AN INSTRUMENTALIZED PARTICIPATORY APPROACH FOR COOPERATIVE KNOWLEDGE ACQUISITION TO BUILD A SOCIAL MABS

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Keywords

Social MABS, meeting, cooperative work, knowledge acquisition, distributed decision making, poultry chain.

ABSTRACT

This paper proposes a participatory and cooperative approach to acquire necessary knowledge to build a MultiAgent-Based Simulation (MABS). This approach is based on role-playing, meeting and Computer Supported Cooperative Work (CSCW) principles. During a meeting firm actors simulate problem solving processes by playing their usual roles. The result of several meetings is a corpus which is analyzed to provide a set of scenarios. It allows the building of a multiactor model.
In this study, we apply the approach to acquire knowledge to model and then simulate decision-making processes in poultry firms. In particular, we seek to understand the probable impacts of individual behaviors in the decision process of managing raw material.

INTRODUCTION

MultiAgent-Based Simulation (MABS) is an efficient way to understand multiactor systems, through the Multi-Agent System (MAS) modelling processes and the analysis of the simulation behaviors when run (Edmonds, 2001). This is due to the MABS's ability to cope with simple entities as well "groups" and "organizations" (A.Drogoul, Vanbergue and Meurisse, 2002; Edmonds, 2001), and interaction between entities and groups.
MAS methodologies (Burmeister, 1996; Fishwick, 1997; Wooldridge, Jennings and Kinny, 2000) and methodological proposals for computer simulation (Fishwick, 1996; Gilbert and Troitzsch, 1999) define processes and models to represent computational agents, their interactions, organizations and environments. An important step in MABS building is to identify the agents to be introduced into the model. Unfortunately, most methodological proposals (Ferber and Gutknecht, 1998; Iglesias, Garijo, Gonzalez and Velasco, 1996; Parunak, Sauter and Clark, 1997) underestimate the difficulties faced when building computational agents. They consider that agent identification is a straightforward operation during two modelling phases: analysis and design phases. Our goal, is to propose a method for "real agents" identification and knowledge acquisition to build socio-economical simulation models.

Document Analysis or Knowledge Acquisition?

Generally, the modelling process of a MABS is based on the knowldge provided by descriptive documents. Thanks to those documents, the agents can be identified through a linguistic analysis (Parunak et al., 1997).
Multiactor systems, particularly within a non-delimited organization (see definition in Section) are often characterized by the difficulty to get documents describing the organizational functioning of such organization. In this case, a Knowledge Acquisition (KA) step is necessary to build agent-based simulation. During a KA phase, domain experts (also called *thematicians* (A.Drogoul et al., 2002)) are called up.
Actually, there are two main reasons to introduce the target system actors to the modelling process during KA process. First, those actors hold the necessary domain knowledge. Second, as shown in (A.Drogoul et al., 2002; Bousquet, Barreteau, d'Aquino, Etienne, Boissau, Aubert, Page, Babin and Castella, 2002), most of thematicians enter the design of the multiagent simulations because they are interested in understanding the global target system. Indeed, in situations where they cannot explain their contributions and the consequences of their decisions, neither deductively or analytically, the knowledge acquisition phase is necessary to explicit such knowledge.
An agent-based simulation encompassing individual and collective knowledge provides a useful tool to evaluate the consequences of individual decisions on the global target system. Our case study is understanding the im-

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pacts of individual behaviors and knowledge in the decision processes of managing raw material in a poultry chain (see Section).

A new methodological framework

To deal with these two issues, namely the lack of descriptive documents and the need to identify the pertinent agents of an organization, we propose a new methodological framework. Our approach is to be used during the analysis step of modelling process. It provides a domain model called *multiactor model*, to be used by the modellers during the design phase (see Figure 1). The multiactor model is used to build defined agent models in MAS methodologies.

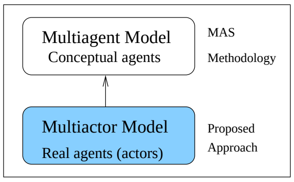

Figure 1: *The multiactor model position in MABS design process*

The main objective of the approach is to gain some understanding of the organizational patterns and decisional processes of firms, on the basis of initial model objectives. In fact, a knowledge acquisition process is essential for the building of a simulation model.
In order to collect and acquire the necessary individual and collective knowledge to build a MABS, our approach uses the meeting and cooperative work principles. It is inspired from the Computer Supported Cooperative Work -CSCW- techniques. This method is also based on role-playing during meetings. It involves several roles: thematicians, expert thematicians and modellers. (see section).

Concepts

A "role" is what the actor is expected to do (Yu and Mylopoulos, 1994), in accordance to his commitments and organizational rules. Moreover, an actor cooperate with other actors in accordance to their commitments. He also exchanges knowledge and coordinates his activities.
A "non-delimited organization" represents an unbounded organization, without a legal status. For example, a wheat chain or a national book market.
"Target system" characterizes the organization to be modelled and various decision processes within it. Decision-making processes are seen as a series of interactions between stakeholders (Bousquet et al., 2002).
In the next section, we present our own approach, which leads us to present, in section , a real case study. we propose an example of decision-making processes in a poultry chain. In the section , we discuss some related works to our research area. We finish with some concluding remarks and further works.

PROPOSED APPROACH

This approach aims at: (i) understanding the structure and functioning rules of the target system through the building of MABS model; (ii) dealing with "real agents" identification (iii) and leading to a domain model, called multiactor model, to be used to design MABS.
In this approach, we postulate that we can understand multiactor systems when "real agents" are interacting. We assume that actors behave more instantaneously when reacting to some events in their environment (e.g. information requests, activity requests, etc.).

Involved roles to apply the approach

The notion of role in a modelling process has already been introduced in several works (Bousquet et al., 2002; A.Drogoul et al., 2002; Edmonds, 2001). Our approach is based on the attendance of several actors, with various roles: expert thematicians, thematicians, and modellers. Modellers are in charge of building the simulation models (Fishwick, 1996). The expert thematicians and thematicians are domain experts. The differences between the two roles are the knowledge handled, their MABS interest and objectives. Expert thematicians are domain researchers, policy makers, etc. who handle general knowledge and observations of the target system. The thematicians are professional experts (e.g. firm managers). They have a specialized point of view.

Simplified view of the approach

Figure 2 is a scheme of our approach. The analysis process of a non-delimited organization follows several steps:

- The process starts with an abstraction step, which depends of the model objectives. The abstraction is built after several individual expert interviews have been carried out.
- A knowledge acquisition process is necessary to understand organizational functioning and collect domain knowledge. It can be a *collective* or an *individual* knowledge acquisition. A *corpus document* results from this step.
- The analysis of the corpus provides a more precise view of handled knowledge (micro and macro knowledge), relationships between actors, interactions, etc.
- finally, a *multiactor model* is built.

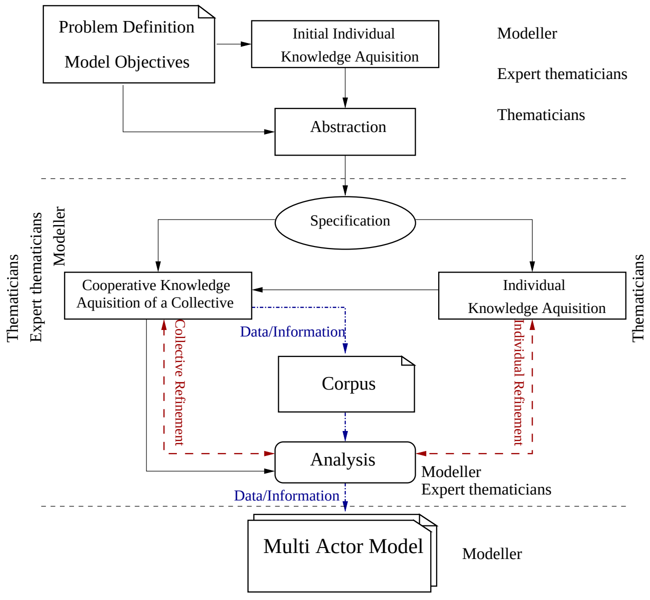

Figure 2: *Simplified view of the proposed approach*

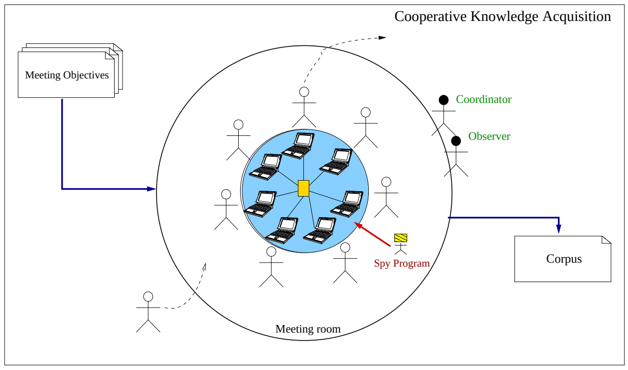

Figure 3: *Cooperative Knowledge Acquisition of a Group*

Abstraction

An abstraction gives a simplified structural view of the target system. In this stage, the expert thematician and thematician roles are involved. Each expert has a subjective point of view (Edmonds, 2001) of the target system and the model. Thus, the refinement degree of our model is to be chosen.

$$\Phi = \langle F, E \rangle \quad (1)$$

where F = set of identified groups (subsystems), and E =Evolution environment of F

Example (see Section) A poultry chain consistes in a set of competing firms. Each firm has its own organizational structure, strategies, etc. A firm is then considered as a group within the poultry chain.

Collective knowledge acquisition

Collective knowledge acquisition consists of role-playing meetings. A meeting (Figure 3) is characterized by a set of common objectives and a set of participant actors (thematicians). A meeting objective can be an initial model objective or be defined by the participants themselves. The thematicians interact to solve proposed objectives. The knowledge acquisition runs using:

- *a communication framework*. It is an information dialogue framework, composed of laptop computer network that can be moved to any meeting room. Each computer contains a generic application, with a very simple interface, and communicates with other applications via CORBA (Common Object Request Broker Adapter) layer.
  This framework also contains a *spy program* that collects all exchanges. The stored data is called *corpus documents*. For each exchanged message, the spy program associates a sequencing identifier (including serial number within a conversation). It also stores the sender and receiver of each message, as well as the message's content.

- *meeting principles (face-to-face)*. Each meeting participant uses the application installed on his own computer. He is able to: (1) play his usual role in the firm (2) describe this role (3) communicate with actors he chooses (4) use, or define some keywords or domain concepts. Communications are done with natural language.

- *Observer and coordinator participation*. Meetings are coordinated by the modeller (called *coordinator* in this case). An expert thematician (meeting *observer*) observes the meeting development.

Important Remarks (1) For each meeting, functionalities can be used or referenced by actors, such as databases, computational resources (like linear programming -LP- optimization); (2) If an unvailable role seems to be relevant and is called up by a meeting participant, then a new role player is invited.

Analysis step

After several meetings, the corpus documents are analyzed (Figure 4) : (1) by conversation representation (UML diagram sequencing, state machines, Dooley graphs) -see Section -; (2) by role analysis, which allows to discover activities and decisions (see example below); (3) by role dependencies (Yu and Mylopoulos, 1994) analysis, which allows to discover goal and resource dependencies.

Example

- Role = *Purchaser*: carry out a new raw material purchase;

- Decision = *Buy (Yes/No)?*;

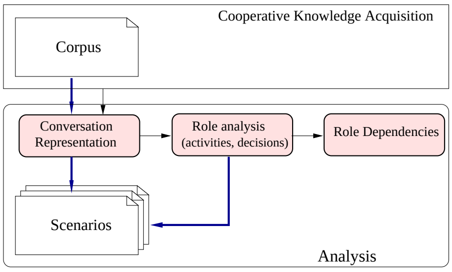

Figure 4: *Analysis Step*

- Activities = *Request critical information* from other actors (potential use?, global profit?), *provide requested data*.

Notion of scenario

For each discussed objective during a meeting, a *scenario* is built as follows (detailed example in section):

Scenario	Scenario name
Objective	Raw Material Purchase
Participant roles	Purchaser, etc.
Interactions	Exchange contents, conversation models
Decisions	Buy (yes/no?)
Activities/Role	Compute profit

A scenario S is a 4-tuple

$$S = \langle < SO >, IS, CR, R \rangle; \qquad (2)$$

In a scenario, a role is defined as an abstract actor. Let n be the number of identified roles.
SO="Scenario Objective", IS=Interaction sequences, CR=Conversation Representation, $R = \{R_i\}_{i=1..n}$ a set of pertinent roles, and

$$R_i = \langle < RoleName >, A_i, K_i \rangle;$$

A_i=Acquaintances of R_i, K_i=R_i's handled knowledge;

After several meetings, a **library of scenarios** is progressively built and enlarged.

Remark In order to verify or refine collected knowledge, some feedback is necessary. It can be a collective knowledge refinement (i.e. new meetings) or individual interviews.

Note. Generally, the chosen groups during the abstraction step have a heterogeneous organizational structure. This allows various scenarios for the same objective.

Individual knowledge acquisition

Individual knowledge is the results of individual interviews. A thematician can be asked to explain his sentences (requests, answers too ambiguous), and also to describe an activity process, that he mentioned during meetings.
The individual knowledge acquisition is a refinement and verification step of the collected information.

Multiactor model

Let p be the number of involved participants and m be the number of scenarios after several meetings.
The multiactor model encompasses the accepted knowledge by domain experts which is:

1. a simplified view of the target system that we call the *abstract system* Φ (Equation 1);
2. a set of pertinent "real agents" A involved in the set of scenarios S. $A = \{A_k\}_{k=1..p}$;
3. for each actor a, $a \in A$, (i) his roles (ii) his knowledge base; (iii) his methods base; (iv) his acquaintances; (v) his language (words, concepts, etc.);
4. a set of role dependencies D, $D = \{D_l\}_{l=1..d}$ (d is the number of discovered dependencies);
5. a library of common objectives O, $O = \{O_l\}_{l=1..o}$ (o is the number of solved objectives during the various meetings);
6. a library of standard scenarios S, $S = \{S_i\}_{i=1..m}$.

Given the sets (1) and (2), the multiactor model Γ is defined as

$$\Gamma = \langle \Phi, A, O, S, D \rangle; \qquad (3)$$

CASE STUDY: The Poultry Chain

Our research aims at designing a poultry chain model to understand the contributions of individual actors to the use of raw materials. It will be used to simulate the consequences of new regulations, price and production technique variations.
Our multiactor model was developped in four phases: The abstraction, the collective knowledge acquisition, the information analysis and finally the setting up phases.

The abstraction phase

A poultry chain is a very complex organization. To conceive its abstraction, we have carried out several *individual interviews* with domain experts (expert thematicians) and industrial actors (thematicians).

The abstract architecture (Figure 5) represents a poultry chain as composed of a set of competing firms within the agricultural raw material market and poultry market. Each firm has its own organizational structure, objectives, functioning rules, and a set of local knowledge and skills.

$$\Phi_{PoultryChain} = \langle F, E \rangle; \qquad (4)$$

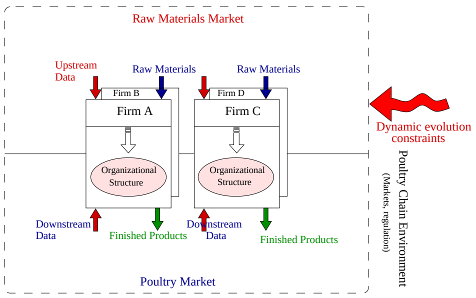

Figure 5: *Poultry Chain Abstraction*

F=$\{Firm\ A$, $Firm\ B$, $Firm\ C$, $Firm\ D$, etc.$\}$
$E = \bigcup E_i$, and $E_1 = Raw\ Material\ Market$,
$E_2 = Poultry\ Market$

The collective knowledge acquisition phase

Initially, we invited to a meeting actors, chosen by a firm manager (firm A, in Figure 5 and Table 1).

Thematician	Roles (as defined by actors)
Purchaser	Proposes new raw material
Formulator	Provides cheapest diet formula following nutritional and economic constraints
Manufacturer	Manufactures animal meal constrained by stock capacities, technological constraints
Nutritionist	Introduces/modifies nutritional constraints
Quality coordinator	Ensures best product quality
Manager	Proposes global strategies Assigns tasks

Table 1: Meeting participant Actors

The meeting objective is chosen by thematicians: “new raw material (RM) opportunity, do we buy it?”. Then, a meeting is hold.

The interaction sequencing

To solve the proposed objective, Table 2 shows a sequence of exchanged messages between participant actors. This sequence is a part of the corpus documents.

Information Analysis

We represent the conversations (as depicted in Table 2) using *Speech Acts* (Parunak, 1996). Conversations are analyzed using three tools: UML diagram sequencing, state machines, and Dooley graphs.

Sender	Receiver	Message content
P	F	Opportunity(wheat,price, wheat characteristics) Can we use it?
F	M	planning and stock possibilities?
M	F	I can use it in 07 days.
F		OK ! I compute operation profit
F	P	Yes, we can buy it, but wheat can’t be received before 07 days
P	F	OK! I negotiate the delay

F=Formulator, P=Purchaser, M=Manufacturer

Table 2: Interaction sequencing IS

Identified roles

Given the initial set of meeting participants (see Table 1), we identified three pertinent roles (Table 3) .

Actor/role R_i	Acquaintances A_i	Knowledge K_i
Purchaser Opportunity	Formulator	data=RM,Price, RM characteristics
Formulator new RM	Purchaser Manufacturer	method=Optimization program data=RM characteristics table
Manufacturer new RM	Formulator	method=stock control program data=stock capacities, production planning

RM=Raw Material

Table 3: Acquired knowledge

$R = \{Purchaser_{opportunity}$, $Formulator_{newRM}$, $Manufacturer_{newRM}$.

Conversation representation: state machine

Figure 6 diagrams the state machine SM_1 of the previous conversation (see Table 2). Note that to refine the acquired knowledge, some individual interviews have been udertaken.

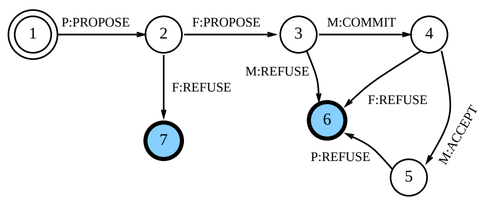

Figure 6: *State machine* SM_1*: case raw material purchase*

Identified scenario: The *"RM Opportunity"* scenario

The scenario S_1 was identified. Following Formula 2 it is writen as:

$$S_1 = \langle \text{``}RMopportunity'', IS, SM_1, R, A, K\rangle$$

IS=Interaction sequences, as depicted in Table 2,
SM_1=state machine, Figure 6,
$R = \{R_1, R_2, R_3\}$,
$R_1 = \langle Purchaser_{opportunity}, A_1, K_1\rangle$,
$A_1 = \{R_2\}$,
$K_1 = \{RM, Price, RMcharacteristics\}$.
$R_2 = \langle Formulator_{newRM}, A_2, K_2\rangle$,
$A_2 = \{R_1, R_3\}$,
$K_2 = \{OptProgram, RMcharacteristics\}$.
$R_3 = \langle Manufacturer_{newRM}, A_3, K_3\rangle$,
$A_3 = \{R_2\}$,
$K_3 = \{stockControlProgram, stockCapacities,$
$productionPlanning\}$.

Dependencies between roles

A number of role dependencies are identified. For example:

1. d_1 =*Dependency*$(Purchaser_{opportunity}, Formulator_{newRM}, resource)$: a material resource dependency (optimization program, handled by the Formulator) between $Purchaser_{opportunity}$ and $Formulator_{newRM}$ roles;

2. d_2 =*Dependency*$(Formulator_{newRM}, Manufacturer_{newRM}, resource)$: an informational resource dependency (stock capacities) between $Formulator_{newRM}$ and $Manufacturer_{newRM}$ roles.

The multiactor model setting up

Following the scenario S_1 and the Formula 3, the developped multiactor model represents only one firm (Let be $Firm\ A$) of the poultry chain. It is defined as:

$$\Gamma = \langle \Phi_{PoultruChain}, A, D, O, S\rangle;$$

Where
Φ= Poultry chain abstraction, defined by (4)
A =$\{$$Firm\ A$:Purchaser,
$Firm\ A$:Formulator, $Firm\ A$:Manufacturer$\}$
D=$\{d_1, d_2\}$
O=$\{$Raw Material Purchase$\}$
S=$\{S_1\}$

Additional results

After several meetings, we distinguished several individual and collective decision tasks (e.g. raw material purchase). Moreover, two standard scenario classes have clearly emerged: *strategic* and *tactic* scenarios. The former can be related to strategic objectives, such as consequences of regulation variation or the increase of firm profits. The latter can be associated with usual problem solving, such as raw material purchase.

Remark

After several meetings, a lack of interaction issue emerged. Some meeting participants did not interact to solve objectives. In such cases, these actors can be considered as not pertinent for the model. This issue is a restrective parameter to be addressed.

RELATED WORKS

To build a MABS, two main proposal classes are taken into consideration. The first class consists of participatory approaches which are based on knowledge acquisition processes. These approaches define a domain model to represent the expertise knowledge of stakeholders (Barreteau, Bousquet and Attonaty, 2001; Bousquet et al., 2002; Bars, Attonaty and Pinson, 2002). A knowledge elecitation process integrates acquired knowledge into the expertise model (Iglesias et al., 1996; Fishwick, 1997) of the conceptual agents. The second class is MAS methodologies. These methodologies base the MABS building process on the analysis of the descriptions of the target system and model objectives. However, most MAS methodologies (Parunak et al., 1997; Burmeister, 1996; Kendall, Malkoun and C.H.Jiang, 1996) consider that agent identification is a straightforward operation. Because of this lack, such methodologies are not easily applicable to human or cognitive organizations modelling.
From our understanding of the litterature, until now the proposed knowledge acquisition approaches to build social MABS have been based on individual interviews (Barreteau et al., 2001; Bousquet et al., 2002). Our approach is based on a cooperative knowledge acquisition to avoid skews, possibly resulting from the individual KA techniques.
Very few MABS studies (Edmonds, 2001; A.Drogoul et al., 2002; Barreteau et al., 2001) explicitly describe participatory approaches as well as the roles involved in the design process. On a side, Drogoul and al. (A.Drogoul et al., 2002) introduce three roles: thematician, modeller and computer scientist. Each role intervenes in a model building stage. Those authors propose to define several agents that can learn the expert knowledge. To do so, experts and non-experts exchange knowledge by role-playing games to interactively define agent behaviors. On other side, F. Bousquet (Bousquet et al., 2002), O. Barreteau (Barreteau et al., 2001) and M. Lebars (Bars et al., 2002) build multiagent systems on the basis of individual knowledge acquisition and led participatory simulations on these MAS. In their studies, they simulate the impacts of actor choices during role-playing

games on shared natural resources, and then use the simulation results to resolve conflicts between the stakeholders.

MAS methodologies propose models for conceptual agents. The agents are identified following several approaches, based mainly on the analysis of the furnished descriptive data. For instance, Parunak and al. (Parunak et al., 1997) define a set of agents and agent types using a linguistic case analysis of the problem description. This activity focuses roughly on the Burmeister agent model (Burmeister, 1996). The initial set of agents is used to acquire expert knowledge and behaviors by role-playing or computer simulations. In fact, some actor behaviors are considered as strainforward, thus an expert validation step is necessary.

In role-based methodologies (Wooldridge et al., 2000; Ferber and Gutknecht, 1998), the properties of a role (Wooldridge et al., 2000) are used to create a system behavior model. Roles are then defined and mapped to various conceptual agents. To define the agent behaviors, these methodologies require the designer to have expertise in the target system, so the roles can be identified correctly.

These proposed approaches are individual-centred and neither deal with the descriptive aspects of organizations nor address the tacit knowledge acquisition issues. Our approach introduce participation principle to design socio-economical MABS. It uses cooperative processes to discover and acquire collective (macro-knowledge) as well as individual knowledge (micro-knowledge). Its main principle is to cause an effective participation of actors, so it is pictured as a fly trap.

CONCLUSION

This paper describes our proposed approach to collect necessary knowledge for MABS building. It is a participatory approach, based on role-playing, meeting and CSCW principles. It also provides a dialogue framework as a communication tool for participanting actors. In order to understand organizational structure and functioning of multiactor systems, actors simulate cooperation processes within firms by role-playing games. The interaction sequences are saved and analyzed to build a domain model called *multiactor model*.

Our approach has, as a first challenge, to introduce MABS development processes within industrial organizations. To do so, we have explored some experiments in different firms. At this time, we are using the collected knowledge to develop a poultry chain multiagent based simulation.

The strongest contribution of our approach is its ability to aquire precise collective as well as individual knowledge. However, until now the acquired knowledge is hand-coded, thus it presents a weakness point to be address in further works.

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