REMOTE MEASUREMENT OF GEOMETRIC DIMENSIONS OF OBJECTS

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Abstract

The report compares the methods of remote measurement of the geometric dimensions of objects and, based on their comparison, sets the task of developing a new method for solving the problem of the invariance of the measurement to the rotation of the object around the center of gravity and the distance between the object and the sensor.

Keywords: Analysis, geometric dimensions, measurement, invariance, rotation, scale.

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As you may be aware, the precision of the manufacturing and machining industry is heavily dependent on the accuracy of their physical parameters, and as details become more complex, the demand for their precise measurement also increases. Therefore, the improvement of high-precision methods for measuring the physical dimensions of objects and the proposal of innovations based on new information technologies and nanotechnologies is a very relevant issue.

Although there are various methods for measuring the physical dimensions of objects, currently they are being carried out without contact and at a distance [1, 2]. To implement these methods, television transmitters, laser scanners, ultrasonic transmitters, and thermal imagers are used.

The biggest problem encountered when measuring the physical dimensions of objects is that they are non-invariant with respect to the coordinate system of the transmitter and the physical dimensions depend on the distance of the object from the transmitter [3, 4].

To solve the first problem, two methods are used. In the first method, the object's parameters or characteristics are chosen such that they remain invariant when the object is rotated around its own center of gravity. These parameters belong to the shape parameters, such as perimeter, area, and other shape parameters. However, they are not very informative. Therefore, usually the second method is used. The nature of this method is that the object is either physically or virtually rotated around its own center of gravity to a standard position. In this position, its physical dimensions are determined [5, 6].

The implementation of this method can occur in the following way: After the object is formed by the transmitter, a massive set of coordinates of its contour points $\{A_{i=1,n}\}$ is formed [7].

Based on these points, the center of gravity of the object's representation is determined:

$$x_0 = \frac{\sum_{i=1}^{n} x_i}{n}; \quad y_0 = \frac{\sum_{i=1}^{n} y_i}{n} \quad (1)$$

Afterwards, the point $A_m\ (x_m, y_m)$ corresponding to the second-order moment is determined.

Then, the contour points are determined with respect to the centroid $\{A_i\ (x_i - x_o,\ y_i - y_o)\}$, and their polar coordinates are found.

$$r_{x_i} = \sqrt{(x_i - x_0)^2 + (y_i - y_0)^2};$$

$$\varphi_{x_i} = arctg\,\frac{y_i - y_0}{x_i - x_o} \quad (2)$$

These parameters remain invariant with respect to the object's rotation.

To create rotational invariance, the polar angle of the point $A_m\ (x_m, y_m)$ is determined

$$\varphi_m = arctg\left(\frac{y_m - y_0}{x_m - x_o}\right) (3)$$

On the basis of this polar angle, the sequence of the array is not changed, and the contour point with the first element $\varphi_i - \varphi_m = min$ is brought into the new array. Thus, even if the representation is subjected to rotation, they will always be written in the same sequence in memory.

There are two methods to solve the second problem. In the first method, the parameters are formulated based on the initial parameters, such that they remain invariant to changes in scale. However, in this case, the physical dimensions of objects that differ from each other in size are not measured accurately according to scale. Therefore, it is necessary to use the second method. For this reason, the distance between the object and the transmitter is measured, and the dependence of physical dimensions on this distance is determined and the physical dimensions are adjusted accordingly.

The continuous development of information technology, computer technology, and microelectronics allows these problems to be solved through computer modeling. In this sense, it is possible to measure the physical dimensions of representations subject to rotation and scale changes with high accuracy by using methods such as moment invariants, Fourier transforms, wavelet calculations, and other complex techniques [3,4,5].

Analysis of the literature in the field shows that the known methods cannot completely eliminate these problems. They either solve these problems within a certain limited framework or use special points or lines called "orientation" points. This is not a complete solution to the problem.

Identification of medical signals using a neural network in telemedicine enables diagnosis and treatment at a distance- Nowadays, telemedicine has become widespread. Identification of medical signals using a neural network in telemedicine enables diagnosis and treatment at a distance. Information about the patient in digital form, on the basis of which the doctor will make a diagnosis, must be transmitted to another doctor over the internet without any distortion. Representing digital medical images requires large amounts of data and places high demands on network equipment when transmitting them over communication channels and on the capacity of external storage devices when storing them. Therefore, the task of reducing the volume of transmitted data in digital data transmission systems using data compression is relevant, as it reduces the requirements for the bandwidth of communication channels and is particularly important for telephone communication lines [8].

Neural Networks (NN) are widely used to solve various problems [9, 10, 11]. Among the developing areas of NN application are the processing of analog and digital signals, the synthesis and identification of electronic circuits and systems. The basics of the theory and technology of using NN are widely presented in the MATLAB 6.0 package, where the GUI (Graphical User Interface) for NN - NNTool, was first introduced

For the recognition of objects in images based on their shape, multilayer perceptrons are usually used, which are trained on the basis of the backpropagation algorithm with momentum and adaptive learning rate. In terms of parameters, radial basis networks are used. Radial basis neural networks consist of more neurons than standard networks with feedforward and backpropagation learning, but they require significantly less time to create. These networks are particularly effective when a large number of training vectors are available. As a rule, radial functions have the form $\varphi(x) = f(\|x-c\|)$, where c is a vector that is the center. The radial method represents the separation of vectors in space using a hyper sphere around the central point. This allows us to apply radial neural networks as a local approximator.A standard radial neural network consists of three layers: an input layer, which receives the input signal, a hidden layer consisting of radial neurons, and an output layer that performs weighted summation of the results of the hidden layer. For a vector function

$$\varphi(x) = (\varphi_1(x), \varphi_2(x), \ldots, \varphi_M(x)) \quad (4)$$

For a vector function, defined in an N-dimensional space, this space is nonlinearly φ-separated into two spatial classes X^+ and X^-, if there exists a weight vector w such that

$$w^T \varphi(x) > 0 \quad x \in X^+; w^T \varphi(x) < 0 \quad x \in X^- \quad (5)$$

Thus, the boundary between these classes can be determined by solving the equation.

$$w^T \varphi(x) = 0 \quad (6)$$

It has also been proven that if the dimension M of the vector φ(x) is greater than or equal to the number of separable vectors, then any set of vectors is φ-separable. Applied to neural networks, this means that any task of classifying multidimensional patterns can be solved by a radial neural network if the number of neurons in the hidden layer is greater than the dimension of the input vector, and the output layer consists of only one neuron that performs weighted summation with weight coefficients w.

Therefore, the radial basis network architecture was used for the analysis of cardiograms. The PNN network architecture is based on the radial basis network architecture, but instead of a second layer, it uses a so-called competitive layer, which calculates the probability of the input vector belonging to a certain class and ultimately compares the vector with the class whose probability of belonging is higher. The structure of the PNN network is presented in Figure 1

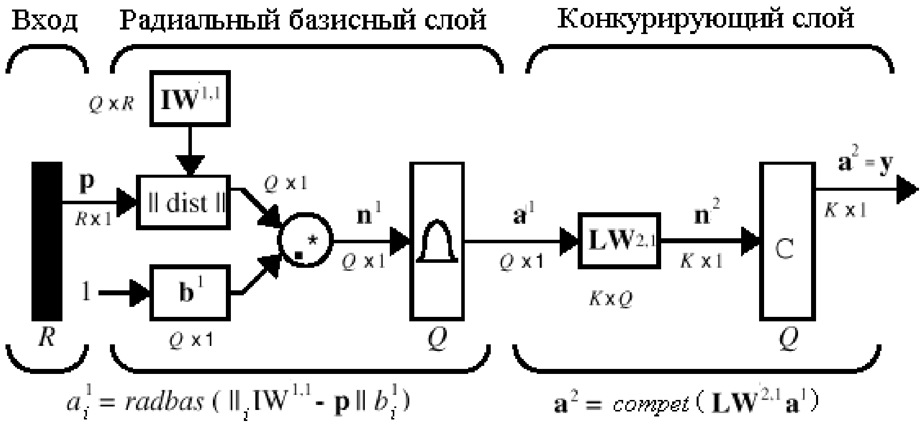

Figure 1: PNN Network Structure

To simulate a neural network, and perform its training and testing, the Neural Network Toolbox package was used in the MATLAB programming environment. It is required to create a neural network for recognizing three types of signals: ECG-normal, ECG-pathology (bradycardia, tachycardia). Each of the signals is represented by a template of size 1000x1. The designed neural network should accurately recognize ideal input vectors and reproduce noisy vectors with maximum accuracy. It is assumed that the noise is a random variable with a mean value of 0 and a standard deviation less than or equal to 0.2.

Let's formulate the work algorithm:

1. It is necessary to input encoded images, EksInputs, EksTargets, into the database.
2. After the images are entered into the database, execute the following command to work with them: load Eks_dataset
3. To create a network, enter the command (Figure 2): net = newpnn(EksInputs, EksTargets, 20)
4. Network training. The application randomly divides input and target vectors into 3 parts:
   60% - used for training
   20% - for validation
   20% - for testing To train the network, enter the command:
   net = train(net, EksInputs, EksTargets)
5. The program's output result, in the form of dividing the workspace into 3 classes, is shown in Figure 3

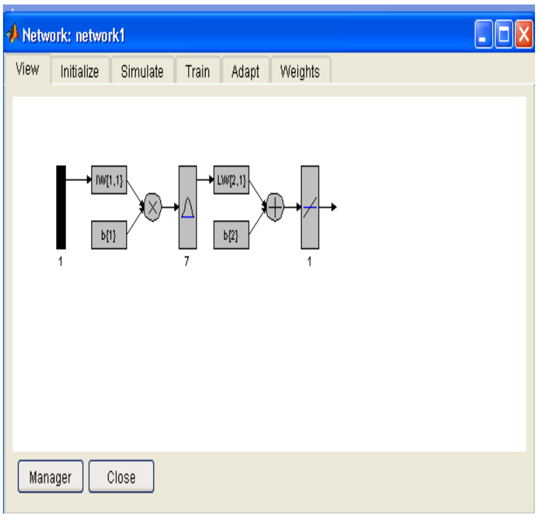

Figure 2: PNN network

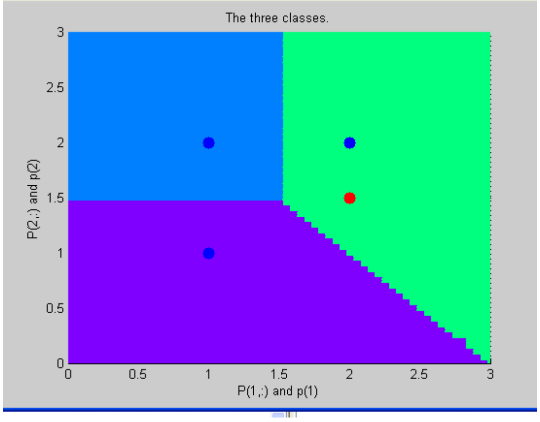

Figure 3: The area of division into three types of ECG signal vectors: normal, bradycardia, and tachycardia.

Conclusions

The study analyzed the possibilities of using radial basis neural network architecture for analyzing cardiac signals. Multi-layer perceptrons trained using the backpropagation algorithm with momentum and adaptive learning rate are usually applied for image recognition based on shape, whereas radial basis networks are used for parameter recognition.

These networks are distinguished by their particularly high learning speed, which allows them to be used for real-time identification of time series, and the ability to obtain useful results with small training sets, even in the presence of erroneous data.

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