Drone Monitoring System DROMOS of Urban Environmental Dynamics

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Abstract. The project aim is the improvement of city management efficiency based on development of decision-making support systems according to the results of monitoring and analysis of urban environment parameters. In order to achieve the research aim will be developed technologies and methods for collecting, accumulation and presentation of urban environment parameters. Developed concept of visualization and methods for analysis of parameter's dynamics from drones sensors.

Keywords. Green Smart Cities, Infocommunication, Computer Science, Sustainable Urban Development, Secure Society.

1. Introduction

The goal of the project is to increase the efficiency of city management based on the development of systems to support decision-making on the results of monitoring and analysis of the parameters of the urban environment in Lviv. Implementation of the project will improve the quality of life of the population and ensure the sustainable development of cities [1-6]. Tasks that are to be solved in the project: development of the configuration of drones and a set of equipment for them in order to monitor a set of parameters of the urban environment (temperature, humidity, noise pollution, level of oxygen, carbon dioxide and carbon monoxide, greening); development of the intellectual algorithm for forming the route of the drones movement in the city area; de-

velopment of methods for automatic verification of cadastral maps; development of methods of complex analysis of accumulated data and their visualization. The development and implementation of these technologies will allow to assess the ecological status of the city, to identify problem areas, to form the basis for supporting decision-making in relation to city development, etc. [7-14]. Developed technologies can be scaled up and spread to other cities and countries.

2. Detailed Description of the Project

The technologies and tools that will improve the quality and the level of monitoring of urban changes and environmental characteristics through the analysis of data of mobile video cameras and sensors are to be developed [15-20]. The data will be transmitted by drones to formulate proposals for solving local problems, in particular, reducing air pollution, verification of cadastral maps, greening local territories, etc. For qualitative monitoring of urban changes, it is proposed:

- Use of drones as agents and collectors of relevant information with the ability to intelligently manage their route of movement;
- Formation and use of a set of modern sensors that allow to obtain the values of certain parameters of the urban environment in space (at specified areas of the city, at different heights) and time with geo-referencing. The sensors provide monitoring of the following parameters: ambient temperature, humidity, oxygen level, carbon dioxide, noise, illumination in the dark and, if necessary, other parameters;
- Development of methods for analysis of the quality of greening of local city areas on the basis of received photo and video images in combination with other characteristics of the urban environment (temperature, humidity, oxygen level, carbon dioxide) for decision making in order to improve the condition of greening;
- Development of methods of automated verification of cadastral maps of the city using photos and video taken with the help of a drone;
- Creation of methods for analyzing the results of monitoring of urban parameters and their visualization with the providing of access to local government and inhabitants. Development of the existing city geoportal by adding it to the new information layers according to the results of urban parameters monitoring;
- Application of Machine Learning methods to study the system of analysis of the results of monitoring in order to develop solutions and measures for adjusting the parameters of the urban environment and forecasting the dynamics of changes in urban characteristics.

3. The Project Features

The project implementation is based on innovative, advanced science methods and modern technologies for monitoring urban changes. The training of the system is based on the analysis of pre-assembled data from different types of sensors and cam-

corders. At the beginning, the drones are given several routes that cover the entire metropolis at different periods of the day. The routes with each subsequent departure are automatically adjusted according to priority and taking into account the routes of other drones (to exclude duplication of site monitoring).

The moderators initially set the conditions, characteristics and indicators, which determine the priority areas of the study (based on expert assessments). The structure of the monitoring system for urban parameters is presented in Fig. 1 [1-14].

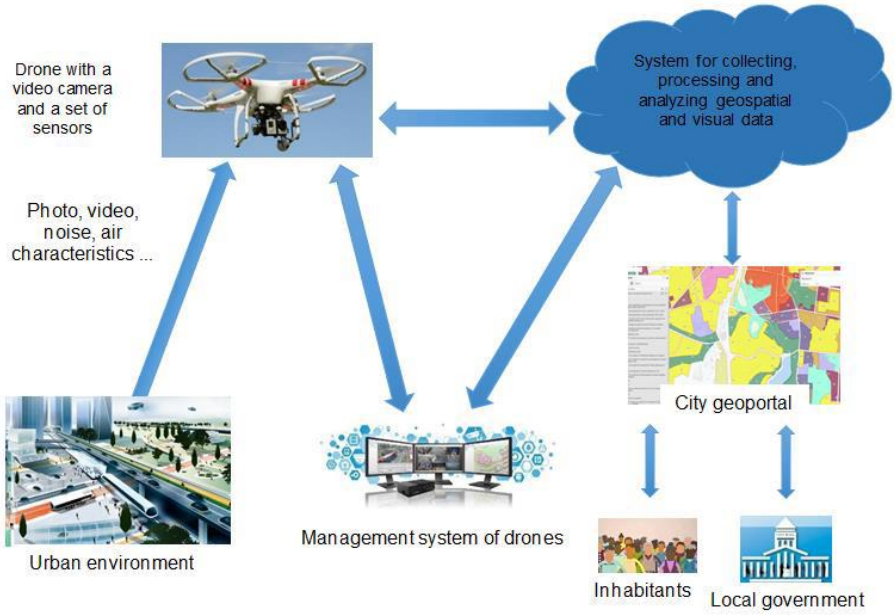

Fig. 1. The structure of the monitoring system of urban characteristics

On the basis of analysis of a data set over a long period of time and using self-learning algorithms, the priority of monitoring tasks for a drone is automatically determined. The accumulated data are analyzed, summarized, integrated and visualized with an overlay on the electronic map of the city's geoportal (Fig. 2). The participation of a person in this process is minimized. There is a constant exchange of information between similar systems of different metropolises to ensure the quality of training systems and to improve the algorithms of analysis and forecasting.

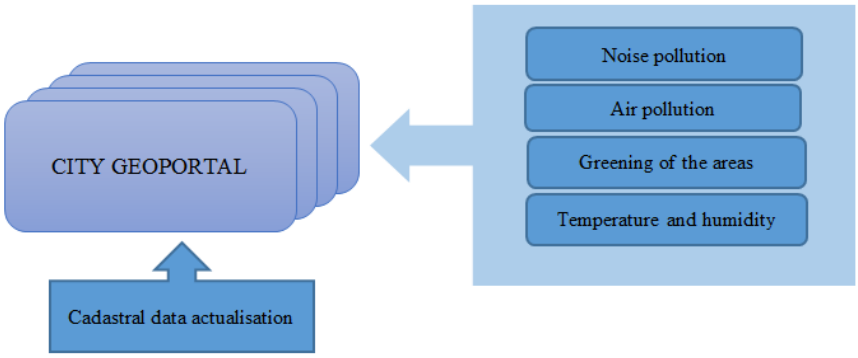

Fig. 2. Supplementing the city's geoportal

The accumulated over a long period of time statistics will make it possible to adjust the rules of learning the system of drones management, and the exchange of accumulated data between metropolises will allow comparative analysis of urban changes and interdependence of monitored characteristics for short-term and long-term prediction of the development of the situation and the development of adequate solutions for the management of urban parameters (Fig. 3). The accumulated statistical data on the results of monitoring of the urban environment will be the basis for analysis of the state of the environment and the development of managerial decisions on the impact of local government.

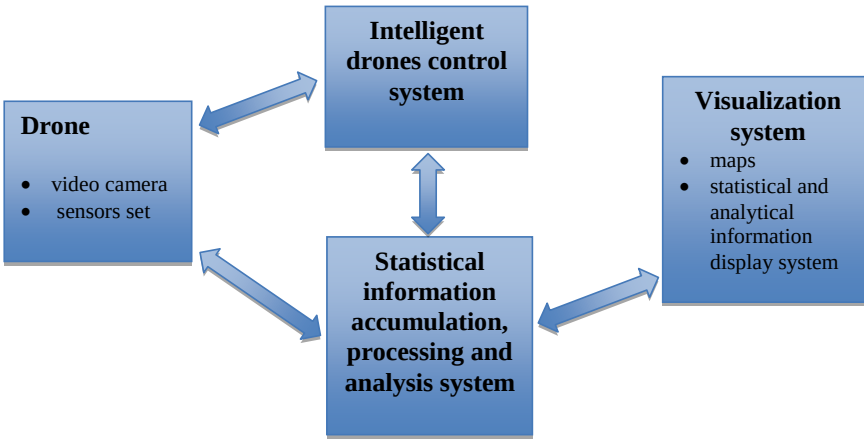

Fig. 3. Urban characteristics monitoring process DROMOS

To conduct a research within the project framework the use of following ***equipment*** is envisaged: a copter-type drone with a payload of at least 1 kg, wind resistance of up to 15 m/s with an on-board camera and an image stabilization system; temperature sensors, humidity, oxygen, carbon dioxide; noise meter; a set of microcontrollers. In order to save money it is planned to rent the equipment.

4. Results Expected to be Achieved

Implementation of the project will have a comprehensive impact on the city's social environment, will provide the basis for a qualitatively new level of management of the urban environment, will improve the control and understanding of the state of the ecological situation in cities to develop solutions for its improvement, which will increase the quality of life, reduce the impact of negative factors on human's health, will enhance the attractiveness of the city for people and increase investments, will ensure the sustainable development of the city. Scientific and technical significance of expected results:

- Development of the intelligent algorithm for formation of drones' routes for monitoring of urban characteristics;
- Developed methods for analyzing the accumulated data of monitoring results of urban parameters and their visualization;
- Development of the methodology for the verification of cadastral maps based on photos and video taken by drones.

The main ***practical results of the project are***:

- Requirements for the technical drones characteristics for use in monitoring tasks of urban parameters;
- Requirements for configuration of sensors for monitoring of urban parameters;
- Development of the existing city's geoportal by adding it with new layers reflecting the results of monitoring;
- Creation of an information base to support decision-making by the local government on city management in the context of improving the environmental situation;
- Quality improvement of the urban environment, improving the quality of life and ensuring sustainable urban development;
- Establishing scientific and technical cooperation between scientists of partner institutions within the framework of the project.

Project results will be available for educational, scientific and socio-environmental institutions and partly for security purposes, open to ordinary residents. According to the results of the project, scientific reports, articles in scientific publications and reports at scientific and practical conferences will be prepared. The project envisages the development of all technologies, considering the possibility of their distribution and application in different cities of Ukraine and Germany, as well as other countries, in particular the EU.

The ***expected economic impact*** of the project in the short term is cost savings through the use of cheaper and more effective monitoring technology of the city drones compared to the use of aircraft and helicopters. In the long run it is the formation of a favorable urban environment and the enhancing attractiveness of the city, which leads to the attraction of investments.

Prospects for project development. The received results of the project, developed technologies and algorithms will provide the opportunity for further research in following directions:

- Methods development for monitoring urban characteristics by a network (swarm) of drones with information analysis and display in real (near) time;
- Development of methods and means of trees monitoring in all types of green spaces (parks, street and courtyard greens, etc.) taking into account the species composition, age, condition, etc.);
- Identification of tree species that die due to climate change; formation of a program of strategic development and replacement of the species composition of greenery in cities;
- Creation of technologies for monitoring and analysis of existing housing development (density, quality, number of inhabitants, demographic composition and availability of necessary elements for the proper functioning of housing such as schools, kindergartens, libraries, shops, pharmacies, polyclinics, etc.);
- Identification of thermal anomalies in urban areas;
- Development of 3d maps for the city's geoportal to help special services of the city (rescue, police, emergency services, etc.) and service providers to solve the problems that arise.

5. Objectives of this Project

The goal of project is to develop technologies and set up a monitoring network for a number of urban parameters based on infocommunication, such as emissions of harmful substances into the air, light levels, traffic intensity, etc., dynamics of their changes and interdependencies over a wide range of sampling times, video monitoring and monitoring tools, placed on drones moving along predetermined trajectories (routes) for operational analysis and solving of such local urbanistic tasks as control of smoke, dust and gas It is important to emphasize the importance of reducing emissions, traffic management, operational detection and localization of emergencies, the state and dynamics of greening of densely populated territories, etc.

Objectives:

- Data collection using mobile sensors and video cameras and analysis of the level of harmful emissions into the atmosphere. The task is to monitor the level of harmful emissions in the city by mobile sensors and video cameras (heat cameras, night vision cameras, infrared cameras, etc.) on drones, as fixed sensors do not provide coverage of the whole area, monitoring at different altitudes and dynamics of changes in space. Analysis of the temporal and spatial distribution of statistics enables the analysis and forecasting of changes in the level of harmful emissions into the atmosphere, depending on the time of day, day of the week or time of year. A system based on artificial intelligence and self-study methods should establish rules for monitoring harmful emissions into the atmosphere and provide a basis for making appropriate proposals for the identification of hazardous locations on various grounds (e.g. emissions from vehicles and their concen-

tration in horizontal and vertical planes, emissions on the busiest streets , emissions from industrial enterprises and various industries in the territories of settlements, evaporation from fuel, which create dangerous situations at the stations oil etc.).

- Optimization of drone routes taking into account pre-collected statistics with localization of zones and their classification by urgency of analysis. The task is to analyze the previous routes of drones with the localization of problem areas with pollution, without proper illumination and during certain periods of traffic jams to allow automatic forecasting of subsequent routes, taking into account the priority of the territory for research and information gathering. Using artificial intelligence methods, the system learns to adjust routes depending on the time of year, time of day and priority of study areas and research problems, such as emergencies, fires, harmful emissions, light quality or traffic jams.
- Separation of emissions from transport, industrial and other sources. Depending on the types of sensors and camcorders installed, the system identifies different types of hazardous atmospheric emissions, taking into account the approach to the hazardous concentration level (concentration level in the air, forecasting the direction of distribution, for example, in kindergartens, schools, residential or non-residential buildings, etc.).
- Formation of proposals for greening of localized territories in accordance with the results of the monitoring of emissions monitoring, areas promising for landscaping (roofs of buildings, expansion of park territory, change of existing trees to more adapted ones, etc.). Not only the data collected to locate areas for exceeding or approaching critical pollution levels, but also to analyze the areas where there are spaces and opportunities for necessary landscaping, such as the availability of roofs for houses to accommodate minisads (roof form, lack of technical or other add-ons, etc.).
- Monitoring the illumination of streets and territories in the dark, as one way of reducing the crime situation. The task is to analyze the quality of illumination of territorial zones, where most often in the dark period of time there are accidents, criminal offenses, accidents with people, etc. with the formation of recommendations for increasing / decreasing the illumination, the time of switching on / off illumination.
- Use of drones for preliminary assessment of emergency. When receiving a call to the number of fire service and rescue personnel (for example, in Ukraine - 112, in the USA and South Korea - 911, in the countries of the European Union - 112), a drone is sent to assess the situation at the national emergency until the moment of departure / during the departure of equipment, estimated : driving route, possibility of driving on the proposed calculated route, type and scales of the National Assembly for optimal choice of equipment (by quantity and type).
- The use of mobile camcorders to monitor the situation on the roads. It is monitoring the situation (identifying traffic violations and obstacles that can lead to a reduction in road capacity) and traffic intensities to predict traffic jams and develop recommendations for traffic management.
- Training of the system by artificial intelligence methods based on collected preliminary data for the possibility of autonomous monitoring of the calculated route of movement of special equipment to the emergency site and monitoring of

the emergency site itself to determine the optimal composition (type and quantity) of special equipment of special services (fire and rescue service, police, ambulance, gas services, etc.). Every inhabitant of any metropolis is interested in providing quality living conditions, especially for children. This encourages the development of systems for environmental monitoring and the development of measures to respond to environmental changes. Stationary encoder systems and pass-by-hazard messages are currently insufficient and do not provide the requirements for the speed and efficiency of response to changes in the situation. In addition, at the present time, there are no systems in place to anticipate the occurrence of threats in certain areas. The collection and accumulation of statistics, their rapid processing using modern technologies and methods of artificial intelligence will facilitate decision-making and develop measures to improve living conditions in metropolitan areas.

One of the goals of the project is to ensure access of metropolitan residents to the results of monitoring urban changes and environmental conditions in metropolitan areas (indicators of pollution, greening, living safety, etc.) through information communication through a specially created information resource with forecasting elements. In order to collect data for effective training of artificial intelligence systems, large-scale and comprehensive monitoring of urban changes and environmental parameters of not only one city but also different cities with different conditions in different countries is required.

6. Stage Plan of Works

Project tasks duration and common meetings are presented by the Gantt diagram on Fig. 4. The main stages of the project:

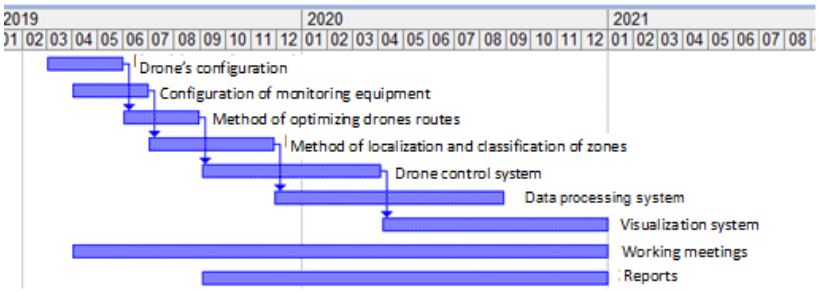

Fig. 4. Gantt diagram of the main stages of the project DROMOS

WP.1. Drone configuration. WP 1 is designed to develop requirements for the drone configuration to implement the basic stages of the collection of operational information within the proposed project.
T.1.1. Conduct joint research on the use of drones in the urban environment and determine the requirements for their configuration.

T.1.2. Conduct research on the drones setting according to the developed requirements for the implementation of the proposed project.
T.1.3. Drones testing
T.1.4. Data analysis
T.1.5. Modification of requirements for the drones configuration according to the received data.

WP.2. Configuration of monitoring equipment. The purpose of the stage is to develop requirements for the configuration of equipment for monitoring urban characteristics

T.1.1. Analysis and selection of equipment for monitoring using drones and requirements for their configuration.
T.1.2. Development of requirements for the installation of monitoring equipment.
T.1.3. Testing equipment.
T.1.4. Requirements Modification for the configuration of equipment according to the received data.

WP.3. Method of optimizing drones routes. The purpose of the stage is to develop a method for optimizing the drones route taking into account the preliminary collected statistical data

T.3.1. Development of the algorithms for the optimization of drones' routes
T.3.2. Implementation of the method of optimizing drones routes in the form of a program module.
T.3.3. Testing this software module.

WP.4. Method of localization and classification of zones. The purpose of the stage is to develop a method for localization of zones, taking into account preliminary collected statistical data, and its classification by urgency of analysis and development of the method of cadastral maps verification.

T.4.1. Development of the algorithms for localization and classification of zones
T.4.2. Cadastral maps verification method development.
T.4.3. Development of methods for analyzing the results of monitoring of urban characteristics and their visualization with the provision of access to city authorities and residents

WP.5. Intelligent drone control system. The goal of the stage is to develop the structure of the intelligent system of operational control of drones based on the methods of Machine Learning.

T.5.1. The drones control system structure development.
T.5.2. The simulation model development for the system.
T.5.3. Making corrections according to the received data
T.5.4. Improvement of algorithms of automatic correction of drones routes according to priority and taking into account the routes of other drones.

WP.6. Accumulation, processing and information analysis system. The purpose of the stage is to develop the structure and algorithms of the system of accumulation, processing and analysis of information for increasing the efficiency of collecting the necessary data and identifying critical zones of urban characteristics.

T.6.1. The system structure and algorithms Development for information accumulation, processing and analysis
T.6.2. Analysis of accumulated data using mobile sensors and video cameras and analysis of the level of harmful emissions into the atmosphere.

T.6.3. Scientific articles preparation based on research results.

WP.7. Visualization system. The purpose of the stage is to develop the structure and algorithms of the visualization system for the mapping of received operational data on urban changes and cadastral map verification results on the city electronic map.

T.7.1. Development of the structure and algorithms of the visualization system operation.

T.7.2. Analysis of the visualization system.

WP.8. Collaborative Workshops. The purpose of the stage is to organize the collaboration between the project participants for planning and step-by-step implementation of the work and project phases.

T.8.1. Research and analysis of methods for classification of emissions from stationary and mobile sources.

T.8.2. Proposal sketches development for the upcoming calls in the framework of such Programmes as Horizon 2020 etc.

T.8.3. Discussions on the methods of presenting the collected urban information for their further elaboration.

T.8.4. Planning the monitoring of illumination of streets and areas in the dark time, as one of the ways of crime prevention.

T.8.5. Discussion of implementation of the module of training system using methods of artificial intelligence on the basis of collected preliminary data; preparation of common publications.

WP.9. Project Management. The WP is responsible for the activities related to the coordination of the project; it includes the technical, administrative, financial, and legal management of the project. The objective of WP9 Project Management is to ensure an effective management of Project: day-to-day administration, project coordination and monitoring of the work in progress.

T.9.1. Overall Project Management.

T.9.2. Project Coordination.

T.9.3. Internal communication, collaboration, and learning.

WP.10. The Dissemination and Communication. Throughout the life cycle of the project this work package will focus on dissemination (aiming at disseminating the project results and achieving the highest possible impact) and communication (aiming at visibility of the project and its results).

T.10.1. Project Web page and awareness raising.

T.10.2. Dissemination of project results.

Collaborative work will be organized by periodical personal Skype conferences and teachers and students' exchange. Conferences will be held on a monthly basis. They will allow to plan and perform step-by-step work. Introductory meetings will be open to other members of the laboratories and institutions involved in the project.

Table 1. Relation to the work programme DROMOS

No	Work programme thesis	Realization
1	The purpose of this action is to support a number of activities that will improve the quality and improve the monitoring of urban	We propose to set up a virtual research laboratory (as an integral part of the overall Smart City system) to monitor urban changes through the use of appropriate drones and an intelligent system for analyzing the statistics collected. In addition, the system should formulate proposals to support decision-making to mitigate or correct negative

No	Work programme thesis	Realization
	and environmental changes such as atmospheric pollution, light levels, traffic intensity, etc. by analyzing data from mobile camcorders and drone sensors to formulate supply proposals local tasks, such as landscaping local areas, traffic regulation, national identification, and more.	urban changes. Existing monitoring systems typically use stationary sensors or camcorders that provide control only in certain areas and do not show the full scale of urban changes in metropolitan areas. This does not reflect the real state of the environment (emissions from stationary and mobile sites, poorly lit areas, lack of landscaping in large metropolitan areas, etc.). A system must be developed to identify and analyze problems, each characterized by its own characteristics and conditions - harmful emissions from fixed and mobile objects, the level of illumination of territories and the identification of emergencies. An additional task is to develop recommendations for planning police patrol routes based on the information collected by the drones about illumination and criminogenic situation in specific territories. It is proposed to develop the system by introducing innovative approaches that will allow the system to learn from previously collected data with the ability to adjust routes and select priority territorial areas and tasks for the study. For example, if a drone in a particular area and at a certain point in time collects contamination data and at this time receives an emergency signal, it must switch to traffic analysis and route estimation of special machinery traffic to the emergency site, preliminary emergency assessment to determine the type and the required amount of special equipment. Thus, time is saved for correcting the actions of the employees of the NA, preliminary determination of the number of participants and equipment, which will improve the effectiveness of the liquidation of the NA. After the data has been collected and transmitted to specialized services, the drone must return to its previous task if it had the resources left, or return to the base. Collected over a long period of time, statistics will allow you to adjust the rules for training such intellectual drones. The exchange of accumulated data between metropolitan areas will significantly improve the training of drones (in different metropolitan areas the frequency of events of different types may differ, but the training of drones on different datasets will result in a uniform distribution of experience). In this case, drone training will increase the efficiency of collecting the necessary data and identifying emergencies in the face of rapid urban changes. After the stage of monitoring urban changes, their identification, classification and prioritization are important. This should be done automatically or, in the absence of sufficient data, semi-automatically with a team of analysts, experts and moderators of the training rules of the monitoring system.
2	These proposals will focus on innovative, cutting-edge science methods and current technologies for monitoring urban change.	System training is organized as an analysis of pre-collected data from different types of sensors and camcorders. In the beginning, drones are given several routes that cover the entire metropolis at different times of the day. Routes with each subsequent departure are automatically adjusted by priority and taking into account the routes of other drones (to avoid duplication of site monitoring). Moderators initially set out the conditions, characteristics and indicators that determine the priority of study areas (based on expert judgment). With a large data set, the drone automatically determines the priority of such tasks. Human involvement in this process is minimized. We propose to establish a constant exchange of information not only between drones, but also between systems of different metropolitan areas, in order to ensure continuous training of systems.
3	These proposals should also foster a stable and integrated interaction	Our urban change monitoring and research lab can be used by colleges, universities, rescue services, urban landscaping services, environmental services and innovation firms. It will also be interesting for it

No	Work programme thesis	Realization
	between the various levels of the urban change monitoring system, research institutions, experts in these fields and other institutions, industry organizations and non-governmental organizations.	companies to test relevant encoders, camcorders, software and identify further development paths. Defining a strategy for monitoring urban change will increase the interest of the average citizen in tracking the ecological changes of their city, making proposals for the analysis of certain territories, and proposing to analyze certain areas of urban changes that are not foreseen by the current capabilities of the system. In order to do this, it is important to maintain a constant feedback link between urban and metro drones received and analyzed from metropolitan drones and metropolitan residents, environmental institutions, educational institutions, relevant control services and special services. If the latter need to communicate directly with residents, it is advisable to use a web-based information resource where they can track the dynamics of emissions in certain areas of their metropolis, levels of illumination, availability of emergencies, etc., the current situation and in retrospect, as well as forecasts . You can also make suggestions for analyzing specific metrics of a given metropolitan area, make suggestions for analyzing parameters that have not yet been analyzed, report nas and other events, and more. The relevant module of our information resource should monitor query statistics to determine the accuracy of the information. The development of joint commercial projects in the public sector and in industry will enhance the motivation to monitor urban changes and effectively address the social and environmental problems of a particular metropolitan society as a whole.
4	This will increase the number of researchers and innovators, including women, in monitoring urban change that can better address the environmental and social problems of society. As a consequence, in the long term, this action will help to achieve the goal of sustainable urban development by improving the monitoring of urban change with the prospect of expanding across the European area and all World and increasing the range of socially valuable innovative products.	We propose to build a network of urban change monitoring systems using drones, where teams will be created with the appropriate equipment to undertake joint socio-environmental projects or to participate in environmental analysis projects. Each team should include experts in various fields of ecology and sociology, information technology and computer engineering, emergency and forensic science and more. In addition, both women and men must be represented in each industry. This will help generate more ideas for analyzing and monitoring urban change, since it is known that looking at the problem from different angles causes the birth of new innovative ideas to solve the problems posed by research projects. Each team writes its own logic (method or algorithm) to analyze urban changes. In the next stage, the proposals received are analyzed and the points of contact are sought and priority of the monitoring tasks is formed. After that, we suggest collecting statistics over a period of time from different metropolitan areas and from different countries to collect and analyze with appropriate teams to improve and modify the system's learning rules. Without the appropriate teams from the listed industries, this cannot be done quickly and efficiently.

That’s why our proposal is related to work program DROMOS in such issues:

- DROMOS will focus on innovative technological process of monitoring and analysis of urban changes, with the possibility of forming proposals for improvement of analysis indicators, drones routes, rules of data exchange between drones and systems from other metropolitan areas, rules of training of the system of monitoring results monitoring and more. Provide specific solutions for Smart City.
- We will use international exchange of monitoring results and work in international teams to formulate new requirements for monitoring urban change, using

innovative methods and technologies, advice and ideas from stakeholders and relevant institutions.

- Our Virtual Research Laboratory for Urban Change Monitoring will be created to develop new methods, approaches and algorithms to improve social and environmental living conditions in metropolitan areas. In addition, we plan to provide feedback to residents of these metropolitan areas. It stimulates their interest and involvement in solving their socio-ecological problems and their home town's tasks and will offer long-term prospects for improving socio-ecological living conditions not only in these territories but also in the country and in the EU as a whole.
- DROMOS will be an open service resource for educational and research institutions, socio-environmental institutions and for security purposes, partially open to the average citizen.
- Monitoring urban changes will make the connection between ecology and industry, sociology and ordinary citizens, emergencies, including catastrophic situations and science, which not only solves problems but also prevents them from forming, or at least mitigates their effects.
- We can collect statistics on the progress / regression of urban change, not only in a particular metropolitan area or country, but across the EU as well as in other countries, and assess the relevance and priority of the tasks of eliminating the effects of these urban changes.

Why we use drones in DROMOS project:

- Rapid and rapid coverage of the flight area for monitoring both horizontal and vertical;
- The ability to adjust the flight route during flight, both automatically and with the operator;
- Fast data collection from the required area and transmission of the danger signal when necessary under certain conditions without returning to the base.

Sensors and camcorders used to achieve the following objectives:

- Different types of encoders allow you to collect different information about the environment, lighting, fires, emergencies, etc.;
- The various settings and power of the camera also allow you to collect different environmental information - identification of smoke from the fire, the level of lighting, the availability of landscaping, roof forms and other landscaping area, the presence of boxes on transport routes, traffic jams, crashes, etc.;
- The ability to remotely and automatically adjust the sensors and camcorder;
- Automated identification of failed encoders and camcorders.

Urban Change Monitoring Laboratory:

- The ability to quickly and quickly exchange data within the laboratory, between participants and drones, and between laboratories of other metropolitan areas and

various institutions, educational, scientific and socio-environmental focus, as well as with special services (rescue, ambulance, police, etc.));
- An element of competition between laboratories to determine the best sets of drone control rules, training the system for monitoring urban changes;
- Many people are interested in monitoring and helping to monitor the level of urban change, especially among women (over 50 percent);
- Localization of operational data to achieve goals quickly.

Why Machine Learning increase student's interest to science:

- Rapid and rapid analysis of large data sets;
- The ability to add and modify both training rules and other necessary rules, in particular event forecasting, route changes, traffic jams and accidents identification, emergency identification, identification of the amount of harmful substances in the atmosphere;
- Simulation of specific situations;
- Achievement of goals;
- The need to create new training rules for the system with the emergence of new conditions for changing the direction of monitoring urban change;
- Formation of new rules for the creation of proposals by the system - new routes, new landscaping areas and more.

7. Conclusion

The project will provide an opportunity for scientific exchanges between the institutions of Ukraine and Germany. Several levels of exchange are planned:

- Ukrainian researchers will have the opportunity to work with German scientists and test the functioning by using new data. During their stay in Germany, postgraduates will have the opportunity to attend the studies offered to students at WISSENSARCHITEKTUR - Laboratory of Knowledge Architecture Technische Universität Dresden;
- Ukrainian researchers will use the project to learn and use automated methods and tools developed in Germany to monitor urban characteristics in large cities. They will begin to develop algorithms for optimizing the drones routes, taking into account preliminary collected statistical data with localization of zones and their classification by urgency, which may be useful for further common projects;
- Scientists and teaching staff will have the opportunity to work together on scientific tasks, check their methods and tools on new data, discuss scientific aspects of the project and prepare common publications and reports on the project. The exchanges will also provide lectures and seminars for the students of the partner university.

For quality monitoring of urban changes, we suggest:

- Use drones as scouts and collectors of up-to-date information;
- Use modern sensors and camcorders on drones to monitor the current state of space and time that do not provide fixed sensors and camcorders;
- Set up a laboratory to analyze the statistics collected through monitoring of urban changes by drones with the involvement of staff from innovative companies and businesses;
- Innovative approaches, such as Machine Learning methods, to teach the system of analysis of urban change monitoring results in order to make decisions and measures to correct urban changes.

The rules of the game (or rather, the air traffic) will sooner or later confirm, as technologies are actively evolving, drones are gaining more opportunities and becoming more accessible to businesses. Further development of the unmanned aerial vehicle market will be facilitated by the spread of precision farming practices, resource efficiency of production and control of urban changes. Unmanned aerial vehicles (UAVs, rarely UAVs) or drones have proven to be a reliable technology for creating maps, plans, and other geodata products. In standalone mode, but under the close control of the operator, UAVs can perform various aerial photography to create photo and video products, produce cartographic products and 3D models, monitor changes and perform various calculations. Aerial photography does not require an airfield and its associated infrastructure. Certified UAV pilots (UAVs) are ready to travel to any place of Ukraine promptly, to adapt to the particularities of the terrain and objects of study, to consider all possible risks and to ensure a guaranteed result.

Directions for using results on on-line infocommunication: orthophotos, digital terrain model, digital terrain model, 3D model, topographic plan, master plan basis, zoning, land use analysis, inventory or audit of community lands, allotted for investor search for site / object, bases for construction project, zone modelling flooding, landslide or flood risk assessment, situational plans, construction monitoring, excavation, environmental impact assessment, interactive maps, highway or rail mapping, mapping and risk assessment s for transmission lines, fiber optic design, development and updating evacuation plans, security systems design, evaluation losses (documentation of accidents and a result of natural disasters).

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