Software Architecture

Life in the Atacama Design Review
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Software Architecture

Description

Software architecture is the structure defined by:
- software components,
- external attributes of those components, and
- relationships (connections) among them.

Motivation

In addition to defining the function & performance of each software component, defining the aggregate behavior & performance is crucial.
## Software Architecture

### Desired Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td><strong>Performance</strong></td>
<td>Responsiveness and overall rate of the system</td>
</tr>
<tr>
<td><strong>Availability</strong></td>
<td>Proportion of operational time and rate of error recovery</td>
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<tr>
<td><strong>Modifiability</strong></td>
<td>Ease and efficiency of change</td>
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<tr>
<td><strong>Integrability</strong></td>
<td>Ability to assemble separately developed components</td>
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<tr>
<td><strong>Testability</strong></td>
<td>Ability to control input and state and observe output</td>
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</tbody>
</table>

### Structural Approach

Distributed, interacting components
<table>
<thead>
<tr>
<th>Software Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mission Planner</td>
<td>Plans rover activities</td>
</tr>
<tr>
<td>Rover Executive</td>
<td>Executes command sequence</td>
</tr>
<tr>
<td>Near-field Obstacle Evaluator</td>
<td>Models obstacles in the near field (≤ 5m)</td>
</tr>
<tr>
<td>Far-field Terrain Evaluator</td>
<td>Models terrain in the far field (5 - 30m)</td>
</tr>
<tr>
<td>Navigator</td>
<td>Generates rover driving behavior</td>
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<tr>
<td>Position Estimator</td>
<td>Localizes rover</td>
</tr>
<tr>
<td>Rover Controller</td>
<td>Controls rover motion</td>
</tr>
<tr>
<td>Science Observer/Planner</td>
<td>Identifies features and generates goals</td>
</tr>
<tr>
<td>Instrument Controller(s)</td>
<td>Control instrument activities</td>
</tr>
<tr>
<td>State Observer</td>
<td>Collects internal state</td>
</tr>
<tr>
<td>Health Monitor</td>
<td>Models rover behavior to detect faults</td>
</tr>
<tr>
<td>Telemetry Manager</td>
<td>Records and prioritizes telemetry</td>
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</tbody>
</table>
Software Components
Mission Path Planner

Model the environment (sun and terrain) and vehicle (power input and output)

Estimate the resources (power) required to reach the goal

Optimize schedule and path to expend minimum and acquire maximum resources

Sequence patterned actions like dense sampling and coordinated driving & sampling

Transmit plan to executive

Replan as requested
Rover Executive

Requirements

Set operating mode
Decompose/elaborate command sequence
Command rover actions to Navigator
Monitor execution sequence
Receive fault reports from Health Monitor
Invoke minimal reactive plans
Signal replan to Mission Planner
Listen to command traffic
Send stop command
Near-Field Obstacle Detector

Requirements

Evaluate traversability of near-field (<5m) terrain

Avoid obstacles >25cm

Approach

Terrain model developed from depth image using region-based correlation method

Obstacle detection by fitting vehicle footprint to terrain

- Slope
- Elevation discontinuity
- Roughness (residual)

Each metric linearized [0,1] and maximum cost assigned to terrain
Far-field Terrain Evaluator

Requirements

Terrain evaluation in the far-field (5-30m) between the resolution of individual obstacle detection (<5m) and orbital maps (30m)

Avoid terrain features like embankments, drainages

Model terrain:
- Geometrically - slopes, discontinuities
- Semantically - smooth versus rough appearance

Consistently incorporate near-field, far-field and orbital terrain information for smooth rover guidance
### Navigator

**Requirement**

Generate motion commands to avoid obstacles and reach goals

**Approach**

Navigator operates on composite terrain evaluation

Utilize onboard sensing to avoid near-field obstacles and allow continuous motion

Select arcs based on speed, obstacle height and goal location
Environment Mapper

Requirements

An environment mapper would aggregate and register environmental sensing to build maps

- Geometric information
- Visual information (color, texture)
- Derived information (geology)

Might be combined with position estimation for simultaneous localization and mapping (SLAM)
Position Estimator
Science Observer performs autonomous feature detection, evaluation, and sampling during rover traverse

**Observation**
- Feature detection (relative similarity, absolute uniqueness)
- Feature classification and evaluation (significance)

**Planning**
- Science cost and benefit estimation
- Science-guided exploration

**Compare sampling strategies to determine the effectiveness of each:**
- Fixed frequency
- Scientist selected
- Science-guided
Vehicle Controller

Requirements

Define command interface
Receive drive commands
Control motors (execute servo control law)
Detect and correct slip?
Signal motion faults
 Transmit instrument data
Instrument Controller(s)

Requirements

Define instrument command interface
Receive instrument action commands from Rover Exec
Control instrument function
Execute calibration procedures and verify calibration
Signal instrument faults to Heath Monitor
Receive and correlate instrument data
Verify data quality (and repeat measurement if needed)
Transmit measurements to Science Observera and Telemetry Manager
State Observer

Requirements

Template variables internal to components
Wiretap command/response messages
Collect state
Feed state to Telemetry Manager
Feed state to Health Monitor
Health Monitor

Requirements

Receive rover/instrument actions (waypoints)

Receive rover/instrument constraints from plans
  • Time, start and finish
  • Energy, initial, final and rate
  • Workspace

Receive module status messages
  • Individual constraint violation

Maintain model of nominal and fault behavior
  • Multi-component constraint violation

Model physical and operational constraints

Send fault messages to trigger contingent actions
Telemetry Manager

Requirements

Eliminate redundant data
Set variable sensitivity and eliminate data “noise”
Apply heuristics for what is important (priorities)
Record science measurements and images
Record complete telemetry record
Assemble daily telemetry block (50M)