Application of robotic systems for fire exploration

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***Abstract*—Robotic systems find their application in many areas of people life nowadays. This research work summarizes the using of a quadcopters for fire exploration with an information-reading algorithm, methods of processing of image color component data, and processing video for fire detection.**

***Keywords*—robotic system, quadcopter, fire exploration, processing of image, fire detection.**

I. Introduction

Nowadays, it is actual using robotic systems in different areas. One of the important problems in Kazakhstan is fire safety and the researches on it has been and remains substantial in Kazakhstan. The relevant application of robotic systems and information technologies in fire safety is using quadrocopters for fire exploration.

Quadrocopters are quite expensive devices that require certain management skills and craftsmanship. In this regard, the use of copters in fire safety is not as extensive as we would like. The widespread use of quadrocopters in the prevention of fire and early detection is the future of fire safety of Kazakhstan. For fire prevention and early detection of fires, quadrocopters are used as surveillance and reconnaissance devices. These quadrocopters are provided with special video cameras and thermal imagers. Quadrocopters are used to monitor large areas, difficult to access and few passable places. [7]. Such locations include forests, peatlands, swamps, mountains, steppes, landfills and more. Copters are also used to check thermal points from satellite images.

There are facts of using quadrocopters for patrolling and monitoring the fire condition of large enterprises and warehouses. Previously, this function was performed by numerous security officers and fire brigades, with constant patrolling and bypassing the territory. Subsequently, their work is performed by several trained employees who, with a certain periodicity, fly around the territory. The most effective actions of which are noted at night, when patrolling the territory of the object using a thermal imager.

During a fire, the key to extinguishing is the choice of the decisive direction for extinguishing the fire. To make such a decision, it is necessary to have as much information as possible about the fire and the object of the fire. But due to the large areas of facilities, complexity and location, it's difficult for a person to come to a fire to assess the scale of the incident and make the right decision as quickly as possible. In connection with the above, progress came to the aid of firefighters [3].

At the moment, the main task of quadrocopters is a fire exploration from the air. Upon arrival to the fire, the specialist as soon as possible launches the quadrocopter and begins to collect information about the fire, namely:

• location of victims in the territory of the fire;

• the location of people at risk from fire and secondary factors;

• determination of sources of ignition;

• threat of fire spreading to other buildings and structures;

• convenient places of approach and access to places of burning and evacuation.

Detection of fire or flame by remote photography or video recording of controlled terrain and their automated analysis are important tasks. Now widely used computer systems using digital image processing. The paper proposes an approach to solving this problem, based on the use of a quadcopter as an unmanned aerial exploration robot and data processing of the image from the robot, which contain or not contain a fire.

Fig.1. Quadcopter with camera for fire exploration

II. Method of fire detection

Analysis of digital video. The functioning of monitoring systems can be based on the analysis of photographs or video sequences, in other words, static or dynamic images. There are two main approaches: the detection of moving objects and color analysis.

The basic idea of building the algorithm (Fig. 2) is that the optimally selected combination of different approaches, each of which allows determining a specific flame feature with high accuracy, it must determine the presence of a flame on video frames received from a quadcopter camera with a high probability.

The flame has a large number of different signs, such as color, variability (dynamics), shape, and the behavior of the smoke that appears with the flame, etc. In this work, following the article [1], attention is focused on two basic signs - color and variability (dynamics).

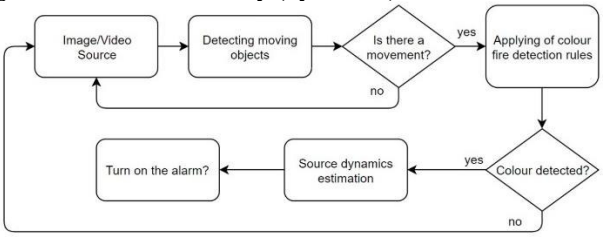

Fig.2. Proposed Fire Detection Algorithm

The principle of detecting moving objects is often used to highlight fires by subtracting successive frames or a background image [2]. In the first case, it finds changes in the images when moving from one frame to another. The main

disadvantage of this method is that overlapping areas in images can be mistakenly taken as background.

In the case of subtracting the background image, the dynamic areas are extracted from the static background image, the main disadvantage is that the area can be extracted erroneously, if the background image is not updated on time or incorrectly. However, this method can be used to assess the characteristics of the fire, for example, to measure the coordinates of a fire front.

Another way to detect areas of fire is color analysis. Specific implementations of this method are based on space analysis of abstract mathematical color models, which are sets of 3-4 numbers. The most common color models are [6]:

- RGB describes each color with a set of three coordinates, each of which corresponds to the decomposition of a color into red, green and blue components;
- YCbCr is one of the ways to encode RGB information, where Y is brightness, Cb and Cr are characterize gamma correction;
- HSL or HSI describes each color with a set of three coordinates - color hue, saturation, lightness [8];
- HSV describes each color with a set of three coordinates - hue, saturation, value

Based on the methods describing the flame in the RGB color model, we find belonging of pixel to the flame image based on the rules by the system [3]:

$$\begin{cases} R(x,y) > R_{mean}, \\ R_{mean} = \frac{1}{K}\sum_{i=1}^{K} R(x_i, y_i), \\ R(x,y) > G(x,y) > B(x,y) \end{cases} \quad (1)$$

where, $R(x,y), G(x,y), B(x,y)$ - red, blue and green values in pixel *(x, y)*, K - total pixels, R_{mean} - average intensity of red color on the basis of three selected rules, according to which the saturation of each possible pixel of the flame image must be greater than a certain threshold value [5].

In some cases, it is possible to describe a flame image in the YCbCr color space, using a fuzzy inference system [4] to make a decision about whether a pixel belongs to a flame image.

Dynamic characteristics of fire allow allocate it from other objects of similar color. Analyzes for temporal changes in intensity for each pixel on several consecutive frames [8]. If these changes exceed a certain threshold value, it is taken for a pixel that belong to the image of the flame. It is assumed that the height of the flame changes with time due to the movements of its tongues, therefore the height is the main dynamic characteristic of the flame [9].

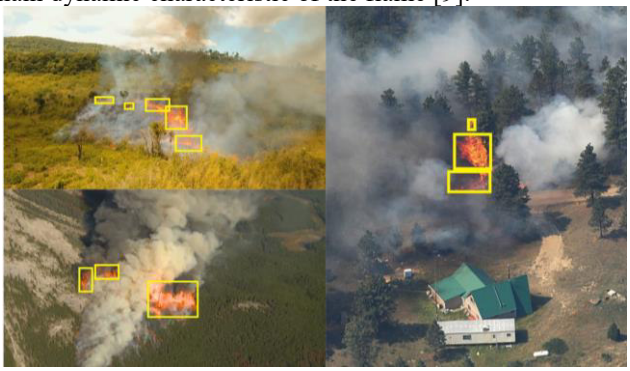

Fig.3. Examples of fire detection from video

In some cases, we take the history of changes in the red channel of each pixel of an RGB image belonging to the fire contour during a short period of time [9]. This data is then used as input in the analysis.

Experimental works carried out based on the above methods of detecting fire. The main aim of this example is to automatically detect fire in video (Fig.3), using computer vision, implemented in real-time with the aid of the OpenCV library. Given the computer vision and image processing point of view, stated problem corresponds to detection of dynamically changing object, based on his color and moving features [11].

III. CONCLUSIONS AND FURUTE WORKS

Thus, the existing results suggests that robotic systems with information technologies can be used for fire exploration and fire detection. Theoretical researches and practical experiments shows that the quadcopter is a multifunctional device that combines automatically the execution of a flight program from takeoff to landing, transmitting the necessary information to detect fire by using data from photographing controlled areas with subsequent computer processing of data. The use of modern image processing tools can significantly improve the efficiency of solving many practical problems. Based on this, future work is the optimization of an automated fire exploration system, the improvement of fire exploration methods using robotic devices.

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