VIDEO STABILIZER FOR AIRCRAFT FLIGHT REGIMES VISUAL DETECTOR

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Abstract: This paper deals with video stabilizer that is a part of aircraft flight regimes visual detector. It describes the procedure of feature points detection and optical flow computation. It also deals with finding homography between consecutive video frames which will be used for backward image transformation. Image transformation should compensate camera movement, so that the resulting video will be stabilized.

Keywords: video, stabilization, aircraft, corner detection, optical flow

1. INTRODUCTION

Aviation industry places great emphasis on reliability of aircraft control systems and flight parameters visualization. The reliability is achieved by intelligent systems that can detect their own incorrect functionality and various backup systems, which provide proper operation in case of primary systems failure.

Another level of the aircraft systems reliability could be a visual identification of the system states. This method of control is not dependent on the monitored systems in the sense that it is a separate unit. There is only a visual contact between the monitoring and the monitored system, hence no major mechanical or any other error may affect the nature of monitoring systems.

2. VIDEO STABILIZATION

Video of flight parameters indicators recorded during a flight in the cockpit may be shivery. This is due to mechanical vibration which may be caused by many factors, for example strong gusts of wind on an aircraft during flight or aircraft movement over uneven surfaces at the start scrolling. Another factor causing the camera tremor can be sudden changes of g-forces, resulting from rapid acceleration or deceleration aircraft movement during acrobatic maneuvers. The impact of factors causing the video being instabilized is practically impossible to completely eliminate. As a result of this fact, the only possibility of video stabilization is its software correction.

2.1. IMPLEMENTATION OF STABILIZER

The basic idea of video stabilizer is that the feature points of every single video frame are found, then the motion of these points between video frames is computed and finally, the frames are shifted so that consecutive frames overlap as much as it is possible.

Results and quality of stabilization strongly depends on good feature points detection algorithm. The motion of camera is determined based on the feature points movement so every single video frame should ideally contain the same feature points. If algorithm chooses a frame pixel that is very similar to its neighborhood it is very unlikely that the same pixel will be found in the next video frame. So it needs to find unique pixels within their local surrounding. Harris corner detector [1] and its slight modification made by Shi and Tomasi [2] is the algorithm, which meets these requirements. For every pixel in the image it selects local window w and slightly moves this window around central pixel in various directions. If window displacement causes large variation E in all directions the central pixel is declared to be one of the feature points.

$$E(u,v) = \sum_{x,y} w(x,y)[I(x+u,y+v) - I(x,y)]^2 \quad (1)$$

Assuming we have found all the feature points of the frame, now we should detect the movement of these points between consecutive video frames. Movement of detected feature points is computed by sparse optical flow technique Lucas Kanade [3]. This method tries to find corresponding feature point $[\mathrm{u_x} + \Delta\mathrm{x}, \mathrm{u_y} + \Delta\mathrm{y}]^\mathrm{T}$ in frame $\mathrm{I_2}$ for given point $[\mathrm{u_x}, \mathrm{u_y}]^\mathrm{T}$ in frame $\mathrm{I_1}$ which minimizes error ε:

$$\varepsilon(\Delta x, \Delta y) = \sum_{x=u_x-w_x}^{u_x+w_x} \sum_{y=u_y-w_y}^{u_y+w_y} \left(I_1(x,y) - I_2(x+\Delta x, y+\Delta y)\right) \quad (2)$$

The next stage of stabilization is finding homography between points found by Shi-Tomasi corner detector (denoted as x'_i) and corresponding points found by Lucas Kanade optical flow(denoted as x_i). Homography H must meet the following relationship:

$$x'_i = H \cdot x_i \quad (3)$$

When the found homography H is applied to current frame it will overlap the previous image. This overlap compensates movement of camera, so there should be no residual motion and video should be stabilized.

3. EXPERIMENTS AND TESTING

To verify the functionality of stabilizer three experiments were proposed. Scene of experimental videos was as shown in figure 1. The scene contains three tracking markers which will be used to determine the results of stabilization. For purpose of stabilization these markers have been erased. First experimental video was filmed under the following conditions: no or minimal camera movement, needles are motionless. Conditions of second video were modified so that the camera movement was significantly bigger, needles are still motionless. Last experiment was changed in that way the needles were moving.

Figure 1: Scene of experimental video

Evaluation of experiments is based on tracking the motion of three markers in the scene. Diagrams shown below depict average markers displacement between consecutive video frames before and after stabilization. Measurement includes first 50 video frames of the recorded test videos. The diagrams clearly show that the displacement of tracking markers after stabilization is significantly smaller then in original video. The worst case scenario for stabilizer is rapid movement of objects between consecutive video frames, as can be seen on diagram 2 around 44-th frame. The stabilizer is based on corner detection but rapid camera movement causes that the image is blurred and the performance of the corner detector is considerably decreased. On the other hand, stabilizer is capable to cope quite well with gradual slow-growing displacement because it keeps the image sharp.

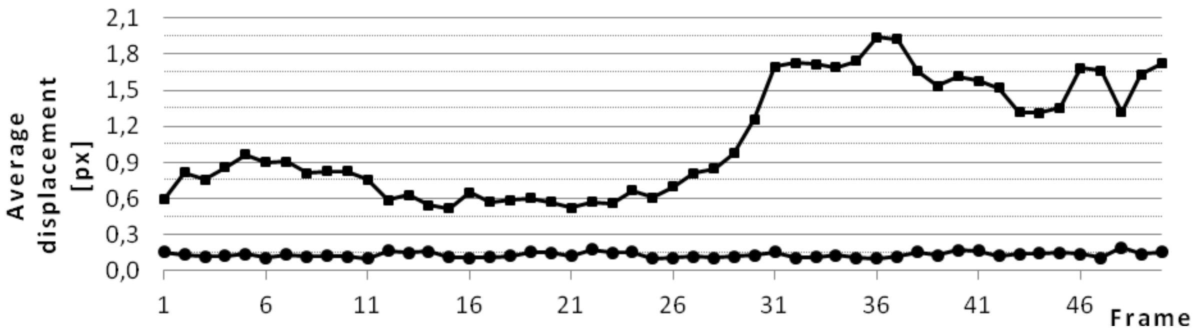

Diagram 1: Experiment 1 - no or minimal camera movement and fixed needle

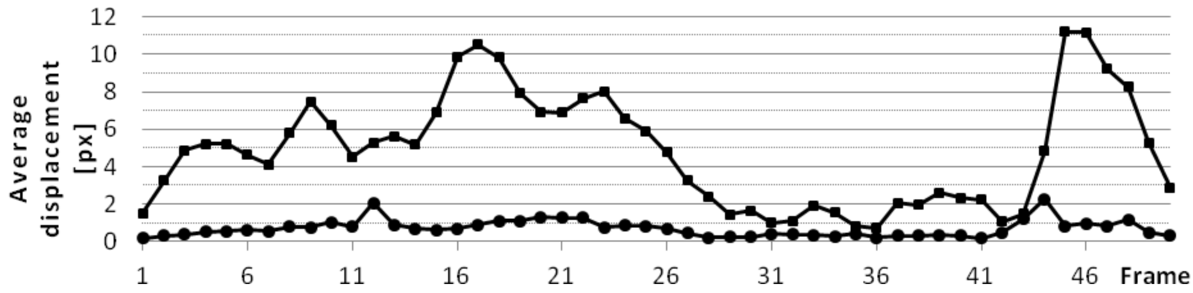

Diagram 2: Experiment 2 - rapid camera movement and fixed needle

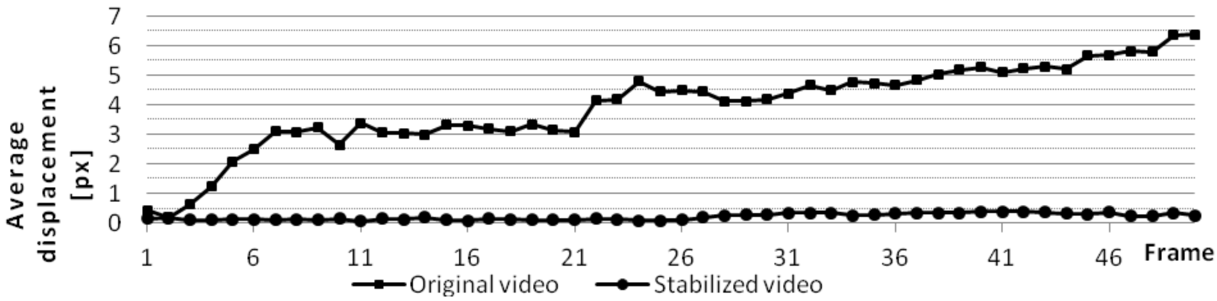

Diagram 3: Experiment 3 – moving needles

4. CONCLUSION

In this paper was proposed stabilization algorithm based on feature points detection, calculation of optical flow and backward transformation of video frames to compensate the movement of camera. The intended use of the stabilizer is to be part of visual detector of aircraft flight regimes. As indicated by the results of experiments stabilizer is able to deal with different situations and flight regimes indicator's behavior. Based on these assumptions it is suitable for intended use.

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