ISSN 2658-5014 (Print)
2021. Т. 3, № 3 (7). С. 17–22
СИИТ
СИСТЕМНАЯ ИНЖЕНЕРИЯ И ИНФОРМАЦИОННЫЕ ТЕХНОЛОГИИ
ISSN 2686-7044 (Online)
http://siit.ugatu.su

УДК 004.89

KNOWLEDGE ORGANIZATION FOR INTELLIGENT DECISION SUPPORT SYSTEM

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Поступила в редакцию 14 сентября 2021 г.

Abstract. In modern world human knowledge – professional and general cultural – is the main resource on which the strategies of society development are based [1]. The strategy of personal development of each individual is also inextricably linked with accumulated decision-making experience and knowledge of other people in a particular subject area. It is especially important to use the accumulated during decision-making experience in situations that are turning points on the path of life. A correctness of made decisions often depends on how the knowledge is pre-processed and presented for reuse by other people. The authors propose an approach to storage organization and use of expert knowledge in subject knowledge system for decision-making support in choosing a specialty when entering a university.

Key words: future profession; university study field; intelligent decision support system; knowledge base; logical inference mechanism; career choice; BPMN model; fuzzy rule.

INTRODUCTION

A purpose of this work is to build an intelligent decision support system (IDSS) that takes into account the knowledge and experience of experts in a given subject area. As the experts are the members of admissions committees of higher educational institutions of both technical and humanitarian orientation, as well as university teachers and psychologists with many years of experience, who had the opportunity to track the life path of several generations of applicants who later became students. This experience, concentrated in IDSS, will allow each user to answer their own questions when making vital decisions. The results of these decisions will depend on the desire to learn, the volume and quality of information assimilation, satisfaction with both the learning process and the obtained specialty. All this will allow each individual to adapt successfully to modern society in the future. Of course, the opportunity to succeed in a profession depends on a whole range of factors, but even the opportunity to choose a specialty "after heart" and, as a result, to achieve a healthier and more fulfilling life is a big and important step for every person. Of course, each applicant is a unique person, who has a certain set of parameters – psychological characteristics and inclinations, a baggage of knowledge, skills and abilities, obtained at the previous stages of training. Nevertheless, the authors make an attempt to bring together such diverse crite-

The work is supported by the RFBR "Methods and models for intelligent decision-making support in the management of software projects implemented in a production enterprise environment" under grant no. 19-08-00937.

ria and achieve the most objective decision from the each individual applicant point of view.

The result of solving the multi-criteria choosing problem should be the optimal specialty (training direction) for the applicant. The choice is made taking into account the specified objective values of the applicant's parameters and his individual preferences.

When solving the multi-criteria task of choosing the best university specialty, the following factors are taken into account:

– multilevel nature of personal (local) criteria system and its non-equivalence (each criterion makes a different contribution to the integral alternative assessment);

– need to take into account simultaneously both quantitative and qualitative criteria for alternatives evaluating;

– need to coordinate the experts opinions;

– multiple selection process;

– compatibility of objective and subjective characteristics of the task elements.

Besides the factors, mentioned above, it should be added that studied in this paper applicant's decision-making process has a large number of alternatives, and is performed under conditions of uncertainty, which adds difficulties in determining the values for each criterion and in choosing the best decision. Since the studied process mainly has a social nature, the most difficult stage is extraction and formalization of information and a process of processing information about alternatives, criteria, and preference systems. A procedure of extracting information is based on the data statistical analysis, contained in database, provided by the University of Alicante. Its aggregation and interpretation is mainly based on the experience, knowledge and heuristic techniques of experts in studied subject area.

IDSS STRUCTURE

In [2] an approach to building a decision support system based on knowledge engineering is proposed. According to this approach, a development methodology and a DSS knowledge base structure were created. A DSS development methodology includes algorithms for forming decision-making recommendations, which is based on knowledge engineering methods and uses an ontological approach for modeling the subject area.

To describe the subject area, documentation, containing admission rules to the university, was analyzed, and interviews with experts in this subject area were conducted. To solve the studied problem of forming the knowledge base, a process model, that takes into account the work of all users in the system, has been developed. The result of this stage is the BPMN model of the DSS knowledge base forming (Fig. 1), in which the decision-making processes were highlighted on the top-level diagram, their hierarchy was determined, on the basis of which the decision-making subprocesses were developed in detail.

Developed process model reflects a causal relationship of made decisions – decision-making procedures – and identifies those places where the user has to evaluate a number of alternatives and make a decision basing on existing knowledge and his experience. When the process model is decomposed to individual works, a set of actions that the decision-maker has to perform in order to choose one of the possible decisions, is obtained. To support the adoption of exactly such decisions, decision support systems are used. Allocation of decision-making processes allows to think through a set of decision-making rules within each process. These rules form the basis of the developed DSS knowledge base [3].

To form the structure of the knowledge base, is proposed to divide a set of decisions into clusters and to aggregate the criteria according to this principle. Obtained subsets will allow to limit the search area and to determine a set of criteria, which will significantly facilitate the problem of choosing the best specialty. Thus, during the modeling process the following clusters were identified: a cluster of general rules for admitting the university, a cluster of rules for choosing the study direction, taking into account the Holland test results, and a cluster of rules for admitting the most suitable for the user specialty in the chosen direction.

According to this structure developed DSS is an intelligent system that includes a knowledge base and a logical inference mechanism, as well as a component for explaining the issued recommendations [3].

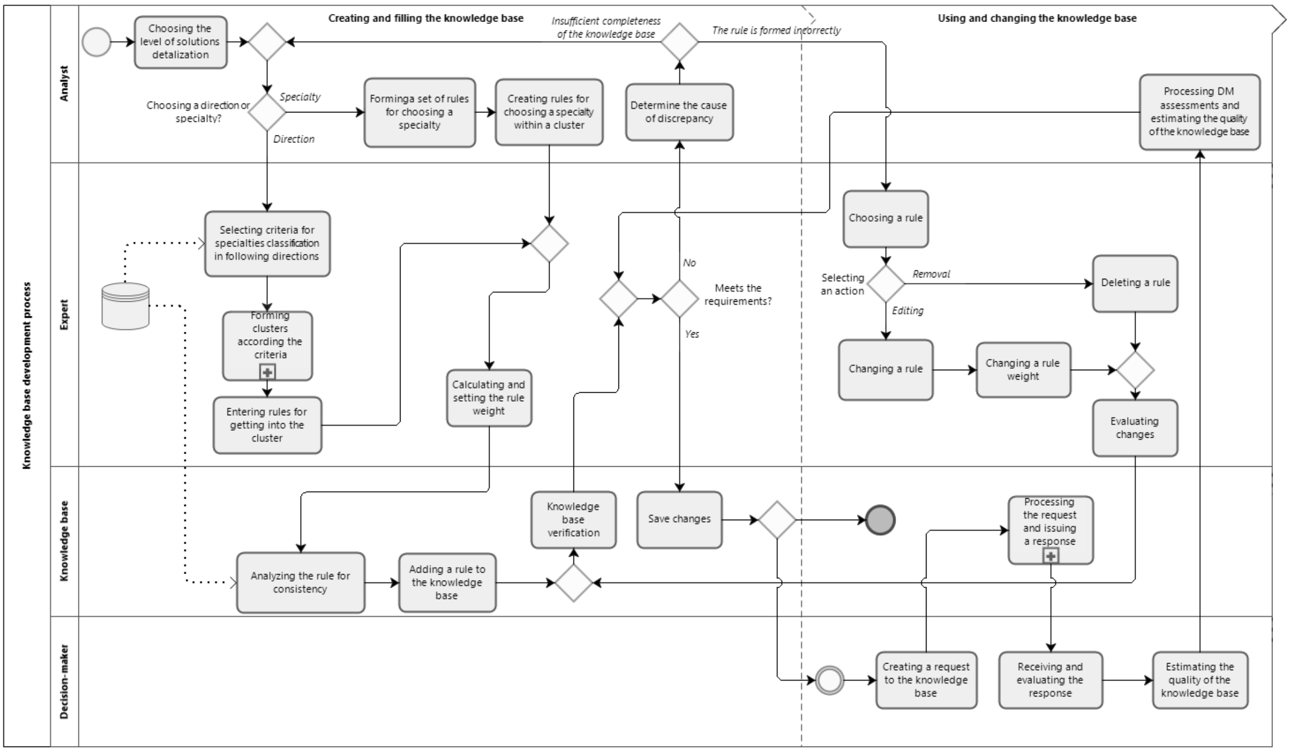

Fig. 1. BPMN model of the DSS knowledge base forming process

Fig. 2 shows the structure of the decision support system developed for choosing a specialty when entering a university.

IDSS ELEMENTS

Let's consider in detail the main elements of the IDSS for choosing a specialty when entering a university: a knowledge base and a logical inference mechanism.

Knowledge base for choosing the best university specialty for training is the core of DSS: it is a set of knowledge on the subject area being studied, which is structured using the developed modular (cluster) structure for forming the subject knowledge [4].

Basing on the proposed modular principle, three modules of rules were developed: general rules for admitting the university, rules for choosing the study direction, rules for admitting a certain specialty, taking into account the rules of successful training in this specialty (Table 1).

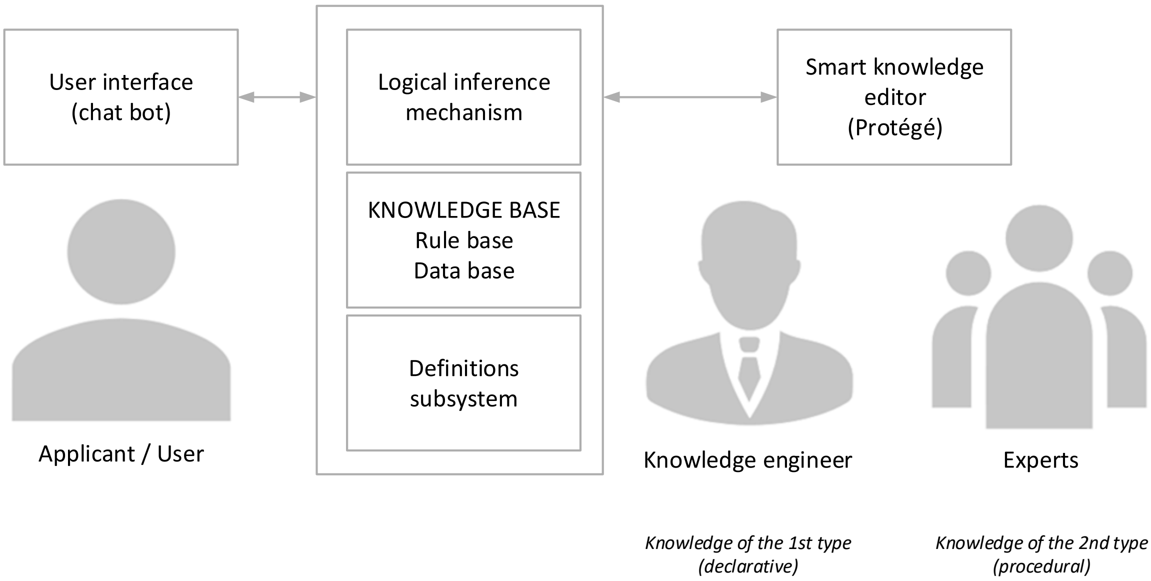

Fig. 2. Structure of the decision support system for choosing a specialty when entering a university

Table 1

Rule class	*Content of the rule*
Class-1	ApplicationRule(?a), Uncertainty_factor(?c), has_value(?c, "Quite_sure"), Applicant(?x), UniversityStudyField(?y), aimsToEnter(?x, ?y), EntranceExam(?z) -> hasToPass(?x, ?z)
Class-2	StudyFieldSuccessStudyRule(?a), Uncertainty_factor(?c), has_value(?c, "Quite_sure"), Applicant(?x), UniversityStudyField(?y), aimsToEnter(?x, ?y), ProfileSocial(?z), hasHollandTestProfile(?x, ?z), isRecommendedToChoose(?y, ?w) -> C.C._SOCIALES_Y_JURÍDICAS(?w)
Class-3	MajorUniSuccessApplicationRule(?a), Uncertainty_factor(?c), has_value(?c, "Sure"), Applicant(?x), QUÍMICA(?y), aimsToEnter(?x, ?y), EntranceMark(?z), hasEntranceMark(?x, ?z), CutOffMark(?w), hasCutOffMark(?y, ?w), has_value(?w, "10.342"), greaterThan(?z, ?w), EntrancePossibility(?b), hasEntrancePossibility(?x, ?b) ->has_value(?b, "high")

Such division will allow each applicant to manage the project of his studies at the university, build a well-founded behavior strategy and form an individual educational trajectory.

DSS knowledge base is proposed to be developed using Protégé 5.1. There are several models of knowledge representation in knowledge-based systems, and the knowledge presented in one model can be transferred into another. The inference production model is used to solve complex problems, because it allows to configure the inference mechanism for the subject area in details and take into account the knowledge uncertainty.

A basic knowledge unit in inference model is the “IF-THEN” rule, which can be used to express space-time, cause-effect and functional relations. Production rules are presented in the ontology and reflect the knowledge obtained from experts. In actual DSS design process, not all the knowledge obtained from experts can be clearly formalized, but should be taken into account. For such cases, the authors proposed the algorithm of generating a decision tree with fuzzy knowledge.

Thus, according to the Takagi-Sugeno-Kang method the fuzzy management rules are formulated, which represent a fuzzy implication in the form [5]:

$$R^{(1)}: \textbf{IF } x_1 \text{ is } A^{P1}_1 \textbf{ AND } x_2 \text{ is } A^{P2}_2 \textbf{ AND } \ldots x_n \text{ is } A^{Pn}_n$$

$$\textbf{THEN } y=y^1=f^{(1)}(x_1,\ldots,x_n).$$

$$\ldots$$

$$R^{(K)}: \textbf{IF } x_1 \text{ is } A^{P1}_1 \textbf{ AND } x_2 \text{ is } A^{P2}_2 \textbf{ AND } \ldots x_n \text{ is } A^{Pn}_n$$

$$\textbf{THEN } y=y^K=f^{(K)}(x_1,\ldots,x_n).$$

Here $R^{(K)}$ is the index of the k-th rule, A^{Pi}_i is a fuzzy set of linguistic meaning identified through the membership functions (MF) to the corresponding fuzzy sets $\mu_{Ai}(x_i)$ for variables x_i, $i = 1,...,n$, where the index P_i indicates the number of a subset of the set A_i. The variables $x_1, x_2, ..., x_n$ form an n-dimensional input vector $\vec{x} = [x_1, x_2,..., x_n]$ of characteristics $x_i \in X$ of the dynamic management process problem situation, and $y = y^k$ is the output signal.

At the same time, to calculate the uncertainty factor in the system, an algorithm for assigning fuzzy values to specific parameters, presented in the rules, taking into account linguistic variables, has been developed. Proposed algorithm is added with a term for resolving conflict situations using the linguistic variable “confidence coefficient”. The expert was asked to assess how confident he is in made decision, indicating the “confidence coefficient”. In addition to assigning fuzzy values to specific variables, represented in the rules, for example: “low”, “medium”, “high”, an algorithm for generating a decision tree, which indicates the confidence degree of a specialist in the rule itself, is proposed.

Since it is inconvenient for a person to think in probabilistic categories, uncertainty factors are linguistic variables {“not sure”, “not very sure”, “almost sure”, “sure”, “quite sure”} [6]. The authors propose to identify the expert's confidence factor when making a decision D_i, based on the proposed set of conditions (A_1 ... A_m), as the confidence coefficient U_S. The correspondence of confidence coefficients to linguistic variables is shown in Table 2.

$$U_s = P/n$$

where P is the number of the linguistic variable in the table, n is the total number of linguistic variables.

Table 2

Linguistic variable	*Confidence coefficient U_S*
“not sure”	0.2
“not very sure”	0.4
“almost sure”	0.6
“sure”	0.8
“quite sure”	1.0

To implement inference based on fuzzy rules, there are separate software products and well-known software product modules focused on mathematical modeling. The authors recommend to form fuzzy rules using the developed ontology on language SWRL and interpret the expert's answers according to the proposed interpretation formulas.

The logical inference mechanism of the knowledge processing algorithm determines the quality of the developed expert system. Chosen output model is the knowledge base interpreter for the user, so the developed system usability directly depends on the quality of interpretation. In this paper, we propose to implement a decision support system in the form of a chat bot. Modular structure of the KB allows to optimize the number of questions asked to the user, determines the intellectual component of the system and brings it closer to natural language system, which increases the level of user confidence in obtained results.

The base for knowledge interpreting process, presented in the form of fuzzy rules in ontological knowledge base, is application of logical inference mechanism to the initial knowledge, consistently through choosing a general study field to choosing a specific specialty within this direction, to obtain the final knowledge of interest to each specific user.

To ensure the knowledge interpretation and receive recommendations, a user interface is being developed with the chat bot technology, which provides a user opportunity to make requests and enter their initial data on the interested problem. Explanation subsystem allows to present arguments to the user, providing justification for the given conclusions.

CONCLUSION

Proposed intelligent decision support system can be used not only by applicants who are facing the further study direction choice. It can be a great help during career guidance events held among high school students, as well as for the university admissions committees’ members during a hot time of submitting documents. System easily adapts to different universities with involving an expert, with the help of which lists of specialties related to various activity areas (technical, social, economic, creative, etc.) are configured. Its implementation in the form of a chat bot allows the system to scale when using call centers. Admission committee employee can focus on consulting applicants, who require non-standard answers in really difficult situations, and switch routine questions and, accordingly, standard solutions to IDSS. Thus, the effectiveness of the IDSS for the university can be associated with the possibility of attracting well-motivated applicants who consciously chose a study direction, which in the future will bring mutual benefit to both the university and the future specialist.

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МЕТАДАННЫЕ

Заголовок: Организация знаний для интеллектуальной системы поддержки принятия решений.

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Язык: Английский.

Источник: СИИТ (научный журнал Уфимского государственного авиационного технического университета), т. 3, № 3 (7), стр. 17–22, 2021. ISSN 2686-7044 (онлайн), ISSN 2658-5014 (печатный вариант).

Аннотация: В современном мире человеческие знания - профессиональные и общекультурные - являются основным ресурсом, на котором строятся стратегии развития общества. Стратегия личностного развития каждого человека также неразрывно связана с накопленным опытом принятия решений и знаниями других людей в той или иной предметной области. Особенно важно использовать накопленный в процессе принятия решений опыт в ситуациях, которые являются поворотными точками на жизненном пути. Правильность принятых решений часто зависит от того, как знания предварительно обрабатываются и представляются для повторного использования другими людьми. Авторы предлагают подход к организации хранения и использования экспертных знаний в системе предметных знаний для поддержки принятия решений при выборе специальности при поступлении в ВУЗ.

Ключевые слова: будущая профессия; область обучения в университете; интеллектуальная система поддержки решений; база знаний; механизм логического вывода; выбор карьеры; модель BPMN; нечеткое правило.

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