Conclusion

Outline

• Introduction & Overview
• Model-based Programming
• Execution of Model-based Programs
• Fundamentals of Model-based Reasoning
• Modeling via State Analysis
• Advanced Methods
  • Conclusion
State Analysis and Model-based Programming

- Model Development:
  - State Analysis provides a disciplined approach to the modeling of components and systems

- Model-based program:
  - Specification of state intent (Control Program)
  - Specification of state behavior (System Model)

- Model-based Executive is made up of 2 components:
  - Control Sequencer (or Temporal Planner & Plan Runner)
  - Deductive Controller (Mode Estimation & Mode Reconfiguration)

- Formal semantics:
  - Legal state evolutions of a factored POMDP
  - Intent expressed in the form of a deterministic automaton

- Performance:
  - Model-based Executive overcomes computational complexity by leveraging a few key assumptions and proven model-based reasoning algorithms

Model-based Autonomy Benefits

Abstraction
- straightforward conversion of system engineering knowledge into flight code
- easier to specify desired state than control actions needed to reach it

Powerful inference engines
- e.g. Livingstone (part of DS-1 Remote Agent), Burton
- more flexible/robust than traditional s/w architectures & rule-based engines

Modularity
- model-based flight s/w can accommodate late design changes
- allows for transparent upgrading of deductive engines

Model reusability
- over time, build up database of models for subsystems and components
- reduce need for single-use flight code

Verifiability
- state-based control code & system models "readable" by system engineers
- model-based approach facilitates use of formal V&V methods
Compilation
• Models can be compiled so that much of the reasoning process is pushed back to compile time allowing diagnosis to be performed quickly (without having to run expensive online reasoning algorithms)

Replanning
• Contingent plans allow an “unsatisfiable goal” exception from the deductive controller to be recovered from by selecting an alternative goal, or sequence of goals

Algorithms
• Fast algorithms developed to support real-time operation in computation-limited systems
• Distributed algorithms to support cooperative operation of multiple spacecraft
Model-based Autonomy: Enabling Technology for Future Missions