General 3D Acquisition and Tracking of Dot Targets on a Mars Rover Prototype

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Goals

- Produce 3D position and orientation; 1cm position accuracy desired
- Acquire the target automatically and track 5cm/sec motion in real time
- Tolerate clutter and obfuscation
Cameras

- Cameras on ceiling, with 4-camera overlap to minimize occlusions
- Pulnix TM-9701 monochrome progressive-scan camera
System Block Diagram

12 cameras on ceiling

Video Sync x 12

Sync Amplifiers

Sync Generator

B/W Video x 12

Video Amplifiers

Video Switch

Video Amplifiers

Video Monitor

Video Monitor

Video Monitor

Video Monitor

Video Monitor

D/A Board

CPU Board

Graphics Board

B/W Video

RGB Video

19" Rack

Analog Lens Control x 12

Client Applications

Ethernet

RS232

Sun Workstation

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Equipment Rack

- Monitors for live & computer-generated images
- VME chassis
  - CPU board
  - Frame Grabbers
  - Graphics board
  - D/A board
- Video Switch
- Video & Sync Amplifiers
- Sync Generator
- Power supplies
Ground Calibration

- Three-dimensional spread of visual targets to characterize cameras
- Arbitrary reference coordinate system
Ceiling Calibration

- Only two-dimensional spread of data available
- Target coordinate system
- Combined with ground calibration
Tracking Software

- VxWorks real-time operating system
- Algorithm:
  - Acquisition
  - Tracking
  - Iris control
- Tasks:
  - ACQTRACK: implements tracker algorithms
  - HTTP: web server to display system status & diagnostic images
  - NTP: synchronizes local clock with external clocks
  - CMD: services commands from remote clients
Logged Output Data

- Tracking status
- Time of data acquisition
- Rover Position
- Rover Orientation
- Positions of tracked dots in 3D
- Positions of tracked dots in 2D in all cameras
Web Browser Display

- **State:** tracking/lost
- **Data if tracking**
- **Links to diagnostic and camera images**

Select an image:
- Display
- Camera 0
- Camera 1
- Camera 2
- Camera 3
- Camera 4
- Camera 5
- Camera 6
- Camera 7
- Camera 8
- Camera 9
- Camera 10
- Camera 11

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Remote Command-Line Tools

- **dumptrack**
  - connects to tracking system and dumps data to standard output
- **cmdtrack**
  - sends commands to tracking system
- **currtrack**
  - connects to tracking system and displays data in full-screen mode
- **savetrack**
  - grabs images from tracking system and saves to files
- **showtrack**
  - grabs images from tracking system and displays in X windows
Test Runs

- Absolute accuracy: Placed tracking target in a few locations on the sand and spot checked with Leica TotalStation – 15.3mm RMS error over 18m
- Relative accuracy: Suspended tracking target from ceiling crane and tracked north-south and east-west runs – 7.6mm horizontal and 6.1mm vertical RMS error with outliers removed
Backing up
Turning in Place
Summary

- Typically operates at 5-6Hz
- Has been in operation since 2003
- Used to initialize IMU state for test runs
- Used to log test runs to analyze results while driving
  - hazard avoidance
  - wheel slippage
  - visual odometry
- Currently in use to support testing of a new version of flight software