Покращення ефективності структури навчального контенту шляхом використання баз знань

Т.Р. Стисло, М.С. Чесановський, Р.В. Рошак
кафедра програмного забезпечення
автоматизованих систем
Івано-Франківський національний
технічний університет нафти і газу
Івано-Франківськ, Україна
styslotr@gmail.com

The improvement of the learning content structure by means of knowledgebased systems approach

T. Styslo, M. Chesanovkyy, R. Roshak
Department of software automated systems
Ivano-Frankivsk National Technical
University of Oil and Gas
Ivano-Frankivsk, Ukraine
styslotr@gmail.com

***Анотація*—Пропоноване дослідження представляє концепцію нового інтелектуального рішення в області цифрових бібліотек та засобів їх інтелектуалізації. Основна ідея пропонованого підходу полягає в розробці інформаційних технологій на основі баз знань, що дозволяють вибирати навчальний матеріал який оптимальний для розуміння студентами відповідності з концепцією зон найближчого розвитку. Пропонована імплементація базується на технології ключових слів, але з індексацією в форматі систем на основі баз знань.**

***Abstract*—The given research presents the new intelligible solution in the area of information library systems. The main idea of proposed approach is developed on the information technologies of knowledgebase that allow the students to find that exact learning material which is optimal for understanding in accordance with the conception of proximal development zone of the student. The proposed implementation uses the technology of keywords, indexed in the format of system knowledgebase.**

***Ключові слова*—автоматизовані бібліотечні системи; видобування документів; оцінка вимірювання ефертивності; запити користувача; релевантність; добування інформації.**

***Keywords*— automated library information systems, documents mining, evaluation of effectiveness measure, user queries, relevancy, information mining.**

I. Introduction

The university and public libraries in Ukraine, Russia and other CIS countries are using a lot of automated information systems for meeting of users' information needs. In our research we have profoundly analyzed the following systems: "ALEPH", "MARK-SQL", IRBIS, "MehaPro", LIBER MEDIA, "UFD/Library" [1-2].

These systems give typical integrated solutions in the area of library technology automation and they are intended for using in libraries of any type and specialization. Such systems meet all the possible requirements to similar systems and they conform to all national bibliographic standards and formats.

All typical library information tasks are implemented in these systems, including technologies of acquisition, systematization, cataloging, reader search, book issue and management. Nevertheless, the contemporary trends of the newest ITs open wide fields for intellectualization of such systems.

II. Implementation of knowledgebase facilities in the environment of automated library systems

The **goal** of this brief outline report is to form the necessary formal and logical foundations for development the intelligible solutions within the frameworks of existing information software support of university libraries in Ukraine and for maintaining the best selection of teaching and methodological support in the process of learning the professional subjects by using the knowledgebase and methods of data mining.

The projected decision support system when one chooses the teaching and methodical materials at the university library is based on the methodology of expert systems in order to have sufficient functionality for managing the data-handling procedure in the context of solving the tasks of resources classification at the university library. Thus the main task of such system is to provide the recommendations concerning the method of dominant characters mining of one teaching source or another in accordance with set of evaluations that are specified by the experts (lecturers of courses), and to set the classifier for specified data set in accordance with available sets of rules that describe the concrete educational problem, solved in learning the specific topic of learning module (LM).

According to the mathematical modulation of information intelligence systems development process for library case one of the key questions is the knowledge representation medium, based on which the system must make the decisions in the certain situations. Thus knowledge representation should be specified by the medium, allowing the transition to representation of information fragments about library resource in the terms of knowledgebase structure (KB), particularly metadata knowledgebase as a support medium of inference on metadata set [3-5].

Def. 1. Let's assume that the learning concept $Conception^1$ for KB_{MD} produces the other concept $Conception^2$ if every initialization of knowledgebase structure with metadata is an appropriate production rule.

Statement 1. Modification

$$Conception^1 \to Conception^2$$

occurs only if

$$[Conception^2]^{Models} \subseteq [Conception^1]^{Models}$$

for all logical models of metadata knowledgebase $Models_{KB_{MD}}$, that set the representation of implemented symbols on universe of knowledge domain objects, where $[Conception^2]^{Models}$ and $[Conception^1]^{Models}$ are expansions (i. e. set of objects for these concepts).

Def. 2. The meaning of concepts can be interpreted as a function that specifies the representation from sets of logical models onto sets of concepts expansion

$$f_{Conception} : Models_{KB_{MD}} \to Conception^{Models_{KB_{MD}}}$$

Def. 3. Let's consider the formal learning ontology FO as set of constraints $Constr_{set}$, that is applied on the set of possible models $Models_{KB_{MD}}$.

Def. 4. Let's Q_{MD} is a modificating enquiry through the metadata knowledgebase in the selected conception $SelectedConception$, and KB_{MD1} and KB_{MD2} two knowledgebases. Let's define the residue for Q_{MD} regarding (KB_{MD1}, KB_{MD2}) as $Q_{MD}^{KB_{MD2}} | KB_{MD1}$, that are gained as a result of:

1) Removal out of Q_{MD} every modificating rule, body-part of which has no matching with KB_{MD2} (as a result we have $Q_{MD}^{KB_{MD2}}$) according to input set $Constr_{set}$.

2) Removal of every modificating literal out of body-part rules in $Q_{MD}^{KB_{MD2}}$, that has matching with KB_{MD1} in the set $Constr_{set}$.

Def. 5. Let Q_{MD} -modificating enquiry through the metadata knowledgebase in the selected conception $SelectedConception$ and KB_{MD1}, KB_{MD2} – two knowledgebases. Then: $\lambda_{nm}(Q_{MD}^{KB_{MD1}, KB_{MD2}})$ is coherent and

$$KB_{MD2} = KB_{MD1} \circ \lambda_{nm}(Q_{MD}^{KB_{MD1}, KB_{MD2}})|_{Constr_{set}}$$

$\lambda_{nm}(Q_{MD}^{KB_{MD2}} | KB_{MD1})$ is coherent and

$$KB_{MD2} = KB_{MD1} \circ \lambda_{nm}(Q_{MD}^{KB_{MD2}} | KB_{MD1})|_{Constr_{set}}$$

Every consecutive modification of the user's (student's) enquiry will meet much better representation of user's information needs. Thus the main results of our study with regards to the effective intelligible methods creation for the relevant information material and relevant learning documents mining.

According to the concept of Bologna process the learning course (LC) consists of content module LM_j, that represents the specific conceptual direction of the course. At the real courses at the National University of Oil and Gas the quantity of content modules vary from one to several modules. Every learning module consists of learning elements (LE) totality LE_k, that are list of topics (or subtopics) of learning module. At the level of formal representation it gives

$$LC_i = \{LM_j\},\ LM_j = \{LE_k\},\ i, j, k \in N$$

We need such a structuring for creation of the approach of student's knowledge control and forming the appropriate projections of its proximal development zone (PDZ) according to before mentioned features. Thus in the terms of keywords set that shows the essence of learning materials at the level of course, learning elements and content accordingly would finally get the following representation form

$$LC_i \to KeyWords_{LC_i}^{set}$$

$$LM_j \to KeyWords_{LM_j}^{set}$$

$$LE_k \to KeyWords_{LE_k}^{set}$$

$$PDZ \cong \left[KeyWords_{LC_i}^{set}\right] = \bigcup_j \left\{ \begin{matrix} KeyWords_{LM_j}^{set} = \\ = \bigcup_k \left[KeyWords_{LE_k}^{set}\right] \end{matrix} \right\}_{j,k \in N}$$

Lets consider some *knowledgebase* with imposed initial constraint hierarchy as an set of informational entities with constraints in the form of atomic predicate from some finite information space $InSp: CH_1,...,CH_{n_{InSp}}$. All changes (*modifications*), that can take place in the context of defined knowledgebase surroundings, will be interpreted as stable consequences of performing of modification predicate queries, which are generated by intelligible system accordingly to the user's instructions, where we have *controlled* parameter (lc, $lc \in LC_i$, lm, $lm \in LM_i$, le, $le \in LE_k$) [6].

In their summation this parameters defines the values of the expected output-parameter ($ocp \to l\_out$):

$$\left[...K_{B\pm}^{CS_{j3}}\left(le_{i3}^{Cset_{i3}}\right)..\right]_{j_3} \to \left[...K_{B\pm}^{CS_{j4}}\left(l\_out_{i4}^{Cset_{i4}}\right)..\right]_{j_4}$$

$$\left[...K_{B\pm}^{CS_{j1}}\left(lc_{i1}^{Cset_{i1}}\right)..\right]_{j_1}, \left[...K_{B\pm}^{CS_{j2}}\left(lm_{i2}^{Cset_{i2}}\right)..\right]_{j_2},$$

where $i_1,...,i_4; j_1,...,j_4 \in N$; C_{set_i} – constraints sets, which are imposed on corresponding parameters; $K_{B\pm}(\,)$ – modificators, that implements the operation of adding / removing from knowledgebase KB of corresponding entry in the form initialized or as well not initialized set of parameters values; CS_j – constraints systems, that defines the influence for each parameters on the final result on some relevant level and possibly existing interdependencies and reciprocal influence of parameters at each other basis as well.

Introduced so far the sets and systems of constraints in the general would form some dynamically functioning constraints hierarchy imposed on over the knowledgebase as the whole entity $KB.CH = \left\{Rules_k . \left\{\{CSet_i\}_{i \in N}, \{CS_i\}_{j \in N}\right\}\right\}_{k \in N}$.

Let be Q_m a modification predicate query i K_B^{CH} some knowledgebase with imposed constraints hierarchy. The semantics imposing allows specification for the set of knowledgebases, each one of which can be chose as an modification of initial knowledgebase $K_B^{init.}$, after the performing of modification predicate query Q_m. Such a set $\left\{\left[K_{B_1}^{CH_1}\right]^m, ..., \left[K_{B_n}^{CH_n}\right]^m\right\}$ will be named as an set of Q_M-modifications of the initial knowledgebase $K_B^{init.}$. Besides, every of Q_m-modifications will in turn have a constraints hierarchies of its own.

Modification predicate rules does have an declarative interpretation in terms of constraints, which are imposed on knowledgebase in the form of hierarchies which in turn is formed up by initial rules it self: $\frac{head}{SC} :- \left[CS, \frac{body}{[RC_1,...,RC_n]}\right]$, where SC – satisfaction condition, RC – relevancy condition, CS – the imposed constraint system.

Def. 6. Modification predicate query Q_m would be interpreted as an set of modification predicate rules with imposed constraints hierarchies $\left\{PR_{Q_m}^i, CH^i = \bigcup_j CS^j\right\}$.

Statement 2. Let Q_M be predicate queries modification and $K_{B_1}^{CH_1}$, $K_{B_2}^{CH_2}$ – some two knowledgebase's. Then its true, that: $\lambda_{nm}\left(Q_M^{K_{B_1}^{CH_1}, K_{B_2}^{CH_2}}\right)$ is coherent and $K_{B_2}^{CH_2} = K_{B_1}^{CH_1} \circ \lambda_{nm}\left(Q_M^{K_{B_1}^{CH_1}, K_{B_2}^{CH_2}}\right)$, and $CH_2 \subset CH_1$, $\lambda_{nm}\left(Q_M^{K_{B_1}^{CH_1} | K_{B_2}^{CH_2}}\right)$ is coherent and $K_{B_2}^{CH_2} = K_{B_1}^{CH_1} \circ \lambda_{nm}\left(Q_M^{K_{B2}^{CH_2}, | K_{B_1}^{CH_1}}\right)$, and $CH_2 \subset CH_1$.

Statement 3. Let Q_m be some predicate queries modification and $K_{B_2}^{CH_2}$ result of Q_m-modification for $K_{B_1}^{CH_1}$. Then finally we will got that:

$$\lambda_{nm}\left(Q_M^{K_{B_1}^{CH_1}, K_{B_2}^{CH_2}}\right) = \left[CS^{CH_2 \setminus CH_1}, head\left(Q_M^{K_{B_2}^{CH_2}}\right)\right].$$

Statement 4. Following from the declared before it will be useful too that:

1) knowledgebase $K_{B_2}^{CH_2}$ would be an Q_m-modification of knowledgebase $K_{B_1}^{CH_1}$ in some constraint system CS^1, if $\boldsymbol{CS}^1 \triangleq \boldsymbol{CH}_2 \setminus \boldsymbol{CH}_1$;

2) $\lambda_{nm}\left(Q_M \cup \left\{lc << [lc \in PS] : \left(K_{B_1}^{CH_1}, K_{B_2}^{CH_2}\right)\right\}\right) \subset K_{B_2}^{CH_2}$;

3) $\lambda_{nm}\left(Q_M^{K_{B_1}^{CH_1}, K_{B_2}^{CH_2}}\right) \cup PS_1\left(K_{B_1}^{CH_1}, K_{B_2}^{CH_2}\right) \subset K_{B_2}^{CH_2}$.

Statement 5. Let Q_m – be modification query and $K_{B_1}^{CH_1}$ –

some knowledgebase with imposed constraints. If the knowledgebase $K_{B_2}^{CH_2}$ is an Q_m-modification for $K_{B_1}^{CH_1}$, then $K_{B_2}^{CH_2}$ is an model for Q_m in the constraints system $CS, CS = CH_2 \setminus CH_1$

Besides, the new definition for modification predicate query would satisfy too the minimal difference notion. That's means, that if we got to do Q_m-modification for $K_{B_1}^{CH_1}$, then the resulted knowledgebase $K_{B_2}^{CH_2}$ would differ from the initial one just minimally, provided the case that constraints hierarchies CH_2 and CH_1 would not include any redundancies. For the purpose of measuring of this characteristic would be most appreciate the next approach:

$$dist\left(K_{B_1}^{CH_1}, K_{B_2}^{CH_2}\right) = \left(K_{B_1}^{CH_1} \setminus K_{B_2}^{CH_2}\right) \cup \left(K_{B_2}^{CH_2} \setminus K_{B_1}^{CH_1}\right) = \;|= (CH_1 \setminus CH_2) \cup (CH_2 \setminus CH_1)$$

Thus, the relation built up on the base statement would be devoid of all the expected shortcomings of the projected translation routine as well.

Generally, by implementation of $R_{K_B^{CH}}$ – transformation for knowledgebase K_B^{CH} there would be completed the construction of the stable model for $\sigma_M^P\left(K_{B+}^{CS+}\left(R_{K_B^{CH}}(Q_m)\right)\right)$ and verification of the fact of satisfaction for resulted constraints hierarchy.

The fulfillment of transformation for the set of modification predicate queries in the set of relevant Prolog-programs allows in the very end to calculate respective Q_m-modifications accordingly to the algorithm.

The detailed review of presented algorithm, allows to get the next sequence of formalized operation, so far as:

1. Lets there to be given modification predicate query Q_m and some initial knowledgebase K_B^{CH}. Lets apply $R_{K_B^{CH}}$ – transformation, which is described by constraints system CS^1 with the purpose of becoming of an new modification query of the kind $Q_M^1 = R_{K_B^{CH}}(Q_M)|CS^1$.

2. Lets Q_M – be modification predicate query, which consist of $K_{B+}^{CS_-^+}$ – rules of modification query Q_M^1: $Q_M = K_{B+}^{CS_-^+}\left(Q_M^1\right)$. Let $Q_M^{''}$ – be modification query, which consist of K_B^{CH} – rules for $Q_M^1 : Q_M^{''} = Q_M^1 \setminus Q_M^{'}$.

3. Lets consider now the logical Prolog-program $\left[\sigma_M^P\left(Q_M^{'}\right), LP.CS^{'}\right]$, which corresponds to $Q_M^{'}$ by imposed constraints system $CS^{'}$.

4. Recalculation of stable models for $\left[\sigma_M^P\left(Q_M^{'}\right)\right]^{LP.CS^{'}}$. All of them would be an $Q_M^{'}$-modification for $K_B^{init.}$, if $CS^{'}$ is correct and not contradictory.

5. From the all stable recalculated models do select those, who satisfy $Q_M^{''}$ by supposition, that $CS^{'}$ does satisfy $CS^{''}$. They would be too an Q_M^1-modifications for $K_B^{init.}$.

6. Lets apply the transformation $R_{K_B^{CH}}$ to the modification of results from previous step by initialized constraints system CS and so far will got the final Q_M-modifications for K_B^{CH} in the imposed CS.

Lets get back to the analysis of well-founded semantic of the kind $S_{Q_M}^f$. $S_{Q_M}^f$ for every modification literals finds out whether this is case of founded, unfounded or *uncertain* (*unknown*) literals actually. Such mechanism can be interpreted as follows: for every predicate $[lc|= l\_out] \in PS$ are assigned some labels pair $\langle CF_1, CF_2\rangle$, where CF_1, CF_2 belongs to the subset of $\{founded, unfounded, uncertain\}$, besides preference is that CF_1–corresponds to values $K_{B+}^{CS_-^+}(lc|= l\_out)$, and CF_2–to values $K_{B-}^{CS_-^+}(lc|= l\_out)$. To keep the right properties of well founded entries as well, all the pairs $\langle CF_1, CF_2\rangle$ should to have own confirmations in $S_{Q_M}^f$.

CONCLUSION

The main contribution of this research is based on the proposed formal logical approach for using the knowledgebase technologies for the purpose of intellectualization of automated and integrated library information systems. The key feature of explored intellectualization is to develop the intelligent module which maintains the filtration and selection of library learning content in accordance with the conception of student's proximity development zone.

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