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IMAGE CLASSIFICATION OF THE FOOD PRODUCTS

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Abstract. *In this work was conducted research related to the problem of the image classification for food products. Based on the research we built several applications. The first one is created for collecting datasets and the second one is related to training of the machine learning model. For building the predictive model I was using Transfer learning and EfficientNet. As a programing language, I was using Python and a very powerful framework - Tensorflow*

Keywords: *image classification, transfer learning, EfficientNet, tensorflow, python, machine learning.*

I. INTRODUCTION

Transfer learning is a modern approach to solving many problems of machine learning. This paper considers the problem - Food products image classification. Using transfer learning and one of the pre-trained models, we are built an image classifier that will classify different food products. For the training, the model classifiers used a dataset built from real videos of products. This fact justifies the relevance of this work because the classification problem is solved on real data, rather than a publicly available and normalized test dataset.

For example, in supermarkets, pre-recognition of goods at the cash register makes it possible to reduce the burden on cashiers and thus reduce the service time of one customer. Optimization of service time of one client is the decision of one of the actual problems of modern retail that does work as a whole actual.

In this paper, we are solving the problem of image classification using a Convolutional Neural Network and datasets created my own for training and testing. At the same time, we implemented a convenient tool for collecting data needed for training and testing ML models. That tool is built as a chatbot using Telegram.

The machine learning model that we implemented, will expect data with labels of the corresponding classes since we are using supervised learning for the training models. The essence of this method is that the data for training must contain the correct class labels for each object in the set. According to these requirements, the developed mechanism for data collection must aggregate them and group them according to classes.

II. LITERATURE ANALYSIS

2.1. Purpose and scope

Designed software products are using to classify a number of food products on the input images. The ability to recognize goods on a photo or video is using in many areas, it helps to improve and automate different processes. Food recognition is

widely used in retail, namely in process automation, time cost optimization, and pricing.

2.2. Problem statement, literature review, approaches to solving

The "Transfer Learning" approach used in this paper is something that, according to researchers, can contribute to the further development of "AGI". Artificial general intelligence is the hypothetical intelligence of a computer program that has the capacity to understand or learn any intellectual task that a human being can. Andrew Yan-Tak Ng, a well-known researcher, and world-class Data Scientist wrote in one of his works: Next to the Teacher Learning approach, the development of the Transfer Learning approach will be a future success factor in commercial machine learning. Transfer training is a situation when the knowledge gained in solving one problem is used to improve the results and generalize in another problem. Deep learning models have some drawbacks - for very accurate and generalized possibilities, very, very large data sets with class labels are required to train the model. Also, the training itself takes a lot of time and resources. As a solution to this shortcoming, an approach to the use of modern, pre-trained models of deep learning was developed. Today, we have the ability to use modern deep network architectures that have been pre-trained on a large data set and the corresponding weights have been retained. The weights can be imported into the model for later use. There are a number of pre-trained models to solve a variety of machine learning problems. This approach takes place in solving problems related to working with text and voice, classification of images and segmentation of objects in images, and so on.

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

We were using the modern approach for solving ML problems called Transfer Learning. Transfer learning is an approach to machine learning that is closely related to deep learning. There is a significant difference between the traditional approach, for building and training machine learning models, and the methodology of transfer learning. The traditional approach is isolated and learning takes place purely on the basis of specific tasks, datasets, and learning individual isolated models on them. Acquired knowledge that can be transferred from one model to another is not stored. During the transfer training, you can use the knowledge (features of objects/weights extracted by ML model) from previously trained models to train new models and solve new problems with a smaller amount of data. Let us now consider the formal definition of Transfer learning, and then use it to understand the different strategies.

Domain D is defined as a tuple of two elements, namely: feature areas and probability distribution - $P(X)$, where X is the data point in the set. Thus we can describe the domain mathematically as $D = \{X, P(X)\}$. The probability distribution $P(X)$, $X = \{x1,..., xn\}$, $xi \in X$. Here Xi reflects a specific feature vector. We can define task T as a two-element tuple of the space of labels of classes - γ and objective function - η. The predicate function can also be denoted as $P(\gamma \mid X)$ from the point of view of probability theory. In this manner the test T can be represented as:

$T=\{\gamma, P(Y \mid X)\} = \{\gamma, \eta\}$, $Y=\{y1,...,yn\}$, $yi \in \gamma$.

Having domain $D1$ corresponding to task $T1$ and domain $D2$ corresponding to

task *T2*, Transfer Learning allows us to calculate the target conditional probability *P(Y1 | T1)* in domain *D1*, using the knowledge obtained in training the model in domain *D2* and task *T2*. In this case, *D1 ! = D2*, and *T1 ! = T2*. When using Transfer Learning in model training, the dataset required for training is usually exponentially smaller than the dataset for which the corresponding model was previously trained.

In this work, I used the architecture "EfficientNet", proposed in 2019 and to this day is one of the most effective models, which achieves the highest accuracy in solving image classification problems. Based on official documentation, "EfficientNet" is a family of ready-made models of various depths and widths. This family includes models: "EfficientNet0", "EfficientNet1", "EfficientNet2", "EfficientNet3", "EfficientNet4", "EfficientNet5", "EfficientNet6", "EfficientNet7". The “EfficientNet0” model is the smallest of all listed, and the size of the input image is 224x224 pixels. Accordingly, the model "EfficientNet7" is the largest and requires the most time and resources for training, the input image size there is 600x600 pixels. A variety of architecture from the EfficienNet family:

Base model	resolution
EfficientNetB0	224
EfficientNetB1	240
EfficientNetB2	260
EfficientNetB3	300
EfficientNetB4	380
EfficientNetB5	456
EfficientNetB6	528
EfficientNetB7	600

Fig. 1. EfficienNet family

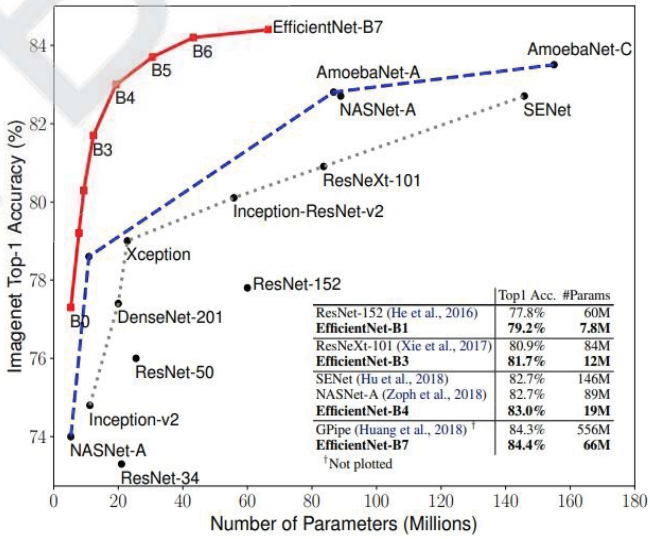

Fig. 2. Modern Pre-trained models

There are also other ready-made architectures of convolutional neural networks for working with images. Compared to other models, EfficientNet is much smaller and shows better results:

Architecturally, the EfficientNet0 model can be divided into the following set of blocks:

Stage i	Operator $\hat{\mathcal{F}}_i$	Resolution $\hat{H}_i \times \hat{W}_i$	#Channels $\hat{C}_i$	#Layers $\hat{L}_i$
1	Conv3x3	224×224	32	1
2	MBConv1, k3x3	112×112	16	1
3	MBConv6, k3x3	112×112	24	2
4	MBConv6, k5x5	56×56	40	2
5	MBConv6, k3x3	28×28	80	3
6	MBConv6, k5x5	14×14	112	3
7	MBConv6, k5x5	14×14	192	4
8	MBConv6, k3x3	7×7	320	1
9	Conv1x1 & Pooling & FC	7×7	1280	1

Fig. 3. Architecture of EfficientNet0

To avoid overfitting of the model, we were using data augmentation for the collected dataset. Overfitting a model is a condition where a statistical model begins to describe the random error in the data rather than the relationships between variables. Image augmentation artificially creates training images through different ways of processing or a combination of multiple processing, such as random rotation, shifts, shear, and flips, etc. Here are examples:

Fig. 4. Image augmentation

IV. RESULTS

The developed product can be divided into two parts:

User interface where user can extend training dataset and actually can try to predict food product name using products images;

Convolutional neural network, trained on its own data set;

We used Telegram platform for building user interface represented as a chatbot. The chatbot is a convenient mechanism that is widely used in various fields. The Chatbot used Python as a programming language and several additional modules to work with the Telegram API and recognize barcodes in the uploaded images. This Chatbot is designed to collect dataset that is needed for training the machine learning model and it is also using for the classification of food products. Using barcode photos and videos of relevant foods, we can easily collect and associate data on the fly with the appropriate class labels - barcode, product name, etc. The classifier model is implemented using a modern approach in in-depth learning, which is called Transfer Learning. There are several options for using Transfer Learning and given the individual requirements and resources, it is important to choose the best option. In the first case, we use a pre-trained model to obtain quality features of objects in training. Using this approach and replacing the last layers of the network, we can re-train and adapt the model to solve the problem of food recognition.

Otherwise, we continue to use most of the weights obtained during the pre-training, and re-train some layers of the network. The second approach requires more resources than the previous one, as it requires more calculations and a much larger set of training data. It is conditionally possible to allocate 4 situations which are possible at use of the Transfer Learning approach:

	Similar dataset	Different dataset
Small dataset	Transfer learning: highest level features + classifier	Transfer learning: lower level features + classifier
Large dataset	Fine-tune*	Fine-tune*

Fig. 5. Transfer learning strategies

In this work, I used part of the existing weights of the pre-trained model and re-trained the twenty final layers of the network. As a result, we implemented a the model that is able to recognize food products on the given images.

The classifier interface is a chatbot built using a modern and convenient messenger platform - Telegram. The user needs to start a chat with the bot, then the bot itself will ask for the desired action and show the appropriate function buttons. Interaction with the developed chatbot is intuitive and takes a few minutes to get acquainted with its capabilities. Here is an example of usage:

Fig. 6. Developed chat bot example of usage

V. CONCLUSIONS

In this paper, we investigated the problem of image classification using artificial intelligence and appropriate approaches using Python as a programming language. The following approaches were used to build an AI model:

1) Deep learning methods and in particular - Transfer Learning
2) Pre-trained model EfficientNet0

In general, we developed a software product for solving the problem of image classification for food products. At the same time, we built another application that we found very useful for data collecting, grouping, and association. The chatbot

expects images of the barcodes and videos about each specific product, then it is decomposing and groups all videos using associated barcodes. As a result, we have folders in the file system for each of the upload barcodes. Each folder contains images decomposed from previously uploaded videos, so we can use these already associated images for training and testing AI models. Also, this chatbot can be useful for solving other AI problems.

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USE OF NEURAL NETWORKS TO MAXIMIZE THE EFFECTIVENESS OF SHOT PUTTERS TRAINING

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Abstract: *The main factors influencing the results of shot put are considered. The necessity of using modern methods for solving forecasting problems is substantiated. The method of artificial neural networks with different architecture is proposed to solve the following problems: finding the percentage of correction of the shot put technique, finding the subtype of the technique, the activation function of the sigmoid and the algorithm of reverse propagation of errors for learning networks. A software package has been developed that allows to find the approximate result of pushing the shot using the technique of "glide" and "from the ground". Examples of calculations in the environment Deductor Studio Lite are given.*

Keywords: *shot put, neural network, prediction, reverse search method, physical culture, athletics.*

I. INTRODUCTION

The current level of development of athletics, in particular shot put, sets the task of developing new, more rational means and methods of sports training that

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