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USING CORRELATION FILTERS TO SUPPORT THE UAV

Annotation. In this paper is about performance evaluation of the tracking algorithms for UAVs - MOSSE and KCF from the library of computer vision OpenCV.
Key words: UAV, OpenCV, correlation filters, MOSSE, KCF.

INTRODUCTION

Tracking of objects is an important component of modern UAVs. Widely used in military operations to destroy targets from UAVs or to follow various objects. For tracking algorithms from drones the following requirements are presented:

- Low computational complexity
- Real-time work.
- High accuracy.

Low computational complexity dependent from lifting weight and energy consumption of drones. Because drones can’t carry a heavy computer. Real-time and high accuracy need to correct control of UAV and to reduce the probability of loss of an object.

For object tracking tasks use various algorithms such as deep neural network, correlation filter, features matching and other. Neural network have a higher accuracy but for real-time work need powerful computer and for correct tracking need big training dataset, which include all possible object. Future matching algorithms is not very precise. But correlation based algorithms have a good precision and can be trained online, so no need collect a dataset.

CONTRIBUTIONS

The principle of work is find the correlation function between the input image and the known kernel (target object). The maximum point of the correlation function will be a new position of the object. One of the advantages of this group of methods is the high speed that is achieved by using the Fast Fourier Transform. As you know in the frequency domain, the correlation can be found as a simple element-wise multiplication[1]. This allows you to get the complexity of the calculations equal O(NlogN) [2].

Most correlation methods have a similar algorithm:

- Initial initialization.
- Definition of the location of the object.
- Update the kernel.

Initialization involves finding the nucleus in the Fourier region. In the initial frame, the object is manually selected. However, when initializing from one frame, the filter may often be unstable due to a change in position, rotation, or change in lighting, so often the original image of the object is subjected to a small affine transform and averaged them. Often, the frame is merged with the sinus window to reduce the noise and focus on the center of the object.

Further, the following image is obtained and in the vicinity of the past position of the object crop a frame. After that, calculate Fourier spectrum of getting frame and multiplied with the known kernel. Next calculate Inverse Fast Fourier Transform and the maximum value for the calculated image will point to the new position of the object. Different loss functions can be used to determine the probability of finding an object. For example, the Peak to Sidelobe Ratio (PSR) method is used in MOSSE [3]. In this method, determine the maximum intensity and the mean and standard deviation of the sidelobe, according to these data determine the PSR.

The kernel update is similar to initialization. In some algorithms, interpolations with past frames can be introduced to create the memory of the algorithm.

Also, in order to improve accuracy and reliability, some approaches can be used by Histogram of Oriented Gradients, features obtained by different methods, for example CNN.

RESULT

To verify the work of the correlation methods was selected the open source library OpenCV for Python. The OpenCV is one of the most popular cross-platform libraries for computer vision, written on C ++. It has two built-in algorithms Kernelized Correlation Filter (KCF) [4] and Minimum Output Sum of Squared Error (MOSSE). These algorithms will be tested on two computers:

- Intel Pentium PC with 2.2 GHz CPU and 4 GB of RAM.
- Raspberry Pi 3 model B+.

For tests, a dataset was collected from several videos that included shooting from a drone:

- Motorcycle;
- Cars.

Picture 1. Frames from dataset.

Testing of algorithms has shown that both algorithms work well enough for objects that do not overlap and do not leave the frame. MOSSE has better cope with overlapping objects and objects that turn around. For both algorithms from scratch is difficult to restore the tracking after leaving the camera's field of view. MOSSE has the much better performance (table 1). For testing on Raspberry Pi was used a dataset with two resolution: 1280x720 and 720x360 and only 1280x720in PC.

Table 1. Performance of algorithms.

	KFC	***MOSSE***
FPS on notebook	20-25	160-166
FPS on Raspberry Pi 3 (720p)	4-5	45-47
FPS on Raspberry Pi 3 (360p)	7-8	69-71

CONCLUSIONS

The studied correlation methods are a good solution for tracking from small UAVs. They provide good accuracy and high performance. These correlation methods will deal well with overlapping of other objects, deformations and turns. However, you need to fine-tune the moment with the restoration of tracking after the object leave the field of view of the camera.

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