Extending agent languages for autonomy

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Background

- BDI agent languages:
  - Useful abstraction for complex systems
  - Mostly used for single agents with static plans
  - Simple, but theoretically sound
- However, lack of direct support for:
  - societal cooperation
  - autonomy and dynamic adaptation
- *Ad hoc* implementations of techniques rather than language support

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Aims

- Extend traditional agent languages with:
  - Declarative goals
  - Motivated behaviour
  - Social cooperation
- Allow development of complete multiagent systems

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Contributions

- Introduction of declarative goals in AgentSpeak(L)
- Dynamic plan creation in AgentSpeak(PL)
- Motivated goal generation in AgentSpeak(MPL)
- Multiagent cooperation through plan delegation
- Normative processing

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Procedural and declarative goals

- Procedural $\rightarrow$ efficient, yet inflexible:
  - Predefined encapsulated behaviours
  - Designer must foresee relevant plans
- Declarative $\rightarrow$ expressive, but not trivial:
  - Desired world states
  - Requires a more complex reasoning mechanism
- How to link desired world states to actions?

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AgentSpeak(PL)

- AgentSpeak(L) + Planning $\longrightarrow$ AgentSpeak(PL)
- Declarative goals are used to determine courses of actions:
  - Desired world states and basic capabilities are specified
  - Interpreter uses planner to generate new plans
  - New plans are stored by the agent, improving it

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Motivations in Meta-reasoning

Motivations

- Root cause of future-directed behaviour
- Studied by a number of other disciplines
- In our work: abstraction of meta-reasoning:
  - Goal generation
  - Representation of dynamic priorities

AgentSpeak-MPL

- AgentSpeak(L) + Motivations:
  - Standard AgentSpeak(L) language
  - External motivation specification
- Motivation model for:
  - Goal generation
  - Plan selection
- Motivation model based on mBDI

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Social AgentSpeak(L)

- Much research devoted to languages for *individual* agents with static plan libraries
- Cooperative strategies implemented *ad hoc*:
  - Generally assume knowledge of others abilities
  - Distributed, but based on *predefined* abilities
- Planning capable agents can drop these assumptions
- Our social AgentSpeak:
  - uses dynamically discovered abilities
  - abilities are plans which agents execute on behalf of others
  - generates new (high-level) plans using these abilities

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Normative Processing in AgentSpeak(L)

- Autonomous agents operating in an open environment need regulation
- *Norms* are the mechanism of choice
- Most research focuses on the *macro* level
- We focus on the machinery in agents that
  - process norms, and change the plan library
  - lead to norm compliance
- Norms can cause plans to be:
  - suppressed in case of prohibitions
  - generated anew to comply with obligations

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Conclusions

- Machinery exists that can be added to agent languages
- They need to be sensibly integrated to languages
- Necessary to create a general-purpose language

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Future Work

- Motivation-based norm acceptance/rejection
- Motivation-modulated planning
- Motivated intention adoption and dropping
- Integration of various notions of declarative goal in AgentSpeak

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Questions?

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