Detection and Severity Classification of Aortic Valve Stenosis

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Task 1. Detection of Aortic Valve Stenosis based on Gaussian mixture-hidden Markov model(GMM-HMM)

GMM-HMM is a statistical model, which describes two interdependent stochastic processes, one is an observable process, and the other is a hidden Markov process. The observation sequence is assumed to be generated by each hidden state according to the Gaussian mixture distribution.

In this study, the MFCCs feature of heart sound signal was extracted, and then the feature was modeled as GMM-HMM model, and a GMM-HMM model was trained for normal heart sound and aortic valve stenosis heart sound respectively.

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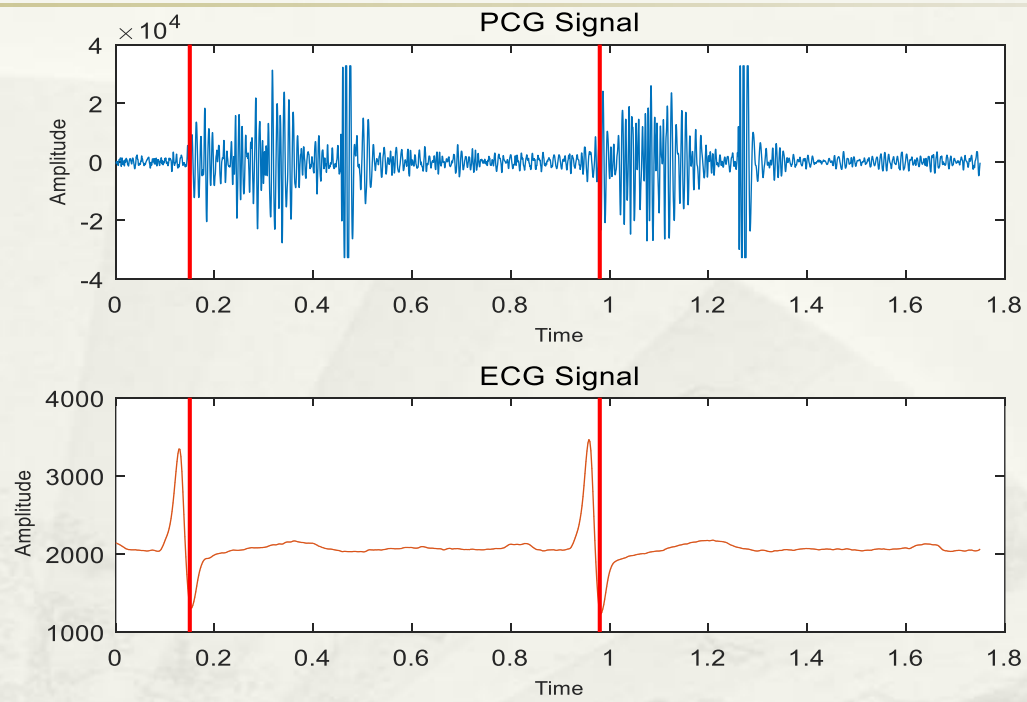
Data preprocessing

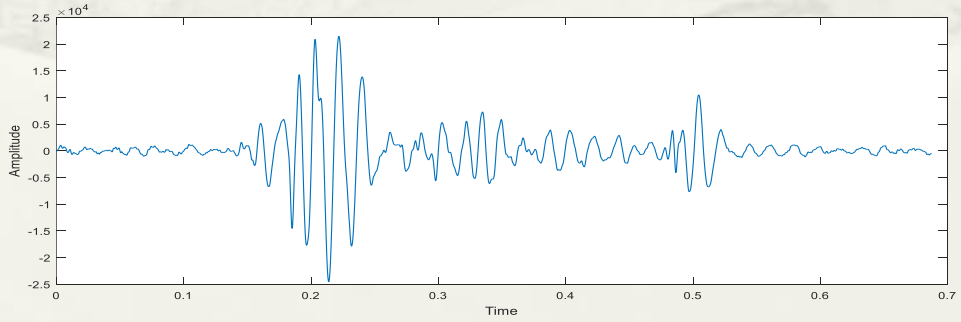
Band-pass filtering: the cutoff frequency is [50,600] and the order is 6

Segment: Contains S1 and S2

Normalization: $xt = \frac{xt}{\max(xt)}$



(a) Raw data



(b) Segmented and Preprocessed data

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Feature extraction

MFCCs (Mel Frequency Cepstral Coefficents) is a feature widely used in automatic speech and speaker recognition. And it can also be used in our heart sound signals. In this study, MFCCs was used as an input feature for the detection of aortic valve stenosis.

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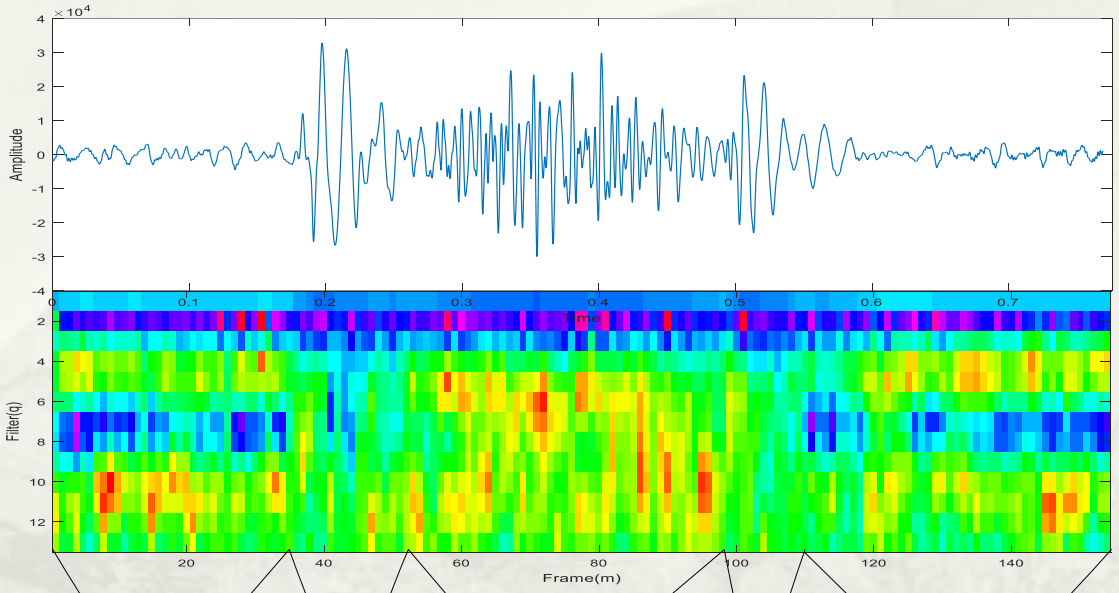
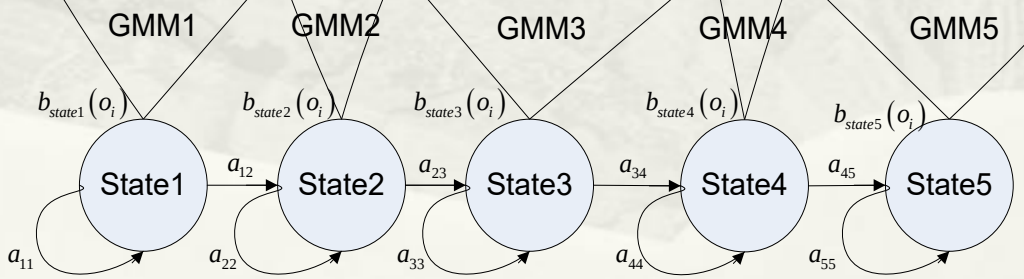
GMM-HMM

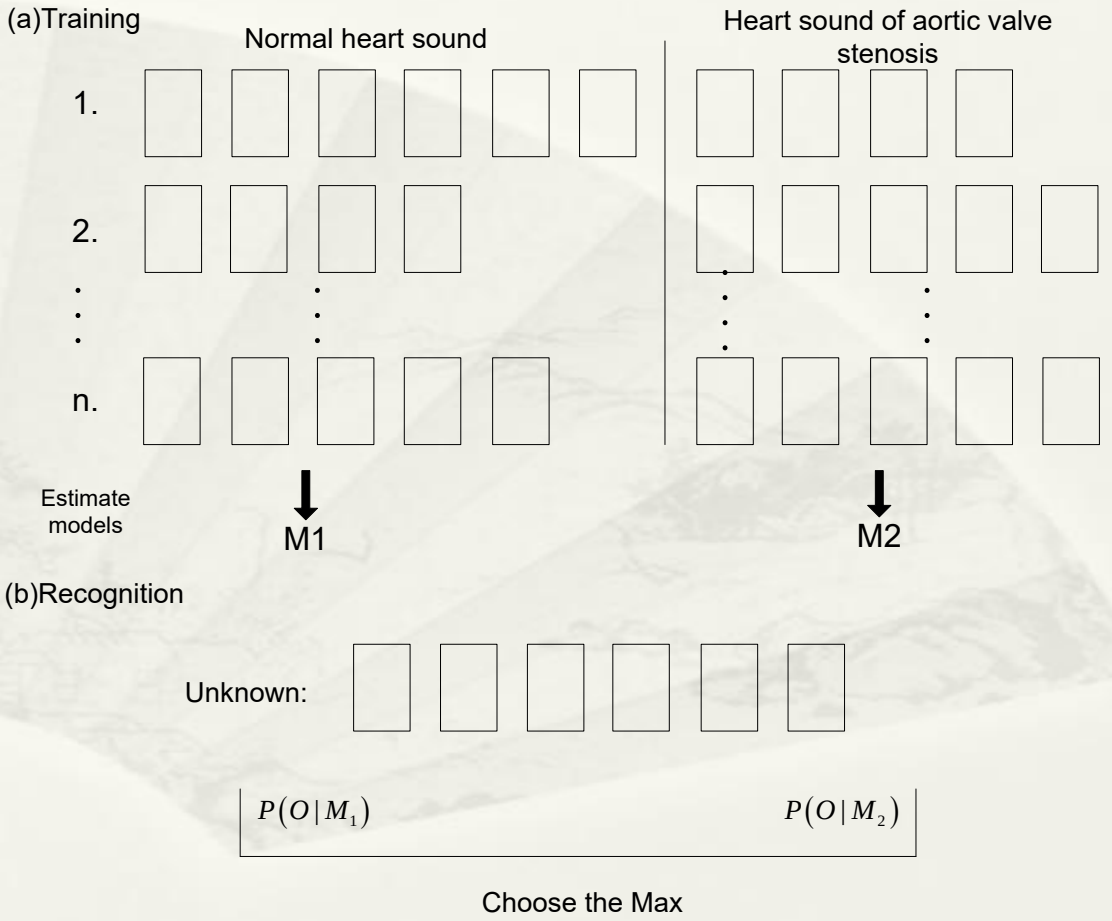
Heart sound signal:



Input signal (MFCCs):

GMM-HMM:





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Task 2. Classification of severity of Aortic Valve Stenosis based on convolutional Neural Network(CNN)

CNN is a common method of image processing, and it can also be used for speech signal recognition and detection. It extracts the deep abstract features of the input data through the convolutional process, and obtains the most effective information through the pooling process. Finally, the deep features are classified by the fully connected layer.

In this study, MFCCs features are extracted and their differences are made to obtain dynamic features, and the three-channel feature is used as the input of CNN. The best classification result is obtained by adjusting the network structure and parameters.

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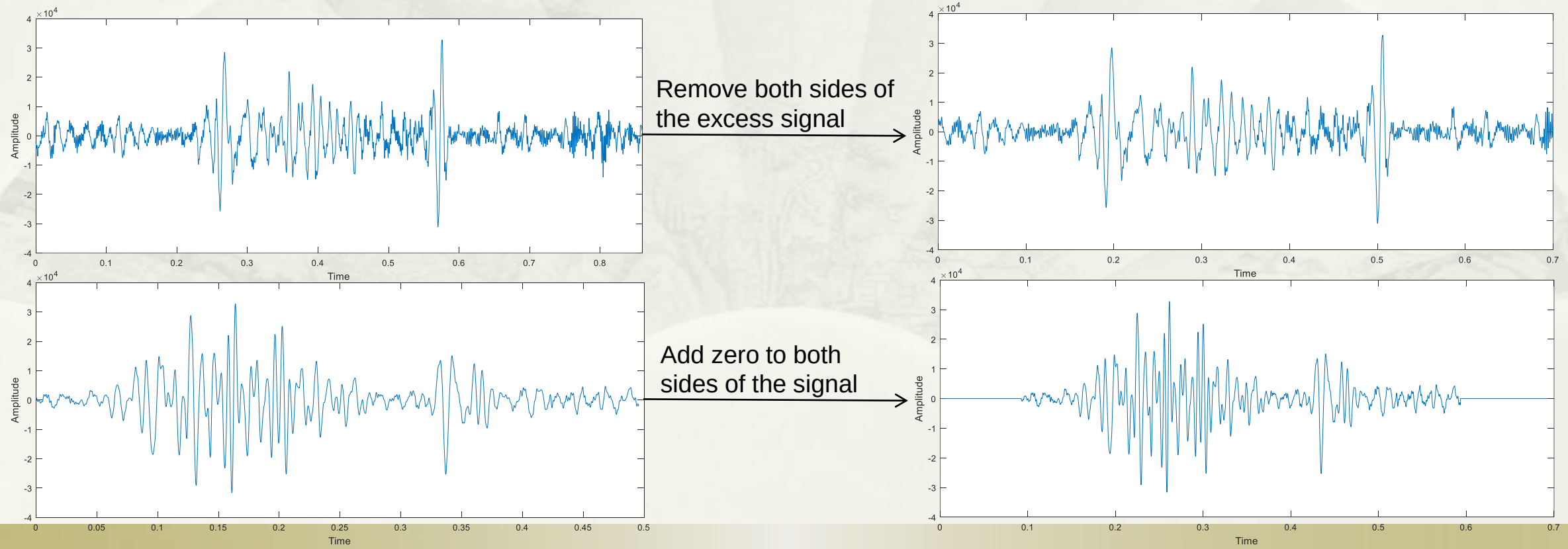
Data preprocessing

Because the input of the CNN used in this study needs to be fixed in length, and the data segment is variable in the previous detection, it is necessary to process the length of the data segment before severity classification. We set the length of the data segment to 0.7s.



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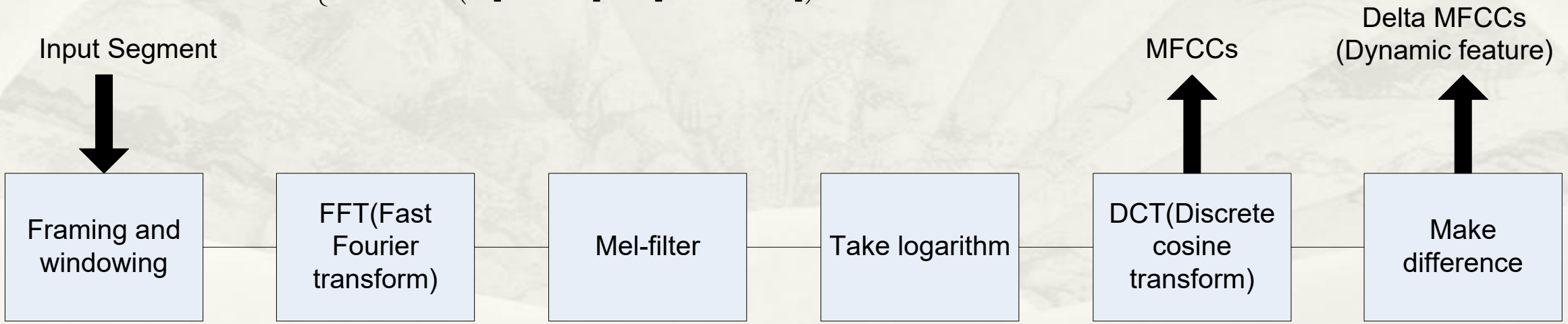
Feature extraction

Because MFCCs extracts static features, in order to obtain dynamic features, it is necessary to perform differential processing on MFCCs.

$$\begin{cases} LMFB = \mathbf{F}[:, 1:M-2] \\ \Delta_1 = \mathbf{F}[:, 2:M-1] - \mathbf{F}[:, 1:M-2] \\ \Delta_2 - \Delta_1 = \left(\mathbf{F}[:, 3:M] - \mathbf{F}[:, 2:M-1]\right) - \Delta_1 \end{cases}$$



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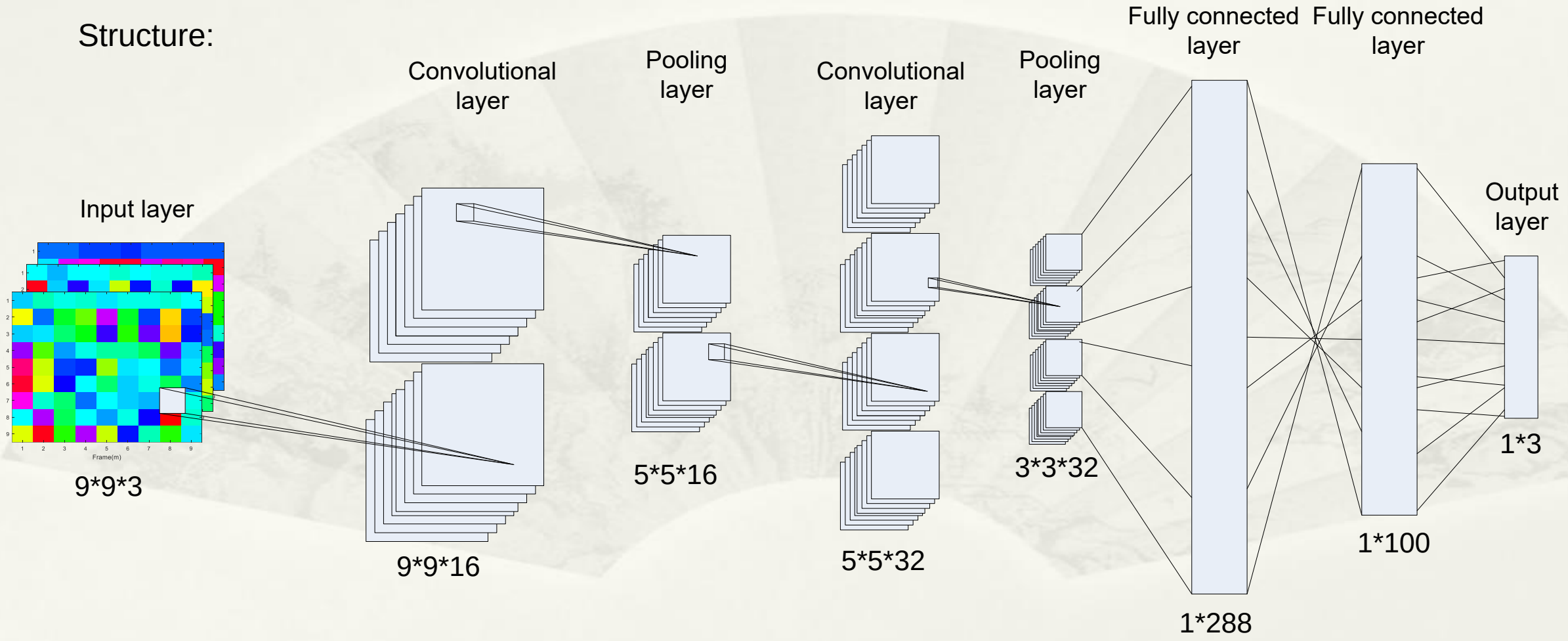
CNN

Structure:



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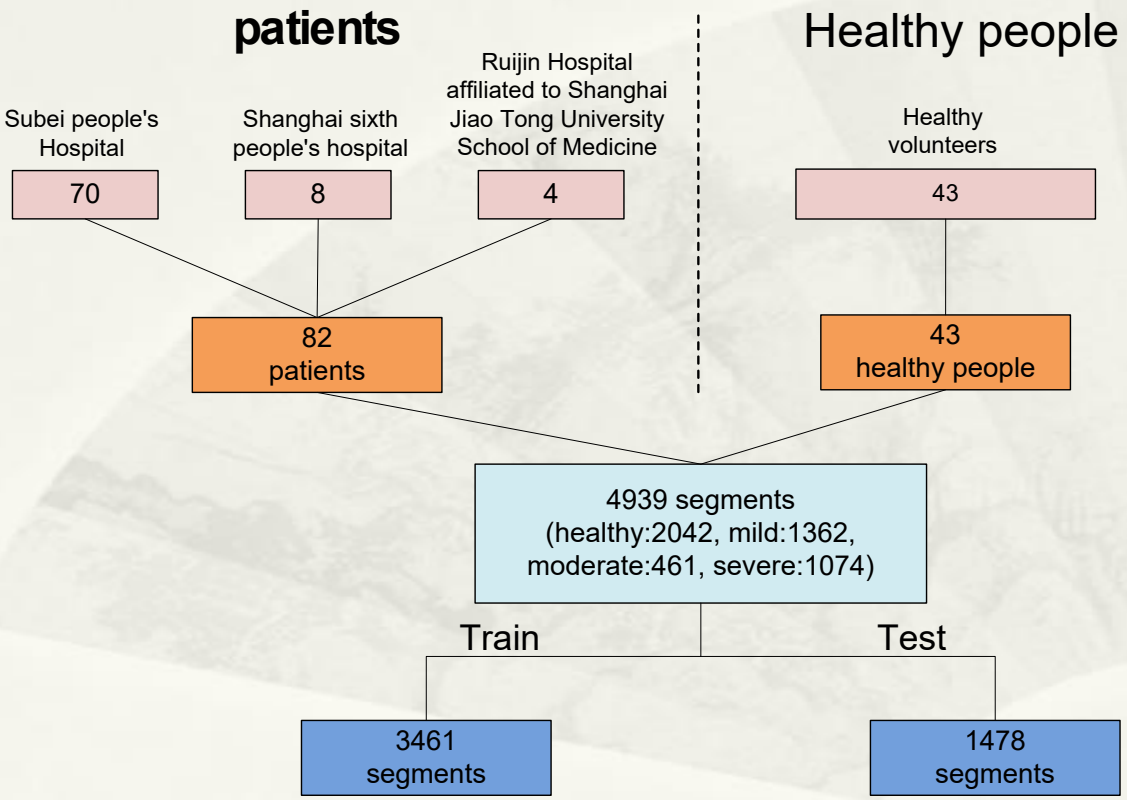
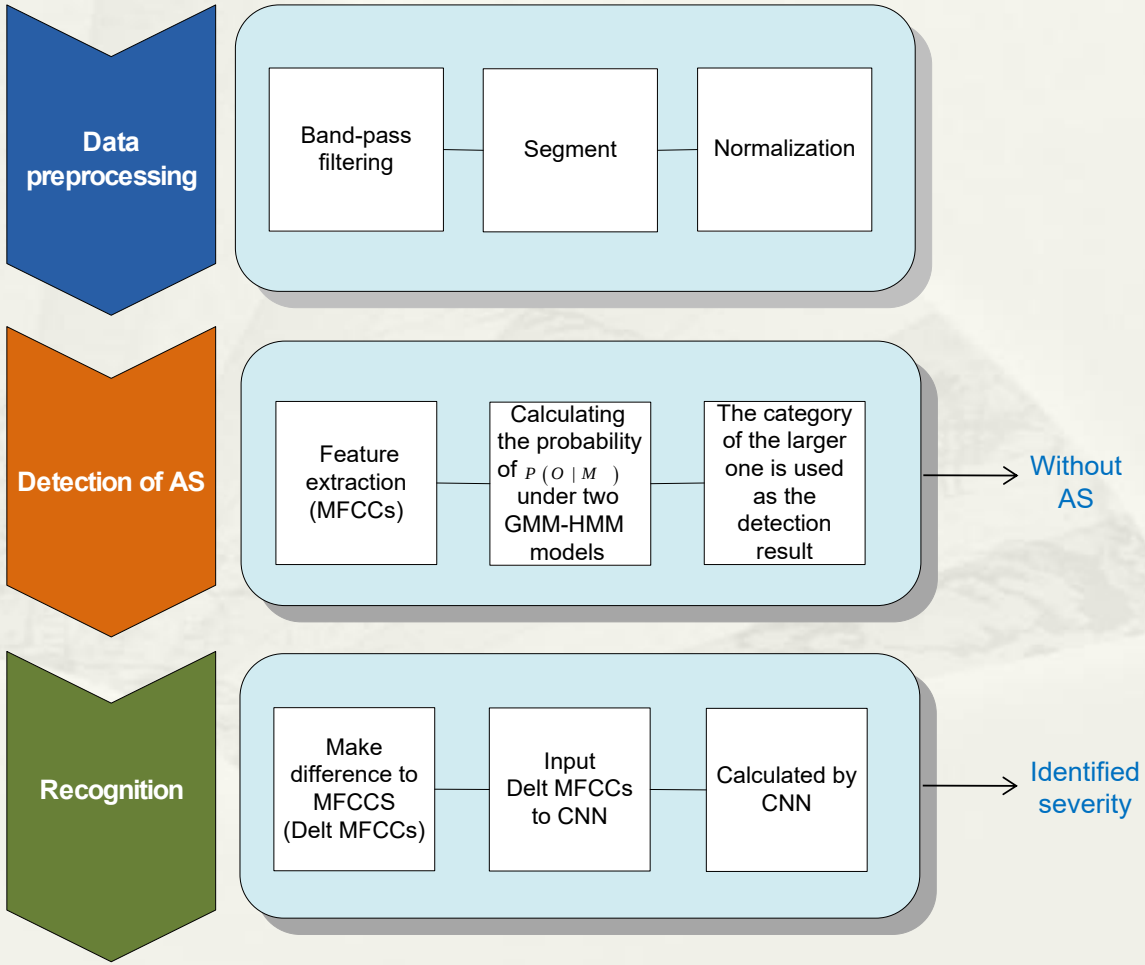
Flow chart of enrolled patients



Flow chart of methodology



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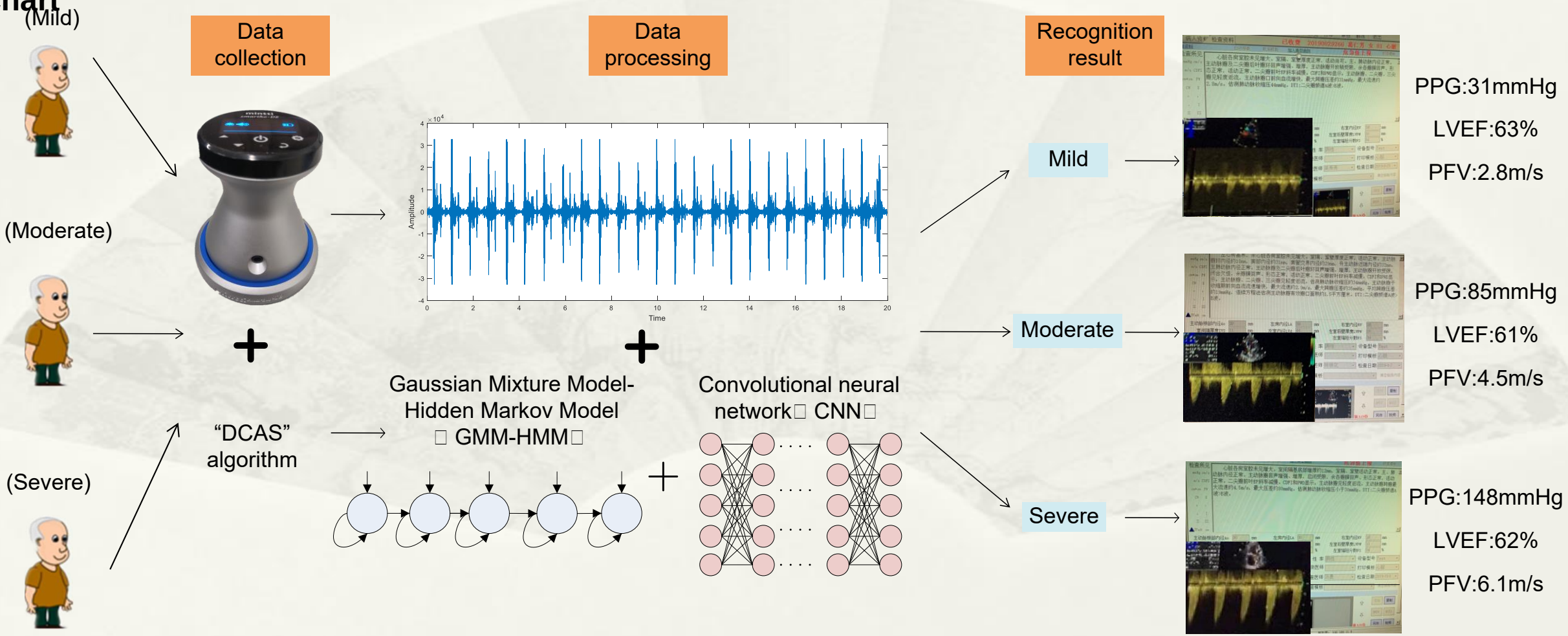
Auscultation flow chart



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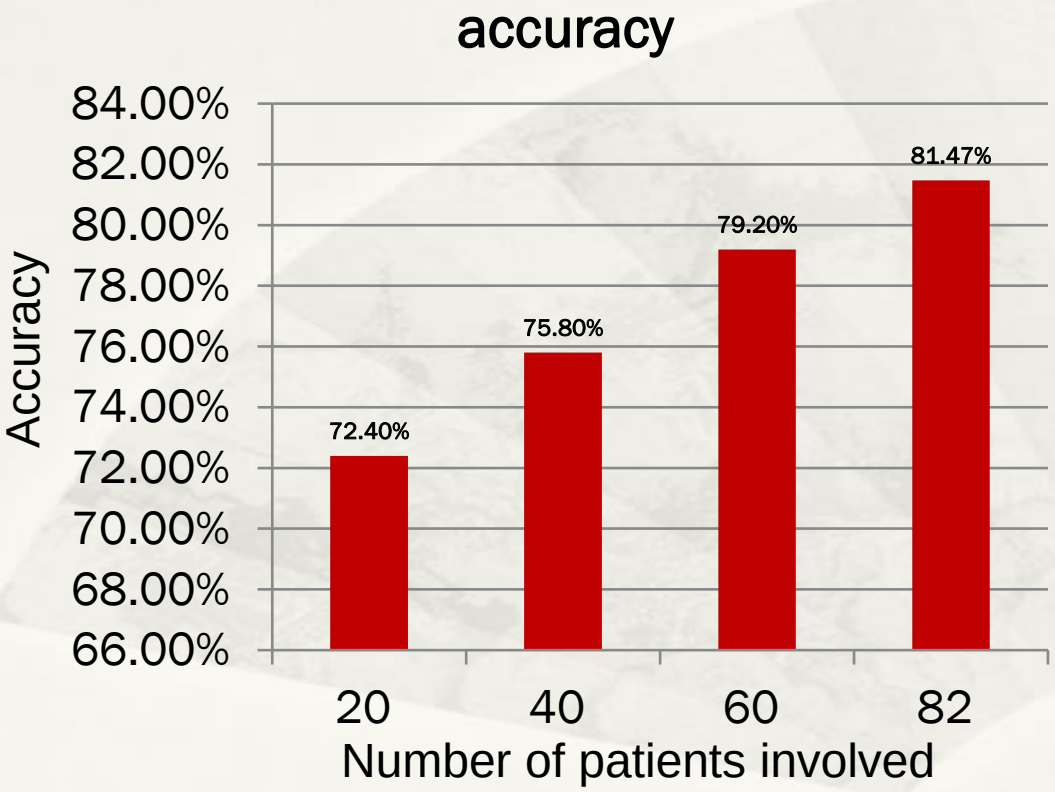

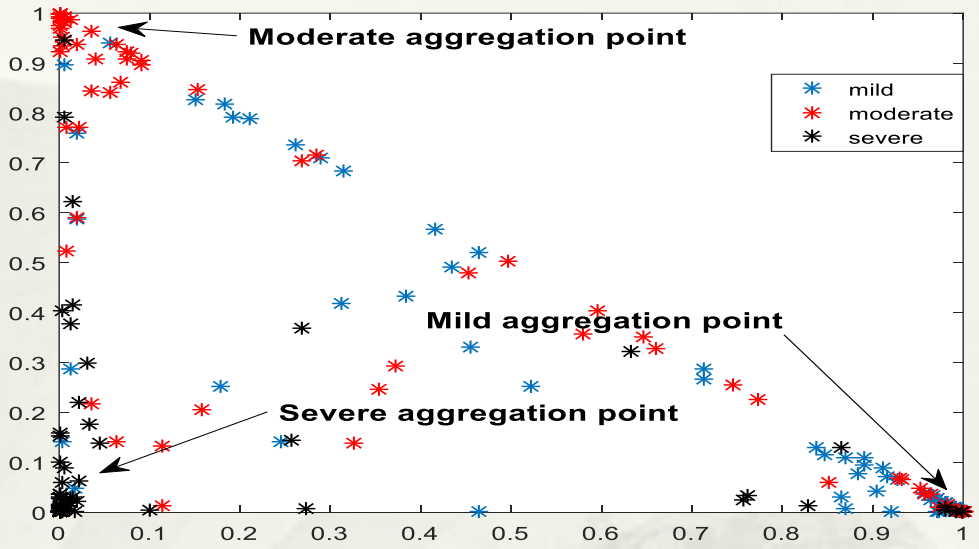

		Stethoscope results		
		Mild	Moderate	Severe
UCG results	Mild	155	12	17
	Moderate	27	51	22
	Severe	14	11	191

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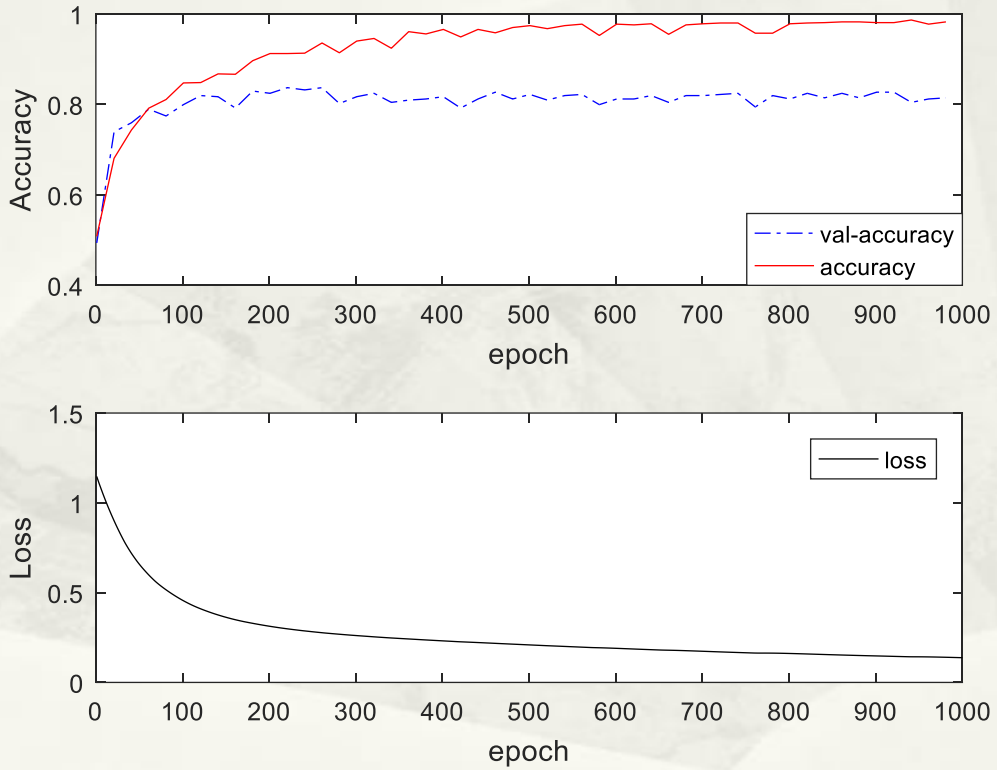

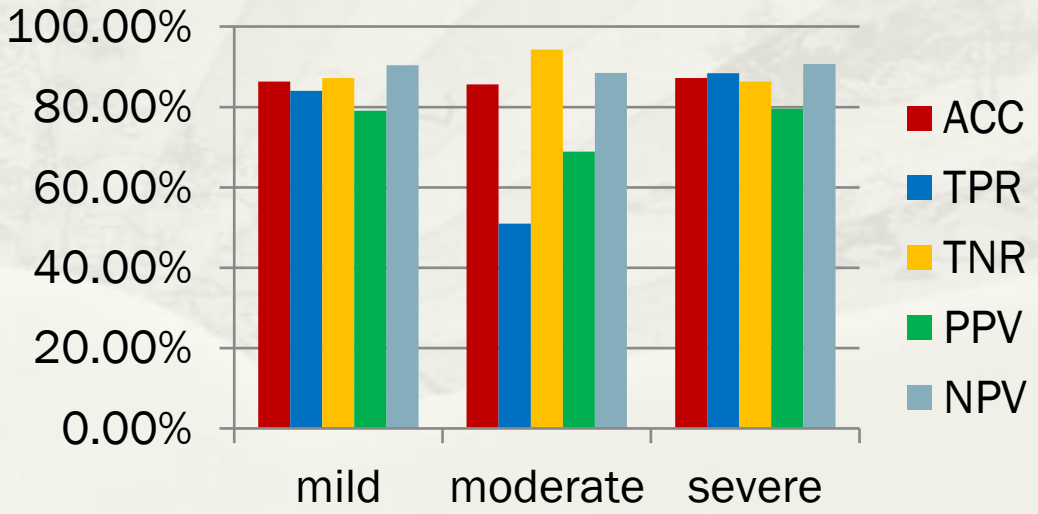

Thank you!