Detection, Identification, Encoding and Processing of Questions in Decision-Making

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Abstract: - The place and role of the questions in interactive decision-making are investigated. The question is understood and defined as the nature phenomenon, which appears in application of human experience during solving of the task. At first a solver has to find the question phenomenon in the form of mismatch between potential experience, necessary for solution, and his real experience. Existing mismatch (question) fulfills the function of an active cause for decision-making control. A cause-question has an objective content that should be primarily detected and identified, similar to causes in nature. A number of methods and means are realized for detecting, identifying and encoding of the question with necessary degree of adequacy. Special question-answer protocols are used for working with cause-questions. The relevant answer to the “cause-question” is a result of processing question, which controls decision-making and provides it with information.

Key-Words: - Reasoning, Decision-Making, Question, Detection of Questions, Identification of Questions

1 Preliminary Bases
The results of theoretical and experimental research of “questions” appeared while interactive decision-making are based on the following statements:

1. The reasoning in natural professional language L is a necessary part of any decision-making process. Productivity and quality of interactive decision-making essentially depends on evolution of the structure and contents of reasoning R(t) used in task Z.

2. The primary function of reasoning R(t) is its “control function” realized with reference to precedents, their selection and comparison with sample task situations, their evaluation and choice, linking of such actions and intermediate results into a single unit.

3. The control function of reasoning is based on operative representation, encoding and processing of mismatch δ(t) between “everything for successful decision-making” (potential experience E_P(t)) and real experience E_R(t) of the solver.

Mismatch δ(t) is a natural phenomenon what names “question” correctly. Any question Q(t) requires the relevant “answer” and it needs to be made in the definite time. The elements of a question-answer pair complement each other as a cause and an effect. A cause-question is formed in the process of decision-making and has an objective content. It is this content that should be primarily detected and identified, similar to causes in nature.

Fig. 1. The place and the main function of the question (St(t)-current situation)

4. The text expression T_r of concrete question Q_k(t) is no more than one of its models adequate to the real
phenomenon with a certain degree.

If an objectively existing cause-question \( Q_k(t) \) is not detected or erroneously identified and coded, then some necessary answer \( A_k(t) \) will not be entered into the decision-making process or an answer \( A_k(t) \) will not meet the requirements of reality.

5. Experience exists and appears as a connected unity of knowledge, abilities, and skills where knowledge executes a system-forming function and primarily provides navigation in the system of experience.

Experience includes a set \( S ( \{ E_i \} ) \) of units of experience \( E_i \), each of them represents an action \( d_i(t) \): As [motives \( \{ I_i \} \)] (1)

As [goals \( \{ N_i \} \)]

If [preconditions \( U_l \)]

Then reaction \( r_i(t) \)

And [postconditions \( U'^l \)]

which is similar on the structure of the conditional reflex. “Conditional activity reflex” (1) represents an important template for search of questions (in processes of comparison and estimation).

The mentioned statements led to such tasks as:

- detecting of “questions” as specific natural phenomena \( Q(t) \);

- identifying of question \( Q(t) \) in its natural environment \( R(t) \);

- its encoding and including to reasoning structure;

- processing of mismatches \( d(t) = Q(t) \) during decision-making.

Research of the named tasks was based on step by step registering of questions and answers in the special protocol (QA-protocol). It has a number of useful interpretations such as:

1. QA-protocol registers decision-making process as research experiment, representing so “the primary measuring information” about decision-making process and about control facilities used in it.

2. Content of the protocol reflects a real reasoning which can be investigated to increase the knowledge about a “phenomenon of reasoning and questions”.

3. Each of the registered questions and answers admits its interpretation an event essential for \( R(t) \) and so for decision-making, that allows to consider the protocol as “a network of events” ordered in time.

4. Protocol is a data structure (QA-structure is presented on Figure 2) with its practically useful set of operations. Such interpretation of QA-structure corresponds to experience of Computer Science in area of data structuring for adequate presentation of QA-protocol

![Fig.2. Question-answer structure (QA-structure)](image)

2 Detection of Questions

Detection of questions is done according to their obvious or implicit “traces” in QA-protocols, or in other words, according to the “traces” in the next textual fragment \( T_r \) attached to the text \( T \) of the protocol. Obvious indicators of questions are detected during analytical overview of the text (scrolling, reading and comparing with the library of “obvious question indicators”). The indicators of questions in the text \( T \) are the following:

- the special sign ‘?’ and keywords (which, what, while, …) of the interrogative sentences;

- any forms of uncertainties (“very much”, “too”, “approximately”, “about”, “in the ranges”, “not less than”, …);

- any forms of modalities (“possible”, “necessary”, “probable”, “reasonable”, “is known”, …);
3 Identification and Encoding of Questions
Identification of the detected question $Q_r(t)$ includes: automated determination of its type with reference to the library of types and inheritance of a relevant type (e.g. inheritance of attributes $G^T = \{g_i^T\}$); reference to the library of sample questions and inheritance of additional attributes $G^E = \{g_j^E\}$.

The developed special editor allows to add the text model $T_r$ of $Q_r(t)$ and $A_r(t)$ by the means that control human attention in case of repeated actions with text.

Automated encoding is done in language of a task (in language of the QA-protocol) and according to the current information in the set of attributes $G^Q$, $G^T$ and $G^E$. Result of encoding, i.e. the textual representation $T_r$ of a question $Q_r(t)$, passes through control predicative processing.

Reference to the data base of questions processed earlier and already included into the model of experience is used in additional (then encoding) purposes. The preliminary set of questions $\{Q_t\}$ relevant to the $Q_r(t)$ is formed. Inclusion of any $Q_r$ into the set $\{Q_t\}$ is accounted in its probability characteristics when the correspondent precedents are taken from the experience $\mathbb{E}^\theta$.

4 Processing of Questions
The basic tasks of question processing are:
- control influence on the decision-making process;
- reduction of informational ambiguity with the help of construction of answers or decisions;
- accumulation and systematization of experience in intellectual reasoning and decision-making.

Each of the named tasks is based on the model of QA-protocol in its current state (as a QA-structure) and the system of corresponding operations. The model takes into account the following: any QA-protocol is structured in terms of “questions” and “answers”, and these units are of different types and contents; construction of each unit can be interrupted by any reason.

Control influence on a decision-making process is realized as a problem of choice of that point (question or answer) in QA(t) which continues the reasoning process.
after its interruption. The task of choice is solved as the interruption system in computers works. As a matter of fact, the choice is done from the set of QA-units, which construction has not been completed yet (such set we call a “front of works”). The choice is realized as “three-step-by-step filtering by rules” on such QA-models as event QA-networks, Petri-nets and PERT-diagrams.

Figure 3. Choice of the current

For each of the named QA-net models it is produced $S(P_1^i)$, $S(P_2^j)$ and $S(P_3^k)$. Logic of rules is unified and corresponded to the scheme of conditional activity reflex. Their realization has production character and includes the usage of attributes of questions and answers registered in the data base of QA-protocol. Results of choosing are compared with each other, ordered and are set for estimation and final choosing.

At the moment for the problem of construction of answers it has been developed a system of editing, linkage of answers with appropriate questions, their connection to a protocol and its network models. Texts of answers also serve the informational source for detection of questions.

Accumulation and systematization of experience in intellectual reasoning and decision-making is done operatively while construction of the substantial-evolutionary theory $\text{Th}(t)$ on informational material of reasoning $\text{R}(t)$. Systematization is based on a system of relations between questions, answers and their sets, and ontology of reasoning domain (as a system of the used concepts $S(\{N_i\})$). Ontology $S(\{N_i\})$ is composed as the active dictionary of sample decisions and precedents; its components are taken from predicative processing of texts $T$ of reasoning $\text{R}(t)$. Interruptions in predication are indicators of the detected questions.

5 Question-Answer Processors

To solve the problem of detection, identification, encoding and processing of questions there was developed the special toolkit - question-answer processor $\text{WIQA}$ (Working In Questions and Answers). It was based on the integrated representation $\mu(t)$ of question-answer processes $\text{QA}(t)$ while decision-making in human-computer environment.

Model $\mu(t)$ is realized as an object-oriented system of classes, and every QA-process is represented by the certain pattern $\mu(t_i)$ of this system. WIQA-processor is constructed from data of the model $\mu(t)$ and its set of operations. Specificity of QA-processors is determined not only by the structure of QA-data and operations, but also by the dynamics of the inner applied models $\mu(t_i)$, that begins from the initial condition $\mu(t_0)$, passes through intermediate steps $\mu(t_j)$ to the condition $\mu(t_k)$ appropriate to the execution of the certain task $Z_i$.

Each next step of WIQA application looks as:

$$\mu(t_{j+1}) = \text{WIQA} (\mu(t_j), d^{QA} k(t)), \quad (2)$$

that allows to consider its meaning $\mu(t_j)$ as the appropriate WIQA condition at the moment $t_j$ and the question-answer action $d^{QA} k(t)$ to be the reason of transition of the system into the new condition.

Interpretation of $\mu(t_j)$ as the certain condition kept in memory of WIQA processor opens an opportunity to qualify it as a sort of system memory, and its data control transitions of the processor from condition to condition, and, hence, provide decision-making. So we can interpret it as:

$$\text{R}_i (\mu(t_{k+1}), k_{k+1}, ...) = \varphi (\text{R}_i (\mu(t_k), k, ...)), \quad (3)$$

where $\mu(t)$ is a sort of the “history” of the next step in decision (dots show that decision depends not only on
the following condition and the time), that asks for application its effective dynamics, i.e. the development of techniques of QA-interaction, in particular as scripts of typical works.

The existence of system memory that is changing and, at the same time, that controls the processors, is the argument to qualify WIQA as the dynamic processor. There are a lot of reasons to assert that such management in decision-making was not used in human-computer systems. Construction and application of $\mu(t)$ add new useful means to human-computer activity.

Realization of question-answer actions takes place in the operational memory of computer, also being the operational memory of the processor WIQA. And each action is the certain executable command of the processor done by a program complex (the interpreter of the processor). Execution of a command is initiated by the certain case from the set of external and internal reasons (interruptions). The type of the interruption (internal or external) depends on the current condition of WIQA. The class of internal reasons includes the typical question-answer relations and results in, e.g.:
- any question included into the model, which answer has not been constructed yet;
- a task, that already has the idea-hypothesis, but the decision has not been got yet;
- any answer, which is not completed;
- preconditions of actions, which realization requires execution of subordinated QA-actions.

The other reasons initiating designer's call to the processor WIQA are considered the external reasons (for example, pre-conditions that result in detection and identification of questions, deadlock in decision-making and etc.).

Existence of the reason is an actual or potential source of its realization as the certain interruption of decision-making. The system of interruptions has the means for their handling (revealing, recording, determining the sequence, execution of interruptions so that a decision could be continued).

The basic peculiarity of the processor WIQA is human-computer interaction. Such interaction should be convenient and effective, so WIQA is constructed as the dialogue environment of operational and integrated systems.

The first WIQA’s version was realized as a simple registrator of decisions during designing and programming. Idea of question as a natural phenomenon and a controlling mismatch was not specified.

In the second version the basic attention was paid on operational screens creating convenient conditions for registration of QA-reasoning and for it uses. Special QA-nets were added to WIQA data structure.

The third version was improved by a subsystem of the network analysis, and the realized idea of QA-control.

The network version is completed according to the component approach on basis of Microsoft ActiveX and Borland MIDAS technologies in Object Pascal. While the development it was applied an integrated environment of fast design of applications for OS Windows Borland (Inprise) Delphi 5.0 Enterprise Edition, additional means of Delphi LMDTools and RxLib 2.75, so as the components of Direct Oracle Access 3.43 (Oracle 8).

6 Conclusion

Question as natural phenomena and artifact fulfils the function of active reason which initiates the generating of reasoning and controlling of their forming. As other natural phenomena a question appears in definite conditions and interacts with a solver of a task. The computer support of the constructive relations between “artificial intelligence” and “question” leads to useful results in human-computer activity and its applications.