Task 244: Autonomous Rendezvous and Docking for Space Debris Mitigation

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Overview

- Team Members
- Purpose of Task
- Research Methodology
- Results, Schedule and Milestones
- Next Steps
- Contact Information

Team Members

Participants:

- Prof. Steve Rock (PI)
- Jose Padial (PhD student)
- Marcus Hammond (PhD student)

Affiliation:

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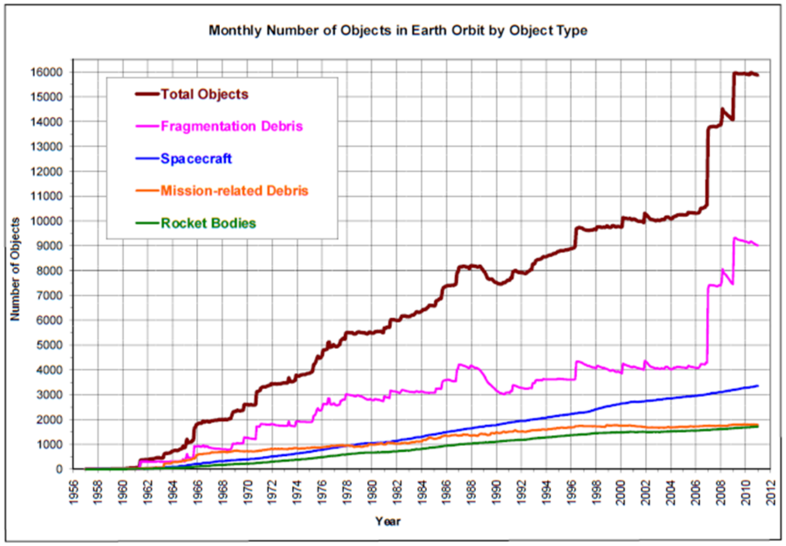
Purpose of Task

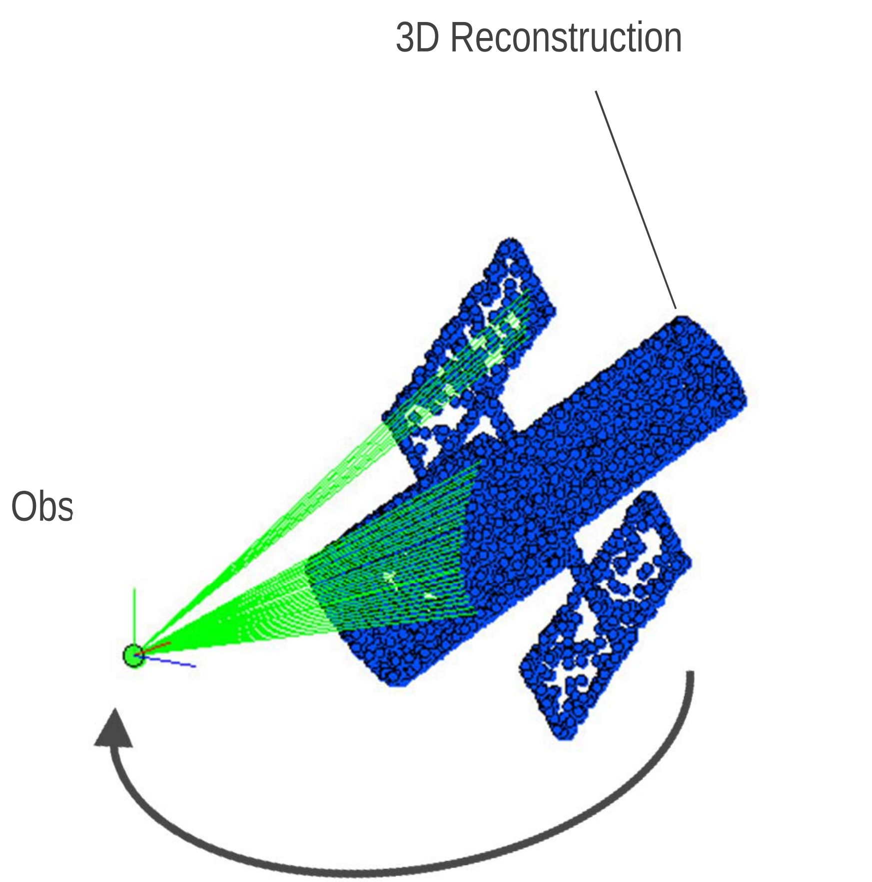
- Goal: Develop new technology to enable safe, autonomous rendezvous and docking with disabled spacecraft or capture of debris
- Objectives: Develop and demonstrate robust autonomous rendezvous and docking (AR&D) sensing technology for
  - Targets undergoing complex, potentially tumbling motion
  - Damaged and/or uncommunicative spacecraft
  - Orbital debris



Retrieval of Westar VI, a stranded communication satellite, courtesy sciencephoto.com

Research Methodology

- Extend (and fuse) our previous work in feature-based (vision) and range-based (LIDAR) SLAM/SfM to achieve
  - Accurate relative pose estimation
  - Accurate and *dense* 3D target reconstruction
  - Robust performance in the harsh lighting environment of space
- Enable capability for potential use on small satellite missions
  - Low weight, size, and power budget sensor suite
  - Camera(s) and low-power LIDAR



Estimate of relative position, orientation, translational velocity, angular velocity

Research Methodology

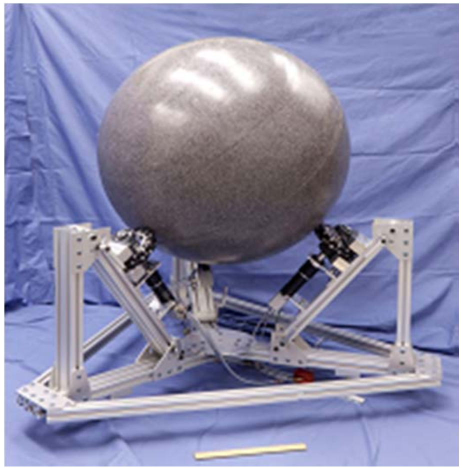
Validate algorithms in laboratory demonstrations using existing facilities within the ARL

- Rotating base motion simulator

  Prescribe complex motion (e.g. torque free) to a target hardware model

- 6DOF gantry

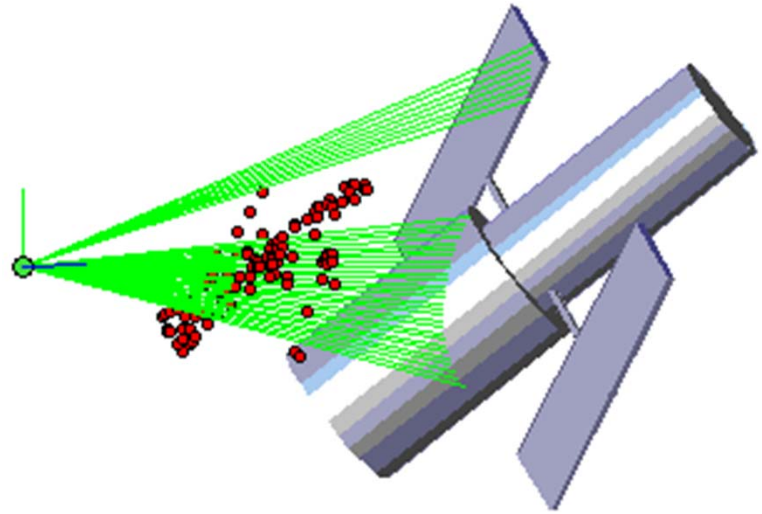
  Fly a sensor suite in a prescribed trajectory to observe tumbling target



Schedule and Milestones

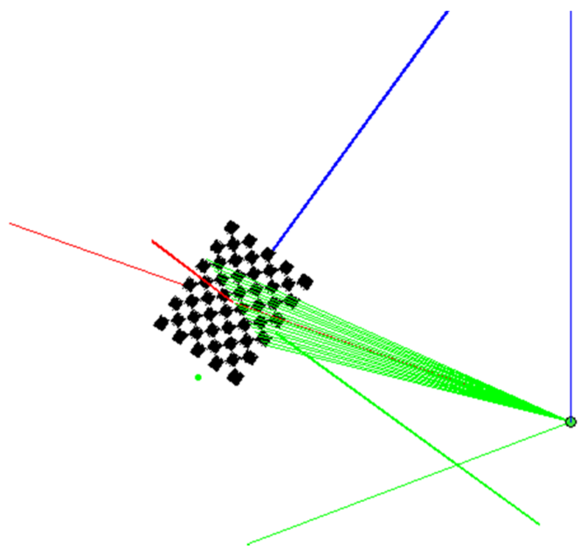
- Year 1:
  - Demonstrate rendezvous and docking using a baseline SLAM algorithm
  - Develop a plan to accommodate lighting anomalies
  - Develop a plan to port the SLAM algorithms to low power proessors
- Year 2:
  - Modify and extend algorithms to account for lighting anomalies
  - Modify and implement algorithms for low-power computer processors
  - Demonstrate extended algorithms using ground-based simulator
- Year 3:
  - Begin development of a small-satellite demonstration

Work to Date: Simulation Environment

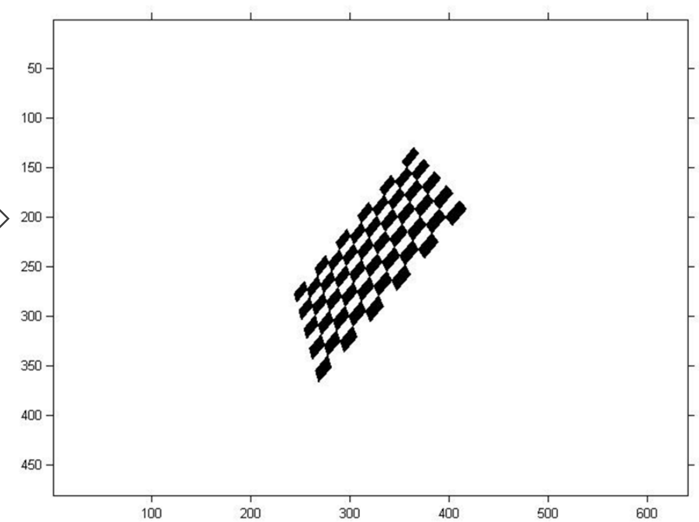


Camera-LIDAR simulation environment

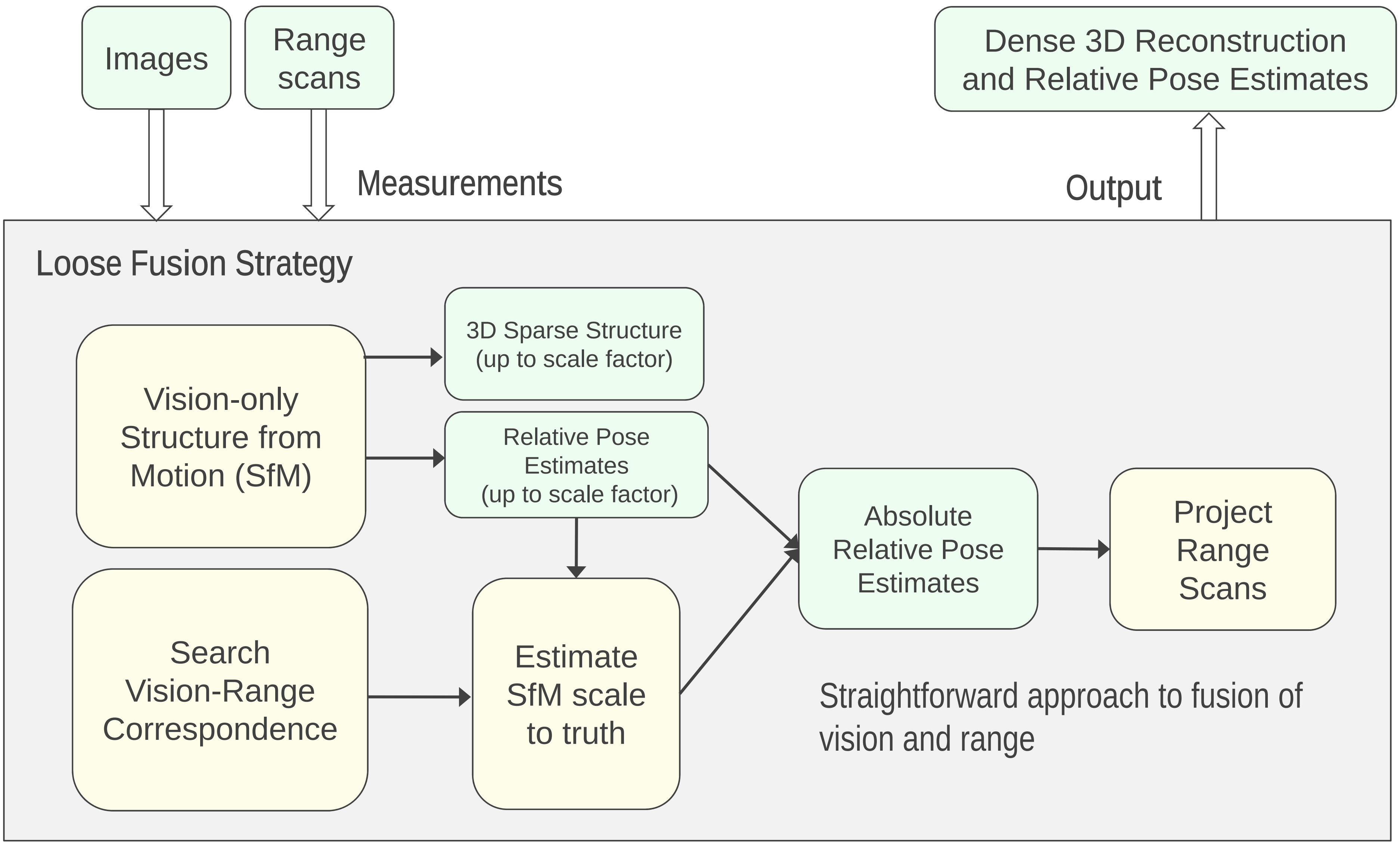
- Simulated LIDAR range scanning of 3D target models
- Simulated images
- Environment designed to allow for injection of noise into any point of the measurement and estimation pipeline



Project 3D target geometry onto image plane



Estimation Framework: Loose Fusion



Estimation Framework: Tight Fusion

Images

Range scans

Measurements

Dense 3D Reconstruction and Relative Pose Estimates

Output

Tight Fusion Strategy

Search Vision-Range Correspondence

SfM-inspired solver that integrates vision data, range data, and vision-range correspondences for accurate, scale unambiguous estimates

Hypothesis:

We can do better than the loose integration strategy by folding the vision data, range data, and vision-range correspondences into a new SfM-inspired tightly-integrated formulation

Contact Information

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