Use of Neural Networks for Pattern Recognition in E-Commerce

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Abstract.
The article is devoted to the substantiation of the expediency of using neural networks for image processing in e-commerce. The differences between the performance of classification and regression tasks due to the construction of neural networks based on images are revealed. The main image processing algorithms that have gained popularity in the scientific community and in the practice of private companies are presented. The basic principles of neural network operation in the process of image processing are presented.

Keywords [1]
E-commerce, machine learning, modeling, neural network, optimization, image recognition, digital channels.

1. Introduction

In modern conditions, there is an intensification of digitalization processes, which is associated with the active development of innovative information technologies. Socio-economic transformations in the outlined conditions lead to the reorientation of companies and consumers to the digital environment. The availability of cloud storage and the development of appropriate algorithms have allowed the accumulation of large amounts of data on an ongoing basis about any processes and phenomena on the Internet, as well as to implement a variety of mathematical models. In modern conditions, the accumulated information should be considered as a valuable resource for optimizing business processes.

An important area of the world economy in the field of services is e-commerce, which allows companies to sell products of certain brands through the use of various digital channels. Significant competition in the digital environment encourages companies to attract innovative approaches to find the target audience and establish effective communications with potential customers on a long-term basis. Users focus on finding and purchasing goods and services on the Internet based on their own preferences, based on different characteristics: price, consumer quality, speed of delivery, prestige and more. To increase the level of conversion, companies in the framework of e-commerce implement comprehensive marketing strategies, which involves a comprehensive analysis of available information about key processes. Sources of information for building appropriate mathematical models can be digital and textual information, video and audio content, as well as graphics. In the field of e-commerce, when establishing communications with potential customers, photos of certain products and a textual description of the main characteristics are actively used. The presented approach is based on the desire of visitors to the web resource to visually evaluate the product of a particular brand and decide on the appropriateness of purchasing the product or service.

Photos can serve as a valuable information resource that can be used to analyze various business processes, but the process of transforming graphic objects into data requires a set of measures. At the present stage of science development, machine learning methods have become widespread, which, thanks to the use of neural networks of various architectures, allow for a comprehensive analysis of graphic objects. In the field of e-commerce, the recognition of photographs through the use of neural networks is carried out to achieve various

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tasks, but the strategic goal is always to maximize profits in the long run. Accordingly, there are prerequisites for further research to improve the methodological approaches to the recognition of graphic objects through the use of neural networks to improve the efficiency of e-commerce.

2. Related works

The question of choosing machine learning methods for the analysis of existing graphic images is relevant in modern conditions and is covered in the works of a large number of scientists. The analysis of professional scientific publications and publications of specialists in the field of Data Science on various resources on the Internet shows that in the process of pattern recognition various methods of machine learning are used. The decision-making process regarding the choice of the appropriate method with a sufficient level of the results accuracy is influenced by various factors: the sample size of graphic objects, quality characteristics of photographs, professional skills and experience of analysts, time frame of the project, funding, computing capabilities equipment, etc.

Peculiarities of using machine learning methods to build recommendation systems in e-commerce are presented in [1]. Along with this, in [2] the peculiarities of using the system of recurrent neural networks for large-scale categorization in e-commerce are revealed. The method proposed by the authors makes it possible to avoid the problems of sparseness and scaling of data and to integrate the existing attributes into the overall presentation.

The modern e-commerce system provides for close integration of companies' web resources with appropriate payment systems, which simplifies the payment process for customers. The presence of a large market for the sale of goods and services in the digital environment encourages fraudsters to develop various schemes of illicit enrichment at the expense of all participants in e-commerce. The team of authors [3] devoted research to the development of methods for using recurrent neural networks to identify fraudulent activities, which involves the use of transaction data in e-commerce. For the security of customers' personal data, convolutional neural networks are also used [4], which allow to implement user identification thanks to face recognition technology.

The active development of e-commerce in the global environment has led to the development of various approaches to the use of neural networks in the analysis of photo content large sets. Using multimodal neural networks, a group of scientists has developed a system for forecasting the demand for goods through the use of photographs and text markup, which makes it possible to increase the efficiency of filling specialized catalogs with goods [5]. To improve the search for relevant content on the Internet, it is important to mark information, including graphics. In addition, it is necessary to segment the photos used in e-commerce by different characteristics (social, consumer, economic, demographic, psychological, etc.). Scientific work is devoted to solving these problems in e-commerce [6].

Active development of computer technology and improvement of machine learning methods, first of all development of more effective neural networks with the corresponding architecture, gives the chance to use the received scientific approaches in the field of e-commerce. Graphic objects are a valuable source of information about the phenomena and processes being studied, but each photo requires the use of a relatively large amount of memory in the process of processing and constructing an appropriate mathematical model. Based on these circumstances, there is a need for further study of the possibilities of using neural networks for image processing in order to improve the efficiency of e-commerce.

3. Purpose

Modern companies in conditions of significant competition between market participants and the constant introduction of innovative approaches are forced to actively seek innovation in the field of e-commerce. In the process of achieving the goals, various digital marketing tools are used in inseparable combination with machine learning approaches. Traditional statistical approaches do not allow optimizing key processes and gaining competitive advantages. Also, statistical methods of data processing involve the use of only digital information, which in some cases can be obtained on the basis of attributes. However, the modern development of the digital environment involves the use of companies and users of content variety (data, text, photos, videos, audio) [7, 8], which provided the use of scientifically sound approaches can be used as a valuable resource for developing effective management decisions.

Based on the development of e-commerce in different areas in accordance with the needs of companies, user needs and the specifics of the relevant markets, it is necessary to develop or improve methodological approaches to neural networks that will transform existing visual content into effective management solutions.

Accordingly, the main purpose of this study is the features of the use of neural networks for image recognition in accordance with the needs of e-commerce. Figure 1 shows the main uses of neural networks in image recognition to improve the efficiency of e-commerce.

There are two main areas of neural networks use in image recognition: classification and regression. Consider each of the areas in more detail:

I. Classification.

1.1. Image recognition (classification) – this approach involves the definition of images and assignment to a certain group in accordance with pre-formed characteristics, which are expressed in mathematical form due to a certain system of constraints. The model allows companies to distinguish one object from another by identifying the existing image by content [9].

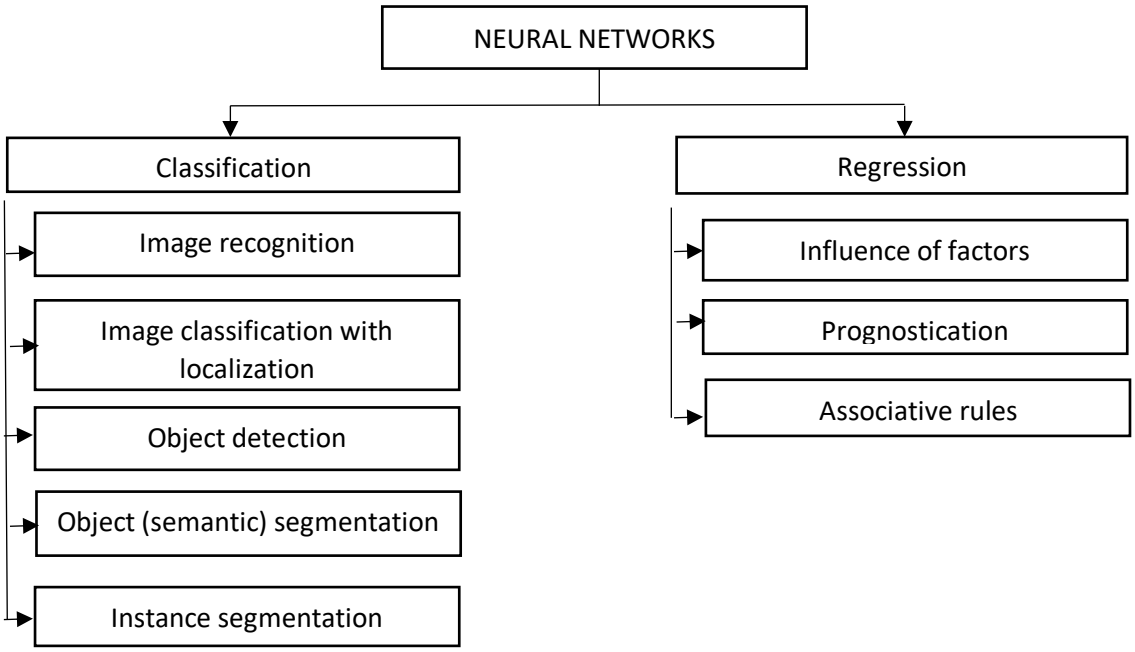

Figure 1: The main directions of using neural networks in image recognition to increase the efficiency of e-commerce [10, 11]

1.2. Image classification with localization – provides for the assignment of an object in the image to a certain class and the selection of a single object using a bounding box, the area of which should be minimal and limited by the size of the identified visual element. The accuracy of the model is characterized by the reliability of the class identification for the object and the closest distances of the frame to the contours of the object in width and height [12].

1.3. Object detection – is an advanced localization task, as it is necessary to select several objects in the image, but the number of objects in the photo is not known in advance. The model involves detecting objects by subtracting the corresponding coordinates and constraints using frames in accordance with a pre-designed classification [13].

1.4. Object (semantic) segmentation – this approach involves dividing the image into separate squares with the markup of each individual pixel in accordance with a pre-formed list of categories. For example, in e-commerce it is possible to form an identification system that relates individual elements to parts of the human or animal body, components of corporate identity, parts of products, parts of buildings and premises, and so on [14].

1.5. Instance segmentation is the task of semantic segmentation of an image with object differentiation, which involves identifying objects in a photograph and counting their number. The model allows to identify on the studied image how many objects are in each formed group according to the used classification [15].

II. Regression.

2.1. Influence of factors – this approach involves the transformation of photos into a numerical format and use as factorial features that in some way affect the performance (volume of traffic, conversion rate, positive feedback, increase the position of the company's web resource in search results, etc.) [16].

2.2. Forecasting is a task of building a multifactor forecasting model, which on the basis of graphically converted graphical elements makes it possible to obtain predictive values of key performance indicators for a certain period of time [17].

2.3. Associative rules. This approach makes it possible to identify relationships between events or objects that are implicit in unstructured data and involve the use of complex models to identify closeness. In association-based e-commerce, it is possible to identify interconnected products or services on the basis of graphic elements with appropriate text markup, and use the results to create referral systems [18].

4. Proposed technique

The process of using graphics as a valuable source of information to build effective neural networks involves a set of steps, the first of which is the translation of photo content into digital form. The existing image can be converted into a 2D function F (x, y), where x and y are the coordinates in space. The digital image represents the amplitude F with finite values of x and y. It is also possible to convert the image into a 3D function with spatial coordinates x, y and z, the represented graphic object is called RGB (Red, Green, Blue) [11].

It should be noted that the use of RGB color space has disadvantages because it is not possible to separate color information from other data. The use of the RGB approach to image conversion has a negative effect on the speed of neural network implementation, as it is necessary to use information about 3 channels in the simulation process. An alternative approach involves the use of color space HSV (Hue, Saturation, Value), which allows specialists to integrate color information into a single channel H (Hue) [19]. The practice of using RGB and HSV shows the feasibility of using both approaches, because based on a set of factors for different sets of images, the optimal result can be obtained by using the first or second color space. The main image processing algorithms are Morphological Image Processing [20], Gaussian Image Processing [21], Fourier Transform in image processing [22], Edge Detection in Image Processing [23], Wavelet Image Processing [24], Image processing using Neural Networks [25].

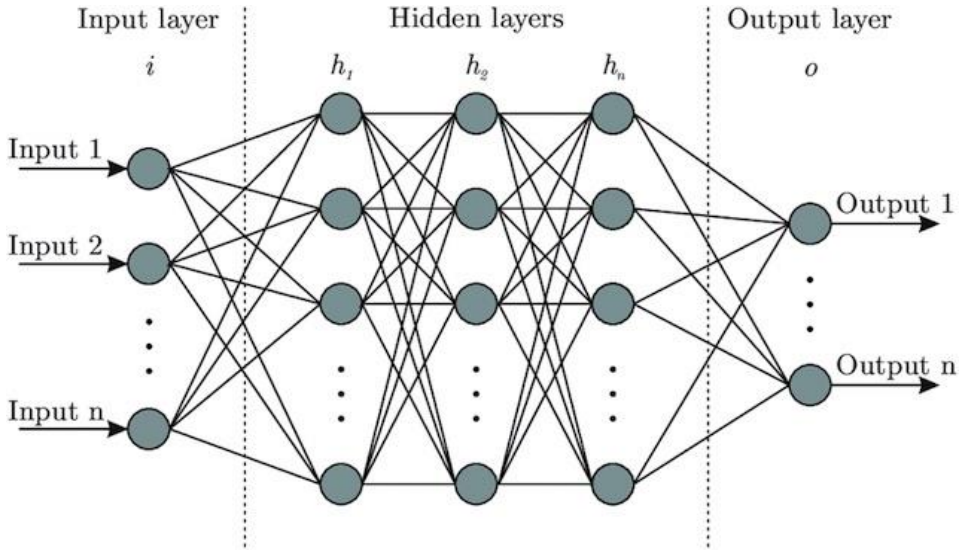

Figure 2: Basic structure of a neural network [26]

Each approach has advantages and disadvantages in the process of image processing, but the greatest prospects for improving the process of recognizing graphic objects, scientists associate with neural networks.

Neural networks are multilayer networks that are created from the basic units of data processing in the system (neurons or nodes). The network works on the principle of functioning of the human brain: data are obtained from the external environment, thanks to neurons there is modeling and training to recognize patterns in information, at the last stage the forecast result is deduced. The basic neural network has three layers:

- Input layer;
- Hidden layer;
- The source layer [27, 28].

Figure 2 shows the basic structure of the neural network. Data is loaded into the neural network through the input layers. The next stage is the process of calculations in hidden layers, the number of which is determined empirically according to the specifics of the primary information and based on the level of qualification of the analyst. In the process of improving the simulation results through the use of a neural network, the number of layers is adjusted according to the value of the selected metrics.

The operation of the neural network in the process of image processing is based on the following principles:

1. The image is divided into pixels, and a single pixel acts as a neuron of the first layer.
2. Each channel is assigned a weight in the form of a probabilistic numerical value.
3. Weighted amounts are calculated as multiplying the weights by the corresponding input data, and the result is used as input to the hidden layers of the neural network.
4. The selected activation function is used for the initial data, deciding whether to activate the neuron or refuse further action.
5. The propagation of data to the next layers of the network occurs only due to activated neurons.
6. The output neuron on the layer is the value with the highest probability.
7. The error is calculated as the difference between the predicted and actual output. Due to backpropagation, the results are transmitted back through the network.
8. A certain number of iterations of direct and reverse propagation of data with gradual adjustment of weights are performed. When the optimal value is reached, the neural network stops the learning process.

Figure 3 shows the operations on the neural network, where a_i is the i-th input, w_i is the i-th weight, z is the output, g is a certain activation function.

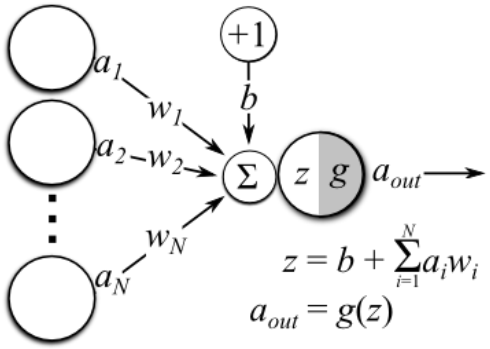

Figure 3: Operations for neural networks' neuron [29]

In the process of building a neural network, it is necessary to determine the activation function. Figure 4 presents the main activation functions used in modern conditions. Among the above functions, the most used is ReLU (linear equalizer with "leakage") [30, 31]. One of the main benefits of use ReLU is the reduced likelihood that the gradient will disappear. The advantages of using ReLU include sparseness, as sparseness occurs in cases of significant increase in units in the layer. In this case, as the number of units increases, the resulting representation becomes more sparse.

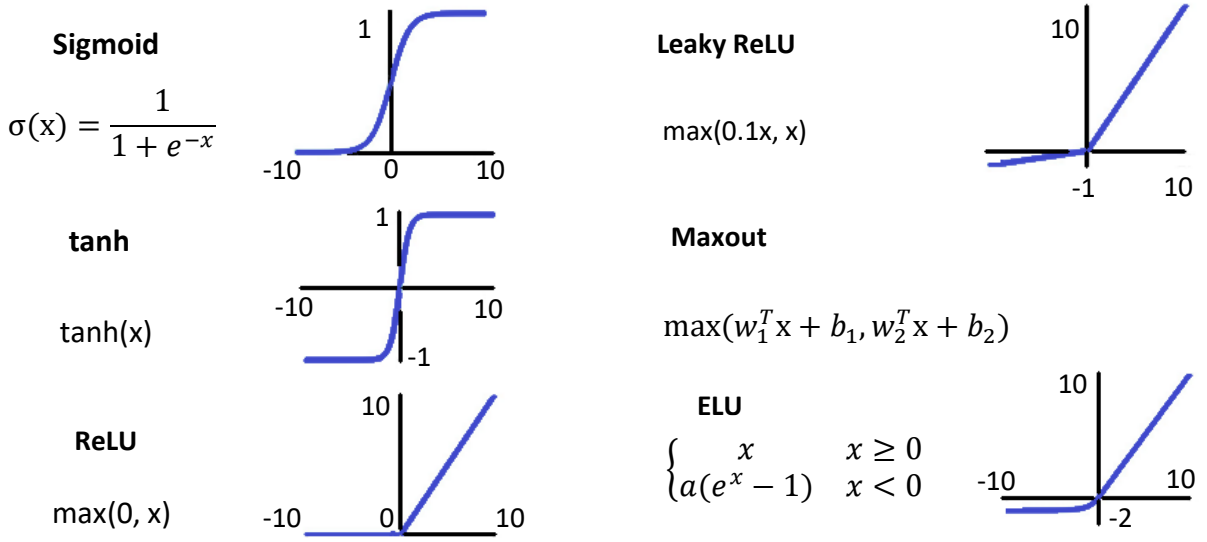

Figure 4: Basic activation functions [32]

The importance of choosing a neural network architecture for image recognition, which will optimize the results in the field of e-commerce, was noted above. The active development of machine learning algorithms in combination with the growth of cloud services and the strengthening of computing capabilities have allowed the use of neural networks with innovative architectures and to obtain higher quality results. Thanks to modern

high-performance networks (Fig. 5) it is possible to achieve the identification of objects in the images in the vast majority of cases and to improve the functioning of processes within the company's e-commerce [33].

Computer vision, which is realized through the use of appropriate neural networks, can significantly improve the efficiency of companies in the digital environment by bringing the processing of visual objects to a new level of quality. The above innovative neural networks for graphic image recognition are the next stage in the development of data science. Due to the evolution of views and the development of progressive algorithms, each neural network has its own life cycle, which ends after the emergence of more efficient algorithms and the loss of relevance of this model.

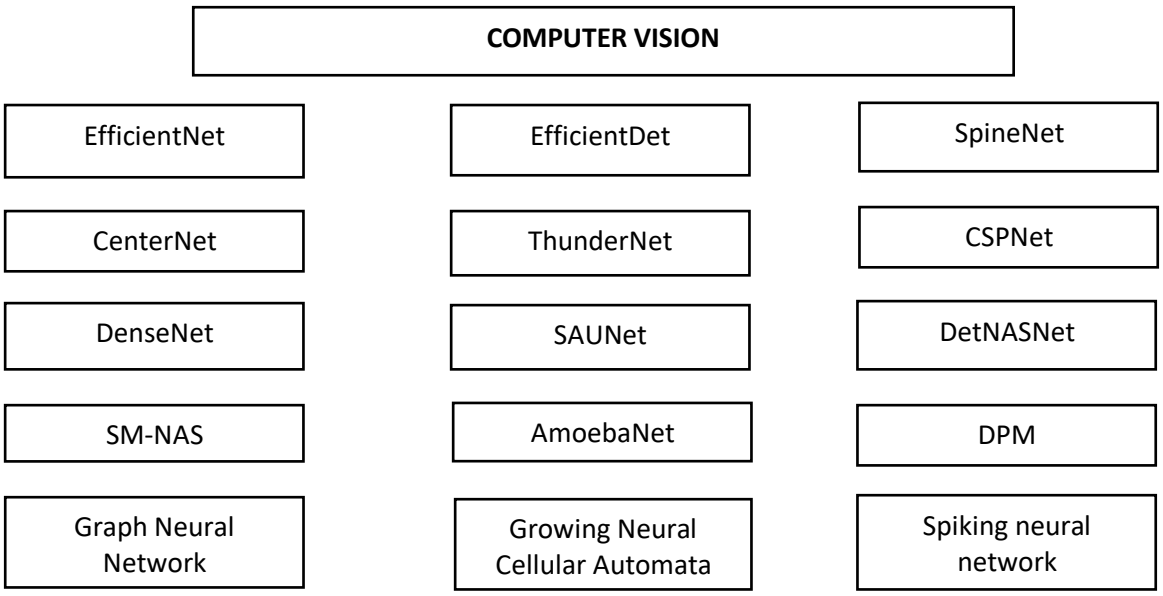

Figure 5: Neural networks for computer vision [34, 35, 36]

Modern scientists in the process of finding the best neural models to solve applied problems direct their efforts to solve the following processes:

- automation of the process of finding the optimal parameters of the neural network according to the specifics of the data and the implemented application tasks, taking into account the development of AutoML approaches, «neural network generates neural network», Neural Architecture Search (NAS and NASNet) [37];
- choice of attention mechanism, attention cards;
- the use of advanced hourglass convolutional networks for object detection tasks in heterogeneous visualizations, which are often used as backbone models in modular architectures;
- search for the optimal modularity system, as modern state-of-the-art architectures (SOTA) consist of a large number of components [38].

5. Results

Interaction with modern customers in the digital environment is carried out in many cases through the use of smartphones. A significant share of Generation Y users and an intensive increase in Generation Z purchasing power is leading to extensive growth in mobile applications. In order to meet the growing demand, modern companies in the process of implementing various e-commerce strategies bring to market innovative mobile applications that help establish long-term communication with the target audience and maximize profits in specific space-time conditions. Thanks to the use of machine learning methods, it is possible to optimize the corresponding mobile application.

This study envisages optimizing the e-strategy for a clothing and footwear company. A large number of Internet companies act as intermediaries between different brands and consumers. Due to the lack of physical storage facilities for clothing and footwear, companies sign cooperation agreements with large warehouses and order the appropriate products at the request of customers. It should be noted that today's customers have significant opportunities to choose goods and are very quickly shifting from one supplier to another in the digital environment. One of the characteristic features of Generation Y is the focus on visualized content and the desire to search for the necessary things through the use of appropriate search engines.

In accordance with the scientific topic, the development and implementation of a mobile application is envisaged, in which the searcher of the necessary clothes or shoes is integrated with the help of photography.

It is envisaged to photograph or download the required item in the module of the mobile application and its identification using machine learning algorithms. Given the limited resources of companies, it is advisable to use the available arrays of clothing and footwear photos to train the neural network. In this study, Fashion-MNIST was used, which contains 60 thousand images to train the model and 10 thousand to test the quality of the results. The use of a model Supervised learning is envisaged, as the primary data for the construction of the neural network are marked. There are the following product categories:

0 – T-shirt/top;
1 – Trouser;
2 – Pullover;
3 – Dress;
4 – Coat;
5 – Sandal;
6 – Shirt;
7 – Sneaker;
8 – Bag;
9 – Ankle boot [39].

The process of selecting and improving the model involves the use of TensorFlow, which is an open library for machine learning in the Python programming language. The flexibility applications of neural network architectures can optimize solutions on an ongoing basis in order to obtain better solutions that will meet the growing demands of today's target audience. The large amount of data makes it possible to significantly improve the quality characteristics of the calculated model of machine learning. However, given the large amount of training and test samples, each image was reduced to an array size of 28 × 28.

Figure 6 shows the increase in the accuracy of the model of identification of the item of clothing / footwear for the following parameters:

- hidden layer of neurons: 110 neurons and relu activation function;
- source layer of neurons: 15 neurons and softmax activation function.

```
Epoch 1/7
1875/1875 [==============================] - 19s 3ms/step - loss: 0.5058 - accuracy: 0.8245
Epoch 2/7
1875/1875 [==============================] - 6s 3ms/step - loss: 0.3819 - accuracy: 0.8616
Epoch 3/7
1875/1875 [==============================] - 6s 3ms/step - loss: 0.3415 - accuracy: 0.8742
Epoch 4/7
1875/1875 [==============================] - 6s 3ms/step - loss: 0.3168 - accuracy: 0.8845
Epoch 5/7
1875/1875 [==============================] - 6s 3ms/step - loss: 0.2985 - accuracy: 0.8893
Epoch 6/7
1875/1875 [==============================] - 6s 3ms/step - loss: 0.2835 - accuracy: 0.8941
Epoch 7/7
1875/1875 [==============================] - 6s 3ms/step - loss: 0.2716 - accuracy: 0.8998
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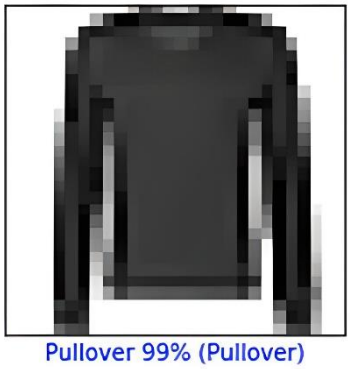
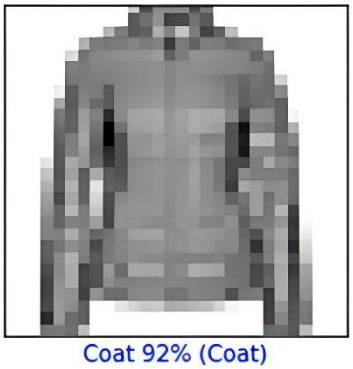
Figure 6: Increasing the accuracy of the selected machine learning model for image identification

At the next stage of checking the quality of the model, the test sample was loaded into the neural network and the accuracy was determined. For the obtained model of clothing and footwear identification, the quality on the test data was 0.8744. A small discrepancy in the values of the quality of the model for test data compared to training indicates the acceptability of the use of the neural network in the corresponding mobile application. The obtained model is used to assess the accuracy of identification of individual items of clothing and footwear in the existing array of images. Figure 7 shows the accuracy of pullover identification the value of the indicator was 99%. Figure 8 shows the accuracy of coat identification, the value of the indicator is 92%. The implementation of the presented model of machine learning allows the application to use a recommendation system, which based on user requests by uploading photos of clothes or shoes, provides the target audience with a high probability of information about the necessary products. Thanks to the implementation of the neural network in cloud storage and the use of powerful computing capabilities, image identification is implemented very quickly.



(a) Accuracy of pullover identification



(b) Accuracy of coat identification

Figure 7: Accuracy of object identification [40]

6. Conclusions

In modern conditions, the recognition of graphic objects through the use of neural networks is carried out through the use of specialized software. However, the best results are achieved through the use of programming languages, primarily in the framework of Data Science uses the Python language. To facilitate the modeling process within this programming language, specialized libraries are used for image transformation (OpenCV, Scikit-Image, SciPy, NumPy, SimpleITK, etc.) and the construction of neural networks (TensorFlow and Keras). The presented research shows the prospects of using neural networks both for image analysis in general and for optimizing the functioning of e-commerce in particular. In the future, it is envisaged to improve machine learning approaches and reorient to the mass use of artificial intelligence to increase the efficiency of the e-commerce market. With the development of more sophisticated teaching methods, including neural networks with innovative architectures, and the evolution of cloud services, more companies will be able to perform relatively affordable data analysis.

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