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DEVELOPMENT OF NEURAL NETWORK AND APPLICATION OF COMPUTER VISION TECHNOLOGY FOR DIAGNOSIS OF SKIN INJURIES AND DISEASES

The object of research is the process of using the technology of artificial intelligence and computer vision in the medical field. The subject of the study is the introduction of the neural network in diagnostic information systems and its collaboration with the mobile application iOS for the diagnosis of skin lesions and diseases. The property of neural networks is their ability to learn based on environmental data and as a result of learning to increase their productivity. After analyzing the existing methods for further implementation in the software product for neural network training, the method of parallelization of sampling training was chosen. One of the most problematic places is the task of diagnostics in the medical field, which requires, along with expert solutions, the use of modern approaches based on artificial intelligence and computer vision. Through the use of artificial intelligence and computer vision, experts try to assess the patient's condition and accurately diagnose, because the human factor is always present in the medical field, so the use of artificial intelligence aims to improve the quality of patient diagnosis. Research methods include computational experiments, comparative analysis of results, object-oriented programming. The study used computer vision techniques, which include methods for obtaining, processing, analyzing and understanding digital images. A neural network for the analysis of injuries and diseases of the skin has been trained and an information system for diagnosing and monitoring the health of the skin has been implemented by creating a mobile application based on iOS. The results of the implementation can give users the opportunity to monitor the condition of their skin, receive recommendations for its preventive treatment, provide advice on the treatment or prevention of diseases, provide information literature.

Keywords: *neural network, graphic visualization, CoreML, mobile application, diagnostic information system.*

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1. Introduction

The global expansion of mobile devices into the consumer market and the annual technological capabilities of mobile devices today provide an opportunity to create and maximize the processes of translating our usual actions and operations in application to mobile operating systems, as well as to apply mobility and capabilities in various areas of our lives [1].

Such ideas and their implementation provide not only hardware updates for mobile devices, such as: improving the camera, increasing the amount of RAM and physical memory of devices, etc. They also provide an opportunity to implement and develop technologies and complex algorithms based on mobile operating systems.

Also, recently, it was possible to see a steady trend of turning mobile devices and mobile applications into a digital assistant who books us tables in a restaurant, on request can order us food from the supermarket, informs us about our work calendar, next meeting, the birthday of a family member and so on [2]. The recent pandemic COVID-19, which isolated man as a social unit and changed the usual ways of performing certain actions, also contributed significantly to this metamorphosis.

One of the problems is the possibility to apply the described approach and information technology to replace the first link of contacts, for example, in the medical field. The question arises as to whether a mobile application can act as a consultant in an area where physical contact is a source of information about the user, such as the medical field of dermatology. This can be the mobile application acting as a consultant, removing this task from the doctor's responsibility and giving him more free time to cover more patients. Also it can be used as recommendation to prevent skin diseases or eliminate their symptoms in the early stages. Gathered information (photos, the time of the disease, the exact date of onset of the disease, the appearance of certain symptoms) could be provided to the doctor.

Thus, *the relevance of research* is the use of modern approaches based on technologies of artificial intelligence and computer vision in the medical field along with expert solutions. Naturally, with the use of artificial intelligence and computer vision, experts try to provide the widest possible assessment of the patient's condition and accurately diagnose, because the human factor will always be present in the medical field, so the use of artificial intelligence aims to improve patient care.

Therefore, *the object of research* is the process of using the technology of artificial intelligence and computer vision in the medical field. *The aim of research* is the introduction of a neural network in the diagnostic information system and its cooperation with the mobile application iOS for the diagnosis of skin lesions, diseases and monitoring skin health by creating an iOS-based mobile app. The functions of such an application are the recognition of injuries and diseases of the skin, the provision of advisory recommendations for the treatment or prevention of diseases, the provision of information literature based on existing skin problems.

2. Methods of research

Artificial intelligence has found the widest application in the field of cancer, because the use of computer vision to study and classify cancers allows avoiding the human error factor, and provides an additional data network for the study of cases in laboratories.

Artificial intelligence has also come in handy in the recent COVID-19 outbreaks in China. Chinese researchers have developed an artificial intelligence (AI) system that has helped doctors distinguish COVID-19 from influenza and other respiratory illnesses in less than three seconds. As the flu season approaches and the second wave of COVID-19s threatens to rise, in many countries, differentiation between two respiratory diseases that have similar symptoms becomes critical to curbing a pandemic. So, researchers at Tsinghua University and Wuhan-based Union Hospital, a subsidiary of Huazhong University of Science and Technology, developed an AI system using a large data set of more than 11,000 CT scans from COVID-19, influenza, non-viral pneumonia, and non-viral community-acquired pneumonia, and other cases not classified as pneumonia.

So, it is possible to see examples of AI assistance, but is it possible to use AI techniques to create primary care? For example, this is possible in the field of dermatology. In Dermatology, it is possible to identify the task of early localization and providing recommendations for primary treatment of skin diseases or preventive action against them. Also, the list of tasks includes determining the diagnosis and nature of the skin disease to assist the doctor. For example, it can be the provision of the widest possible information about the course of the disease (nature, type, time of onset of symptoms, duration of the disease) or the provision of recommendations for disease prevention based on the climate of the region of residence, age. Such tasks will be inextricably linked to artificial intelligence and computer vision technologies and may be available to every smartphone user.

3. Research results and discussion

Today there is an indisputable significant scientific and practical interest in computing structures of a new type – artificial neural networks [3]. It is caused by several successful applications of this new technology, which has led to the development of effective approaches to solving problems that were considered difficult to implement on traditional computers. The name «neural networks» is now claimed by all computing structures that to some extent simulate the work of the brain. But such modeling, for the most part, is very fragmentary, and it is too early to talk about the creation of an artificial brain in the near future, or even some model of it that would duplicate the work of the brain of the most primitive living creatures. This conclusion follows from the extreme complexity of this mysterious work of nature.

The successful development of neural network theory over the last decade has made it possible to artificially copy some global properties of the human mind, namely, learning, generalization, and abstraction.

The property of learning is manifested in the ability of the neural network to change its behavior depending on the state of the environment. Due to this property, neural networks attract considerable attention. There is a wide variety of neural network learning algorithms, each of which has its strengths and weaknesses, but today there is no consensus on why a neural network can be taught and how such learning should be conducted.

The property of generalization allows the neural network to reduce the sensitivity to small fluctuations of the input signals. This property is very important for objects that exist in the real environment. The peculiarity of the neural network approach, in this case, is that the generalization is the result of the properties of the structure and not the work of a special program on a traditional computer.

The property of abstraction allows to create a new entity on the neural network, based on the analysis of input information. This property is especially evident for image recognition tasks. Thanks to it, the neural network can create some ideal images, guided by the input information that has some properties of this image.

The process of building a neural network can be divided into two parts:

1) choice of network type (architecture);

2) selection of weights (training) network.

At the first stage the following questions should be solved:

1) what neurons we want to use (number of inputs, transfer functions)?

2) how to connect them together?

3) what to take as network inputs and outputs?

This task may seem complicated at first glance, but it is not necessary to invent a neural network – there are dozens of different neural network architectures, and the effectiveness of many of them is proven by mathematical statistics. The most popular and studied architectures of neural networks are a multilayer perceptron, a neural network with general regression, the Kohonen network, the Hopfield network, the Hemming network and others.

At the second stage it is necessary to teach the chosen network, that is to pick up such values of its weights that the network worked properly. In practice, neural networks can number in the tens of thousands, so learning is a really complex process. For many architectures, special learning algorithms have been developed that allow to adjust the weights of the network in a certain way.

3.1. Base components of interaction between the mobile application and neural network. There are many software tools for creating and training neural networks, the most popular among them are: Caafe, TensorFlow, Keras. But they only prepare the model itself, and an interface bridge to interact with the IOS mobile application is necessary. This bridge is needed to take full advantage of the user's mobile device, save its confidential data and solve the problem. A general diagram of such interactions is shown in Fig. 1.

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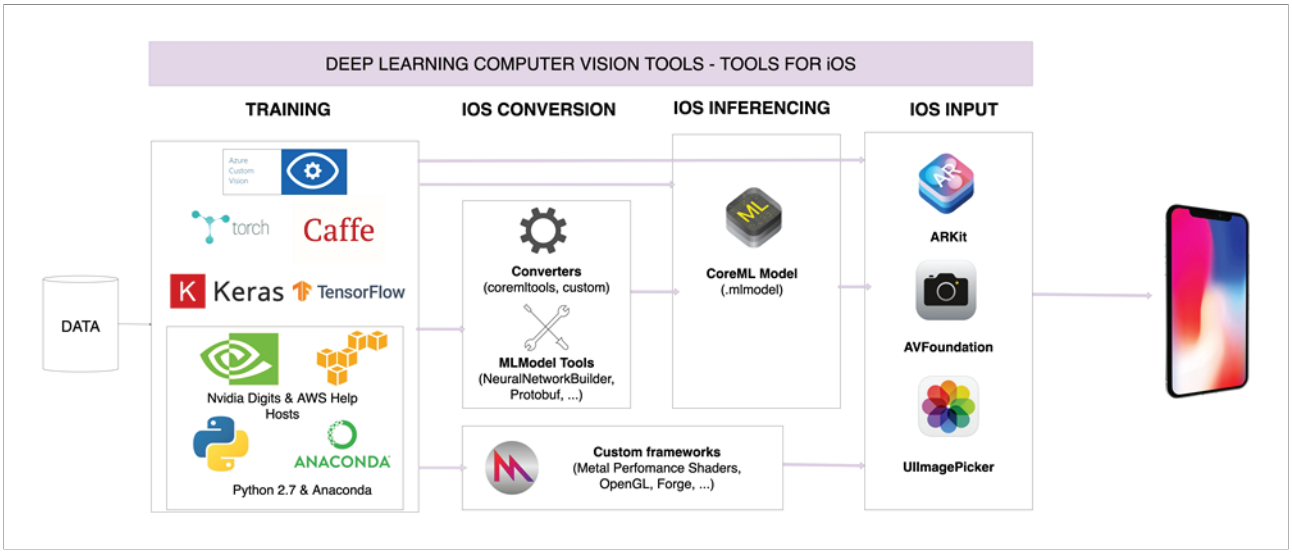

Fig. 1. General Block diagram of the interaction of the iOS application with neural networks

The framework bridge called CoreML will act as our interface bridge for the iOS mobile application. The CoreML library is Apple's core machine learning framework based on Accelerate, BNNS, and Metal Performance Shaders. It offers machine learning models that can be integrated into iOS mobile applications and supports image analysis, natural language processing, audio to text, and audio analysis. Core ML optimizes the use of the neural network on the user's device, using the CPU, GPU and Neural Engine while minimizing memory and power consumption. This means that running the model on a user's device eliminates any need for a network connection, which helps maintain user privacy and improve the user experience.

The «Model» component presented in the diagram shown in Fig. 2 is the result of applying the machine learning algorithm to the training data set, i. e., the neural network created by the developer based on any library. A model to predict based on new input is used. Models can perform a variety of tasks that would be difficult or impractical to write in code.

For example, it is possible to teach a model to classify photos or detect specific objects in a photo directly from its pixels.

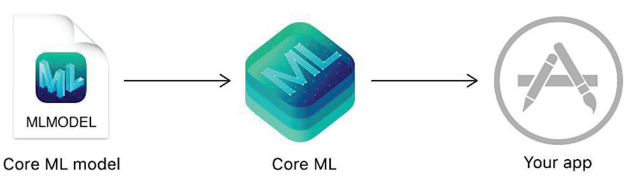

Fig. 2. Scheme of the interaction of the CoreML framework with the user application

The framework provides an opportunity to build and teach a model using the built-in Create ML program complete with a native development environment – Xcode. Models taught with Create ML have the Core ML format and are ready to use in your application. Additionally, it is possible to use a wide variety of other machine learning libraries and then use Core ML Tools to convert the model to Core ML format to integrate the created model into the Xcode development environment. Once the model is on the user's device, it is possible to use Core ML to perform the required tasks.

3.2. Parallel neural network training algorithms. Parallel processing is a combination of two or more processors to solve a neural network problem. This allows to optimize the time spent on the calculation if to compare the results of the use of parallel processes and the results provided by a single processor.

The use of this technique allows to solve problems of large volume and problems with a fixed dimension in a shorter period of time. When considering the possibilities of information processing by the human brain, it also uses the technique of parallel data processing, as it contains a huge amount of information and interconnected processing elements.

The artificial neural network model contains several parallel structures. They are used to increase the efficiency of implementation when using parallel architectures. There are several types of levels of parallelization in artificial neural networks [4].

So, Nordström identified the main levels where parallelization is carried out during the learning phase:

1) training phase level;
2) educational sample level;
3) layer level;
4) neuron level;
5) weight level.

All these levels of parallelization are in the neural network and can be used in parallel, i. e., simultaneously. In order to select the desired level, it is necessary to take into account the number of neurons in the network, processors, features of the computer architecture of the INS, and the task set before it.

When learning artificial neural network is its full learning throughout the network. In order to determine the necessary parameters for the optimal solution of the problem, training consists of a certain number of the experimental selection of network parameters. For example, it is necessary to select the parameter of the required number of neurons in all layers of the network.

To solve the problem of classification, it is possible to choose the method of parallelization of sample learning, because when applying parallelization at the sample learning level, training is used simultaneously on several different samples for training. This point can be considered important because it requires a large number of learning vectors in an artificial neural network to solve the learning problem. When using parallelization methods in the learning phase of the sample, training is used simultaneously in several different training samples. This is important because it often requires a large number of learning vectors in an artificial neural network to solve a large problem.

When using a system that uses only one stream of vectors, they will be sent to the network alternately, and in a parallel system – training vectors are distributed between processors, where each processor has a copy of all data of the artificial neural network. That is, let's obtain a situation where each of the processors is trained in several samples.

3.3. Training classes and optimal methods of their use. To train a neural network on a classification task, it is necessary to prepare a specialized set of data to load into a model with which it can train. Before collecting images for a data set, it is necessary to decide here – what will be the categories or labels of the images – that is, the classes that the model will try to predict.

To classify the model was used near 8,000 photos of benign and malignant moles. These photos were taken from the ISIC dataset [5]. Certain criteria were selected for the photographs (in context of future usage model in mobile application):

- can't be a microscopic image. Many images on the ISIC website are moles placed under a microscope, which is useless to model since a user will not input a microscopic image of their own mole using a phone camera. Some of the images have been cropped so that the black ring does not show, but it can still be a microscopic image if it is possible to see tiny water droplets on the mole or the hairs are overly detailed [6];
- has to be above 299×299 pixels. Results generated by the trained model may be negatively compromised if images are too small for the computer to notice and process;
- can't be a duplicate. Some images are duplicated in the dataset, especially in the malignant category. Needs to make sure to only select one of the duplicates to avoid having the same image twice in our training set.

Therefore, to train the model to search for malignant and virtuous families to identify the symptoms of melanoma (with 2 classes), it was possible to form a collection of 13,121 images for training and 4,385 for testing.

During the experimental configuration of the system, it was found that the partitioning of the classification model on a sub-model with a small number of comparison classes gives a much greater validation accuracy of the model (Fig. 3, 4).

For the best experience, it is necessary to create a classification service class, which should contain references to prepared CoreML models (Fig. 5).

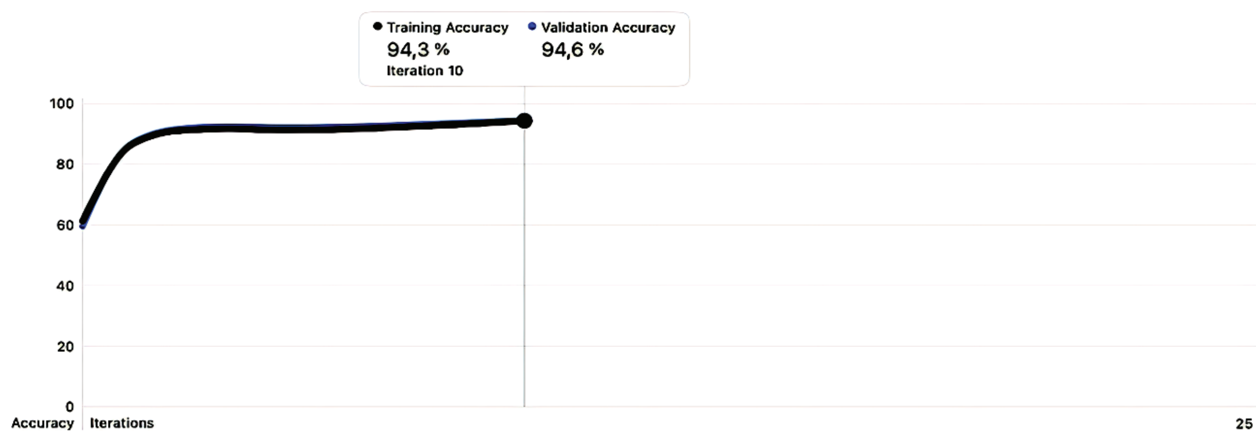

Fig. 3. Result of the training phase for Melanoma classification

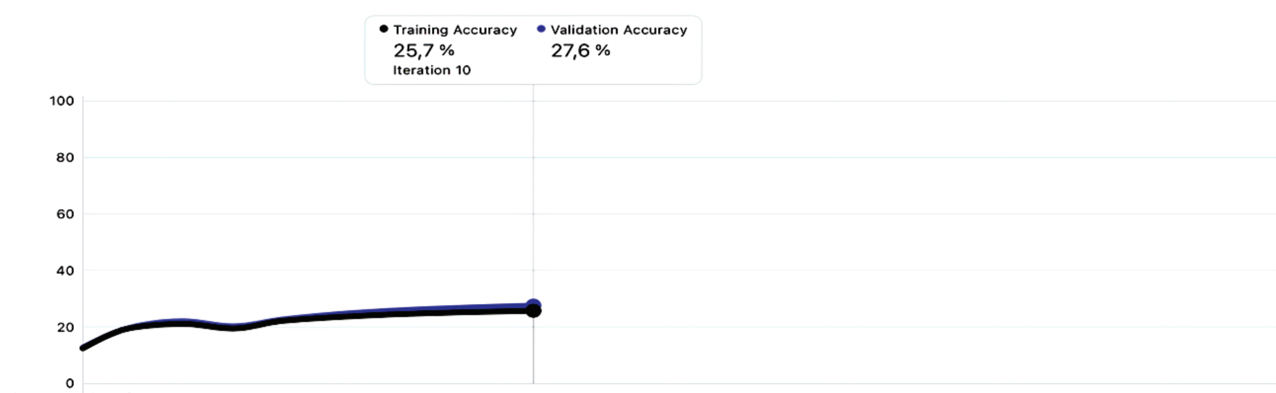

Fig. 4. Result of the training phase for 25 skin diseases classes

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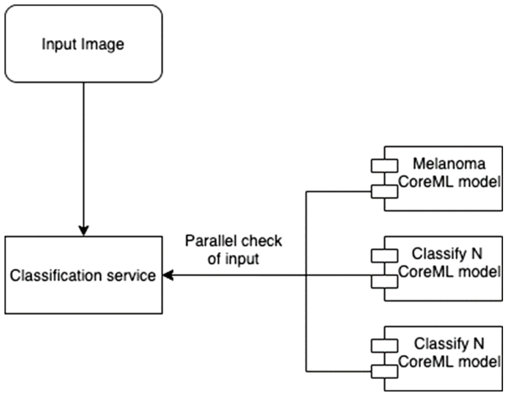

Fig. 5. Example classification service scheme

tion but also recommendations for prevention (generated on the basis of the analysis of its scans) or a referral to a doctor in case of need for expert evaluation.

Data analysis of scans includes utilities for filtering redundant information, normalization of data, their conversion. In particular, a useful method of statistical information processing is Dynamic Time Distortion (DTW), which finds optimal agreement between two times' series [8]. DTW is used as a metric to establish the similarity of two data streams in time-space.

Specifically, in the case of skin disease analysis, this method can be useful because we are dealing with consistent data – examinations and skin conditions that occur over time [9]. Application component's structure scheme is shown in Fig. 6.

3.4. Information system for diagnosing skin injuries and diseases as a mobile iOS application. For the full functioning of the mobile application, its main component was identified:

1. *Input/Output Controller*. Information input and output channel for the user. The main task is to provide the ability to send data to the system and accept the original data from it. For such tasks, view components are used to convey information to the user as efficiently and clearly as possible.

2. *Classification Service*. Service that includes classification models (trained CoreML models). The main task is to process and prepare the input data for processing by models and transfer the result to the notes service.

3. *Notes Service*. Service for storing and transmitting data in local storage [7]. The main task is to save and provide information on request to input/output controller.

4. *Recommendations Service*. Service that uses data from the local repository to generate prepared recommendations to the user in the detection of certain diseases.

The main task of the system is to enable the user to undergo a regular expert examination of their skin. After all, the condition of human skin often signals the presence of more complex diseases, not just cosmetic problems. Also, availability motivates the user to do such a rapid examination more often, because it will not need to see a doctor every time. And after receiving a basic analysis of suspicious areas, the user receives not only informa-

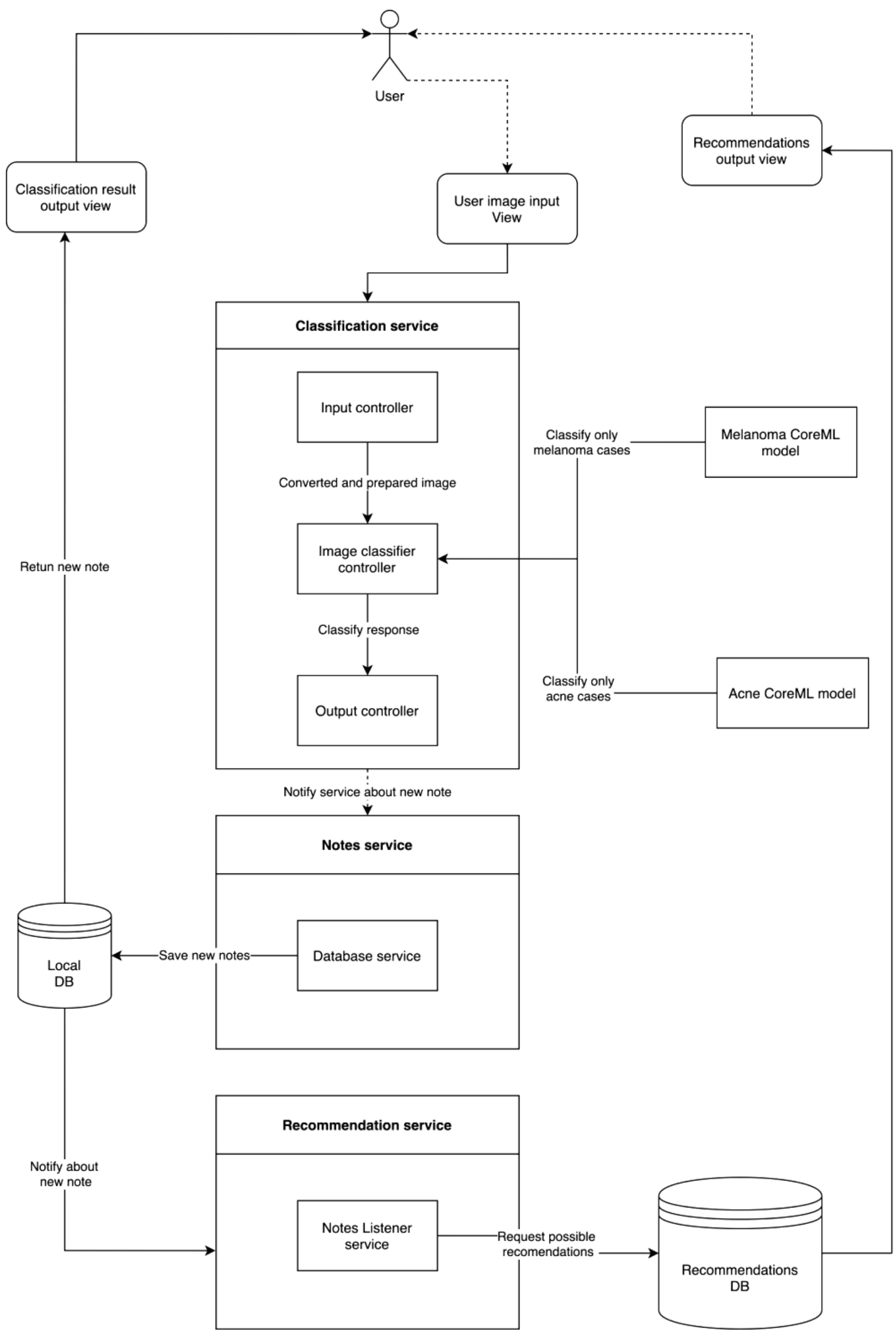

Fig. 6. Application components' structure scheme [10]

Also, based on the analysis of the skin, it is possible to identify the exact starting point of the disease and, if necessary, provide it to the doctor without relying on the short-term memory of the patient.

4. Conclusions

The article describes the approach to the design and implementation of a system for diagnosing skin diseases and injuries, and developed the principle of the system. System based on graphical information provided by the user about the condition of its skin or its individual elements. It analyses them and classify the system provides the user with information about the current condition of the skin and the symptoms of damage. Also system provides a list of preventive recommendations to maintain healthy skin and provides referrals to the hospital in case of need for expert examination by a doctor (for example, in the presence of malignant moles at risk of developing into melanoma).

The results of the implementation can provide users with the opportunity to monitor the condition of their skin more often, to receive recommendations for its preventive treatment. For private clinics, the implemented application can be not only one of the types of additional clients, but also a source of accurate information on the course of skin diseases.

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