Aquisition of Knowledge - From Real to Virtual Embodiment

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Introduction

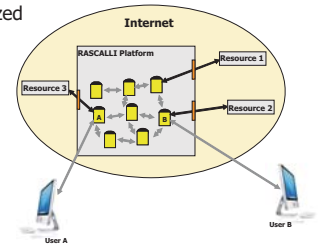
The aim of our research is to realize virtual agents that provide capable assistance to their users in finding and retrieving data from the internet. Therefore the agents have to deal with an environment that is constituted of data including strings of written language, markup tags, audio and image files, log-files of user activities, etc.
The agents are designed to learn via self-experience, from positive and negative feedback by the user, and from communication with other agents of their kind using grounded and agreed upon symbols.
The scope of this research is covered by the EC IST project RASCALLI (http://www.ofai.at/rascalli/) and the Austrian national funded project SELP.

Objectives

To realize agents capable of providing personalized assistance to users in finding and retrieving information from the Internet.

To investigate the impact of the design of the environment, the agents, and of the training situation

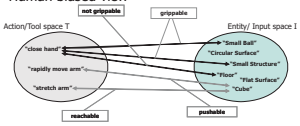
To investigate the requirements for an effective knowledge distribution in a group of agents.



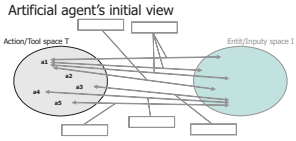
Affordance-Based Approach

For an agent to explore its inherently dynamic environment according to the user's interests it needs to gain a certain degree of autonomous and flexible behaviour. To achieve this, we transfer insights from affordance-based research initiated by Gibson (Gibson 1986) and from affordance-based robotics research (Kintzler et al. 2007) to the design of the virtual agents and their environmental framework.

Human biased view



Artificial agent's initial view



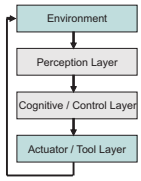
"The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. [...] I mean by it [affordances] something that **refers to both** the environment and the animal." (Gibson, 1986)

Properties of the affordance-based approach:

- Enables the knowledge acquisition process based on self-experience
- Provides flexibility/robustness in task solving strategies and dealing with changing situations (dynamic environment, novel input, sensor channels, tools)
- Provides scalability (with increasing complexity of sensor channels, tools and tasks)

How can the agent acquire knowledge?

How can an agent acquire knowledge about its own capabilities to interact in a given situation?



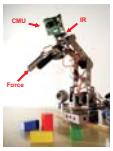
Roadmap:

- Performing **behaviour** using Tools (T)
- **Perceiving** own interactions via sensor channels
- Gaining knowledge about **input situations** (I)
- Gaining knowledge about **outcomes** (O)
- Building **T-O-I triple repository**

Virtual Agents Inspired by Robotics

To realize an affordance based architecture for virtual environments, a virtual embodiment is created. The agents are equipped with a collection of sensor channels geared towards the particular environment, and a set of specialized software tools (actions) through which they interact with the environment. The outcomes of the tools (of applying actions on the environment) are again treated as an input to the agent and perceived via the sensors channels in a way similar to a robot's perception of the consequences of an action application.

Robotic arm with 5 DOF



Sensors

- CMOS camera
- Color blob detector
- Infrared distance sensor
- Force sensor
- Proprioception

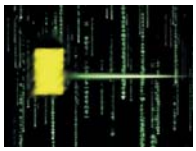
Actions

- Open/Close Gripper
- Raise/Lower
- Go Forward
- Backward
- ...

Initial Behaviours

- Tracking reflex (Curiosity drive)
- Gripping reflex
- Lifting reflex
- ...

Virtual agent in its virtual world



Sensors

- Bag of Words
- Part of Speech tagger
- Hitrate
- File extension
- ...

Actions

- Wordnet query
- Database query
- Wikipedia explorer
- Play music/video file
- ...

Initial Behaviours

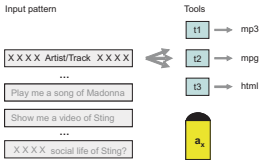
- Curiosity drive
- User satisfaction
- Communication drive
- ...

The design of the virtual agent together with initial drives provides the basis for interaction based knowledge aquisition

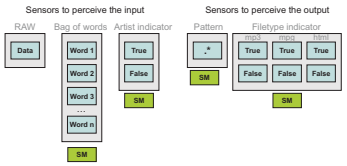
Interaction Based Knowledge Acquisition

Agents acquire knowledge about what they can do based on their own interaction capabilities and their own perception. For each tool application the perceptions of the pre-application (I) and the post-application (O) phase are stored, over time leading to tool-specific (T) application spaces containing all the episodes experienced with the individual tools. By finding similarities and deriving representative descriptions from the individual episodes of an application space a generalization process takes place (Irran et al. 2006).

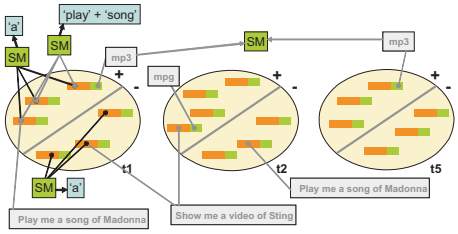
Input situations



Sensors

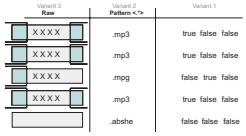


Knowledge acquisition

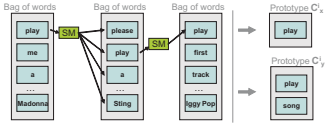


- Comparing stored episodes
- Finding similarities
- Deriving prototypes

Outcome

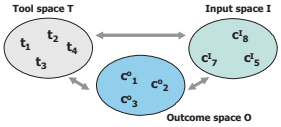


Similarity measurement



T-O-I Knowledge Repository

The I-T-O triplets derived in the interaction based knowledge acquisition process form the knowledge base of an individual agent. With this knowledge base the agent is capable of solving tasks:



- **Return tools** which lead to a given outcome when performed on a given entity: {o,i}->{t,...}
- **Return outcomes** which result by performing a given action on a given entity: {t,i}->{o,...}
- **Return input types** which result into a given outcome by using a given action: {t,o}->{i,...}
- **Return input tool tuples** that lead to a given outcome: {o}->{(t,i),...}
- **Return tool outcome tuples** that are related to a given entity: {i}->{(t,o),...}
- **Return input outcome tuples** that are related to a given action: {t}->{(i,o),...}

Communication using Symbols

Objective:

Enabling the agents to exchange task solving strategies:

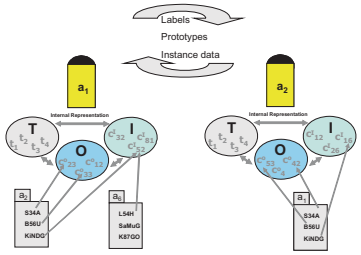
- Which tools or tool chains to use in a given situation
- How to react on a given input
- How to reach a desired outcome

Role of Communication:

- Enables the exchange of knowledge - to learn from experiences of other agents
- Allows acquiring strategies for situations previously not encountered by an individual agent
- Decreases the search space for possible and successful action chains

Establishing common labels using negotiation cycles

By using labels, the agents can exchange information more efficiently than by exchanging prototype representations or raw data. This demands that the agents have to reach a certain level of common understanding on the task related set of concepts. Therefore a negotiation process takes place. It results in established common labels, which allow the exchange of knowledge between agents with different knowledge bases and different internal representations.

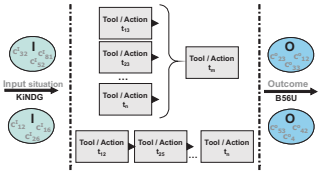


Example:

- Agent a_1 tries to get a strategy to solve a certain input situation i_1 that should result in a certain outcome o_1
- Agent a_1 has to ensure that a_2 has a similar concept of the input situation i_1
  - if they have not already agreed on a label they start a negotiation process
  - this negotiation process includes the bidirectional exchange of prototypes or raw data
  - after a termination condition is reached the label assignment process takes place (might include generation of new prototypes)
- The same negotiation and label assignment procedure is established for the outcome o_1

Exchanging task solving strategies

After the sufficient amount of agreed labels is established the exchange of task solving strategies can take place.



Acknowledgements

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