Web as a Tool for Some Diagnostic Problem Solving

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***Abstract*— The definition of systems that helps users to automatically access information important to their own needs is a very relevant domain of research. In this contribution a solved application of Fuzzy set theory technique to the definition of flexi ble systems for locating and accessing information on the Web is presented. A purpose of our research is also a fact, that there are various ways to access the big amount of available and mostly unknown information for users. Clustering methods are also appropriate for helping on the process of document retrieval. We introduce a fuzzy clustering methodology for solved system. There is determined a vector space through fuzzy multiset. Interface provides the users with tools for navigating through hierarchies of documents and visualizes selected documents with using of fuzzy clustering for indexing in the HSC interface.**

***Index Terms*— Information Retrieval, Clustering, Semantic Web, Fuzzy ontology.**

I. Introduction

Web is the largest available repository of data. The definition of systems that helps users to automatically access information important to their own needs is a very relevant domain of research. An important research works are aimed at defining tolerant to imprecision, uncertainty and vagueness in the elicitation of users' preferences and able to learn them through an interactive and adaptive behaviour. We are interested in the fuzzy approach to define solved flexible system, which support an automatic access to information on the *Web*. There are some known relevant systems such as *Information Retrieval Systems* on the Web with the search engines and systems for the electronic commerce.

In information retrieval, solved fuzzy set methodology approach provides a framework for modelling flexibility and handling vagueness and uncertainty, which are intrinsic to information. The flexibility is expressed through different processes of information retrieval system. It has been applied to flexible queries and document representation and to a flexible evaluation when matching queries with documents. Solved system do not only retrieve documents of which representation corresponds exactly to the query but also documents that match the query partially. Solved approach extends this idea by giving the user the possibility to assess documents that are partially relevant.

There is also a relevant aspect related to the way in which the information items are formally represented. Generally, documents produce a unique documents representation for users. On the *www* some standard for the representation of semi-structured information are becoming more and more employed, such as XML. This fact leads to exploit their structure in order to represent information they contain.

Data mining can be either based on fitting models to or to determining patterns from observed data. A fitted model plays the role of inferred knowledge. A decisional activity in data mining is to establish whether the model reflects useful knowledge or not. There are many methods of soft computing, which have been proposed to solve some aspects of the problems about data mining tasks.

We solve two approaches to model, which describe the problems of information retrieving. In model with search engines on the *www* the information is considered as belonging to a unique and huge database. This database is centrally indexed for retrieval purposes. A type of model, which is based on the distribution of information on distinct databases, independently indexed, gives rise to the *distributed or multi-source* information retrieval problem. In this case the solved model constitutes distinct sources of information and the databases reside on distinct servers each of which can be provided with its own search engine, i.e. information retrieval system. Fig.1 illustrates a solved fuzzy ontology approach in information retrieval process.

A common solved problem mentioned above models is list fusion. In the case in which we have a unique, huge and distributed information repository, like in the *www*, and distinct information retrieval systems with search engines, the metasearch engines have been used to improve the effectiveness of the individual search engines.

The main aim of metasearch engine is to submit the same query to distinct search engines and to fuse the individual resulting lists into an overall ranked list of documents that is presented to the users.

The fusion methodology has to be able to handle situations in which a document may appear in more than one list and in various positions within them.

In the case of multi-source information retrieval the task is to merge the lists resulting from the processing of the same query by generally distinct search engines on the distinct databases residing on distinct servers.

II. Problem Solving

There is an information filtering, i.e. a variety of processes involving delivery of information to users who need it. This is

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possible by developing fuzzy linguistic information representations based on *XML*.

The great amount of information available across the *Web* can improve the information access [1], [2], [10], [11]. Operating in textual domains, filtering systems or recommenders systems evaluate and filter the great amount of information available on the *Web* usually stored in *HTML* or *XML* to users in their search processes. There are two used principles: *Content-based filtering system* and *Collaborative filtering system*.

Content-based filtering system filters and recommends information by matching user query terms with the index terms used in the representation of documents, ignoring data from other users. This system tends to fail when little is known about user information needs (when the query language is poor and so on).

Collaborative filtering system use explicit or implicit preference from many users to filter and recommend documents to a given user, ignoring the representation of documents. This system tends to fail when little is known about the user, or when the user has uncommon interests.

There is fuzzy clustering, which is applied to the set of domain documents. Then, we use a heuristic approach methodology for selecting and appropriate number of clusters. Then we apply fuzzy clustering for selected cluster data. Elements with a smaller membership should have less influence on the final partition than elements, which have larger membership. Visualization of the clusters is not so easy. There is considered application of Shannon's map to the whole data set and initial position of data selected at random. The fuzzy clustering algorithm does not only compute the fuzzy partition but also permits to compute membership functions values for any arbitrary data point. There is applied also entropy based fuzzy means, which permits this.

The ontology construction has been made analyzing a collection of Web pages of the same knowledge domain, and studying the coincident terms in the different pages. Ontology provides a context for the data described by that ontology. The ontology construction requires the application of a significant amount of human intelligence to determine the exact meaning of each intended concept.

A. Fuzzy Technique Approach Application

Application of fuzzy techniques approach to model flexible system for the access to information on the WWW is also realized within the solved problem. The aim is to design the system that can represent and manages the vagueness and uncertainty, which is characteristic of the process of information searching and retrieval. When some specific information is searched, this point and click access paradigm is unpractical, and the effectiveness of the results strongly depends on the starting page. The definition of systems plays an important role that help users to automatically access information relevant to their needs [1], [2]. The research is aimed at defining systems tolerant to imprecision and uncertainty in the elicitation of users' performances and able to learn them through an interactive and adaptive behaviour. The fuzzy technique approach is the definition basis of flexible system for locating and accessing information on the Web.

The research contains also fuzzy information retrieval model with indexing mechanisms and query languages, fuzzy document clustering, fuzzy data mining, fuzzy approaches to distributed information retrieval, fuzzy recommender systems and so on.

Fuzzy set Theory approach has been successfully employed within *Fuzzy information Retrieval model* for defining flexible query language, able to capture the vagueness of user needs as well as to simplify the user system interaction. This aim has been pursued at two levels. Through the definition of soft selection criteria (soft constraints), which are more expressive selection criteria that allow the specification of the distinct importance of the search terms by means of weights with different semantics. Another level of flexibility concerns the definition of soft aggregation operators specified by means of linguistic quantifiers.

Fuzzy associative mechanism generating based on clustering techniques have been defined in order to cope with the incompleteness characterizing either the representation of documents or the users' queries. Fuzzy thesauri and pseudo-thesauri ca be used to expand the set of index terms of documents with new terms by taking into account their varying significance in representing the topics dealt with in the documents. The degree of significance of the associated terms depends on the strength of the associations with the documents' descriptors.

Fuzzy data mining can be either based on fitting models to or to determining patterns from observed data. A fitted model plays the role of inferred knowledge. The power of the Fuzzy data Mining when handling real and numerical data is appreciated and brings process robustness and understandability. A decisional activity in data mining is to establish whether the model reflects useful knowledge or not. For this kind of activity a subjective human judgement is often required.

Operating in textual domains, filtering systems or recommender systems evaluate and filter the great amount of information available on the Web, stored in XML documents (or HTML) to assist people in their search processes. The use of fuzzy linguistic modelling can be very useful to help users in the expression of their information needs. The permanent aim is the problem of *improving the query language of search engines.* A fundamental problem with the existing Web is that the data is machine-readable but not machine-understandable. The semantic web appears to create a new form of Web content meaningful to computers as well as human. The others most known systems are Information Retrieval Systems (on the Web, the search engine), and systems for electronic commerce.

B. Fuzzy data mining

Various soft computing approaches have been proposed to solve some aspects of the data mining problems effectively. Fuzzy set theory to data mining and Web mining is very efficient tool. Data mining is an interdisciplinary field. It has a general goal of predicting outcomes and uncovering relationships in data. It is based on algorithms aimed at discovering hidden patterns and associations from large amounts of data stored in information repositories. Tasks of data mining can be descriptive (discovering interesting

patterns describing the data), and predictive (predicting the behaviour of the model based on available data).

The power of the Fuzzy set theory when handling real and numerical data is appreciated and brings robustness and understandability in knowledge discovery process. Fuzzy data mining algorithm is based on the construction of *Fuzzy decision trees*. Fuzzy decision tree is the extension of classical decision tree to handle numerical and fuzzy data.

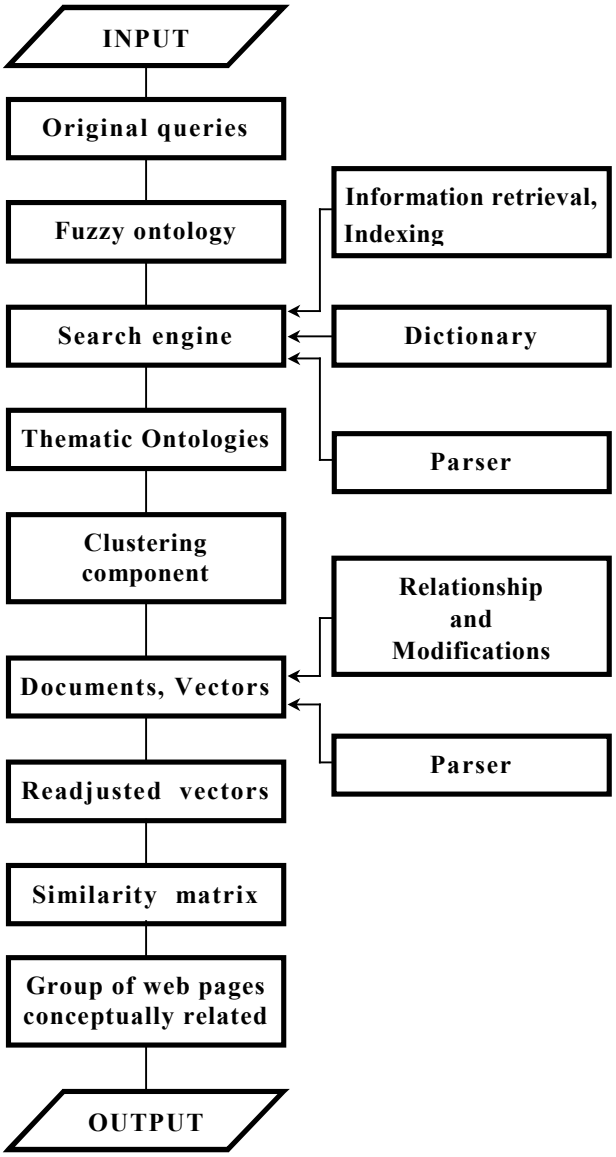


Fig.1 Fuzzy ontology in information retrieval process.

We define the vector space through fuzzy multiset. Each web page is treated as *n*-dimensional vector, where each component is a fuzzy multiset representing the membership of each extracted term.

Practical relevance of solved approach is connected also with proximity between two patterns (objects). If we have two patterns "p_1, p_2", their proximity "px" is a mapping to the unit interval such that it satisfies the following two conditions:

- *"reflexivity":* $px(p_1, p_1) = 1$
- *"symmetry":* $px(p_1, p_2) = px(p_2, p_1)$.

Proximity notion approach is the most generic that constitutes a minimal set of requirements – what we impose is straightforward: *"p_1"* exhibits the highest proximity to itself and the proximity relation is symmetric. From this point of view, we can envision that in any experimental setting, these two properties can be easily realized (in case of object collections we arrange a matrix form). Proximity requirements accommodation (constraints or hints) can be realized in the form of a certain performance index whose minimization leads to the optimal partition matrix.

In experiments with usable membership function μ – one of the usable forms is as follows:

$$\mu_{act} = \mu_{prev} \pm \frac{\sqrt{(\mu_i - \mu_{prev})^2}}{Q_{hist}} \quad (1)$$

where μ_i belongs to particular document. The previous value of membership function μ_{prev} determines the actual value of membership function μ_{act} and μ_i provide a membership value of each document D_i (i=1, , n). Q_{hist} is the number of queries that have confirmed the intended meaning of the term Q, which is used as a denominator in order to reduce the effect of later learning in order to stabilize the values.

There is a fundamental question on the Web – *how to specify a search for information*? Classical Internet search is based on specification of *keywords*, without more complex interactions. The use of fuzzy linguistic modelling is seemed to be very useful to help users in the expression of their information needs.

Fuzzy labels can be attached to the recovered documents according to a membership function with understanding of the meaning and acceptance of vagueness. The potential advantages of fuzzy ontologies include not only improved satisfaction with query results, but also the potential to represent the domain knowledge. This approach should remove artefacts caused by sharp transitions between ontologies. The set of elements in Fig. 3 with the assignment function μ_{E0} is dissolved over the elements of the bottom sets. The composed objects function is the set with the assignment function illustrated in Fig. 4. The assignment coefficients of the singular objects (E_1, E_2, E_3, ...) to the given concrete element (E5) are equal to the discrete points of $\mu_{E0,5}$. Fig. 3,4 illustrate the capability of the organizational memory to determine the overall assignment or membership of a single (composed) object to the overall knowledge stored in the organizational memory, the capability to identify the degree of membership of a single (composed) object (i.e. word) to the overall knowledge, i.e. local similarity/global similarity or local membership/global membership.

The new query is obtained as follows [5]:

$$Q_{new} = c_1 Q + \frac{c_2}{n_r} \sum D_r - \frac{c_3}{n_{nr}} \sum D_{nr} \quad (2)$$

where: Q is the initial query,
Q_{new} is the new query,
n_r is the number of relevant documents,
$n_{n,r}$ is the number of nonrelevant documents,
D_r is the relevant document representation,
D_{nr} is the nonrelevant document representation,
c_1, c_2, c_3 are the constants.

We realize an algorithm for query expansion based on the partial judgments of retrieval documents. There are introduced one classical approach and two fuzzy approach methodologies. Fuzzy principles are applied with constant four relevant levels and then with changeable amount of judgments from two to nine relevant levels in accordance with their real needs. The scale values are from very relevant state to non-relevant state. The degree of a membership of judged document to a relevance level is classically on the binary base.

There is realized following approach. We define an effect e_j as a fuzzy set represented as a set of ordered pairs of a generic element y_j and its grade of membership function. We determine *fuzzy causes vector amounts* (μ_A) to the solution of the fuzzy relational equations [8], [9]:

$$\mu_{e1}(y_1) = (\mu_{a1}(x_1) \wedge r_{11}) \vee \ldots \vee (\mu_{an}(x_n) \wedge r_{n1})$$
$$\mu_{e2}(y_2) = (\mu_{a1}(x_1) \wedge r_{12}) \vee \ldots \vee (\mu_{an}(x_n) \wedge r_{n2})$$
$$\ldots\ldots\ldots$$
$$\mu_{em}(y_m) = (\mu_{a1}(x_1) \wedge r_{1m}) \vee \ldots \vee (\mu_{an}(x_n) \wedge r_{nm}) \quad (3)$$

which is derived from relation:

$$\mu_E = \mu_A \circ R \quad (4)$$

This equation represents the simulation of the cause-effect „input-output" connections that is done by way of interpreting the compositional Zadeh's rule of inference, where $\mu_A = (\mu_{a1}, \ldots, \mu_{an})$ is fuzzy causes vector with elements $\mu_{ai} \in [0,1]$, $i=1,\ldots,n$, interpreted as some significance measure of a_i causes. Parameter $\mu_E = \mu_{e1}, \ldots, \mu_{em}$ is fuzzy effect vector with elements $\mu_{ej} \in [0,1]$, $j=1,\ldots,m$, interpreted as some significance measures of e_j effects. Parameter R is the fuzzy relational matrix with elements $r_{ij} \in [0,1]$, $i=1,\ldots,n$, $j=1,\ldots,m$, characterizing the degree to which cause a_i influences upon the rise of effect e_j. The sign "$\circ$" represents the operation of *max-min* composition.

Taking into account the fact that operations $\vee$ and $\wedge$ are replaced by *max* and *min* in fuzzy set theory, system of equations (3) is rewritten in the form:

$$\mu_{ej}(y_j) = max\,(min\,(\mu_{ai}(x_i), r_{ij})) \quad (5)$$

where $i=1,\ldots,n$, $j=1,\ldots,m$. To define the measure of the causes and the effects significances we use the membership functions of the fuzzy terms a_i ($i=1,..,n$), and e_j ($j=1,\ldots,m$). Following form uses the simple and convenient for tuning analytical model of the membership function:

$$\mu^T(v) = \frac{1}{1+\left(\frac{v-\beta}{\gamma}\right)^2} \quad (6)$$

where β, γ are parameters of tuning. Parameter β is coordinate of maximum [$\mu^T(\beta)=1$]. Parameter γ is the concentration parameter. Fig. 2 illustrates the model of membership function.

The first phase is to formalize the document judgments. The second phase is to transform them onto the terms occurring in these documents. The objective is to build new query with the best couples (term, weight). The new query is built by considering the terms extracted from the judged document and the judgments of these documents.

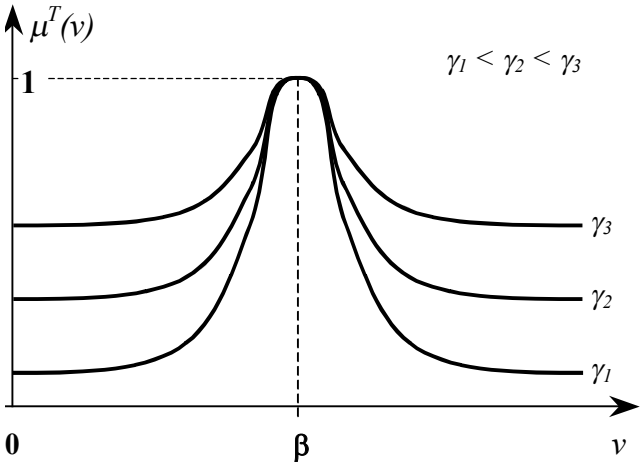


Fig.2 A membership function model.

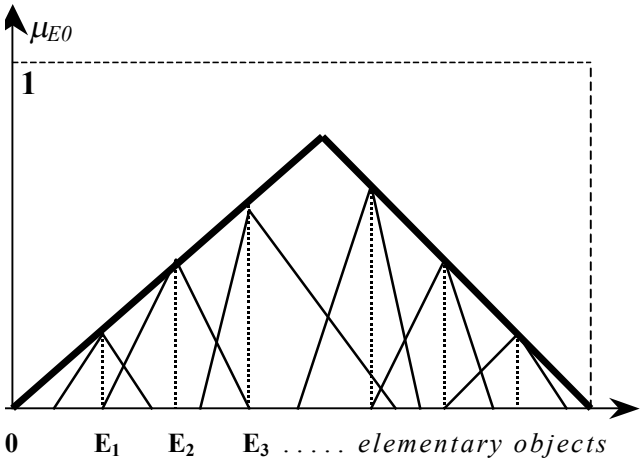


Fig. 3 Clustering of concept sets

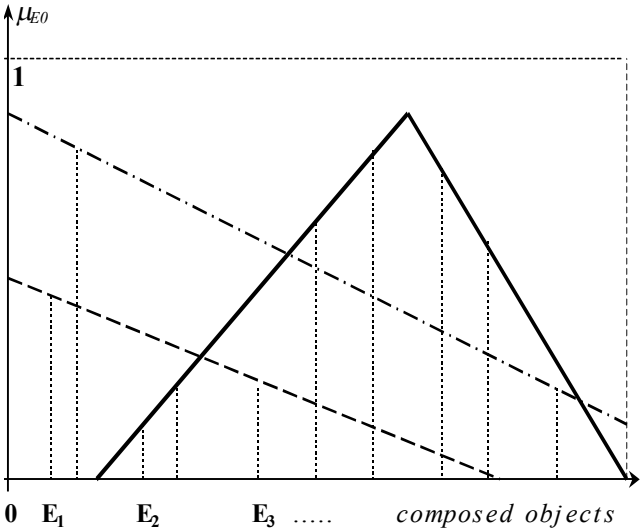


Fig. 4 Clustering of concept sets

We use a modified term weight expression such as *Mercure Information Retrieval System approach* in this form:

$$w_{ij} = \frac{k_1 * ft_{ij} * \log\frac{N}{n_i}}{k_2 * ft_{ij} + k_3 \frac{h_j}{\Delta d}} = \mu_d(t) \quad (7)$$

where:

w_{ij} is link weight between term t_i and document j,

ft_{ij} is the frequency of occurrence of the term i in document j,

n_i is the number of document containing the term t_i,

h_j is the width of document d_j,

N is the number of documents of the collection,

k_1, k_2, k_3 are the constant parameters,

$\mu_d(t)$ is the document representation as a membership function.

A term occurs in the document d at a certain degree of membership. The final weight of this term is mostly aggregated by *Maximum/Minimum* pair operators. There are judged documents produced. Mostly one feedback iteration is realized. For each intended relevance feedback methodology and for each query we submit the query to the Information retrieval system.

Fuzzy feedback approach is compared to the classical binary approach. The top twenty documents are judged according to the considered method and also the new query is built according to the used methodology approach. This query is submitted to the *Information retrieval system*, which returns a ranked list of 800 documents. At the end of experiment three lists of 800 documents are selected for each query. One list is the result of classical binary feedback, and the others two lists are the results of two fuzzy feedbacks approaches. Fuzzy feedback search with changeable judgments from two to nine levels was realized also by special modified chaos theory principles combined with entropy measure. A classical measure precision developed in *Information Retrieval domain* and used in *TREC* programme evaluates created lists. Realized experiment involves nine precision measures. P_n with $n=10,...,800$ is the precision at n documents. It is measured by following way:

$$P_n = \frac{\text{"number of relevant documents"}}{\text{"number of retrieval documents which are kept"}} \quad (8)$$

System is functioning this way that the user can decrease the number of documents retrieved by the first query or can query the web again with a different vocabulary to retrieve a new set of documents.

Each one of the new queries has a fuzzy compatibility degree with the original query that is determined from the synonymy degree between the words included in it and the words specified in the original query. It must be mentioned that some results are counterintuitive when we compare the values of confidence and certainty, which discloses that where the rules relate two items very frequent, the confidence is quite high by the certainty is not.

Fig. 5 illustrates the precision curves of realized experiments at different points P_n (see Table I.). The solved methods improve the classical methodology approach and the best documents are in the top of the retrieved-document list. We consider also membership functions of the three, five and seven relevance levels. Experiments show that the further refinement by considering of others fuzzy levels (i.e. more than five fuzzy sets for solved parameter evaluation) has been offered no relevant contribution to information retrieval process quality for used domain knowledge set. The most significant quality has been achieved by five relevance levels (see Fig.5).

Results and experiments undertaken on TREC collection have relevant conclusions and show the effectiveness of the solved approach.

We have the same example. Conditions also are the same as above-mentioned processes, but methodology approach is different. Nowadays we create a new methodology with entropy calculation and modified chaos theory applying. The chaos theory provides very valuable complementary information, which is not possible to obtain by another analysis means. There are determined and analyzed real cases by chaos theory approach in dependence on infliction of phenomena entropy. There are some of the expected advantages of created method over the direct synthesis via the entropy and density function. Research by this way is not finished, but it provides nowadays very interesting partial conclusions.

There is also solved an automatic quick ontology construction with “fuzzy groups” for extending the traditional documents representation as vector of terms. This approach encodes informativeness of XML elements according to their structural position. The approach was inspired by [7]. Examples in this case are simply and shortly illustrated by Fig.6 and Fig.7, where are representations of XML documents in a cluster.

We compute membership functions to the initial clusters. A fuzzy clustering algorithm does not only compute the fuzzy partition but also permits to compute membership values for any arbitrary data point. An entropy based fuzzy means permits this.

Fuzzy logic elements give an adequate basis to handle these partial judgments. When users have more levels, they can easily make choices to assign documents to important levels which best match their idea and perceptions of the documents.

Table I. Values for precision curves

Approach	*P10*	*P20*	*P30*	*P50*	*P80*	*P150*	*P300*	*P500*	*P800*
classical	0,515	0,45	0,29	0,26	0,22	0,19	0,16	0,14	0,11
three relevance levels fuzzy	0,58	0,51	0,33	0,28	0,25	0,21	0,19	0,17	0,15
five relevance levels fuzzy	0,64	0,62	0,57	0,48	0,46	0,44	0,41	0,28	0,27
seven relevance levels fuzzy	0,65	0,64	0,6	0,5	0,48	0,47	0,44	0,33	0,29

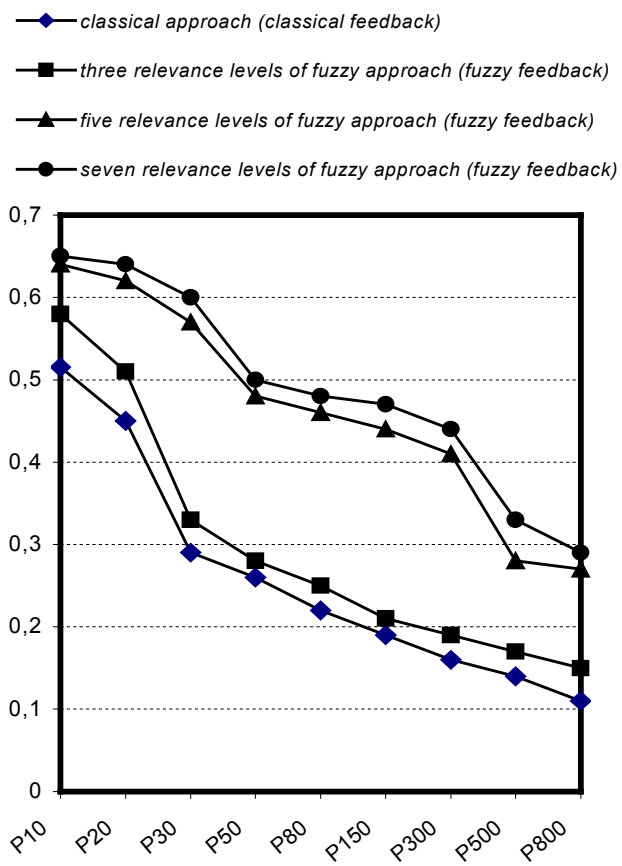
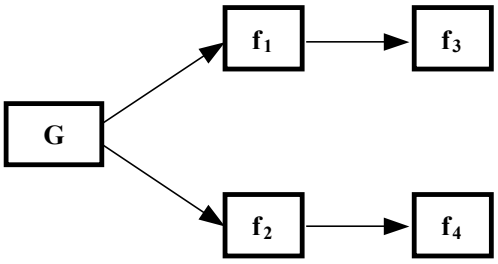


Fig. 5 Courses of precision curves for 4 solved methodology approaches



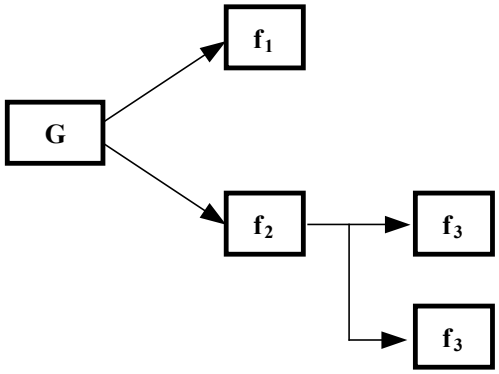
$$\equiv (1/G, 0.5/f_1, 0.5/f_2, 0.3/f_3, 0.3/f_1) =$$
$$= (0.5/1, 0.3/2) * f_1, (0.5/1) * f_2, (0.3/1) * f_3$$

Fig.6 An example of XML documents representation in a cluster

A flexible and effective information retrieval is the goal of our effort. The main goal of information retrieval is to retrieve relevant documents in response to a user need [5], [6].

The semantic web has been developed by the following way. The Web is dense of noisy, low-quality and unreliable content [1], [2]. It is known that if we have obtained information about Web document quality, we need to realize additional sources of specific information. The problem is that users typically do not make the effort to give explicit feedback. Web search engines can collect implicit user feedback using log files. However, this data is still incomplete.

To achieve better issues of evaluation the direct participation is necessary. The use of fuzzy linguistic modelling to facilitate users in the expression of their judgments can be a good start to increase the participation of users in the evaluation models of the quality of Web documents. It is also useful to develop mechanisms to store such judgments in the structure of personal Web documents would facilitate the quality evaluation. This is possible by developing fuzzy linguistic information representations based on *XML*.



$$\equiv (1/G, 0.5/f_1, 0.5/f_2, 0.3/f_3, 0.3/f_3) =$$
$$= (0.5/1) * f_1, (0.5/1) * f_2, (0.3/2) * f_3$$

Fig.7 An example of XML documents representation in a cluster

An encoding informativeness of XML elements according to their structural position is an effective approach. A methodology for evaluating the informativeness of an element is to divide a membership degree initially equal to "1" by the nesting level of the element. Fig.7 illustrates a cluster of XML documents encoded according to this approach.

A communication module is illustrated in Fig.8.

III. Conclusion

In information retrieval, solved fuzzy set methodology approach provides a framework for modelling flexibility and handling vagueness and uncertainty, which are intrinsic to information. The flexibility is expressed through different processes of information retrieval system. It has been applied to flexible queries and document representation and to a flexible evaluation when matching queries with documents. Solved system do not only retrieve documents of which representation corresponds exactly to the query but also documents that match the query partially. Solved approach extends this idea by giving the user the possibility to assess documents that are partially relevant.

The others most known systems are Information Retrieval Systems (on the Web, the search engine), and systems for electronic commerce. The research contains also fuzzy information retrieval model with indexing mechanisms and query languages, fuzzy document clustering, fuzzy data mining, fuzzy approaches to distributed information retrieval, fuzzy recommender systems and so on.

Existing Web has fundamental problem. This problem is that the data is machine-readable but not machine-understandable. The Semantic Web appears to create a new form of Web content meaningful to computers as

well as humans, and its development involve a creation of new technologies to formalize the knowledge on the Web, and creation of new applications like the Web.

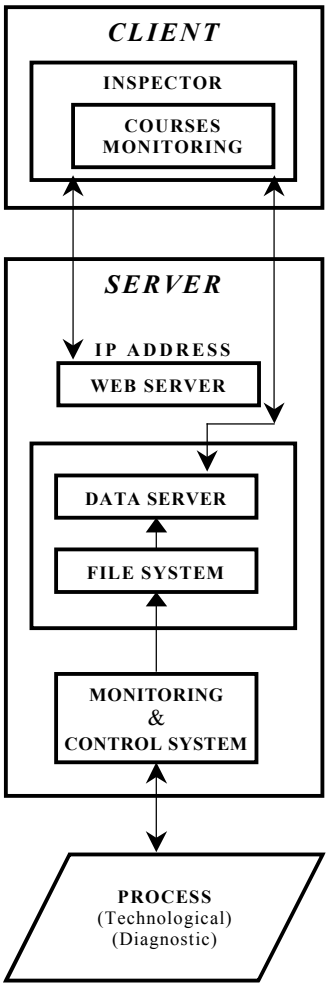


Fig.8 A communication module

Ontology is usually conceived as a hierarchical description of a set of concepts, a set of properties and their relationships, and a set of inference rules. The concept of ontology is central to the development of the Semantic Web. In this context, the semantic Web is a web of distributed knowledge bases, and intelligent agents can read and reason about public knowledge with the guidance of the ontology [3]. In an ontology many aspects appear which require flexible knowledge representation, learning and reasoning notions of approximate equality in data, semantic equivalence of syntactically different structures, robustness against inconsistent or partial data, and so on. Then the fuzzy techniques can be used to avoid rigid definitions and to manage uncertainty in hierarchical representations of concepts and in inference or matching processes. The Semantic Web is also a collection of Web applications described by ontology.

The semantic Web must provide definitions for linguistic terms used by humans with the aim of enabling machines to provide better solutions. In this context the Fuzzy linguistic modelling can have an important role [4].

The flexible nature of the fuzzy ontology may support a wide range of approaches to the problems of retrieving relevant, accurate, appropriate and most of all useful information which is a relevant key aspiration of research of semantic web.

Future work includes working with larger data sets. In this case, a hierarchical clustering methodology seems to be appropriate tools. Tools for document clustering and structuring permit to have a better understanding of the documents available.

The interfaces provide the user with tools for navigating through hierarchies of documents and visualize selected documents and similar ones. Similarity is based on Wordnet 1.7 and Latent Semantics Analysis.

Further research is directed to task of improving the query language of search engines, identifying Web content of demanded quality and also developing the Semantic Web problems.

Further research is also directed to task of applying fuzzy set technique, which is combined with modified principles of chaos theory approach. Nowadays we create a new methodology with entropy calculation and modified chaos theory applying. The chaos theory provides very valuable complementary information, which is not possible to obtain by another analysis means. There are determined and analyzed real cases by chaos theory approach in dependence on infliction of phenomena entropy. There are some of the expected advantages of created method over the direct synthesis via the entropy and density function. Research by this way is not finished, but it provides nowadays very interesting partial conclusions.

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