Concurrent-Scene/Alternate-Pattern Analysis for Robust Video-Based Docking Systems

S89-18

N93-22815

146799

p. 2

Suraphol Udomkesmalee

Jet Propulsion Laboratory, California Institute of Technology
4800 Oak Grove Drive, Pasadena, California 91109
(818) 354-0614

ABSTRACT

A typical docking target employs a three-point design of retroreflective tape, one at each endpoint of the center-line, and one on the tip of the central post. Scenes, sensed via laser diodes illumination, produce pictures with spots corresponding to desired reflection from the retroreflectors and other reflections. Control corrections for each axis of the vehicle can then be properly applied if the desired spots are accurately tracked. However, initial acquisition of these three spots (detection and identification problem) are non-trivial under a severe noise environment. Signal-to-noise enhancement -- accomplished by subtracting the non-illuminated scene from the target scene illuminated by lase diodes -- can not eliminate every false spot. Hence, minimization of docking failures due to target mistracking would suggest needed inclusion of added processing features pertaining to target locations.

In this paper, we present a concurrent processing scheme for a modified docking target scene which could lead to a perfect docking system. Since the non-illuminated target scene is already available, adding another feature to the three-point design by marking two non-reflective lines -- one between the two end-points and one from the tip of the central post to the center-line -- would allow this line feature to be picked-up only when capturing the background scene (sensor data without laser illumination). Therefore, instead of performing the image substraction to generate a picture with a high signal-to-noise ratio, a processed line-image based on the robust line detection technique (Hough transform) can be used to fuse with the actively sensed three-point target image to deduce the true locations of the docking target. This dual-channel confirmation scheme is necessary if a fail-safe system is to be realized from both the sensing and processing point-of-views. Detailed algorithms and preliminary results are presented.

Automatic target recognition and pattern recognition research has been the main focus of Dr. Udomkesmalee for the past five years. The original research was funded by MICOM's research directorate to enhance the target identification and tracking performance of an optical correlator-based seeker system, to be employed in the Optical Precision Deep Attack Missile System (OPDAMS). Transferable technologies to AR&C applications are:

1. Portable/progammable optical pattern recognition hardware -- Optical correlator based on Binary Phase-Only Filters with scalable/rotatable raster scan servo to provide a scale/rotation invariant target identification and tracking system.

2. Pre-processing and post-processing algorithms for optical pattern recognition -- Image processing via Fourier's amplitude modulation and blob detection techniques to enhance the input

scene's object-to-background characteristics; and correlation convolution mask definition to enhance the output correlation image.

3. Correlation spots tracker -- PC-based real-time correlation peak detection system to provide position corrections to the optical seeker's inertial platform.

4. Texture and line segments analysis -- High-speed, feature extraction and low-level recognition to isolate object shape and background using Texture energy transform, Hough transform, and Curvature transform.

5. Scale/rotation estimation techniques for unidentified objects -- Object's shape size and orientation estimation using geometrical moments, Fourier extraction, line and curve signatures.

6. PC-based Image processing system -- Optical correlation simulation and image analysis system based on 386PC, Imaging Tech.'s frame grabber, and Eighteen-Eight Laboratories' Array Processor.

Currently at JPL, we are not funded for AR&C research. However, many of the autonomous vision activities at JPL directly benefit the AR&C technology, and there exists an active desire for participation in this technology transfer. Other applicable AR&C technologies from JPL's GNC are:

1. Spatial, High Accuracy, Position Encoding Sensor (SHAPES) -- laser diodes, CCD, and a picosecond streak tube to provide 3-D position sensing and multiple-targe tracking capabilities.

2. CRAF/CASINI's Target Star Tracker -- CCD and processing modules to support Spacecraft attitude determination by locating, identifying and computing the position of guide stars and to assist in platform pointing by locating "reference features" for extended targets.

3. ASTROS II Star Tracker -- High efficiency and accuracy CCD-based tracker with extended targets and multiple target tracking capabilities.