Dimensions of Adjustable Autonomy

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Outline

- What is an Autonomous Agent?
- What is Adjustable Autonomy?
- Dimensions that can be "adjusted"
  - Independence
  - Control
  - Goals
- Perspectives on AA in participant’s systems
- Discussion
- Summary

What is an Autonomous Agent?

Interacts with its environment
1. can sense its environment
2. make decisions, and
3. take action

What is Autonomy?

The breadth of goals that an agent has the authority to accomplish and that it has to achieve those goals (Barber et al.)

Motivation

``Our goal is to design a framework for human centered autonomous systems that allows users of the system to interact with the system at whatever level of control is appropriate whenever they choose to do so, but minimize the need for such interaction” - (NASA, 1998)
Dimensions of Adjustable Autonomy

**Ideal Adjustable Autonomy ("the Super Agent")**
- Intelligent support e.g. a good secretary (with ESP?)
  - different levels of autonomy for different tasks
  - intelligent acceptance of commands: notify if not capable, interpret correctly, clarify ambiguities
  - if it knows what you want, it does it within its capabilities (quietly), takes care of "details"
  - if it is unsure - it will ask (if the "cost" of a bad decision is risky or costly)
  - learns from experience, doesn’t repeat errors

**Dimensions of Adjustable Autonomy**
- **Goals** - control over selecting goals to pursue
- **Control** - decision-making control over which options are exercised in solving goals
- **Independence** - range of possible ways available to accomplish a goal

**Adjusting Independence**
- Independence is the number of different ways that an agent is allowed to try to achieve its goals
- Example systems: 3T (Bonasso et al., NASA). RAPs (Firby)

**A System with Adjustable Autonomy**

**Autonomy for Each Goal**

**NASA systems**
- NASA Ames, Moffet Field, California Gregory Dorais
Dimensions of Adjustable Autonomy

**Independence Control in RAPS**
- Developer can specify different methods for achieving the same task
- The system can ask a human to perform a task
- Planner re-plans if a task is failing
- Low-level primitive skills can be combined to accomplish tasks in many ways

**RAPS, cont.**
- User can restrict the search space for planning
- Users can “disable” sensors and skills
- Users can have mixed-initiative interaction
- Result – guiding without taking complete control

**Adjusting Control**
- Autonomy w.r.t. each Goal is how much control the agent has over how to pursue the goal and the lack of interference by other agent(s)
- Example: Adaptive Decision-Making Frameworks (ADMF), Barber, et al.

**Decision-Making Styles**
- Command-driven – no decision-making by “self”
- True Consensus – equal partner with others
- Locally Autonomous/Master – decision making completely by “self” (may delegate)

**A coherent set of individual decision-making styles for all participating agents**
- Representation: (D, G, C) where
  - D = decision-makers and their strengths
  - G = set of goals under consideration
  - C = authority-over constraint – agents committed to perform the goals decided upon by the DMF (penalty for failure to perform tasks)

**One framework is not best for all situations the agents may encounter**
- Changing the framework allows better performance by adapting to current conditions
Goal Adjustment
- Adjustment of Autonomy means changes to goals and objectives of an agent
- Example system: EASE, application: simulation environments (Scerri & Reed)
- User adjusts the autonomy of the MAS by adding, removing, or suspending goals

Adjustable Autonomy in EASE
- 1 user with 1 software actor (multi-agent system)
- User does all reasoning to decide on changes in autonomy (not agents)
- User makes off-line or on-line changes to modify actor behavior with the available graphical tools

System of 1 User and 1 Actor

Discussion
- Three types of adjustable autonomy described
- Others possible
- Much work still to be done in this area

Who Uses AA?
- NASA
  - long term space missions, Kortenkamp et al.
- Honeywell
  - safety critical process control, Musliner et al.
- Interactive theatre
  - Blumberg, Hayes-Roth, et al.
- Human collaborative support
  - Tambe, Pynadath, et al.
Summary

- Different characteristics that are used to adjust autonomy
  - Goals
  - Independence
  - Control

Questions?