THE INTERNATIONAL EMERGENCY MANAGEMENT SOCIETY

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A TIEMS Special Issue Covering

2016 TIEMS First Conference in Ukraine

The International Emergency Management Society Newsletter - Special Edition

***The** TIEMS network constitutes a large international multidisciplinary group of experts, with different educational backgrounds and various experiences. Their knowledge and experience are important to share with other experts worldwide. TIEMS has therefore decided to issue this additional newsletter, which we now call TIEMS Newsletter – Special Edition. This is our the **fifth** issue, which we have dedicated to the **papers presented at the inaugural October 2016 TIEMS Ukraine Conference**. We invite other conferences and workshops, and RTD projects to use the opportunity to present the conference and workshop presentations and RTD projects to present articles of their results in the upcoming Special Edition Newsletters. We plan to have an issue three times a year. Please, give us feedback, and send us new articles for publication.*

Alex Fullick
TIEMS Scientific Newsletter Editor

Articles in this issue

This issue is dedicated to

2017 TIEMS Ukraine chapter

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Message from TIEMS President

The first TIEMS conference in Ukraine with the newly establshed TIEMS Ukraine Chapter as host, took place in Kiev Oct 12-13, 2016, as a joint event combining The 2nd International TIEMS DCEM Conference and The 2nd Secure Society Conference Ukraine SOSECUKR, see

http://sec-control.fi/dcem2016/EN.html

The event was ran as a round table for raising the issues of challenges, changes and responsibilities in building a modern secure society in accordance to European standards. It was open to all experts across the full spectrum of political sciences, economics, social sciences, diplomatic corps, security and safety engineering, applied IT and geo-information. The obejective was to helping policy- and decision-makers to become aware of potential sustainable security solutions.

The key topics covered were:

- Non-governmental and volunteer organizations in civil protection in Ukraine
- Harmonization with international standards – Legal aspects and challenges
- Modelling and simulation of disasters, emergency situations and response
- Recreation of abandoned areas polluted by radiation and illegal landfills
- Remediation of heavy industrial sites affected by armed conflict
- Lessons learned – C4I, UAVs and robots for emergency services in Ukraine
- Developing modern curriculum of education in CBRNE protection and safeguarding of crowd

The TIEMS Ukraine Chapter was established November 7th, 2016, and TIEMS Ukraine Chapter President and Director, Andre Samberg was the main host of the conference, and he received the Chapter Approval Certificate from the TIEMS international representative at the conference, George Markowsky, who is the Chair of TIEMS Academy and member of TIEMS International Board.

It is my pleasure to present the papers presented at the first TIEMS conference in Ukraine in this Special Edition of TIEMS Newsletter.

Furthermore, the Ukraine Chapter plans the following events in 2017:

26 May:

- TIEMS Ukraine Chapter Conference on Reforms in First Responding System and Civil Protection in Kharkiv, Ukraine

24 July - 7 August:

- TIEMS Ukraine Chapter Summer School on Vulnerability Assessment of Critical Infrastructures in the Post-Soviet Era: Case Ukraine, Kyiv, Ukraine

TIEMS Ukraine Chapter has also applied to be host for TIEMS Annual Conference in 2018.

I like to thank the TIEMS Ukraine Chapter for its initiatives and I wish the chapter good luck further with its work for making Ukraine a more resilient society.

I finally like to thank all participants making TIEMS first conference in Ukraine a great success!

Oslo 13th April 2017

K. Harald Drager, TIEMS President

Editor and Co-editor Messages

Alex Fullick

The Ukraine TIEMS Chapter was officially announced on October 7th, 2016. Before the official announcement an enthusiastic group had already planned their first conference for Oct 12-13, just a few days after being recognized as a full-fledged TIEMS chapter. By all accounts, it was a great inaugural success and I look forward to hearing of more great successes from our newest chapter.

In response to the conference, this Special Edition TIEMS Newsletter is dedicated to the many white papers submitted and presented at the 1st Ukraine hosted TIEMS conference. I hope you enjoy these research papers, as much as I'm sure the conference participant did.

Happy Reading!

Regards,

Alex Fullick, *MBCI, CBCP, CBRA, v3ITIL*

TIEMS Special Edition Newsletter

Andre Samberg

Managing director of the TIEMS Ukraine Chapter Professor Andre Samberg successfully gathered the group of Ukrainian experts.

Although people can understand speaking English, writing in English can be an obstacle. The TIEMS Ukrainian Chapter is a gate for many of them to enter the international community with the similar professional interests. Professor Andre Samberg takes a role of an advisor, and helps them to prepare the papers following the Western standards, for instance. It is well known that Ukrainian experts are the world class. With a small push by TIEMS, we believe that those people will be more successful and be able to share their ideas, achievements and will find new co-operations in the near future. The first TIEMS conference in Ukraine was of the great interest, and the new one is forthcoming soon.

Regards,

Andre Samberg

Professor & Managing director of the TIEMS Ukraine Chapter

The fact sheet of TIEMS Ukraine chapter as of 27 January 2017

The background

Ukraine is a large country in Eastern Europe known for the Black Sea coastline and forested mountains. It is bordered by Russia to the east and northeast, Belarus to the northwest, Poland and Slovakia to the west, Hungary, Romania, and Moldova to the southwest, and the Black Sea and Sea of Azov to the south and southeast, respectively. Its capital is Kyiv. Ukraine has an area of 603,628 km2 (233,062 sq mi) making it the largest country entirely within Europe and the 46th largest country in the world. It has a population of about 44.5 million, making it the 32nd most populous country in the world.

Ukraine has had acceptable nationwide network of firefighting and rescue services because of a large number of nuclear power plants, coal mines, chemical manufactures, heavy industry etc. On the other hand, volunteer first responder units were discontinued after Ukraine became a part of the former Soviet Union in 1939.

In 2009, Ukrainian volunteers and experts in rescue services, environmental monitoring and emergency management initiated negotiations with TIEMS (The International Emergency Management Society). Since then negotiations were suspended and re-started several times because of the changing political scene in the country. Contact persons changed as well.

In the summer 2014, a new group of volunteers and experts with the guidance of an expert from Finland rebooted the process of establishment of TIEMS Ukraine Chapter. Given the green light by the main office of TIEMS and its President, the preparation work began.

During this period a couple of international conferences were run by this enthusiastic group, namely:

- First International Secure Society Conference Ukraine SESOCUKR 2014, November 18-21(http://sec-control.fi/dd) and
- Second TIEMS DCEM Conference on Disaster Control and Emergency Management 2016, October 11-14 (http://sec-control.fi/dcem2016/EN.html).

A final application of the establishment of TIEMS Ukraine Chapter was submitted to TIEMS on July 22nd, 2016. It was finally accepted and the **TIEMS Ukraine Chapter was born on November 7th, 2016.**

The status
TIEMS Ukraine Chapter is an international non-stock not-for-profit non-governmental organization.

TIEMS Ukraine Chapter is a subsidiary of The International Emergency Management Society TIEMS. It is operated by the rules of TIEMS and supervised by the main office of TIEMS which is located in Brussels in Belgium.

TIEMS Ukraine Chapter is independent from any state and governmental institutions anywhere.

TIEMS Ukraine Chapter is run on the volunteer base.

TIEMS Ukraine Chapter is the only legal representative of TIEMS on the entire territory of Ukraine.

The mission

TIEMS Ukraine Chapter was formed:

- to advance the science of first responding, civil protection, environmental protection management, disaster relief, emergency, disaster, risk and crisis management;
- to educate individuals in the science of first responding, civil protection, disaster relief, emergency, disaster and crisis management;
- to foster the exchange of information pertaining to the science of civil protection, environmental protection management, disaster relief, emergency, disaster, risk and crisis management;
- to develop, place into practice and maintain standards and ethics applicable to aspects of in the aforementioned fields of applications;
- to provide means for the exchange of ideas among those interested in the aforementioned fields of applications;
- to encourage, publish and distribute books, periodicals, treatises, and other scholarly and practical works to further the science of first responding, civil protection, environmental protection management, disaster relief, emergency, disaster, risk and crisis management.

The main objectives

- To advance practical and scientific knowledge in the various disciplines of first responding, civil protection, environmental protection management, disaster relief, emergency, disaster, risk and crisis management including but not limited to, aerial surveying and mapping, space imagery, navigation, multi-source data interpretation, information management, location based 112 services and the related sciences in furtherance of the public welfare, security and safety, and in the interests of those who practice in the profession and those who use its services and products.
- To encourage public programs for first responders and decision makers relating to civil protection, environmental protection management, disaster relief, emergency, disaster, risk and crisis management endeavors such as mapping, charting, surveying, navigation, location based 112 services, and resource and environmental surveys and studies, working with governmental and private organizations in furthering such programs.
- To foster understanding and cooperation and to expedite the exchange of knowledge and ideas among the members of the Chapter and with those of other national and international organizations with similar or related interests.
- To serve the membership and the public as a central source of information, reference, and consultation on the disciplines represented in the Chapter.
- To contribute to the education of the general public about the nature of, and benefits to be realized from, the products and services provided by the profession.
- To further the national and international recognition and understanding of the profession and its various disciplines.
- To establish and maintain a code of ethics for the profession.
- To establish and apply standards for competence and performance for the various disciplines represented in the Chapter as appropriate to the welfare of the general public.
- To hold meetings for the exchange of scientific and technical information and for the exhibit of products and services.
- To encourage, publish and distribute books, periodicals, treatises and other scholarly and practical works applicable to the disciplines in the Chapter.
- To encourage and support education programs essential to the development and maintenance of the profession.
- To recognize and honor the leaders of the profession.
- To do and perform any lawful act and service to further the growth and recognition of the profession.

Equal opportunity legislation

TIEMS Ukraine Chapter aims to ensure that it provides equal opportunities:

a) In the services it provides to residents, applicants and other customers.

b) In access to membership of TIEMS, the committees and the engagement of members and other volunteers in its activities.

c) In its recruitment and employment of staff.

TIEMS Ukraine Chapter seeks to ensure that no person is treated less favorably than any other person or group of persons applying for employment or work under contract to the chapter on the grounds of their gender, marital status, family circumstances, employment status, disability, race, color, ethnic or national origin, nationality, age or religion orientation.

Responsibility as a service provider

Residents - As a public body, TIEMS Ukraine Chapter will seek to provide sufficient and appropriate information to residents and other customers by a method that ensures information is available regardless of disability or impairment.

Agreements with other Housing providers - TIEMS Ukraine Chapter will seek to ensure that outside parties involved in agreements comply with the TIEMS Ukraine Chapter's own standard, as a minimum, regarding equal opportunities.

Contractors/Consultants Equality Compliance - As recipients of public subsidiary, TIEMS Ukraine Chapter will seek to ensure that public funds are not used to promote practices that may be based on discrimination. Consequently, TIEMS Ukraine Chapter will seek to award to those Contractors and Consultants who develop and implement an Equal Opportunities Policy or agree to abide by the Chapter's Equal Opportunities Policy.

The Community - TIEMS Ukraine Chapter actively promotes its involvement in networking and supporting local community groups and encourages the promotion in all forms.

Harassment and Grievance - TIEMS Ukraine Chapter has implemented Dealing with Harassment Policy and Complaints Handling Procedure to respond to complaints of harassment or grievance in order that such cases are dealt with fairly and impartially.

Confidentiality - TIEMS Ukraine Chapter will seek to ensure that the staff and management committee members observe the Code of Conduct in terms of confidentiality and in relation to personal information regarding tenants, clients, and staff, Committee Members and others, regardless of their circumstances, status or any other factors.

Health and Safety - TIEMS Ukraine Chapter will seek to implement a Health and Safety Policy to ensure that everyone is equally informed and aware that their health and safely needs are given fair and equal consideration.

Training and Development - TIEMS Ukraine Chapter will facilitate training for staff and committee members in order to recognize the importance of equal opportunities and, where necessary, provide additional training for staff that recruit, select and train employees.

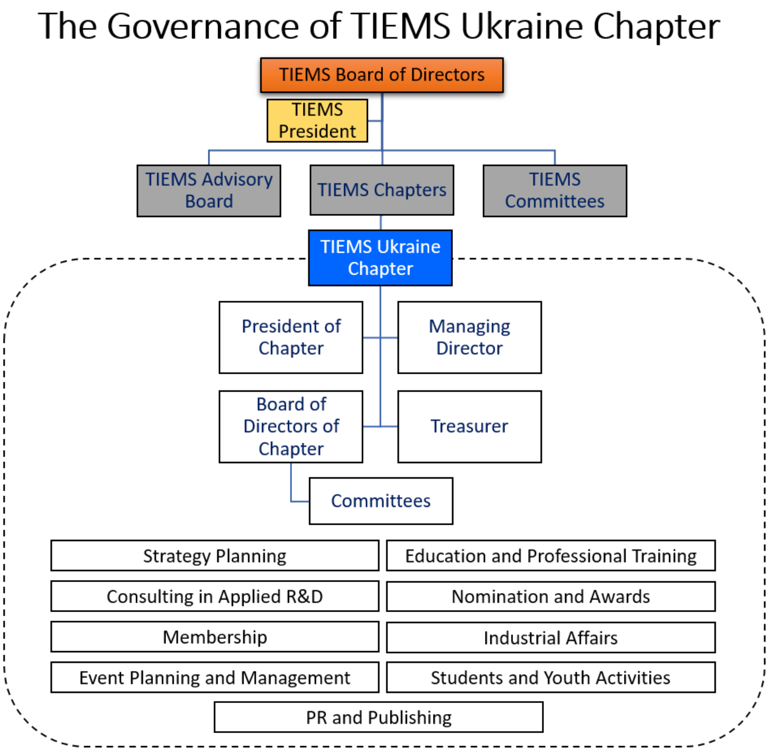
Employment

TIEMS Ukraine Chapter will seek to ensure that all individuals will be treated fairly and equally and any decisions on staff development, recruitment and selection will be based on the essential job evaluation and criteria. TIEMS Ukraine Chapter is a recognized 'Positive about Disabled People' user which demonstrates our commitment to good policies and practices in the employment with people with disabilities. The TIEMS Ukraine Chapter's pay system is transparent, free from bias and based on objective criteria.

Financing

Main sources of financing are membership payments, sponsorships and donations.

The activities of TIEMS Ukraine Chapter shall not be conducted for profit, but rather, shall be exclusively devoted to the achievement of its stated purposes. No part of any revenue generated by the Chapter shall inure to the private benefit of any individual, director or officer of TIEMS Ukraine Chapter.



The management of TIEMS Ukraine chapter 2017-2019:

President of Chapter and Managing Director Mr. Andre Samberg
Vice-president and Chairman of Board of Directors Mr. Yevhen Yakovlev
Treasurer Mr. Sergii Ponomarenko
Secretary Mr. Serhii Chumachenko

Directors 2017-2019:

Chair of Committee of Strategy Planning Mr. Andre Samberg
Chair of Committee of Education and Professional Training Mr. Volodymir Zaslavskji
Chair of Committee of Consulting in Applied R&D Mr. Andre Samberg
Chair of Committee of Nomination and Awards Mr. Oleksii Mikhno
Chair of Committee of Membership Mr. Sergey Stankevich
Chair of Committee of Industrial Affairs Mr. Viktor Korobka
Chair of Committee of Event Planning and Management Mr. Serhii Chumachenko
Chair of Committee of PR and Publishing Mr. Serhiy Khoperskyi
Chair of Committee of Students and Youth Activities Mr. Boris Pospelov

The control system of heterogeneous wireless sensor networks

Samberg Andre, Romaniuk Valery, Romaniuk Anton, Lysenko Oleksandr, Stepanenko Eugen

TIEMS Ukraine (UKR) Chapter, Military Institute of Telecommunication and Information, National Technical University of Ukraine «Igor Sikorsky Kyiv Technical Institute», Kyiv, Ukraine

Abstract: In this paper demonstrates the feasibility of using cost effective, flexible, and scalable sensor networks to address critical bottlenecks of the emergency response process. The directions of efficiency increase of the wireless sensor networks are proposed. They consist in the implementation of new methods and radio network management functions, coordination and intellectualization of the methods, corresponding to different OSI-model levels, and also coordination of the network resource management purposes distribution.

Keywords: wireless sensor networks, control system, mobile sensor, OSI model

Reference to this paper should be made as follows: Author(s) (2006) 'paper title ', Int. J. Ad Hoc and Ubiquitous Computing, Vol. X, No. Y4, pp.000–000.

Biographical notes: Samberg Andre, Doctor of Engineering, professor, Romaniuk Valery, Doctor of Engineering, professor, Romaniuk Anton, postgraduate, Lysenko Oleksandr, Doctor of Engineering, professor, Stepanenko Eugen postgraduate

Introduction

When a disaster occurs, the chaotic setting of limited resources, unreliable communication infrastructure, and inadequate information produces a very difficult environment for the emergency services. Wireless sensor networks (WSN) is a type of ad-hoc network that can change locations and configure itself in real time. WSN is self-organizing networks that have been recently deployed in many emergency areas, agriculture areas and livestock monitoring. However, these applications rely mainly on manually measuring and controlling the parameters such as moisture, homogeneity, temperature, pH, oxygen, soil nutrients, etc. Autonomous monitoring devices such as sensors warrant potential use in emergency or agriculture monitoring, in military sphere.

Distinctive features of WSN are network self-organization, dynamic topology, decentralized control and heterogeneity of network elements. Advantages of the WSN are easy nodes configuration into the network, lack of network infrastructure, high survivability, and work on the motion of all the network elements etc., Sitharama et al. (2012).

Main text

Most networks are heterogeneous and consist of a set of different types of networks: stationary, mobile, aircraft, underwater, allowing to monitoring a large number of physical parameters.

The effectiveness of WSN functioning depends on the efficiency of the network control processes and therefore variants of the control systems building.

Features of WSN control system are:

- multidimensional caused a large number of sub-systems, components and connections between them;
- multi-variability determined by a variety of individual subsystems targets, the diversity of their characteristics, requirements and performance indicators;
- versatility and hierarchy resulting from the need to solve a variety of management tasks at different levels and stages of system operation;
- the strong dependence of the functioning of the WSN parameters and external influences.

At the same time to WSN control system should meet the following basic requirements:

- providing the monitoring of specific objects (zones) with a certain intensity in a given time with a given quality;
- transferring different types of monitoring traffic (data, video);
- providing adaptive and distributed functioning the network with the possibility of self-organization;
- making decisions in real or near-real time;
- minimum amount of service information; optimizing network performance;
- maximum automation of network control processes.

The main WSN control principles are: adaptability, functionality, distribution, coordination of interactions, hierarchy and optimal automation of management processes.

Earlier construction of MANET control system was reviewed, in Minochkin et al. (2008), and with using with UAVs in Lysenko et al. (2015). We propose a new functional model of the network control system with allocation of two major subsystems: monitoring control and telecommunications control.

Monitoring control includes the following functions:

- deployment management - collecting information about the objects of observation, define methods the of nodes placement, selection the type of sensor nodes within the parameters and environmental monitoring, type of the organization of a sensor network, etc.
- covering control – defining the type of object cover (targets, areas, zones, sectors, selecting covering pattern depending on the degree and cover ratio);
- supervision control – calculation of sessions observation of sensors and network connectivity.
- quality monitoring control.

Control of telecommunications component includes the following steps:

- collection information about the state of the network (the decision on the network volume, frequency, depth data collection method);
- analysis of this information: identifying of the situation in the network (zone and the node), verifying that the network implement its functions and determine the necessity for control action;
- identification of management objectives with further detailing them on the sub-targets and development of decision (choosing access protocol, routing method, the method of service information distribution, etc.);
- implementation of decisions (set the transmission power, a method of monitoring, resource reservation, distribution service messages, etc.).

At the stage of operational management according to accepted performance criteria consistently evaluated the state of the sensor network, and measures are taken (in accordance with the plan and the actual situation) to retain its indicators of efficiency functioning within specified limits or takes their optimization.

The number and specific operating control tasks determined by the characteristics and conditions of functioning of the network, as well as the accepted technological solutions in its inception.

We propose a new architecture of building heterogeneous WSN management system that includes: for heterogeneous network - coordination and intellectualization decision-making processes for each class of WSN; for each WSN - coordination and integration of OSI layers by objectives and functions of control (Fig. 1).

Functional model consists of the following subsystems:

- collecting and storing information about the network status;
- analysis and decision making separately for monitoring and telecommunications;
- intellectualization and coordination;
- implementing solutions for network control.

Features of functioning of WSN and specificity of tasks assigned to them, requires an amount of different telecommunication control solutions, main of which are: control of radio resource topology, routing, loading, data quality (QoS), security, and others (Fig. 2).

Coordination and integration of OSI layers (cross-level).

Existing approaches to designing telecommunications networks require the independence of the OSI layer control functions. Since each level of the stack protocol works independently.

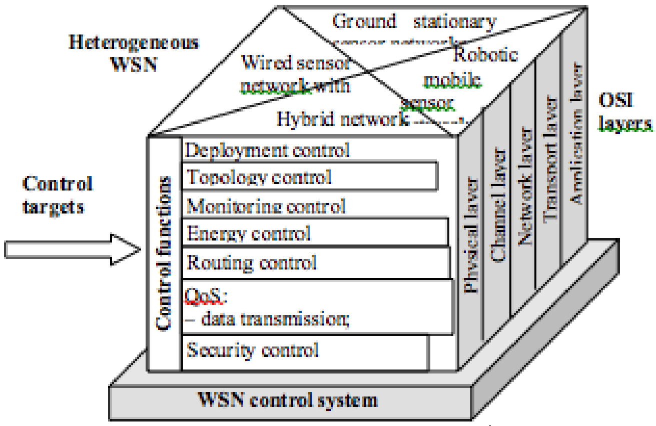


Fig. 1.Levels and WSN control functions

However, this approach ignores the WSN features and does not allow optimization of performance at each level of the OSI (or at all) under requirements of network functioning and different conditions of particular type of traffic. Therefore, proposed introduction of add-on OSI layers, that will coordinate the control levels and implement this optimization.

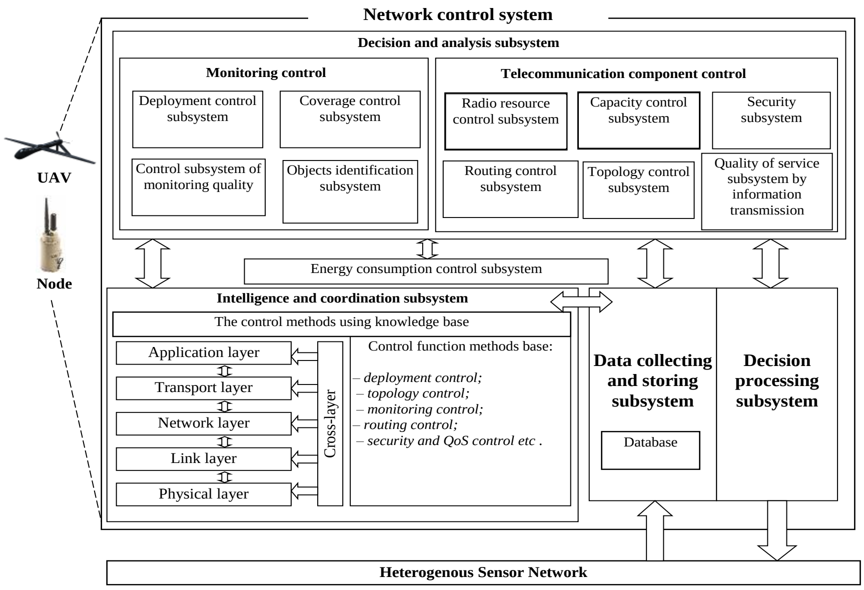


Fig. 2. Functional model operational control system of the WSN

Intellectualization network control.

For taking decisions to transfer information control system should identify the situation - the state of the network, directions (this is available for the device to use fuzzy sets in the absence of full information on network status) and choose from a variety of possible management methods by optimum for a given situation.

Conclusions

Proposed new architecture of heterogenous WSN. Its features are: splitting management tasks into functional monitoring subtasks, data transmission, reducing energy consumption, coordination and intellectualization of control functions.

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Assessment of industrial air pollution using remote sensing data: Mariupol industrial area case study

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Abstract: This paper describes a study of smoke spatial distribution from pipes from largest industrial facilities in Mariupol. The area of industrial smoke distribution was mapped by interpretation of satellite imagery for 2005-2016 years. The ground plots of constant and periodic air pollution were mapped for Mariupol industrial area.

Keywords: air pollution, industrial emissions, satellite imagery, spatial distribution, qualitative assessment, health protection.

Reference to this paper should be made as follows: Bunina A., (2016) 'Assessment of industrial air pollution using remote sensing data: Mariupol industrial area case study', Int. J. Emergency Management, Vol. X, No. Y4, pp.000–000.

Biographical notes: Bunina Anastasiia is a postgraduate student of Institute of Geology, Taras Shevchenko National University of Kyiv. Her research focuses on environmental monitoring using remote sensing methods and GIS technology.

Emission of various pollutants from industrial enterprises causing critical state of environment (atmosphere, hydrosphere, lithosphere, biosphere) within industrial agglomerations of Ukraine. Especially, such problem exists for Mariupol industrial area (Ukraine). More than 50 large factories working in the city, which undoubtedly affecting its environment. The steel industry is most intense source of pollution, which includes Ilyich Iron and Steel Works (operating since 1897) and Azovstal Integrated Iron-and-Steel Works (open in 1933). High levels air pollution significantly affects the state of health of city residents. The environmental situation in Mariupol leads to a sharp increase in diseases, including cancer. It should be noted, the mortality rate is higher in areas with more pollution. In some way, this can be considered even as emergency.

Mariupol belong to the one of environmentally troubled cities in Donetsk region and whole Ukraine (see Figures 1 diagram). In addition, environmental condition is complicated by unfortunate location of residential area and Azov sea resorts around the metallurgical enterprises.

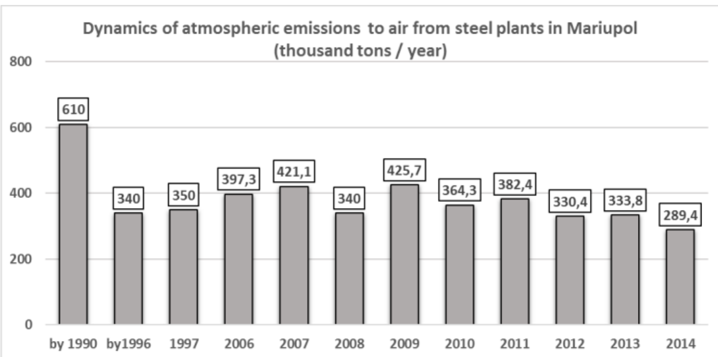


Figure 1. Dynamics of atmospheric emissions from steel plants in Mariupol (Ministry…, 2015a; 2015b).

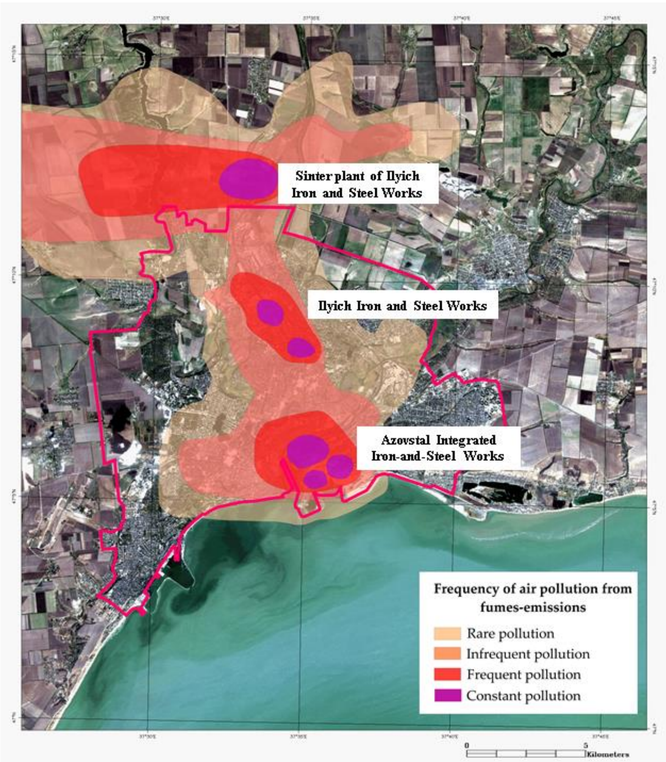
Particular attention should be paid dangerous industrial emissions (including heavy metals), which through the atmosphere, due to horizontal and vertical movement of air masses, accumulate in the surface layers of soil.

Anomalies of heavy metals typically extend to a distance of 10 km from the emission source, because metals bound as dust fraction of industrial emissions. Meteorological conditions and terrain elevations can make atmospheric transfer corrections in the direction of prevailing winds may spread contamination up to 15-30 km (Dzhuvelykyan et al., 2009).

Medium resolution multispectral satellite imagery was used to assess the spatial extent of area affected by air pollution from industrial facilities in Mariupol. It was determined the spatial distribution of smoke from pipes of Azovstal Iron and Steel Works factory, Ilyich Iron and Steel Works factory and other industrial enterprises. The area of industrial smoke distribution was mapped by interpretation of Landsat-5, Landsat-7 and Landsat-8 multi-temporal satellite imagery for 2005-2016 years.

Satellite images were analysed in the period from February till April for each year. The wind rose during this period was determined as follows: eastern wind (≈36%), southward, southwestern and western winds (18%, 11% and 9%, respectively). Such pattern of wind rose typical for this area over all year.

The ground plots of constant and periodic air pollution from industrial facilities were identified and mapped according to satellite data interpretation. Designated plots spatially associated with the Azovstal Iron and Steel Works and Ilyich Iron and Steel Works. They are located in central and metallurgical zones of Mariupol. These plots were rated in four categories according to the frequency of recurrence spread fumes, as shown in Figures 2 map. Obviously, over time the pollutants from atmosphere are deposited in soils of relevant parts of land surface.



Figures 2. Ground plots of periodic air pollution from fumes-emissions of industrial facilities within the Mariupol industrial area

So, the described technique provides a quick qualitative assessment of soil and air pollution from industrial facilities in wide area without great expenses. Outcomes of the study are useful to make recommendations for the environmental and health protection in residential territories, farmlands, etc.

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Three-level remote monitoring of peat bogs for fire safety

Lyudmila Lischenko, Nataliya Pazynych, Hanna Krylova, Mykola Lubskyi*

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Abstract: The three-level technique for monitoring of peat bog fires is described. It includes detection of the peat bogs localities, which may have an igneous threat or peat fires, using the satellite imagery, field research that comprise identification of overheated areas and detection of the subterranean smoldering after all fire-prevention measures via drones and determination the latent subterranean residual sources of heat and fire extinguishing efficiency control using portable pyrometer. Described measures used while peat fires on the territory of Chernihivsky region of Ukraine in October, 2015.

Keywords: peat fires, thermal infrared satellite imagery, emissivity, radiation temperature, unmanned flying vehicle, peat bogs.

Reference to this paper should be made as follows: Lischenko, L., Pazynych, N., Krylova, H., Lubskyi, M. (2016) 'Three-level remote monitoring of peat bogs for the fire safety', Int. J. Emergency Management, Vol. X, No. Y4, pp.000–000.

Biographical notes: Lischenko Lyidmila is a candidate of science in remote sensing. She is a senior researcher in Department of aerospace research in geoecology at the Scientific Centre for Aerospace Research of the Earth. The main specialization is interpretation of satellite images of the geological, landscape and geoecological phenomena and processes.

Pazynych Nataliya is a candidate of sciences in geography. She is a senior researcher in Department of aerospace research in geoecology at the Scientific Centre for Aerospace Research of the Earth. Her primary research interests include geomorphologic studies the Earth's surface using remote sensed data.

Hanna Krylova is PhD student in Department of aerospace research in geoecology of the Earth at the Scientific Centre for Aerospace Research of the Earth. Her primary research interests include remote sensing methods development for heat stress assessment in the natural and urban environment.

Mykola Lubskyi is PhD student in Department of geoinformation technologies in remote sensing of the Earth at the Scientific Centre for Aerospace Research of the Earth. His actual research focuses on methods of thermal imagery processing and enhancement of thermal fields' informativity.

The significance of the peat bogs remote monitoring is that peat bogs cover 2 – 3% of dry lands and contain 25% of soil carbon stoke of the Earth. Peat fires are the most common events of carbon emission and smoldering fires can continue for several years. The latent burnings take place in the subterranean peat layer, and can resist moisture and rains and they can continue to smolder in autumn and winter under snow cover.

The fires of drained peat bogs cause the emission of huge amount of suspended particles such as ash and greenhouse gases (carbon dioxide, nitrogen oxide, sulfur dioxide, ammonia, formaldehyde, benzapyrene, phenol, aldehyde, etc.). The large amounts of nitrogen and phosphorus compounds from the burned peat flow to the river system and cause the eutrophication of water bodies and sharp decreasing of the river water quality.

The continuous peat smoldering has the negative consequences for the environment far beyond the fire area.

The peat fire can occur when the critical moisture for the peat-bogs is nearly 73%. However, peat can be dehydrated to the much lower values. The continuous droughts decrease peat moisture level can decrease up to 40% and become dry and inflammable and fire can spread into the deep thickness. Fire spreading stops only when the burning comes down to ground water. Today Ukraine has about 1 million ha drained peatlands, the most of which are located in the Northern part of Ukraine called Polissia. In most of the peat floodplains of small rivers on vicinity of Kyiv (Irpin, Zdvyzh, Teteriv, Oster, Trubizh rivers and its tributaries), in the swampy parts of the Desna and Dnieper floodplains the thickness of peat in some places is 6-7 m. Kyiv City is ringed by the complex natural peat bog assemblages, which can both sustain stability and become dangerous in the certain conditions.

Peat bog monitoring includes three levels: regional (using satellite imagery), local research (using unmanned aerial vehicle) and field research (using portable thermometric equipment).

To determine the fire hazardous areas at the peatlands the following information should be derived: peat bog location, peat deposits' thickness, bog moisture, microclimate features and weather broadcast (Pazynych, 2012).

Some of these indicators can be obtained by using multispectral satellite imagery. Thus, the Terra MODIS spectroradiometer can be used at the regional level, because of its ability to receive imagery in thermal range of electromagnetic spectrum. There are also standard products of Terra MODIS such as MOD14A2, which allows collecting the short-term and 8-day composites for the total surface temperature excesses, i.e. "hot spots".

The more accurate detection of the fire localities which can be performed at the regional level requires more detailed data. TIRS sensor, located on Landsat-8 satellite provides thermal 16-bit imagery with 100 m spatial resolution and 16-days survey frequency imagery in two channels (TIR) at 10.8 and 12.0 μm.

Inversed Planck's law is used for transformation of spectral density of thermal infrared radiation which is obtained from satellite data into Earth's surface temperature:

$$T = \frac{c_2}{\lambda \ln\left(\frac{\varepsilon(\lambda)\cdot c_1}{\lambda^5 \cdot L(\lambda)} + 1\right)} \quad (1)$$

where $L(\lambda)$ – spectral density of the land surface (calibrated TIRS imagery data), $\varepsilon(\lambda)$ – spectral emissivity, c1 and c2 – first and second constants of Planck's law correspondingly, λ – electromagnetic radiation wavelength (Jiménez-Muňoz and Sobrino, 2003). Thermal emissivity is its own, independent characteristic of the surfaces and it must be determined separately from the temperature and can be derived from specific directories and handbooks.

As a result of the geomorphological analysis of digital elevation models (DEM), the retrospective area mapping, comparison and decoding of the multitemporal images, the distribution limits of peat bogs are defined. The early spring and autumn imagery in the most appropriate. Longitudinal and transverse profiles construction helps to determine the most depressed areas where stagnation and organic residues accumulation are occurred.

In the valleys of such large rivers as the Dnieper and Desna the accumulation of peat occurs in the former riverbeds, the floodplain's wall areas and low terraces. But for small rivers the peat accumulation can occupy the entire floodplain, especially where the channel slope is small and as a result the river flow slows down. To determine accurately the limits of the distribution of peat and peat soils the satellite imagery processing is performed. The main features of the peatlands manifestation on the satellite images are the specific configuration, the morphological pattern and spectral properties. As the result of the interactive processing and the spectral analysis of multispectral satellite images, a floodplain is analyzed and differentiated, the areas of peat bog distribution are detected and delineated, the conditions of a riverbed and drainage channels and its contents are determined.

The separate test areas, which has been considered as dangerous are studied in detail. The technology of its research includes the following stages:

- The detection of the peat bogs localities, which may have an igneous threat, using the satellite imagery interpretation, DEM analysis and difference spectral indices: moisture, aridity and vegetation, monitoring of peat lands conditions using the middle and high spatial resolution images and the technology of the calculation of absolute land surface temperature over the TIR range;

- The application of drones: a) to identify overheated areas over the peat bogs, b) to record the ignition sources, c) detection of the underground smoldering of the peat bogs after all fire-prevention measures;

- The using of the field thermal imagery device (thermographic camera) in order to determine the latent underground residual sources of the increased temperature of the peat and control the efficiency of the fire extinguishing, and also monitor the thermal conditions of the potentially fire hazardous peat-bogs.

Field research includes of drones with board infrared camera provide the control over the fire hazardous areas and the identification of the local latent seats of fire. The portable thermal-infrared camera allows the fire-prevention measures quality controlling and reveals the latent underground peat smoldering in the extinguished areas. Monitoring of the thermal conditions of peat-bog areas is also possible.

In the conditions of global warming and dewatering, the peat fires can provoke the further climatic changes due to the excess of carbon emission. The holistic approach to remote sensing complexes (satellite, airborne, ground, and verification ones) can be applied to prevent the fire events on the peat bogs, control the fire extinguish and observe the remaining subterranean smoldering seats.

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Geological emergency assessment using satellite radar interferometry: Krivoy Rog urban area case study

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Abstract: The technique for geological emergency assessment using satellite radar interferometry is described. The dataflow for Sentinel-1 SLC synthetic aperture radar (SAR) imagery processing is defined. The application of the described technique is demonstrated over Krivoy Rog (Ukraine) urban area.

Keywords: Geological emergency, synthetic aperture radar, satellite radar interferometry, interferograms coregistration and deramping, coherence map, Krivoy Rog urban area.

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Human activity leads to an anthropogenic impact on the natural landscape. Building industrial and energy potential, concentration of population in urban areas, environmental pollution has is challenged in crisis of natural and social systems. The frequency and scope of man-made and natural disasters dramatically increases.

Environmental hazard maps on-demand delivering is an urgent need now. It emphasizes the relevance of methods development for geo-environmental condition assessment to forecast, prevent or mitigate the disasters aftermath (Alcántara-Ayala and Goudie, 2010).

Such problems are really important within the industrial regions of Ukraine. Krivoy Rog urban area is typical one. It is the zone of very high anthropogenic impact and environmental hazards. Also this area is under the influence of adverse geological drivers. Urban area located within the geological fault zone. It is geologically unstable territory. In addition, the iron ore is mining by open-pit quarrying in the Krivoy Rog urban area.

Thus, the Krivoy Rog urban area is a potential place of natural and man-made disasters, such as dips, landslides, sinkholes, infrastructure violations, etc. In this regard, one of the priorities is a information system development for regional geo-environmental monitoring as a first step in the prevention of emergency situations. That would include the geological, hydrogeological, geodesic measurements, as well as observation of the dynamics of natural and man-made processes and changes at the land surface.

The wide-scale integrated monitoring system development requires large financial and time expenses. The remote sensing is an efficient technology in this case. The present-day Earth's observation systems provide data with the required spatial resolution and revisit time. The satellite imagery and modern geoinformation technologies enable the capability and reduce the cost of emergency monitoring. Satellite imaging covers a large territory simultaneously, extracts high variety of land surface features (Titarenko, 2014).

Optical satellite imaging makes it possible to build a digital elevations model (DEM). But there are lot of limitations for this. Optical sensors are not operating at night. Data availability is highly dependent on weather conditions such as clouds, fog, haze, humidity.

Radar images do not have these drawbacks, but they were always very expensive. But there is new Sentinel-1 radar satellite system with a high spatial resolution and fine revisit time was launched in the public domain. The twin Sentinel-1A and Sentinel-1B satellites have – for the first time – combined to show their capability for detecting even small deformations in land surface using radar interferometry.

The two-satellite 'radar vision' mission carries advanced radar to provide an all-weather, day-and-night supply of imagery. The Sentinel-1B satellite is now orbiting Earth 180° apart from its twin, Sentinel-1A, at an altitude of almost 700 km. Both satellites in the same orbit together can cover the whole globe every six days. This technique is particularly useful for generating accurate maps of surface deformation over wide areas, such as those caused by tectonic processes, volcanic activities or landslides (Geudtner et al., 2014).

Interferometric synthetic aperture radar (InSAR) mode exploits the phase difference between two complex radar observations taken from slightly different sensor positions and extracts information about the land surface. The Interferometric Wide (IW) swath mode is the main imaging mode over land for Sentinel-1. It acquires data with a 250 km swath at 5×20 m spatial resolution.

In order to perform radar interferometry, the input imagery should be two or more Single Look Complex (SLC) products over the same area acquired from slightly different satellite positions and at different times. For interferometric processing two or more images are co-registered into a stack. One image is selected as the master and the other ones are the slaves. The pixels in slave images will be aligned with the master image to sub-pixel accuracy. Co-registration ensures that each ground target contributes to the same (range, azimuth) pixel in both the master and the slave image.

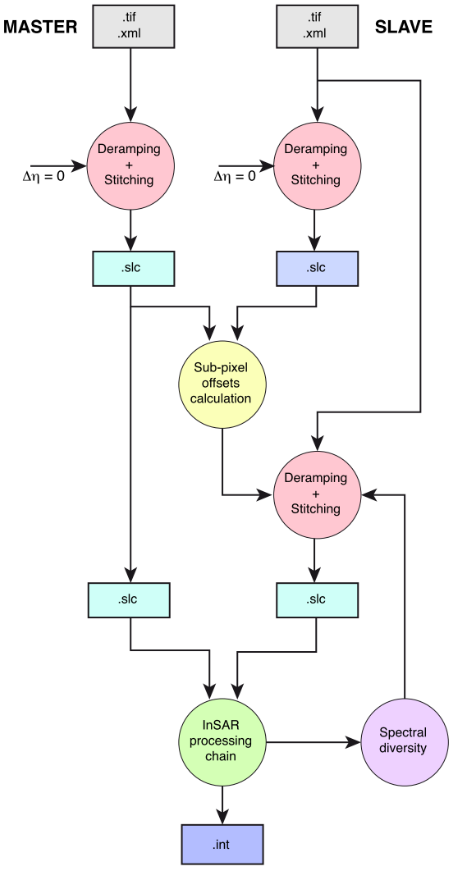
Through the interferometric processing, we shall try to eliminate other sources of error to be left with only the contributor of interest which is typically the elevation or the displacement. In the interferogram formation step we shall remove the flat-land phase.

The flat-land phase is estimated using the orbital and metadata information and subtracted from the complex interferogram. Flat terrain should produce a series of regularly spaced, parallel fringes. Any deviation from a parallel fringe pattern can be interpreted as topographic variation. With the same operator the coherence estimation is performed during the interferometry.

The coherence between master and slave images can show if the images have strong similarities and are therefore good candidates for generating a DEM. Loss of coherence can produce poor interferometric results.

The interferometric processing general dataflow is described by the Fig.1 diagram (Grandin, 2015).

Figure 1 Radar data interferometric processing flowchart



In the first step, the standard deramping procedure is applied to both master and slave images. The deramping is carried out for each burst separately. In a second step, the actual time lag between the master and slave image is corrected by taking into account pixel offsets. After sub-pixel correlation of the slave image against the master one, an affine transformation is determined by least-squares fitting of the pixel offsets.

Although the corrected images already yield interferograms with a reasonable quality, the above method is still insufficiently accurate for high-precision applications, such as monitoring of small land surface deformation. Imperfection of the coregistration can be observed in places where sub-pixel offsets have yielded ambiguous results, resulting in a poor estimation of the affine coefficients. These residual errors are manifested as phase jumps across burst boundaries. The last step is final interferogram calculation.

Now we can calculate the over-baseline value relative to the reference DEM. It must be performed many times over area of interest for permanent monitoring. Described technique was applied to the Krivoy Rog urban area during the 2015/2016 period.

In summarize, the technique described is a useful and versatile tool for analysis of geological emergency hazard. Radar interferometry is potentially capable to detect not only the catastrophic sinkholes of land surface, but also their precursors. Permanent radar monitoring will provide reliable and rapid information for the emergency response services and local authorities to assess the geological condition of the terrain and to forecast the possible disasters.

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Satellite monitoring technology for the pyrological conditions of forest areas

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Abstract: The main tasks of the informational and analytical monitoring system for prediction, revelation, tracking for development of the seasonal high fire risk sites within the woodlands with high level of radionuclide contamination from the Chornobyl origin are formulated. The monitoring system based the means of remote sensing, telematic and GIS (geoinformation system)-technologies. Number of unresolved problems to using of remote sensing and GIS-technologies are specified.

Keywords: forests, pyrological conditions, high fire risk sites, monitoring system, aerospace data, forecasting.

Reference to this paper should be made as follows: Azimov, O.T. (2017) 'The satellite monitoring technology for the pyrological conditions of the forest areas', *TIEMS Special Issue Ukraine*, Vol. X, No. Y4, pp. 000–000.

Biographical notes: Oleksandr Telmanovich Azimov is a Doctor of Science in Geology and Remote Sensing and Leading Researcher in Department of Energy and Mass Exchange in Geosystems at the Scientific Centre for Aerospace Research of the Earth of the Institute of Geological Sciences of National Academy of Sciences of Ukraine. His primary research interests include remote sensing methods, environmental ecology, emergency management and exploration geology.

The forest fires are key factor of the disturbance and dying of forest stands. They reduce the resistance of the forest vegetation due to these disturbances and drying individual trees, areas or whole massifs of forest. In addition to the urgency of the forest fire problem in Ukraine is caused by the large area of forests at the high density of radionuclide contamination from the Chornobyl origin above 10 Ci/km^2. This area is 63.8 ths. ha, the most of which (98%) is located within the Kyivska and Zhytomyrska oblasts (Zibtsev and Savuschyk, 2000). For post-accident period the forest fire problem in this region became pointed as a result of the change of forestry management and socio-economic conditions.

It is known (Azimov et al., 2004) that forest fires in the nuclear contamination zone accelerate the vertical migration of radionuclides beyond the boundaries of the primary nuclear fallout. After the crown fire 60–80% of radiocesium (^{137}Cs) passes into the mineral part of soils, while this value is 20–40% in the normal conditions. Radionuclide concentration may be increase more than 5 times in soil and air even at 5–6 km away from the fire location and can reach the critical values at the near fire front. Therefore, the crown radioactive fires are quite fairly qualified as the emergencies of local or even regional scale.

In particular, in 1992 during the catastrophic fires in the Chornobyl Exclusion Zone and the Zone of Absolute Resettlement the concentration of ^{137}Cs in air has been increased by 200 times over the contaminated areas (Zibtsev and Savuschyk, 2000). Within the fire location and at the soil contamination density of 0.5 Ci/km^2 the excess of maximum admissible concentration of B (MACB) for ^{137}Cs in air has been observed, as well as the excess of MACA is recorded at density of above 7 Ci/km^2. About 8% of pre-fire soil storage of ^{137}Cs from the forest ecosystem can be transferred outside of primary nuclear fallout. During the fire radionuclides drop into finely dispersed state and move upwards together with the convective fire column to the height of 6–12 km. The aerosol smoke cloud keeps during the week, month and one to five years in lower and higher troposphere, and stratosphere, respectively. Radionuclides arrive to the latter after heavy wildfires. The second transfer of nuclides increases the risk of radiation exposure to people and provokes the deterioration of their living conditions.

Therefore, the important condition for the stabilization of fire state in the forests of Ukraine (and particularly those that are contaminated by radionuclides) is the formation and functioning of the efficient monitoring system for fire protection, which could include the operating control, forecasting, identification, tracing, extinguish the fires (Azimov, 2002; Azimov et al., 2004; 2014). The development of this system is possible on the base of the scientific analysis and estimation of main components for radiation and forest fire situation, flammability, pyrology structure for the forest reserves, the meteorological conditions, the sources of fire, the existing fire protection system in the forestry enterprises, etc. In our opinion, improvement of the structure and methodical principles for the forest monitoring in our State requires the consideration the aerospace segment as one of the most important component. This is argued by the relevant prerequisites.

So, today it is realistic in Ukraine to obtain the aerospace information regularly as the multispectral images in visible, IR, and microwave ranges of electromagnetic waves at the spatial resolution from ones meters to ones kilometers. In recent years, the scientific and methodological foundations of satellite data interpretation have been further developed and the different problems for the forest science and forestry were settled. The quality software for efficient processing and analyses of satellite data for remote sensing of the Earth (RSE) and recording the results of this processing were developed and delivered to the wide range of users. There has been extensive development of the Global Information Systems (GISs) and navigation ones (GPS), Internet-, telematic and crowdsourcing technologies, unmanned aerial vehicles (UAV) usage, etc.

There is therefore the real objective to develop the adapted efficient method and construct the appropriate informative-analytical modeling system for forecasting, revealing and observing the forest fires by means of RSE data according to the landscape conditions in Ukraine. The main developments and results of system functioning must provide the informative support of the Management Services, which make the decisions on prevention and recovery of fire consequences in the forest areas. The key procedures in the system operation are the followings (Azimov, 2002; Azimov et al., 2004):

- Segmentation of the wooded areas within the studied territory by vegetation type clusters;

- Forecasting of the seasonal high fire risk sites within the woodlands studied by satellite imagery data;
- Plotting the suitable special digital networks by mean of GIS;
- Establishment of the experimental, interactive, analytical, modeling system of forest fire monitoring on a basis of RSE data processing and using the telematic, crowdsourcing, and GIS-technologies;
- Informative support to make the management decisions by the teams of the State Emergency Service of Ukraine (SESU), the Ministry of Ecology and Natural Resources of Ukraine (MinEcoResources of Ukraine) relative to the prevention and liquidation activities of the forest fires;
- Implementation of the main methodical techniques of forest fire monitoring by a set of ground, remote and GIS data into the structural subdivisions of the SES of Ukraine, MinEcoResources of Ukraine, etc.

It is evident that the above mentioned tasks have to base on the available qualitative digital satellite images acquired from the satellite platforms such as NOAA, LANDSAT, SPOT, Ikonos, Terra, Sentinal, ERS, RadarSat, etc. In addition to, the digitized information of the NOAA covers the same area to 6 times a day. At present the investigative and methodical testing for the most of these works was performed and the main their results were implemented into the activities of a number of specialized enterprises and organizations.

The physical principles for the research methods are the known natural relationship of change of spectral vegetation brightness in visible, IR, and microwave ranges, which is caused by the changes in the physical (burning) and physiological (chlorophyll content, leave structure, amount of water in the plan, etc.) states of vegetation, as well as the conditions of its growth place (i.e. degree of wetness for the rhizosphere, ground water depth level, toxicant pollution, etc.) that can be revealed from RSE data (Lyalko et al., 2006). The advantages of studies by a set of methods are undeniable. Because the joint application of the different remote sensing surveys over wide range of electromagnetic spectrum and ground measurements to control the wildfire risk, phyto- and sanitary conditions in woodlands comprehensively haven't been used in the forestry and the observations of emergencies connected with the fires. Traditionally, the forestry uses the satellite imagery data for the regional investigations of the vast areas. The proposed development focuses on the comprehensive assessment of the vegetation cover for the studied regions using the up-to-date satellite scanner data.

The suggested methodical approaches are worth to intrude on terrain of the Ukrainian Polissia (the areas of Rivnenska, Zhytomyrska, and Kyivska oblasts as a case study), where forest and peatland fires are the threatening hazard that the recent facts show.

Nevertheless, it must be born in mind when develop and realize the informative-analytical modeling system based on RSE/GIS-technologies there is a number of unresolved problems. Since the capability to identify and measure some phenomena, processes or objects (among those a locality of fire origin) is determined by sensor resolution (spatial, spectral, radiometric, temporal ones). That is why in prospect it needs to study the following issues (Azimov, 2002; Azimov et al., 2004):

- Forecasting forest fire situations (identification of spatial and temporal localization of the area for the probable fire events).

- Determination of the limit sizes (at the minimal area) of fires differed by their severity under conditions of various landscape elements under the varied temporary and hydrometeorological conditions (season and time of data acquisition; atmosphere transparency; cloudiness at the different heights and its differentiation to type and thickness; wind speed at the different heights; precipitation in before and at the time of survey; steady snow cover with the various characteristics; effect of heat noises from the industrial objects and settlements, etc.), which can be identified with the high probability using the different RSE data and a priori ground information.

- Integration of GIS and mathematical models of aerosol migration (as well as those containing radionuclides) through air under different weather conditions to predict radiological consequences of fires in forests and at the peatlands; and so on.

We consider that the priority expected results of the work on the development and construction of the informative-analytical modeling system for operative control of the forest area conditions in Ukraine to prevent the emergencies connected with fires must be the followings:

- Development and approbation of the methodical procedures for forecasting, revealing and tracing forest fires using satellite images and the UAV survey data interactively;

- Construction of experimental interactive informative-analytical modeling system for monitoring forest fires on a basis of remote sensing data analysis using telematic, crowdsourcing, and GIS-technologies;

- Fulfillment of the informative support for the management decisions regarding the prevention and mitigation of consequences due to the forest and peatland fires.

It is logical that the characterized development would be the special subsystem in the Governmental Informative-Analytical Emergency System (Azimov et al., 2006).

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Emergency medical care on motorcycles in Ukraine

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Abstract: All-Ukrainian Union of Paramedics is launching the project "Emergency medical care on motorcycles in Ukraine." The city in which it is appropriate to start the project is Kyiv, considering the factors such as traffic, congestion and time of arrival of the ambulance to the patient. We plan the first prepared bike (with equipment and medicines) onto the road of Kyiv in April 2017.

Keywords: emergency medical care, motorcycles, ambulance

Reference to this paper should be made as follows: Vus Y. (2017) ‘Emergency medical care on motorcycles in Ukraine’

Biographical notes: Vus Yaroslav was born in Kyiv, Ukraine. In 2012 he graduated from the Medical University of Alexander Bogomolets. Since 2012 he has been working in the center of emergency medical care and disaster medicine in Kyiv. In 2015 became the head of the Ukrainian Union paramedics. He is developing emergency medical care in Ukraine on motorcycles, and teach everyone the basics of first aid. He spent a large amount of training for Ukrainian military personnel in a combat zone.

Introduction

It’s very difficult to reach the injured in the big city in time. Because of the non-compliance to traffic rules by drivers and traffic jams, it takes 20-25 minutes to arrival. 70% of people die before the arrival of emergency car. At the same time the motorcycle need only 5-7 minutes to get to the injured. Motorcycle Emergency Service works together with the Center for emergency medical care and disaster medicine in Kyiv. Call will be received at the single call center of the city. Motorcycles will operate on weekdays from 8.00 to 20.00 and during mass events. One doctor will drive a motorcycle. If the call is complicated paramedic or another doctor will go as a passenger. The service is free of charge for the public. NPO plans to provide the motorcycles with medicines and fuel on its own and through charity donations of sponsors and concerned citizens.

The cases, in which the Motorcycle Emergency Service is necessary

The arrival of emergency on motorcycles is necessary in cases:
1) **Scout:** accident, fire, mass trauma (for medical sorting, counting the number of victims, scale assessment of emergency event);
2) **Emergency calls:** cardiopulmonary resuscitation, life-threatening bleeding, cramps, myocardial infarction, stroke, shocks, etc. - cases where response time is very important;

3) **Cases where treatment can be carried out on the spot**: minor trauma, neuro-circulatory dystonia, acute respiratory viral infection, hypertensive crisis and so on;
4) **Other cases** - to stabilize the patient's condition and prepare for hospitalization.

The benefits of emergency medical care on motorcycle

The benefits of emergency medical care on motorcycle are:
1) **Response time:** 5-7 minutes instead of 20-25;
2) **Arrival into difficult to get places**;
3) **Lower cost of equipped motorcycle:** 500 000 UAH for equipped motorcycle instead of 3 million UAH;
4) **Lower motorcycle fuel consumption**: the car consumes 12 litres of fuel per 100 km, motorcycle - 6 litres;
5) **The advantage for the state** is reduction of disability and increase in the birth rate.

The Conditions for start the Motorcycle Emergency Service

All-Ukrainian Union of Paramedics is a non-profit public organization. It is on the account of the union that we collect funds for the project. Currently, members of the union have ready given equipment for the sum of 250 000 UAH. So we are already half-way to the project goal.

To start, the following is needed:

- used motorcycle Honda CBF600S (2010 year model costs 160 000 UAH);
- **to equip it** costs about 40 000 UAH;
- **to provide a doctor with specialized medical clothing** (helmet, turtle protection, neck protection, trousers, jacket, raincoat, boots, gloves) costs 30 000 UAH;
- **ECG machine** - 20 000UAH.

To start the project another 250 thousand UAH are needed. This amount will save 70% of citizens who are victims of accidents.

Implementing and maintaining emergency medical care on motorcycles will save public money and also improve the quality and speed of first aid. So it will improve public health, reduce disability and improve the demographic situation in Ukraine.

Improving pre-emergency situational awareness of nuclear facilities using UAV-borne thermal and radiation measurements

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Abstract: Rapid express detection and preliminary identification of pre-emergency situation at nuclear facilities using drones equipped with infrared and radiation sensors are considered in this research. The authors propose development of a miniature unmanned aerial vehicle equipped with high-precision thermal infrared camera able to detect remotely internal warming up of hazardous facilities. The second sensor is an exact-detectability radioactive probe. This one is intended for more detailed survey of local warming point on close-range distance. Multi-source airborne monitoring is supposed to present additional information on the monitored facilities based on different physical principles rather than those currently in use.

Keywords: nuclear facilities, airborne monitoring, unmanned aerial vehicle, infrared radiometer.

Reference to this paper should be made as follows: Dudar, T., Stankevich, S. and Kovalenko, G. (2016) ‘Improving pre-emergency situational awareness of nuclear facilities using UAV-borne thermal and radiation measurements’, Int. J. Emergency Management, Vol. X, No. Y4, pp.000–000.

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Sergey Stankevich is a doctor of science in Remote Sensing. He is a Head Researcher in the department of geoinformation technologies in remote sensing of the Earth at the Scientific Centre for Aerospace Research of the Earth. His current research focuses on remote sensing methods, sensors, multi/hyperspectral imagery analysis and applications.

Grigorii Kovalenko is a doctor of science in Physics and Mathematics. He is a Head of Laboratory of Radioecological Safety and Radiation Monitoring at the Ukrainian Scientific Research Institute of Environmental Problems. His scientific interests are in the field of territories and population protection from radionuclides emission.

A number of nuclear facilities (NF) are located through over the territory of Ukraine, including three operating uranium mines (the Kirovograd oblast), uranium enrichment enterprise (the Dnipropetrovsk oblast), and Nuclear Power Plants (NPP) equipped with fifteen operating nuclear reactors (the Rivno, the Khmelnitsk, the Mykolaiv, and the Zaporizhia oblasts). Three processes are currently being developed at nuclear fuel cycle facilities, namely, uranium mining, uranium processing, and electricity production at NPP with deferred decision on reprocessing of spent fuel (SF) for 30-40 years. All these facilities are of high risk for the population and the environment and radiation level is always an important parameter which has to be continuously monitored and controlled.

The information-measuring systems of different automation levels have currently been functioning at NF. Accident-prone situations, causes of their origin, and options for their elimination are reflected in safety regulations and specific documentation. However, these data are not duly systematized and the public society is not properly informed. These facts negatively affect the image of the industry and people's attitudes towards it.

Available monitoring systems, including airborne remote gamma-rays control, are based on hazardous for personnel in situ measurements. So, engagement of remote monitoring system using unmanned aerial vehicles (UAV) is of high priority not only for Ukraine but also for other NATO countries where CBRN risk drivers are present. Systems of UAV-based remote gamma-rays measurement have been developed in Ukraine and are partially in use [Barbashev et al., 2011]. Such systems are able to detect after accident radionuclides emission. Therefore early warning systems for pre-accidental conditions identification should be developed and applied.

The overall presented research objective is rapid express detection and preliminary identification of pre-emergency situation at NF using drones equipped with infrared and radiation sensors. We consider development of a miniature UAV equipped with high-precision infrared camera and radiation sensor able to detect remotely internal warming up of hazardous facilities by its thermal infrared radiation. Infrared remote monitoring is supposed to present additional information on the monitored facilities based on different physical principles rather than those currently in use.

The dry spent fuel storage facility (DSFSF) next to the six-unit Zaporizhia NPP (ZNPP) was the first NF to be considered in terms of an aerial infrared monitoring possible application (Stankevich et al., 2015). The space imagery demonstrates the location of DSFSF and its occupancy (Fig. 1).

Figure 1 Location of DSFSF next to the ZNPP

The DSFSF safety operation is mainly connected with formation of so called “pillows” of mono atomic hydrogen that can cause depressurization of facilities and release of radioactive substances into the environment under conditions of temperature rise or any other external disturbance (for example, welding service). Compliance with the temperature regime can thus serve as an additional measure for the safe DSFSF operation.

The other NF to consider in terms of an aerial infrared monitoring possible application can be, for example, the Industrial Complex for Solid Radioactive Waste Management which is under construction on the territory of the Chernobyl Exclusion Zone and the description of which is available at http://chnpp.gov.ua. The Complex includes three facilities for solid radioactive waste management, closed into unified technological cycle. It is designed for acceptance, treatment and/or disposal of solid radioactive wastes (RAW) accumulated during operation period and those generated during ChNPP decommissioning and operational RAW of Shelter Object.

Recently, small-sized unmanned aerial vehicles (UAV) are increasingly used in air monitoring of various facilities, including the benefit of emergency prevention. The main requirements imposed on the UAV in such cases are prompt and informative monitoring. The UAV of vertical take-off and landing provide certain advantages in NF aerial survey: simplicity in operation, flexibility, reliability in regime of flight around the facilities, and possibility to hover at the height if necessary, etc.

Multi-copter is considered as a new-generation promising platform for emergency facilities aerial monitoring [Lysenko et al., 2014]. These are versatile, structurally robust, compact and economical UAV. They can be also used for NF monitoring. For any particular case the following has to be developed: technical requirements to UAV’s payload: payload’s size, weight and power consumption parameters, operation range, etc.; requirements to UAV flight performance: aerodynamic design, propulsion system, takes-off weight, service ceiling, operation velocity, etc.

Preliminary analysis of the NF temperature conditions (on the DSFSF example) shows that in the process of monitoring the air temperature contrasts of 30-40 K is necessary to identify, and distinction between the DSFSF absolute temperature deviations has to be not less than 10 K. Modern thermal cameras able to calibrate and measure remotely the facilities temperature (infrared radiometers) meet mentioned requirements. Many companies offer small-sized thermal cameras of far infrared band. Some of these cameras are specially designed for installation on unmanned vehicles; others foresee such a possibility [Bendig et al., 2012]. However, the requirements to instrument basic specifications have to be developed: working spectral band, spatial resolution, minimum detectable temperature difference (MDTD), design concept (sensor array, optical arrangement, filter lens, calibration unit, etc.).

UAV-borne radiation detection sensors have to meet the following requirements: detect both beta/gamma radiation and X-rays; battery powered with customizable reporting intervals and low power modes that can enable long-term battery powered operation; wireless communication between one or more monitors and the communication bridge or PC based data collection [Martin et al., 2016].

So, it is proposed to consider aerial infrared monitoring for nuclear facilities using UAV equipped with high-precision infrared camera and exact-detectability radioactive probe. This type of monitoring is supposed to be based on a different physical principle. In the first phase, the total area of NF site is inspected by thermal infrared imaging. In case of potentially dangerous local heating detection the monitoring second phase begins. The multi-copter hovers at low altitude over suspicious point and examines the possible radioactivity leakage using a radiation sensor. All collected information is transmitted through the radio-link to the ground control station in real-time. That is why it might be considered as an independent multi-source of information and this will increase the likelihood of pre-emergency condition detection and the population awareness about possible risk to health and the environment.

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Admittance spectrometer for operator functional state assessment

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Abstract: A device for operator functional state assessment is developed. The controller generates a sinusoidal test signal, the amplitude and frequency of which can be controlled by software. The signal is formed by sending a tabulated sine curve, which is stored in the controller ROM, to a pulse-width modulator. Then the signal is filtered and scaled in the analog part of the device and fed to an external electrode. After passing through the human body, the test signal comes to the input of a variable-gain amplifier.

The software forming of the reference sinusoidal voltage and the measurement of the resulting current are synchronized with each other by hardware.

The procedure described in the paper allows one to determine the human body admittance over a wide frequency range using a relatively simple hardware implementation. The compact design of the device allows it to be used in operator functional state assessment.

Keywords: Functional state of operators, computer diagnostics, admittance spectrum, admittance components

Reference to this paper should be made as follows: Author(s) (2017) 'paper title ', Int. J. Ad Hoc and Ubiquitous Computing, Vol. X, No. Y4, pp.000–000.

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The heart of the device for operator functional state assessment is a measuring controller, which consists of a 16-bit single-chip microcontroller and an analog part comprising a low pass filter (LPF) and a variable gain amplifier. A block diagram of the controller is shown in Figure 1.

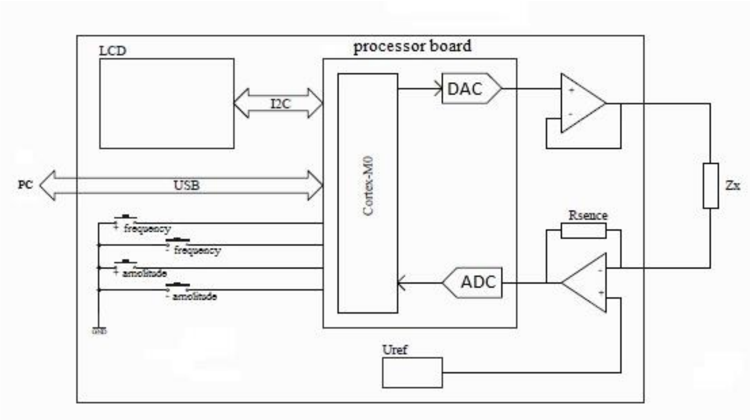
The controller generates a sinusoidal test signal, the amplitude and frequency of which can be controlled by software. The signal is formed by sending a tabulated sine curve, which is stored in the controller ROM, to a pulse-width modulator. Then the signal is filtered and scaled in the analog part of the device and fed to an external electrode. After passing through the human body, the test signal comes to the input of a variable-gain amplifier. The microcontroller selects the desired gain, and the amplified signal comes to the built-in analog-to digital converter (ADC) input where it is converted into a 10-bit code.

The ADC conversion results are multiplied by two reference signals that are in quadrature, and each product is integrated over a period. The results of integration are also averaged over a specified number of periods. Then the phase and amplitude of the signal that has passed through the human body or a calibration resistor are calculated, after which the active and reactive component of the human body admittance together with the admittance modulus and argument are determined. This measurement algorithm is implemented by a microcontroller program.

The device is shown in Figure 2. Its components are as follows:

- controller case, which has frequency switching buttons and amplitude control buttons;
- measuring electrode (in the form of a tablet), which is secured to the dorsal side of a hand;
- passive electrode (in the form of a clip), which is secured to the wrist of the other hand. Inactive electrodes of a similar shape are widely used in standard electrophysiological studies, for example, in electrocardiography.

Figure 3 shows the display of the device for operator functional state assessment.



Rsense. - feedback resistor;
LCD - display;
Uref. - reference voltage source;
Zx - object under measurement with an unknown admittance.

Figure 1 - Block diagram of the device for operator functional state assessment

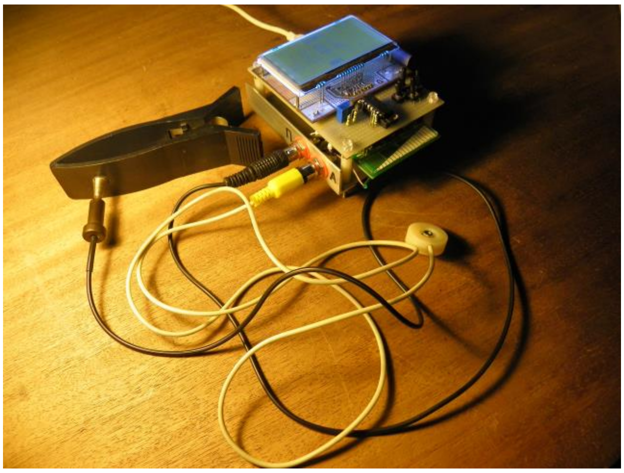


Figure 2 - Device for operator functional state assessment

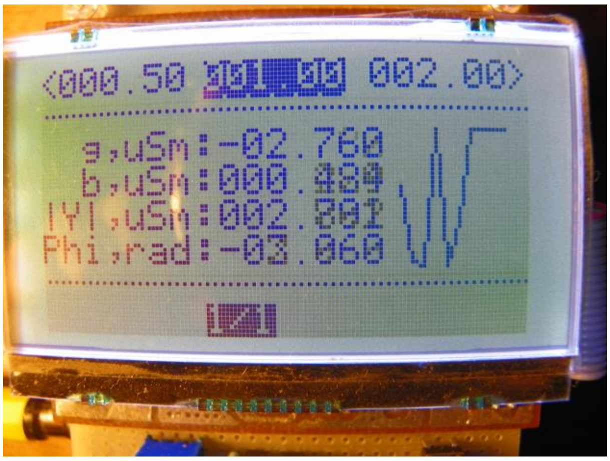


Figure 3 – Display of the device for operator functional state assessment

On the display, three measuring frequencies are shown: the active frequency in the middle (highlighted) and the previous and the next frequency on the left and on the right, respectively. Below the upper dotted line, from top to bottom: the active component of the admittance (μS), the reactive component of the admittance (μS), the admittance modulus (μS), and the admittance argument (rad).

The meter operation algorithm is as follows. The reference sinusoidal signal is generated by an STM32F0 32-bit microcontroller, which has a built-in 12-bit digital-to-analog converter (DAC). The amplitude of the reference signal is set by software using the "+ Amplitude" and "- Amplitude" buttons. The frequency of the reference signal is also specified by software using the "+ Frequency " and "- Frequency" buttons.

The reference signal comes to an operational-amplifier-based buffer follower, which alleviates congestion at the built-in DAC output. From the buffer follower output, the reference signal comes to the circuit under measurement with an unknown admittance Zx.

The circuit under measurement determines the current variation law, and the current is converted into a voltage using an operational-amplifier-based circuit. The conversion factor is determined by the value of the feedback resistor Rsense.

A bias voltage equal to half the amplitude of the reference sinusoidal signal is fed from the reference voltage source Uref. The voltage from the current-to-voltage converter, which is proportional to the input current and is in anti-phase with it, comes to the built-in ADC input.

The software forming of the reference sinusoidal voltage and the measurement of the resulting current are synchronized with each other by hardware.

So the amplitude and phase of the reference signal are known, which allows one to determine by software the amplitude and phase of the measured voltage from the current-to-voltage converter and to calculate the parameters of the circuit under measurement.

The parameters of the reference sinusoidal signal (frequency and attenuation coefficient), the measured parameters of the circuit under measurement, and the input voltage waveforms graphics are displayed on an IC2 liquid crystal graphical display.

The device is powered from the USB interface. Provision is also made for transferring the measured data to a PC and customizing the settings of the admittance meter via the USB digital interface.

Using an experimental prototype of the device, clinicophysiological studies have been conducted, and the vegetative nervous system tone has been compared with the vegetative nervous system state diagnosed with the use of an electo-apupuncture system. The results are summarized below.

1. There exists a reliable correlation between the measured admittance and the electro-acupuncture diagnosis data in the current frequency range 0 to 50 kHz. The correlation profile at each particular frequency has peculiarities of its own for each particular individual under examination.
2. The frequency dependence of the admittance parameters has characteristic peak values in the second half of the frequency spectrum: from 16 to 62.7 MHz.
3. The electro-acupuncture diagnosis data and the admittance values of individuals under examination have individual distinctions, thus making it possible to assess the vegetative nervous system tone of a particular individual at a later time.
4. The admittance and electro-acupunctural diagnosis data have reliable distinctions in different days of examination, which is an indirect indication of the sensitivity of the methods employed to the influence of both individual (work and rest regime) and external (meteorological and geomagnetic) factors. This may be used in instant diagnosis of the vegetative nervous system tone.

So the above procedure allows one to determine the human body admittance over a wide frequency range using a relatively simple hardware implementation. The compact design of the device allows it to be used in operator functional state assessment.

Emergency risk assessment of critical infrastructure

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Abstract: In article described method of assessment risk for pipelines in Ukraine as a part of critical infrastructure. This method based on the analytical procedure – ANP-process.

Keywords: critical infrastructure, risk, pipelines, ANP-process.

Reference to this paper should be made as follows: Author(s) (2006) 'paper title ', Int. J. Ad Hoc and Ubiquitous Computing, Vol. X, No. Y4, pp.000–000.

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Introduction

Modern threats to critical infrastructure in Ukraine due to the presence of these factors. One of the most important among them is the continuation of hostilities in eastern Ukraine. These actions create a number of new risks to critical infrastructure. These facilities are technologically dangerous enterprise as power plants (nuclear, hydroelectric), water supply, gas pipelines and other pipelines, bridges, storage tanks, ports and so on.

Assessment of risk of an accident at these facilities is one of the most pressing problems in the context of protection, the environment, both in Ukraine and in other countries that border it.

One of the most important critical infrastructure, damage which can lead to significant economic consequences for Ukraine and all of Europe is pipelines. This publication provides a method for risk assessment of an emergency pipeline to transport Ukraine.

Main Text

Ukraine has one of the world's largest pipeline networks and infrastructure, providing transportation of oil and natural gas to European countries, critical volumes. The output of the system elements of the network will lead to significant consequences for the economy not only of our country but also for several other European countries. For the risk assessment for pipeline transportation was elected ANP-process [1,2]. As risk factors were selected following - the human factor, weathering, landslides, earthquakes, fires, floods and karst.

Alternatively identified three risk levels that correspond to preparedness measures to eliminate the consequences of emergency situation - low risk, medium risk and high risk.

Net for assessment is shown in Fig. 1, and the results of this evaluation are shown in Fig. 2. The evaluation was conducted using a computer model.

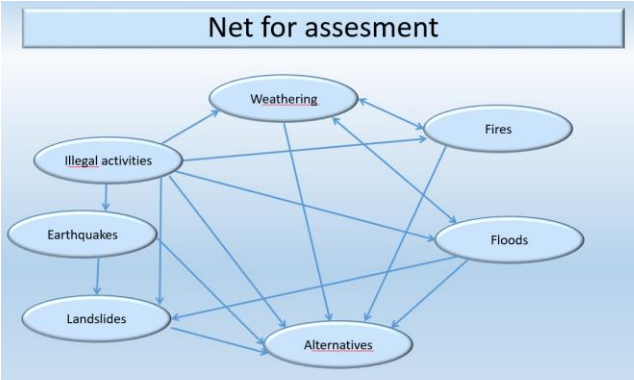

Fig1. Clusters and Net for Assessment

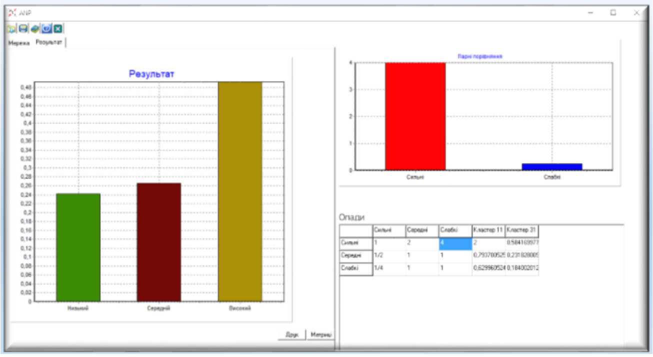

Fig 2. Assessment Results

According to the results of the risk assessment for the pipeline system is high. The greatest influence on the formation of such risks level is the human factor (the risk of terrorist acts and sabotage). The remaining factors affecting much less. Evaluation was based on the geographical location of pipelines, Fig 3.

Fig. 3. Assessment results of the main gas pipeline of Ukraine

The most dangerous areas for the operation of the pipeline system of Ukraine is the territory adjacent to the border with the Russian Federation and territories which are in the mountains of western regions of Ukraine.

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Methods of determining the location of the radio sources in sensor networks based on WLAN

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The National Academy of State Border Service of Ukraine named after Bohdan Khmelnitsky, Khmelnitsky, Ukraine

Abstract: Problems of definition of location of a radio sources in sensors networks on the basis of WLAN are considered. Using the mathematical apparatus of the extended Kalman filter is developed recursive algorithms for determining the location of the RE using the methods of TDOA and RSS. Analysis of the obtained algorithms and their comparison with the known executed using statistical modeling.

Keywords: the radio sources, wireless sensor networks, TDOA, RSS

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Biographical notes: Tovkach I.O., postgraduate; Zhuk S.Ya., Ph.D., professor; Tkachuk P.S., postgraduate

Introduction

Recent advances in wireless sensor networks (WSN) open new possibilities in solving the problem of determining the location of radiation sources (RS) This task has a wide range of applications such as: rescue transactions, autonomous observation and monitoring of industrial processes and environment (monitoring of fauna), control and management of mobile objects, etc. In case of accomplishment of rescue transactions, WSN provide a possibility of determination of location of members of rescue teams (for example, a fire brigade), and also technical means (for example, robots), to facilitate the achievement of the goals. One of important features of WSN is the possibility of tracking mobile objects (targets).

Main Text

WSN represents a set of the miniature and inexpensive devices equipped with different types of sensors, the small microcontroller and the transceiver which are integrated with the help of the WLAN network, using radio channels for data transfer, but not cable connections. The WLAN network is a flexible data transmission system which can be applied as extension or an alternative of a cable local area network in the building or within a certain territory.

When an object emits, its location can be determined using passive detection methods: the time difference of arrival (TDOA) [1] and the received-signal strength (RSS) [2] Fig. 1. Measurements in the TDOA method are differences of ranges to the target between sensors of network and the basic sensor $R_i - R_0$, $i = \overline{1, n}$.

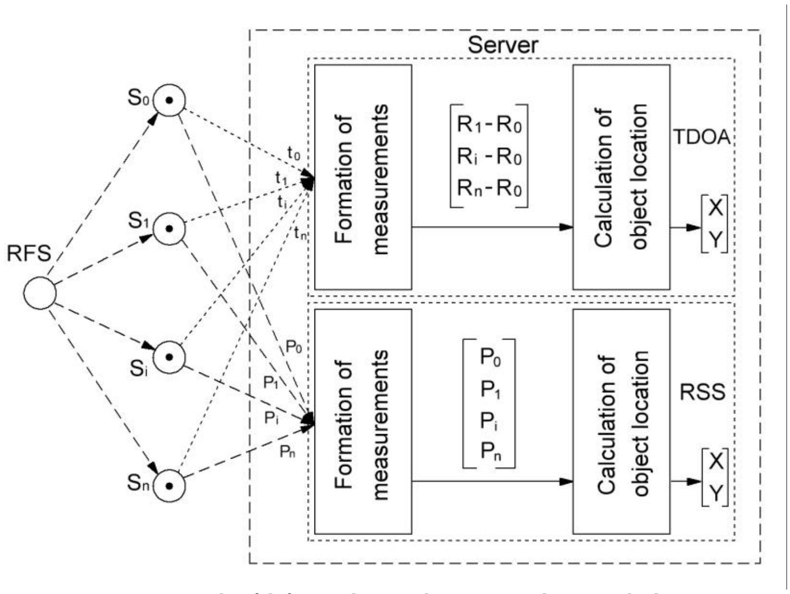

Fig. 1. Principle of definition location by TDOA and RSS methods

Measurements in the RSS method are values of strength of the accepted signals P_i, $i = \overline{0,n}$. The option of placement of sensors in WSN is shown in fig. 2.

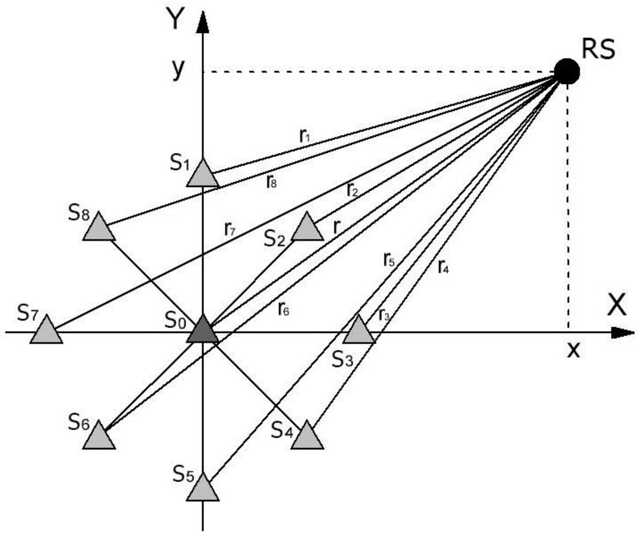

Fig.2. The configuration of the sensor network with 9 sensor

The analysis is carried out: WSN configurations on the basis of WLAN, standards of the accepted signals in order to solve problem of identification of objects, methods of a passive location. One of standards of data transfer which can be used by RS is Wi-Fi IEEE 802.11. The information is transmitted in a sequence of frames. Frames contain source (Address 2) and receiver (Address 1) MAS-addresses, frame number (Sequence Control) as sequence, body of frame, and a check sequence of a frame for error correction. It allows to distinguish among themselves both RS and the separate frames radiated by them.

With use of a mathematical apparatus of the expanded filter of Kallman, recurrent algorithms of definition of location of RS in sensor network by means of the TDOA and

RSS methods are developed. The comparative analysis of precision characteristics of the received algorithms and their comparison with known, and also with the lower limit of the Cramer-Rao by means of statistical modeling is made.

As an example in fig. 3 and fig. 4, dependences of the actual RMS of errors of assessment of location of RS on coordinates of X (a curve 1) and Y (a curve 2) are shown the developed algorithms when forming measurements on the basis of the TDOA and RSS methods respectively using. The values of RMS varies from 2 to 45 m. At the same time WSN has the configuration shown in fig. 2, $r = 100$ m. RS is located on a circle with a radius of 300 m relative to the reference sensor S0. RMS of measurement errors when using the methods of TDOA and RSS $\sigma_{\Delta} = 1.5$ m and $\sigma_P = 1$ dB respectively.

To improve the accuracy of the positioning of the RS it is appropriate to perform complex processing of data obtained by the RSS and TDOA, as well as the construction of trajectories and determination of motion parameters of the RS by measurement-based methods.

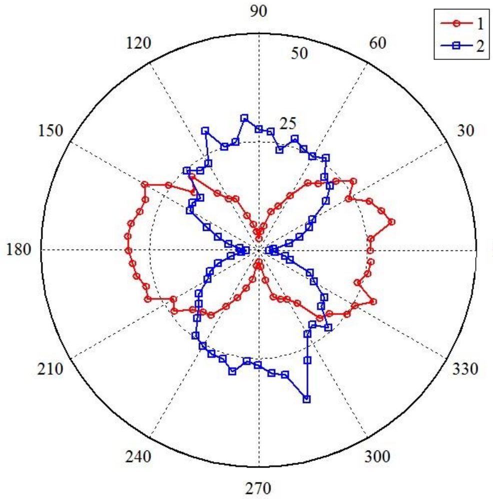

Fig. 3. RMS of errors of assessment of location of RS of the TDOA method

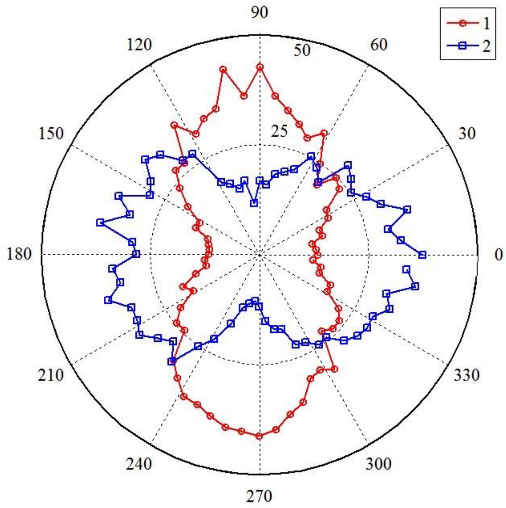

Fig. 4. RMS of errors of assessment of location of RS of the RSS method

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Adaptive filtration of parameters of movement of the maneuvering UAV according to sensor networks

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Abstract: On the basis of a mathematical apparatus of the mixed Markov processes in discrete time optimum and quasioptimum adaptive algorithms a filtration of parameters of the movement UAV according to sensor network with use of a time difference of arrival method are synthesized. Devices that they are realized, are multichannel and belongs to the class of devices with feedback between channels. The analysis of a quasioptimum adaptive algorithm is made by means of statistical modeling.

Keywords: UAV, wireless sensor networks, optimum and quasioptimum adaptive algorithms, parameters of the movement, TDoA

Reference to this paper should be made as follows: Author(s) (2006) 'paper title ', *Int. J. Ad Hoc and Ubiquitous Computing*, Vol. X, No. Y4, pp.000–000.

Biographical notes: Tovkach I.O., postgraduate; Zhuk S.Ya., Ph.D., professor

Introduction

At the present time the development of technologies for construction of unmanned aerial vehicles (UAVs), their availability and massive use for a wide range of problems has led to the emergence of a new class of threats [1]: application in the terrorist purposes, photographing of the secret objects, receiving unauthorized access to information in WLAN networks, invasion on the forbidden territory, etc. This leads to the need to develop security systems that solve the problem of detection, positioning and motion parameters of the UAV.

Main Text

When an UAVs emits, its location can be determined by wireless sensor networks (WSN) with use of a time difference of arrival method (TDOA) [2].
A feature of modern UAVs is the ability to perform sudden maneuvers, and maintain the same position in the point in space. Therefore, the synthesis of adaptive algorithms for filtering of motion parameters of the UAV according to the WSN, which also performs detection of various types of its movement is important.
The UAV movement with different types of maneuver in rectangular system of coordinates can be described using stochastic dynamic system with casual structure in discrete time [3]

$$u(k) = F_j u(k-1) + G_j \omega(k), \quad j = \overline{1, M}, \qquad (1)$$

where $u(k)$ - the state vector including parameters of the movement UAV; F_j, G_j, $j=\overline{1,M}$ - known matrixes; $\omega(k)$ - uncorrelated sequence of Gaussian vectors. Change of structure of model (1) is executed by means of a switching variable $a_j(k),\ j=\overline{1,M}$, which belongs to the class of chains of Markov.

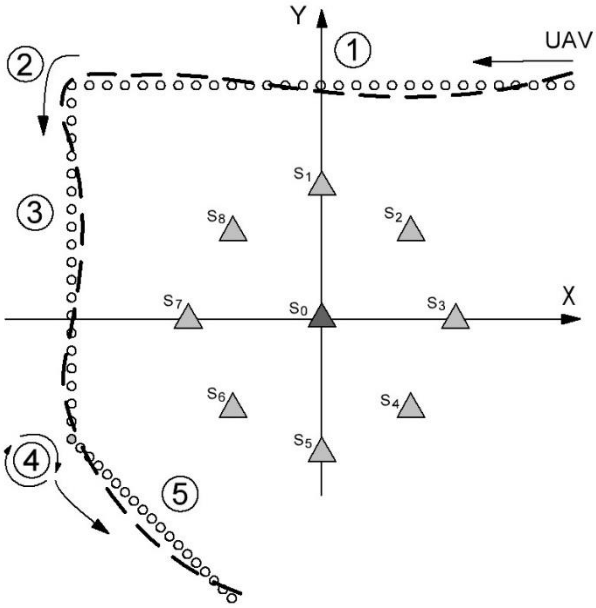

Fig. 1. The configuration of the sensor network with 9 sensors and the UAV trajectory of movement.

On the basis of a mathematical apparatus of the mixed Markov processes in discrete time optimum and quasioptimum adaptive algorithms of a filtration of parameters of the movement UAV according to touch network with use TDOA are synthesized. The optimum algorithm is recurrent and describes evolution of joint a posteriori probability density continuous $u(k)$ and discrete $a_j(k)$ components. The device realizing it is multichannel with number of channels *M* and belongs to the class of devices with feedback between channels. In the quasioptimum algorithm Gaussian approximation of conditional a posteriori distributions of a vector $u(k)$ is carried out. The quasioptimum device in general keeps the structure and feedback inherent in the optimum device.

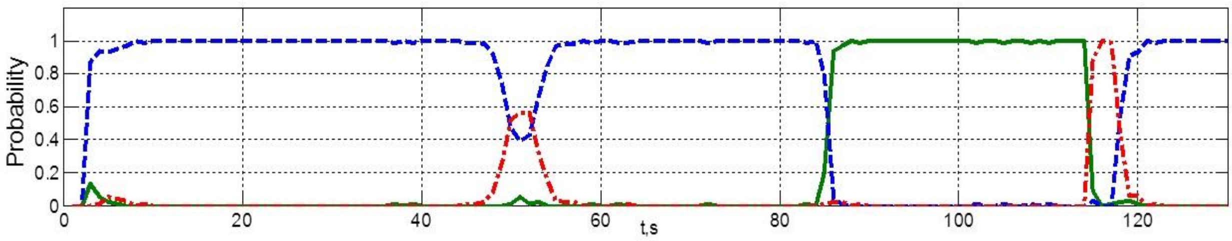

Fig.2. The probability of determining maneuvers

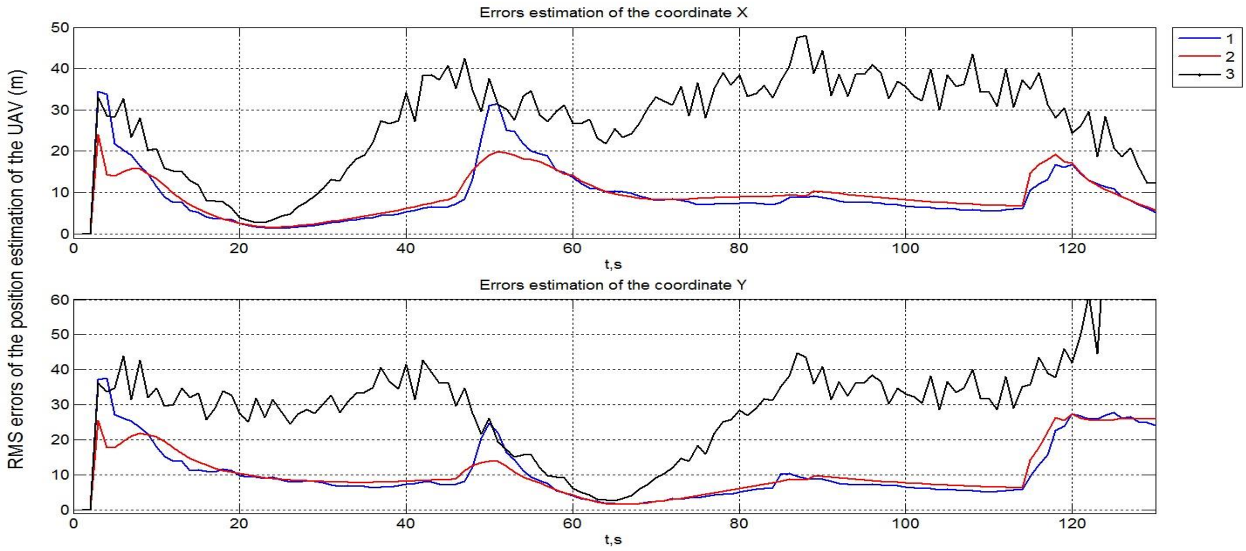

Fig. 3. RMS errors of the position estimation of the UAV when using adaptive filter

Efficiency analysis of a developed quasioptimum adaptive filtering algorithm of parameters of movement of the UAV it is carried out by means of statistical modeling. The model of the movement UAV describes three types $M=3$: hanging $j=1$, almost uniform motion $j=2$, the movement with maneuver $j=3$. Sensor network (Fig. 1) consists of nine sensors located along a circle with a radius of 100 m relative to the reference sensor S_0. For descriptive reasons works of an algorithm the test trajectory of the movement UAV which includes five sites (fig. 1) has been created. RMS error of measurement of difference of distances $\sigma_\Delta = 1.8$ m, rate of receipt of information $T=1$ s. Tests were carried out for hundred realization.

Fig. 2 shows the dependence of the probability of recognition of movement of the first (curve 1, continuous line), second (curve 2, the dashed line) and third (curve 3, the dash-dotted line) types, obtained by Monte Carlo method. Fig. 3 shows the dependence RMS (curve 1) errors of the position estimation of the UAV according to the coordinate *X, Y* obtained by Monte Carlo method and RMS (curve 2) estimation errors calculated using adaptive filter. Also in fig. 2 dependences RMS (a curve 3) errors of measurement of location of the UAV are shown.

As appears from results of modeling, application of a trajectory filtration allows to reduce RMS of errors of definition of location of the UAV in comparison with RMS of errors of definition of location by TDOA method by 2 – 4 times. At the same time the adaptive filter allows to distinguish hanging and almost uniform motion of the UAV with probability close to unit.

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Deployment of wireless sensor networks using unmanned aerial vehicles in emergency areas

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Abstract: (ABS) This paper addresses the questions of deploying wireless sensor networks for operational monitoring of emergency area. Proposed ways of localizing nodes using manned and unmanned aircraft. Also it is considered mathematical problem of rational topology synthesis of wireless sensor networks using repeaters based on miniature UAVs; proposed a method of solving the problem using the knowledge base of specially designed rules of such repeaters placement, which avoids exhaustive search of network graphs to get close to the optimal solution in real time.

Keywords: (ABS) emergency, monitoring, sensor, network, throughput, knowledge base, deployment, topology, UAV

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Introduction

Recently it is acquired a widespread use of remote control methods for rapid detection of radiation, chemical and biological conditions in cases of extremely high air pollution on the territory of emergency. Such methods may find its application in wireless sensor networks (WSN), which is pointed out by Lorincz et al. (2004) and Ramesh et al. (2009), consisting of compact sensors (terminals) equipped with a wireless interface, which are connected to the data processing center (DPC) through the gateway (coordinator) directly (in case of line of sight) or with retransmission of packets through intermediate nodes (routers).

The key issues of the use of such networks is the issue of networks deployment in contaminated areas and aspects of planning the optimal network topology. Therefore, purpose of article is scientific substantiation of new methods of rapid deployment and synthesis WSN topology for monitoring in emergency area.

Problem Statement

One of the key issues is the use of WSN is network deployment issues such as nodes placement in contaminated areas, as direct application of human resources is not acceptable because of the risk to health. One possible way to network deployment may be the use of manned aircraft, such as using Mi-8 helicopter mining system (HMS), upgraded for sensors, or robotics, such as unmanned aerial vehicles (UAV) with direct placing or remote placing using rocket launch.

One of the key problems in deploying WSN is the task of finding a rational network topology of relay nodes (routers), namely definition of their position on the ground and the relationships between them. Rational WSN topology will reduce traffic and reduce energy consumption at the nodes, which in turn will increase network uptime and reduce the overall cost of its maintenance.

Let us consider the example of WSN architecture using UAVs (Figure 1).

WSN consists of a set of *N* sensors (ED) placed with coordinates $(x_i, y_i), i = \overline{1, N}$, in some area of size *r* (sq. m), often called as sensor field. In order to collect data from sensors and transmit to the gateway it is used a set of *K* relays (routers) based on miniature UAVs placed at a height *h* with its projection coordinates $(x_{0k}, y_{0k}), k = \overline{1, K}$ and radio coverage of radius *R*(m). If sensor is located in UAV radio coverage area, data through repeaters network get on gateway and then via global networks in data processing center.

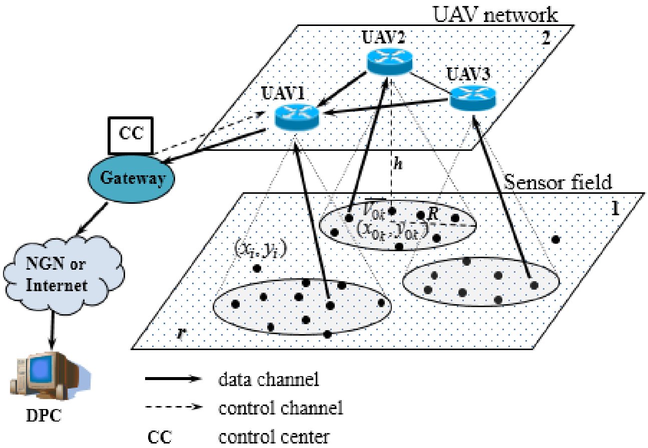

Figure 1 Example of WSN architecture using UAVs

Under network topology, we mean a set of geometric locations of nodes and the probability of communication use between them for message delivery: $(\|R_i\|, \|p_{ij}\|), i, j = \overline{1, N},$ where $\|R_i\|$ is a set of WSN nodes; $\|p_{ij}\|$ is a set of probabilities of using communication between nodes. Thus, WSN can be represented as a weighted directed graph, consisting of a set of vertices (nodes) and edges (channels). Construction the routes from ED to the gateway is realized by using a dynamic programming algorithm - the method of Bellman-Ford. Criterion function of this algorithm (Bellman function) defines the conditional cost of data flow transporting between adjacent nodes of route:

$$W = C_m + C_r \underset{\|R_i\|}{\longrightarrow} \min, \quad C_m = \begin{cases} C_m^{nom} \\ 0 \end{cases},$$

$$C_r = \begin{cases} \dfrac{U_{RX}^* + U_{TX}^*}{U_{\max} - U_w^*} C_m^{nom}, (U_{RX}^* + U_{TX}^*) \le (U_{\max} - U_w^*) \\ \infty, (U_{RX}^* + U_{TX}^*) > (U_{\max} - U_w^*) \end{cases},$$

where C_m - conditional cost of WSN node, which receives zero value with the repeated use of node in the topology (it allows to minimize the number of repeaters), C_m^{nom} - conditional nominal cost of node, C_r - conditional cost of relaying, U_{RX}^*, U_{TX}^* - actual

traffic through the node taking into account repeated relaying, U_{max} - maximum traffic through the node, U_w^* - equivalent density of data flow emitted by adjacent nodes taking into account competition for multiple access to radio channel.
Thus, we can formulate the following mathematical statement of the problem - to find a network topology (UAV repeaters location), that minimizes the cost of transporting the data flows from sensors to gateway, when the constraints on network resources, structural connectivity and network operation parameters are performed:

$$X_0 = \arg \min_{X_0 \in \Omega_{1,2}} C(X) = \arg \min_{X_0 \in \Omega_{1,2}} \sum_{i=1}^{N+K} \sum_{j=1}^{N+K} W_{ij} \ , i \neq j \ ,$$

$$\Omega_1 : \{X \in r, \ p_{ij} \leq PER^0, P \leq P^0, N \leq 1000, K \leq 100\} \ \Omega_2 : \{s(m_{ab}) \geq s^0, \ t_з(m_{ab}) \leq t_з^0, \ a, b = \overline{1, N}\} ,$$

where X – vector of projections coordinates of UAV set placement; PER^0 – threshold of packet error rate in the channel; P, P^0 – network reliability and its threshold; $s(m_{ab}), \ t_з(m_{ab}), s^0, t_з^0$ - throughput and delay in the route m_{ab} and the corresponding thresholds.

Method for Problem Solving

The problem of designing a rational WSN topology from a formal point of view is similar to the problem of forming the topological structure of any wireless network. There are currently approaches to solving such problems based on the use of algorithms for combinatorial analysis, such as Rishi and Vandana (2014). Application of the theory of graph enumeration for solving the problem of topological optimization provides the possibility of obtaining the exact solution for small networks therefore this approach is effective for small networks.

The main disadvantage of algorithms for constructive enumeration of graphs is the inability of their application for building large-scale network topology, because the number of generated graphs grows exponentially with the growing of network nodes number. It determines the feasibility of developing an alternative approach to the design of a rational WSN topology.

Lysenko and Valuiskyi (2012) proposed to solve this problem with own developed method, which represents a computational procedure that includes the following steps:

1. Evaluation of network connectivity. In the case of mobile sensors initially it is forecasted the duration of their stay in the radio visibility zone of UAV repeaters, and in the case of fixed – immediately it is assessed the degree of sensors coverage by UAVs repeaters. If conditions on the connectivity and network reliability is not performed, it performes the procedure of placing the UAV so that to cover all of nodes.
2. Evaluation of given functional parameters (throughput and delay of routes).
3. Improved search algorithm for a rational UAVs topology.

The essence of improvement lies in the fact that for reducing the exhaustive search of topologies, it is used a set of rules for UAVs placement that enables to find a rational solution and minimizes the time of its search.

The rules represent rules of the production type, which consist of conditions and actions. In case of the same effect of multiple rules it should apply the meta-rules. Rules can be classified depending on the desired goal - to provide connectivity, custom or system optimization. For example, to ensure the network connectivity, UAVs should be placed such a way that cover as many nodes as possible. To maximize the throughput of the network - to redistribute flows of under loaded routes.

Thus, the application of the method will reduce the enumeration of possible graphs and get a rational solution (which differ from the optimum on 5-7%) in real time (units / tens of seconds). In practical terms such WSN can be implemented on the basis of modern element base, for example, computing board with embedded processor (in which may be implemented above method), radio modules XBee, a set of sensors.

Conclusions

In this paper, we considered the questions of rapid WSN deploying for operational monitoring of emergency area. It was proposed ways of localizing nodes using UAVs and HMS of Mi-8. Also it is considered mathematical problem of WSN rational topology synthesis using routers based on UAVs. It was proposed a method of solving this problem using the knowledge base of specially designed rules of such routers placement, which avoids exhaustive search of network graphs to get close to the optimal solution in real time.

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Urban green zones' interaction with heat waves in Kyiv city

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Abstract: We studied the role of the urban vegetation of Kyiv city in mitigation of heat waves effect. By using UAV and satellite survey, different species and different plant density were compared at a level of a single tree, a residential block, street, and a residential district. Heat tolerance of different tree species was also tested. Clear relationships between greening level and average summer temperature within residential districts were observed. We found that a sufficient plant density for a residential block is 35% and this level mostly is not met in Kyiv. Among tested species, Horse Chestnut was found to be the most efficient species concerning cooling and CO_2 absorbance. The research can be regarded as a first step to the development of urban greening strategy in Ukraine considering climate change.

Keywords: green zones, urban vegetation, heat waves, climate change, UAV mapping, satellite mapping

Introduction

According to climate research data, Ukraine, as well as other European countries, faces climate change effects resulting in essential temperature increase and drought in summer months over the whole country (Hoornweg, 2010; Jylhä et al., 2008). Heat effects are critical in urban areas due to lower surface albedo, less air circulation, and less shading. Urban heat waves and heat islands are considered to be the major environmental problem of the 21th century (Taha, 1997). In 2003, more than 70,000 people died in Europe from a severe heat wave, and these extreme events will increase in coming years (Hoornweg, 2010).

Urban vegetation can decrease temperatures in cities through shading and evaporative cooling (Bernatzky, 1982; Dimoudi and Nikolopoulou, 2003; Georgi and Dimitriou, 2010). Besides, plants provide other positive effects in cities including CO2 absorption during daytime, noise isolation and dust retention. It can be considered that urban vegetation is an essential element forming city microclimate. A number of researchers around the world provided a scientific background for management of urban green zones (Adams and Smith, 2014; Georgi and Dimitriou, 2010; Helfter et al., 2011; Lindén et al., 2015; Ng et al., 2012; Norton et al., 2015; Skelhorn et al., 2014). However, these outputs cannot be extrapolated from one region on another due to a local specificity of climate, plant species, soils and water availability.

Our research aimed firstly assessing the actual level of greening in different parts of Kyiv and comparing it with average surface temperature. At the next stage, we studied shading properties of main tree species typically grown in Kyiv. And finally, we studied heat stress tolerance of different tree species themselves.

Methods

Satellite Thermal and Visual Mapping

Surface temperature map of Kyiv was generated on a base of thermal infrared imagery (TIR) derived by Landsat-8 satellite. Validation with ground temperature measurements and atmospheric correction was performed as described in Stankevich and Filipovich (2013). The temperature map was calculated as averaged surface temperature in June-August during 2013-2015 years period.

High-resolution (0.46 m/pixel) RGB image of Kyiv derived from World-View 2 satellite in 2015 was used to calculate the density of vegetation. For this purpose, supervised classification of the image was performed and the vegetation density was calculated as a percentage of “vegetation” class.

Thermal and visual map were spatially averaged on a base of a preliminarily created net of residential districts. Parks, reservoirs and private housings were excluded from calculations.

UAV-Based Thermal and Visual Mapping

To study temperature allocation around specific urban elements such as buildings, trees or flowerbeds, aerial thermal imaging of city areas was performed with an unmanned aerial vehicle (UAV). Three residential blocks, two boulevards and one street of Kyiv were mapped to achieve variability in tree density and species composition.

For the survey, we used thermal imaging camera Flir Vue Pro mounted on multi-rotor UAV DJI Inspire-1. The UAV was also equipped with RGB camera; therefore, thermal maps could be compared with visual maps. The flight was performed at 100 m altitude resulting in spatial resolution of 4 cm for thermal images and 3 cm for RGB images. The images were captured with 60-70% overlap and after preprocessing were stitched into orthomosaic using Pix4D software.

Gas-Exchange Measurements

In order to estimate the photosynthetic activity of park trees under a heat wave, we measured light-induced CO2 uptake by intact leaves of the trees with gas analyzing equipment. Five tree species which are the most typical for Kyiv were selected: Norway maple (*Acer platanoides*), Horse Chestnut (*Aesculus hippocastanum*), Small-Leaved Lime (*Tilia cordata*), Black Locust (*Robinia pseudoacacia*), and Black Poplar (*Populus nigra L.*). 15 mature trees were tested (3 leaves from the lower part of each tree species in threefold repetition) on midday at the sunny weather with the air temperature of 30-35°C in July 2016. CO2 fluxes were measured with CO650 Plant CO2 Analysis Package (Qubit Systems Inc., Canada) based on the infrared gas analyzer and leaf camera (3 x 3 cm) with a stable light source (LED). A detailed description of the gas-exchange system can be found at http://qubitbiology.com.

Results

Surface temperature and plant density distribution in different residential districts of Kyiv has been analyzed; the most heated areas are located in Eastern part of the city, where average summer surface temperature reaches 35-37°C. These areas correspond to relatively new districts (Troyeschyna and Poznyaky) with the lowest level of vegetation density of 0-10%. The temperature in the range of 34–35°C is also observed in the Northern part (Obolon district) and central areas of the city. The vegetation density in these areas reaches 10-15%. The lowest temperatures are found in the residential blocks of the Golosiyivskiy District, Borschagivka, Svyatoshyno, and Syrets. Surface temperature there does not rise above 33°C, and green areas cover 20-40% of the territory.

There is a clear relationship between temperature patterns in residential blocks and density of green areas. Most of the newly built-up areas suffer from heat due to exceedingly rare plantings. Oppositely, in old regions of Kyiv dense tree covering provides a significant cooling effect.

The analysis of thermal and visual maps of three residential blocks with various plant densities, calculated as surface coverage by vegetation (7%, 35% and 47%), has indicated several cooling capacities of plants:

1. The surface temperature of trees and grass plots is significantly lower than the temperature of other surfaces. While the temperature of asphalt and roofs can reach 45°C and more, vegetation does not heat above 25–30°C. This is primarily caused by higher reflection of sunlight (vegetation is lighter than asphalt), and, secondly, by evaporation of water from the leaf surface, which results in a temperature drop.
2. Tree surface is cooler than the surface of grass plots. The reason is that the volume of canopies is larger than the volume of grass plots, and therefore trees have a higher heating capacity per square meter of surface.
3. Most trees create good shade sufficient for significant cooling of the shaded surface. The temperature of shaded surfaces can be close to the temperature of the plant itself, i.e. 25–30°C.

Finally, visual and thermal mapping together with temperature classification of fragments of two Kyiv boulevards have been indicated that:

1. Horse Chestnut provides most shade and surface cooling: trees with canopies of 8 to 12 m in diameter planted in two rows with the frequency of 1 tree/15 m provide cooling of the whole territory in between the trees, with street coverage by vegetation is 68%. This value could be used as a benchmark to ensure the homogeneous cooling of territory.
2. Poplar produces the least amount of shade. Even in the case of planting density 1 tree/7.5 m cooling occurs in shaded zones only, which account for 10% to 30% of the surface depending on the position of the Sun.
3. Maple provides sufficient shade; however, its size is smaller compared to Horse Chestnut, and therefore with the same planting density Horse Chestnut will provide more efficient shading and cooling.

Tolerance of trees to heat waves was assessed as a measure of photosynthetic activity of intact leaves under air temperature of 30-35 °C; Black Poplar demonstrated the highest and maple demonstrates the lowest CO_2 assimilation rates. Horse Chestnut, Lime and Locust revealed nearly similar photosynthetic rates. Following the results, Black Poplar and Maple were ranked as the most and the least heat-tolerant species correspondently.

Discussion

According to our results, in Kyiv city vegetation plays a significant role in forming the local microclimate. Temperature patterns in residential blocks clearly depend on the density of green areas. Most of the newly built-up areas suffer from heat due to non-observance of standards applicable to the size of green areas within residential territories. Green zones are almost absent in the areas adjacent to industrial facilities, major roads, and junctions. The lack of greening causes extremely high temperatures and creates a threat to health and life of citizens.

Gas exchange and high-resolution thermal imaging research identified pros and cons of particular tree species. Poplar tree turned out to be the most resistant to high temperatures, having got more active photosynthetic processes during the heat wave. Horse Chestnut, Black Locust, and Linden demonstrate smaller but still high photosynthetic activity during hot weather. However, due to its pyramid shape, Poplar does not provide a sufficient shadow and surface cooling. Structure and form of black locust canopy suggest that this species will provide less shade than Horse Chestnut. Maple creates a good shadow, although it is vulnerable to heat stress. Horse Chestnut is, therefore, the most efficient species in term of making a comfortable microclimate for citizens during heat waves. It actively absorbs carbon dioxide and releases water during summer heat waves, creating a deep shadow.

We performed a set of metrics calculations that can be used further as a guideline for municipal services. In particular, we found the minimum sufficient vegetation density in residential blocks is equal 35%. In most of the residential blocks of Kyiv, this level is not met. We also calculated the density of tree planting that could provide cooling effect even in unshaded areas. However, in order to develop a strategy for effective urban greening in Ukraine, these data should be updated with wider research that will include more climate parameters, different cities, and different weather conditions.

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