Integrated Resource and Path Planning

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Integrated Resource and Path Planning

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Goal: Investigate and develop technology for integrating activity planning and scheduling techniques with robotic motion and path planning techniques.

Objectives:

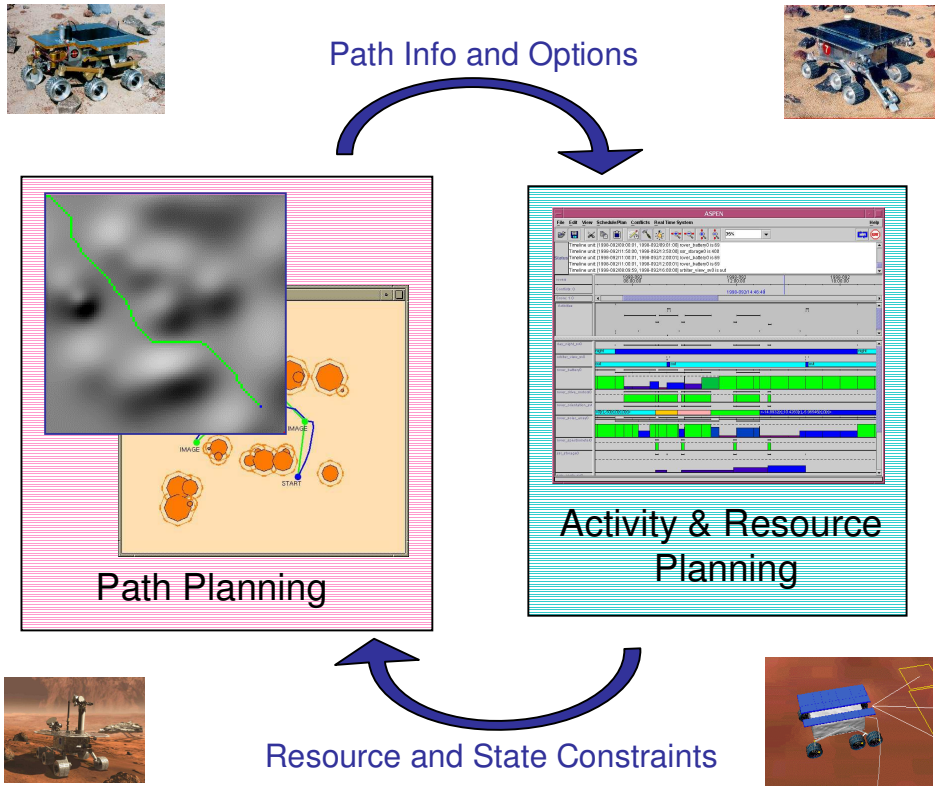
- Share relevent information between activity/resource planner and navigation path planner to help coordinate rover operations.
- Enable path planner to provide relevant path information (e.g., estimated traverse distance, route, major waypoints) to resource planner, as well as providing qualitatively different path options that can be evaluated for global benefit.
- Enable resource planner to pass current constraint preferences to path planner (e.g., requirements for power usage, communication windows, etc.) that will aid in path selection

Accomplishments to date:

- Completed initial integration of CASPER resource planner with two path planning systems – Tangent Graph and D*.
- Developed interface for the exchange of information between systems
- Have integrated systems and approach with the CLARAty rover architecture, and tested on multiple platforms

Schedule:

- FY01: Developed capability for generating science operations plan to collect science at multiple targets
- FY02: Demonstrate on rover hardware and in ROAMS simulation capability for communicating current path information from path planner to resource planner
- FY03: Demonstrate capability for communicating situation-related constraint information to path-planner that affects chosen routes to science targets.



NASA Relevance & Benefits:

- Enabling to future missions that utilize smarter rovers to traverse long distances and must perform intelligent decision-making onboard
- Reduction of mission costs through increase in autonomous navigation capabilities
- Increased capability for onboard benefit/risk analysis of traversal options
- Increased time for science. Smart navigation capabilities enable more science collection during mission.

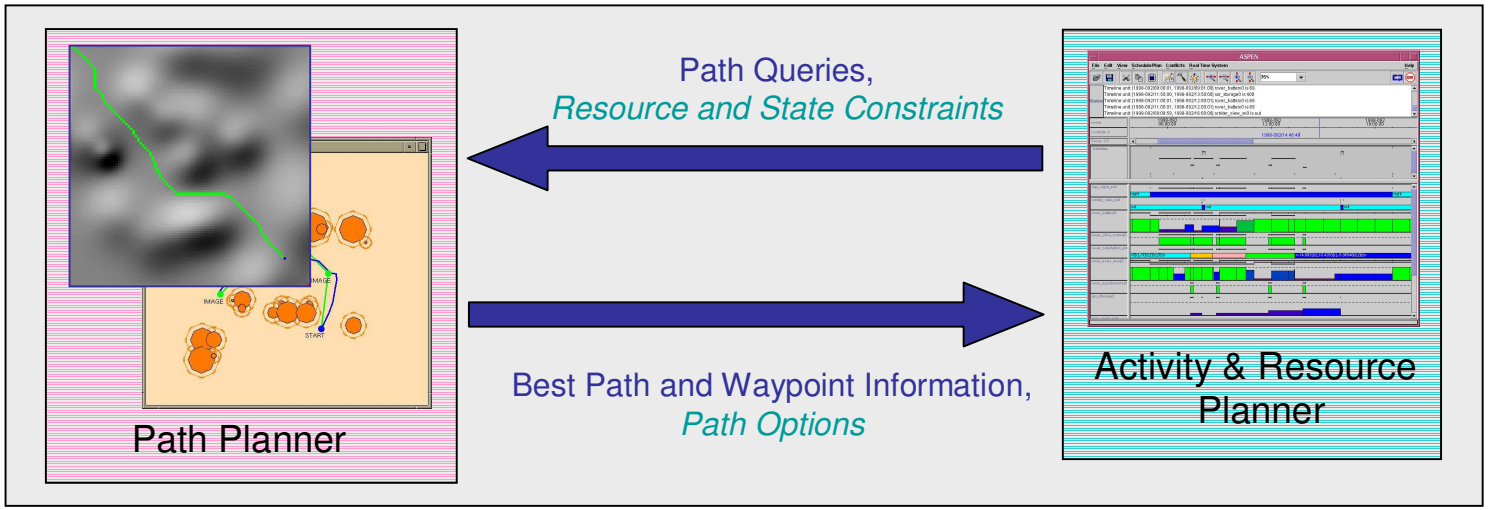
Task Overview

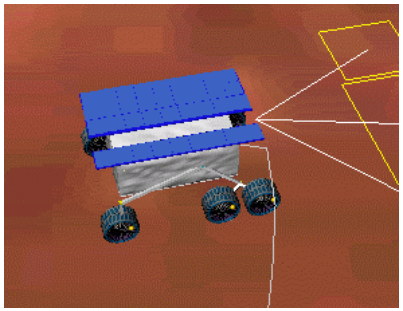
- More closely integrate activity planning and scheduling with path planning capabilities
- In past, integration has been done in minimal fashion
  - Activity planners typically have little knowledge of spatial reasoning constraints
  - Path planners typically have little knowledge of resource requirements and operations constraints
  - Both systems make decisions that affect the other
- Increased sharing of information will produce more efficient traversal schedules and allow for better analysis of different route options

Key Research Objectives

- Enable path planner to provide relevant path information to activity planner
  - Queries will return information on planned route, traverse distance, major waypoints, etc.
  - Path information and activity plan will also be updated iteratively as map changes
- Enable activity planner to pass focused set of constraint information to path planner
  - Additional constraints will aid in path selection
  - E.g., power usage, shading requirements, comm windows
- Enable activity planner to consider qualitatively different options from path planner

System Overview





Recent Accomplishments

- Completed initial integration of CASPER activity and resource planner with two different styles of path planning systems
  - Path planners:
    - Tangent Graph - vector-based approach
    - D* - grid-based approach
  - Developed interface for exchange of information between planners
  - Path information (traverse distances, waypoints) can be obtained during activity plan generation and dynamically during execution
- Developed visualization tool to show combined output of both activity and path planning processes

Recent Accomplishments, cont.

- Tested integration in both simulation and using hardware
  - Tested both path-planner integrations using ROAMS high-fidelity simulation tool
  - Supported multiple Rocky 7 and 8 demonstrations using Tangent Graph integration
  - D* integration will be evaluated using hardware by year-end

Current and Future Directions

- Current Work:
  - In process of testing D* integration with rover hardware in different terrains
  - Working with CLARAty task to easily obtain new terrain maps based on panoramic images
  - Formulating plan with CMU for integration of CASPER and TEMPEST
    - TEMPEST is version of D* that accepts additional constraint information
    - Being developed through Mars Technology Program for MSL mission

- Future Work:
  - Integrate with TEMPEST path planner
  - Develop capability for communicating focused set of constraint information from activity planner to path planner
  - Enable activity planner optimization algorithm to consider different path options