Sketch Understanding for Robots

A review of Marjorie Skubic's research in Sketch-Based Robot Navigation

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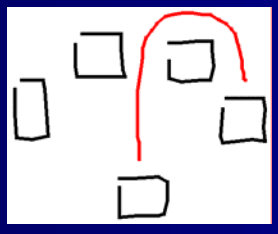
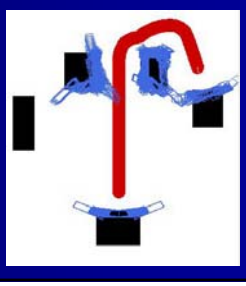
Sketch / Nav Summary

- Fuzzy relationships between points and obstacles
- Landmark points in the path (events)
- Use Sonar/laser scanners to match current position to a landmark, follow the command





Overview

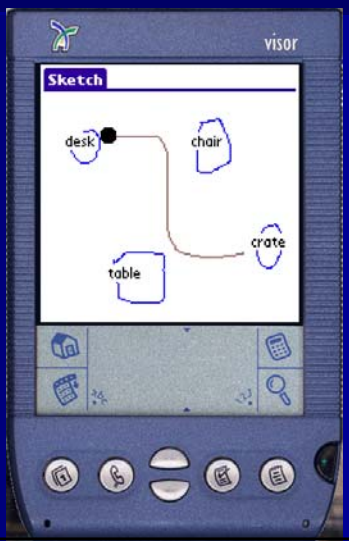
- We're looking for a representation that can unite sonar/laser range sensors and qualitative sketches
- Multiple scopes of discussion (confusing)
  - Sketches
  - Sensors
  - Simulator
- Large body of work since 2001, one paper in 2006 that changes everything

History since 2001

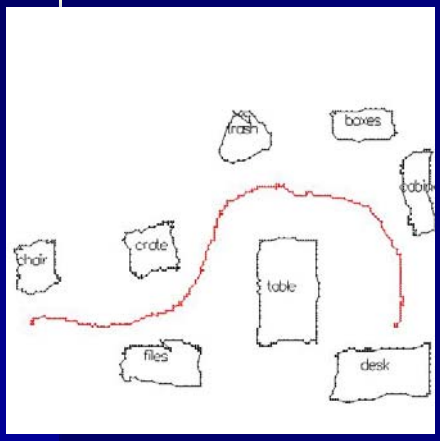
- "Extracting Navigation States from a Hand-Drawn Map", ICRA 2001
  - Navigation states based on sketches
- M. Skubic, S. Blisard, A. Carle, P. Matsakis, "Hand-Drawn Maps for Robot Navigation," AAAI 2002
  - User study / comparison of previous work
- "Qualitative Analysis of Sketched Route Maps: Translating a Sketch into Linguistic Descriptions," *IEEE Transactions on SMC Part B, 2004*
  - Extracts landmark points from a path
- "Sketch-Based Navigation for Mobile Robots," *IEEE 2003 International Conference on Fuzzy Systems*
  - Robot simulator experiment using the previous work
- "A Sketch Interface for Mobile Robots," *IEEE 2003 Conf. on SMC*
  - Adds a slick user interface to the previous work
- "Robot Navigation Using Qualitative Landmark States from Sketched Route Maps," ICRA 2004
  - Adds some mathematical extensions to 2003, uses a real robot experiment
- "Using a Qualitative Sketch to Control a Team of Robots," ICRA 2006
  - More than one robot, new interface, major changes

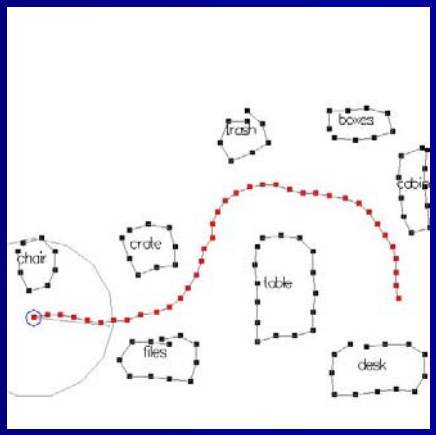
The Sketch Interface

- Objects
- Labels
- Paths
- Delete
- Start
- Move
- Undo
- Send

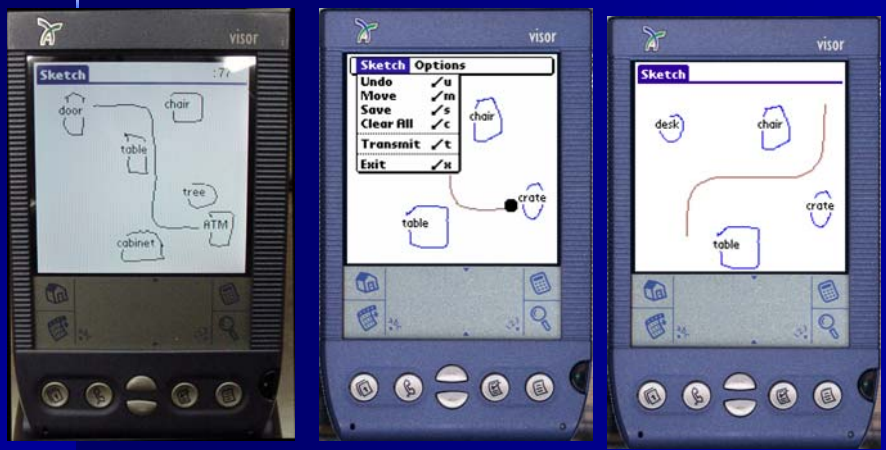


Resampling



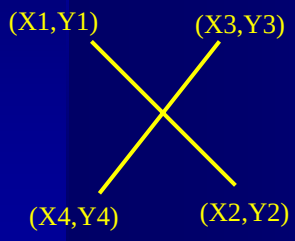


Screenshots



Determining Crossed Marks

- Use the slope equations of lines
- Endpoints of strokes determine the line
- A pair of decision parameters can be computed
- If both parameters lie between 0 and 1, then the two strokes must have an intersection



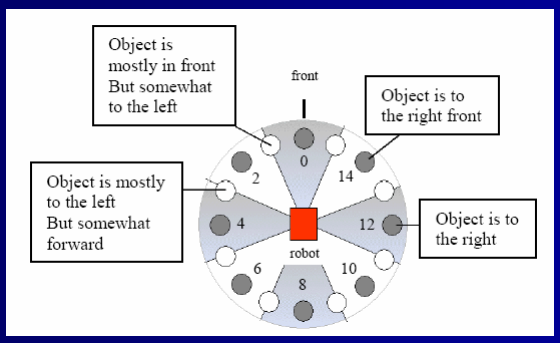
$$u_a = \frac{(X4-X3)(Y1-Y3) - (Y4-Y3)(X4-X3)}{(Y4-Y3)(X2-X1) - (X4-X3)(Y2-Y1)}$$

$$u_b = \frac{(X2-X1)(Y1-Y3) - (Y2-Y1)(X1-X3)}{(Y4-Y3)(X2-X1) - (X4-X3)(Y2-Y1)}$$

IF $(0 < u_a < 1)$ AND $(0 < u_b < 1)$ THEN the lines intersect

Navigation States

- Describe the relative environment with fuzzy terms
- All the discrete objects visible within a sensor radius



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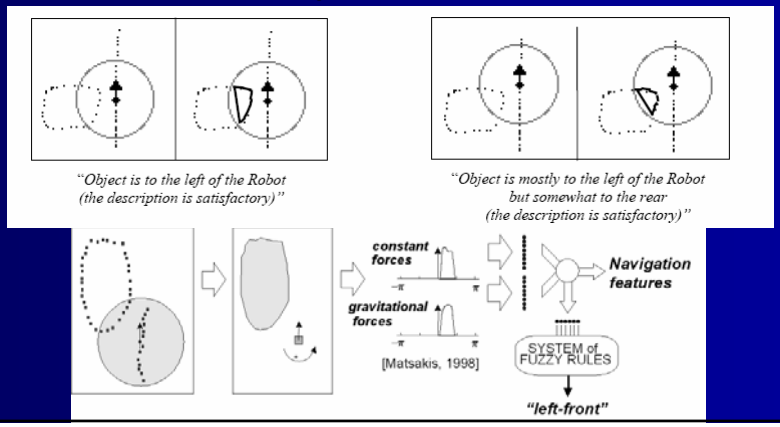
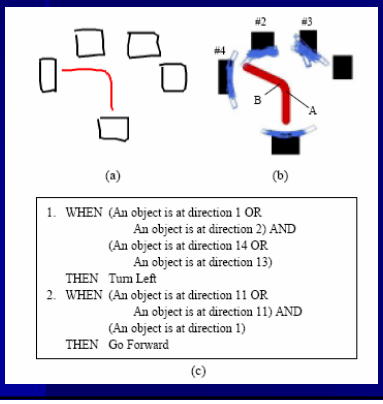
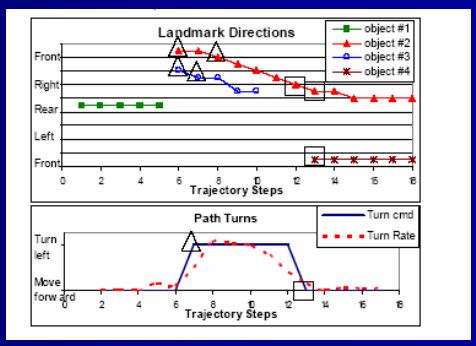


Path Landmarks

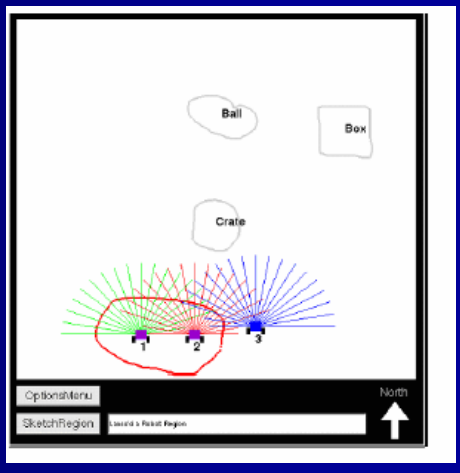
- Discrete important points
  - Based on change of heading





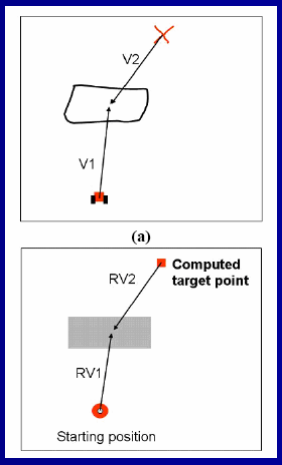
Multiple Robots

- Tap creates
- Lasso selects
- X issues GoTo
- Paths
- Arrow for delay
  - (Menu, HMM)



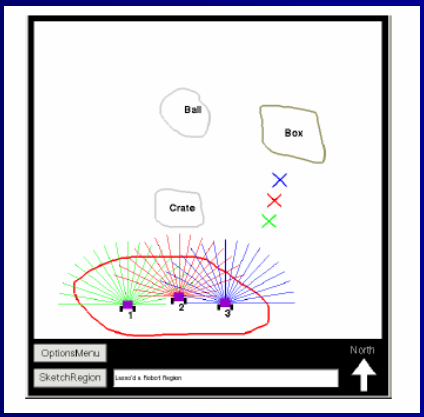
Relative Coordinates

- Conversion from sketch coordinates to robot coordinates
- Uses a reference object (closest to the target point)



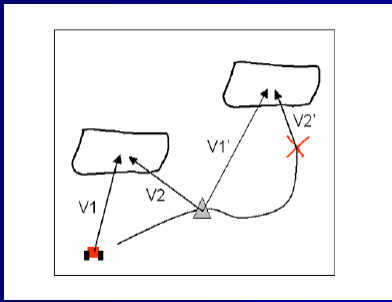
Multiple Commands

- Sorted by distance



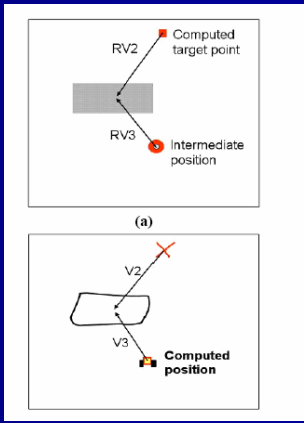
Paths

- Intermediate points evenly spaced
- Contradicts earlier work



Updating the Display

- There's no GPS
- Relative vectors
  - Requires exact knowledge of the obstacle centers



AAAI Experiment

C. Robot Implementation

The robots used for this experiment were commercially available, four-wheeled, slip-steer robots equipped with laser rangefinders and internal gyroscopes (Fig. 1). The robots were controlled with software developed through the Player/Stage project [11]. The robots used wireless access bridges to communicate with the controlling computer through the use of the IEEE 802.11b protocol. In order to provide a consistent experimental environment, participants interacted with the simulator, and the robots were directed by manually issuing waypoints from the controlling computer.

Conclusion

- Basic mechanism is really cool
- Great question of sensor fusion
  - Real world
  - Qualitative sketches
  - Limited sensors
- Not much conversation about the sensors
- Latest paper doesn't add up
- User studies aren't very compelling
- Interface isn't terribly innovative
- Future work: Combine with SLAM