Application of Artificial Intelligence in Medicine

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***Abstract* — Blood is one of the most essential parts of the human body, and it comprises of the Red Blood Cells, White Blood Cells, and Platelets. Complete blood count characterizes the condition of well-being. Hence, segmentation and identification of blood cells is very important. Up to this day, many hospitals and health centers still use the old conventional method which involves manual counting of blood cells using haemocytometer along with other laboratory equipment's and chemical compounds, which is a time-consuming and tedious task. In this work, the author presents a machine learning approach for automatic identification and counting of three types of blood cells using Detectron2, a popular PyTorch based modular computer vision model library. Detectron2 detector has been trained on public blood cell detection data hosted at Roboflow. Overall, the computer-aided system of detection and counting enables us to count blood cells from smear images in less than a second, which is useful for practical applications.**

Keywords: Machine learning, Deep learning, Medicine, Blood Cells

1. INTRODUCTION

The development of artificial intelligence has gained new momentum since the beginning of the 21st century. Some important problems that were supposed to remain unresolved for a long time, they are just being resolved. Superior results are being achieved in some domains in which computers could not be compared to humans. Although it came to the fore only at the beginning of the 21st century, this area has a long history of development. Conceived in the works of Alain Turing, in the 1940s, it has been actively developing since the 1950s, when the first perceptron was constructed, the first system that teaches simple laws and is a distant forerunner of modern neural networks [11].

The application of artificial intelligence in medicine is the use of machine learning models to search medical data, which helps to better understand the patient's state of health. Thanks to advances in computer science and informatics, artificial intelligence (AI) is soon becoming an integral part of modern medicine. Artificial intelligence algorithms and other AI-powered applications are used to support healthcare professionals in the clinical setting [7].

Currently, the greatest use of artificial intelligence in medicine is in the establishment of medical diagnoses and analysis of medical images. Tools or support in establishing diagnoses help service providers to make the right decisions about patients' treatments, medications, mental health and other needs by giving them quick access to information or research that is relevant to a particular patient. In medical imaging, AI tools are used to analyze CT scans, X-rays, MRI as well as other tests.

Also, the COVID-19 pandemic, which has created major challenges for many healthcare systems, has accelerated the process of testing new technologies that rely on artificial intelligence. Research and results of these tests are still being purchased, and general standards for the use of artificial intelligence in medicine are still not defined. However, the possibility of AI being useful to clinicians and researchers as well as patients is constantly increasing. At this point, without doubt can be said that AI will become a key part of the digital systems that shape modern medicine [8].

2. ARTIFICIAL INTELLIGENCE

Artificial intelligence is perhaps the oldest field of computer science, which deals with all aspects of mimicking cognitive functions to solve problems in the real world and building systems that learn and think like humans. Therefore we often call it machine intelligence to compare it to human intelligence. Programs that allow computers to function in a way that is similar to human intelligence, are called artificial intelligent systems. British mathematician Alan Turing (1950) was one of the founders of modern computer science as well as artificial intelligence. He defined intelligent behavior of computers as the ability to reach the human level of performance in cognitive tasks, and this later became known as the "Turing test". The area of artificial intelligence is at the intersection of cognitive sciences and computer science. Artificial intelligence is now attracting huge interest because of the success in machine learning [11].

2.1 Machine Learning

Machine learning is a branch of artificial intelligence that deals with techniques and methods that allow computers and other machines to learn based on experience, without explicit programming (Derived from the first definition of machine learning as a branch of science given by Arthur Semuel in 1959: A discipline that allows computers to learn without explicit programming). Enormous advances in machine learning have been driven by the development of new statistical algorithms along with the availability of large data sets and low cost calculations. Today, an extremely popular method is deep learning [4].

2.2 Deep Learning

Deep learning is part of the wider family of machine learning algorithms based on convolutional neural networks which have a long history. Deep learning is very popular today because it achieves amazing results even on human level. The best example is the recent achievement of the Thrun group, where they succeeded in applying deep learning to classify skin cancer with a level of competence that can be compared with human dermatologists [5].

3. NEURAL NETWORKS

An artificial neural network in the broadest sense of the word is an artificial replica of the human brain, which attempts to simulate the learning process. An analogy with the real biological model is actually quite shaky because with many details replicated, there are still many phenomena of the nervous system that have not been modeled by artificial neural networks. Furthermore, the characteristics of artificial non-neural networks that do not agree with those of biological systems. A neural network is a set of interconnected simple process elements, units or nodes, whose functionality is based on a biological neuron. In doing so, the power of the network comes from the connections between individual neurons, ie. the weights that are reached in the learning process based on a learning data set. The neural network processes data by distributed parallel operation of its nodes. The basic building block of a neural network is called a neuron. In the literature often uses the name Unit. Neurons connections have their own weight, which we can identify with the synapse and their strength. If the neuron signal is strong enough, the neuron will pass the signal to the subsequent neurons [8]. The value that a neuron needs to reach to pass a signal is called a threshold (Bias). The weights of connections between neurons and the threshold adapt during the learning phase. Various models have evolved from the basic idea of neurons that differ mainly in the way they transmit signals. We group neurons into layers, and all layers form a neural network. Input signals are sometimes called the input layer, however it does not consist of neurons. Except the input layer the network must also have an output layer. When the network consists only of input layer (input data) and output data layer then we will say that it is a single-layer neural network. When the network between input and output layer has one or more layers of neurons, than these layers are called hidden layers. Neurons in the same layer are not interconnected, but each neuron in the layer is associated with some neurons in the next layer [1]. One input data can consist of several signals. It is common to the input data to be divided into a learning set, a validation set, and a test set to ensure the proper operation of the network on unprecedented data. If we do not ensure proper sharing of this data, overtraining problems can occur. It is a phenomenon in which the network is fully adapted to the training data and loses the ability to adapt to new instances of the problem (overfitting). The test data set is only used to evaluate the network, so this data must not be used in learning algorithms [2]. If we focus on one hyperparameter, the natural way would be to try to train the network several times, each time with a different value of the selected hyperparameter and opt for the one that gives the best results on the set for testing. However, when a neural network is put into use, it can be assumed that its performance is significantly worse than that of the test set. The reason is that we are re-training and testing the network implicitly adapted to a set of test data, so the network does not actually have the ability to adapt to new data [2]. The solution to this problem is an additional set of data that we call a validation set. After the learning phase is over and when the network achieves satisfactory results on the data set for validation, then on the test data we can check if it is ready for actual use.

4. MODEL OF ARTIFICIAL NEURON AND NEURAL NETWORK

At first sight, it might be wrong to conclude that artificial neural networks represent a mathematical model of real neural network, but that is not the case. To some extent, artificial neurons are inspired by the way biological neurons function, but their mathematical model represents a significant simplification of the work of real neurons and the only real relationship between a biological neuron and an artificial neuron is that both are connected with the goal of learning and realization of some functionality. Biological neurons realize their functionality through impulses, while, although there are pulse neurons networks, artificial neurons represent only a mathematical model of the elementary constituent of a larger architecture that can be trained to solve a specific problem and which, again by convention, is called a neural network, so the alternative name for an artificial neuron is a newly formed term perceptron [6].

Therefore, the artificial neuron is a simple classifier which accepts the input vector, denoted by χ, the weight vector representing the synaptic weights for the artificial neuron, denoted by ω and we apply an activation function φ on their scalar product, which is typically a nonlinear function.Therefore, a mathematical model of a neuron, when it comes to the model in the picture can be represented by an equation

$$y = \varphi (\chi * \omega)$$

The values of the elements of the weight vector, can be adjusted manually either on the basis of experiments or on the basis of the propagation of gradients in a process called supervised learning. One neuron does not represent a significant classifier model, but if we have many, their usefulness and classification power increase when they are connected into an architecture called an artificial neural network. In its simplest form, an artificial neural network represents layers of artificial neurons [6].

5. APPLICATION OF ARTIFICIAL INTELLIGENCE IN IDENTIFICATION AND COUNTING BLOOD CELLS

A complete blood count (CBC) is a very important test. The three main types of blood cells are red blood cells(RBCs), white blood cells (WBCs) and platelets [3]. Red blood cells, ie. erythrocytes are the most abundant cell type in the body. Their main role is to transport oxygen from the lungs to the tissues and carbon dioxid in the opposite direction. Erythrocytes have the shape of a biconcave lens. This form of erythrocyte provides maximum elasticity and flexibility, allowing them to go through very narrow capillary spaces without rupture of the cell membrane. Average diameter is about 7,8 μm to a thickness of 2,4 μm on the periphery, or 1 μm or less in the central part of the cell [3]. Erythrocytes consist of about 70% water, while the remaining amount is mostly hemoglobin whose concentration ranges from 140g / l (in women) to 160g / l of blood (in men) and which is the respiratory pigment. The cell consists of a membrane (lipo protein structure) and a cytoplasm without a nucleus and most other cellular organelles. The cell membrane of erythrocytes ensures the shape and plasticity of red blood cells and the stability of their internal environment. It is a very dynamic structure, important to sustain its existance. The number of red blood cells in healthy people depends on various factors. Most often on gender, age, altitude. The percentage of blood that makes up erythrocytes is called hematocrit and is 40-45% [10]. White blood cells, ie. leukocytes make up only 1% of the total number of cells in the blood. Their role is multiple. Immunological is most often mentioned, ie. their role in defense from disease. Leukocytes originate in the bone marrow, but part of the development of some types of leukocytes also takes place in the thymus, lymph glands and nodes, as well as the spleen. They are very important for the interpretation of laboratory blood analysis. In one liter of blood, in case of adults, there are between 4-11 billion white blood cells. Leukocytes differ from other cell types in appearance, representation, place of origin and function. According to the shape nuclei and membranes they are divided into granulocytes (with granular cytoplasm and lobes by that nucleus) and agranulocytes (with homogeneous cytoplasm and round nucleus). The most important organ when it comes to white blood cells is the thymus gland (thymus), which is located below the sternum, because it is essential for the development of one of the subtype of lymphocytes, T lymphocytes. Leukocytes contain about 80% water, a large amount of glycogen that serves as a source of energy, lots of nucleoproteins, histamine and heparin. Of the physical characteristics, the most important is an amoeboid movement as it passes from the blood to the tissues. The shape of the leukocytes varies. All peripheral blood leukocytes are round in shape. Granules in the cytoplasm have specific granules that are dyed with acid and base dyes, and there are also neutral granules. The lifespan of leukocytes is different. Some leukocytes are formed in the bone marrow and they stay there until the need arises. For example, granulocytes once they are released and after they reach the bloodstream they stay there for another 5 days [10]. Platelets are small blood components whose main role is to stop bleeding by plug formation and blood coagulation. Since the number of these blood cells is huge, the traditional way of manual counting of blood cells using a hemocytometer is very long, and often wrong, because the accuracy largely depends on the skill of the person performing the analysis. Therefore the automation of counting different blood cells would greatly facilitate the whole process. With the development of machine learning, applications that are used for image classification and object detection become more accurate. As a result, methods based on machine learning are applied in different fields. Specifically deep learning methods have different applications in medicine, such as detection of abnormality and localization on chest X-rays, automatic segmentation with detection of local errors in MRI images of the heart, detection of diabetic retinopathy on retinal fundus images. So it is worth considering in-depth learning methods that can be used to identify and count blood cells [3].

6. MATERIALS AND METHODS

Google Colab was used to analyze the data and create the model. Because it supports many popular machine learning libraries, it provided a suitable environment. Python and its libraries (PyTorch, Pandas, Numpy, Matplotlib) were used for implementation. We used Roboflow to collect and prepare data. Roboflow is a Computer Vision development framework for data collection, containing public collections of data that is available to users, and also allows users to access their data collections. We used the popular PyTorch library Detectron2 for detection and classification of objects. Detectron2 is a system that lets the most modern computer vision technologies to be included in the workflow. Detectron2 includes all the models that were available in the first version, such as Faster R-CNN, Mask R-CNN, RetinaNet and DensePose. It also features several newer models such as the Cascade R-CNN, Panoptic FPN, and TensorMask [13]. We used a Faster RCNN neural network. We classified the data into two groups: the learning group (80% of the data) and the group for testing (20% of data). We used 765 COCO (Common Objects in Context) image.

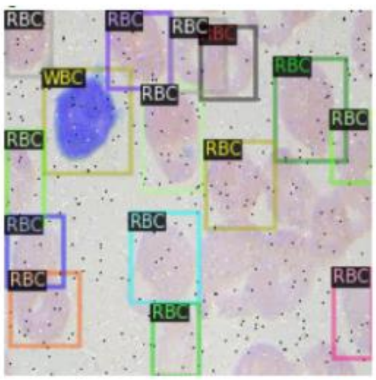

Figure 1. Example of a learning model

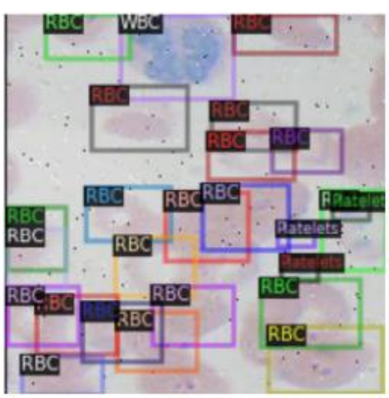

Figure 2. Example of a learning model

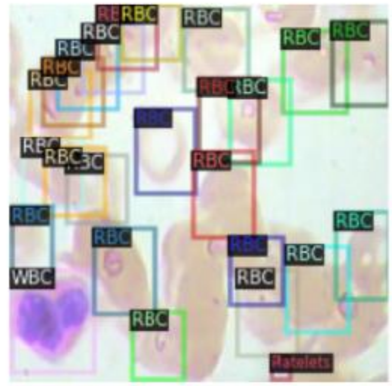

Figure 3. Example of a learning model

7. RESULTS

The following are examples of results obtained for imported data.

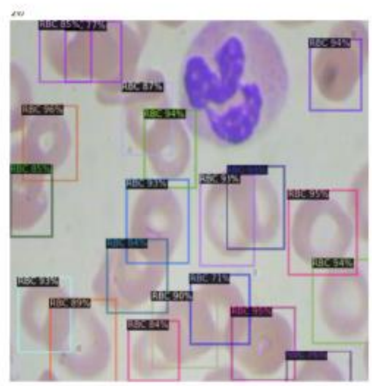

Figure 4. Example of a result

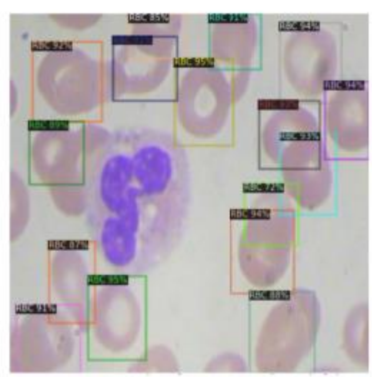

Figure 5. Example of a result

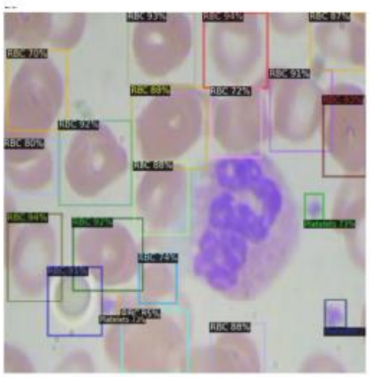

Figure 6. Example of a result

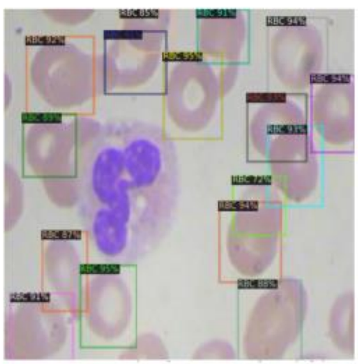

Figure 7. Example of a result

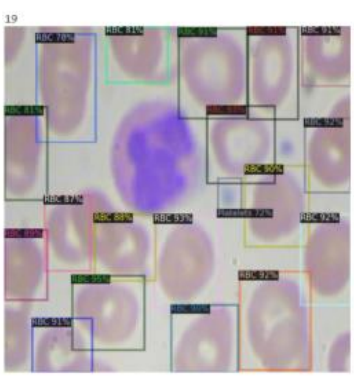

Figure 8. Example of a result

8. CONCLUSION

As we have already mentioned, the application of artificial intelligence grows day by day more and more. In this growth, machine learning stands out as its largest branch, while deep learning is developing within it, which has increasingly significant application. In this paper, we have dealt with the application of artificial intelligence in medicine, while the greatest emphasis is placed on its application in hematology. In medicine,the greatest benefit of using artificial intelligence comes from considerable saving of time and human capacity when performing tasks that are logical and repetitive. Also, most importantly, such algorithms mostly have better accuracy and efficiency than the human could provide. The example given concerned with the detection of red blood cells, white blood cells and platelets, the accuracy of this algorithm was very high. Similar algorithms aided by artificial intelligence are widely used for detection of pneumonia, various changes in the proteins, feeling of comfort of patients via AI assisted phone calls… What is certain to us is that they make life much easier at the moment.

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