КРАТКИЕ СООБЩЕНИЯ| SHORT REPORTS

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УСТРАНЕНИЕ ДЕФЕКТОВ НА ФОТОГРАФИЯХ С ИСПОЛЬЗОВАНИЕМ НЕЙРОННЫХ СЕТЕЙ

ELIMINATION OF DEFECTS IN PHOTOS USING NEURAL NETWORKS

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Аннотация *Применение математического аппарата нейронных сетей становится весьма важным инструментов при решении различных задач искусственного интеллекта. К числу таких задач можно отнести и задачи распознавания образов. В данной работе приводится пример использования нейронной сети для идентификации дефекта на фотографии, а затем устранения такого дефекта.*

Материалы и методы, результаты и обсуждения. *В предлагаемой статье рассматриваются специальные алгоритмы работы нейронной сети, которые предназначены для распознавания графических образов, а также алгоритмы поиска дефектов на графических изображениях с последующим их устранением.*

Огромное количество фотографий на бумажных носителях со временем хранения подвергаются физическим повреждениям (в отличии от фотографий на электронных носителях). Чтобы решить такую задачу в необходимо разработать алгоритмы поиска и распознавания дефектов на фотографиях, а также алгоритмов по устранению этих дефектов с помощью математического аппарата нейронной сети.

Заключение. *Решения, которые предлагаются по результатам выполненной работы в рамках рассматриваемой статьи, дадут возможность пользователям восстановить старые фотографии с дефектами, которые могут быть бесценными не только для них, но и для всего общества – например, фотографий исторических событий, великих людей нашего государства.*

Ключевые слова*:* алгоритм, нейронная сеть, искусственный интеллект, нейрон, персептрон.

Abstract. *The use of the mathematical apparatus of neural networks is becoming a very important tool in solving various problems of artificial intelligence. Pattern recognition problems can be attributed to the number of such problems. This paper provides an example of using a neural network to identify a defect in a photograph, and then eliminate such a defect.*

Materials and methods, results and discussions. *The proposed article discusses special algorithms for the operation of a neural network that are designed to recognize graphic images, as well as algorithms for finding defects in graphic images with their subsequent elimination.*

A huge number of photographs on paper are subject to physical damage over time (unlike photographs on electronic media). To solve such a problem, it is necessary to develop algorithms for searching and recognizing defects in photographs, as well as algorithms for eliminating these defects using the mathematical apparatus of a neural network.

The article discusses approaches to the development of a neural network for recognizing defects in photographs with their subsequent restoration.

Conclusion*. The solutions that are offered based on the results of the work performed within the framework of this article will enable users to restore old photographs with defects that can be invaluable not only for them, but for the whole society - for example, photographs of historical events, great people of our state.*

Keywords: algorithm, neural network, artificial intelligence, neuron, perceptron.

Introduction. This article discusses approaches to using a neural network to recognize defects in damaged photographs and eliminate these damages.

To date, there are many photographs that have lost their usefulness over time, but are very important for our citizens, in particular photographs of war times. In old wartime photographs,

there is no color at all. The durability of photographs, in the form in which we are accustomed to seeing them, leaves much to be desired, because photographs lose their structure in a relatively short period of time.

To date, a huge number of tools have been developed that allow you to find defects in photographs and restore it. At first glance, it seems that a graphical editor can be used to solve such a problem. Another approach for solving problems of this kind is to use the theory of neural networks.

Figure 1 shows an example of photographs with defects that need to be recognized, and then the background corresponding to these defects should be restored.

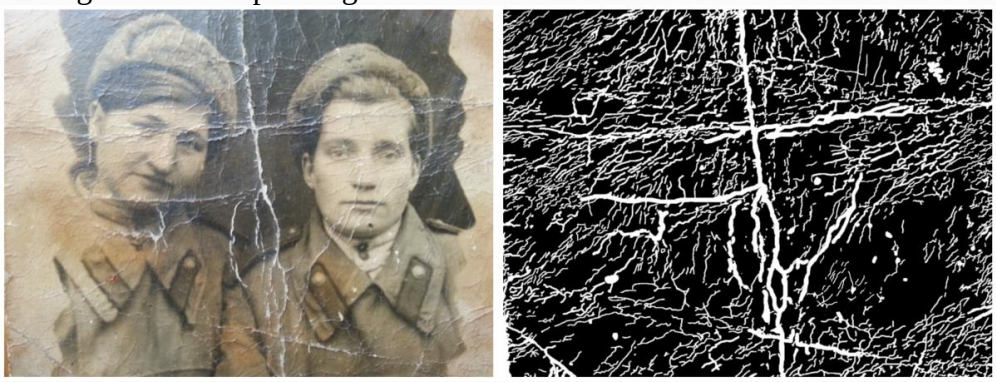

Figure 1. Photo defects

Restoring photos using traditional tools consists of the following steps:

– it is necessary to find all the defects in the image: breaks, scuffs, glare, holes, bends;

– you also need to paint over the found defects, using a special technology based on the pixel values around the damage;

– colorize the image with the received data.

Restoring photographs using a neural network makes it possible to determine possible defects as input data, and then, based on the developed neural network, replace areas of photographs with defects with the background of areas where these defects were detected.

Materials and research methods. To implement this task, it was decided to develop a neural network. Based on the mathematical model (1) of a single neuron developed a neural network.

$$y_i(t) = f_2\left(a_{20i} + \sum_{i=1}^{N} a_{2i} f_1\left(\sum_{k=1}^{K} a_{1k} x_k(t) + a_{10k} \right) \right), \qquad (1)$$

where i = 1, 2, . .., N - the number of neurons in the second layer;

k = 1, 2,... , K – the number of neurons in the first layer;

f_1, f_2 – activation functions of neurons of the first and second layers;

a_{10k} – initial excitation of the kth neuron of the first layer;

$a_{20\,i}$ – initial excitation of the i - th neuron of the second layer;

$a_{2\,i}$, a_{1k} are the weight coefficients of the i - th neuron of the second layer and kth neuron of the first layer;

$y_i(t)$ – i- th coordinate of the output vector;

$x_k(t)$ is the k-th coordinate of the input vector.

Figure 2 shows a block diagram of a multilayer network, which is used in the development of a neural network:

Enter ***First layer*** ***Second layer*** ***Third layer***

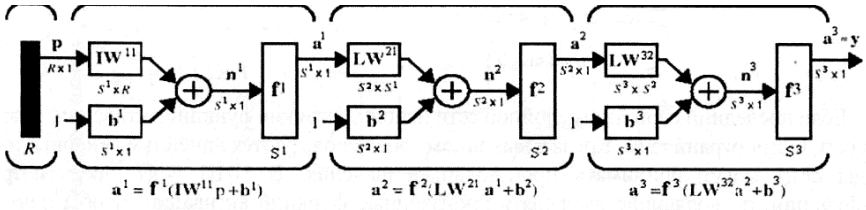

Figure 2. Structural diagram of a three-layer network

In order to build a neural network that would recognize images, while not being difficult from a computational point of view, and also providing invariance to various image distortions, it is necessary to apply in this case convolutional neural networks.

Research results. The developed network architecture implements the main paradigms:

– on the input neuron (output previous neuron) is served not all image , but only her separate part ;

– usage very small set by weight coefficients , for big quantities connections ;

– decrease spatial dimensions photos .

The next stage of work is training the neural network to recognize defects. In order to evaluate the quality of defect recognition in photographs, in the presented work, the root-mean-square error function is used as a criterion, which can be calculated by the following formula:

$$E^p = \frac{1}{2}(\mathrm{D}^p - \mathrm{O}(\mathrm{I}_p, \mathrm{W}))^2 \quad (2)$$

where E^p is the standard error of defect recognition for the *p* - th training pair, D^p is the desired network output, $O(I^p, W)$ is the network output depending on the p *-th* input and the weighting coefficients W.

Using the error function as a criterion for assessing the quality of recognition, while the values of the error function can be applied in order to improve the quality of defect recognition. To do this, the graph of the error function is constructed, and then the search for the minimum of the function is carried out using gradient methods. We expand the resulting analytical error function in a Taylor series, we get:

$$E(W) = E(W_c) + (W - W_c)\frac{dE(W_c)}{dW} + \frac{1}{2}(W - W_c)^2 \frac{d^2 E(W_c)}{(dW^2)} + \ldots\ldots \quad (3)$$

For the resulting function (3), we find the derivative, which we equate to zero in order to find the extrema of the error function. After a series of elementary transformations, we obtain the following expression:

$$W_{min} = W_c - \left(\frac{d^2 E(W_c)}{dW^2}\right)^{-1} \cdot \frac{dE(W_c)}{dW} \quad (4)$$

The optimal value of the weight coefficient calculated by formula (4) makes it possible to increase the efficiency of defect recognition in photographs, which ultimately increases the efficiency of the proposed solutions.

In the process of training a neural network, it is necessary to take into account the maximum size of identified defects, so that later such a defect can be eliminated with a certain probability .

To eliminate defects, image sections with defects are segmented, and then they are painted over with a certain color, after which, taking into account the background closest to the defect, color reconstruction is performed. To solve this problem, a special class has been developed that implements a convolutional neural network of arbitrary architecture and apply them to various tasks. A very important result of this work is the development of a neural network training algorithm, which takes some time. The developed algorithm for training a neural network with a teacher, which is shown in Figure 3.

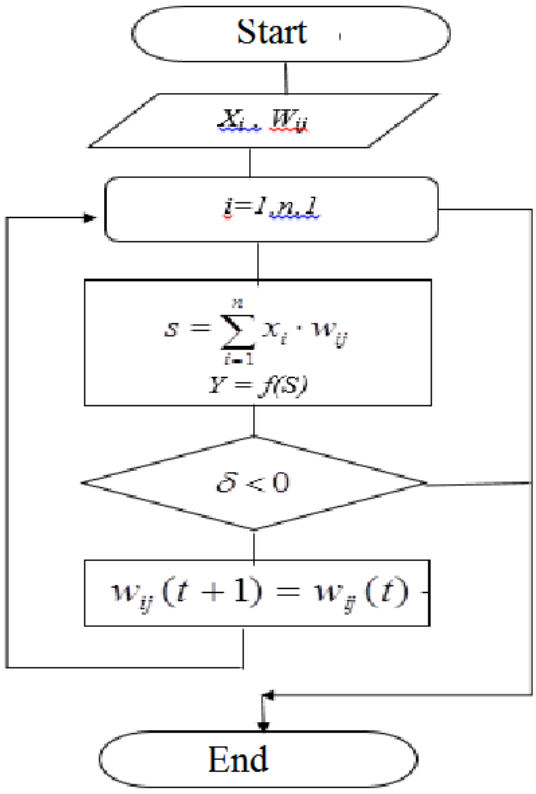

Figure 3. Block diagram of the supervised learning algorithm

Conclusion. An experiment was conducted based on the results of the neural network. The same photo was edited using the Photoshop editor and using the developed neural network, the results are shown in Figure 4.

Figure 4. The results of the neural network

a) in Photoshop b) in the neural network

Thus, the developed neural network, with its normal training, allows, firstly, to recognize defects and its background, and then to restore them. The solutions proposed in this paper can be used to restore a huge number of photographs that are of great value to most people.

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