Solving binary classification problems by means of convolutional neural networks with the use of TensorFlow framework

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This article is devoted to the task of classifying cats and dogs using a convolutional neural network and TensorFlow framework.

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Classification is an integral part of everyone's life. Day after day, the human brain classifies many things with incredible accuracy and ease.

But in case of a computer, this task is not so trivial. For example, how can you distinguish an orange from a lemon using a computer?

Fig. 1. A lemon and an orange

If you use basic conditional operators, you may need a thousand conditions to distinguish a lemon from an orange. It is necessary to take into account the color and size, shape, pattern on the peel, etc.

But a trained neural network can easily perform such a task. Classification of irises is one of the popular classification tasks [1].

Fig. 2. Iris Versicolor and Iris Virginica

You can classify irises based on just four unique parameters (length and width of the sepal, length and width of the petal). The task of image classification is solved with the help of convolutional neural networks.

The convolutional neural network, which was proposed by Yann LeCun in 1988, is a special architecture of artificial neural networks, which is designed for effective image recognition and is part of the deep learning technologies [2]. The network architecture got its name due to the use of the convolution operation, which is based on the fact that every fragment of an image is multiplied by

the convolution matrix (kernel) element by element, and the result is summed up and returned to the corresponding position in the output image.

Let us consider how one can solve the problem of classifying cats and dogs with the help of the convolutional neural network. The tensorflow framework will be used when building the network.

The initial data set should be prepared before processing, all images must be grayscale and must not exceed the size of 70x70 pixels. This will help accelerate the process of training the neural network, and we will not use excessive resources of the operating system.

Fig . 3. Stages of image preprocessing (from left to right: original image, grayscale image, image the size of which has been reduced to 70x70 pixels)

Network topology. Since this task belongs to the category of binary classification – the task of classifying various elements into two groups – we have only two input neurons.

A hidden layer was chosen by experiment.

The following combinations were tested in the course of the experiment:

1, 2, or 3 convolutional layers, each of which consisted of 32, 64, or 128 neurons, for each of which 0, 1, or 2 subsampling layers were used. The experiments showed that networks with three convolutional layers for which a subsampling layer was not used produced the best results (Fig. 4).

Fig . 4. Prediction accuracy (on the left) and network error rate (on the right)

Despite the fact that the network with three convolutional layers and 128 neurons (red line) had the best prediction accuracy, a network with three

convolutional layers and 64 neurons (blue line) has the lowest error rate.

The scalar result of every convolution corresponds to the activation function, which is a particular non-linear

function. This can be any function. But hyperbolic tangent functions $f(x) = \tanh x$, $f(x) = |\tanh x|$, or sigmoid functions $f(x) = (1 + e^{-x})^{-1}$, were traditionally used for this task.

But in the 2000s, a new activation function, ReLU (rectified linear unit) [3], was proposed and studied, which made it possible to significantly speed up the learning process and simplify calculations (due to the simplicity of the function itself), which means that a

calculating the function $f(x) = \max(0, x)$.

That is, this is actually the operation of cutting the negative part of the scalar value. As at 2017, this function and its modifications (Noisy ReLU, Leaky ReLU and others) are the most frequently used activation functions in deep neural networks, in particular, in convolutional networks. But we will use a usual ReLU function when solving this problem.

Fig . 5. Plot of the rectified linear unit function

For the output layer, you need to first perform subsampling. The pooling layer, or subsampling layer, is a non-linear compression of a feature map, where a group of pixels (which usually have the size 2×2) are compressed to one pixel, undergoing non-linear transformation. The main idea of pooling lies in the fact that if some features have already been detected during the previous convolution operation, then such a detailed image is no longer needed for further processing, and it is compressed to a less detailed one.

A sigmoid function was chosen as the activation function for the pooling layer. A sigmoid is a smooth S-shaped monotonically increasing nonlinear function,

which is often used for “antialiasing” values of a certain parameter. A logistic function $\sigma(x) = \frac{1}{1 + e^{-x}}$ is often meant by a sigmoid function.

For network training, a data set consisting of 22,451 images was used, and validation, in turn, was performed in case of 2,495 images.

The results of this experiment showed that the neural network with three convolutional layers consisting of 64 neurons each, the ReLU activation function, allows one to perform the best classification of cats and dogs based on images. In the course of the experiment, we developed a model of a neural network which can identify with an accuracy of 87% (Fig. 6) whether a cat or a dog is depicted in an image.

Fig . 6. Accuracy of the resulting network

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