CS344M
Autonomous Multiagent Systems

Prof: Peter Stone

Department or Computer Science
The University of Texas at Austin

Good Afternoon, Colleagues

Are there any questions?

Good Afternoon, Colleagues

Are there any questions?

— do RoboCup agents anlyze ops' comm?

— What should an agent do when comm is impossible?

— Is there research on non-verbal comm between agents?

— How/when are teams established?

— How would you compute action utility?

— How do you resolve conflicts in joint commitments (beliefs)?

— Alternatives to BDI?

Logistics

- Programming assignment 4 - any questions?

Soccer server communication

- What is the soccer server communication protocol?

- How does it relate?

- Does an ACL make sense in the soccer server? If so, under what circumstances?

An example protocol

Joint Intentions – Setting

How agents **form and disband** teams

Joint Intentions – Setting

How agents **form and disband** teams

- Agents in dynamic multiagent world

- Neither complete nor correct beliefs

  – Positive introspection: know own beliefs

- Changeable goals, fallible actions

- Don't know others' beliefs/goals

UTCS *Department of Computer Sciences*
The University of Texas at Austin

Starting Point – Individuals

Persistent goal: relative to q to achieve p

Starting Point – Individuals

Persistent goal: relative to q to achieve p

- p false, but desired true
- p will keep being desired unless:

Starting Point – Individuals

Persistent goal: relative to q to achieve p

- p false, but desired true
- p will keep being desired unless:
  - p true
  - p impossible
  - q false

Starting Point – Individuals

Persistent goal: relative to q to achieve p

- p false, but desired true
- p will keep being desired unless:
  - p true
  - p impossible
  - q false

Intention: persistent goal, belief throughout that it's being done

Starting Point – Individuals

Persistent goal: relative to q to achieve p

- p false, but desired true
- p will keep being desired unless:
  - p true
  - p impossible
  - q false

Intention: persistent goal, belief throughout that it's being done

- What's the role of q?

Starting Point – Individuals

Persistent goal: relative to q to achieve p

- p false, but desired true
- p will keep being desired unless:
  - p true
  - p impossible
  - q false

Intention: persistent goal, belief throughout that it's being done

- What's the role of q?

- What's the difference between goal, intention?

2 proposals for teams

Joint commitment not just intention where agent is team

2 proposals for teams

Joint commitment not just intention where agent is team

Weak: Joint intention $\equiv$ mutually known intention: each intend to do their part of collective action

2 proposals for teams

Joint commitment not just intention where agent is team

Weak: Joint intention $\equiv$ mutually known intention: each intend to do their part of collective action

Strong: Same, except mutual knowledge persists until mutually known that activity is over

2 proposals for teams

Joint commitment not just intention where agent is team

Weak: Joint intention $\equiv$ mutually known intention: each intend to do their part of collective action

Strong: Same, except mutual knowledge persists until mutually known that activity is over

Why too weak and too strong?

Joint Commitment

Weak achievement goal (WAG): relative to q *with respect to a team* to achieve p

Joint Commitment

Weak achievement goal (WAG): relative to q *with respect to a team* to achieve p

- Individually wants p

Joint Commitment

Weak achievement goal (WAG): relative to q *with respect to a team* to achieve p

- Individually wants p
  OR
- Believes p true, impossible, or irrelevant, AND has a goal of team knowing it.

4 cases

Joint Commitment

Joint Persistent Goal (JPG): relative to q to achieve p

- mutually believe p false, but mutually know all desire p true
- mutually believe that each have WAG p until
  - mutually believe p true
  - mutually believe p impossible
  - mutually believe q false

Joint Commitment

Joint Persistent Goal (JPG): relative to q to achieve p

- mutually believe p false, but mutually know all desire p true
- mutually believe that each have WAG p until
  - mutually believe p true
  - mutually believe p impossible
  - mutually believe q false

Intention: joint persistent goal, mutual belief throughout that it's being done

Joint Commitment

Joint Persistent Goal (JPG): relative to q to achieve p

- mutually believe p false, but mutually know all desire p true
- mutually believe that each have WAG p until
  - mutually believe p true
  - mutually believe p impossible
  - mutually believe q false

Intention: joint persistent goal, mutual belief throughout that it's being done

- Intend own action, commited to others'

Joint Commitment

Joint Persistent Goal (JPG): relative to q to achieve p

- mutually believe p false, but mutually know all desire p true
- mutually believe that each have WAG p until
  – mutually believe p true
  – mutually believe p impossible
  – mutually believe q false

Intention: joint persistent goal, mutual belief throughout that it's being done

- Intend own action, commited to others'

- Overhead: automatic goal to communicate status

Establishing JPGs

- Communication (basis for KQML)

- Observation (requires co-presence)

Establishing JPGs

- Communication (basis for KQML)

- Observation (requires co-presence)

- Any other way?

Locution: What is said (physical)

Locution: What is said (physical)

Illocution: What is meant

{Per,Il}locution - p.14

Locution: What is said (physical)

Illocution: What is meant

Perlocution: Intended effects

{Per,Il}locution - p.14

Locution: What is said (physical)

Illocution: What is meant

Perlocution: Intended effects

Example: "Please close the window."

Discussion

"Capabilities for teamwork cannot be patched on, but must be designed in from the start."   (Grosz, 1996)

Discussion

> "Capabilities for teamwork cannot be patched on, but must be designed in from the start." (Grosz, 1996)

- Agree or disagree?

STEAM

- An implementation/extension of joint intentions

- Goals

    – Anticipate teamwork failures
    – Flexibility and re-use

STEAM

- An implementation/extension of joint intentions

- Goals

    – Anticipate teamwork failures
    – Flexibility and re-use

- Joint intentions doesn't do it all, though

STEAM

- An implementation/extension of joint intentions

- Goals

  – Anticipate teamwork failures
  – Flexibility and re-use

- Joint intentions doesn't do it all, though

  – Coherence: all use same plan, commitment protocols
  – Communication cost — decision theoretic
  – Replanning — role dependencies

Team Operators

- Have preconditions, effects, termination rules

- Automatically establish joint intentions

Team Operators

- Have preconditions, effects, termination rules

- Automatically establish joint intentions

- To establish, "all team members must simultaneously select" a team operator to establish a joint intention

- Agents maintain "team state:" model of team's mutual beliefs

Domains

- Attack:

    – Fly to holding point
    – Send out scouts
    – Shoot at enemy

- Transport:

    – Escorts protect transports

- RoboCup

Observed Problems

- Commander returns to home alone after failing, others stayed

Observed Problems

- Commander returns to home alone after failing, others stayed

- Scout never returned, others got into infinite loop

Observed Problems

- Commander returns to home alone after failing, others stayed

- Scout never returned, others got into infinite loop

- One got orders first and went ahead alone

Observed Problems

- Commander returns to home alone after failing, others stayed

- Scout never returned, others got into infinite loop

- One got orders first and went ahead alone

- All out of ammunition, but failed to realize unachievable

Observed Problems

- Commander returns to home alone after failing, others stayed

- Scout never returned, others got into infinite loop

- One got orders first and went ahead alone

- All out of ammunition, but failed to realize unachievable

Solved generally with STEAM

Evaluation

- Used in 3 domains with different characteristics

Evaluation

- Used in 3 domains with different characteristics

- STEAM rules can be re-used

- Flexibility: solves initial problems, can deal with small changes to environment

Evaluation

- Used in 3 domains with different characteristics

- STEAM rules can be re-used

- Flexibility: solves initial problems, can deal with small changes to environment

- Communication efficiency

- Encoding and modification effort

CYC – Doug Lenat

- Attempt to program common sense

CYC – Doug Lenat

- Attempt to program common sense

- > 1 million rules

  – "Trees are usually outdoors."
  – "Once people die they stop buying things."
  – "Glasses of liquid should be carried rightside-up."

CYC – Doug Lenat

- Attempt to program common sense

- > 1 million rules
    - "Trees are usually outdoors."
    - "Once people die they stop buying things."
    - "Glasses of liquid should be carried rightside-up."

- Ongoing effort since 1984

CYC – Doug Lenat

- Attempt to program common sense

- > 1 million rules
  - "Trees are usually outdoors."
  - "Once people die they stop buying things."
  - "Glasses of liquid should be carried rightside-up."

- Ongoing effort since 1984

- Potential applications?

CYC – Doug Lenat

- Attempt to program common sense

- $>$ 1 million rules

  – "Trees are usually outdoors."
  – "Once people die they stop buying things."
  – "Glasses of liquid should be carried rightside-up."

- Ongoing effort since 1984

- Potential applications?

  – Some listed on their web site
  – Question answering, retrieval of captioned information, machine translation, speech recognition, semantic data mining, . . .