Navigation Issues Based on Images

Adalat Pashayev
İnstitute of Control Systems
Azerbaijan National Academy of Sciences
Baku, Azerbaijan
adalat.pashayev@gmail.com

Ulviyya Kadasheva
İnstitute of Control Systems
Azerbaijan National Academy of Sciences
Baku, Azerbaijan
kadaseva.ulviyyee@gmail.com

***Abstract*—Unmanned aerial vehicles are effectively used to monitor the transport corridor. The research is dedicated to the provision of autonomous movement during the flight of unmanned aerial vehicles in the transport corridor. For this purpose, some issues of autonomous navigation of unmaned aerial vehicle are considered.he research is dedicated to ensuring the autonomous navigation of unmanned aerial vehicles. To ensure this navigation without the use of GPS, the method of navigation by reference objects encountered in the video is considered. In the research work, the main object of reference is non-dividing, non-intersecting roads in the transport corridor.**

Keywords—unmanned aerial vehicle, navigation, autonomous, invariant, image recognition, transport corridor monitoring

I. INTRODUCTİON

In modern times, unmanned aerial vehicles have a wide range of uses, both in military and civilian conditions. Examples include monitoring of transport corridors, transportation, and so on. The use of unmanned aerial vehicles is one of the most effective methods of monitoring transport corridors. Any transport corridor can change due to both man-made and natural influences. Monitoring of this transport corridor is one of the conditions for safe and effective use of the corridor. One of the such issue is the location, tracking and control of unmanned aerial vehicles. These devices have different navigation methods. Currently, one of the main approaches in this direction is the application of GPS technology. GPS - global positioning system allows to determine the coordinates of the device with high accuracy by receiving electromagnetic signals from the satellite network, working in continuous mode. This technology, which is applied to unmanned aerial vehicles, determines the location of the device and regulates its movement [1].

For autonom navigation of unmanned aerial vehicle (UAV) investigates in [2]. An UAV receives current coordinates from a GPS receiver via a Bluetooth connection with a navigator computer without human intervention. With this point, the optimal trajectory is drawn to the next destination. During the flight, the navigator computer provides information on which direction and how far to turn. This information is used in the servos of unmanned aerial vehicles.

To date, unmanned aerial vehicle navigation techniques have been proposed in three main categories. 1) inertial navigation; 2) satellite navigation; 3) vision-based navigation. Visual-based navigation from these methods provides richer information about the earth's surface and objects than others [3].

It is possible for unmanned aerial vehicles to navigate with GPS in the open air, at an altitude without any obstacles. However, at lower altitudes, where obstacles may be present, this approach is not appropriate. [4] proposed optical flow navigation for autonomous movement of unmanned aerial vehicles in such areas.

During the flight of drones in a given corridor, navigation is carried out mainly by GPS technology. However, in case of any problems with the use of GPS, it is effective to apply the method of navigation based on videoimages. In the presented paper it is proposed a method of navigation based on the images displayed by the camera.

II. PROBLEM STATEMENT

The main disadvantage of the widely used GPS method is that the performance of unmanned aerial vehicles is completely dependent on GPS. Where there is no GPS, there are obstacles to the movement and control of these devices. For this reason, a system is required for unmanned aerial vehicles to navigate autonomously which is not depend on GPS.

Various methods have been proposed to regulate the autonomous navigation of unmanned aerial vehicles without the use of GPS. Some of the methods are shown in the introduction. Other one of such method is vision-based navigation. The main approach in this method is to determine current location of UAV based on observed objects by the device and their coordinates. Observed objects include power plants, roads, bridges, road crossings, buildings and other infrastructure facilities, as well as single trees, steep cliffs, rivers, lakes and other natural objects. The device recognizes these objects and determines its current coordinates and location based on their coordinates. The images and coordinates of the objects must be known in advance. To store this information, a database is created and the parameters of the objects are processed and placed in the database. The image obtained by the device must also be processed. The results obtained are compared with the data in the database to determine which of these objects corresponds to the database. The location of the device is determined based on the coordinates of the image object. It is known that there are always roads in the transport corridor. The problem statement is to develop an algorithm identification of roads - curves, windings in the transport corridor based on vision.

III. PROBLEM SOLVİNG

As noted, important infrastructure, such as reference objects, is used to find location of the device. Roads in the transport corridor are taken such as infrastructure in the research. Thus, the device must take a photo of the earth's surface during flying without GPS. Depending on the road in the image, it must determine its approximate location.

The following approach has been proposed to solve the problem.

To solve the problem, firstly must be known the images and coordinates of all the roads that the device can observe. Certain characteristics are determined by processing these images. These characteristics are placed in the database as a factor indicating the appropriate road. The unmanned aerial vehicle captures video of the earth's surface during the flight, if there are paths in these images, finds them. Relevant features are also determined from the images received by the device, as well as certain features determined from the processing of the images placed in the database. These features are compared with those in the database and the appropriate one is selected.

Through the application of this method, drones can provide autonomous movement on the trajectory without GPS. There are a number of problems here. Images from unmanned aerial vehicles have a number of features. Thus, the device can capture images in different forms: at different distances, at different angles, in different directions and scales. With this in mind, it is necessary to find characteristics that allow to eliminate these problems.

Each of the part of roads can be identified as a curve, because the research is focused curved roads. There are different methods for identifying curves: interpolation polynomials, Bezier curves, etc. However, the B-spline model is chosen to identify the curves in the study. The main reason for choosing this method is that the B-spline is stable invariant to operations such as rotation and scaling. Application of the B-spline method provides invariant identification of curves [5,6,7].

A. *Application of B-spline method*

In this method the given continuous connected curve is divided into several segments. Each segment includes the same number of control points. The displacement of any control point affects only the segment into which this point enters. The procedure for constructing curves with a B-spline is given in (1).

$$Q(u) = \sum_{i=0}^{n} P_i N_{i,k}(u) \quad (1)$$

In this equation:
u is a parameter of the function representing the curve parametri, $u=n-k+2$
n is defined as number of control points -1,
$P_i(x_i, y_i)$ – control points,
$N_{i,k}(u)$ – basis function,
k is the number of points per segment on which the curve is divided and $2 \le k \le n+1$ is true for k.

The construction of the B-spline is based on the structure of the basis function $N_{i,k}(u)$. The procedure for setting up basis functions is given in (2).

$$N_{i,k}(u) = \frac{u-t_i}{t_{i+k}-t_i} N_{i,k-1}(u) + \frac{t_{i+k+1}-u}{t_{i+k+1}-t_{i+1}} N_{i+1,k-1}(u) \quad (2)$$

$$t_i = 0,1,2, \dots n+k$$

As can be seen from the structure of the base functions, these functions do not depend on the control points. For this reason, both the road images placed on the base and the curves of the road images received by the device are approximated by the B-spline and control points are determined. The base characteristics of the B-spline are its control points. Control points are placed in the database as a characteristic.

B. *Image processing*

As mentioned, the placement of previously known roads (curves) in the database means the determination and placement of certain characteristics (control points) from these roads. A comparison between curves also means a comparison of their corresponding characteristics. In order to obtain these characteristics from the images and to construct a suitable spline, the image must be processed and separated from the image as a road curve.

As known, the images taken will not consist only of roads. The image will contain unnecessary objects and pixels. Therefore, firstly the images must be cleaned of "dirty" data. Non-informative pixels are discarded by image processing, as it is more efficient to work with images that have only the required number of dots. When it comes to image processing, there are a few steps involved. The steps and sequence of these are shown below.

1) Converting the image to a grayscale image.

Images are given us in color RGB format. Instead of working with different colors, it is better to make the image a single color. The conversion method is given below:

$$0.3R + 0.59G + 0.11B \quad (3)$$

Here, R, G, B represent the red, green, and blue color distribution in the image pixel, respectively [8].

2) Smoothing.

Each image may contain random, unnecessary pixels and a collection of pixels. For example, a shadow, a small object flying outside, and so on. Working with images means working with pixels and their colors. Therefore, these factors are affected and it is advisable to discard them during processing. Using the smoothing algorithm, the image is cleared of "adventitious" pixels.

3) Edges detection of objects on the image.

Defining the edges of objects in the image brings the image to black and white. At this stage, the Canny Edge Detection algorithm is applied. Only black (or white) pixels play an informative role after the application of the edge detection algorithm [9, 10].

4) Extracting object from image.

At this stage, it is required extract the road-curve from the various objects in the image. To do this, using the Connected Component Labeling algorithm, each object in the image is extracted as a separate set of pixels [11]. Of these sets, it is assumed that it represents the required curve which have the most pixels.

C. *Thinning*

At the end of the processing, the image should be in black and white, consisting only of a curve. Despite the processing of the image, the curve in the final image will not be at the desired thinness. It is necessary to thin the thickness of this curve to 1 pixel. After the thinning operation, the number of black dots in the image decreases again. It is important to apply this algorithm. In the last step, the curve in the image should be taken as a sequence of pixels instead of a set of pixels. The construction of this sequence is done by checking the adjacent pixels of each pixel. To build this sequence is

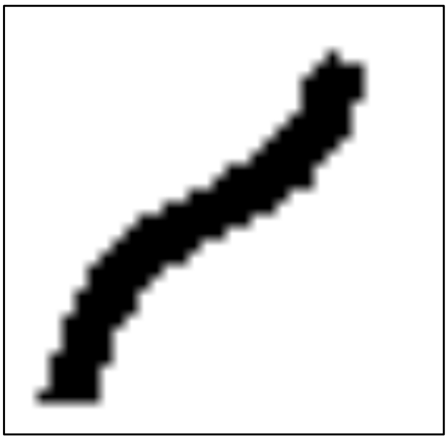

Fig. 2. Given curve

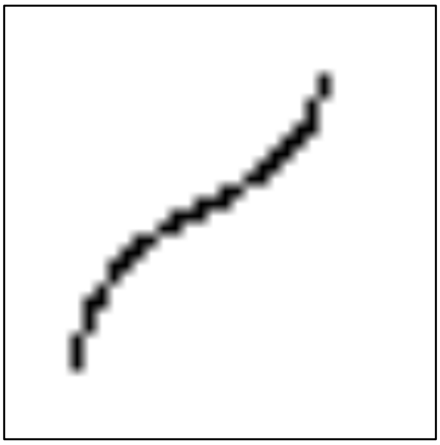

Fig. 1. Curve after thinning algorithm

more difficult and impossible for thicker curves. In the research, Zhang-suen Thinning algorithm is applied to the images [12]. The essence of this algorithm is to study the black neighbours pixels of each black pixel. As a result, the object in the image - the curve is thinned to 1 pixel, and the number of black pixels is sharply reduced. Fig. 1 shows any curve taken. The result obtained after applying the thinning to this curve is given in Fig. 2.

With the adjacent pixel approach, the set of black pixels representing the curve is brought to the pixels sequence. It should be noted that the number of black pixels may be slightly reduced when assembling the sequence. Certain characteristics must be determined in a certain method from the sequence of points obtained. For the B-spline, these characteristics are the control points. Each of these steps applies to known images and the image captured by the drone. The characteristics of the known images are placed in the database and the characteristics of the image received by the device are compared with those in the database. The one that matches the known images is determined. The current position of the unmanned aerial vehicle is determined based on the coordinates and position of this route [13].

IV. CONCLUSION

The proposed method can be used as one of the alternative methods for autonomous navigation during the monitoring of transport corridors by unmanned aerial vehicles.

The advantage of the proposed method is that the device can determine its location without the use of GPS.

There is the long processing of images is the disadvantage side of this method here.

REFERENCES

[1] https://en.wikipedia.org/wiki/Global_Positioning_System

[2] Tae Hyun Kim & Denny Toazza, Navigation Control of an Unmanned Aerial Vehicle (UAV), Bachelor Thesis in Computer and Electrical Engineering, November 2009.

[3] Yuncheng Lu, Zhucun Xue, Gui-Song Xia, Liangpei Zhang, A survey on vision-based UAV navigation, Geo-spatial Information Science, volume-21,2018.

[4] Aasish C, Ranjitha E., Razeen Ridhwan U, Bharath Raj S, Angelin Jemi L., Navigation of UAV without GPS, 2015 International Conference on Robotics, Automation, Control and Embedded Systems.

[5] F.S. Cohen, Zhaohui Huang, Zhengwei Yang, Invariant matching and identification of curves using B-splines curve representation, February 1995, IEEE Transactions on Image Processing 4(1):1 – 10.

[6] Sandeep Pande, Manna Chetty, Position Invariant Spline Curve Based Image Retrieval Using Control Points, August 2019, International Journal of Intelligent Engineering and Systems 12(4):177-191.

[7] Zhaohui Huang and Fernand S. Cohen "Affine-invariant moments and B-splines for object recognition from image curves", Proc. SPIE 1964, Applications of Artificial Intelligence 1993: Machine Vision and Robotics, (11 March 1993).

[8] https://www.dynamsoft.com/blog/insights/image-processing/image-processing-101-color-space-conversion/

[9] J.R.Parker, Alghorithms for Image Processing and Computer Vision, second edition, Wiley Publishing,Inc, pp.21-251.

[10] Reinhard Klette, Concise Computer Vision, An Introduction into Theory and Algorithms, springer –Verlag London 2014, pp. 43-121.

[11] Costantino Grana, Daniele Borghesani, Rita Cucchiara, Connected Component Labeling Techniques on Modern Architectures, Image Analysis and Processing - ICIAP 2009, 15th International Conference Vietri sul Mare, Italy, September 8-11, 2009.

[12] https://rosettacode.org/wiki/Zhang-Suen_thinning_algorithm

[13] Sabziev E.N, Determining the location of an unmanned arial vehicle based on video camera images, Advanced Information Systems, -2021, Vol.5, № 1, - p.136-139.

[14] Tarik Abu-Ain, Siti Norul Huda Sheikh Abdullah, Bilal Bataineh, Khairuddin Omar, A Fast and Efficient Thinning Algorithm for Binary Images, December 2013, Journal of ICT Research and Applications 7(3):205-216.

[15] Lynda Ben Boudaoud, Abderrahmane Sider, Abdelkamel A Kamel Tari, A new thinning algorithm for binary images, Conference: 2015 3rd International Conference on Control, Engineering & Information Technology (CEIT).

[16] Yumin Tan ,Yunxin Li, UAV Photogrammetry- Based 3D Road Distress Detection, International Journal of Geo-Information, 12 september 2019.

[17] Jinqiang Cui, Shupeng Lai, Xiangxu Dong, Ben M Chen, Autonomous Navigation of UAV in Foliage Environment, December 2016, Journal of Intelligent & Robotic Systems 84(1-4).

[18] Muthukrishnan.R, M.Radha , Edge Detection Techniques For Image Segmentation, International Journal Of Computer Science & Information Technology (Ijcsit) Vol 3, No 6, Dec 2011.

[19] Chenfan Sun, Wei Zhan, Jinhiu She, and Yangyang Zhang, Object Detection from the Video Taken by Drone via Convolutional Neural Networks, Mathematical Problems in Engineering, Volume 2020,13 October 2020.