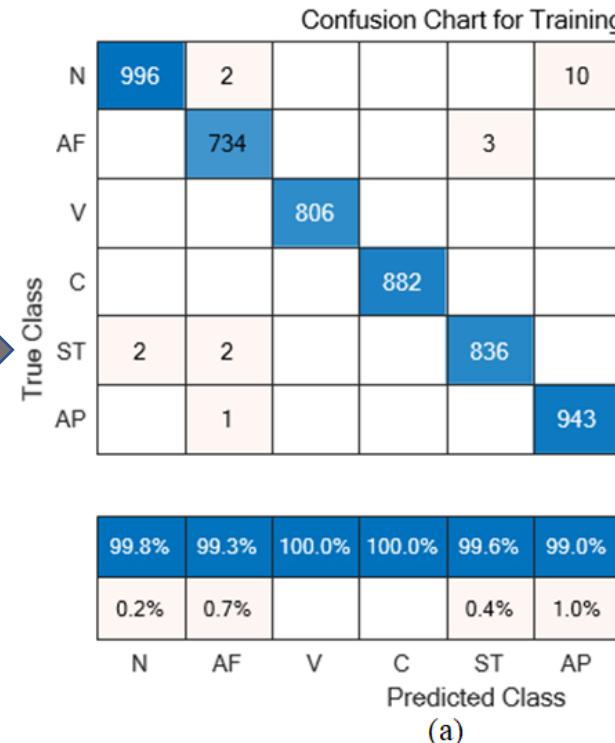
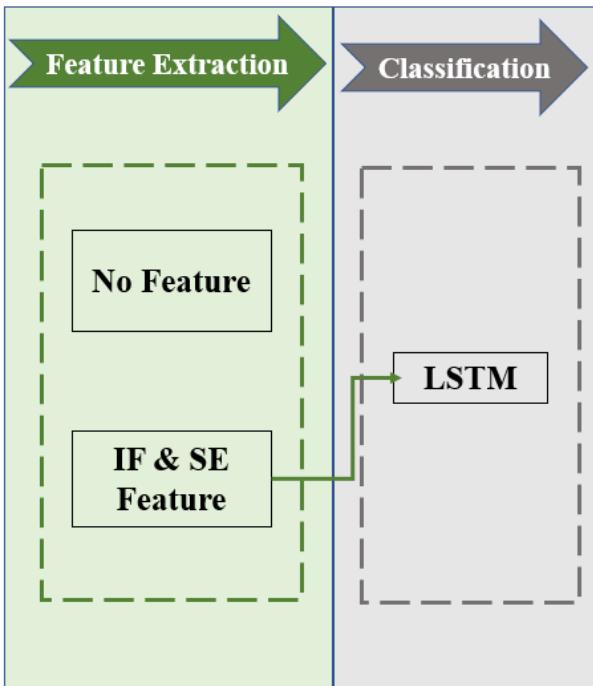
Training accuracy = 43.972%

Testing accuracy = 43.253%

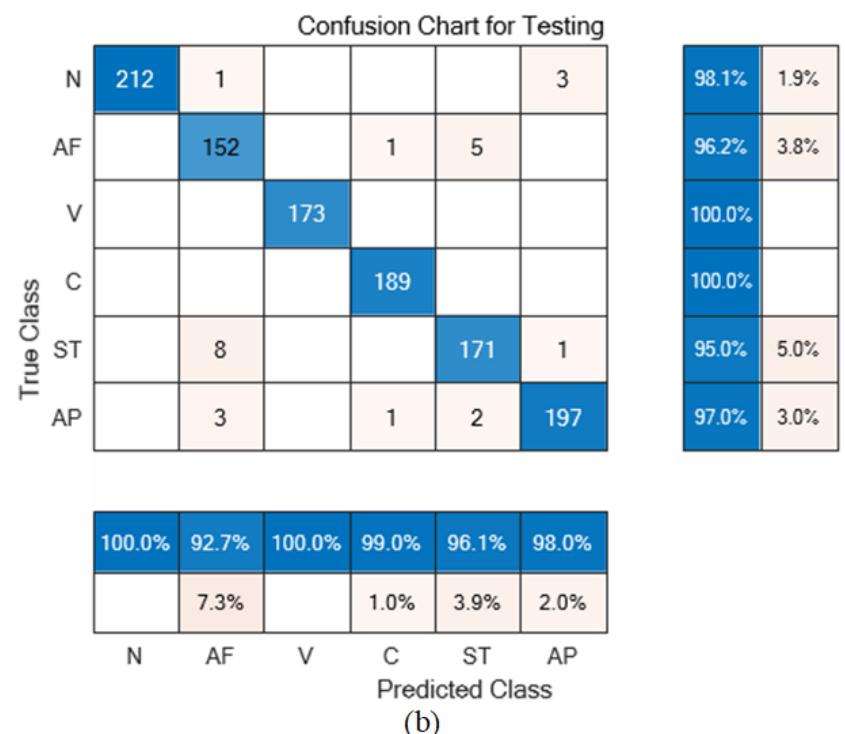
Deep Learning——LSTM Network



Deep Learning——LSTM Network



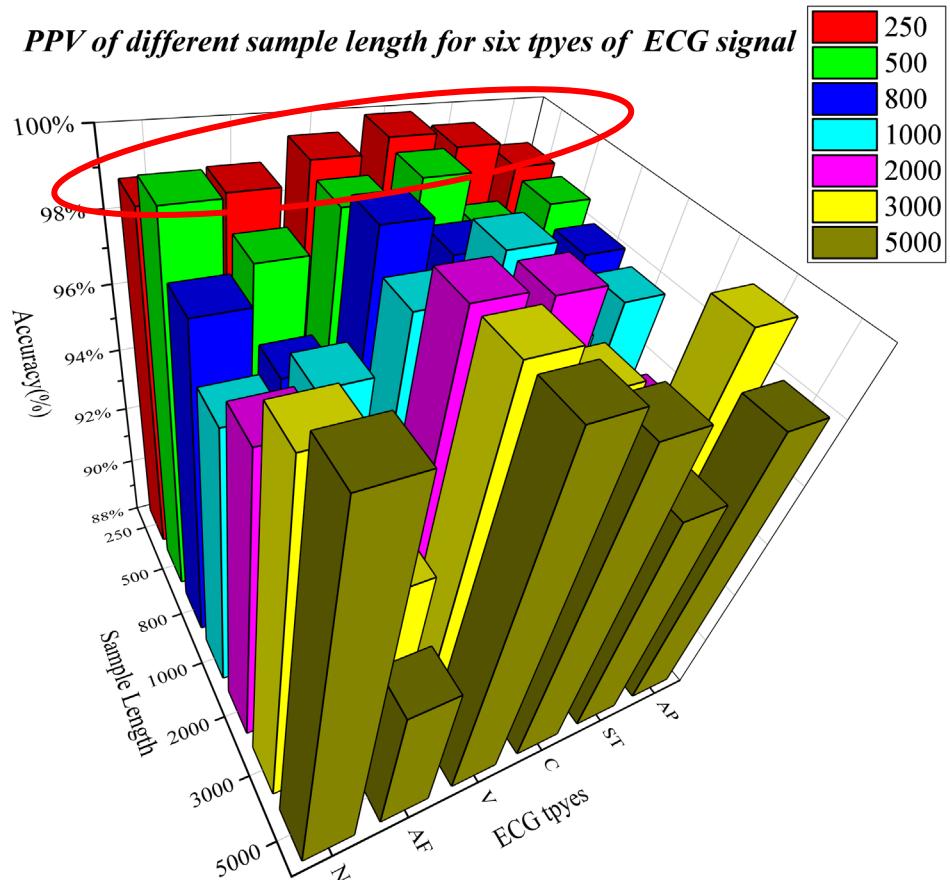
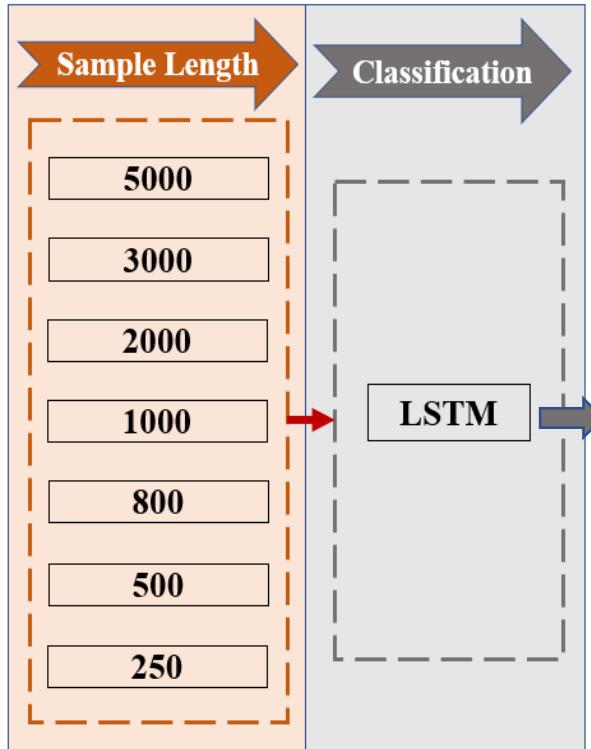
98.8%	1.2%
99.6%	0.4%
100.0%	
100.0%	
99.5%	0.5%
99.9%	0.1%



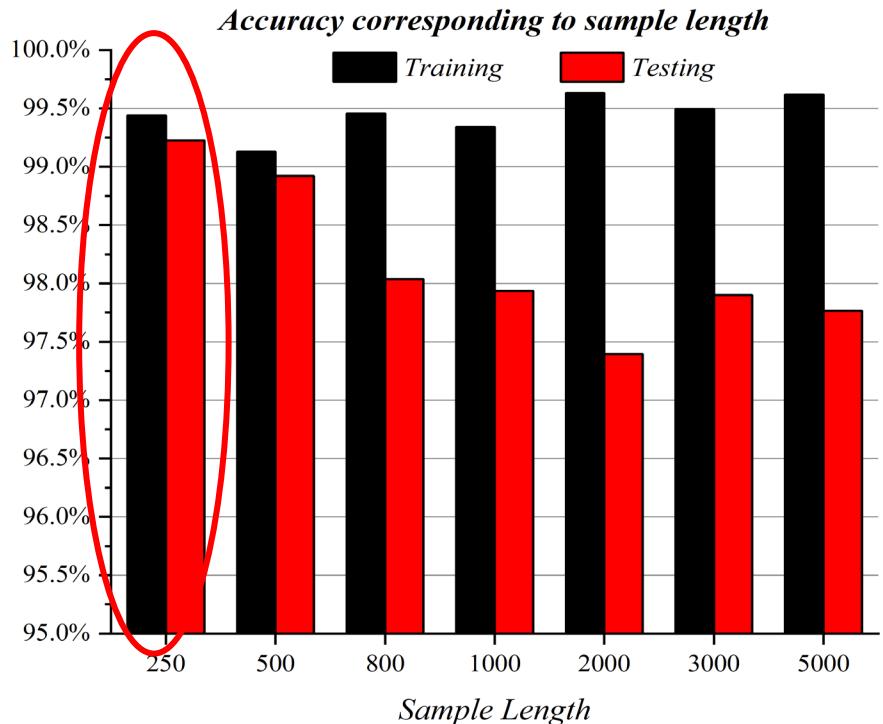
Training accuracy = 99.617%

Testing accuracy = 97.766%

Deep Learning——LSTM Network



Positive Predictive Value (PPV)
正阳率（精确度）



Training Accuracy = 99.441%
Testing Accuracy = 99.224%

第五部分



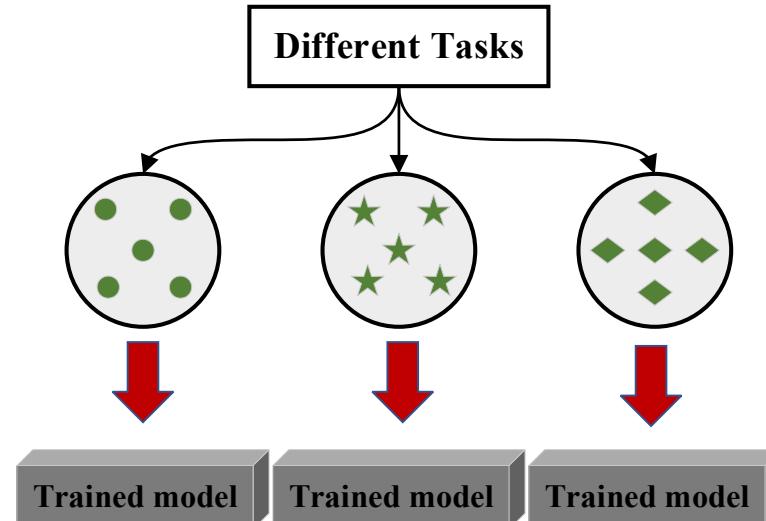
Part 05

Transfer Learning-Based Classification

(基于迁移学习的分类算法)

Standard Machine Learning

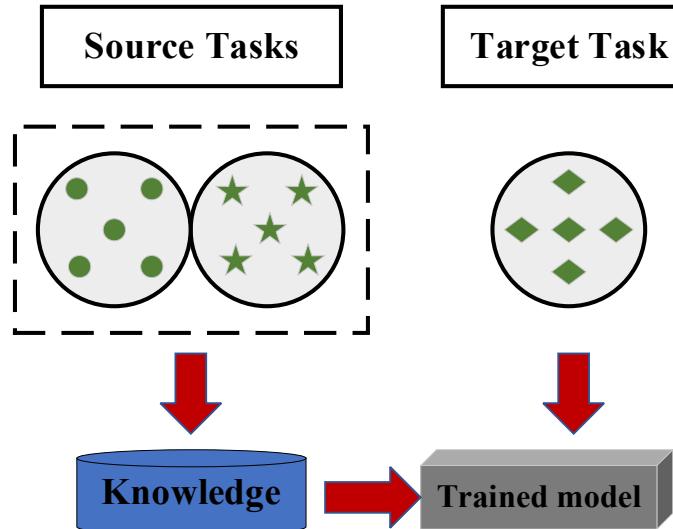
Learning Process of Classical Machine Learning



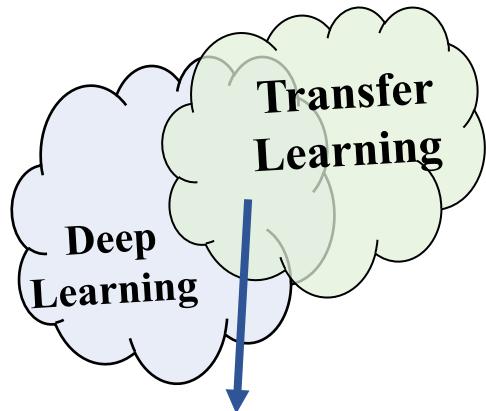
(a) Classical Machine Learning

Transfer Learning

Learning Process of Transfer Learning



(b) Transfer Learning



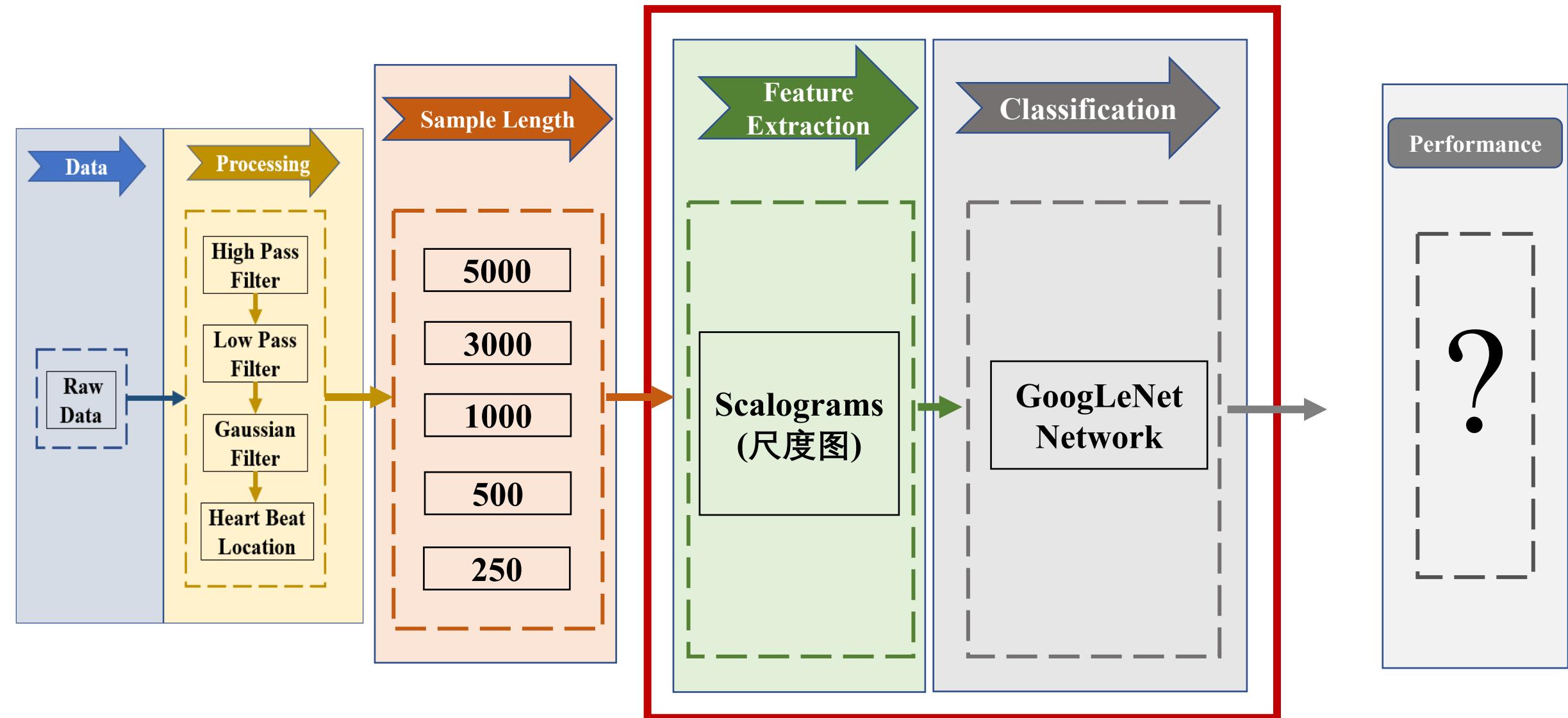
● *GoogLeNet*

● *SqueezeNet*

● *AlexNet*

⋮

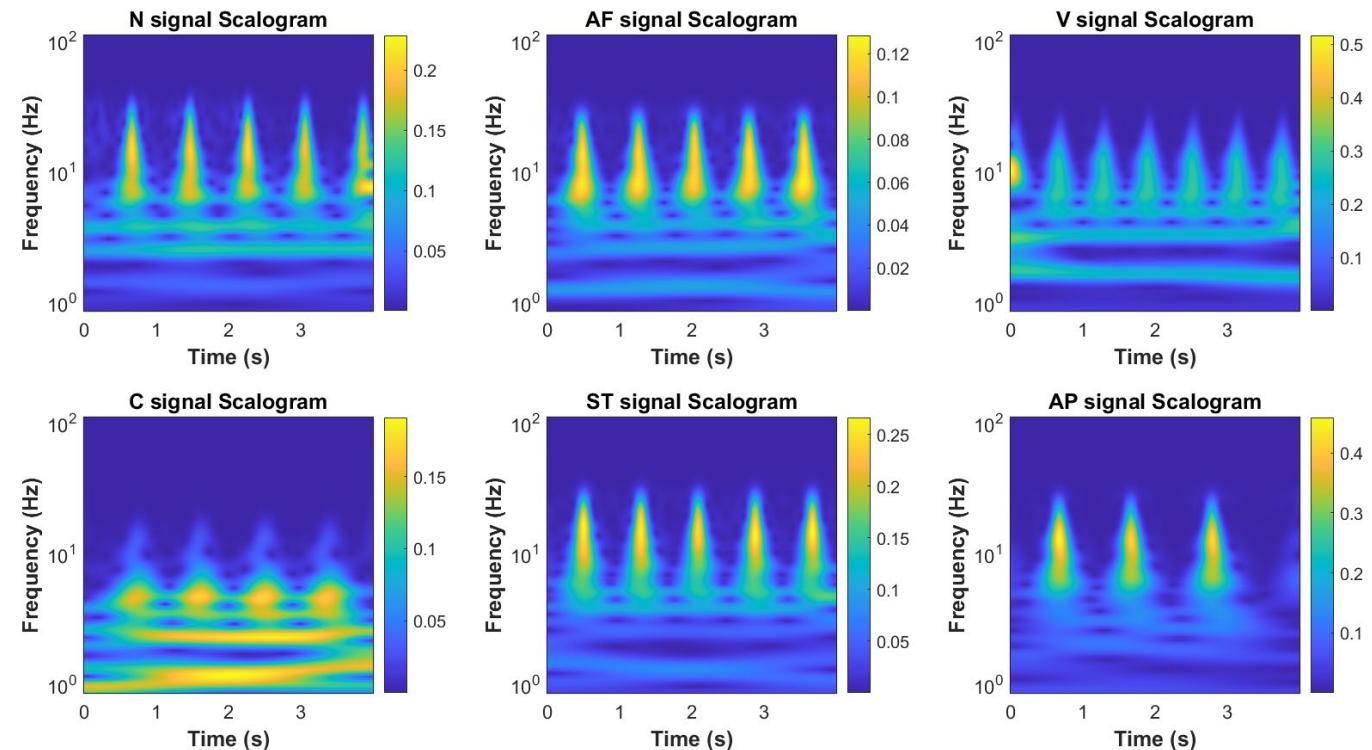
Transfer Learning——GoogLeNet Network



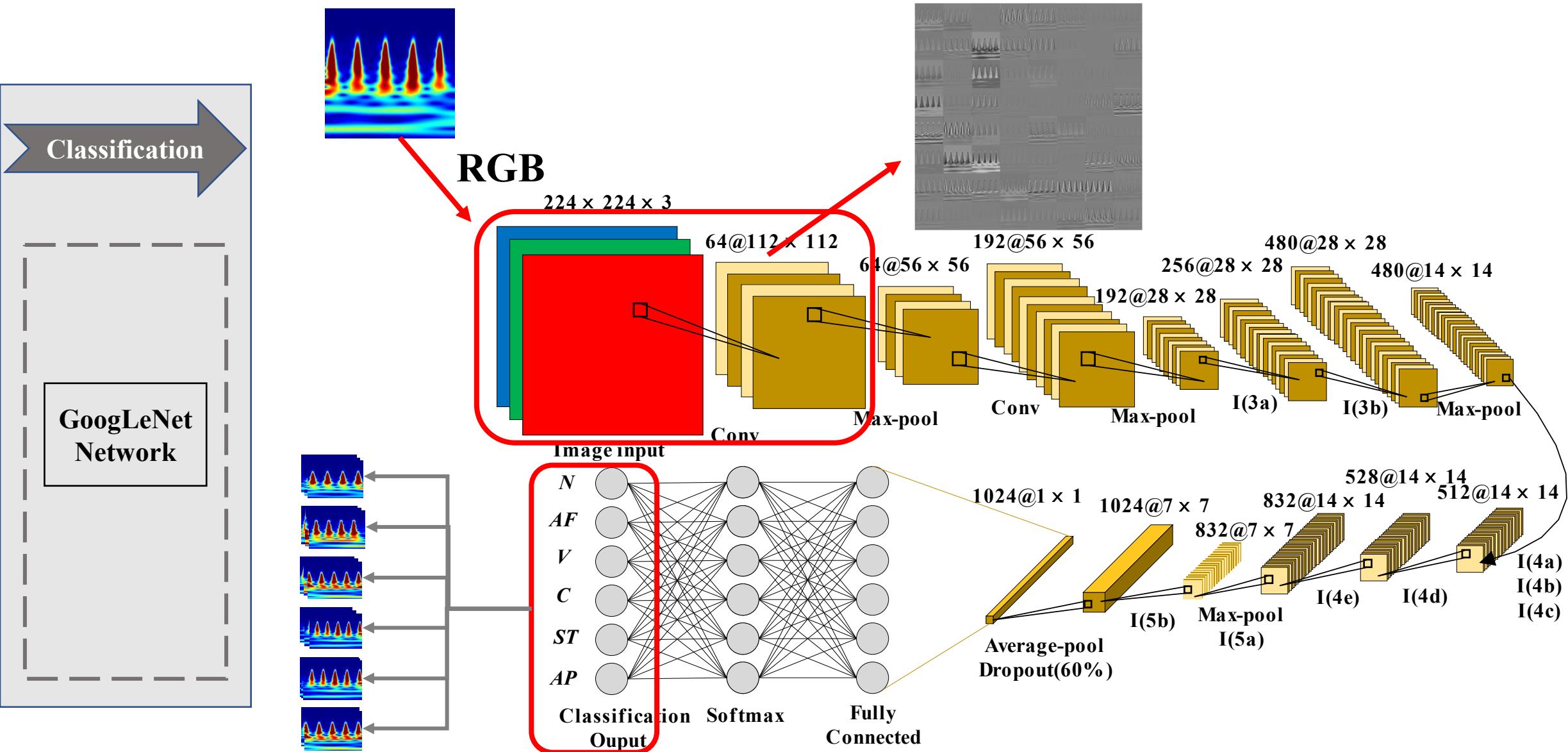
Transfer Learning——GoogLeNet Network



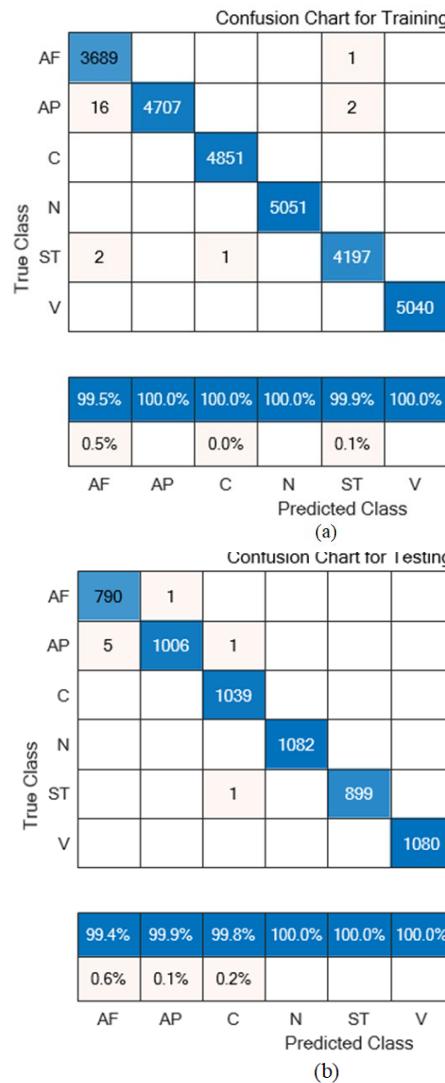
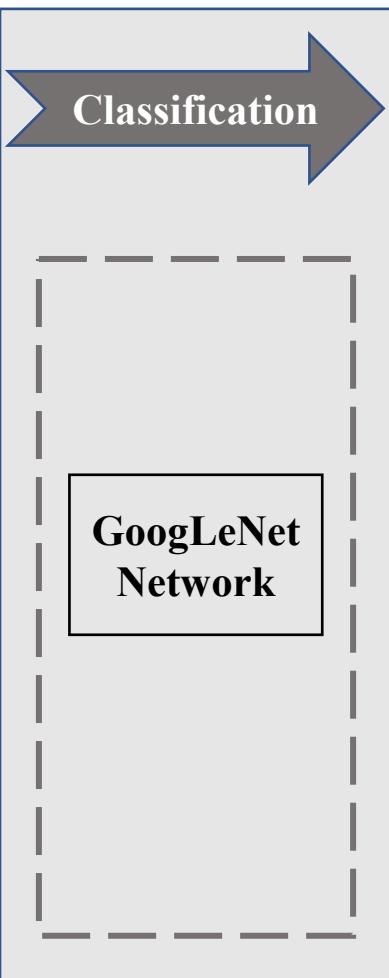
Short-Time Fourier Transforms(STFT) (快速傅里叶变换)	Continuous Wavelet Transform (CWT) (连续小波变换)
Time-Frequency feature	Time-Frequency feature
Fixed time window and frequency window (时间窗和频率窗——不随频率而改变)	Adjustable time window and frequency window (时间窗和频率窗——可随频率需要改变)



Transfer Learning——GoogLeNet Network



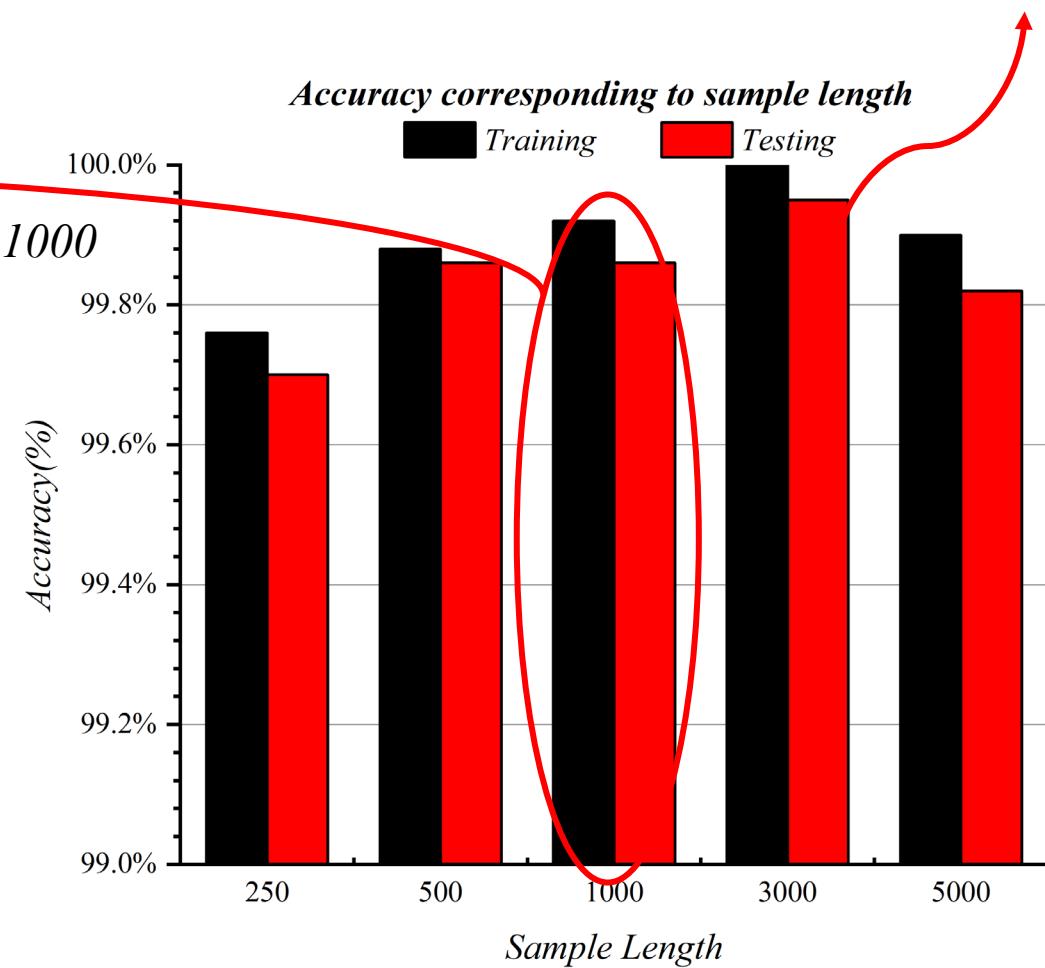
Transfer Learning——GoogLeNet Network



Training accuracy = 99.92%

Testing accuracy = 99.95%

Sample length = 1000



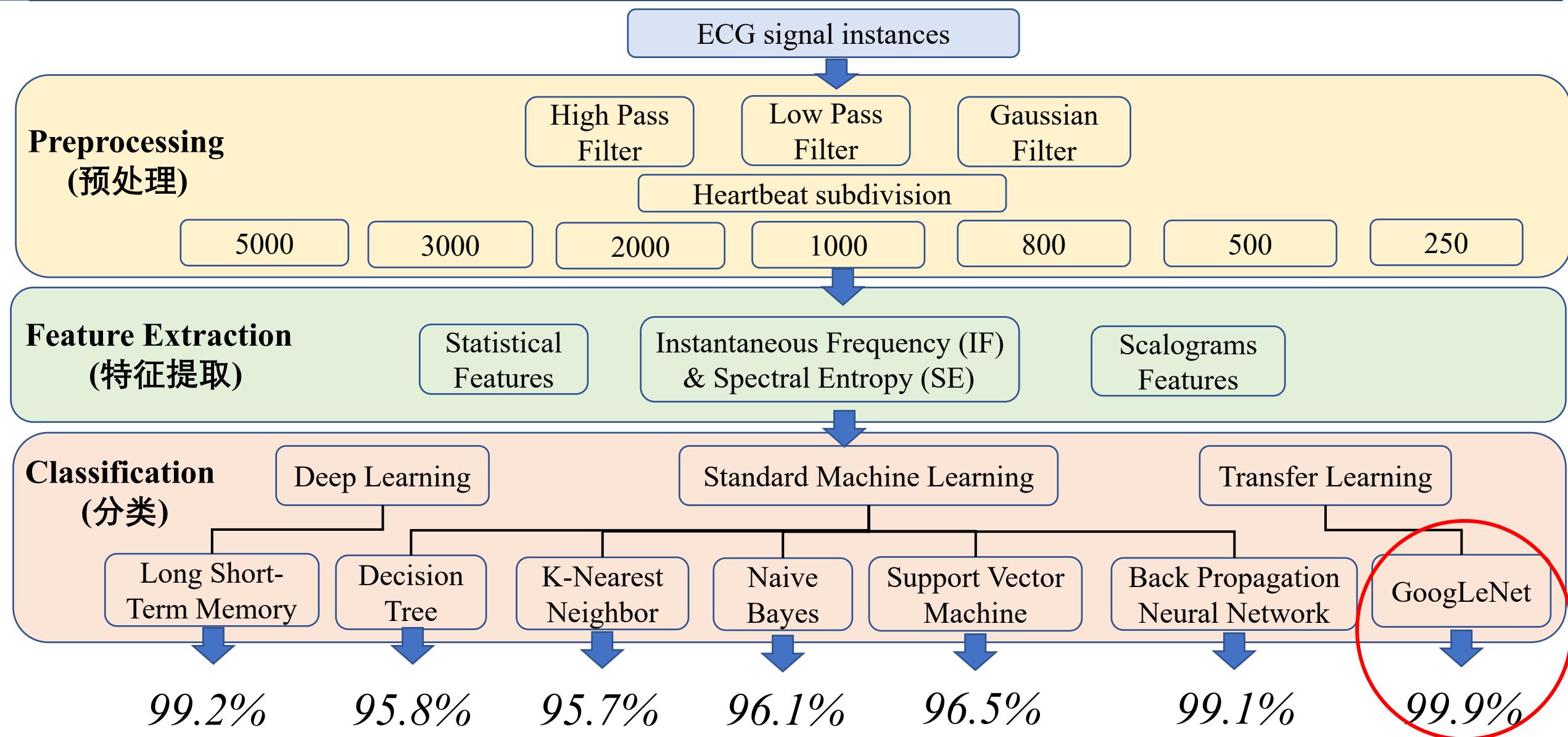


第六部分

Part 06

Conclusions (总结)

Conclusions





Thank You !