A Hybrid Soar/Echo Model of Tactical Decision Making

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Introduction

- Tactical decision making is an abductive reasoning task. That is, given a set of observations (e.g., speed, heading, visual ID, ...), find the best explanation(s) (e.g., friendly, hostile, ...).

- An abductive reasoning task includes both hypothesis formation and hypothesis evaluation, thus requires both explicit rule-based reasoning (e.g., if a target does not reply the radio warning, it is hostile), and implicit uncertainty management (e.g., what's the likelihood of no response given hostile).

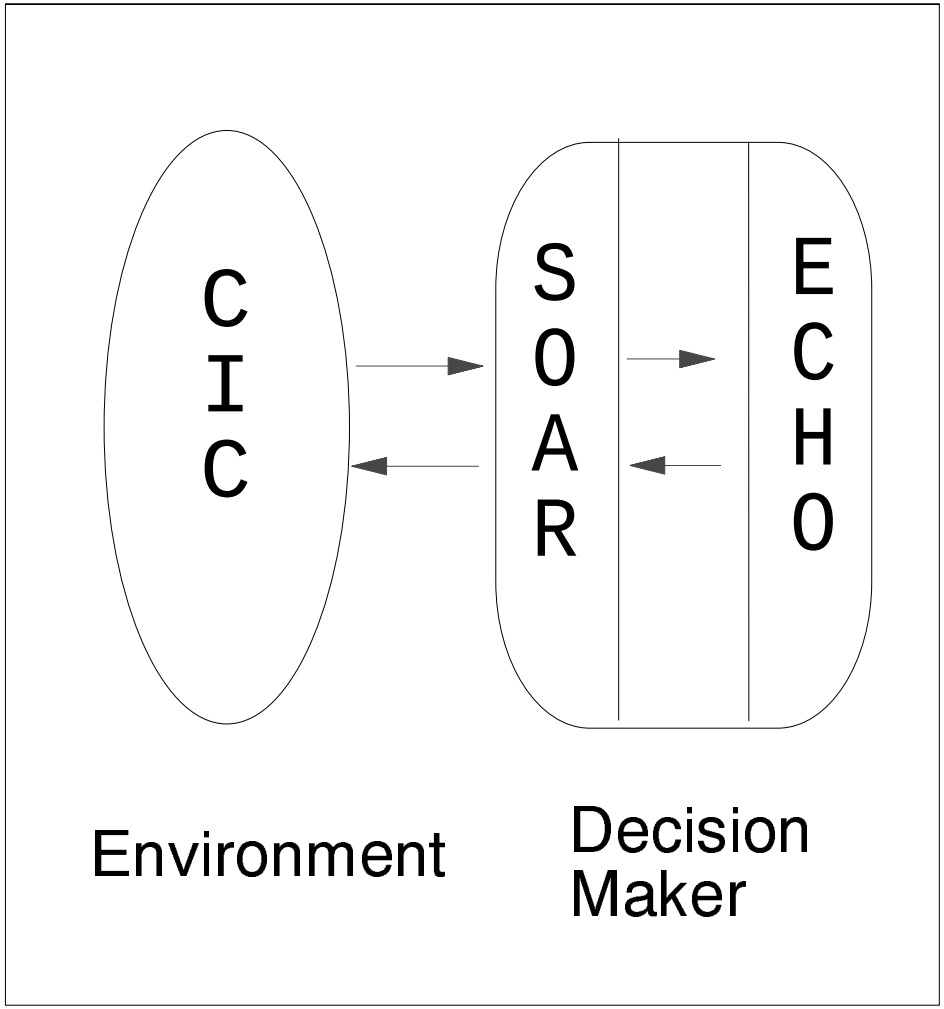
A Hyrid Soar/Echo Model

- Echo is a connectionist implementation of Thagard's Theory of Explanatory Coherence (1992), which is a theory of abduction. According to this theory, the best explanation is the one with the most explanatory coherence based on all current hypotheses, evidence and explanatory relations.

- Integrating Soar and Echo addresses both hypothesis formation and hypothesis evaluation, thus may produce a plausible model of human abductive reasoning.

Model Components

- CIC serves as a perception and action execution component.
- Decision maker consists of Soar and Echo. Soar builds a situational model based the input from CIC. Echo monitors Soar WM and provides evaluations. Soar makes decisions and outputs them to CIC.



Model Development

- Environment: Linux (Red Hat 4.1) + Soar 7.0.4 + CIC 2.7 + TCL 7.4 + TK 4.0 + UEcho 4.0.

- CIC and Soar communicate via reading and writing two text files, MLData and Status. File MLdata is used by CIC to inform Soar about the progress of a scenario, and by Soar to communicate decisions back to CIC. File Status is used to control and mark who has control of the process.

- Soar and Echo communicate via the monitor facility. Echo is called before each decision phase.

```
monitor -add before-decision-phase-cycle
get-echo-results
```

Communication in Details

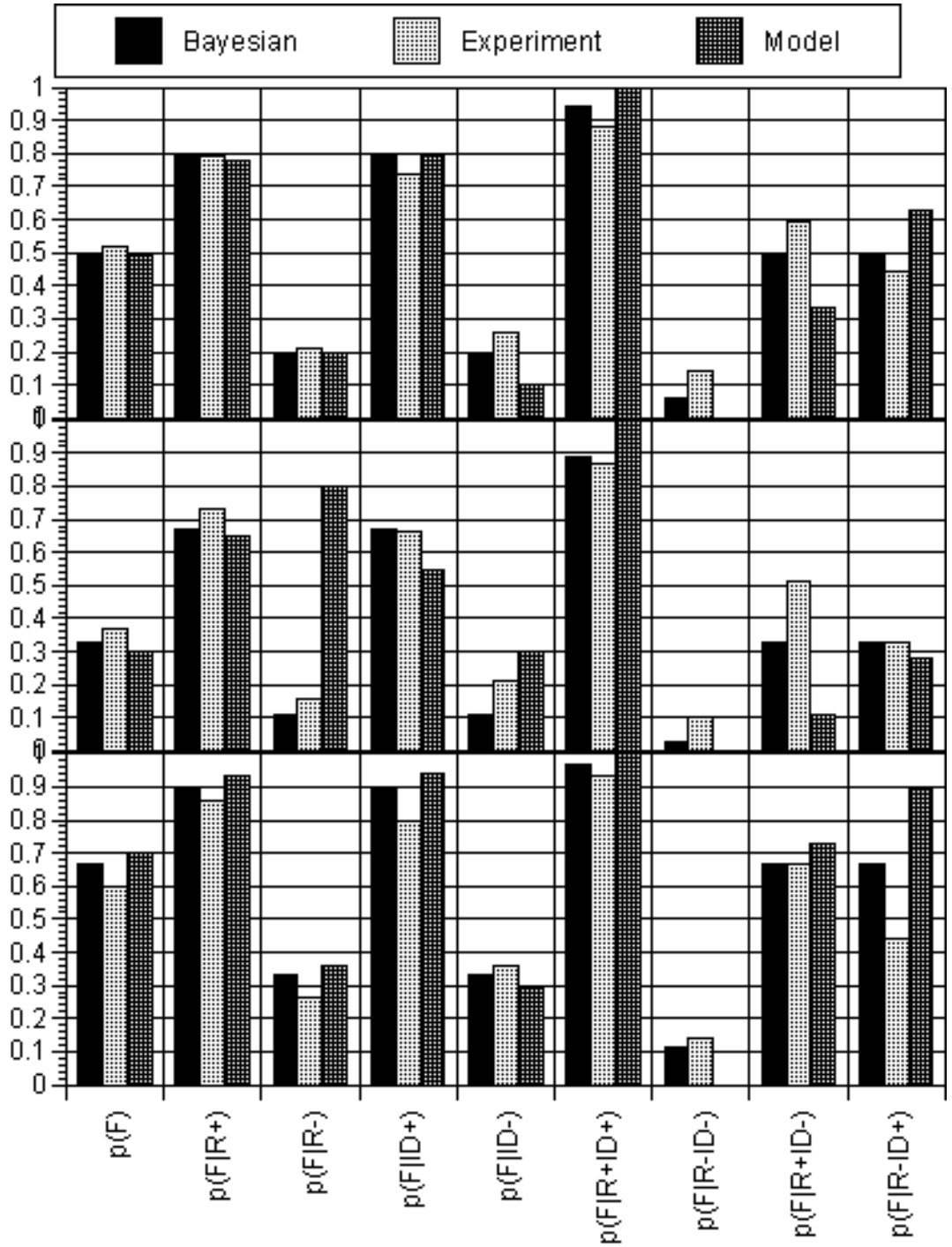
```
soar> run

1:    O: O2 (wait)No action
5:    O: O4 (read-input)Reading Input.
 Periodic update at time 4
     Flight target 1061 is 008 miles away,  with identity
friendly
 Total target number is 1
UECHO: Activation of hy1061h is 0.010
UECHO: Activation of hy1061f is 0.010

6:    O: O5 (hook)hook target 1061
8:    O: O10 (warning)send warning to 1061
10:    O: O16 (check-route)check route of target 1061
send uecho e_singledata e1061on
UECHO: Activation of hy1061h is 0.002
UECHO: Activation of hy1061f is 0.180

13:    O: O21 (read-input)Reading Input.
 Periodic update at time 20
   10 seconds have passed since warning, assume no response.
send uecho e_singledata e1061n
UECHO: Activation of hy1061h is 0.186
UECHO: Activation of hy1061f is 0.051
...
Soar: Please learn a new case: Target1061 is friendly
```

Model Evaluation 1

- Base Rate Learning
  - Base rate information plays an important role in human abductive reasoning.
  - It has been shown that, in some circumstances, people can automatically and accurately acquire and use base rate information (e.g., Hasher & Zacks, 1979, 1984).

Results --

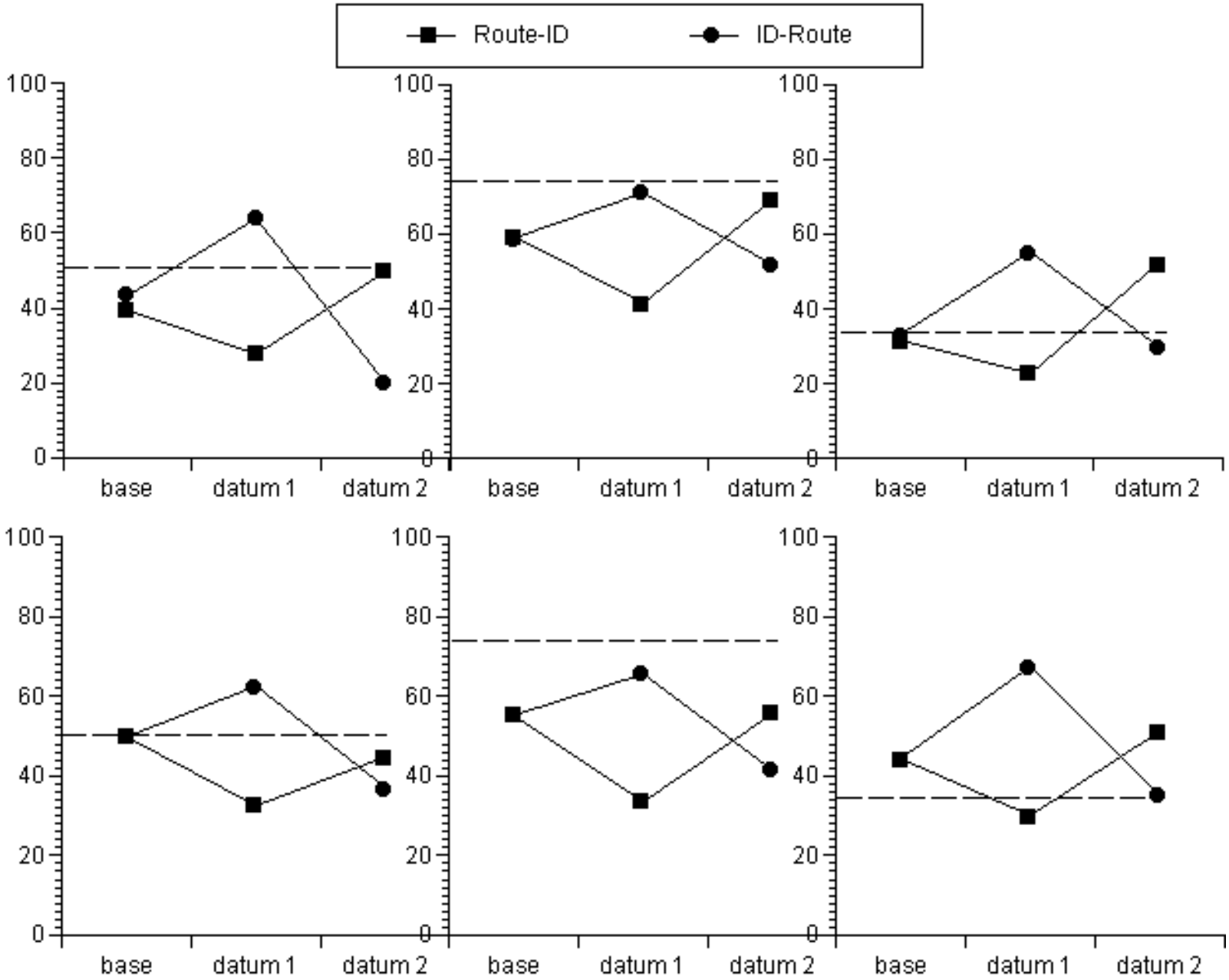
Base Rate Learning



Model Evaluation 2

- Order Effects
  - A fairly robust finding in literature: One prefers hypothesis H1 when evidence A is given before evidence B, and prefers hypothesis H2 when B is given before A.
  - Anchoring and adjustment heuristic -- people adjust a current belief based on how strongly the new evidence confirms or disconfirms this belief (e.g., Hogarth & Einhorn, 1992).

Results -- Order Effects



Conclusions

- The Soar/Echo integration model simulates human abductive reasoning reasonably well. While Soar models hypothesis formation, Echo captures the uncertainty management in hypothesis evaluation.
- Learning in Soar has not been implemented.
- Model fine-tuning is needed.