Airport Signs and Markings Recognition for Enhanced Runway Incursion Avoidance

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Motivation & Introduction

Runway safety has been a major concern in the aviation industry. In the United States, an average of three runway incursions occur daily. Pilot deviations is the primary reason for runway incursions. Our project targets the detection and recognition of the runway holding position signs and runway hold-short lines to alert pilots of a potential runway incursion. We leverage the standards of airport signs and markings (red background + white characters for holding position signs and 2 dashed lines + 2 continuous lines for hold-short lines) for the detection purposes.

Figure 1 Runway Incursion Scenario and Project Objectives

Challenges & Future Work

- Set up a database for airport markings and signs and combine feature-based methods to existing methods to enhance the robustness against perspective distortion, image blur, night operation and false positive caused by similar objects
- Expand the capability to detect taxiway location and direction signs, ILS holding position signs and those of safety interest
- Implement the algorithms on a digital signal processor (DSP) to achieve efficient standalone detection and recognition

References

- Pilots Handbook of Aeronautical Knowledge, FAA-H-8083-25A
- Fleyeh and etc. Road and Traffic Sign Detection and Recognition, Advanced OR and AI Methods in Transportation
- Lai and etc. An Efficient Real-Time Traffic Sign Recognition System for Intelligent Vehicles with Smart Phones, 2010 International Conference on Technologies and Applications of AI
- Bieniecki and etc. Image Preprocessing for Improving OCR Accuracy, MEMSTECH 2007
- Barresi and etc. Airport Markings Recognition for Automatic Taxiing, 2013 Conference on Design and Architecture for Signal and Image Processing

Work Flows & Algorithms (MATLAB Simulation)

(223 continuous test images are obtained from an actual aircraft ground operation at KPAO)

Figure 2 Work Flow for Runway Holding Position Sign Detection and Recognition

- Color Balance – Adjust for color variations
- RGB to HSV – Color-based sign detection
- OCR Pre-Processing– Remove noise before OCR
- Sign Validation – Verify the recognition result is valid
- Similar red objects like wind sock, light box contribute to false positive detection

Accuracy = 95.1%		Actual		
		Sign Present	Sign Not Present	Precision
Detection	Sign Detected	8	9	47.1%
	Sign Not Detected	2	204	99.0%
	Recall	80.0%	95.8%	

Table 1 Holding Position Sign Detection Result

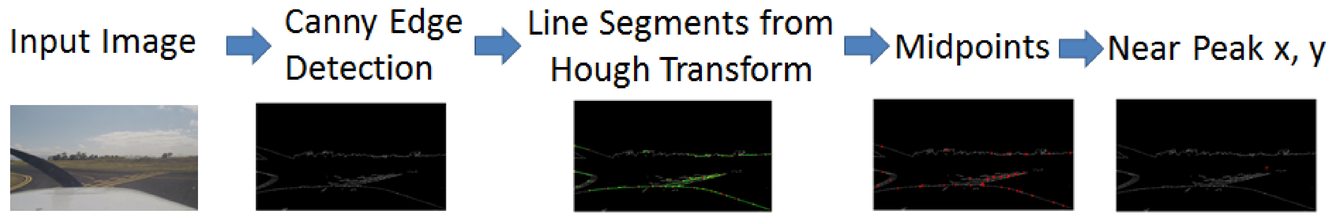

Figure 3 Work Flow for Runway Hold-Short Line Detection

- Line Segments from Hough Transform – Identify major line features
- Hough Line Midpoints – Indicate positions of continuous lines
- Near Peak x, y – Locates farther boundary of the runway
- Hold-short lines are likely to occur 100 pixels below the peak
- Current image frame leverages previous detection results
- Taxiway lines and etc. contribute to false positive detections

Accuracy = 89.7%		Actual		
		Line Present	Line Not Present	Precision
Detection	Line Detected	30	21	58.8%
	Line Not Detected	2	170	98.8%
	Recall	93.8%	89.0%	

Table 2 Hold-Short Line Detection Result