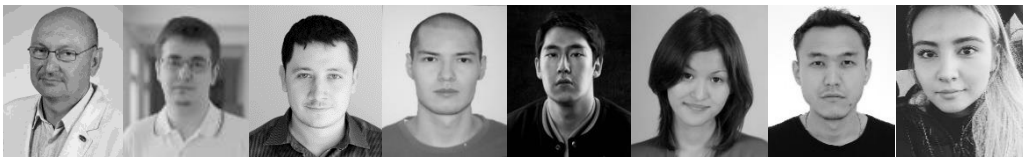
Intelligent unmanned aerial vehicle technologies

R Muhamedyev[1,2,3]*, K Yakunin[1,3], Y Kuchin[1,3], A Symagulov[1,3], S Murzakhmetov[1,3], M Ospanova[1], I Assanov[1], M Yelis[1]

[1]Satbayev University, Kazakhstan, Almaty, Satpayev str., 22A
[2]ISMA University of Applied Sciences, 1 Lomonosova str., bld. 6, Riga, Latvia
[3]Institute of Information and Computational Technologies. Kazakhstan, Almaty, Pushkin str

**Corresponding author's e-mail: ravil.muhamedyev@gmail.com*



Abstract

We consider the economic and technological prerequisites for the use of Intelligent Unmanned Aerial Vehicle Technology (IUAVT) in an urban environment to solve the following problems: monitoring hazardous geophysical processes, environmental pollution monitoring, monitoring of technical and engineering structures, traffic monitoring. We discuss research problems and the main limitations that need to be solved to use IUAVT effectively.

Keywords: unmanned aerial vehicles, urban environment, environmental pollution monitoring, monitoring hazardous geological and geophysical processes, machine learning.

1 General

Successes in urban management are usually associated with the collection and practical application of large amounts of data, including spatially distributed resources and objects for monitoring and process control. This data can be collected using stationary systems, platforms with low mobility (for example, using cars) and several types of highly mobile platforms (spacecraft, aerial photography, unmanned aerial vehicles (UAVs)). Among listed technologies, UAVs have very serious advantages in obtaining data of a small and partly medium scale in terms of efficiency, cost, and resolution (Table 1).

Table 1 Applications of spatially distributed data acquisition systems

Type of machine	Radius of action	Cost	Operativeness	Resolution and cost	Main limitations	Source
Satellites	Unlimited	27$/km^2-Geo 44$/km^2- Geostereo	Up to 60 days Up to 100 days for stereo shooting (Note 1)	0.46 m for panchromatic photographs, 1.86 m for multispectral.	Resolution, especially for multispectral photographs. Minimum scale 1: 10000 (for panchromatic images). A more accessible view of Geo satellite images requires a digital elevation model obtained from other sources.	[1, 2]
Airplanes and helicopters	150 km on average	Depends on the area 2200 $ / km2 with an area of 5km2, 30 $ / km2 with an area of 750km2.	5 days and more (note 2)	Up to 0.04 m	High cost of rent for flights, very high cost of shooting in case of small area.	[3, 4]
UAV	On average 10 km	Depends on area 750 $ / km2 with an area of 5km2, 15 $ / km2 with an area of 750km2	1 day	Up to 0.04 m	Limitations on payload weight and flight time, control requires a high-bandwidth communication channel. Weather dependent.	[1, 3, 5]

It is necessary to solve the problem of developing technologies for data collection using highly mobile platforms and data processing to support decision-making in the city management system.

The use of such data is relevant when specialists deal with spatially distributed technical or natural systems. Such systems in the city include a significant group of human life support systems, transport, technical and architectural structures, etc. Such problems could be solved with the help of intelligent technologies, which include machine learning and decision support systems. In this regard, the set of solutions combining artificial intelligence systems and UAV-based platforms will be called Intelligent Unmanned Aerial Vehicle Technology (IUAVT).

We consider the economic and technological prerequisites for the use of UAV-based data acquisition systems in an urban

environment to solve the following problems:

- Monitoring hazardous geophysical processes;
- Environmental pollution monitoring;
- Technical and engineering structures monitoring;
- Traffic monitoring.

We determine research areas and problems that need to be solved to use them effectively.

One of the significant components of the IUAVT is computer vision, which should solve the tasks of object identification (cv1), object verification (cv2), object recognition (cv3), determining the distance to objects and their visible characteristics (speed, size, etc.) (cv4).

The most advanced algorithm for solving the cv1 problem is the YOLO algorithm [6]. An example of the Use of such network for traffic evaluation in Almaty has shown in Figure 1 provided by the Flycam [7].

Figure 1. Recognition of traffic objects in Almaty

To solve problems cv1, 2, 3, the Siamese networks [8] are effectively used, when two images are processed by two identical pre-trained networks. As a result, image vectors are calculated, then compared with each other using the triple component loss function (Triplet loss). Methods for solving the cv4 problem depend on the subject area and technical support.

The main limitations of the IUAVT are [9]:

- Limited flight time;
- Weather dependence;
- Limited payload;
- Limitations in solving computational problems on board of the UAVs;
- Legal restrictions on the use of UAVs in urban conditions;
- To solve highly specialized problems, it will be necessary to create specialized data sets and models of neural networks;
- Control problems.

2 Conclusion

Therefore, due to mobility, efficiency and relative cheapness, UAVs are becoming an important tool for ensuring the sustainable development of megacities and improving the urban environment. Using intelligent UAVs to solve the above problems of urban management is determined by economic and social preconditions.

Although, in the process of applying IUAV, methods of overcoming technical limitations (limited battery capacity, significant dependence on weather conditions, limiting the payload weight), solving data processing problems (pattern recognition and classification for special cases, processing large volumes of data) and control (flight indoors and without a GPS signal, flight of a UAV group) should be proposed.

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