



Neural network based noise cancellation of EGG signals

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Abstract

AIM: This abstract introduces our study work on Noise Cancellation of EGG Signals by Neural Network, which aims at removing noise from the noisy EGG signals.

METHODS: Noise cancellation can be considered as a mapping from noise included signal space to noise free one. In general, such a mapping is a complex nonlinear function. Although Volterra filter can perform nonlinear mapping, the processing procedure is very tedious and complicated because the number of the parameters resulting from Volterra series expansion increases exponentially with the series order. The multilayer perceptron can implement complicated nonlinear mapping and specially the one required for performing the mapping from noise included to noise free space by some learning algorithm. And thus a complete noise cancellation system is formed. Such a system has a very good adaptive and robust property. As an example, we propose a four layers of perceptron model and analyze its mechanism to suppress noise. For a given four layers of perceptron, the transform from input to output can be divided into

three subtransforms, *i.e.*, from input to the second layer and then to the third layer, finally to output layer. Supposing X to denote $N-0$ dimensions of input EGG signal vector with noise, Z do $N-1-D$ the second layer output vector, then

$$Z = f(Y) \quad Y = WX + Q$$

Where W is $N-0 \times N-1-D$ weight matrix; Q is $N-1-D$ threshold vector which is made of the thresholds of the second layer of neurons; $F = \{f-i, N-1\}$ D vector function ($i = 1, 2, \dots, N-1$). $f-i$ is defined as Sigmoid function, in the form

$$(f-i)\{1/[1 + \exp(-y-i)]\}$$

One can perform singularity decomposition on W , *i.e.*

$$W = UDV^T$$

Where D is the diagonal matrix composed of singularities, $d-1 \geq d-2 \geq \dots \geq d_{N-1} \geq 0$; U, V are two orthogonal matrix made up of the left and right singularity vectors, respectively. It can be proved that the waveform corresponding to the singularity vector with large values is similar to that in the input signal X , while the waveform corresponding to the singularity vector with small values is similar to that of noise. Thus a part of the noise can be suppressed by the transform WX .

In the sub transform from the second layer to the third layer, nonlinear function, Sigmoid (\cdot), play a prominent role. If the input consists only of noise, most of values from the output of the second layer are less than the threshold of Sigmoid and consequently the neurons are in the restrained state. The output is very small and thus the noise is further suppressed.

If the transfer function of the network output layer is the same as that of the second layer or the third layer, so is the noise suppressed mechanism. If it is linear, the noise is suppressed at the same degree as is done by using WX .

After the these three sub transforms, the noise cancellation of the whole neural network from the input to the output is fulfilled.

RESULTS: The simulation is performed on three sets of noisy EGG data. The root mean errors are in Table 1.

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Table 1 The Root Mean Errors

	GE33A	MOT13C	LINA	GE70A
RMSE	6.43	7.56	7.72	6.78



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