MONITORING TEAMS BY OVERHEARING: A MULTI-AGENT PLAN-RECOGNITION APPROACH

Team – Ones and Zeroes

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SOURCE

- Kaminka , G.A., D.V. Pynadath, and M.Tambe (2002). Monitoring Teams by Overhearing: A Multi-Agent Plan-Recognition Approach, *Journal of Artificial Intelligence Research*, 17:83-135.

OUTLINE

- Background
- Plan Recognition
- Implementation
- Social Structures
- YOYO*
- Case Study
- Related Work
- Conclusion
- Future Work

BACKGROUND

- Problem
  - Need for online monitoring of teams of cooperating agents
  - Cannot rely on agents to always communicate their state to the monitoring system
- Solution
  - A monitoring agent can use plan recognition to infer the state of the agents based on the observed routine messages

PLAN RECOGNITION

- Inferring the plans of intelligent agents by observing the agents' actions.

- How is this done?
  - Knowledge of team hierarchy
  - Knowledge of plan hierarchy
  - Relationship between the two hierarchies

PLAN RECOGNITION

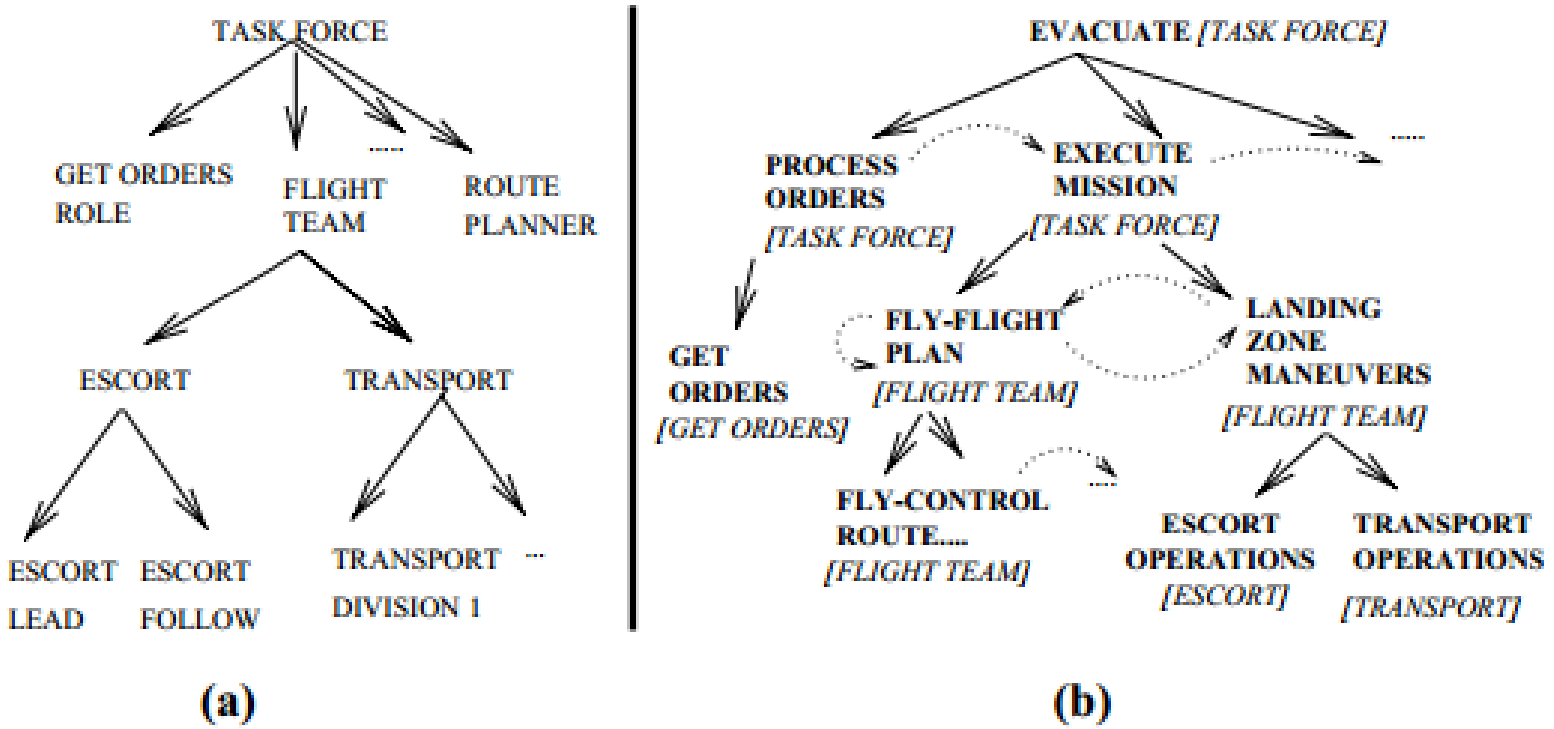


Figure 1: Portions of the team-hierarchy (a) and plan-hierarchy (b) used in our domain. Dotted lines show temporal transitions.

PLAN RECOGNITION PROBLEMS

- Agents make very few observable actions
- Agents change states discretely
- At all times a monitoring system must infer the state of all agents.
- Real time responses
- Scalability

IMPLEMENTATION

- OVERSEER
  - Monitoring system capable of monitoring large groups of previously deployed agents
- OVERSEER includes
  - Efficiency → linear time probabilistic plan recognition representation
  - Predicting future observations by understanding social procedures of teams
  - YOYO*, algorithm that takes knowledge about the team hierarchy to model the agent team using a single structure instead of modeling each agent individually

MONITORING A TEAM BY OVERHEARING EXPLOITING SOCIAL STRUCTURES

- Social Structure – structures of interactions between agents that make the decisions of one team member dependent at some degree on those of the teammates
  - Addresses scarce observations, since agents rarely communicate at the same time
- Relies on estimating when agents will change their internal state
- Uses this temporal model to base the estimations
  - Plan execution times vary depending on
    - external environment
    - when a plan-step is executed internally
    - outcome of a plan-step
- As complexity of agent behavior increases so does the complexity of the temporal model

MONITORING A TEAM BY OVERHEARING EXPLOITING SOCIAL STRUCTURES

- Team Coherence – agents in teams work together, as a team-member they are ideally in agreement about joint goals and plans

- Use coherence as a heuristic to preferring hypotheses in which team members agree up, over ones which they disagree about

EXPLOITING PROCEDURES THAT MAINTAIN SOCIAL STRUCTURES

- Idea
  - Clashing Beliefs can't exist without flawed logic
- Examples
  - Narrow down answers in a test
  - Against all killing, but for the death penalty

- Idea
  - Removing agent independence allows easier predictions for the entire team of agents
- Examples
  - Basketball – If the ball switches teams then the opposite team won't stay on offense. The logical action would be to switch to defense.

STATS

- Monitoring independent agents individually leads to a result of 4% accuracy on average.

- Using social knowledge and the previous ideas the accuracy has an average of 84%

PLAN RECOGNITION FOR OVERHEARING

- YOYO* relies on a single plan hierarchy to represent all team members as one.
  - Has a probability of how likely an action will be chosen
  - Efficient for reasoning about coherent hypothesis

ACCURACY EVALUATION

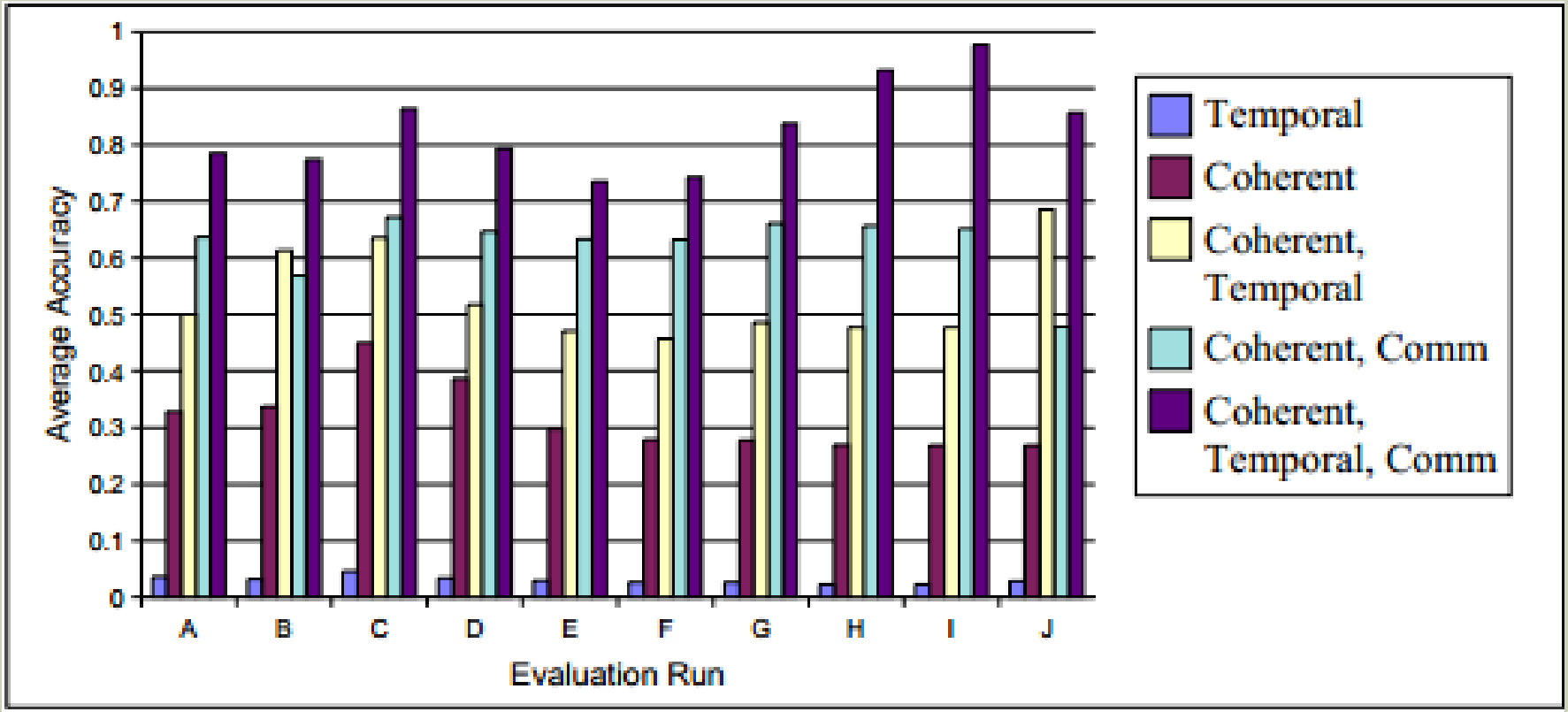
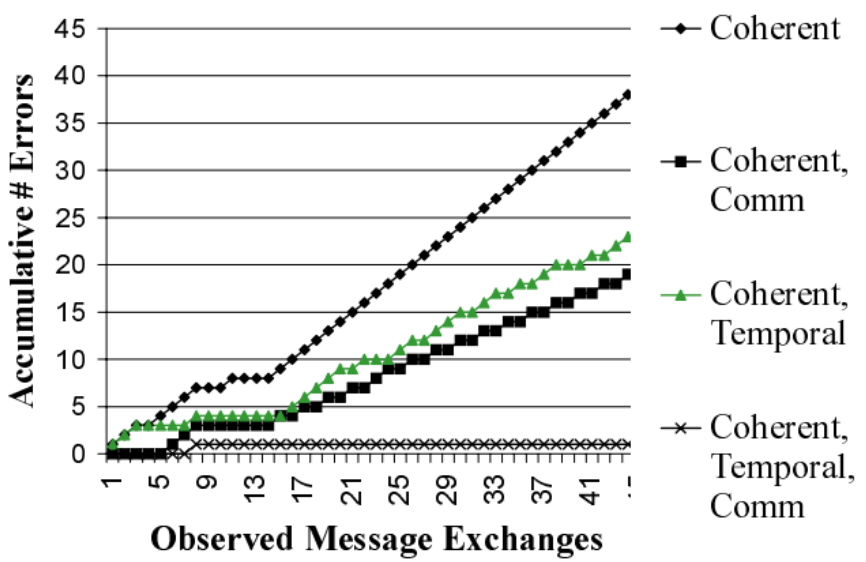
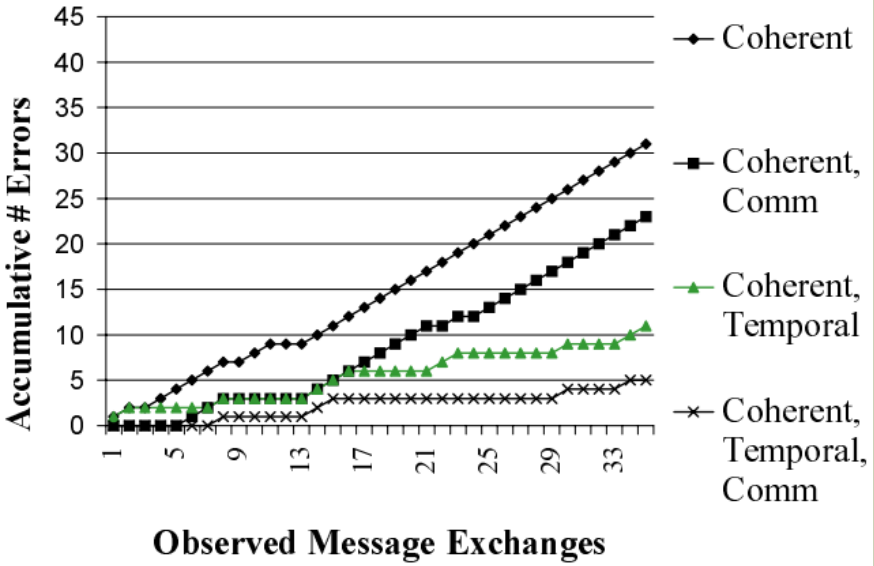


Figure 5: Percent accuracy in sample runs.

ACCURACY EVALUATION



(a) Run I



(b) Run J

Figure 6: Accumulative number of errors in runs I and J.

ACCURACY EVALUATION

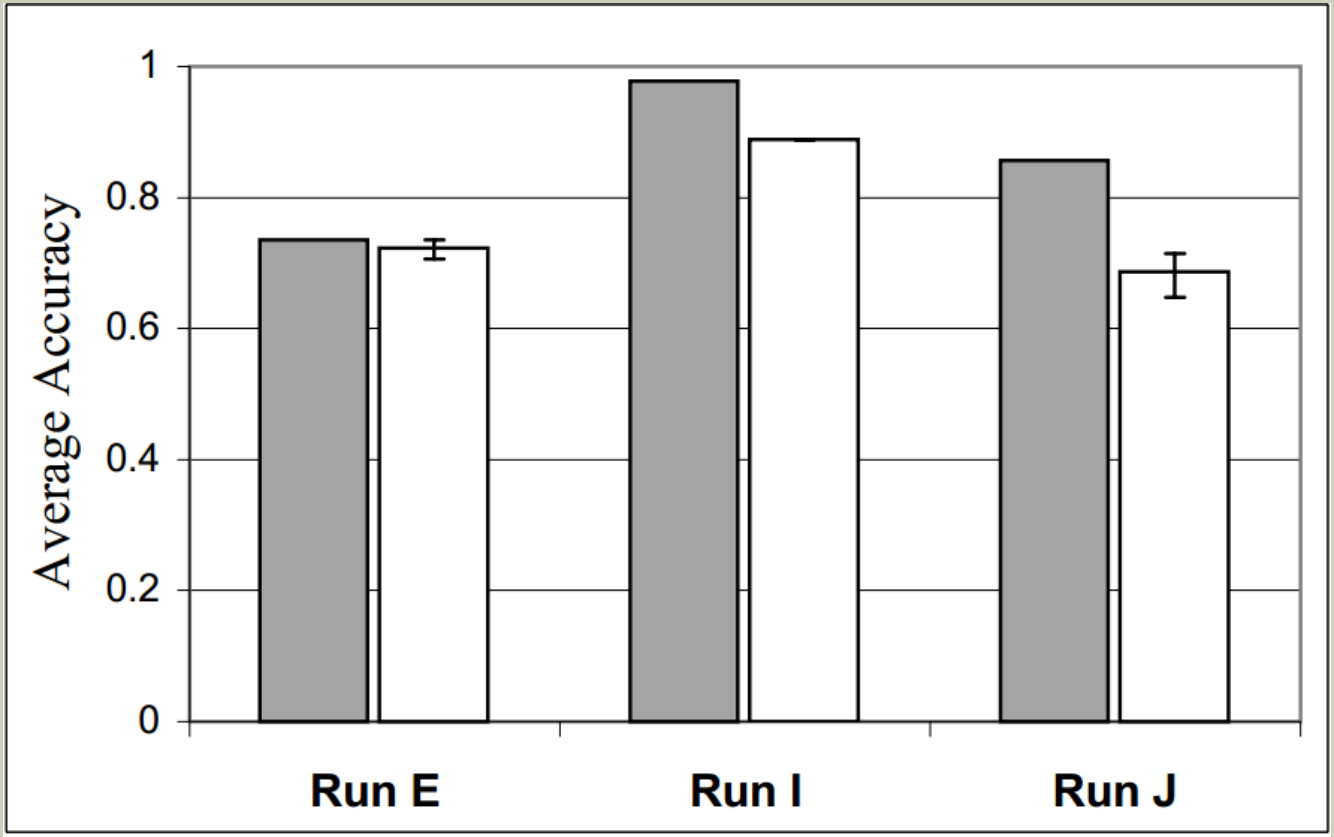


Figure 7: Comparison of average accuracy results with 0% and 10% observation losses.

ACCURACY EVALUATION

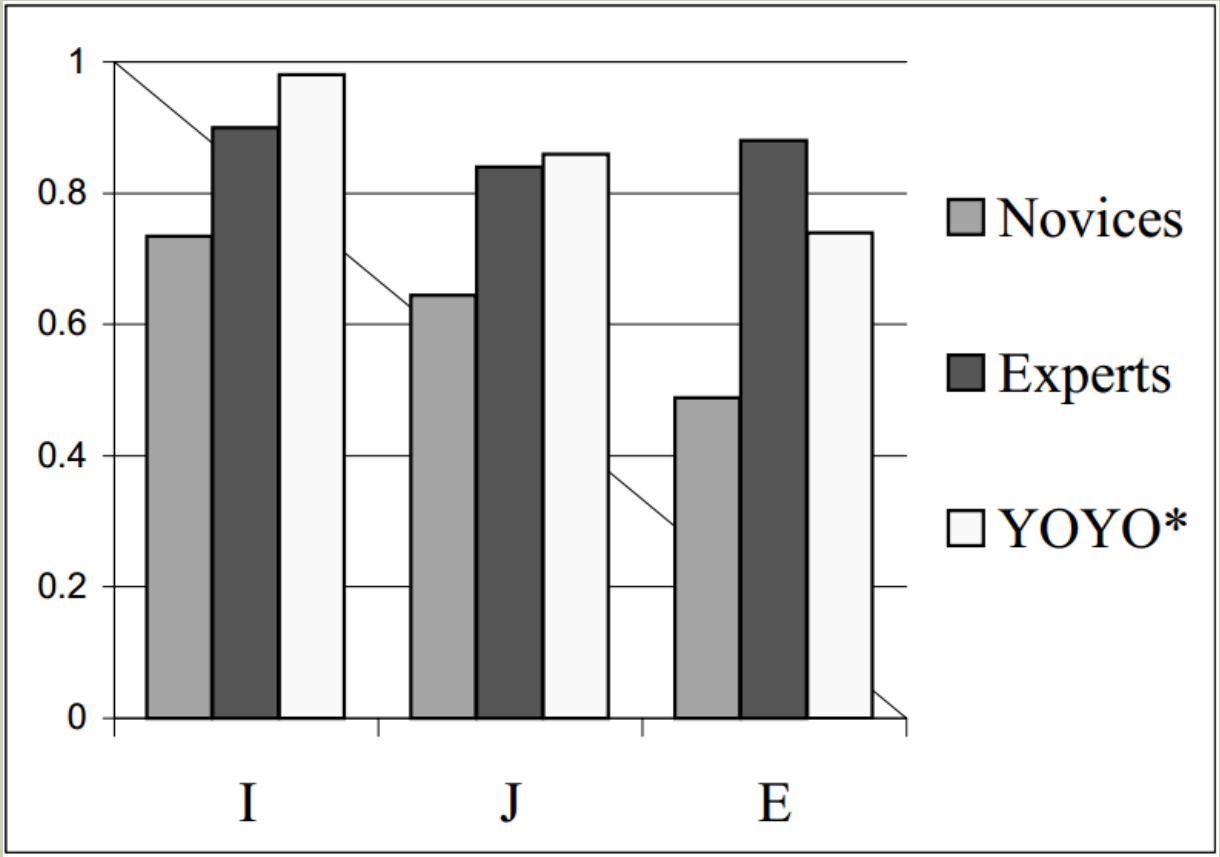


Figure 8: Accuracy of human novice and expert monitors compared to OVERSEER.

RELATED WORK

- Aiello et al.
  - Overhearing can improve the outcome of the agents.
  - Example:
    - Two people are having a conversation and someone raises a question to which the other does not know the answer. An outside person provides input which answers the question, benefitting the person that raised the question to start.
- Devaney & Ram, 1998
  - Use pattern matching to recognize team tactics in military operations

CONCLUSION

- Monitoring by overhearing
  - Become more important with increasing need to monitor agent systems
    - Particularly distributed or deployed
- OVERSEER
  - Uses
    - An efficient probabilistic algorithm for plan recognition
    - YOYO*
    - Social structures and procedures

FUTURE WORK

- Use of rote-learning to predict when messages will be observed
  - Good → normal runs
  - Bad → rare patterns of communication arose
- In depth exploration of the role of learning
- Learning mechanisms that derive plan hierarchy and team hierarchy from conversation records

QUESTIONS?

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