OBJECT TRACKING USING OPTICAL FLOW

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Abstract

Tracking objects in real-time has a variety of applications in many fields. Optical flow based tracking is one such tracking mechanism which can track moving objects even under complex backgrounds and different light conditions. The research presented in this paper discusses the feasibility of using optical flow to track moving objects captured in a camera view, to extract basic information related to the objects. The motion of a simple pendulum, a ball falling through a viscous medium and fish swimming in a fish tank were used to demonstrate the validity of the method.

1. Background

In computer vision, tracking objects is an important area. Although there are many algorithms and methods to track, to count or to identify objects, the most commonly used methods use background subtraction and color based tracking. In this research, optical flow is used to track objects. Optical flow is the amount of image movement within a given time period. This method of tracking can be easily converted into parallel processing and it is much faster than conventional tracking methods.

In background subtraction methods, the image of the background is captured at the beginning. Then, each frame of the video is compared with the initial frame. By this, moving objects can be identified due to the difference. This method can identify and track objects even under complex backgrounds. The major disadvantage of this method is the requirement of a static background. Another method is to identify certain properties of the tracked object and to follow it. This method can track objects even under complex backgrounds and can tolerate background changes or camera movements. But, if similar objects appear in the background, the tracking may fail. The optical flow based tracking which is used in this work is limited to track moving objects. However, this can track objects under highly complex backgrounds. Although a rotating camera might produce misleading values during the rotation, as soon as the rotation stops, tracking can commence. It is not necessary to describe the objects in details. In addition, velocity and flow information at each point can be acquired directly if the optical flow tracking method is used.

2. Methodology

Three separate experiments were carried out to determine the feasibility of optical flow based tracking; (1) Tracking a simple pendulum, (2) Tracking a ball falling through a viscous medium, and, (3) Tracking moving fish in a tank. A number of scenarios were used to determine the robustness of the technique and the effect due to external factors. Figure 1 show the steps followed in developing software for image enhancing and tracking in the MatLab® environment.

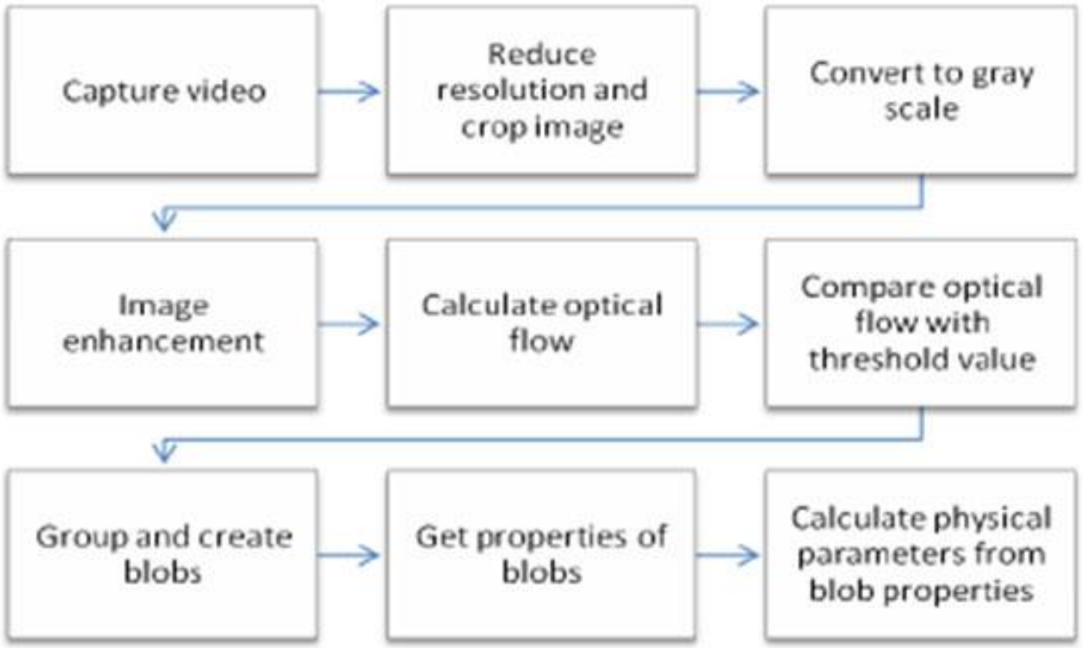

Figure 1: Flow chart of processing

A low camera resolution (800×600 pixels) was used to reduce the computational time. Often, there are unnecessary objects in the background. For example, when tracking the ball through the viscous medium we are only interested in the region of the tube. By cropping the region to include only the tube, the computing time could be reduced considerably.

During the image preprocessing phase, histogram equalization of brightness and contrast can be used to highlight features and to normalize the overall brightness of the frame. By using a moving average filter, salt and pepper noise can be removed [1]. When tracking the pendulum, image enhancing techniques did not increase the overall accuracy since the limiting factor for the accuracy was the frame rate of the camera. But when tracking fish in a tank and a ball in a viscous medium, brightness normalization increased the accuracy since the lighting conditions were not controllable and changed from time to time.

Optical flow calculations are carried out based on the gradient of intensities. Therefore it was necessary to convert the RGB colour images to grayscale images. The Horn-Schunck method [2] was used in this research to calculate the optical flow. A median filter was used to remove salt and pepper noise in images.

Two consecutive frames (10 fps) were used to compare the intensities. The optical velocity of each point was calculated as a vector. Inside the program, the vector was represented as a complex number where the real part represented the horizontal velocity component and the imaginary part represented the vertical velocity component. This information can be directly used to calculate the mass flow rate in a region of interest.

To identify the moving objects, the magnitude of the optical flow vector was used. The image was converted to a black and white image with white pixels having a larger optical flow magnitude than a predefined threshold. Pixels were then grouped, creating blobs. Depending on the size, suitable blobs were selected and their centres of gravity were calculated. This information was used to monitor and track the objects.

3. Tracking Results

3.1 Tracking a simple pendulum

A simple pendulum was designed with a spherical mass of diameter . A white paper was used as the background. To capture the video, a web camera was positioned 0.5 m away from the equilibrium point. The camera was placed perpendicular to the plane of movement. Optical flow values at different points of the frames were calculated and drawn on the frame.

The blobs were created after the noise filtering and thresholding. The object was identified and tracked based on the size and the maximum number of blobs. Each time the pendulum reaches an extreme, its real velocity and optical velocity drops to zero. At that moment tracking fails. This drawback can be overcome by introducing a blob counter. If the object is still and fails to be tracked, the previous position must be maintained. Since the duration between frames was defined by the camera, the velocity of the pendulum can be calculated. According to Newtonian mechanics, the period of the oscillations should be 2.03 sec. The value calculated using the image analysis process is 2.00 sec.

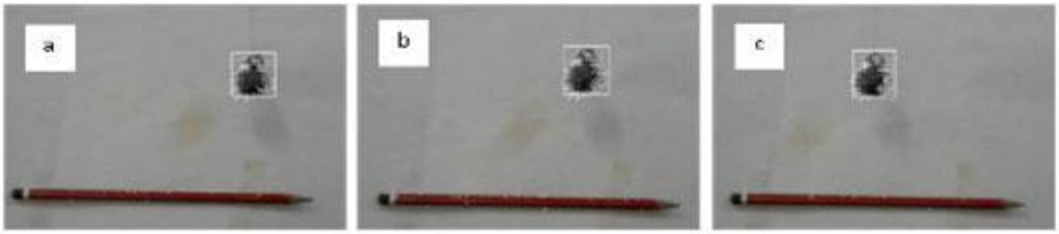

Figure 2: Tracking the horizontal displacement of the pendulum

3.2 Tracking a ball falling through a viscous medium

The optical tracking method was used to calculate the terminal velocity of a ball dropped in a high viscous medium. Both the medium and the tank were transparent and the dark iron ball could be seen from a side of the tube. A camera was set up to capture the video of the falling ball. By cropping, the tube was selected and the optical velocities were calculated. The noise was removed by choosing a threshold, and the moving ball was identified and grouped as a blob. Tracking the position of the ball was carried out which in turn led to the calculation of the velocity.

3.3 Tracking moving fish in a tank

The camera was fixed above the fish tank on a tripod. A video stream was obtained and the optical flow calculations were performed to identify the fish. Only the size of the blob was defined. The number of fish was determined by counting the number of blobs. It was assumed that each blob with a predefined size represented only one fish. As expected, when the fish are close to each other, identifying them as separate objects was difficult. In addition, the ripples seen on the water made tracking more complex.

4. Conclusions

Through the above experiments, it was demonstrated that optical flow can be used to track moving objects. Optical flow can be used to track either a single moving object or multiple moving objects. The method works well in outdoor environments as well as under laboratory conditions. Shadows can cause complications when using optical flow.

References

[1] Rafael C. Gonzalez and Richard E. Woods.(1992) Digital Image Processing. Addison-Wesley

[2] Horn, B.K.P. & Shunck, B. G. (1981) Determining Optical Flow, Artificial Intelligence, 17, 185-203