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**СУЧАСНІ МЕТОДИ ДОСЛІДЖЕННЯ ПАРАМЕТРІВ ДОРОЖНЬОГО РУХУ****Паснак І.В., Рогальський Р.Б., Грицюк С.А.****MODERN METHODS OF STUDYING THE PARAMETERS OF TRAFFIC****Pasnak I., Rogalskyi R., Hrytsiuk S.**

*The purpose of the work is to analyze and improve modern methods of studying the parameters of traffic with using of unmanned aerial vehicles. The basis of the analysis of the current state of the problem is the necessity of developing a new way of studying the parameters of traffic for increasing the efficiency of transport research. The method of studying the parameters of traffic in which the use of unmanned aerial vehicles with a digital video camera will allow the study of traffic parameters in different places of the street-road network by flight and hovering over the necessary areas of the street-road network with the receipt of video recording of traffic. For realization of the presented method of studying traffic, an algorithm for conducting studies of parameters of transport and pedestrian flows has been developed. Requirements for the technical means for carrying out researches are described and the possible variants of researches using the offered method are described.*

**Keywords:** transport research, efficiency improvement, traffic flow, pedestrian flow, research algorithm, street-road network.

**Introduction.** Owing information on the current state of the problems in transport, obtained through a variety of research methods and data analysis, is a prerequisite for planning and designing a street-road network (RN) and improving road traffic organization. This is the basis for substantiating the proposed solutions on compliance with existing problems, eliminating existing deficiencies and improving the conditions of the transport system. The rapid growth of automation requires a systematic approach to ensure the functioning of the field of road traffic. The basis of this approach is the study of connections and dependencies in the system "Road conditions – traffic flows".

It is known that speed is the most important parameter of a traffic flow and determines the traffic performance. However, along with the speed, the first of two main target traffic functions is still traffic safety. In order to perform tasks related to salvage and assistance, special-purpose vehicles of the operational services should be able to move quickly and safely in difficult road-transport conditions. However, the growth of au-

tomobile leads to over-saturation of vehicles on RN, which significantly influences the main parameters of the traffic flow, in particular on speed, density and traffic intensity. Therefore, the specified requirements for the movement of special vehicles cannot always be combined in practice. The above example is one of many current issues to solve, which will help develop and implement new methods for studying traffic parameters.

**Formulation of the problem.** Transport research is a process of collecting information about a road or other mode of transport. The purpose of such research is to create preconditions (by getting initial data) for planning, designing and optimizing in the system "Road conditions – traffic flows". Also, the data obtained by the above will be useful for optimizing the routes of traffic of special vehicles and the safety of their movement [1].

In today's conditions, in most cases, the collection of information on the parameters of transport and pedestrian flows is carried out by the method of field observations, which involves the involvement of a number of accounting targets. However, with the development of advanced technologies, the possibility of their application in various areas of human activity raises the question of the feasibility of involving a large number of people in conducting transport research. Therefore, the issue of maximal automation of such activity with the attraction of a minimum number of researchers seems to be actual.

Taking into account the above, improving the efficiency of research of parameters of transport and pedestrian flows by developing a new method of conducting road traffic parameters is an actual task of the present day and has a scientific and practical value.

**Analysis of recent research and publications.** The authors of this work have begun studies in the foreground [1, 2], but they relate mainly to the analysis of the current state of the problem and the coverage of perspective directions of study of traffic parameters. Similar issues were considered in [3], where the author car-

ried out an analysis of perspective directions of the use of quadrocopter in the elimination of fires and emergency situations, as well as other studies.

It is also worth noting the work of foreign scientists, where such issues were considered. In particular, in [4] the possibility of using quadrocopter devices for studying the parameters of pedestrian flows is considered. [5] examines the use of an unmanned aerial vehicle (UAV) for collecting traffic data, in particular defining the type of vehicle and tracking its traffic. The possibility of monitoring traffic flows using UAVs and further processing of received video materials is presented in [6]. The article [7] considers the optimization of UAVs routes for gathering information on traffic flows. However, the given work deals only with certain cases of research and information gathering, therefore, it is necessary to develop a method for studying the parameters of the traffic, which would provide an increase in the efficiency of research of parameters of transport and pedestrian streams for solving problems in the field of traffic organization and other related sectors of activity.

**Purpose of the article.** The purpose of the work is to analyze and improve modern methods of studying the parameters of traffic with using of UAV.

**Main content.** In order to obtain traffic intensity indicators in the section of roads, data from short-term observations of intensity and composition of the flow at a stationary accounting point can be used. The calculation of the intensity of traffic in this case is carried out with the obligatory division of the flow composition by capacity, indicating the time and date of observation. However, taking into account the costs necessary for the establishment and maintenance of stationary points of study of traffic, for the study of road traffic indicators it seems expedient to use modern technical means for fixing traffic flows, which would limit the need to attract people for research [8]. In the aforementioned direction, it was suggested to use a method with the use of a DVR for the study of road parameters (Ukrainian Patent №79573).

This method of studying the parameters of traffic involves the use of a DVR installed in a passenger car. The car is parked in the place of RN, which is necessary for research, and the study of the parameters of traffic [8] is underway.

Video registration can be carried out both in the presence of a person and autonomously. After conducting the necessary research, the results are processed by the use of a personal computer. The obtained data can be displayed in the form of tables or charts depending on the task of the research. For conducting research it is expedient to determine the intensity of motion by the method of field observations using the method of 6-minute intervals of time. This method is to measure the number of cars on the section under study 6 minutes in the morning (8.00) and evening (18.00) high periods, as well as in the afternoon (13.30).

However, this method has a number of shortcomings, since it provides for the fixation of the traffic flow only in a certain section of RN.

For a more complete picture during the processing of video materials, it would be advisable to ensure that the camera is mounted on top of the subject under study (for example, crossroads) in order to be able to comprehensively explore the parameters of motion in all directions. Here, the use of a quadcopter, which will allow video recording of transport and pedestrian streams by "hovering" above the intersections and obtaining better video, looks promising. In the future, it can be processed in the office environment, which will reduce the number of researchers [1].

It is worth noting that today unmanned aircraft is actively developing (development of UAVs, in particular drones, multicopters, etc.), since the scope of their applications is extremely wide. Already today they are used in many areas of human activity, in particular in agriculture, during the construction of various objects and structures, for search and rescue operations, delivery of correspondence, etc. Quadcopters have also found their application in photography and cinematography, because they can easily and inexpensively make pictures from a height and at different angles. As we see, world experience shows that quadcopter machines can be an effective tool for monitoring and mapping the territories, and research in this area is extremely important and promising [1].

Taking into account the above, a method of studying the parameters of the traffic (the application for a patent of Ukraine u 2017 08079) was developed. The work of the method of studying the parameters of the traffic consists in the use of UAV with a digital video camera, flight and hovering over the necessary areas of RN for receiving video recording for control of traffic parameters. As a result, it is possible to reduce the reaction time to change the parameters of the traffic, to reduce the time of obtaining data on the parameters of traffic in the required places of RN by flight and the freezing of the UAV with a digital video camera with the receipt of video recording of the traffic process.

For the implementation of the proposed method of studying the parameters of traffic with the use of UAV, an algorithm for carrying out research on transport and pedestrian flow parameters is presented (Fig.) [11].

Taking into account [1, 9], it is recommended to use quadcopter with the following parameters for transport studies [11]:

- a camera with high resolution (for clear video shooting of transport and pedestrian streams);
- the possibility of GPS guidance (to increase the effectiveness of positioning over a certain area of RN);
- the possibility of "hovering" over the specified place (in order to obtain a clear video of the object under study);
- auto-return in emergency situations (to prevent loss of a quadcopter in the event of low battery charge or poor signal of the control link);
- increased autonomy of work (to ensure continuous video capture);
- increased range of information management and communication (to enable the possibility of exploring large sections of RN or a separate transport area).

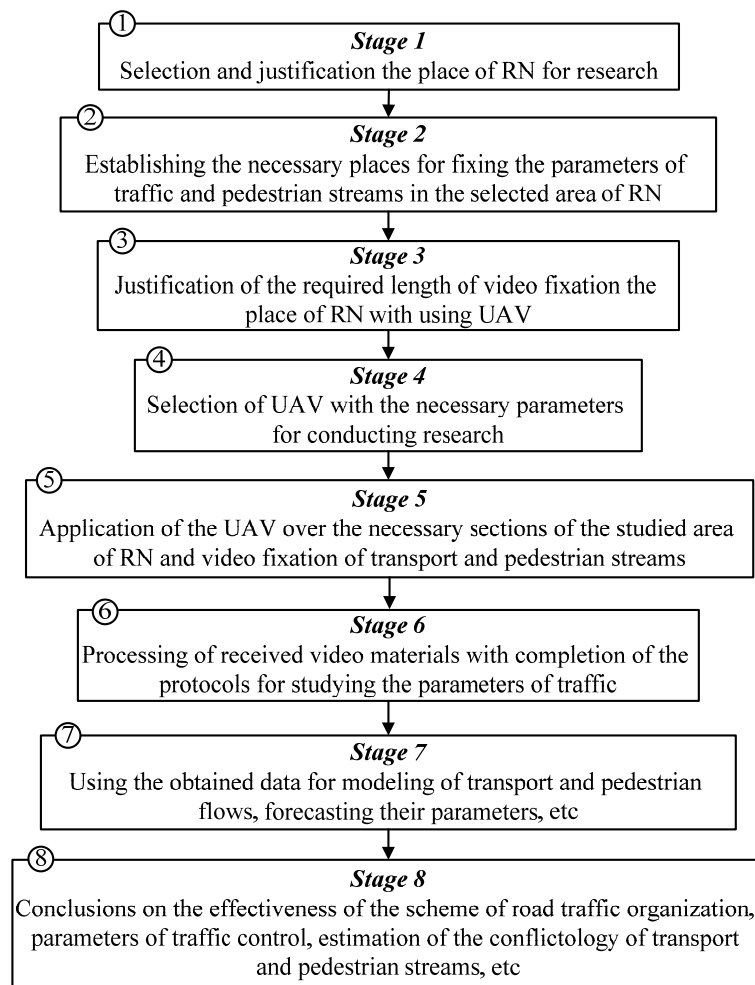


Fig. Structural diagram of the simulation model for studying the parameters of transport and pedestrian flows using the proposed method [11]

Working out a video in office conditions will allow the researcher to obtain the following data [1, 9]:

- intensity and composition of traffic on RN;
- the intensity and composition of the traffic on the roads that enter the city;
- intensity of pedestrian traffic;
- speed of traffic on RN;
- traffic delays at intersections and in separate sections of RN;
- the location and conditions of the parking of vehicles;
- initial data to optimize the route of special vehicles [10, 12];
- conditions of movement in points of periodic accumulation of people (stadiums, parks, stations, etc.).

So, as we see, the using of quadcopter in the field of transport research will make it possible to substantially facilitate the work of researchers and increase the efficiency of their work, and the resulting video material will also be useful during the educational process to improve the quality of student perception of material.

**Conclusions.** The basis of the analysis of the current state of the problem is the necessity of developing a new way of studying the parameters of traffic for in-

creasing the efficiency of transport research. The method of studying the parameters of traffic, in which the use of UAVs (dron, quadcopter, multicopter, etc.) with a video camera, allows to study the parameters of traffic in different places of RN by flight and hovering over the necessary areas of RN with the receipt of video recording of traffic. To implement the proposed method with the use of UAV, an algorithm for conducting research of transport and pedestrian flows parameters was developed. The requirements for UAV for conducting research are outlined and possible research options are described with the use of the proposed method.

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**Паснак І.В., Рогальський Р.Б., Грицюк С.А.** Сучасні методи дослідження параметрів дорожнього руху.

На підставу аналізу сучасного стану проблеми обґрунтовано необхідність розроблення нового способу дослідження параметрів дорожнього руху для підвищення ефективності транспортних досліджень. Розглянуто спосіб дослідження параметрів дорожнього руху, в якому застосування безпілотного літального апарату з цифровою відеокамерою дасть змогу здійснювати дослідження параметрів дорожнього руху в різних місцях вулично-дорожньої мережі шляхом польоту та зависанням над необхідними ділянками вулично-дорожньої мережі із отриманням відеозапису дорожнього руху. Для реалізації представленого способу дослідження дорожнього руху розроблено алгоритм проведення досліджень параметрів транспортних та пішохідних потоків. Окреслено вимоги до технічних засобів для проведення досліджень та описано можливі варіанти проведення досліджень з використанням запропонованого способу.

**Ключові слова:** транспортні дослідження, підвищення ефективності, транспортний потік, пішохідний потік, алгоритм досліджень, вулично-дорожня мережа.

**Паснак И.В., Рогальский Р.Б., Грицюк С.А.** Современные методы исследования параметров дорожного движения.

На основании анализа современного состояния проблемы обоснована необходимость разработки нового способа исследования параметров дорожного движения для повышения эффективности транспортных исследований. Рассмотрен способ исследования параметров дорожного движения, в котором применение беспилотного летательного аппарата с цифровой видеокамерой позволит проводить исследования параметров дорожного движения в разных местах улично-дорожной сети путем полета и зависанием над необходимыми участками улично-дорожной сети с получением видеозаписи дорожного движения. Для реализации представленного способа исследования дорожного движения разработан алгоритм проведения исследований параметров транспортных и пешеходных потоков. Определены требования к техническим средствам для проведения исследований и описаны возможные варианты проведения исследований с использованием предложенного способа.

**Ключевые слова:** транспортные исследования, повышение эффективности, транспортный поток, пешеходный поток, алгоритм исследований, улично-дорожная сеть.

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