Goal Autonomous Agent Architecture

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1. Introduction

There are two levels of agent autonomy, behavior autonomy and goal autonomy. However, most of the existing effort is focused on behavior autonomy.

A reactive agent responds immediately to its percepts based on so-called *condition-action rules*. Humans have many such reflexes, for example, closing the eyes when something is approaching them. The whole knowledge of the agent is then encoded into these rules.

Although such agents can be implemented very efficiently, their range of applicability is very narrow. Even for very simple environments, the need for an *internal state* arises to keep track of specific information, when the complete access to the environment is not guaranteed.

If a reactive agent is extended by some sorts of goal information, the agent can then combine its perception with the possible outcome of its actions in order to choose actions, which lead towards the goal state. A goal-based agent has a planning unit to find the appropriate sequence of actions to reach its goal. Just behavior autonomy is not enough for agents to operate in a complex, dynamic environment. An agent needs to reason and decide by itself how to select the next goal and what actions it should take so that its goal is attended to successfully. An agent should be able to improve its behaviors over time, that is, it becomes better with experience at selecting the next goal and achieving the goal by taking correct actions. Hence, an autonomous agent should present not only behavior autonomy but also goal autonomy.

2. Goal Autonomous Agent Model

In this section, we present a goal autonomous agent model that supports both behavior autonomy and goal autonomy. Based on Goal Net, goal autonomous agents are not only able to choose the right action towards its current goal, but also able to reason the next goal to achieve towards its overall goal [1].

[**Definition**] A goal autonomous agent can be formally specified as a tuple, GAA = (S, A, M, FG, FA, K, R, E), where

- S is a set of states defining agent goals,
- A is a set of actions defining agent behaviors,
- M is an agent goal model represented by the composite state goal model, i.e. Goal net,
- K is the knowledge of the agent,
- R is a set of situation-action rules defining reactive behavior of the agent,
- FG is the functions for goal selection defining goal autonomy of the agent,
- FA is the functions for action selection defining behavior autonomy based on the selected goals,
- E is the agent environment that the agent lives in and perceives.

A goal autonomous agent mainly consists of the following tasks, which are executed repeatedly and form a PR^2A cycle:

1) **Perceive**: The agent perceives its environment continuously to sense any new situations.
2) **Reason for goal selection**: The agent infers the next goal, based on its goal model, knowledge, and the perception of its environment.
3) **Reason for action selection**: The agent infers actions based on the selected goal, knowledge, and the perception of its environment.
4) **Act**: The selected actions are executed.

The goal selection and action selection are done by the functions FG and the functions FA. The functions FG decide the next goal of the agent, based on the goal selection algorithms of the Goal Net. The functions FA decide the next group of actions the agent needs to perform, based on the action selection algorithms of the Goal Net. Most of the current agent models predict the next goal (state) of agent based on the past states:

$$S_{n+1} = f(S_1, S_2, \ldots. S_n)$$

In our proposed agent model, the next state of an agent is a function of the past states and the predicted future states so that the "optimal" actions can be selected:

$$S_{n+1} = f(S_1, S_2, \ldots S_n, pS_{n+1}, pS_{n+2}, \ldots pS_{n+k})$$

where pS_{n+1} is the predicted state of S_{n+1}, $k>0$.

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There are two types of actions, reactive actions and goal-based actions. The reactive actions are selected based on the condition-action rules. The goal-based actions are selected by the functions FA.

The goal autonomous agent model is a hybrid model. It supports both high-level goal-based reasoning based on the Goal Net and low-level reactive rule-based reasoning based on the condition-action rules. By supporting different reasoning processes the goal autonomous agents are enabled to act as an "anytime" agent. No matter how complex the environment is, there is always an action available for the agent to execute. The action is either an action reasoned by the Goal net or a reactive action inferred by condition-action rules.

3. Goal Autonomous Agent Architecture

The goal autonomous agent model consists of eight units, which include *perception* unit, *process* unit, *control* unit, *action* unit, *communication* unit, *knowledge* unit, *compute* unit and *data* unit as shown in Figure 1.

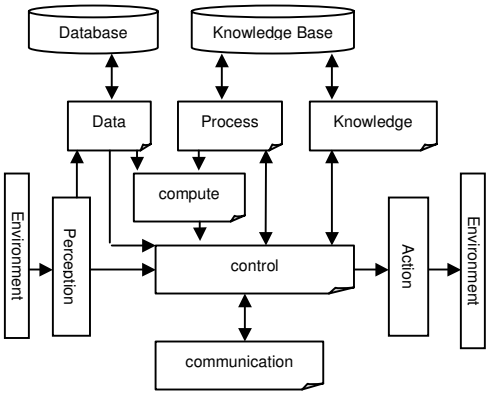

Figure 1. The goal autonomous agent architecture

- The perception unit senses the agent environment. It contains a list of states to indicate the status of the environment. If the environment changes, the perception unit will update the database through the data unit and notify the control unit to take actions against the change.
- The process unit contains the goal(s) of an agent and their relationships (Goal nets). The Goal nets will be loaded into the process unit from the knowledge base after the agent starts to work.
- The action unit contains all the actions the agent might perform.
- The control unit makes decisions on both agent goal selection and action selection based on selected goal. Moreover, if the perception unit of an agent detects an environment change, the control unit will enable the reactive action against the changes.
- The compute unit defines the goal selection function and the action selection functions. The goal selection algorithms, action selection algorithms and action selection mechanisms are implemented in the compute unit. The control unit will call the functions in this unit to select the next goal and actions according to the goal model given in the process unit.
- The knowledge unit maintains the knowledge of the agent, which is used to handle the real world problems.
- The data unit defines data access mechanism to data resources.
- The communication unit defines the communication mechanism between agents.

A goal autonomous agent is always trying to pursue its current goal while inferring its next goal and actions based on the current situation. No matter how much the agent has already computed, there is always an action available for the agent to execute. The action is either a goal-based action or a reactive action. In the case there is an unexpected change in the agent environment, a reactive plan will be available. The occurrence of such unexpected events will be used to improve and optimize the agent's goal model and the reasoning algorithms. Furthermore, the iterative improvement enables the agent to easily adapt the action plan to unexpected situations.

4. Conclusion

The goal autonomous agent presented in this paper works as a continuous process that combines both reaction activity and planning activity. It presents both behavior autonomy and goal autonomy.

The goal autonomous agent model and architecture have been presented to describe the goal autonomous agent from the logical view and the structural view respectively. In this research, a re-usable agent framework has also been developed for designing and construction of the goal autonomous agents.

References

1. Shen Z. Q., Gay R. and Tao X. H., "Goal-Based Intelligent Agents", *International Journal of Information Technology*, Vol 9, No. 1, pp. 19-30, 2003.