BDI Model

Briefs,Desires,Intentions

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1 Introduction

Using cognitive modelling techniques for simulating human behaviour,without requiring people interactions can make real-time events automatically in the environment to and reflect the state.It will save a lot of resources,time and money.Beliefs, desires and intentions(BDI)agent is a kind of intelligent agent.BDI model describes the basic characteristics of agents' mental state since the BDI logic system is easy to be realized in the computer.In recent years, many scholars have used Java, Jason or some other languages to implement BDI agent model in computer.

Chapter 2 introduces the BDI model with the description of its three attributes respectively.An detail interpretation of the brief BDI agent architecture is represented in chapter 3.Chapter 4 describes three kinds of BDI implements and their architectures.In chapter 5,several BDI applications are represented and chapter 6 discusses the challenges BDI agents face to as well as the advantages of BDI model.

2 BDI model

The BDI model is a popular architecture of agent for intelligent agents situated in complex and dynamic environments.The model has its roots in philosophy with Bratmans theory of practical reasoning[1].Intelligent agents are smart such that they can operate flexibly and rationally when they face to different environments.They can do things to an extent without direct operations of humans and can also control over their behaviours and internal states.Additionally,agents can have interactions with other agents such as multi-agents systems.Furthermore,agents can perceive the environment and make in-time responds depending on the environment changes.Moreover,agents are able to exhibit goal-directed behaviour by taking the initiative[2].Practical reasoning involves two important processes:deciding what goals we want to achieve, and how we are going to achieve these goals.The former process is known as deliberation,the latter as means-ends reasoning[3].As a theory of practical reasoning,BDI model has three attributes that are belief,desire and intention.

2.1 Beliefs

Beliefs represent the informational state of the agent and be updated appropriately after each sensing action[4].Belief means how the agent look at the world and it is the basis of BDI model.An agent can use sensors to perceive the environment to get signals to believe.Belief is not the same concept as knowledge.Beliefs are only required to provide information on the likely state of the environment,but knowledge is the realization of a fact.Beliefs are just the state believed by agents but no one can ensure what they believe are true.Simple to say,knowledge is true belief.

2.2 Desires

Desires represent the motivational state of the agent[4].They represent objectives or situations that the agent would like to accomplish or bring about.They are state of affairs that the agent would wish to bring about or to keep.Desires may be achieved or never achieved,and it doesn't need to believe that desires must be achieved.Desires are different from goals although they are pretty similar.Desires can be inconsistent and the agent need not know the means of achieving these desires.

2.3 Intentions

Intentions are desires or actions that the agent has committed to achieve[5].Intentions are stronger than desires.Desires are just wishes that may be achieved or may be not,but intentions to an extent are decided to be achieved.Michael Wooldridge concluded four roles of intentions playing in practical reasoning[3].First,intentions driving means-ends reasoning means that intentions have decisive influences on actions the agent will execute.Second,intentions constraining future deliberation means that options that are inconsistent with this intention will not be entertained.Third,intentions persisting means that intentions will be never given up unless the reason is rational.Finally,intentions influencing beliefs upon which future practical reasoning is based means that believing intentions will be achieved.

3 BDI architecture

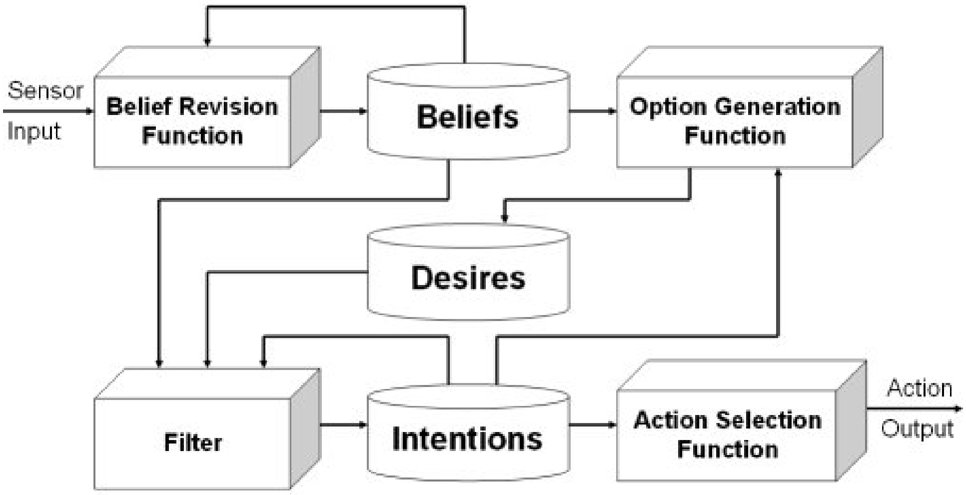

Figure 1: Brief BDI architecture (resource from Melkor.cz,2011)

Table 1: Components of brief BDI agent architecture

Component	Meaning	Formalization
Beliefs set	Information about the current environment which the agent has	B
belief revision function	determines a new set of beliefs depending on perceptual inputs and the agents current beliefs	$B \times P \to B$
Options	determines desires depending on the agents current beliefs	$B \times I \to D$
Desires set	possible courses of actions available to the agent	D
Filter	determines the agents intentions depending on current beliefs, desires, and intentions	$B \times I \times D \to I$
Intentions set	the agents current focus	I
Action selection function	determines an action to perform depending on current intentions	$I \to A$

Figure 1 shows a brief architecture of BDI agent,it has seven main components and beliefs, desires and intentions are in the middle.And the explanation of using the seven components of BDI architecture as well as giving the formulas of each function are presented in table 1.

4 BDI implementations

Since Michael Bratman came up with the notions of beliefs, desires and intentions in 1987,a lot of people are interested in this field and try to improve no matter theories or practices.During the last 27 years,some implementations of DBI agents were designed by different people.Three simple BDI implementations are presented in this chapter.

4.1 Intelligent, Resource-Bounded Machine Architecture (IRMA)

IRMA is the first system implementing the BDI model and is introduced by Bratman,Israel and Pollack in 1988[6].As it named as "Resource-Bounded",it doesn't have ability to perform arbitrarily large computations in constant time. The more complex computations are,the more time the agents spent on.In the 1980s,researchers came up with dealing with plans to improve resource-bounded agents.They have the idea that constructing some plans in previous,and distinguishing plans-constructed steps from plans-executed steps.

Besides the beliefs set and desires set are same to the abstract BDI architecture,there is a dataset named "Intentions stuctured in plans" that store the plans has been adopted and the plans the agent knows about stored in the plan library.In addition,the filtering process becomes stronger that has two component,one is compatibility filter operate in parallel with the filter override mechanism.The deliberation process is not affected by the filter override mechanism thanking to the parallel.The filter override mechanism encodes the agents sensitivities to problems and opportunities in her environment - that is,the conditions under which some portion of her existing plans is to be suspended and weighed against some other option[6].

The core idea of this architecture which is designed for resource-bounded agents is to strengthen the filtering process and construct plans pro.The powerful filtering process constrains the overall amount of practical reasoning necessary as well as the independent plan function reduce the amount of means-ends reasoning necessary. Therefore,it reduce the computational time in both deliberation and means-ends reasoning aspects.

Although IRMA solve some of the problems faced up by resource-bounded agents, there are other design problems,such as means-ends analysis and the weighing of conflicting options,that are common to a wide range of architectures for rational agency[6].Furthermore,the architecture is a bit rough that the agent can only get beliefs from perceptions and there is no input pointing to the desires set.

4.2 Procedural Reasoning System(PRS)

Procedural Reasoning System was developed by the Artificial Intelligence Center at SRI International during the 1980s and was used as a fault detection system for the reaction control system of the NASA Space Shuttle Discovery[7].PRS is a system that reasoning and achieving tasks in the dynamic environment.

PRS agent consists of five components which are beliefs,plans,goals,intentions and interpreter.Unlike the abstract DBI agent architecture,PRS agent architecture is presented as Centric.All the data connect to the interpreter who stays in the center of this architecture.An interpreter manipulates these components,selecting appropriate plans based on the system's beliefs and goals,placing those selected on the intention structure,and executing themA10.The database stores the set of current beliefs coming from the environment,and the goals are expressed as what the agent wants to do.The knowledge area(KA) contains plans.Each KA consists of a body, which describes the steps of the procedure,and an invocation condition,which specifies under what situations the KA is useful.Together,the invocation condition and body of a KA express a declarative fact about the results and utility of performing certain sequences of actions under certain conditionsA10.We can treat the body of KA as plans and the invocation condition as triggers.When the beliefs and goals are matched and trigger the invocation conditions,then the plan will be sent to the Intention structure which contains the tasks that the system has chosen for execution.However,all the transmissions between two sets are need to go through the interpreter.

The environment gives perception to the monitor though the sensors, then the monitor transfers the treated information into the database stored as beliefs.Both beliefs and goals are matched directly with invocation conditions by using unification onlyA10.After that,the body of KA is triggered.The interpreter will select appropriate plans and place those selected on the intention structure.The intention will execute the selected plans or convert some un-elaborated sub-goals into new goals.Finally,the actions will be executed to affect the environment again,and the goals are achieved.

4.3 Distributed multi-agent reasoning system(dMARS)

Distributed multi-agent reasoning system is an extension of procedural reasoning system with implementation environment written in C++ for building complex, distributed, time-critical systems[9].Similar to PRS,dMARS architecture also contains an interpreter to run the entire system.Perception is input into a queue of events instead of beliefs set.Event queue represents that perceptions of the agent are mapped to events stored in a queue.It contains the acquisition or removal of a belief,the reception of a message,and the acquisition of a new goal[5].The interpreter picks up an event from the queue of events,usually the first one in the queue,and map them to the plans which stored in the plan library,While updating the event queue by perception and internal actions to reflect the events that have been observed[10].After matching the event and its corresponding plan,the generation of possible desires will come up.Subsequently,select an available plan from the set of matching plans.The context of this plan must be a logical consequence of the beliefs of the agent.Push this selected plan onto an existing stack when the event is an external one,which means no plan has generated it,or on a new intention stack when the event is an internal one whcich means that a previous plan generated it.At last,While the event queue is empty,select an intention stack,take the top plan,and execute its current step.If this step is an action, execute it, otherwise if it is a subgoal,post it to the event queue[8].

5 BDI applications

With the increasing needs of intelligent agents,more and more applications base on BDI model are applied in our life.As we introduced above,PRS and dMARS are both BDI-based systems for the reaction control system of the NASA Space Shuttle Discovery.Additionally,an air-traffic management system,OASIS,is well-known as a BDI-dased agent.The system architecture for OASIS is made up of one aircraft agent for each arriving aircraft and a number of global agents including a sequencer wind modeller coordinator and trajectory checker[4].Furthermore,robot soccer which are designed using BDI model becomes very popular in universities.

We can feel that,BDI agents bring many profits to human beings,they make the life more convenient.However,it still has development space in this field.

6 Discussion

Although the BDI model is developed during about 30 years,some obstacles are not overcame and some challenges are still there.Most BDI implementations do not have an explicit representation of goals.As we introduced above,the IRMA and the basic BDI model don't exist explicit goals.The agents should reason the goals from the current beliefs and intentions.Besides,the BDI model contains three attributes, beliefs,desires and intentions.In some situations,not all the three attributes are needed.Sometimes,an agent collect the beliefs and jump to intentions directly without desires.However,for some distributed multi-agents,just three attributes are not sufficient to execute the actions.Like the dMARS,although it implements distributed multi-agent reasoning,it is not easy to understand it better just using these three attributes.Furthermore,the agents in the multi-agents system don't have a explicit mechanisms for interaction and integration among them.When an increasing number of agents join the system,the interaction with each agent will be more and more difficult. As an intelligent agent, the BDI agent don't have a good ability to learning from from past behavior or other agents behavior.So that the rate of development will not be high if lack mechanisms to learn from others.

However,BDI model has its own advantages.Beliefs, desires and intentions are similar to the mental activities of human beings.With the wildly used of computers and mobile devices,the situation of multi-agent interaction will be better.As many computer languages and logic languages are grasped by more people,the BDI agent will bring human beings more surprises.

7 Conclusion

An overview of BDI model is presented.The BDI agent belongs to intelligent agent which are autonomous,computational entities.The BDI agent execute actions on the basis of BDI model that containing three main attributes which have close relationship with each other.The brief BDI agent architecture is a clear description of process of BDI agents work.And They follows the practical reasoning theory.Different BDI implements show different architectures,but the core idea of these agents are still beliefs,desires and intentions.With an increasing number of BDI applications go into the humans life,more challenges come up too.

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