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EXPERT ESTIMATIONS FOR INFORMATIVENESS AND RECOGNITION OF SELECTED TERRAIN

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Abstract—Development and research of cartographic software of visual correlation-extreme navigation systems has been done. Selection of informative features has been developed by using Speed-Up Robust Feature descriptors and expert estimations of reference image.

Index Terms—Speed-Up Robust Feature; expert estimations; correlation-extreme navigation system; informativeness; cartographic dayabase.

I. Introduction

Application of correlation-extreme navigation systems (CENS) allows carrying out correction of a course and speed of the UAV in the conditions of lack of communication with satellites. Correlation-extreme navigation systems operation is based on using already known information on aircraft route sites (reference information). Receiving the current information from sensors, CENS by means of correlation-extreme methods compares it to the reference (Fig. 1). Thus, CENS defines the current error of basic navigation system. Correlation-extreme navigation systems doesn't require additional hardware and is carried out on airborne digital computer by means of program software [1]. Realization of cartographic database is essential for reliable operation of CENS.
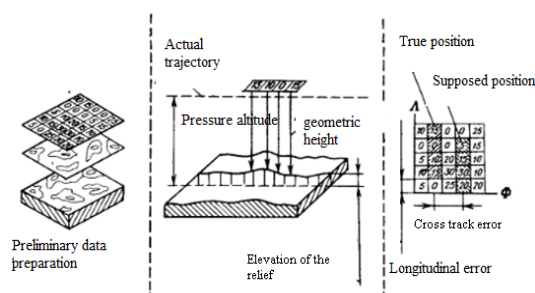

Fig. 1. Principle of action of CENS of the terrain field

II. Problem Statement

The program of terrain study has been developed in Matlab 2014. The image is processed by means of OpenSURF library. The function OpenSUR is an implementation of Speed-Up Robust Feature (SURF). Speeded Up Robust Features detects landmark points in an image, and describes the points by a vector which is robust against (a little bit) rotation, scaling and noise [2].

In case of determination of the points coordinates of terrestrial surface by means of comparing algorithms of reference and current images of correlative type as criterion of informativeness of the selected direction of approach the condition of exceeding value of correlation radius of a brightness field of some preset value can serve.[3]

After partition, we subject each quadrant to different distortions: shading, lighting and rotation and then research the matching points on the reference images. If the feature point is steady, the matching repeats from current image to reference one.

It can be seen that on the low-informative section, the variance of reliable points is generally concentrated on stationary sections (footpaths, lines of plantings), but isn't recognized, there were a shadow.

III. Solution of the Problem

The criterion of determination of reliability of the most stable characteristic geometrical feature of elements of object composition decides on probability at least 0.75, and also possibility of determination of the directions of approach of the unmanned aerial vehicle (UAV) to the preset area, the surfaces providing the most effective processing of the initial information (Figs 2 and 3).

For the first quadrant:

– blue point is the reliable points with weight factor > 0.75;

– red point are non-reliable with weight factor < 0.75.

Total quantity of feature points is defined on a reference image of the first quadrant – **2815**; revealed reliable feature points – **1450**; revealed non - reliable feature points – **1365**. Ratio between reliable and non-reliable feature point in percents: **52%** to **48%.**

For the second quadrant:

– blue point is the reliable points with weight factor > 0.75;

– red point are non-reliable with weight factor < 0.75.

Total quantity of feature points is defined on a reference image of the second quadrant – **1997**; – revealed reliable feature points – **1383**; revealed non – reliable feature points – **614**. Ratio between reliable and non-reliable feature point in percents: **70%** and **30%**.

Feature of an observed reference image is its informational content as there are elements of stationary objects (building), and also objects which dynamically change (cars). As these objects are not steady, on temporary distortions, it is recommended to the human-operator to automate this process. He has to specify areas which need to be excluded from cartographical information as they aren't reliable.
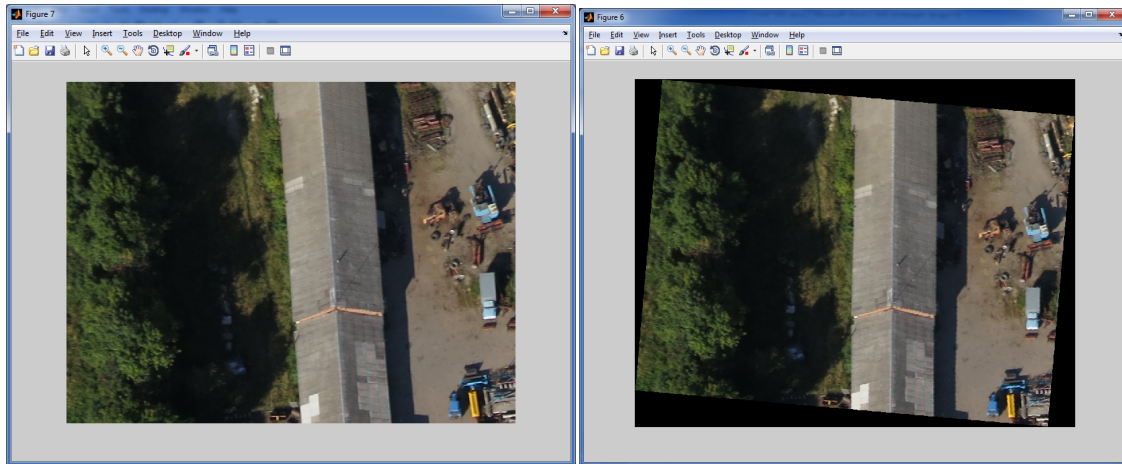

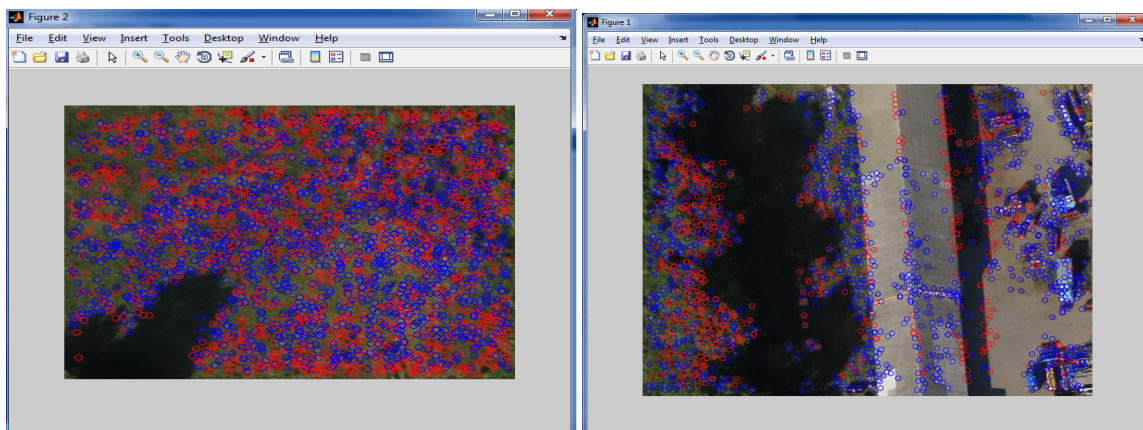Fig. 2. First quadrant under the distortion by the rotate

Fig. 3. Distribution of reliable and non- reliable SURF feature points for the first and second quadrants

It is observed also the site is a low informative, because there a shadow (textural features).

In case of the solution of the task of a choice of the most informative sections of an earth surface and characteristic geometrical signs of elements of object composition the conversions corresponding to algorithms of processing of the current images realized in onboard equipment of UAV system are used.

For extending a unified template the estimation of informativeness from the point of view of human's perception and perspective of using it for improving machining and creating the reference image it was decided to use expert estimations.

Three terrain templates are presented on which objects are seen from different location. These images were subjected into different types of edge detection and BLOB objects [3].

IV. RESULTS

80 people were interviewed. Results of expert estimations and recommendation are performed below (Figs 4–8 and Tables I–V).

Recommendations: according to expert estimations it is observed that most images under the distortions were recognized. Almost 85% of people identify template with a help of mutual arrangement so in this case we need to build 3-D model of stella, globe, post, philharmonic because under expert estimations exactly these objects were recognized as unique and stable, another one will be neglected. Also consistent windows structure is important feature and may be characterized as texture feature.
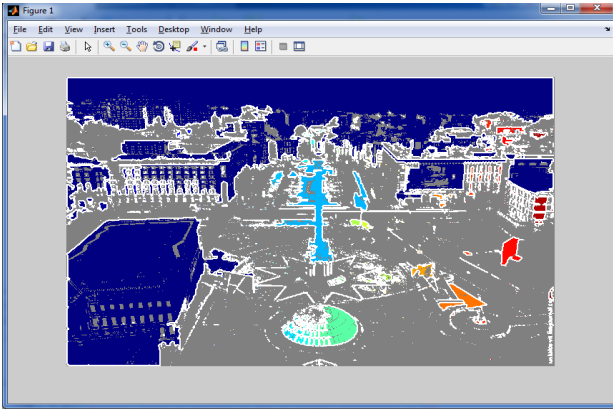
Fig. 4. The labeled objects using the jet colormap, on a gray background, with region boundaries outlined in white
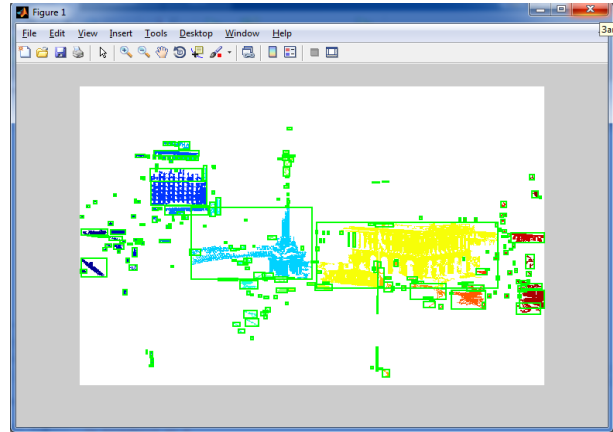

Fig. 5. Display each connected objects

TABLE I

RESULTS OF EXPERT ESTIMATION

	Yes,%	No	Stella, %	Globe, %	Post	Philharmonic	Mutual arrange-ment, %
1	100	0	100	100	0	0	100
2	75	0	100	87.5	37.5%	12.5%	100
3	100	0	50	100	0	0	87.5
4	100	0	50	100	25%	12.5%	100%
5	100	0	25	62.5	12.5%	37.5%	100
6	37.5	62.5	12.5	37.5	25%	25%	37.5

TABLE II

RESULTS OF EXPERT ESTIMATION

	Yes, %	No	Stella, %	Globe	Philharmonic, %	Mutual arrangement, %	Road	Ukraine hotel, %
1	100	0	100	25%	100	75	12.5%	100
2	100	0	100	12.5%	100	75	0	100
3	100	0	100	25%	100	75	0	100
4	100	0	100	37.5%	100	100	0	100
5	100	0	100	0	62.5	75	0	87.5
6	50	50%	50	0	25	50	37.5%	37.5

Recommendations: in this image under the different types of edge detection almost 90% recognized stella, philharmonic and hotel Ukraine, so 3-D model of these objects will be created, like in previous example. According to mutual arrangement you can determine your current position.

Recommendations: almost 75% of people can identify the terrain from this prospect. With a help of expert estimations we observed key objects: The Statue of Liberty, platform (star) and island. Platform has an unusual shape – star, that will be recognized as a BLOB structure in all position. And the Statue has a specific form all of these help in matching.

Recommendations: like in previous images more than 80% of people recognized template with a help of three objects The Statue of Liberty, platform (star) and island. So 3-D model of these objects is needed (will be enough) on the map to spot the terrain. Almost all methods of edge detection are correct.

Recommendations: nearly 65% of people can identify Coliseum. No need to create 3-D model of the scene because the distortions are insignificant at this height, it's enough to build 2-D model using stationary objects which were determined by expert estimations.
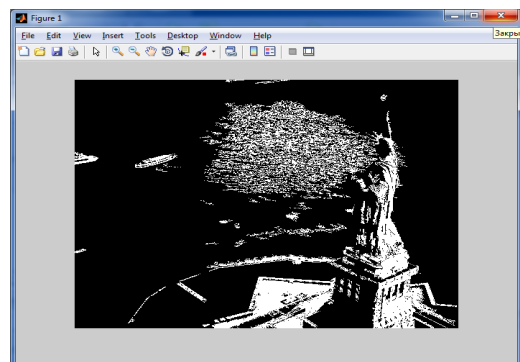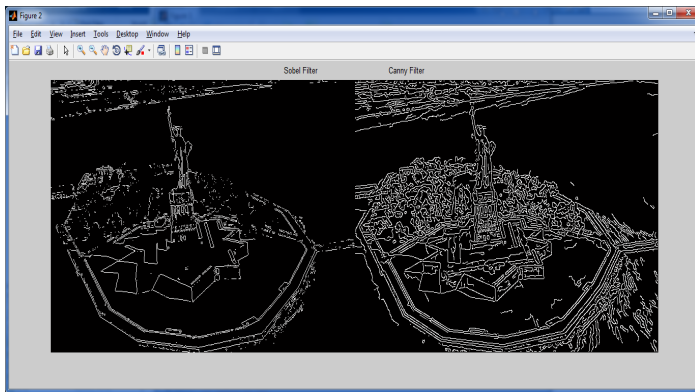

Fig. 6. The grayscale image
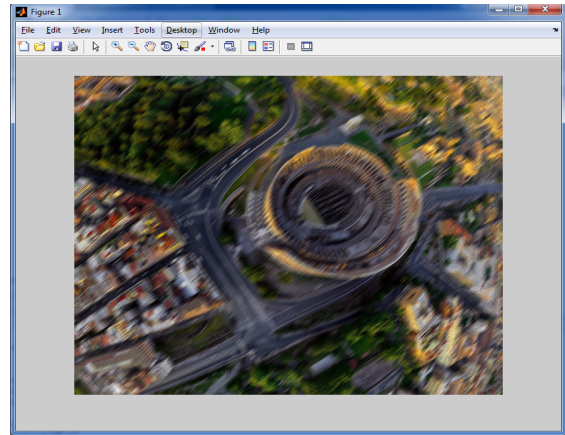
Fig. 7. Both the Sobel and Canny edge detectors

Fig. 8. The blurred image

TABLE III

RESULTS OF EXPERT ESTIMATION

	Yes	No	The Statue of Liberty	Water	Platform (star)	Island
1	100%	0	100%	25%	62.5%	25%
2	100%	0	100%	25%	75%	37.5%
3	87.5%	12.5%	87.5%	25%	50%	25%
4	100%	0	100%	0	62.5%	62.5%
5	75%	25%	75%	25%	62.5%	62.5%
6	50%	50%	25%	0	50%	0

TABLE IV

RESULTS OF EXPERT ESTIMATION

	Yes	No	The Statue of Liberty	Island	Platform (star)	Mutual arrangement
1	87.5%	12.5%	87.5%	87.5%	87.5%	50%
2	100%	0	87.5%	25%	87.5%	75%
3	75%	25%	75%	50%	12.5%	50%
4	87.5%	12.5%	87.5%	37.5%	87.5%	37.5%
5	75%	25%	75%	12.5%	75%	50%
6	100%	0	100%	75%	100%	75%

TABLE V

RESULTS OF EXPERT ESTIMATION

	Yes	No	Coliseum	Road	Mutual arrangement	Arch
1	87.5%	12.5%	87.5%	62.5%	62.5%	25%
2	75%	25%	75%	50%	50%	12.5%
3	75%	25%	75%	37.5%	37.5%	12.5%
4	75%	25%	75%	12.5%	25%	12.5%
5	62.5%	37.5%	62.5%	50%	50%	0
6	75%	25%	25%	25%	25%	0

V. CONCLUSION

The cartographic data base of visual CENS was developed. It was realized in the software environment Matlab and with the help of SURF method. The criterion of determination of reliability of the most stable characteristic geometrical feature of elements of object composition decides on probability at least 0.75.

For identification of reference image (map fragment) at researching of expert estimations the most informative objects were selected. According to this, at creating the reference image could be recommended to form or use methods that allow emitting exactly these objects.

If experts identify terrain according to periodic structure (repeating), consistent windows structure of Coliseum or post, it is possible to save these objects in the reference image as texture features. If it is not recommended to use a complex approach of feature detection.

For sufficient height of flight the features of three-dimension objects is irrelevant, that's why it's enough two-dimension model and detected stationary objects according those features that were formed with a help of expert estimations.

For low height of flight the recommendation is to use three-dimension model of a scene. In this case the model is simplified through those three-dimension objects that were left as the most recognizable.

Feature points detection is recommended to use when human is absolutely can't recognize terrain due to absence of characteristic feature and it is caused to mismatching. Spot pattern is easy to recognize by machine not by human.

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М. П. Мухіна, К. С. Младенцева, І. В. Баркулова. Експертне оцінювання інформативності та розпізнавання обраного рельєфу місцевості
Розроблено та досліджено картографічне програмне забезпечення для кореляційно-екстремальної навігаційної системи. Розглянуто особливість виявлення методом SURF. Представлено оцінку інформативності та розпізнавання еталонного зображення.
Ключові слова: прискорене розпізнавання робасних характерних особливостей; кореляційно-екстремальна навігаційна система; інформативність; картографічне забезпечення баз даних.

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М. П. Мухина, К. С. Младенцева, И. В. Баркулова. Экспертное оценивание информативности та распознавания выбранного рельефа местности

Разработано и исследовано картографическое программное обеспечение для корреляционно-экстремальной навигационной системы. Рассмотрено особенность обнаружения методом SURF. Представлено оценку информативности и распознавания эталонного изображения.
Ключевые слова: ускоренное распознавание робастных характерных особенностей; корреляционно-экстремальная навигационная система; информативность; картографическое обеспечение баз данных.

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