Thinking…

…***inside*** the box

Error Detection and Diagnosis in Soar Agents

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Objective

The objective of the Robustness in Behavior Modeling project is to:

- Develop methodologies for robustness
- Demonstrate application of these methodologies in a non-trivial application
- Describe how this approach will generalize to other applications

Recourse

- ***Reduce*** failure situations
- ***Represent*** the environment
- ***Recognize*** progress and failure
- ***Resource*** allocation
- ***Reason*** / diagnosis
- ***Response*** alternatives
- ***Recovery*** actions
- ***Remember*** successful approaches

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Problem *Reduction*

- Recovery capability does not replace expert knowledge; it fills in the gaps
- Rigorous application of proven software engineering techniques to the design and implementation of rules-based agents is needed
  - Human interface improvements
  - Eliminate errors due to ill-defined specifications
  - Verification & Validation should be applied

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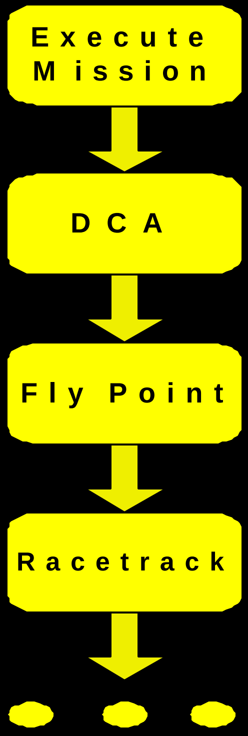
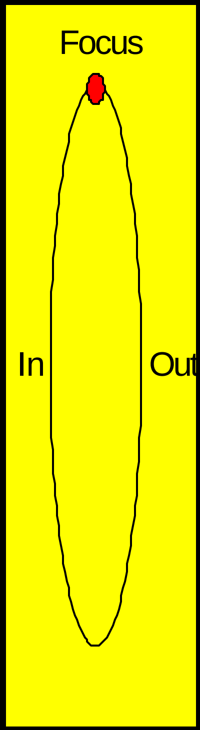
Represent the Environment

- Qualitative representation
  - Space represented as regions, intervals, and ranges rather than discrete points or values
  - Broad, complete domain coverage
  - Redundant and hierarchical
- Example - Racetrack
  - Within a ballpark area of the point
  - Approaching or diverging from point





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Recognize Failure

- Recognition must precede recovery
- Monitor goal progress
  - Evaluation functions based on problem space representations
- Evaluations may indicate
  - Failure
  - Success
  - Lack of success
  - Negative trend
- Anticipate impending failure in addition to detecting failure as it occurs

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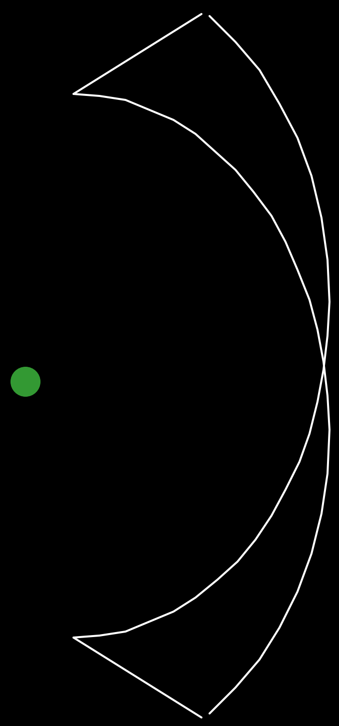
Resource Allocation

- Filter out unnecessary information
  - Example: barometric pressure less important in encircling a missile site
- Focus on critical information
- Each situation has a risk value based on perceived danger to the agent
  - Example:
    - Failure in transit is low risk
    - Failure in combat is high risk
- Variable sampling rage



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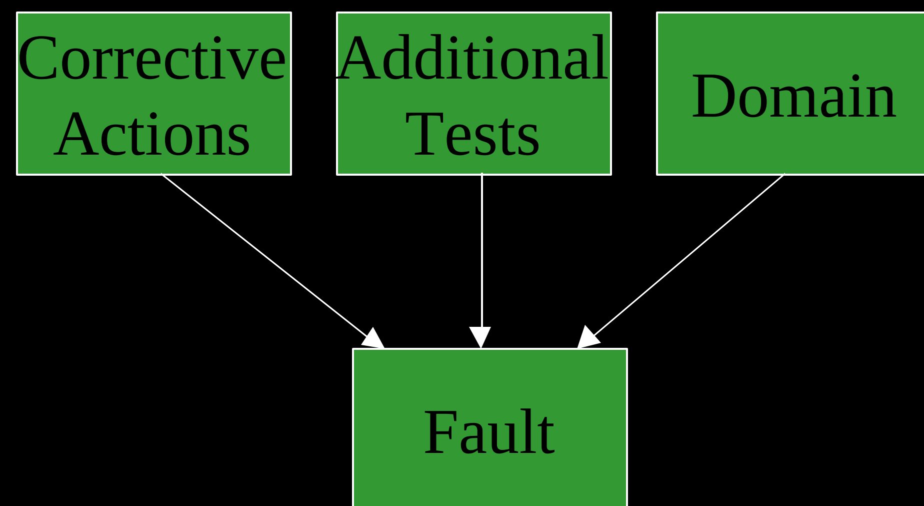
Reason / Diagnosis

- Possible causes
- Explain groups of symptoms
- Domain for further investigation
  - Flight
  - Communication
  - Radar
  - Weapon



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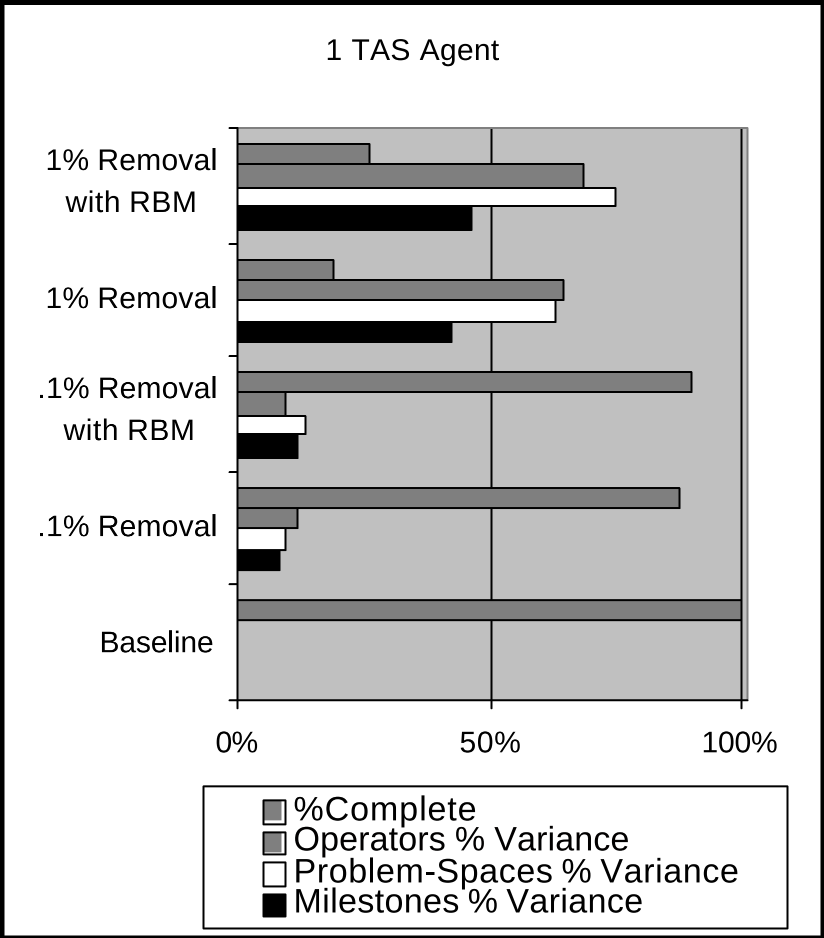
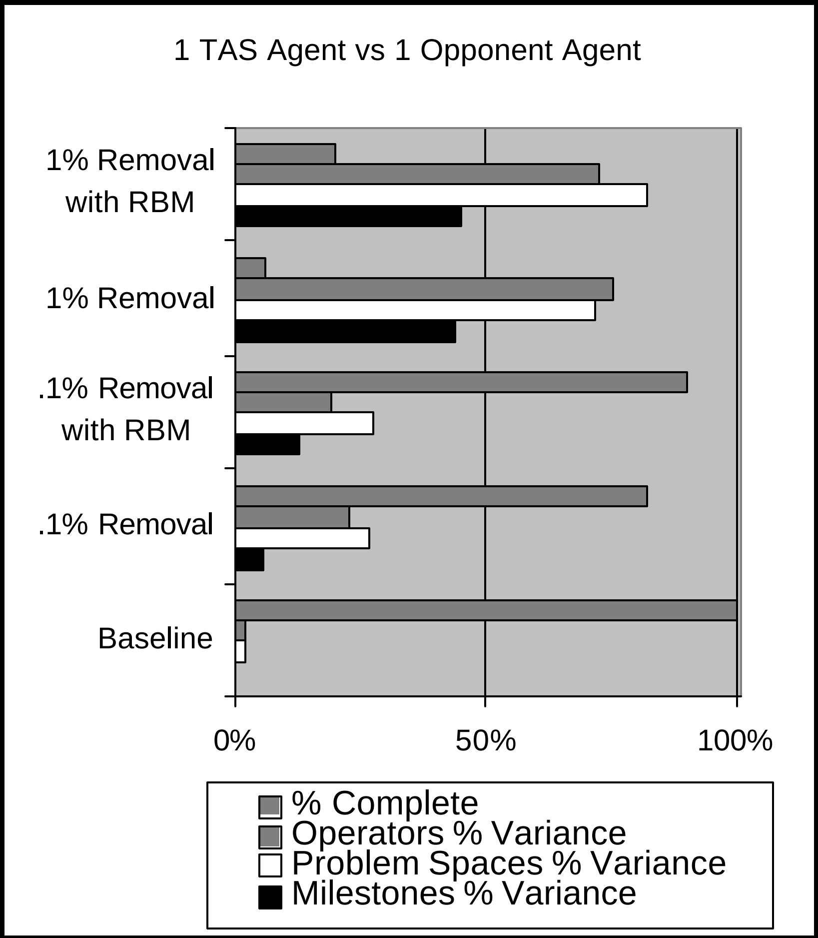
Responses

- Contextually appropriate
- Preplanned known solutions
- Use causal models of problem space to suggest appropriate recovery actions
- Even without detailed suggestions of specific actions, sufficient information provided by the model suggests a generic domain of possible actions

Comparison





TAS agent without opponent

TAS agent with opponent

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Metrics

Remove .1% Productions		
	1S	1Sv1D
Avg MS Variance	8.1%	5.4%
Avg PS Variance	9.7%	26.7%
Avg OP Variance	11.9%	22.7%
% Complete	87.8%	82.0%
with RBM		
Avg MS Variance	11.5%	12.9%
Avg PS Variance	13.4%	28.0%
Avg OP Variance	9.3%	19.7%
% Complete	90.0%	90.0%
Mission Incomplete		
Not instrumented	100.0%	100.0%
Instrumented	0.0%	0.0%
MS = Milestones		OP = Operators
PS = Problem Spaces		1S = 1 TAS Agent
1Sv1D = 1 TAS Agent vs. 1 Task Frame Agent		

0.1% Random Rule Removal

Remove 1% Productions		
	1S	1Sv1D
Avg MS Variance	42.2%	44.1%
Avg PS Variance	63.1%	71.5%
Avg OP Variance	65.0%	75.7%
% Complete	18.8%	6.0%
with RBM		
Avg MS Variance	46.3%	44.9%
Avg PS Variance	74.7%	82.1%
Avg OP Variance	68.4%	72.9%
% Complete	26.0%	20.0%
Mission Incomplete		
Not instrumented	86.5%	95.0%
Instrumented	13.5%	5.0%
MS = Milestones		OP = Operators
PS = Problem Spaces		1S = 1 TAS Agent
1Sv1D = 1 TAS Agent vs. 1 Task Frame Agent		

1.0% Random Rule Removal

Conclusions

- Steps of *Recourse* are plausible descriptions of recovery mechanisms
  - Sufficient to model recovery
- Pay off in terms of
  - Reliability, time, understanding, cost
- Solution can be generalized to any system that posts results and waits for responses
  - Proactively anticipate and design for failure
  - Broad, complete domain coverage
  - If what you are doing is wrong, try something else

Future Work

- Communications and planning domains
- Learning successful applications of recovery
- Anticipation
  - Attempt to anticipate impending failure in addition to detecting failure as it occurs
  - If error detected in future state, attempt to avoid it in present
- Biological organisms
  - Studying the behavioral system of biological organisms
  - Model their reactions to unexpected environments
- Emotional modeling
  - Use frustration to suggest alternative approach

Nuggets

- Provides a methodology for enhancing the robustness (reducing the brittleness) of rules-based systems
- Provides a small library of portable "qualitative physics" evaluation production rules
- Through the development of an automated testing system, demonstrates efficacy
- Improves the "believability" of symbolic agents

Coal 

- TacAir-Soar has several different "types" of domains requiring coverage – we have only applied this solution to the spatial reasoning domain
- Experimental results would be more convincing with better experiment design (in the works)
- Look-ahead search (anticipation) would further enhance this capability by extending it beyond errors-as-they-occur
- Still somewhat labor intensive, although there appear to be some possibilities for re-use and automation

Robustness in Behavior Modeling

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