Power Line Detection for Millimeter-Wave Radar Video

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Abstract

To ensure the flight safety of helicopters, millimeter-wave radar imaging systems have been developed in both industry and academia. One application of such radar systems is to image the high-voltage power lines, and thus help the pilot to avoid power-line-strike accidents. In this dissertation, we present automatic power line detection algorithms for the radar video. We investigate the defining characteristics of the power lines in the radar video. The power lines appear as parallel straight lines in the radar video, and Hough transform can be employed to detect them. The major challenge is that the radar videos are exceptionally noisy due to the ground return, and the noise points could fall on the same line which results in signal peaks after the Hough transform which are similar to the actual power lines. To differentiate the power lines from the noise lines, in the first part of this dissertation we train a Support Vector Machine to perform the classification. We exploit the Bragg pattern, which is due to the diffraction of electromagnetic wave on the periodic surface of power lines. We propose a set of features to represent the Bragg pattern for the Support Vector Machine classifier. We also propose a slice-processing algorithm which supports parallel processing, and improves the detection of power lines in a cluttered background. As adaptive algorithm is also proposed to integrate the detection results from individual frames into a power line detection decision, in which temporal correlation of the power line pattern across frames is used to make the detection more robust. Simulation results confirm the effectiveness of the proposed algorithm. In the second part of this dissertation, we further propose to utilize particle filter to more formally capture the temporal correlation of the power line objects, while the power-line-specific features are embedded into the conditional likelihood measurement process of the particle filter. Because of the fusion of multiple information sources, the detection of power line is more effective. We also propose a general framework of cascaded particle filters that takes advantage of the independence of different aspects of the object state, and decomposes the original tracking problem in a high-dimensional state space into several simpler cascaded tracking problems in low-dimensional sub-spaces. The reduced-dimensionality simplifies the problem and thus renders the solution more robust. Experimental simulations validate that the proposed approach can significantly improve the power line detection results.

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