Review of subjection between ANN topology and it’s efficiency in solving the problem of improvement image resolution

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Abstract. The article discusses the influence of ANN topology on its efficiency in solving the problem of increasing the image resolution. An empirical approach is used to establish the fact and determine the nature of the influence. At the beginning of the article, the most commonly used topological techniques for constructing an ANN, which are used to solve the problem of increasing the image resolution, are described. Then, the process of creating an ANN is described based on the above topologies. After that, the learning process of ANN is described. A supervised learning algorithm was used to train the networks, and a set of 7000 images was used as training data. At the end of the article, an assessment of the efficiency of the trained ANN is carried out, through which the effectiveness of topological solutions is determined. To assess the performance of an artificial neural network, a validation dataset of 100 image is used. Two algorithms are used to assess the quality of enhanced images: SSIM and PSNR. The interpretation of the results obtained is also given.

1. Introduction
Artificial neural networks are one of the modern tools. As with any other tool, its effectiveness depends on the "skill" to use it. Artificial neural networks have a number of parameters, the setting of which is determined solely by the developer when solving a specific problem. On the other hand, artificial neural networks have a wide range of applications. It is the wide scope of application of artificial neural networks that determines the relevance of the problem of the effectiveness of setting the parameters of an artificial neural network when solving a specific problem.

One of the areas of implementation of artificial neural networks is the area of processing graphic information [1–7]. Thus, the article discusses the effectiveness of various topological solutions at the design stage of an artificial neural network, which will be used to increase the resolution of a raster image.

2. Review of the most common typologies
Analyzing the main solutions using artificial neural networks, it was found that a "modular approach" is used [8, 9]. This is manifested in the possibility of identifying segments or blocks in the structure of an artificial neural network.

It was possible to identify seven main topological approaches used in the design of an artificial neural network to improve image resolution. Based on each topological approach, a neural network
was designed, the architectures of which are shown in Figure 1 a) - g). Their differences boil down to different ways of connecting segments (in series - in parallel) and the position of parallel links.

Figure 1. Basic techniques for building an artificial neural network architecture
3. Education of ANN designed on the basis of various topologies

To assess the effectiveness of the above-described topological approaches, an artificial neural network with an appropriate architecture will be designed on the basis of each of them. The structure of the module or segment of each artificial neural network is identical and is shown in Figure 2. The structure of the segment was chosen as one of the simplest. A segment structure is a sequence of connected convolutional and activation layers. The number of such pairs is three.

![Segment structure](image)

**Figure 2.** Segment structure

The "Deep learning toolbox" in the "matlab" environment was used as a software development tool. A supervised learning algorithm was used to train the networks, and a set of seven thousand images was used as training data. Note, that all artificial neural networks were trained using the same dataset and the same learning algorithm.

4. Discussion

The problem of the influence of ANN topology on its efficiency in solving the problem of increasing the image resolution has not been previously considered. Usually, questions related to the topology of artificial neural networks lie in the mathematical plane. As presented in [10, 11]. That is, the issues are considered in general terms, that is, the fundamental ability of a network with a certain topology to converge and generalize.

To evaluate the improved images using artificial neural networks, and in fact, the work of artificial neural networks, two methods were chosen, namely: Peak Signal-to-Noise Ratio (PSNR) and Structural Similarity Index (SSIM). The results are shown in Table 1.

A few words about the effectiveness assessment methodology. A package of 100 images was prepared. Each neural network processed each image from the package. Then, using the PSNR and SSIM methods, the efficiency of the artificial neural network was evaluated for each of the images. Then the mathematical expectation was calculated for the package for each of the methods. Thus, in Table 1, the averaged values are summarized. Also included were the results for the bicubic interpolation-based image resolution method.
Table 1. Evaluation of ANN performance

| Names of ANN architecture for image resolution enhancement | The name of the efficiency assessment method | PSNR   | SSIM     |
|-----------------------------------------------------------|----------------------------------------------|--------|----------|
| ANN indicators with architecture type a)                  |                                              | 24,95271 | 0,846614 |
| ANN indicators with architecture type b)                  |                                              | 24,9411  | 0,845199 |
| ANN indicators with architecture type c)                  |                                              | 24,89921 | 0,844977 |
| ANN indicators with architecture type d)                  |                                              | 24,92849 | 0,845765 |
| ANN indicators with architecture type e)                  |                                              | 24,91644 | 0,843343 |
| ANN indicators with architecture type f)                  |                                              | 24,83958 | 0,844148 |
| ANN indicators with architecture type g)                  |                                              | 24,96082 | 0,846482 |
| bicubic interpolation method                              |                                              | 24,4716  | 0,845389 |

For convenience of perception, the results shown in Table 1 are presented in Figure 3 and Figure 4 in the form of graphs.
Figure 4. Results of performance evaluation with PSNR

The most efficient topological approach is the architecture shown in Figure 1 g). Although it is worth noting that architecture a) also showed a fairly high result.

5. Conclusion

The results obtained can be interpreted as follows, namely: the higher the number of sequentially connected layers, the better the network is able to distinguish hidden features. On the other hand, the level of noise in the useful signal grows as the number of layers connected in series increases. The problem of signal noise can be smoothed out by introducing parallel connections. But with the introduction of parallel links, efficiency drops significantly. Thus, a balance is needed, which is reflected in the architecture in Figure 1 g).

The presented results in the article can be used in the design of artificial neural networks that are used to increase the image resolution.

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