Development of a web system for recognizing the images taken by UAV

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Abstract—**The paper focuses on development of a web system for recognizing the images taken by UAV. According to the concept, the development for such system includes three main steps: development of machine learning model, web system development and deployment. First step was taken from open-source ML model "EfficientNetB0". Web system developed using the Python library "Streamlit". For the last step deployment service "Heroku" was chosen. Basic requirements for the functionality, architecture and user interface of the web system developed in this project were formed.**

Keywords—Web system, Machine Learning, Web development, Heroku, Streamlit.

I. INTRODUCTION

Nowadays web applications are using for every sphere. It is one of the most popular and fast-growing branches in Ukraine IT cluster. In today's information society, the web system is an integral part in any field, it provides information support and functionality. With the help of web systems, such tasks as supporting the brand, providing information on the Internet, expanding the potential audience of readers, increasing popularity, informing the public and others are solved.

Especially today, the great interest of IT-engineer is using of Machine Learning (ML) in web development. At the same time, for creating the modern web applications its need to have front-end, back-end and DevOps teams [1].

On the other hand, increasing the using of unmanned aerial vehicles (UAVs) [2-3]. In addition, UAV, also known as a drone or a quadcopter, is a popular gadget in today's world that people actively use for aerial photography.

At the same time the problem of recognizing the images taken by UAV is very actual today [4-6]. The development of a web-based system for image recognition is relevant and necessary now, because there are having many opportunities to use this system. Such a web system, the main content of which is the recognition of uploaded images taken by UAVs, is called a personalized web system of various directions, which provides a set of services to its users. They are characterized by simple interfaces and a built-in image recognition system.

In this work for image recognition, it is proposed to use ML technology [7-8].

The purpose of the study is to focus on web programming with ML, which is using for development of a web application for recognizing the images taken by UAV.

II. STATE IF THE ART

Web design is one of the most important technologies for developing Internet resources. A good website that contains useful information is the best for promotion the brand and has convenient functionality.

The use of information systems at the moment is gaining more and more popularity. Every year, the volume of the latest technologies is only increasing. Accordingly, the number of users of information systems is also increasing [9]. The service market is represented by various information systems, and most often they are based on web technologies.

The implemented web application will be a one-page site (landing page), which is currently gaining the most popularity [10]. Thus, it is necessary using of Content Management System (CMS), which provides the opportunity to create page templates in manual or automatic mode. Let's consider the following most popular CMS for front-end development.

Joomla! [11] is a free CMS for the development of information portals, written with use of programming languages PHP and JavaScript. This CMS uses MySQL database management system (DBMS) or other standard industrial relational DBMS as database storage. It is built on a model-view-controller web application framework that can be used independently of the CMS that allows you to build powerful online applications. This software distributed under the GNU General Public License (GPL) [12].

WordPress is a site CMS with open-source code, which is written in PHP with use of MySQL as database server and released under the license GNU GPL version 2 [13]. This

management system was originally developed as a CMS for creating blogs, but over time the functionality has increased and allowing the system to acquire a tool for creating information resources and portals of any complexity. WordPress allows without difficult to extend the functionality of the system with the help of some ready-made modules, as well as yourself created extensions.

Drupal is open-source CMS uses as data storage relational database as MySQL or PostgreSQL and also is written in PHP [14]. Also, Drupal is the system with robust content management tools, sophisticated APIs for multichannel publishing, and a track record of continuous innovation. It is famous for its extensive and constantly improving functionality, since it is a web application framework. Drupal is free software licensed under the GNU GPL and developed by an international community of enthusiasts.

Django is a CMS that encourages rapid development and clean, pragmatic design and used by thousands of websites and organizations [15]. Django was designed to help developers take applications from concept to completion as quickly as possible. Django takes security seriously and helps developers avoid many common security mistakes. It is a powerful framework created using the Python language [16-17], which is a high-level and object-oriented programming language.

Streamlit library is CMS with an open-source app framework for Machine Learning and Data Science teams. It is also written in Python and allows creating pages using library components (for example, input, button, etc.) [18]. So, this CSM was chosen for developing the web application because it has deal with ML.

There are also many different technologies for creating the back-end part. Let's consider some of them.

Node.js is an open-source, cross-platform JavaScript runtime environment [19]. It is designed to build scalable network applications. It can handle many connections simultaneously. Almost none of the functions in Node.js work directly with I/O, so the process never blocks. Because nothing is blocked on Node.js, it is easy to develop scalable systems.

DigitalOcean is an American provider of cloud infrastructures, headquartered in New York and with data centers around the world [20]. DigitalOcean has the cloud computing services, with predictable pricing, robust documentation.

Amazon Web Services (AWS) also provides a cloud computing platform for rent to individuals, businesses, and governments on a subscription basis [21]. The technology of AWS virtual machines allows subscribers to have at their disposal a full-fledged virtual cluster of computers, which is always available via the Internet.

Google Cloud Platform is a set of cloud services that run on the same infrastructure that Google uses for its consumer products [22]. Google Cloud Platform provides infrastructure-as-a-service (IaaS) and serverless computing environments.

Heroku is a cloud platform-as-a-service (PaaS) platform that supports a number of programming languages. Heroku is owned by Salesforce [23]. Heroku is one of the first cloud platforms and initially only supported the Ruby programming language, but now the list of supported languages also includes many others like Python and PHP. Heroku servers use Debian or Ubuntu (which is also based on Debian) operating systems.

Heroku has features for a developer to build, run and scale applications in a similar manner across most languages. Applications that are run on Heroku typically have a unique domain used to route HTTP requests to the correct application container or *dyno* [24]. Each of the dynos are spread across a "dyno grid" which consists of several servers. All Heroku services are hosted on Amazon Elastic Compute Cloud (Amazon's EC2) cloud-computing platform [25].

Heroku provides services and tools for building, running, and scaling web applications. So, this technology was chosen for creating the back-end part.

On the basis of the general architecture of the web applications creation, after conducting an analysis of existing developments, creating a comparative characteristic and considering possible problems, it is possible to formulate a list of requirements for the web application to be developed.

It is necessary to create a web application designed to access a service that recognizes images taken by a UAV, which is like a one-page website.

For the user, the program should perform the following functions:

a) uploading a picture;

b) image recognition;

c) output of the image recognition result.

After considering technologies for front-end and back-end parts, it was decided that Python must be used as the programming language for program development.

III. MACHINE LEARNING IN WEB DEVELOPMENT

Machine learning (ML) plays one of the key roles when it needs to find a new approach to solving old problems in the constant progress of technology.

The impact of ML is huge for almost all areas of human activity and the purpose of using ML products is to improve the productivity of work processes [7-8]. Also, it is solving tasks that require a great deal of mental and intellectual effort from developers and discovery of solutions for problems impossible to perform under certain existing conditions.

Web development has an opportunity to progress with use of ML capabilities in projects. From analyzing information more accurately and correctly to increasing development capabilities, because ML has the ability to organize processes much more easily and productively [26].

There are many technologies based on ML. One of them is the technology of EfficientNet, that was first introduced by Tan and Le in 2019, and it is among the most efficient models that reaches accuracy on image classification transfer learning tasks [27].

EfficientNet provides a family of models (B0 to B7) that represents a good combination of efficiency and accuracy on a variety of scales. Such a scaling heuristic allows the efficiency-oriented base model (B0) to surpass models at every scale, while avoiding extensive grid-search of hyperparameters.

As a result, the depth, width and resolution of each variant of the EfficientNet models are hand-picked and proven to produce good results, though they may be significantly off from the compound scaling formula [28].

The first step in the development of any software is the development of its architecture (Fig. 1). In software development terminology, the term "architecture" has a very vague meaning. In general, this term is close to the term "design" when talking about structural design rather than code design. If it is generalized, then the following stages should be understood under this term [29]:

– division of the future software into minimal structural elements necessary for its implementation;

– sequential unification of defined structural elements into logical groups until a single integrated system is obtained;

– description of data structures that will be used for interaction between structural elements or their groups;

– description of connections between structural elements or their groups, it means directions of data flows between elements and their content;

– a description of the rules and restrictions that should be followed when writing the code and when deploying the finished application.

Additionally, having expanded the concept of architecture before the start of development, it can be added as a last point the selection for each structural element or their logical group of the corresponding software technology, or the decision on the need for own implementation of such technology within the framework of the software being developed.

When developing a web application, the main attention is paid to the design of the web resource. At the first stage of information design, an internal structure is created, taking into account the fact that future users have the opportunity to simply navigate the presented resource.

The web design process usually consists of three parts:

– development of the resource concept, where the main ideas are put forward, as well as an analysis aimed at identifying the needs of end users;

– logical design, where a scenario of future work is formed, probable portal pages and hypertext links between them are described and methods of enlivening pages with the introduction of multimedia are considered;

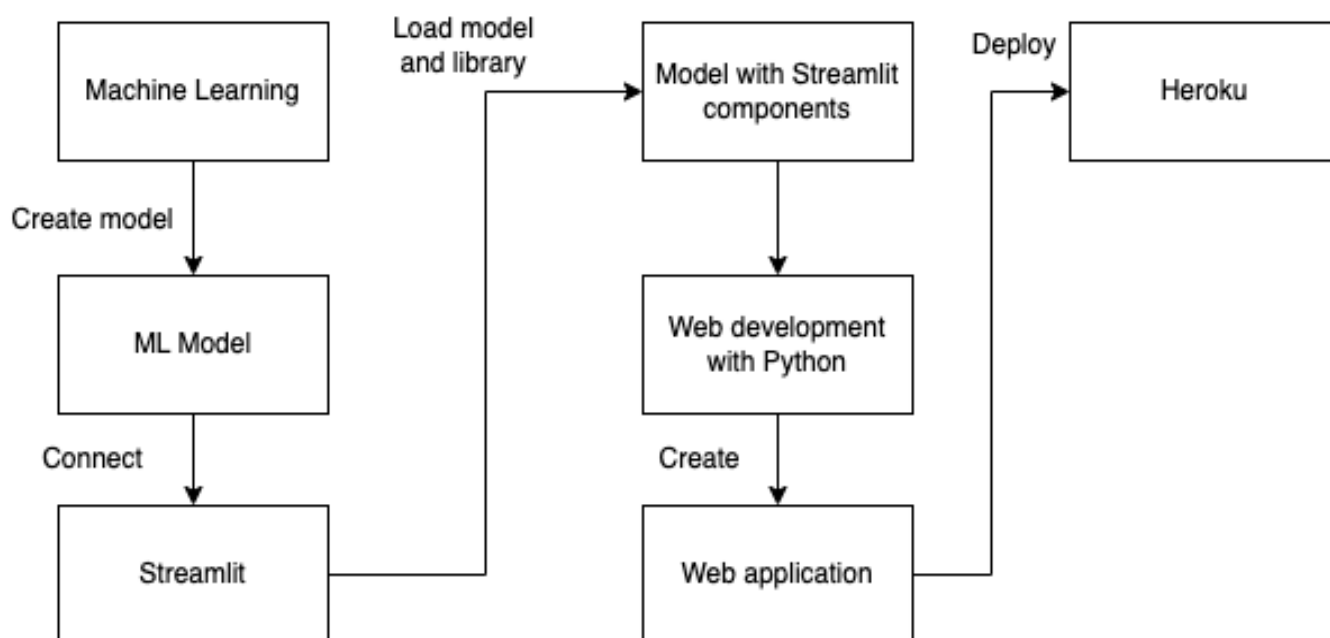– physical design, direct web application creation.

Fig. 1. Web system architecture

To create web system with spoken above technologies such as Python as programming language and Heroku as deployment platform it need to start from development.

The client part was implemented as a single-page web application using the Streamlit library. It has all general web components that can be presented on the web application. In our case it has to display header with title, button for uploading image, field for displaying image, button for recognizing image and field for displaying the result.

For the web application developed within the framework of this project, it was decided to combine several architectural styles that harmoniously complement each other.

The full concept of a web application means that the service will be based on a client-server architecture, to work on the Internet. The server part was implemented using the service-oriented architecture. The main service was the server software that represented by the Heroku hardware platform. This service is responsible for delivering client-side software

code to browsers in response to client requests for the Internet address that the web application have.

The web application was designed in such a way that the application works correctly under various operating systems (Linux, Windows, iOS) and in various browsers (Edge, Google Chrome, Mozilla Firefox, Safari).

When developing the web application, was decided that mostly neutral and contrasting color solutions should be used. The basic design of the web application should be developed in a rather neutral way. There should not be a large amount of text information on the page. The web application design should not include: banners; a large amount of text is merged; too dark, too light and aggressive color combinations or graphic solutions.

Web system development lifecycle (Fig. 2) includes the following steps: the system booted up -> opened the main page -> uploaded a picture -> delete picture it or recognize it -> output the result.
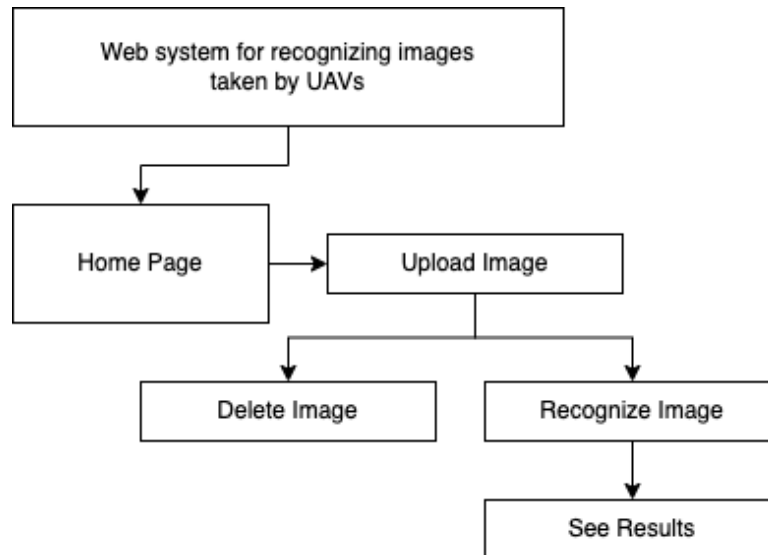
Fig. 2. User actions of developed web system

It means, when the main pages are loaded, the user has the option of uploading pictures, the next step can be two actions:
1) types of pictures
2) recognize the picture

If user select deleting the picture, then the user can upload another picture. After the image is recognized, the user can view the recognition result. A similar process is available on the mobile version of the application.

According to the conditions, web application was designed as landing page. It includes all the main structural elements that are used to download and recognize images taken by UAV (Fig. 3).

Web application development includes the process of creating a web page layout, on which all other elements will be strung later. The composition includes main content – the central area where the content is placed.
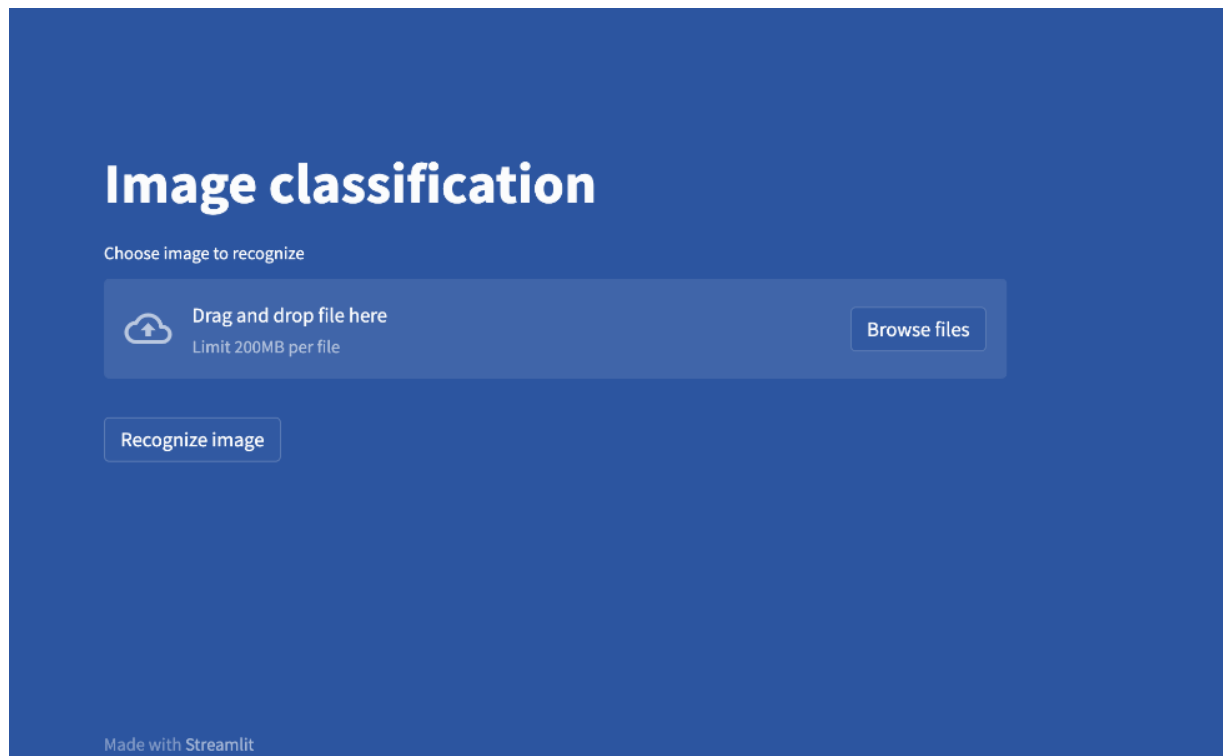

Fig. 3. Interface of web application

At the same time, the so-called structural blocks of the web application are formed – separate modules, each of which plays a certain role and is responsible for a certain functionality of the resource.

After developed such a system it has to deploy it on Heroku, because it contains GitHub integration [30]. That's why it is easy to connect GitHub account to Heroku account and choose GitHub repository in Heroku and deploy it. But before deploy it should be created configuration file – Procfile that tells Heroku out deployment settings.

When deployment is successful it can go to link for web application, and it can begin recognizing the images taken by UAV by opening the main pages and the user has the option of uploading pictures.

V. CONCLUSIONS

In this work, all the software tools that will be used during the development of the web application, which is the main goal of this project, were selected and described.

All selected technologies are free and open-source software. They make it possible, if necessary, to make changes to the software code of the tools themselves to adjust them for the development of a specific project. The chosen stack of technologies allowed to quickly and qualitatively develop a web application, namely, an analysis of front-end frameworks was also carried out and the Streamlit library was selected, as well as all the modules that can be added to the development of the front-end application to make a unique and modern web application. Also, the analysis of the back-end was carried out, and the technology Heroku was chosen.

This project, namely the web application, was designed and developed for recognizing images taken by UAVs on the Internet. This system allows the user to conveniently view the collected information.

Basic requirements for the functionality, architecture, and user interface of the web application developed in this project were formed.

Also, this project can be used as an additional middleware step in ML recognizing images to allow users to check result correctness.

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