The SRS Spatial Reasoning System

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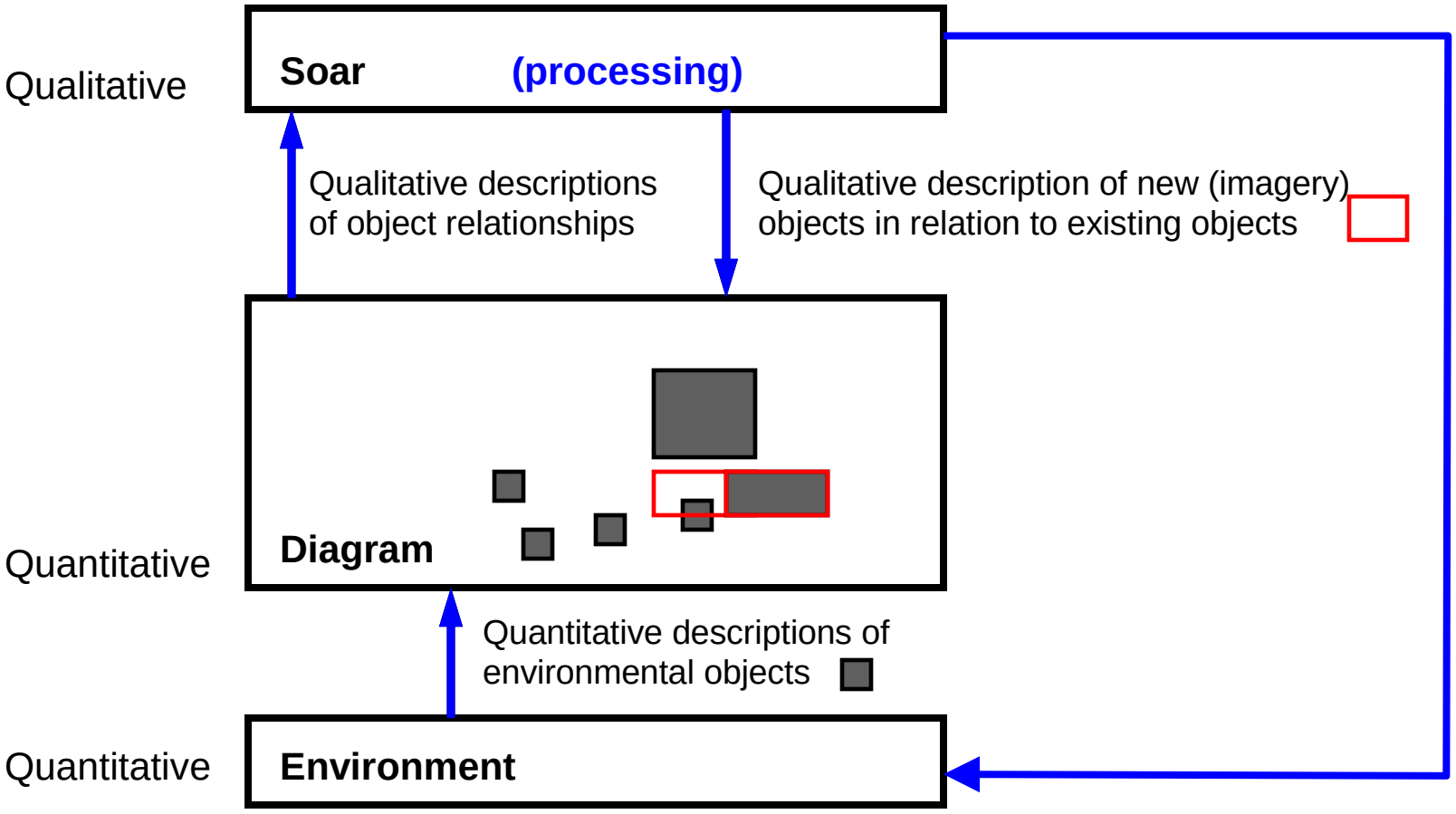
Overview

- Introduction
- Motivating problem
- Translating between qualitative and quantitative representations
- System overview
- Implemented agent example
- Summary and Conclusion

Bimodal Spatial Reasoning



Motivating Domain

- ORTS is a real-time strategy game, SORTS is the interface developed to play it
- RTS games are viewed as a map, with many units per player
  - The agent is not a part of the environment
  - This allows us to overlay perception with imagery
- Perceptions are the polygon outline of every object

Motivating Problem: Route Planning

- Problem: find a path from a source location to a target, avoiding obstacles
- This is solved by existing algorithms, but is a good challenge for a general spatial reasoning system

Agent

Obstacle

Goal

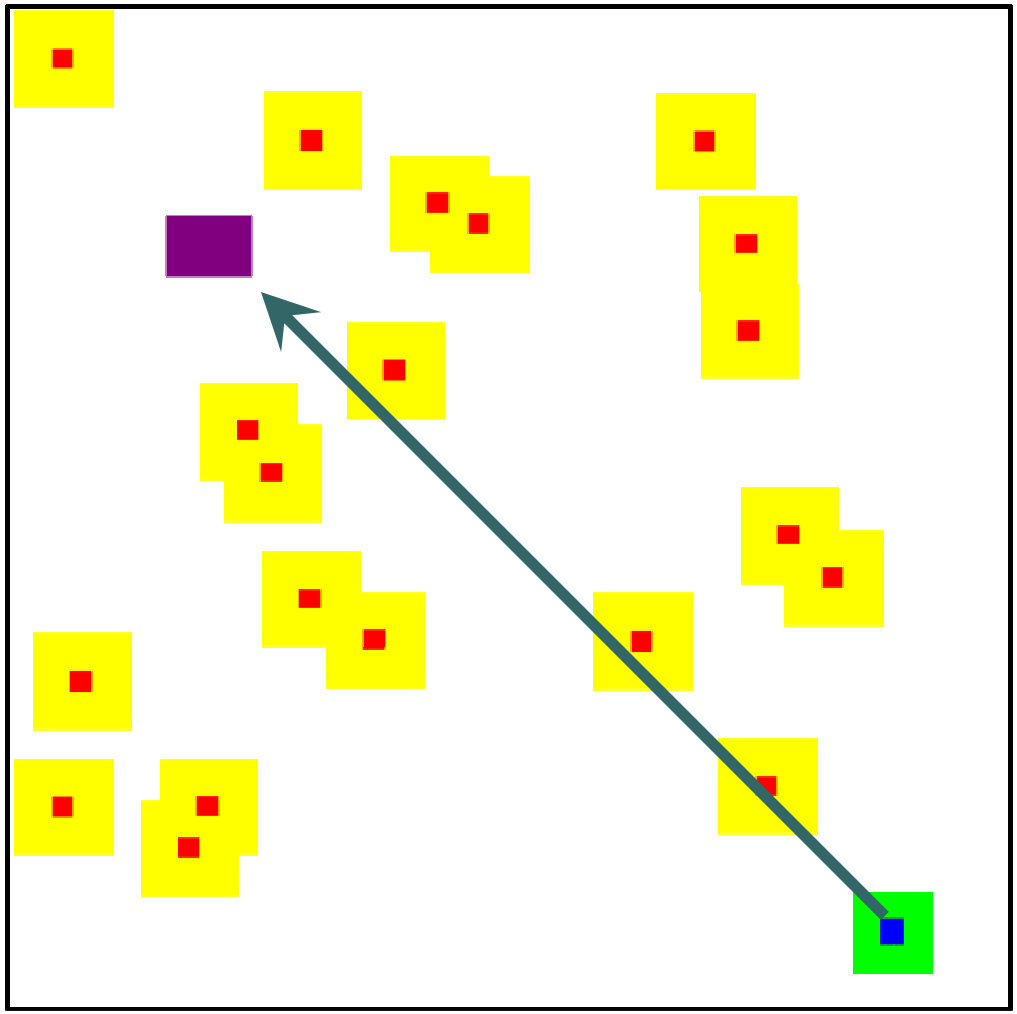
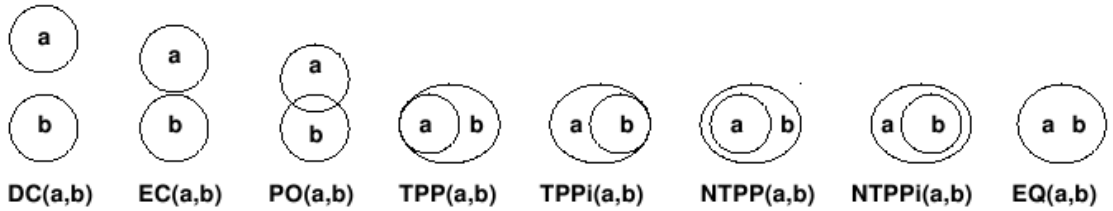


Diagram-to-Soar Interface

- Qualitative spatial reasoning will occur in Soar, and many relationships useful for QSR have been studied
- RCC (Region Connecting Calculus) describes topological relationships:

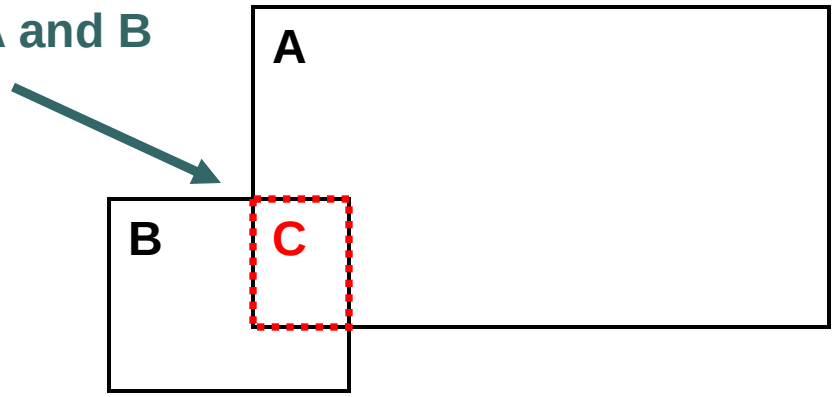


- Orientation relationships ("A is to the right of B") can be easily extracted
- Other relationships (distance and size) can be encoded as magnitudes, and easily compared in Soar

Soar-to-Diagram Interface: Predicate Projection

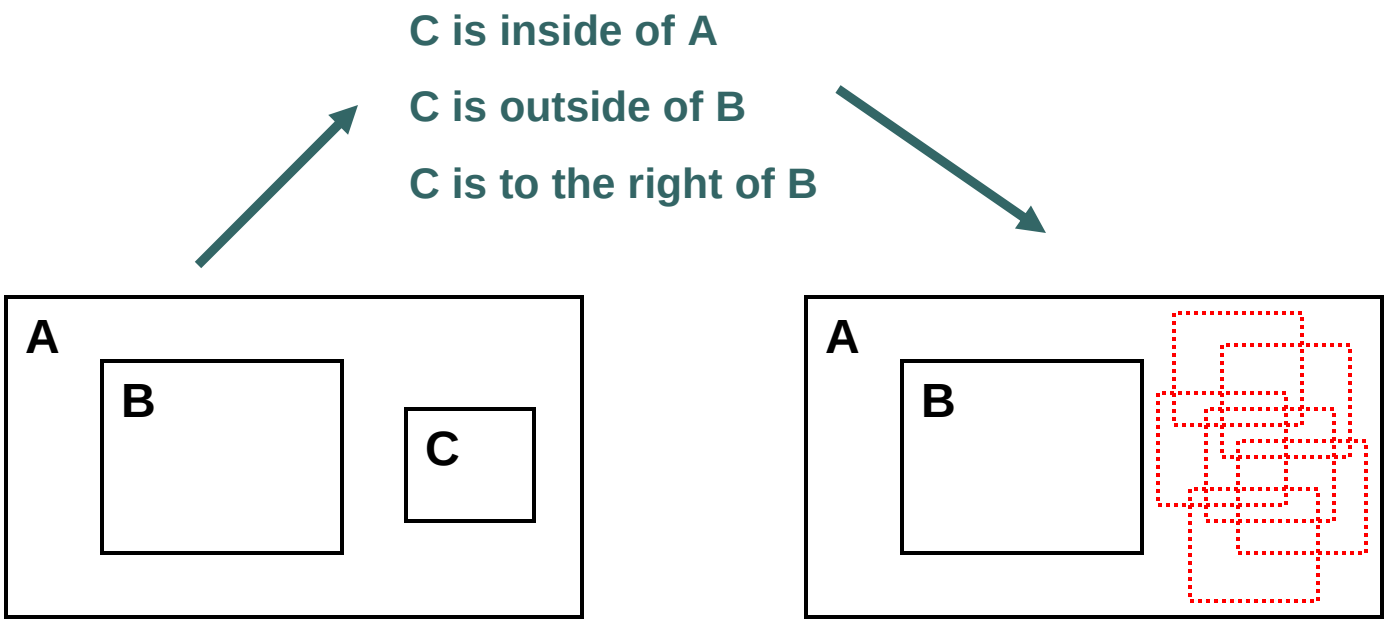
- How to translate symbolic descriptions to precise quantitative images, with generality?
- First strategy: direct description
  - Use basic geometric properties
  - Description can apply to at most one object in the diagram

C is the intersection of A and B



Predicate Projection, continued

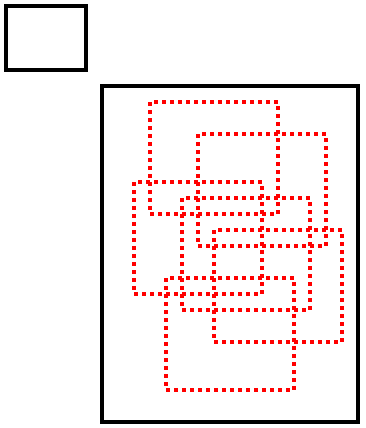
- Alternate strategy: use the same kind of abstract predicates extracted from the diagram
- This results in an underdetermined image (indirectly described by constraints)



Predicate Projection, continued

- Direct descriptions are useful, but only in some circumstances
- Indirect descriptions are useful, but tend to be vague

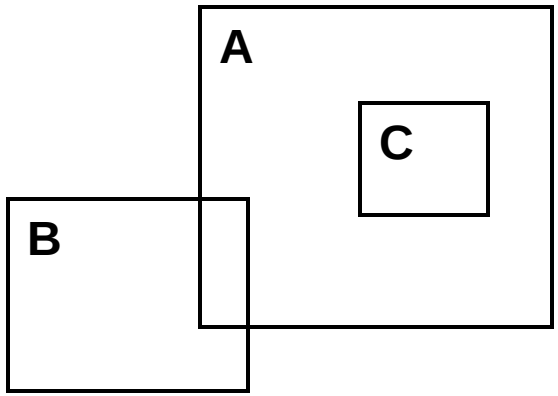
- Can we add more information to indirect descriptions?
  - Adding more constraints can only go so far
  - Apply some order over the possible images, and return extremes
  - *Preferences* for nearest and furthest images from a given object are used
  - Preferences are not constraints, but rules for choosing among images that meet constraints



Implementation: Querying Relationships

- Topological, orientation, and distance queries supported
- Need to select from the huge number of true relationships in the world
- Partial match retrieval system is used:

```
^query
  ^relationship discrete
  ^primary-object A
  ^value false
```



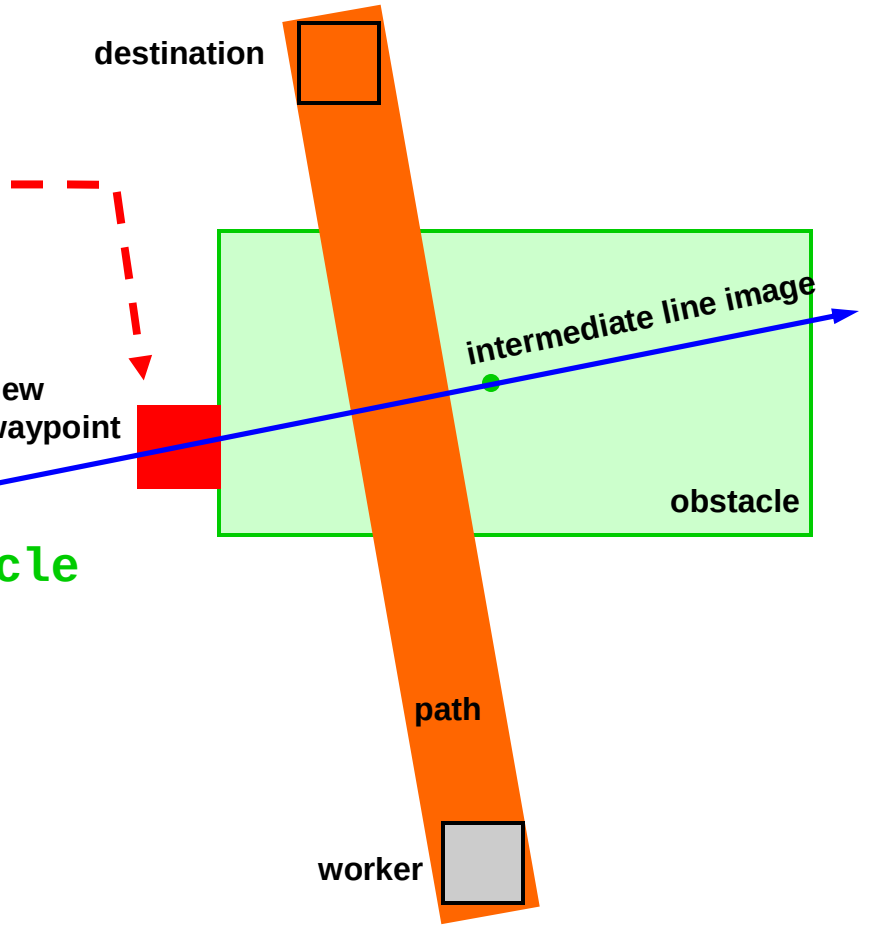

```
^query-result
  ^retrieved
    ^relationship discrete
    ^primary-object A
    ^reference-object B
    ^value false
  ^retrieved
    ^relationship discrete
    ^primary-object A
    ^reference-object C
    ^value false
```

Implementation: Building Images

- Direct and indirect descriptions allowed
  - Direct: lines, hulls, intersections, scaling
  - Indirect: inside/outside constraints, near/far preferences
- Problem: many images need temporary, intermediate images to be constructed
  - Solution: Allow images to be composed together

Image example: Creating a Waypoint

```
^image.indirect
  ^shape.object.id worker
  ^outside.object.id obstacle
  ^near
    ^rank 1
    ^object.image.line
      ^intersecting.object.id obstacle
      ^perpendicular.object.id path
  ^near
    ^rank 2
    ^object.id path
```

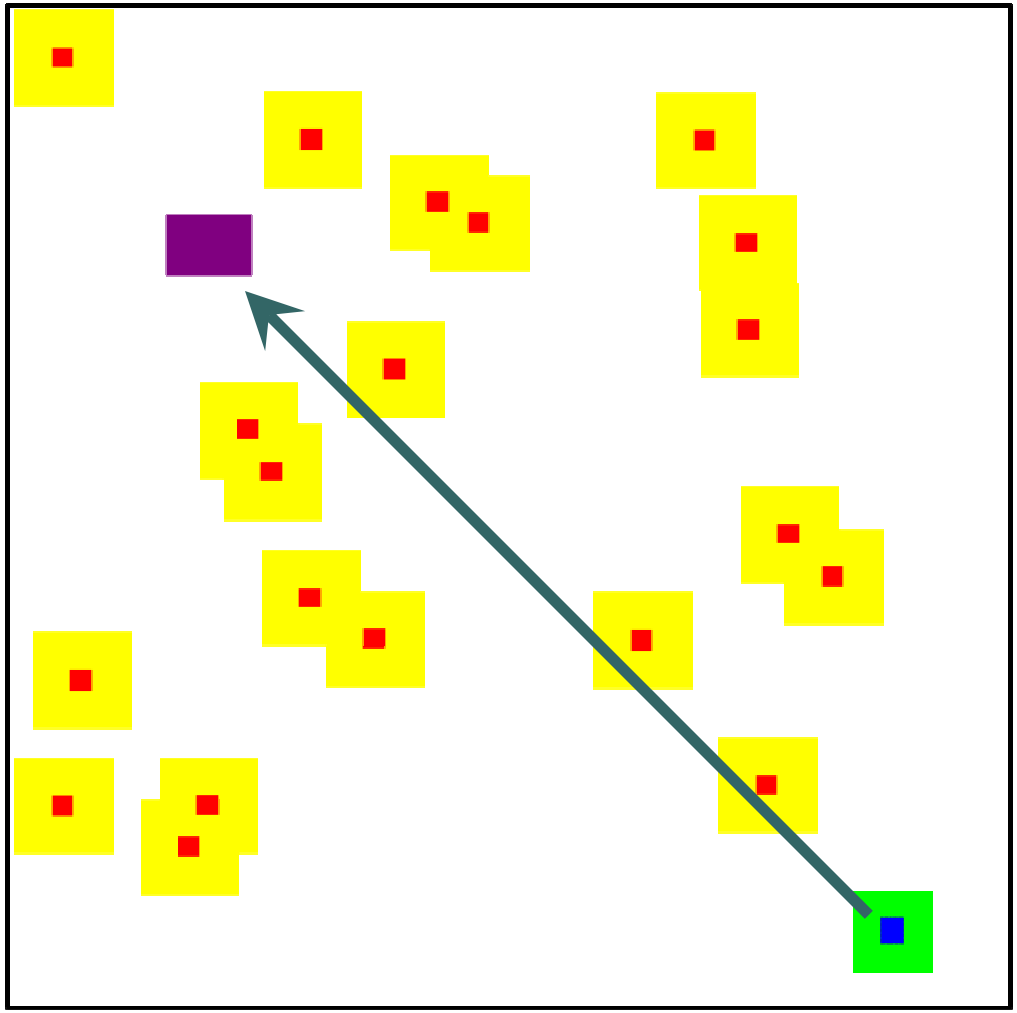


Route-Finding Agent Overview

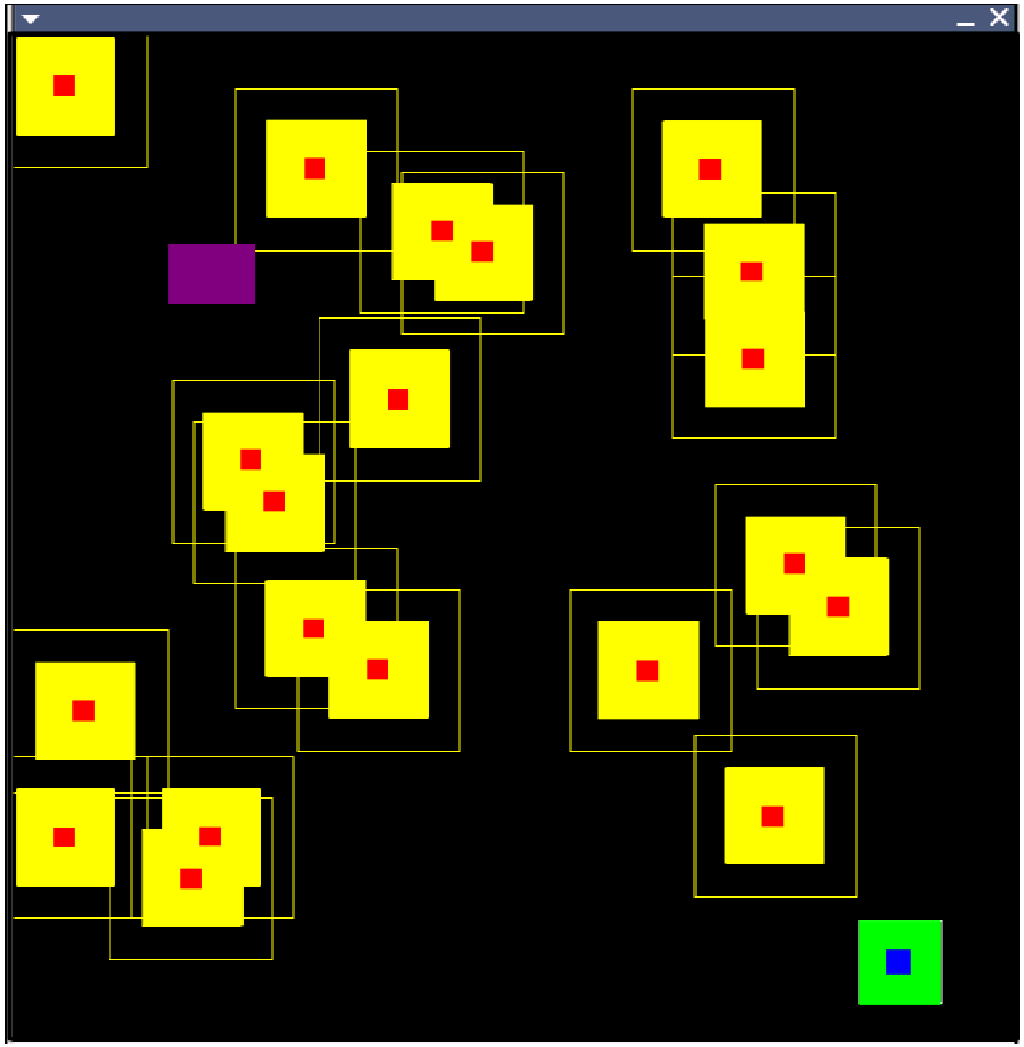
Agent

Obstacle

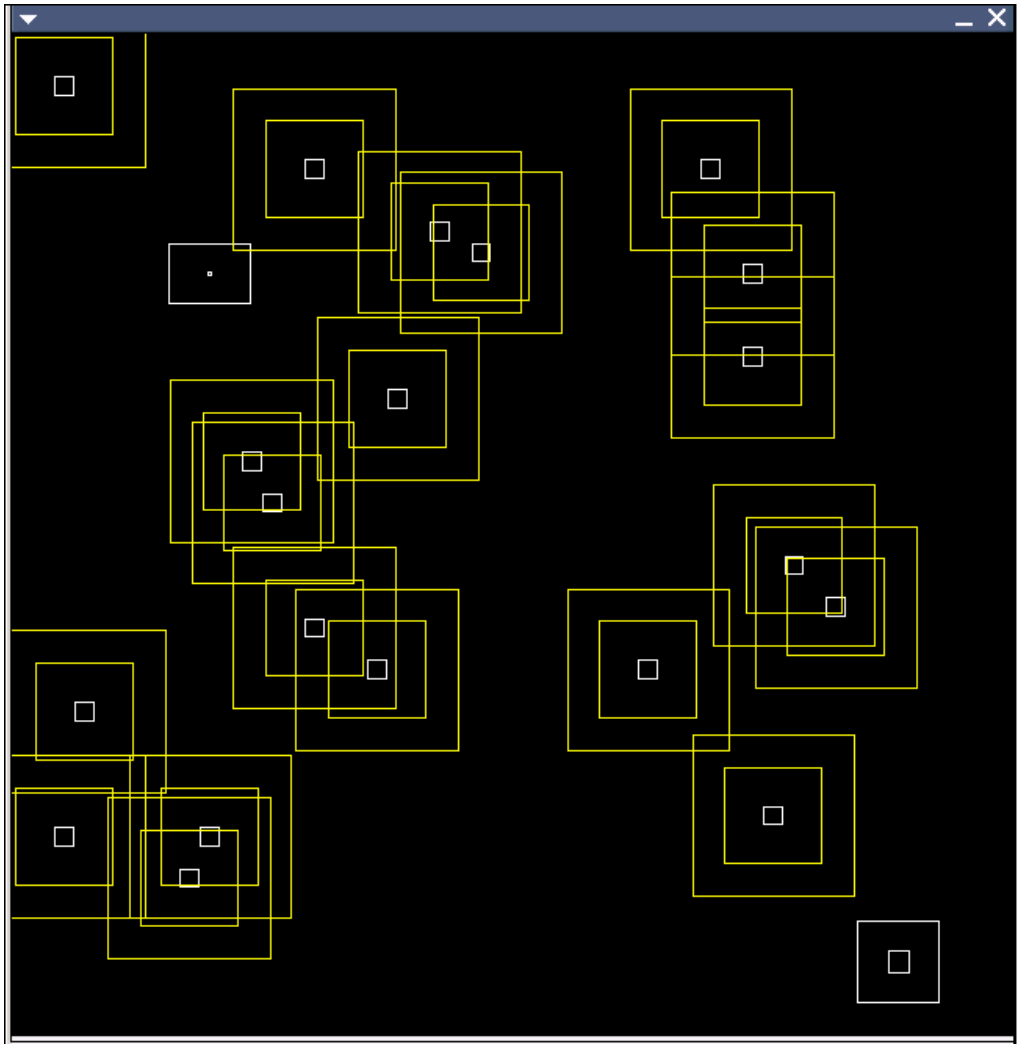
Goal



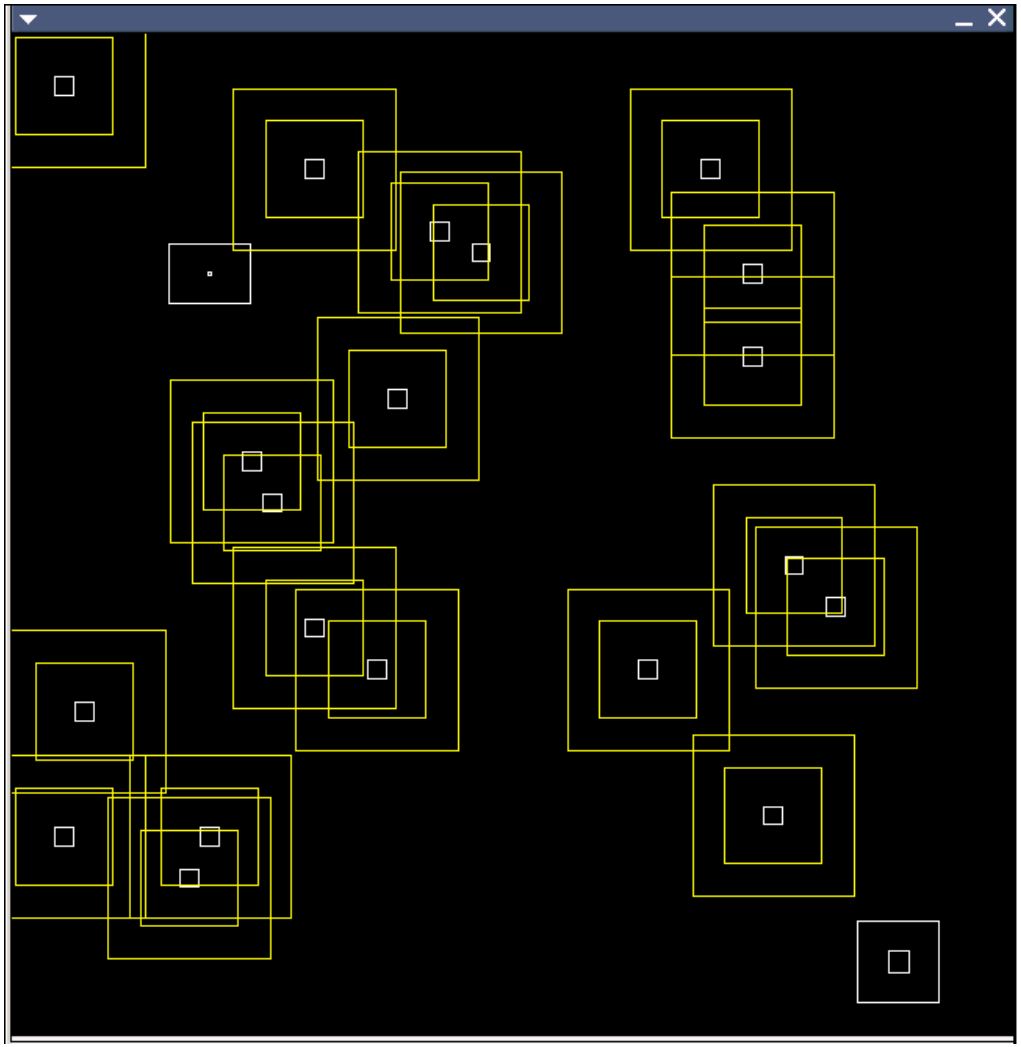
Route-Finding Agent



Route-Finding Agent



Route-Finding Agent



Summary

- Spatial reasoning in a cognitive architecture can be addressed by a bimodal representation system
  - This requires scrutiny on the interface between the quantitative and qualitative levels
- The qualitative description of images can be accomplished through direct descriptions, or indirectly through sets of constraints and preferences
- SRS was implemented to use this kind of image description

Conclusion: Gold Nuggets and Coal Nuggets

- Gold:
  - SRS enables new kinds of problem solving in Soar
  - SRS's image creation language is very flexible, and addresses an underexplored problem
- Coal:
  - No 3D support, only supports convex polygons
  - Not well tested / optimized yet
  - No funding

Questions?