Multi-layer neural network for solving problems of recognition of drained crop areas

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Abstract. The article deals with the design and software implementation of neural network modules for solving problems of image recognition. In particular, it describes the development of a module for network training and recognition of input pulses, which made it possible to recognize, process and analyse aerial photographs of agricultural crops as objects of identification based on the use of a multi-layer deep learning neural network. The practical use of the software tool is possible for the study and study of the peculiarities of cultivation in conditions of irrigation and differentiated placement.

1. Introduction
Work on artificial neural network (NS) models has a long history. The development of detailed mathematical models began more than 70 years ago with the work of F. Rosenblatt et al. The renewed interest is due to the development of new topologies and algorithms, the emergence of new methods for implementing analog ultra-large integrated circuits, some interesting presentations, as well as a growing interest in studying the functioning of the human brain. NS are widely used for pattern recognition, classification problems, optimization problems, forecasting, data analysis, decision-making and adaptive management.

2. Materials and methods
Within the framework of one scientific direction on improving reclamation technologies using artificial intelligence tools, a software implementation of a neural network in the Matlab neuromodule for solving recognition problems was developed and implemented in the form of two software prototypes.

The complete signal recognition algorithm can be represented as follows:
1. The signal is digitized with a certain sampling frequency.
2. The resulting set of samples is divided into windows of several ms.
3. Next, a wavelet transform of the signal is applied, which translates the signal from a time representation to a time-frequency representation.
4. The input of the neural network receives the received data, a set of windows into which the signal was divided. At the output of the neural network-the classification of each input window, weighted in the probabilities of groups of phonemes (phonemic probabilistic characteristics). The general scheme of the speech recognition system is shown in Figure 1.
Figure 1. Block diagram of the neural network training process for analyzing remote monitoring images

The integrated MATLAB system (Neural Network Toolbox-neuromodule) was chosen as the platform for implementation, which provides extensive capabilities for processing various data (pulses, signals, images, etc.) and performing time-consuming mathematical calculations. Also, a large set of various functions for working with neural networks is included in the Neural Network Toolbox package of the Matlab system, which allows you not only to set the network architecture, but also to choose a learning algorithm. It is assumed that the NS will be implemented in two stages: the first stage is the creation and training of the network, the second is the addition of the recognition module.

Training of a neural network occurs as follows:

1. From the audio signal, 20 windows with a length of 2000 samples are selected sequentially, to which the wavelet decomposition on 3 levels was then applied. Thus, vectors of wavelet coefficients of the 3rd level of detail are formed for use as input data of the neural network.

2. Next, a training sample of the network is constructed, consisting of 20 vectors of wavelet coefficients for sound samples and the same number for noise.

3. A unidirectional three-layer network is created, the input layer of which contains 63 neurons, the output layer contains 2.

4. The last stage is the training of the network [5-8]. Fragment of the NS training listing in the Matlab neuromodule:

```matlab
phonems='n'; ccp=0; ccn=0;
for ii=1:20
name=sprintf('piping%d.wav',ii);
masP(:,ii)= wavread(name);
Fram=3000;Nfr=2000;
forff=1:20
[c,l]=wavedec(masP(Nfr:Nfr+Fram,ii)',6,'db8');
DCELL=detcoef(c,l,'cells');
Pat(:,ff)=DCELL{3}';
Nfr=Nfr+Fram+1;
end
ccp=ccp+1;
ifccp>1
Pp=[Pp,Pat];
elsePp=Pat;
end
end
for ii=1:20
```
To implement the NS training procedures, the built-in functions of the Matlab neuromodule were used:

- `newff (pr, [S1 S2 S3 ], {'logsig' 'logsig' 'logsig'}, 'traingdx')` - creating a unidirectional network;
- `[net, tr] = train(NET, P, T)` - neural network training;
- `wavread (name)` – data reading function;
- `wavedec (x, N, 'wname')` – multi-level discrete data decomposition;
- `detcoef(c, l, 'cells')` is a vector of detail coefficients of a multi-level data decomposition.

Thus, the proposed algorithm for the functioning of the module for creating and training NS [9-11] can be represented in the form of the following flowchart, shown in Figure 2.

As a result of the program, the Neural Network Training window is called, which shows the process of training the neural network, and allows you to view statistics after the training is completed. The training window is shown in Figure 3.

![Figure 2. The "Neural Network Training Model" dialog box](image)

Thus, it is assumed that the NS will be further implemented in the neuromodule of the Matlab software environment, in the form of two modules, the first is used to create and train a neural network, and the second is used to recognize the incoming pulse at the "input".

4. Conclusion
The implemented program is designed for recognition, processing and analysis of aerial photographs of agricultural crops as objects of identification based on the use of a multi-layer deep learning neural network. The use of the software tool is possible for the study and study of the peculiarities of cultivation in conditions of irrigation and differentiated placement.

![Figure 3. The result of segmentation of aerial photographs of agricultural crops](image)

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