Fast Line Tracking for Intelligent Unmanned System using Kalman Filter

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Abstract. Line tracking is widely applied technique in intelligent unmanned system. This paper proposed fast line tracking algorithm applying Kalman filter to reduce computation region by prediction of next state. Probabilistic Houtgh transform is performed for extraction lines and experimental result shows speed up tracking with maintaining high accuracy.

Keywords: Line tracking, Hough transform, Kalman filter, intelligent system.

1 Introduction

Recently, there are many of unmanned systems which are operated by image information. However, small system cannot equip powerful computation unit to manage image processing. This paper proposes fast line tracking for low-performance embedded system. Line is fundamental feature to comprehend circumstances. In this approach, we present line tracking algorithm to decrease computation with narrowing region of interest by prediction applying Kalman filter. In continuous video frames, target feature moves adjacently from previous frame. The aim of this paper is predicting probable position of line in next frame.

2 Line Tracking

2.1 Probabilistic Hough Transform

Hough transform is a feature extraction technique in image processing field [3], [5]. Various shapes can be detected such as line, circle and rectangle. Fig. 1 shows Hough space which transformed from our test image. Small rectangles mean high probable point for existence of lines in image and large rectangles stand probable region of line in next frame. In this paper, we applied probabilistic Hough transform instead of original one for speed up [4]. Probabilistic Hough transform uses only a subset of points on image for voting. It makes tracking much faster but the accuracy can be lower if the subset is too small to extract characteristics of feature in comparison with original image.

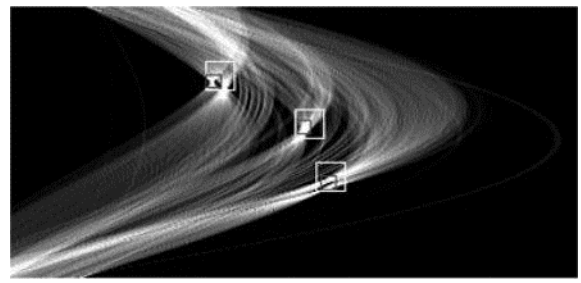

Fig. 1 Result of Hough Transform and probable range

2.2 Applying Kalman-Filter

The original Kalman filter was invented for trajectory estimation in space [2], [6]. However, it has been effectively used in very wide range of real applications. Kalman filter is based on two fundamental concepts of probability theory: mathematical expectation and variance. On every step it calculates the most optimal parameters for model using new measurements and prediction from the previous state.

Applying Kalman filter in our algorithm, we used a simple physic model of motion:

$$\text{Current Position} = \text{Previous position} + \text{Velocity} \quad (1)$$

This motion model was implemented in Kalman filter for prediction in Hough space. The main idea is reducing searching area by use the prediction to find new position of the line from previous state.

3 Experimental Result

This section explains experimental results of presented algorithm. This research was fully implemented on C++ using OpenCV 2.3 library for image acquisition and basic pre-processing steps.

Testing data have been taken from previous research [1]. It contains landing scenes of fixed-wing airplane, and its resolution is 320 by 240 with 25 frames per a second. In fig. 2, they show result of tracking in binary format and with tracked lines:

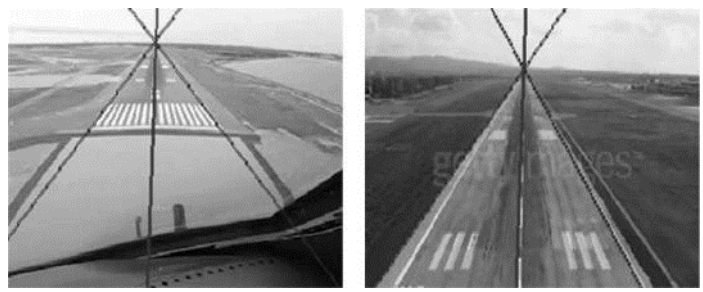

Fig. 2 Snapshots of line tracking

Algorithm was tested on x86 machines, results shows significant improve of performance especially in speed of computations in comparison with 'without Kalman filter'. Performance enhanced about 3 times in case of tracking landing strip from aerial vehicle.

Table 1 shows elapsed time and FPS which are measured in many executions. Kalman filter and several techniques facilitate precise tracking in short term.

Table 1. Performance analysis

Condition	Elapsed Time	FPS(Frame per Second)
Without Kalman Filter	3.0864	230.97
With Kalman Filter	0.4792	959.35

4 Conclusion

In this paper, we proposed fast line tracking algorithm and showed feasible result. In some embedded system, it has limitation to execute image processing due to lack of performance. Prediction by Kalman filter narrows computation region maintaining positive tracking. Furthermore, probable Hough transform also speeded up tracking period.

Acknowledgments

This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education, Science and Technology(grant number: 2012006817).

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