Mission-Level Path Planning

Life in the Atacama Design Review
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Description

Mission-Level Path Planning roles

Energy-cognizant, global path planning
- Coarse path selection over multi-kilometer ranges
- One mission-level plan request per day
- Plans are energy-optimal

Coarse planning of major rover activities
- Placement and timing of Drive, Charge and Hibernation actions
- Representation of intermediate, position-referenced science activities

Provides framework for high-resolution planning
- Science planning
- Local navigation
Key Motivating Requirements

Requirements Specification:

1.0 Success Criteria, Year 2
   • Distance: 5 km/day for 10 days
   • Data sets: 100 regional, 10 detailed over 10 days

2.4 Navigate Over Horizon

2.5 Use Resources Efficiently

2.6 Advance Autonomy and Self-Awareness

6.4 Autonomous Traverse

6.5 Autonomous Investigation

7.1 Operations Personnel
Specific Functions

Global navigation
• Path selection for multi-kilometer traverses to science investigation sites

Augments rover safety and autonomy
• Large-scale terrain obstacle avoidance (hills, ravines)
• Energy resource management (solar, activity loads, finite battery)
• Operational constraint enforcement (spatial, temporal)
• Re-planning as rover state evolves

Provides skeleton for high-resolution plan
• Placement and timing of major actions
  Drive, Solar Charge, Hibernate and position-based Science actions
• Position waypoints specified at resolution of regional DEM
• Minimum battery energy guidelines

Offline and online planning
• Used in offline mode by scientists to aid in selecting targets
• Used in online mode by robot given final mission specification
Properties/Qualities

Usability

Should be easily adapted to new scenarios, at runtime

Performance

Must enable baseline operations concept

• Preliminary off-board planning by scientists
  Fast enough to make repeated planning runs with different constraints
• Early morning initial on-board planning
  Fast enough to re-create plan finalized by science team
• Re-planning
  Fast enough to prevent pauses longer than a few seconds
• 24 hours between initial plans
  Small enough memory to enable 24 hours of planning and re-planning
Design Considerations

Dominant Issues

Performance
- The software must operate under anticipated rover computer and memory resources

Development and Integration
- The software must be developed in time for significant testing

Important Metrics

Performance Parameters
- Time and memory for typical Year 2 planning problem

Reliability
- Mean time between fault (memory, planning, other)

Trades

Development time vs. value to LITA vs. value to research
Technical Approach

Baseline Design

- TEMPEST planner using Incremental Search Engine (ISE)
- X, Y, T search space
- Energy-based objective function
- Atacama year 1 functionality plus:
  - Goal actions
  - Enhanced action and local constraint specification
  - Planning to an ordered list of goal sites/actions
  - Off-board planning for science team
- Science activity modeling:
  - Site surveys (e.g. coverage, long-duration SPI) modeled as goal actions
  - Traverse science (e.g. periodic measurements) folded into Drive/Charge actions
- Performance similar to Atacama year 1
Technical Approach

Extended Design

- X, Y, T, E search space
- Reward-based objective function
  - Goal actions have positive reward
  - Other actions discount reward
- Possible further extensions beyond baseline:
  - Planning under uncertain action costs (time, energy)
  - Multiple goal actions (e.g. science options for varying reward vs. cost)
  - Optional goals (planner selects goals to maximize reward)
- Enables greater science autonomy
  - Continuous re-evaluation of goals based on evolution of state
- Performance slower and more memory-intensive than Atacama Yr 1
  - 4-D state space
  - Specific numbers TBD
Technical Approach

What can we expect?

Baseline plus:
- Reward-based objective function
- Multiple goal action options
- Goal skipping
Implementation Issues

Prototype Testing

Significant testing in simulation
Other planning modules must be available prior to full tests

Potential Failure Conditions

No plans found given mission specification

Major Schedule Issues

Reward-based planning undeveloped
Tighter integration with other modules than in Yr 1
New functionality must be tested
  • Hibernation and general energy management
  • Science activity planning

Offline planning training for science team
Graduation of principal developer around September