CAP6938-02
Plan, Activity, and Intent Recognition

Lecture 1:
What, Why, How?

Instructor: Dr. Gita Sukthankar
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Schedule: T & Th 1:30-2:45pm
Location: CL1 212
Office Hours (HEC 232):
T 3-4:30pm, Th 10-11:30am

Outline

- Course details
- Research process
- What is plan/activity/intent recognition?
- Why is it difficult?
- What are potential applications?
- Example domain: Robocup
- Homework:
  Reading: H. Kautz, A Formal Theory of Plan Recognition and its Implementation (1991) (link on web page)

Introductions

- Introduce yourself:
  - Your name
  - Masters or Ph.D/how many years at UCF?
  - What did you do before coming to UCF?
  - Which faculty member(s) do you work with?

Evaluation

- Final project (potentially publishable quality):
  - Written report
  - Software demo/video
  - Oral presentation
- Homework:
  1. Written review/oral presentation of related work
  2. Research re-implementation of algorithm in one of the papers
- Reading and class discussion
- Midterm exam

Research Process

- <u>Problem</u>: something other people have cared about, found difficult, failed to solve completely
- <u>"Hammer"</u>: adaptable technique that has been used with some success for problem solving
- <u>Evaluation</u>: procedure for (hopefully) proving that your hammer is better, usually involving building a system or working with an existing data set
- <u>Application</u>: showcases why the problem is important
- <u>Publication</u>: communicating with a community of people that find the problem of interest

Research Process

Good news!

This course is meant to introduce you to:

1) An interesting research problem
2) A toolbox of useful problem-solving “hammers”
3) A broad list of related work

Papers in this area have appeared a broad range of conference venues:

major AI conferences: AAAI, IJCAI, UAI, AAMAS

vision conferences: CVPR, ICVS

application specific conferences: ITS (tutoring systems), IROS (robotic systems)

What is PAIR?

Plan recognition:

Recognizing goals, plans and behaviors from the union of observations, prior knowledge, and closed-world assumptions (Kautz)

Levels of Action

- Physical movement
  - Movement sensor fires
- Behaviors
  - Running, grasping, lifting, ...
- Plans
  - Getting a drink of water
  - Describes conventional way of achieving a goal
- Goals
  - Quench thirst

Distinctions

- Plan recognition usually refers to the process of recognizing plans from atomic actions (e.g. actions taken through a user interface).
- Activity recognition usually refers to the process of recognizing behaviors from physical movement, collected from cameras/wireless sensors.
- Goal recognition often refers to recognizing a user's eventual destination from physical movement.
- Intent recognition (less well defined): some classification based on a person's actions that possesses potentially predictive value (my definition)

Problem Dimensions

- Keyhole versus interactive
  - Keyhole
    - Determine how an agent's actions contribute to achieving possible or stipulated goals
    - Model
      - World
      - Agent's beliefs
    - No model of the observer – fly on the wall

Problem Dimensions

- Keyholeversus interactive
  - Interactive
    - Agent acts in order to signal his beliefs and desires to other agents
      - Speech acts – inform, request, ...
    - Discourse conventions
      - "Two PI's made it to the Darpa meeting"
      - Evolution of cooperation
    - Recognizing cooperation/team members actions

Problem Dimensions

- Ideal versus fallible agents
  - Mistaken beliefs
    - John drives to Reagan, but flight leaves Dulles.
  - Cognitive errors
    - Distracted by the radio, John drives past the exit.
  - Irrationality
    - John furiously blows his horn at the car in front of him.

Problem Dimensions

- Reliable versus unreliable observations
  - "There's a 80% chance John drove to Dulles."
- Open versus closed worlds
  - Fixed plan library?
  - Fixed set of goals?
- Metric versus non-metric time
  - John enters a restaurant and leaves 1 hour later.
  - John enters a restaurant and leaves 5 minutes later.
- Single versus multiple ongoing plans

Problem Dimensions

- Desired output:
  - Set of consistent plans or goals?
  - Most likely plan or goal?
  - Most critical plan or goal?
  - Interventions observer should perform to aid or hinder the agent?

What makes PAIR hard?

- High computational cost
- Plan library requirements:
  - Libraries can be incomplete or inaccurate
  - Difficult to author (making learning attractive)
  - Individual differences
  - Mistakes/irrational behavior from act
- Domain-specific characteristics make generalization across domains difficult
- Specific to activity recognition:
  - Identifying transitions between behavior
  - Data association
  - Obtaining reliable tracking data (vision)

Applications

- User interfaces
- Speech dialog systems
- Tutoring systems
- Smart living environments
- Adversarial reasoning for games or battlefield analysis
- Improved coordination in multi-agent systems
- Analysis of motion capture data
- Robotic systems
- Many more.....

Example Domain: Robocup

- Simulation league: Independently moving software players (agents) play 10 minute soccer games on a simulated field
- Other soccer leagues: small-sized, middle-size, 4-legged (AIBO), humanoid
- Other Robocup challenge domains:
  - Urban Rescue: robots have to rescue victims trapped in a collapsed building
  - Robocup@Home: robots doing household tasks and interacting with humans

Robocup AIBO league

PAIR Research in Robocup/Soccer

- Single bot behavior recognition
- Coach league
- Model-based diagnosis of team failure
- Learning by observation
- Camera-based game analysis

Single Bots: HMM Approach

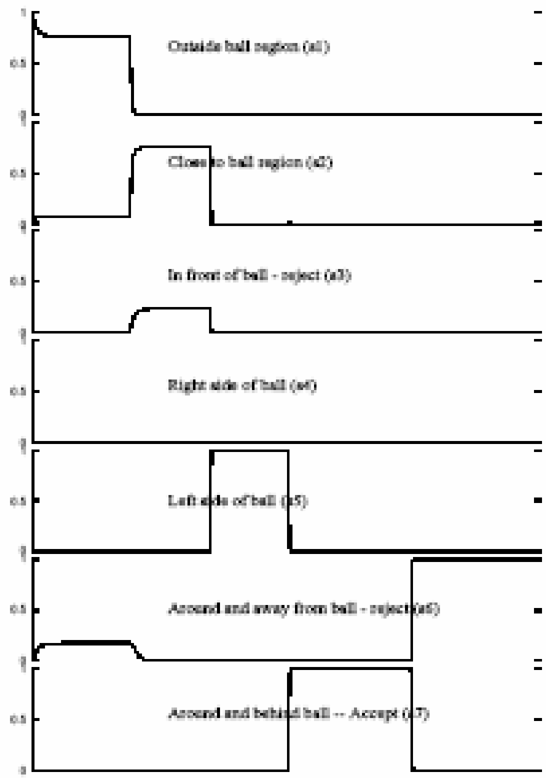


Figure 5: Go-Behind-Ball Behavior HMM probabilities

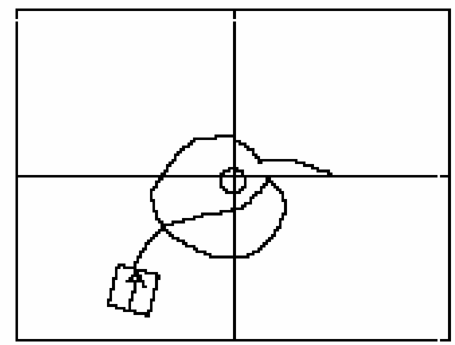
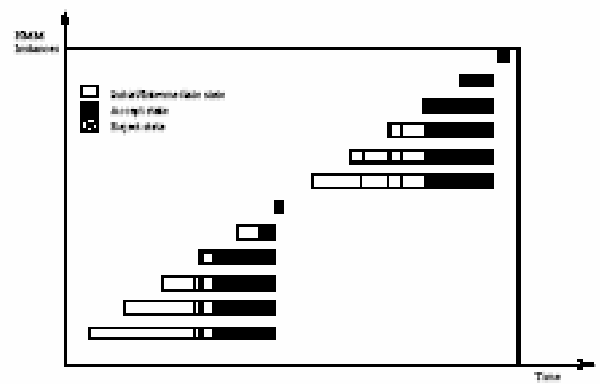
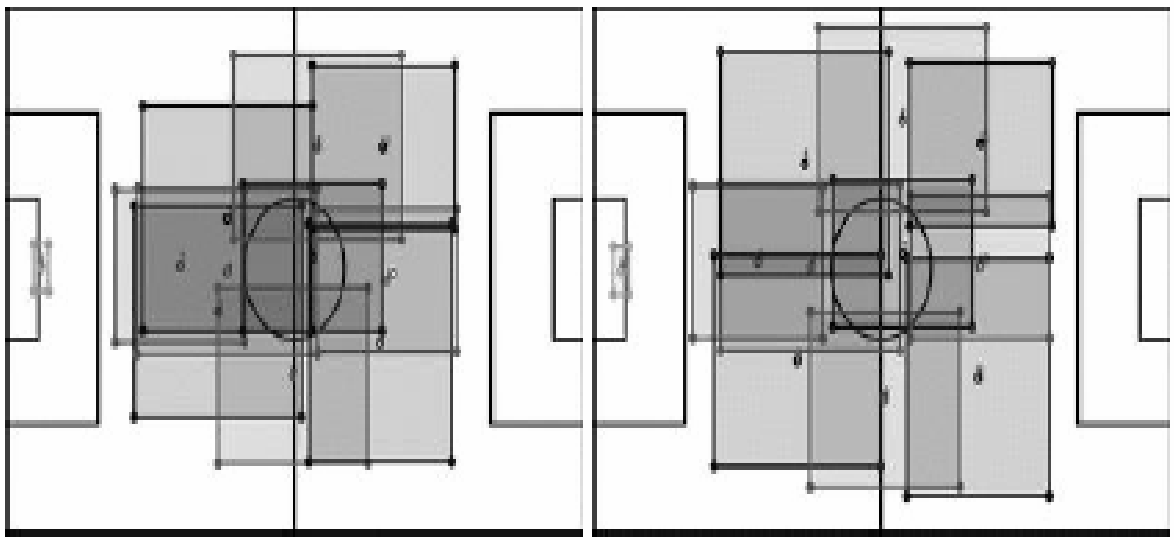


Figure 6: Robot Trajectory



(Han and Veloso, Automated Robot Behavior Recognition Applied to Robotic Soccer, 1999)

Coach League: Parametric Models



(a) After Phase 1 (b) After Phase 2

Fig. 1. The learning of the CMUnited99 formation from RoboCup2000 games.

(Riley, Veloso, Kaminka, An Empirical Study of Coaching, 2002)

(Kuhlmann, Knox, Stone, Know Thine Enemy: A Champion Robocup Coach Agent, 2006)

Detecting Team Failure with MBD

Model-based Diagnosis

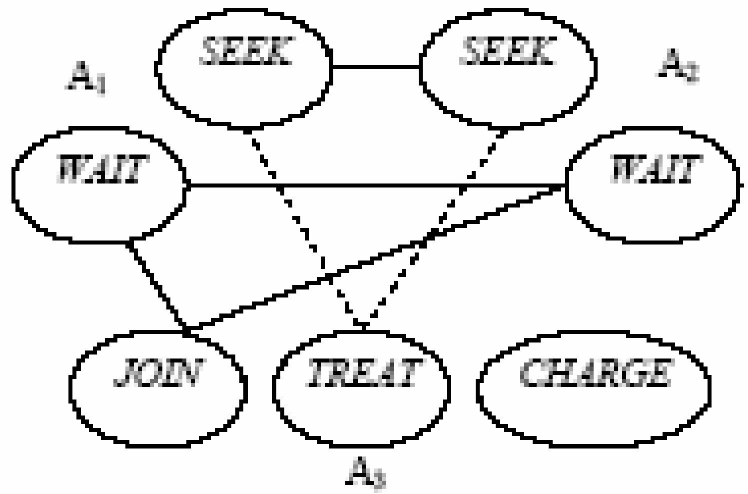


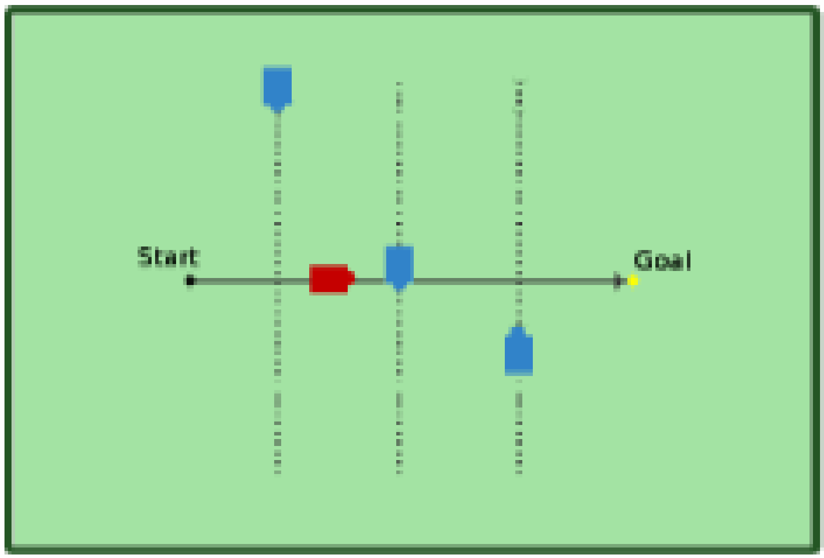
Figure 1: The coordination graph for team $\{A_1, A_2, A_3\}$.

(Kaminka and Tambe, Robust Agent Teams via Socially Attentive Monitoring, 2002)

(Kalech and Kaminka, Towards Model-Based Diagnosis of Coordination Failures, 2005)

RL Learning by Demonstration

3-Agent Evasion Problem



(Chernova and Veloso, Tree-based Policy Learning in Continuous Domains through Teaching by Demonstration, 2006)

Camera-Based Systems

Figure 5: Estimating the camera parameters by taking the current parameters, projecting the field model using the current parameters onto the image (left), finding the correspondences between model points and the imagepoints (middle), and adjusting the camera parameters to achieve minimal errors (right).

(Beetz et al., Computerized real-time analysis of football (soccer) games, 2005)

Conclusion

- Many interesting problems to tackle in a variety of domains
- Homework:
  Reading: H. Kautz, A Formal Theory of Plan Recognition and its Implementation (1991)
  (link on web page)
- My office hours:
  - Now: 3-4:30pm
  - Thurs morning: 10-11:30am

References

1. H. Kautz, Plan Recognition (presentation)
2. Han and Veloso, Automated Robot Behavior Recognition Applied to Robotic Soccer, In Proceedings of IJCAI-99 Workshop on Team Behaviors and Plan Recognition, 1999
3. Riley, Veloso, Kaminka, An Empirical Study of Coaching, In Distributed Autonomous Robotic Systems 6. 2002
4. Kalech and Kaminka, Towards Model-Based Diagnosis of Coordination Failures, In National Conference on Artificial Intelligence, 2005
5. Chernova and Veloso, Tree-based Policy Learning in Continuous Domains through Teaching by Demonstration, In Proceedings of the Modeling Other Agents from Observations (MOO 2006), 2006
6. Beetz et al., Computerized real-time analysis of football games, IEEE Pervasive Computing, 2005