

CAPRICE: knowledge acquisition tool based on game approach

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The problem of knowledge acquisition is becoming the bottleneck of knowledge engineering. Monotonous character of current procedures for knowledge acquisition is one of reasons because of the knowledge acquisition dragged on long time. We present our approach, which makes knowledge acquisition more pleasure for expert and allows to shorten the time for knowledge base forming. In CAPRICE system the dialogue with expert is organized in the form of specific computer games — Expert Games. Special procedures analyze protocols of Expert Games, “restore” expert’s knowledge and place it in knowledge base. Experimental results show the effectiveness of proposed approach.

Knowledge acquisition is always seen as a difficult task during the construction of a knowledge based system. In the broad sense, the knowledge acquisition is the transmission of the experience for resolving certain problems by means of computer system. In case of expert systems, the experienced human expert is the main source of knowledge. It is necessary to elicit his professional knowledge and to represent it adequately in knowledge base. The person which does all these things and in general is responsible for creating of expert system is called knowledge engineer. Knowledge engineer is analogous to the system analyst in traditional computer systems design. Knowledge acquisition is difficult and time consuming process, in the course of which knowledge engineer faces many problems, such as (Hart, 1986):

- human knowledge is complex and messy and often ill-formulated (intelligence is easy to recognize, but more hard to define);
- item humans find it difficult to articulate what knowledge they have and how they use that knowledge to solve problems;

- item the more expert someone becomes at a task, the more 'un-conscious' his or her knowledge becomes and etc.

As a result, knowledge engineering is very time-consuming process. From this point of view, the narrow place of existing methods of knowledge acquisition is its incapability to keep up the permanent expert's interest to work with knowledge engineer. Today the process of knowledge base forming is a very monotonous procedure containing no creative moments. This process has become the insufferable obligation for expert and this is one of reasons because of the stage of knowledge acquisition dragged on long time.

Here we present CAPRICE system — knowledge acquisition tool based on game approach. Five main principles of the game approach for knowledge acquisition can be noted:

- The dialogue between the expert and knowledge engineer looks as an attractive computer game — as popular known computer games and puzzles; such games will be called as Expert Games.
- Expert games are organized for investigating problem domain: they are based on problem terminology and are games with professional interest. During such games the situation is similar with the real one. The expert estimates it and makes decision according to his experience. All expert's operations during the game are file in the protocol of the game.
- After the game, special procedure resolves reverse problem: it analyzes protocol of game, "restores" expert's knowledge and creates formal knowledge structures.
- Expert Game is not directly connected with the problem domain. It includes game principle in "pure form". Description of problem domain is read from the external file at the beginning of the game.
- Each Expert Game demands some initial information. Such information is obtained from another Expert Games. The very first information can be put into the knowledge base by knowledge engineer.

We had created and examined a number of Expert Games based on different game principles. They allow to elicit different types of knowledge. For example, the game “Blackbox” (Ginkul et al., 1992) elicits new positive and negative training examples, “Labyrinth” (Ginkul et al., 1992) forms repertory grids, “Bulls and Cows” (Ginkul, 1993) reveals the sequence of simple intermediate steps in expert’s reasoning and etc. It is supposed, that knowledge engineer creates the main knowledge acquisition scenario by means of Game Editor.

Below we describe Expert Game “Blackbox”, which is included in CAPRICE system. First version of system focuses on following class of problems:

- It deals with diagnostic problems;
- It considers only attribute problem domains, e.g. such problem domains, for which the descriptions of any decision or any problem situation is represented in the form of a set of attributes, having a finite number of values. Notice, that very wide class of problems can be represented by means of attribute model.
- It forms IF-THEN rules for knowledge representation.

Differential diagnostics of diseases, which is indicated by ache in thorax, is used to illustrate the main point of Expert Game.

1 The “BLACKBOX” Expert Game

1.1 Initial Information

The game works by crib prepared by knowledge engineer. The known description of some decision (training example) is used as the capacity of crib. Also knowledge engineer must place into the knowledge base the set of all potential decisions.

The main idea of “Blackbox” based on the desire “to torment” the expert, to make him to advance suppositions based on incomplete data. Such way makes clear the “inward kitchen” of expert’s reasoning.

At the beginning of the game the expert's opponent (computer plays his role) has one training example and places it "into the blackbox". Expert must solve hidden decision — that is his game task. Computer can tell the expert about some fact from the example by the stipulated fee. If he "pays" once again, expert could learn the next fact and e.g. — the game goes on tour by tour. The points are used for payment in the game.

Knowledge engineer varies rules of the game by means of the following game parameters:

D — size of start points;

P — set of potential decisions;

L — size of minimal pay for fact.

To learn the next fact about hidden decision expert must "spend" more than L points in previous tour. Formaly, tour $i + 1$ can begin if in tour i the following condition was satisfied:

$$L \leq \sum_{p \in P} \max(0, C(p, i) - C(p, i - 1)),$$

where $C(p, i)$ — size of stake on decision p in tour i and $C(p, 0) = 0$ for all p from P .

If new fact changes his mind, expert can decrease or annulate previous stakes. But if he decreases some stake for E points on tour i , then he saves only EQ^{i-1} points (they are added to total resource), where Q — is denominator of progression ($0 < Q < 1$). Another part of decreased stake is lost.

The game is finished either when opponent tells about all facts from the description or when expert guesses the decision. At the end of the game computer displays hidden decision, then correctly made stake is enlarged (denote G — coefficient of enlarging) and its points are added to the points, which aren't used up. Incorrect stakes (its points) are lost. Subtraction between start and final points indicates the success of expert's gaming.

Example of BLACKBOX's game protocol is shown in Tab. 1. Values of parameters are: $D = 950$, $L = 100$, $Q = 0.66$ and $G = 2$.

1.2 Example of game protocol

TOUR 1		
KNOWN INFORMATION		
1. Strengthening of pain when breathing or cough		
DECISION	STAKE	TOTAL
Stenocardia	50	950
Myocardial infarction	30	
Stomach ulcer	20	
TOUR 2		
KNOWN INFORMATION		
1. Strengthening of pain when breathing or cough		
2. Does not caused by meal		
DECISION	STAKE	TOTAL
Stenocardia	100	850
Myocardial infarction	90	
TOUR 3		
KNOWN INFORMATION		
1. Strengthening of pain when breathing or cough		
2. Does not caused by meal		
3. Pain localizates in left side of thorax		
DECISION	STAKE	TOTAL
Stenocardia	130	760
Myocardial infarction	120	
Functional cardiopathy	40	
TOUR 4		
KNOWN INFORMATION		
1. Strengthening of pain when breathing or cough		
2. Does not caused by meal		
3. Pain localizates in left side of thorax		
4. Strengthening of pain after probing		
DECISION	STAKE	TOTAL
Osteochondrose	80	730
Sharp mialgia	70	
Titce syndrome	50	
Stenocardia	50	

TOUR 5		
KNOWN INFORMATION		
1. Strengthening of pain when breathing or cough		
2. Does not caused by meal		
3. Pain localizates in left side of thorax		
4. Strengthening of pain after probing		
5. After great muscular efforts		
DECISION	STAKE	TOTAL
Sharp mialgia	200	490

1.3 Obtained Information

Emphasize, that for successful gaming we need in only one training example for some decision. In our example we have a description of Sharp Mialgia. From the game protocol new descriptions of different decisions can be elicited. Rules of the game force the expert to make suppositions (as stakes made on concrete decisions) and what's more — true suggests for successful gaming. Besides that, there is direct profit for expert to recall wrong stakes as soon as possible and thus to save at least its part.

Now consider special procedure, which looks through the game protocols “from the point of view of knowledge engineer” and creates formal IF–THEN rules.

1.4 Preliminary protocol analysis

Before hand, it is necessary to exclude non–perspective information from the protocol. We must take into account the game motivation of expert's behaviour. Most unfavourable expert's behaviour are shown in Fig. 1. It means that expert deliberately uses optimal game strategy: he simply “buys” facts without employing his knowledge. Procedure does not examine such cases. Good situation is shown in Fig. 2.

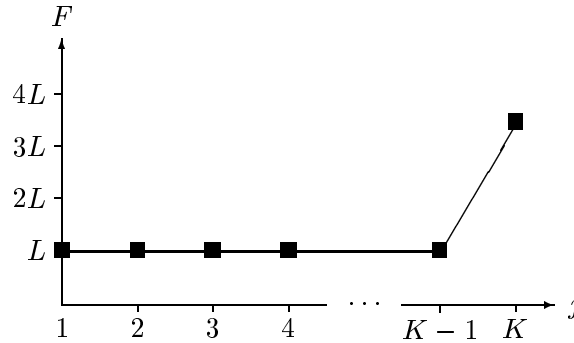


Figure 1: “Bad” case of expert’s gaming

The difference $F(j) - L$ fixes the deviation from optimal game strategy. It is the main criterion, which indicates in what extent expert had used his problem knowledge during the game.

1.5 Protocol analysis

Now consider two ways for IF-THEN rules forming. For example, in the Tour 3 the expert know following facts:

1. Strengthening of pain when breathing or cough;
2. Does not caused by meal;
3. Pain localizates in left side of thorax

and he puts 100 points (from total 760) on decision Stenocardia, 120 points on Miocardial Infarction and 40 points on Functional Cardiopathy.

Focus on Myocardial Infarction. In tour 3 expert put 120 points on Myocardial Infarction and in the next tour that stake was decreased. We suppose that expert tried to use the next rule

IF (Strengthening of pain when breathing or cough) and (Does not caused by meal) and (Pain localizates in left side of thorax) and also (CONDITION C),

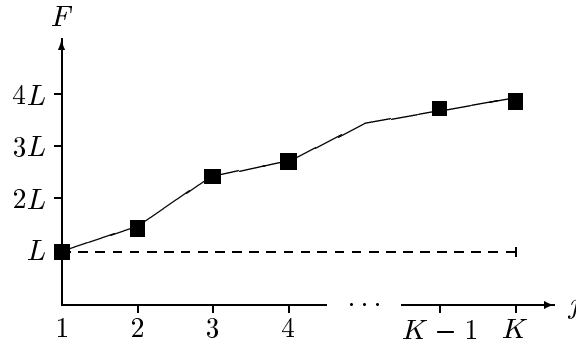


Figure 2: “Good” case of expert’s gaming

THEN (Myocardial infarction),

but **CONDITION C** doesn’t appear further and in Tour 5 expert rejects this rule. Procedure notes this rule and tries to determine the **CONDITION C** from another games.

Another way consists of the confidence coefficients are set for each rule. First of all, made stakes are reduced to interval $[0,1]$. For example, simple formula may be used:

$$W(p, j) = \frac{C(p, j)}{F(j)}$$

Then for Tour 3 we have:

IF (Strengthening of pain when breathing or cough) and (Does not caused by meal) and (Pain localizes in left side of thorax),

THEN (Stenocardia) with (0.45);

IF (Strengthening of pain when breathing or cough) and (Does not caused by meal) and (Pain localizes in left side of thorax),

THEN (Myocardial infarction) with (0.41);

IF (Strengthening of pain when breathing or cough) and (Does not caused by meal) and (Pain localizates in left side of thorax),

THEN (Functional Cardiopathy) with (0.14).

Rejection of Myocardial Infarction in tour 5 means that combination of facts 1–5 together with Myocardial Infarction is not available in the problem domain. Procedure represents such information in the form of six IF–THEN rules:

IF (Strengthening of pain when breathing or cough) and (Does not caused by meal) and (Pain localizates in left side of thorax) and (Strengthening of pain after probing) and (After great muscular efforts),

THEN NOT (Myocardial infarction);

IF (Myocardial infarction) and (Does not caused by meal) and (Pain localizates in left side of thorax) and (Strengthening of pain after probing) and (After great muscular efforts),

THEN NOT (Strengthening of pain when breathing or cough);

IF (Strengthening of pain when breathing or cough) and (Myocardial infarction) and (Pain localizates in left side of thorax) and (Strengthening of pain after probing) and (After great muscular efforts),

THEN NOT (Does not caused by meal);

IF (Strengthening of pain when breathing or cough) and (Does not caused by meal) and (Myocardial infarction) and (Strengthening of pain after probing) and (After great muscular efforts),

THEN NOT (Pain localizates in left side of thorax);

IF (Strengthening of pain when breathing or cough) and (Does not caused by meal) and (Pain localizates in left side of thorax) and (Myocardial infarction) and (After great muscular efforts),

THEN NOT (Strengthening of pain after probing);

IF (Strengthening of pain when breathing or cough) and (Does not caused by meal) and (Pain localizes in left side of thorax) and (Strengthening of pain after probing) and (Myocardial infarction),

THEN NOT (After great muscular efforts).

Thus we can see, that enough number of rules would be obtained from only one game protocol.

2 CONCLUSION

In this paper we report about game approach for knowledge acquisition. The CAPRICE system was built on the basis of the game approach (using Common LISP and C++ for IBM PC). It contains the number of different Expert Games. We had examined CAPRICE in such problem domains, as diagnostics of gormonal balance of tomatoes and irido-diagnostics (medical diagnostics based on examination of iridescent membrane of eye). In some cases we combined game approach with another methods (Quinlan, 1990).

In brief, advantages of the game approach are following:

- it is an automatized approach,
- it not forces the expert to verbalize his knowledge,
- it makes knowledge acquisition more pleasure procedure for expert,
- it allows to shorten the time for creating knowledge base,
- it not rejects the using of another methods.

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