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Submission Title: [Stress analysis for rehabilitation patients using neural network for ECG-RRI with WBAN]

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Abstract: [A use case of dependable wireless body area network(WBAN) for learning and recognition of patient stress with machine learning is introduced.]

Purpose: [information]

Stress analysis for rehabilitation patients using neural network for ECG-RRI with WBAN

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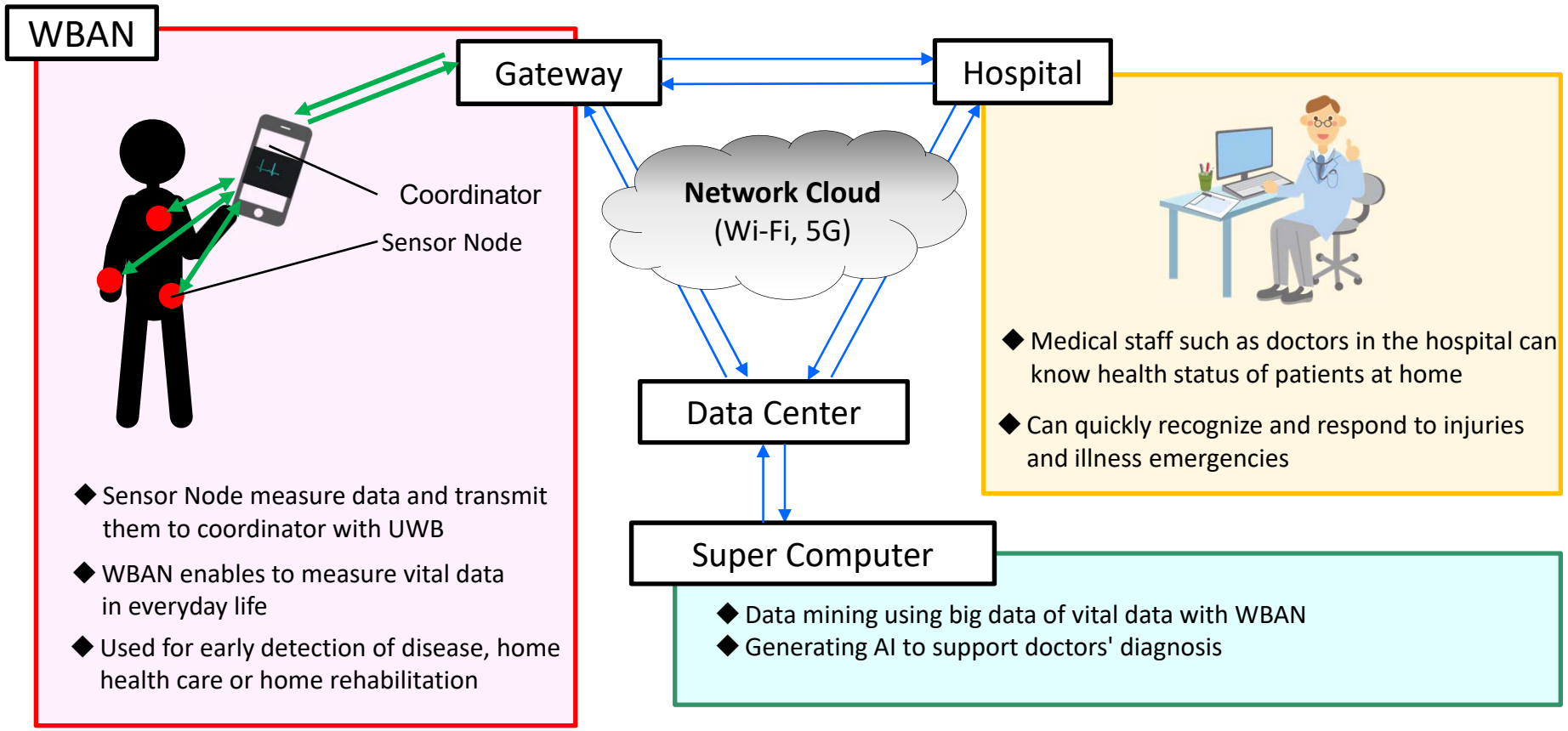
Agenda

1. Introduction : motivation, system model, aim of the research
2. Proposal Method : Preprocessing, Pre-training
3. Performance Evaluation : evaluation for proposal method
4. Conclusion

1.1 Health Monitoring with WBAN



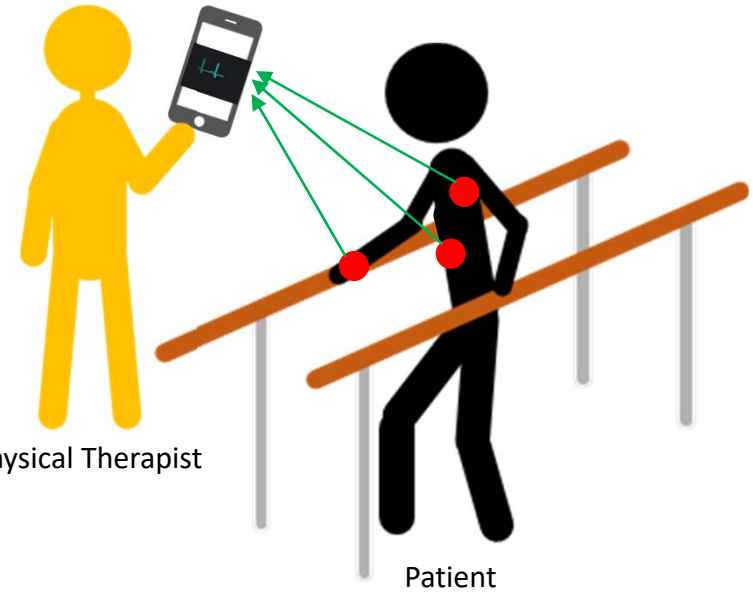
1.2 Care for Rehabilitation Patient

➢Physical Support

- Create training menus based on type and weight of injury or illness
- Health monitoring with vital data such as heart beat and body temperature measured by WBAN

➢Mental Support

- Proposal of a training method that matches the individual characteristics of the patient so that the patient can rehabilitate with high motivation without stress
- Sense the patient's mental stress from the patient's appearance (facial expression, speech, etc.), and provide care for it



- ◆ Patient mental stress is less noticeable to the therapist than physical anomalies
- ◆ The system to assess patient stress is needed to make it easier for the therapist to provide appropriate care to the patient

1.3 The Objective of the Research

➢System Model

- WBAN coordinator performs training of NN in order to reduce communication delay

➢Objective

- Proposal for real time stress analysis method with Neural Network using ECG data from WBAN
- Reduction of calculation complexity for processing such as training of NN because WBAN coordinator has limited processing capability

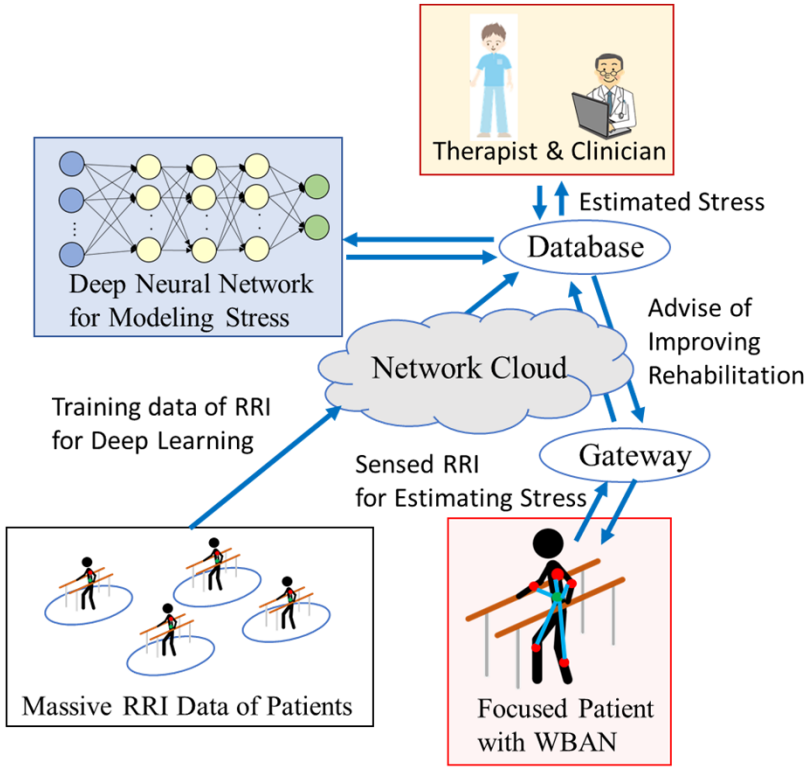
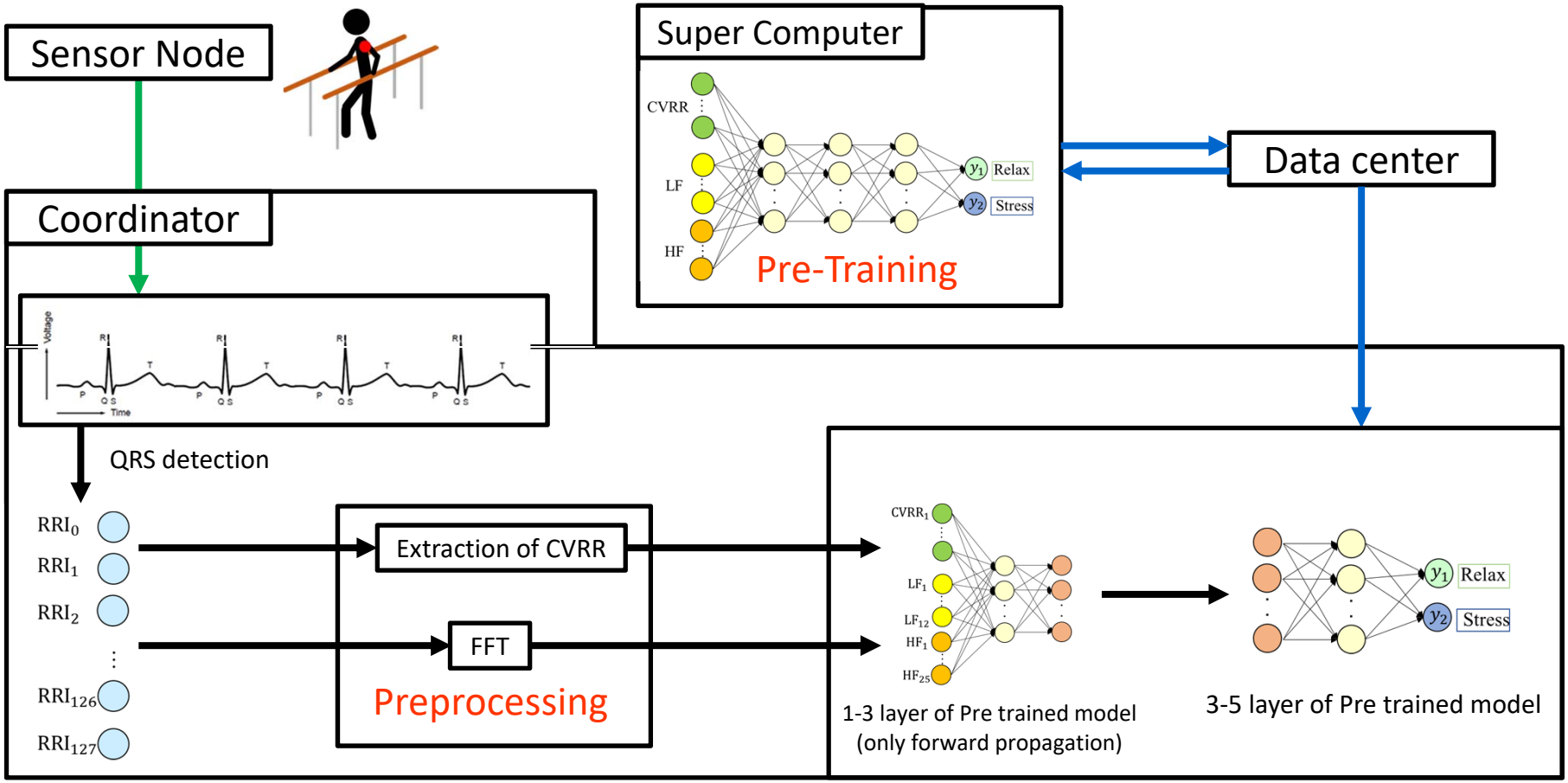


Fig. 1 Entire System for stress analysis

2.1 System Model



2.2 Features in heartbeat regarding stress

- In this research, the following parameters included in RRI are extracted by preprocessing before training NN.
- It is known from medical knowledge that these parameters are correlated with stress.

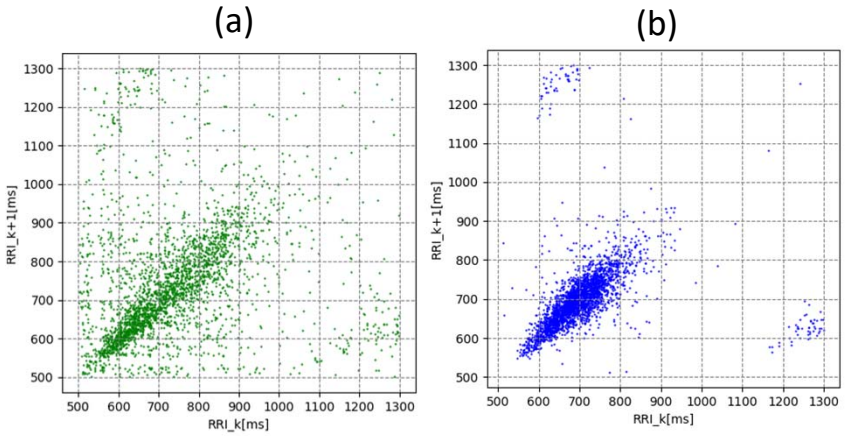


Fig. 2 Poincare Plot (a)relax (b)stress

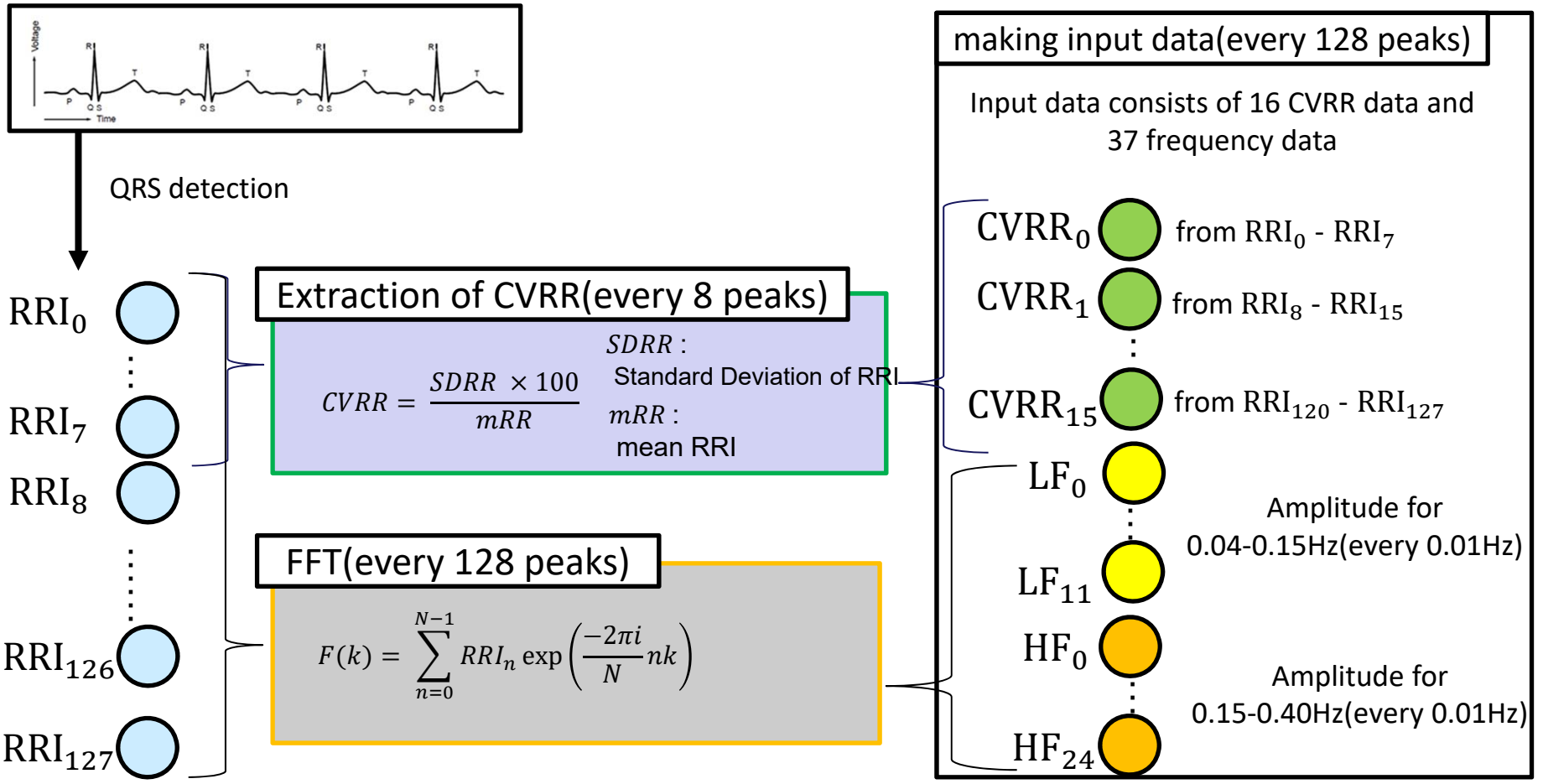
➢CVRR (Coefficient of Variation of R-R interval)

- Indicator of the magnitude of RRI variation
- When the patient feels stress, the variation of RRI decreases so the value of CVRR decreases

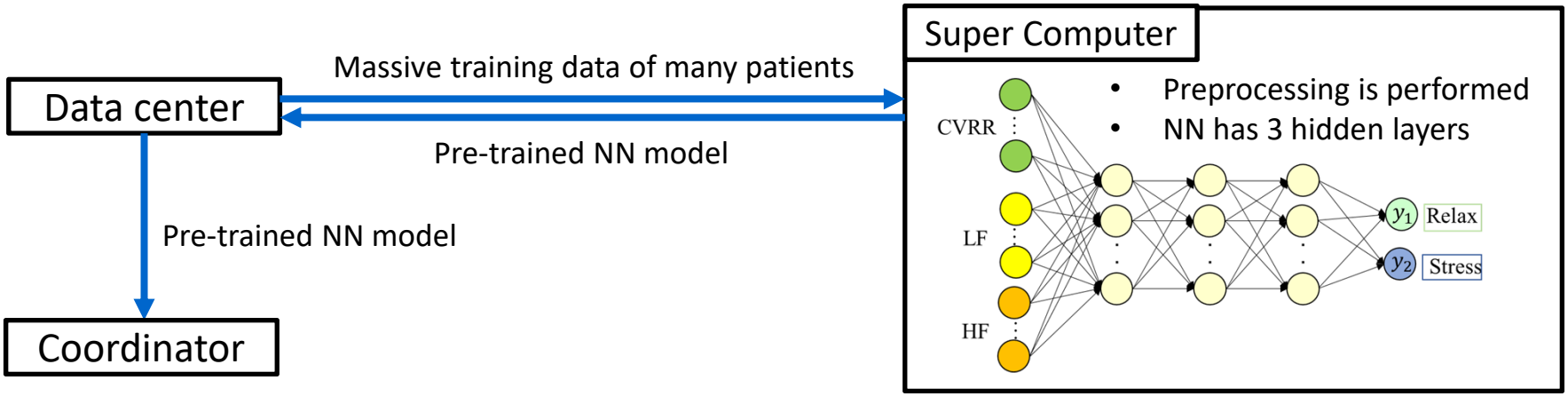
➢Frequency spectrum

- Sympathetic and Parasympathetic activities appear in the LF(0.04Hz – 0.15Hz) and HF(0.15Hz – 0.40Hz) band.
- When the patient feels stress, LF is relatively larger than HF.

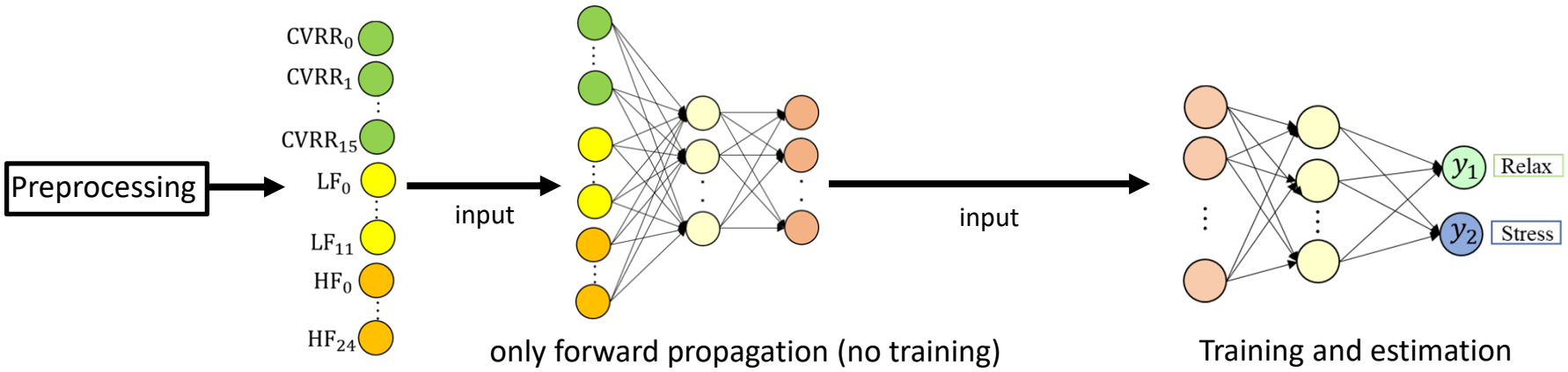
2.3 Preprocessing



2.4 Pre Training



- Pre-trained NN with 5 layers is divided into 2 NN with 3 layers
- In coordinator, the weights of the first 3 layers are not updated



3.1 Performance Evaluation

➢Simulation. 1 Evaluation for Preprocessing based on medical knowledge

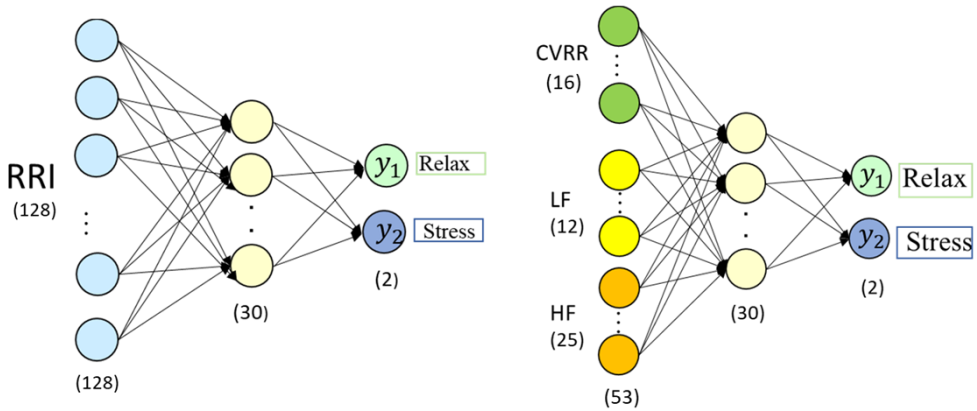
- Use data obtained by labeling “stress” or “relax” to the actually measured RRI
- Compare calculation complexity and the accuracy of stress estimation with and without derivation of CVRR and frequency spectrum.

➢Simulation. 2 Evaluation for feature extraction by Pre-training

- Pre training uses artificial RRI data generated based on actually measured RRI
- WBAN Coordinator performs training and estimation using measured RRI data and pre trained model.
- Compare calculation complexity and the accuracy of stress estimation with and without Pre-training

3.2 Simulation. 1

- Evaluation for Preprocessing
- Compare calculation complexity and the accuracy of stress estimation with and without derivation of CVRR and frequency spectrum by FFT.



(a)without Preprocessing (b)with Preprocessing

Fig. 3 Architecture of NN

Table. 1 Parameters in Simulation. 1

Preprocessing	Yes	No
input units	53	128
hidden units	30	
output units	2	
activation function(hidden layer)	ReLU	
activation function(output layer)	softmax	
loss function	crossentropy	
learning rate	0.01	
Optimizer	SGD	
batch size	18	
number of training data	45	45
number of test data	45	45
Number of trials	10	

3.3 Result of Simulation. 1

- When preprocessing is performed, accuracy after training increases by more than 10%
- The amount of calculation until convergence is reduced to 1/10

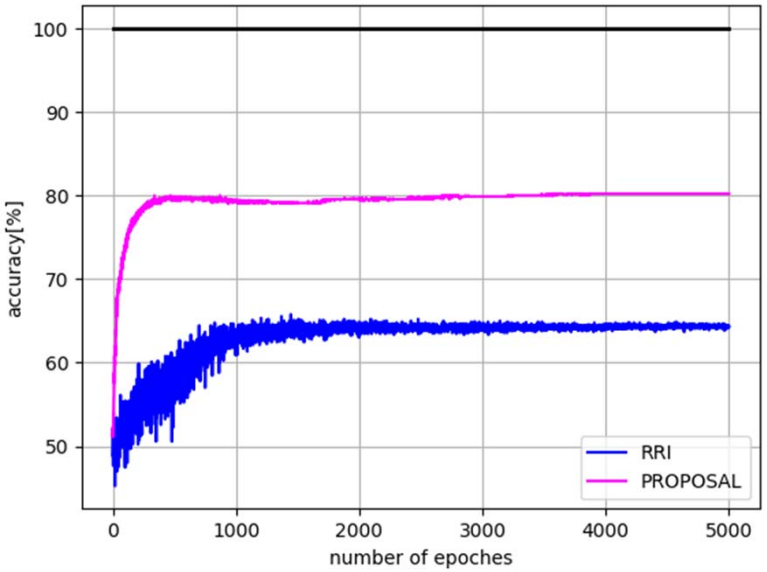


Fig. 4 number of epochs vs. accuracy

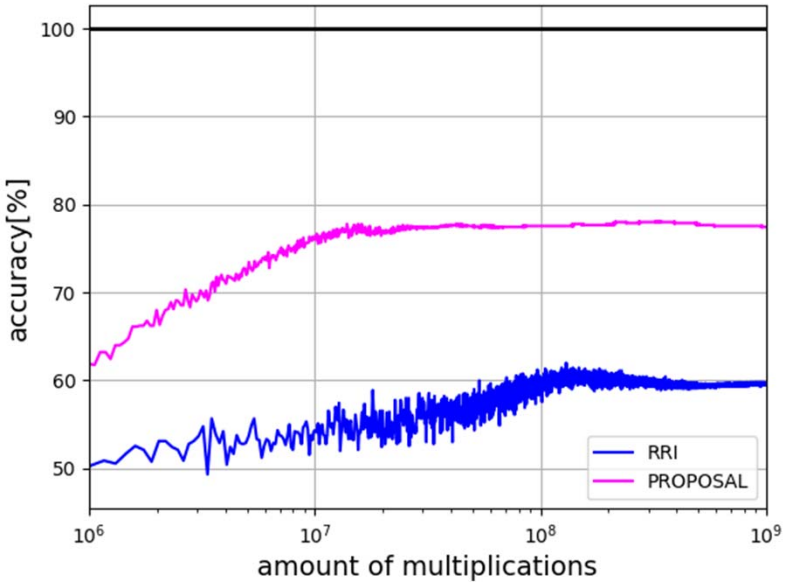
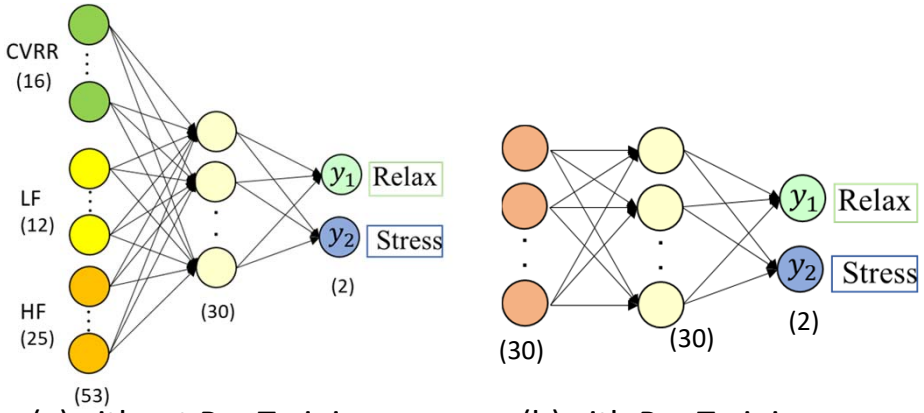


Fig. 5 number of multiplications vs. accuracy

3.4 Simulation. 2

- Evaluation for Pre training
- WBAN Coordinator performs training and estimation using measured RRI data and pre trained model.
- Compare calculation complexity and the accuracy of stress estimation with and without Pre-training



(a)without Pre Training (b)with Pre Training

Fig. 6 Architecture of NN

Table. 2 Parameters in Simulation. 2

Pre Training	Yes	No
input units	30	53
hidden units	30	
output units	2	
activation function(hidden layer)	ReLU	
activation function(output layer)	softmax	
loss function	crossentropy	
learning rate	0.01	
Optimizer	SGD	
batch size	20	
number of training data	60	60
number of test data	60	60
Number of trials	10	

3.5 Pre Training

- Pre training uses artificial RRI data generated based on actually measured RRI

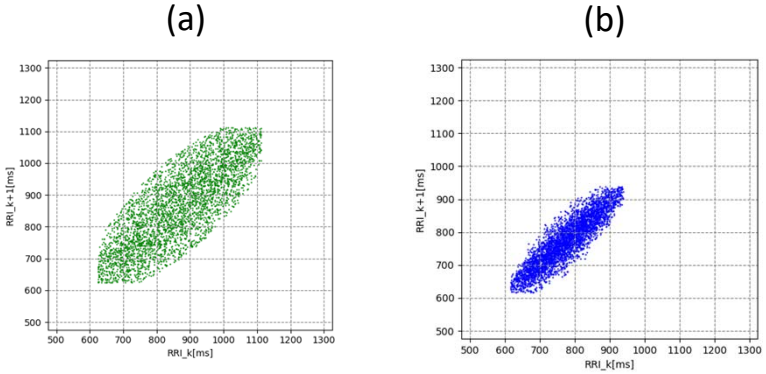


Fig. 7 Poincare Plot of Artificial RRI (a)relax (b)stress

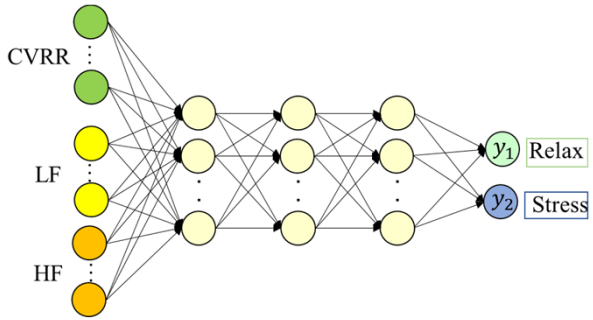


Fig. 8 NN for Pre Training

Table 3. Parameters in Pre Training

input units	57	
hidden units	30	
Hidden layer	3	
output units	2	
activation function(hidden layer)	ReLU	
activation function(output layer)	softmax	
loss function	crossentropy	
learning rate	0.01	
Optimizer	SGD	
batch size	20	
number of training data	10000	10000
Number of trials	10	

3.6 Result of Simulation. 2

- Convergence within 100 epochs by pre training using artificial data, increasing convergence value
- The amount of calculation until convergence is reduced to 1/10

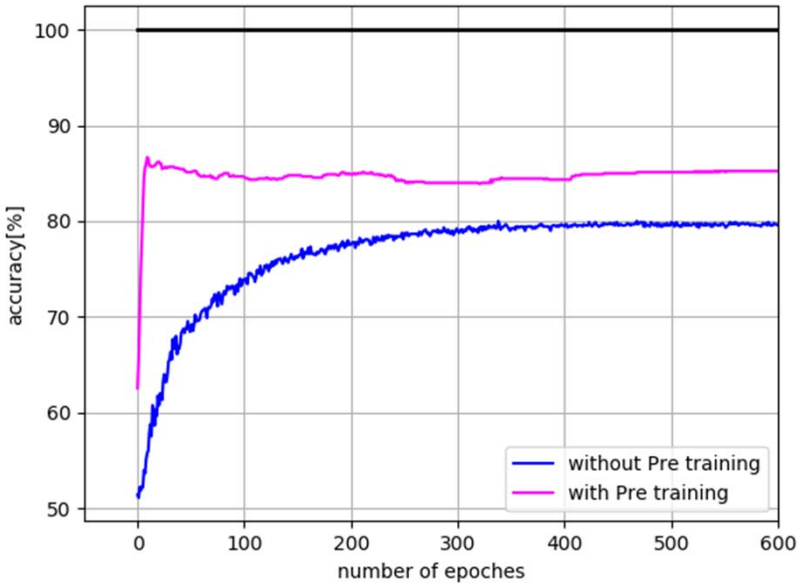


Fig. 9 number of epochs vs. accuracy

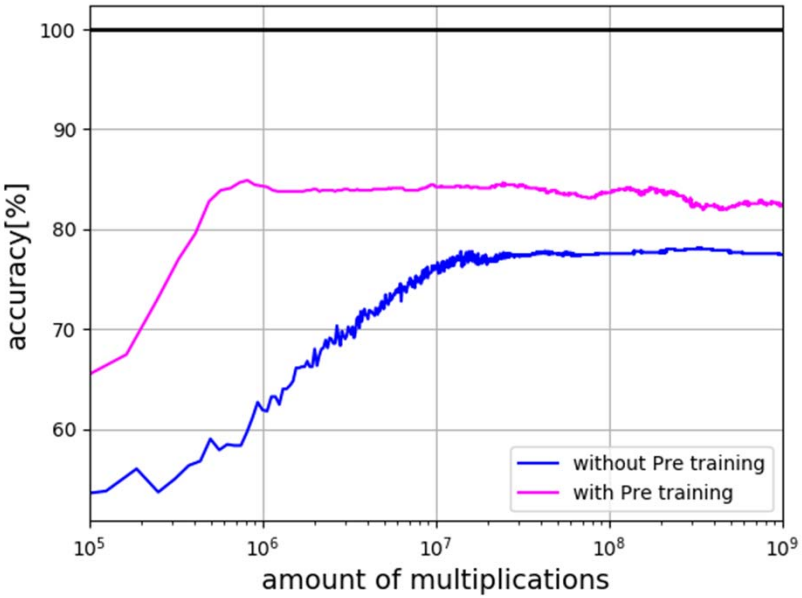


Fig. 10 number of multiplications vs. accuracy

4 Conclusion and Future Work

◆ Conclusion

- Assumes that WBAN coordinator performs machine learning processing

⇒Reduce the amount of calculation required for training by extracting features in RRI in advance

⇒Reduce the amount of calculation at the coordinator by training with the data of others in advance

- Introduction of preprocessing based on medical knowledge and Pre Training using artificial RRI

⇒Confirmed decrease in the amount of calculation required for training and increase in accuracy

◆ Future Work

- Theoretically determine the values of hyper parameters such as the number of units in the hidden layer
- Arrangement of generation formula of artificial RRI used for simulation
- Stress estimation for 3 classes

Thank you for your attention

Appendix 1. Measurement for RRI data

- Measurement with Silmee Bar type (TOSHIBA)
- I measured data while watching videos that evoke the emotions of "stress" and "relax" for about 60 minutes each and gave label
- To improve learning efficiency, only data with 500[ms] <RRI <1300[ms] excluding outliers are used.

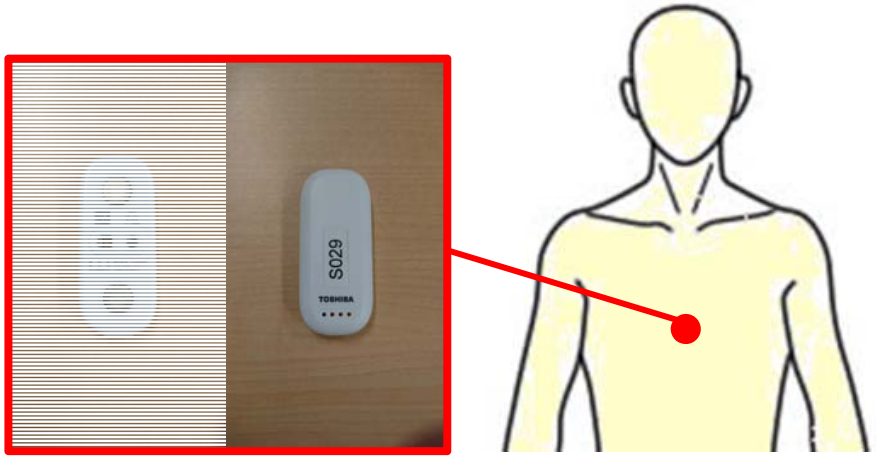


Fig. Location of Sensor Node

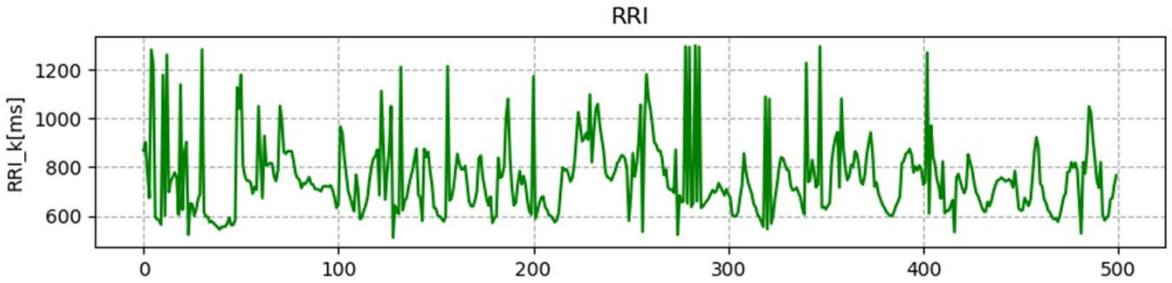


Fig. Measured real RRI data(Relax)

Appendix 2.1 Artificial RRI

Table 4. part of Artificial RRI generation parameters

	real RRI		artificial RRI	
Label	relax	stress	relax	stress
min	500	550	500~800	500~650
Max	1000	950	920~1200	850~950
average	800	750	700~900	650~800

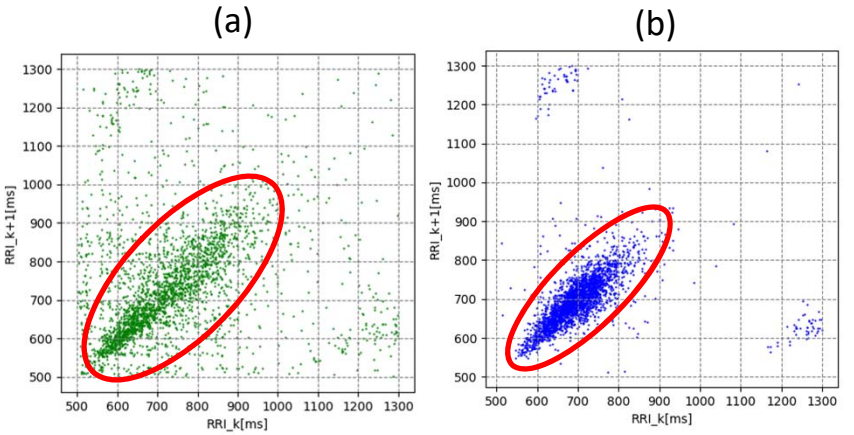


Fig . real RRI

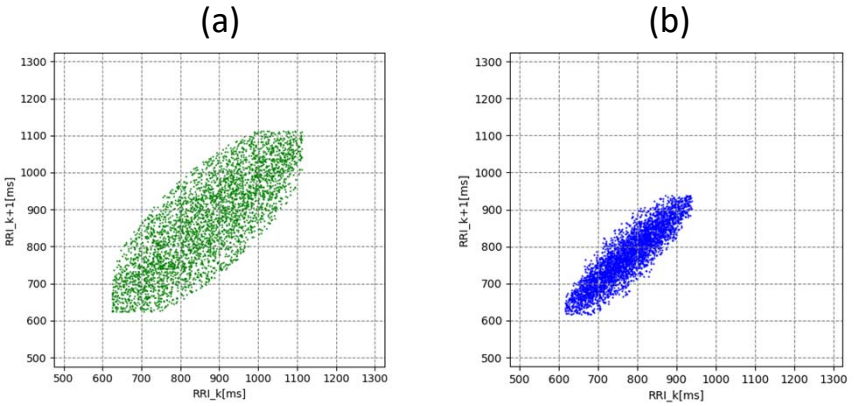


Fig . artificial RRI

Appendix 2.2 Artificial RRI

- Simulation results of training with 200 artificial data and estimating real data
- Accuracy of identification varies greatly depending on training data of artificial RRI

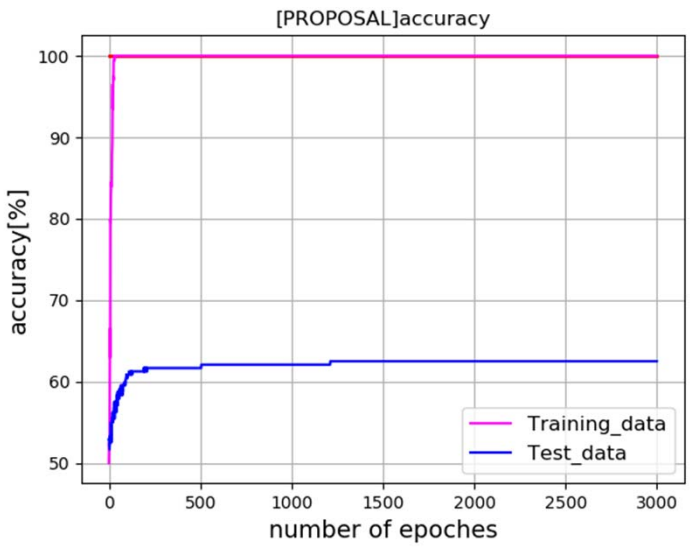


Fig . Training with Artificial RRI(a)

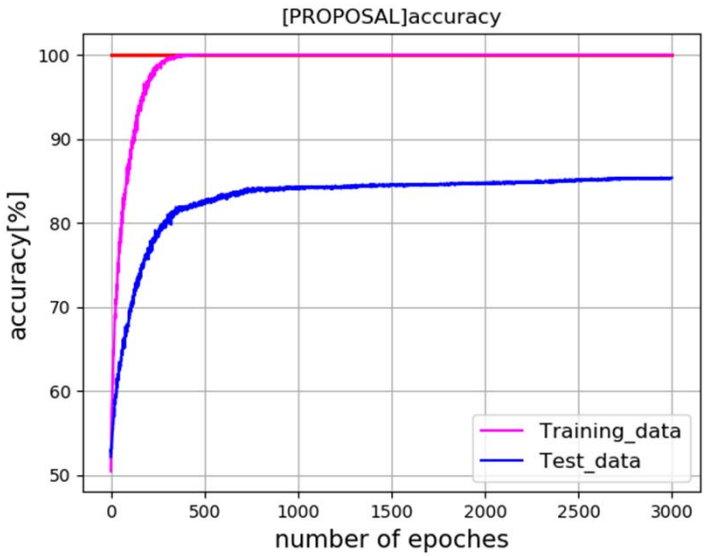


Fig. Training with Artificial RRI(b)