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Semantic Analysis Models and Methods of the Text Information in the Building Normative Base

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Abstract: ***The research is aimed at overcoming the uncertainties associated with the reform of legislation regarding the technical regulation of the building industry. The main goal of the paper is to systematize the normative base of building of Ukraine in the conditions of adaptation of normative documents to the requirements of the European Union. In order to achieve this goal, an analysis of the peculiarities of the information resource of the normative base was conducted and the nature of the uncertainty contained in the normative documentation of the industry was investigated. The status of modern electronic databases of normative documentation in the building and building materials industry of Ukraine is described. The scheme for identifying different documents on the same issue is proposed. The possibility of applying models and methods of fuzzy mathematics to formalization of texts of building norms and rules and expression of their semantics in the internal language of the Semantic Text Information Analysis System is shown. The practical value of the paper is seen in the improvement of the organizational and technical system "Technical Regulation in Building" by minimizing the number of regulations on the same issue and achieving consistency between normative. The paper's scientific novelty of is to apply the model of artificial intelligence to the solution of the problem of semantic analysis of documents contained in electronic bases of normative documentation of the system of technical regulation in building. The capability of artificial neural networks of the ImegNet category to solve the problem of semantic analysis text documents of Building Normative Base is proved Further researches will focus on forming the Text Information Semantic Analysis System knowledge base and adapting the Deep Structured Semantic Model to the task of assessing the degree of closeness between a Semantic Request and a Semantic Normative Document. The results can be used to improve other workflow systems.***

Keywords: building norms, collision, semantic analysis, artificial neural network, text information.

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I. INTRODUCTION

The integration of Ukraine into the European law space has led to significant changes in the technical requirements and organization of building technology. These changes relate to requirements for construction products and the effectiveness of normative-law support [1].

Uncertainty is caused by the adaptation of the Ukraine ND to the EU requirements [2, 3]:

- Amending some legislative acts;
- The practice of simultaneous using of NB documents, the separate provisions of which are not harmonized;
- Inconsistency of legislative acts, documents of the NB regarding the conceptual apparatus and terminology.

The accumulation of problems related to changes in the systems of standardization, standardization and regulation of permitting procedures in construction in accordance with world standards, contribute by:

- Changes of environmental impact requirements;
- Changes of base of raw materials, production technologies of building materials and technologies of building;
- Increased demand for unique buildings and structures.

Uncertainty caused by these external environment transformations leads to the need to create additional documents to normalize the order of action in uncertainty case. The accumulation of such NDs complicates the TR process as a whole and can lead to law collisions. In such circumstances, the tasks of intellectual search and processing of NB text documents are relevant and timely. Moreover, the evolution of intellectual linguistic systems provides opportunities for the development of such systems.

II. ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

A. Abbreviations and Acronyms

- ANN – Artificial Neural Network.
- BN – Building Norms.
- DSSM – Deep Structured Semantic Model.
- EU – European Union.
- FR – Fuzzy Rule.
- FSA – Filtered Selection of Applicants.
- FU – Fuzzy Uncertainty.
- NB – Normative Base.
- ND – Normative Document.
- FPRND – Fuzzy-plural representation of ND.
- FPRR – Fuzzy-plural representation of request.

- SND – Semantic Normative Document.
- SR – Semantic Request.
- TD – Text Document.
- TI – Text Information.
- TISAS – Text Information Semantic Analysis System.
- TR – Technical Regulation.

B. Some common concepts

Concept 1. Semantic Analysis is the procedure of extracting semantics from TI and expressing this semantics by internal language of TISAS.

Concept 2 [4]. Knowledge Base of TISAS is a part of system that includes itself NDs, presented as FRs:

$$If \ <condition> \ then \ <conclusion>. \quad (1)$$

In this paper, the conditions and conclusions of the rule are blocks of formalized textual information on building norms and rules that make up the NB in building.

Concept 3. Contradictory Rules (1) are FRs that lead to collision of different nature.

Concept 4 [5]. Juristic collisions are a variety of contradictions in the field of law, the essence of which is the presence of differences between the prescriptions of normative legal acts or normative and interpretative acts aimed at regulating the same social relations or clarifying law norms.

Concept 5 [6]. Collisions of normative acts are the contradiction between the juristic prescriptions of the relevant acts, which is manifested in differences in the process of regulation of similar social relations. Here we are talking about contradictions that arise only between juristic acts, which offer different content and form of the way to regulate social relations.

Concept 6 [5]. Juristic technique is a system of means, methods and techniques aimed at developing and implementing legal norms, with the aim of rationalizing it and ensuring the effectiveness of legal regulation of social relations.

Concept 7. In this work, FU is uncertainty, which is a consequence by:

- Collisions of different nature;
- Unclear presentation of information;
- Semantic uncertainty related to ambiguity of concepts and terms.

C. Analysis of current state of the NB information resource in the Ukraine building industry

NB documents in construction are cross-sectoral in nature, since building objects and construction products are created and operated almost in all sectors of the state's economy and the parameters of building products and their creation processes have been and are subject to state regulation.

State regulation of the NB in building is carried out by such documents as:

- Laws;
- By-laws;
- Normative and technical documents containing norms defining mandatory requirements in the building, urban planning and architecture.

Rapid changes in the sphere of industrial relations necessitate the transformation of the NB, which requires processing of the ND in-time.

At the legislative level, some steps have already been taken to implement TR in the territory of Ukraine. The Law of Ukraine [7] has been adopted and enforced. However, this document does not take into account the peculiarities of TR in the building industry.

That is why the material of the research is the information resource of the NB in building:

- State standards;
- State building norms;
- Departmental building norms;
- Regional building norms;
- Specifications.

Additional requirements to the organization of production in the building of objects that have industry specificity can be set by industry BNs and NDs [8].

An analysis of the current state of the technical regulation system in the building of Ukraine, conducted in [1], showed that a considerable part of the NB documents are out-dated acts that are still in force. New normative and technical acts (more than 1000), adopted since 1991, have been developed in unstable conditions of the economic and financial crisis. Only in 2009, under the influence of globalization trends in the country's building industry, 185 NDs were adopted. And although in 2017 the Cabinet of Ministers of Ukraine abolished a considerable number of normative-technical acts [9, 10], the NB in construction remains overloaded.

Thus, the object of research includes:

- Current international normative documents in the field of building and industry of building goods;
- Current state normative documents in the field of building and industry of building goods;
- Amended and cancelled building normative in Ukraine.

The accumulation of a large number of normative by-laws, which detail the provisions of the laws, complicates and slows down the process of TR as a whole and leads to the unsystematic process of implementation of NDs.

To ensure systematic of NB in building have to:

- To achieve consistency between regulations;
- Optimize the number of normative acts on the same issue;
- Avoid unreasonable duplication of norms;
- Adopt the necessary acts in-time;
- To harmonize the issued acts with those which were adopted earlier (to cancel in due time the acts and their parts that contradict the new act, to make necessary changes to the existing acts);
- Minimize references to invalid norms;
- Systematically use terminology.

However, failure to comply with the special rules of juristic technique in the development of normative-technical acts and NDs, in particular the terminology of legislation, leads to collisions of various nature and complicates the search for legislative information for users.

Problems of juristic technique are common to modern countries of the world, as recorded by the papers of lawyers from different countries [11 – 13].

With:

- The problem of correct and unambiguous use of terminology in urban planning and special legislation is particularly acute, which is complicated by the need to harmonize Ukrainian and EU legislation [14];
- There is no comprehensive state information and law system of regulation of urban development activities [15].

Improvement of the existing NB in construction is carried out by introducing such permanent measures as:

- Coordination of the NB's adaptation in the field of building to the requirements of EU legislation;
- Complex development of TR in construction;
- Implementation of technical regulations for building products, buildings and structures.

Successful implementation of these measures in the described conditions requires the use of information and intellectual systems of various purposes, and the Internet provides ample opportunity for multidimensional and prompt search of information in electronic databases.

The most common information retrieval and information tools in the TR system in the construction of Ukraine are [1]:

- «State building norms of Ukraine»;
- «Normative PRO»;
- Information Reference System «Budstandart»;
- «Bud-Inform».

These software systems are equipped with a search engine that allows you to find documents by name, text or keywords. However, solving the automatic search problem is significantly complicated by FU, which is associated with the processing of large volumes of not sufficiently systematic TI. The reasons for the occurrence of FU in the documents of the TR may be different. Analytical review of the European experience of building engineering showed that most often the uncertainty associated with the excess of information arises when solving the problem of multicriteria optimization [1, 12]. In Ukraine, the solution to this problem is complicated by the FU, which has to do with the need to harmonize Ukrainian and EU legislation [14].

The paper [16] deals with the issue of automatic detection of uncertainty caused by the presence of excess information.

In this paper:

- A scheme for identifying redundant information and resolving conflicts of parameters and rules in the documents in the building industry is proposed;
- Is shown the logic of a decision support system that can function in the presence of excess information.

However, [16] focuses on the development of a data structure and an algorithm for detecting redundant information that manifests in the existence of more than one ND with instructions for determining one regulation parameter. Further analysis and optimization of the NDs number on the one question remains to the experts as the approval of the current NDs requires understanding of the content of the TI.

In [17], the influence of uncertainty is being investigated, that related to:

- Implementation of the provisions of European documents on the design of building constructions in the practice of construction of Ukraine;
- Increasing demand for unique buildings and structures.

In such conditions, the fuzziness of a user's request is often due to the introduction of a parametric method, which ultimately departs from the definition of specific quantitative normative parameters and defines only:

- The goal to be achieved as a result of the implementation of the normative requirement;
- Significant characteristics of this normative requirement.

The responsibility for how a specific normative requirement will be implemented rests with the designer and the builder. In such conditions, there may be a variety of acceptable solutions that can implement a specific normative requirement and create a safe environment for humans. However, the complex automation of the decision-making process is complicated by the possibility of juristic collisions. That is why the research conducted in this paper is aimed at solving the problem of the search for ND not by the words of the texts, but by the semantics of Normative Document contained in Electronic ND Bases in Building and Building Materials Industry (Fig. 1).

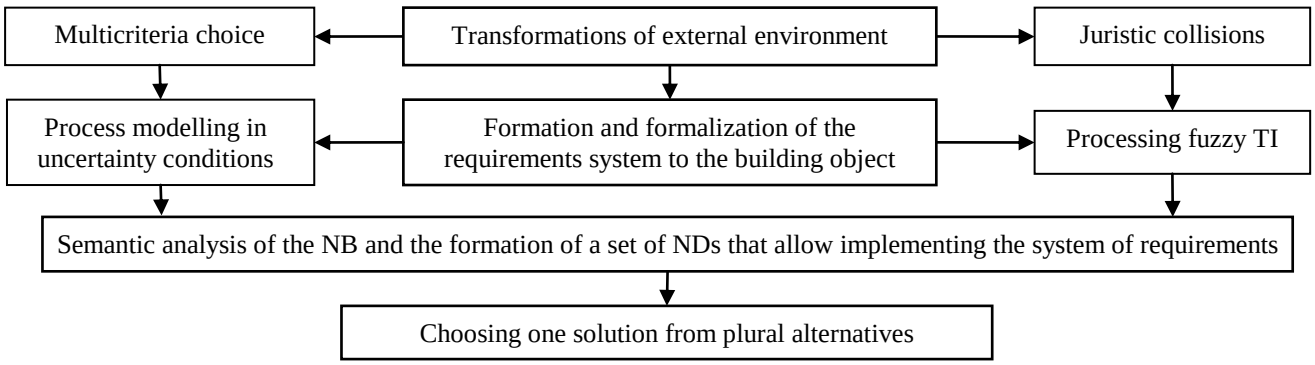

Fig. 1. Decision formation scheme under uncertainty conditions

III. BASIC MATERIAL

D. TISAS modelling

In Fig. 2 is shown the TISAS model, which is develop for semantic analysis of NB texts in building and building materials industry.

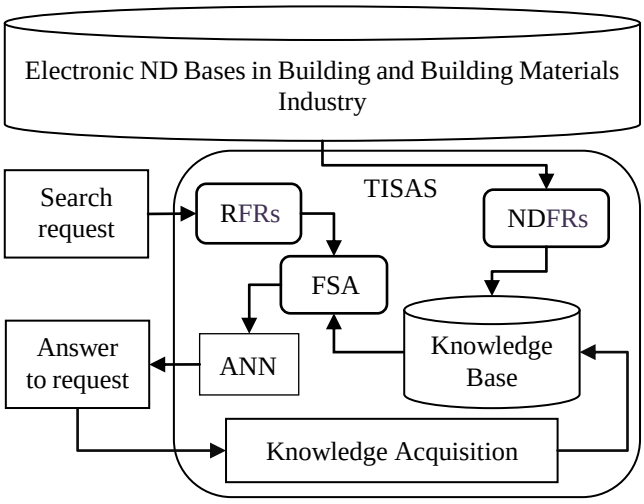

Fig. 2 TISAS Model

The formal statement of task is to map the SR with the SNDs stored in Electronic ND Bases in Building and Building Materials Industry.

Wherein:

- A user request is a sequence of words $Z=\{z_1,..., z_r, \ldots, z_R\}$ and plural of keywords $K_{ZH}=\{k_1, ..., k_{Zh}, ..., k_{ZH}\}$;
- Each ND belonging to a plural of documents in NB $D=\{ND_1, ..., ND_m, \ldots, ND_M\}$, is a sequence of words $ND_m=\{w_1, ..., w_i, ..., w_{NDm}\}$ and characterized by plural of keywords $K_{NDm}=\{k_1, ..., k_{NDp}, ..., k_{NDP}\}$;
- R is request length; ZH is the number of request keywords; M is number of documents in Electronic ND Building and Building Materials Industry; LND_m – is length of ND_m; NDP is number of keywords ND_m; m – index of TD.

Usually the conditions R = ND and ZH = NDP are not fulfilled, so the input vectors of SR and SNDs models usually have different dimensions.

That is why one of the main requirements for ANN, which is intended to assess the degree of compliance of SRs and SNDs of TISAS, is the capability to manipulate vectors of different dimensions.

In Fig. 3, shows one of the ANN models of the ImegNet category, which is develop to solve the problem of TI semantic analysis [19, 20].

DSSM is able to compare SR to SNDs of NB documents in Building and Building Materials Industry [20, 21].

Wherein, ANN builds vector TD models and evaluates the degree of semantic correspondence of S_R and S_{ND} as cosΘ, where:

- S_R is a fuzzy vector of request model;
- S_{ND} is vector model of ND Bases in Building and Building Materials Industry;
- Θ is angle between vectors S_Z and S_{ND}.

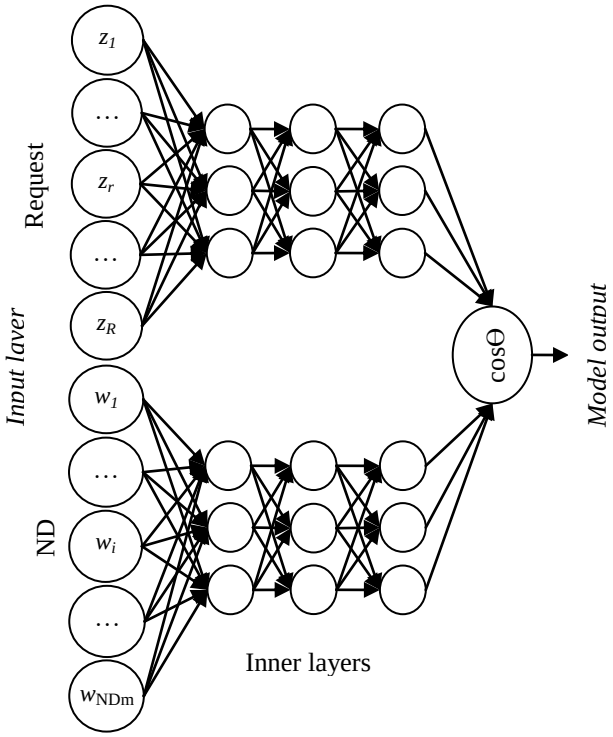

Fig. 3. DSSM

The purpose of hidden DSSM layers is to resize the input vectors. This gives DSSM the ability to manipulate vectors of different dimensions.

To compare the semantics of the texts, DSSM inputs are provided by TD.

After that DSSM:

- Converts a request words sequence to an S_R vector in L-measurable space ($S_R \rightarrow S_{LR} \in R^L$);
- Converts a sequence of words ND into a vector S_{ND} in L-measurable space ($S_{ND} \rightarrow S_{LND} \in R^L$);
- Defines cosΘ between vectors S_{LR} and S_{LND}.

This capability became crucial when choosing ANN for TISAS [21, 22].

There is enough works that describes the architecture, the principle of vector dimension manipulation, and DSSM learning algorithms [22, 23]. For example, in [23] it is shown that the input layer of the original DSSM is a plural of trigrams of letters.

Working with trigrams does not require too much resource, but such a representation of TI significantly reduces the capability of ANN to extract semantics in the presence of phrases whose content is not transmitted by a simple sequence of words.

One method to solve the problem of taking into account semantics of established word combinations, which can be considered as a semantic unit, is to represent TI as vector models using the word2vec algorithm [22, 23]. However, this solution to the problem of semantic analysis of TI significantly increases the size of the input layer DSSM.

Increasing the size of the input layer leads to:

- Increasing the number of relationships between neurons;
- Increasing the duration of training;
- Needs to increase computing resources.

An analysis of the current state of the organizational and technical system "Technical Regulation in Building" in Ukraine showed that:

- On the one hand, the Building Industry NB information resource and the juristic rules that provide for its legal regulation contain a large number of established phrases and expressions that may have ambiguous interpretations;
- On the other hand, the information resource of the NB in building contains a considerable part of TI that can be formalized and presented in the form of FRs (1) by fuzzy mathematics methods.

The fuzzy plural representation of the input data provides the opportunity to resize of the DSSM input layer to be reduced significantly.

E. The fuzzy-plural representation of TI in the TISAS

The rework of the input data is to form the Knowledge Base ontology of TISAS and to represent the user request in the form of FRs.

For this reason, it was proposed in this paper to use:

- User request forming in the form of RFRs (2) and keywords K_{ZP}:

If $<R=\{z_1, ..., z_{LR}\}>$ then $<RFRs\&K_{ZP}>$,
where RFR: if $<x_i \in X_i \& y_i \in Y_i \& \{ND_h\} \in D>$; (2)

- Formalized valid ND in the building and building products industries formed in accordance with the prescriptive method save in the knowledge base as NDFRs (3), belonging $D_1 \in D$ and keywords K_{NDP}:

If $<ND_m=\{w_1, ..., w_{LND}\}>$ then $<NDFRs\&K_{NDP}>$,
where NDFR: if $<x_i \in A_i \& y_i \in B_i \& \{ND_h\} \in D_1>$; (3)

- Formalized valid NDs in the industries of building and building products, formed according to the parametric methods of rationing, to store in the knowledge base in the form NDFRs (4), belonging $D_2 \in D$ and keywords K_{NDP}:

If $< ND_m=\{w_1, ..., w_{LND}\}>$ then $<NDFRs\&K_{NDP}>$,
where NDFR: if $<x_{jg} \in A_{jg} \& y_{jv} \in B_{jv} \& \{ND_h\} \in D_2>$. (4)

In the rules (2) – (4):

- x, y – input variables given in the areas output of fuzzy rules X and Y, respectively;
- A, B – statements that are blocks of formalized TI;
- i (i=1, …, I) – the parameter index of the from the search request and the rules formed to determine it according to the prescriptive method;
- j (j=1, …, J) and g (l=1, …, G), v (i=1, …, V) – the indexes of the series of alternative rules and TI blocks formed according to the parametric method;
- & – logical operation "and".

The search scheme for NDs whose semantics are close to the semantics of the request with precision ε (ε is a given number) is shown in Fig. 4.

In Fig. 4 also shows the FSA (Fig. 2) by the keywords of the user's request.

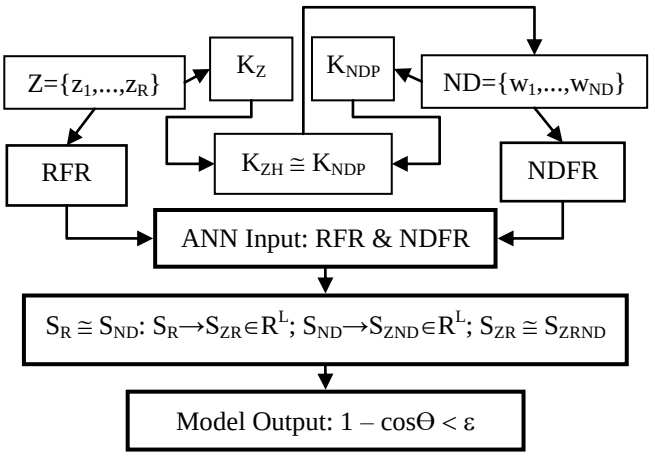

Fig. 4. The scheme of search for similar in the content of the Normative Documents

IV. RESULT AND DISCUSSION

This paper shows the feasibility of using ANN of the ImegNet category to solve the problem of TI semantic analysis. However, insufficient attention is paid to other means of knowledge manipulation, although the operation of searching the answer to the request can be implemented using semantic networks.

The multidimensionality of semantic networks allows representing a lot of semantic relations that link particular concepts, concepts and events into sentences, and sentences into texts. However, the arbitrariness of the structure of semantic networks requires a variety of information processing procedures, which complicates software.

It should also be noted that the presentation of input data in the form (2), (3) implies the possibility of using Fuzzy Neural Networks of Adaptive Resonance Theory. The advantage of these networks is the capability to display NDFRs directly on the ANN memory card, which significantly shortens the learning time of ANN [24, 25]. That is why, in the future, the research for a hybrid Neural Network that combines the benefits of Adaptive Resonance Theory and DSSM is not excluded.

V. CONCLUSION

As a result of the conducted research:

- The NB in Building and Building Materials Industries is found to contain a large amount of insufficiently ordered requirements that provide goals, criteria and performance characteristics to ensure the reliability and safety of the building site;
- The principle of formation of a fuzzy TISAS knowledge base in conditions of the introduction of a parametric normalization method into the text information system is shown;
- The expediency of fuzzy plural representation of TI in the TISAS when applying ANNs of the ImegNet category to the solving of the problem of semantic analysis of TI is substantiated.

Further papers will focus on adapting DSSM to solve the problem of semantic analysis of fuzzy TI in the Building Normative Base,

training ANNs, and implementing TISAS in the building system TR system.

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