Visualization of Moving Objects in Thermal Image

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Abstract— **Motion detection in color or thermal imaging has become one of the major components of surveillance and monitoring systems. Since thermal images are usually presented as gray scale images, the need for smart assistance in surveillance for the operators has risen. A common way of emphasizing detected motion on an image is pseudo coloring. In this paper, an application for pseudo-coloring of thermal image areas with detected motion is provided in order to give an adequate visualization and draw attention of the operator to the moving objects. For motion detection SURF (Speeded Up Robust Features) detector key points are used along with Optical flow estimation (Lucas-Kanade method). Every detected region is presented by its center found by motion detection on two successive frames. Complete object motion detection and visualization is obtained using several more image processing techniques: morphological image processing, image segmentation and pseudo-coloring. Results are presented on the experimental dataset made for this purpose only.**

***Index Terms* — motion detection; thermal image; SURF; optical flow; pseudo-coloring.**

I. Introduction

Motion detection has become widely populated in military and civilian surveillance systems which has become critical for the rapid response to a certain event. Safety is one of the major problems in the 21st century, so developing this type of technology leaves many options for improvement in future use. Typical applications of motion detection are: security systems, vehicle navigation, video image reconstruction, computer vision etc. Moving object detection is the core and fundamental task of every surveillance system which is the focus of this paper.

Motion analysis is one of the most challenging tasks in digital video processing. The main challenge is to detect moving objects competently in real time. The key is to follow the change in the frames and to extract corresponding regions of the moving object and the object itself as quickly and efficiently as possible. This process becomes increasingly complicated and difficult with the presence of noise, complex backgrounds, variations in illumination, and the shadows of static and moving objects. In this paper, we propose a software image processing approach for motion detection on thermal images by retaining only the moving object of interest.

The main goal of this paper is to give an overall software image processing approach for appropriate visualization of detected motion. The rest of this paper is categorized as follows. Section 2 gives the description of the proposed object motion detection and visualization application. Section 3 shows the experimental results of our proposed system. Section 4 concludes this paper. The last section includes references.

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II. The Method

A flowchart of the algorithm for the proposed method is given in the Fig. 1. Brief description of each step of motion estimation process in the figure is discussed in the following section.

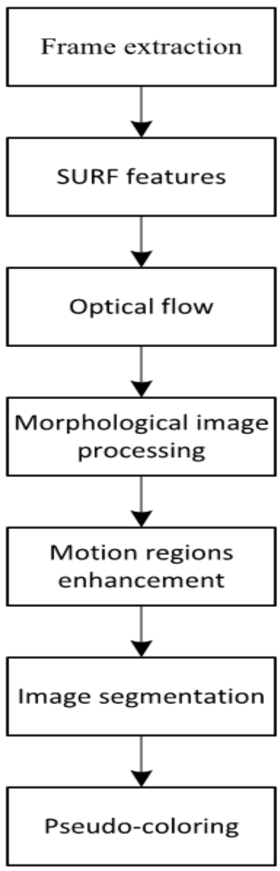

Fig 1. Flowchart of the system for moving object detection and visualization

Static thermal camera is used to capture frames that are being processed. In order to avoid occlusions, multiple different scenes are recorded. Frames are taken by Vlatacom Research and Development Institute Multi-sensor imaging system vMSIS 2 – CHD - C1200 [2]. The basic idea of Multi-sensor system is to combine data from different types of sensors (thermal sensor [3], color cameras, low light cameras [4], SWIR cameras [5], laser range finders [6], etc.). Dedicated software for image preprocessing effectively filters vibrations and rain which is the key component of external surveillance systems. This system has a pan/tilt platform and operates in enhanced temperature range (Fig. 2).

Fig. 2. Vlatacom vMSIS 2 – CHD – C1200

The SURF (Speeded Up Robust Features) algorithm [7] is used to extract the feature points from two consecutive frames. SURF is a local feature detector and descriptor. The role of the descriptors is to produce a unique description of a feature calculated from the area surrounding the point of interest. It can be used for tasks such as object recognition, image registration, classification etc. It is partly inspired by the scale-invariant feature transform (SIFT) descriptor. After SURF points extraction and matching, fixed threshold method is adopted to exclude the matching points on the targets that were not moving, the least square method is employed to solve the global motion parameters. Advantage of using SURF is reducing the number of points algorithm should be applied on which reduces computational cost compared to the algorithm applied on the whole image grid points.

Optical flow presents an apparent change of a moving object's location or deformation between frames [8,9]. Its estimation is used in many applications. Optical flow estimation yields a two-dimensional vector and motion field that represents velocities and directions of each SURF point of an image sequence. Lucas-Kanade algorithm [10] has been chosen for the estimation of Optical flow because of its high accuracy and its basic principle that uses the change of intensity between two consecutive video frames for motion detection. It assumes that the flow is essentially constant in a local neighborhood of the pixel under consideration, and solves the basic optical flow equations for all the pixels in that neighborhood by the least square criterion. Lucas-Kanade optical flow method provides visual representation of area over the moving object and the relative speed intensity of moving objects. Furthermore, points with low or zero speed vector intensity were excluded from following calculations and are considered as a part of the background which makes the algorithm more efficient.

Morphological image processing (dilation) with square structural element achieves approximate object region detection [11].

Additional enhancement of the whole process of object detection and visualization application is achieved using difference in brightness between two frames in order to match the actual object border more accurately. Precise object region detection is achieved through further morphological image processing (erosion and dilation) with square and disk structural elements of different sizes.

In combination with image segmentation with multiple thresholds [11] and pseudo-coloring (hot color map) appropriate visualization is provided. A pseudo-color image is a color image derived from a grayscale image by mapping each pixel intensity value to a color according to a table or a function. It can make some details of interest more visible.

III. Experimental Results

We implemented all of the mentioned algorithm steps (Fig 1.) in Matlab. In order to illustrate proposed algorithm one of the most suitable scenes is selected and Fig. 3 shows two consecutive frames extracted from video made by static thermal camera.

Fig. 3. Two consecutive frames recorded by vMSIS 2 – CHD – C1200

In Figure 4 SURF features are extracted and matched from two consecutive frames.

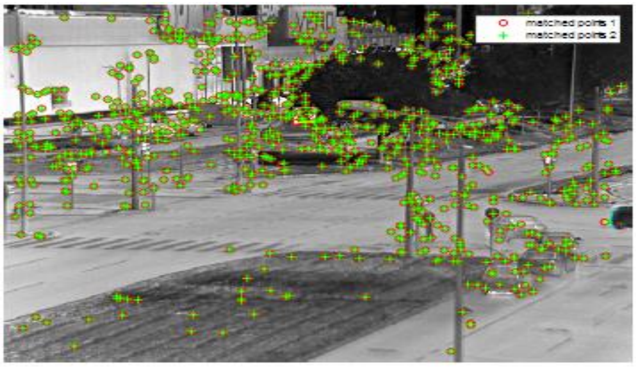

Fig. 4. Extracted and matched SURF features from two consecutive frames

Optical flow (Lucas-Kanade method) makes use of the flow vectors of moving objects over time to detect moving regions in an image which is shown in Fig. 5.

Fig. 5. Optical flow estimation based on SURF points

The following step forms a binary image where remaining SURF points, that with the highest certainty represent moving objects, were white dots on black background. The result of morphological image processing dilation with square structural element is shown in Fig. 6.

Fig. 6. Morphological image processing - dilation with square stracturale element

Aditional precision in object detection through frames brightnes difference alongside with morphological image processing – erosion followed by dilation is presented in Fig. 7.

Fig. 7. Motion region enhancement

Image segmentation is employed in order to emphasize objects of interest and separate them from the background which is illustrated in Fig. 8.

Fig. 8. Image segmentation on extracted regions

Fig. 9 shows the result of pseudo-coloring of the objects that are emphasized with the help of image segmentation.

Fig. 9. Pseudo-color image on segmented region of interest

Final result of the proposed procedure of moving object detection and visulisation is reported in the Fig. 10.

Fig 10. Motion detection and visualization – regions of interest clearly differentiated from the background

IV. Conclusion

This paper presents a design of a system for moving object detection in thermal image sequences. The proposed system employs several methods: extracting and matching SURF, estimating Optical flow by Lucas-Kanade method in reduced number of SURF points, morphological processing, segmentation and pseudo-coloring. Speeded Up Robust Features, as the most suitable to detect moving objects by the intensity changes of frames, are used as feature detectors. The combination of morphological erosion and dilation extracts significant features of region shapes from binary images after which blob analysis introduces these shapes to the next step as foregrounds (using pseudo-coloring on mentioned blobs). The detection performances are verified through the experiments based on the data using the actual footage of vehicles.

For the future work, an adaptive threshold filtering should be applied on inadequately matched SURF points and points with low velocity estimated by Optical flow, which would make this system more efficient. Also the algorithm can be developed to detect and identify overlapping objects and occlusion or transparencies during object tracking. Further research will be focused on developing a color based tracking method which can deal with both partial and complete occlusions effectively.

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