Formalization of Ukrainian-Language Content for Fuzzy Product in Court

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Abstract. This paper is devoted to the development of a method of formalizing Ukrainian-language content for fuzzy output production systems. Three variants of variables, which described in a text document, were proposed. The application's effectiveness of the proposed variants of variables initialization for production systems in the field of justice was carried out. It was made on the example of the processing of the verdicts texts in separate articles. The studies were conducted using the automated system Neuro-Adaptive Learning ANFIS in MATLAB. The best accuracy were provided by normalized initialization functions which used the positional calculus system with the least possible basis.

Keywords: decision-making, court sentence, Ukrainian-language content, ontology, fuzzy production system, the order ratio, graph.

1 Introduction

There are different models of information technologies implementation in the justice field in the world practice [1]. The concepts of "e-justice", "e- proceedings", "e-court" or "online court" have been fixed by law. Ukraine is a member of the continental legal system. Among the countries with such legal model, the most developed is e-proceedings of Germany, where the filling of documents, processing and adjudication are done in electronic format [2]. The sentencing process formalizing is a discussion issue. The large volume of legal norms, documentation of cases, the pressure of responsibility for the human fate, the ambition of a just sentence creates a diversity of attitudes to this question [3]. Recognizing that modern advanced technologies will not replace the lawyer profession, it can be argued that they allow professionals to work effectively with large amounts of information that passes through the analytical system.

The work [4] emphasizes the steady interest increase to the intellectual systems use in various fields, particular, in jurisprudence. Modern intellectual systems use knowledge bases that are formed according to the subject area. One of the main results of [4] is the development of data extraction method based on the ontological knowledge base of syntax analysis of Ukrainian-language text documents.

The study results on the construction of the product rules base and its optimization are presented, for example, in [5]. This study develops models and algorithms for optimizing the design of conjugated fuzzy knowledge bases using the criteria of "precision output - complexity" as a min-max clustering problem.

In another work [6], a study was conducted on the comparative analysis of four hybrid artificial intelligence models for the prediction of probable fires; each model consists of an adaptive neuro-fuzzy inference system (ANFIS) [7] combined with a specific metaheuristic optimization algorithm.

In this paper, authors set out to develop a common knowledge base of sentencing in the combination of different circumstances to create a basis for determining similar sentences in similar in composition and circumstances of the crimes. Such knowledge base can be used as a reference or training base.

2 Related Works

As you know, the production system $System$ formally displays $System: Input \rightarrow Output$, where in the most general sense, the input is given information $Input$ that should affect the output result $Output$. In common case, the input information $Input$ is verbal, qualitative, nonmetric, unstructured, or poorly structured. This information may contain a description of the phenomenon, object, process. It is necessary to distinguish such information about one or more attributes, features, properties of these phenomena, objects or processes that are significant in the sense of influencing the output result $Output$. The outputs $Output$ contain information about possible alternative solutions, thus this information can be considered more structured.

The research conducted in this work is a further development of the binary relation $Listening: Court \rightarrow Court\ Process$ that is introduced into the basic ontology of the law system [8]. The preliminary results reported by the authors in [9, 10, 11] allowed us to determine the model and stages of building a knowledge base for sentencing, namely the presentation of knowledge in the form of a fuzzy inference product model.

The development of the knowledge base goes through these four stages.

At the first stage, the authors formed the structure of the ontology of the court decision, which is outlined in [9]. The developed ontology of the sentence is a structure that clearly illustrates the relationship between the concepts that are the classes of input (offerder's personality, judge's personality, circumstances burdening and mitigating the crime) needed to make a decision and the degree of punishment presented by a fine, restriction and imprisonment (real and conditional), public works (Fig.1).

The ontology of a court sentence has become the basis for developing a model of a productive decision support system (DSS) in court.

At the second stage, in [10], this article's authors constructed a system of fuzzy inference to support court decisions. In such form, the construction of the ontology of the court decision allowed to develop a general model of DSS in a court that has the form:

(Fine, Years, RF, Public Works, Condition) = F(Severity, Mitigation, Personality, Burden, Lawyer), (1)

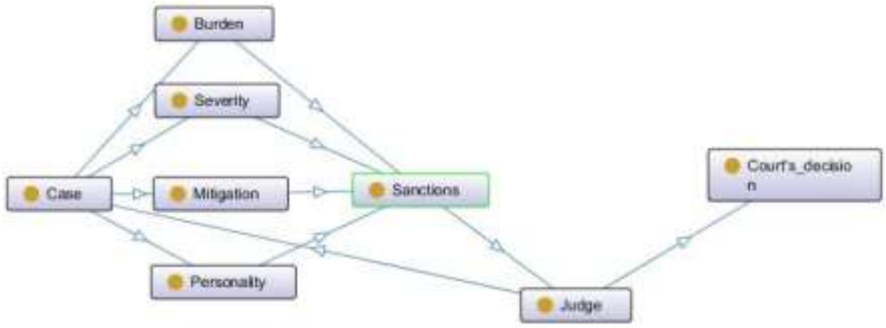


Fig. 1. Ontology of making a court decision

where F is the corresponding output algorithm; Severity is characterizes the severity of the crime; Personality is characterizes the guilty person; Mitigation are mitigating circumstances; Burden are circumstances that burden the punishment; Lawyer is the level of neutrality of a court's decision and takes value with the term {loyal, neutral, strict}; Fine is the size of the fine; Years are the number of years of imprisonment; RF (Restriction of freedom) is restriction of freedom; Public Works are Public Works.

Condition determines the actual or conditional entry into action.

General ideas were tested on the implementation of the DSS for a separate article of the Criminal Code of Ukraine in two variants, with Mamdani and Sugeno algorithms [10]. The experiment was conducted on sentences under Article 185 of the Criminal Code [12] of Ukraine on theft contained in the register of court decisions of Ukraine [13].

An interesting feature of production systems is that the *Input* information at the input of system is textual, and at the output there should be information containing a quantitative component. This feature gives rise to the need to initialize qualitative variables that are characterized by natural language. Therefore, in the third stage it is necessary to build a model of concepts developed by the ontology. This requires the creation of algorithms for handling existing court cases. The theoretical substantiation of the stage is outlined in [11], which proposes a method of constructing a membership function for fuzzy sets of terms of a linguistic variable that allows to formalize verbal information for production systems.

Next, in the fourth stage, it is necessary to build the production base and optimize it. By optimization we mean ensuring the achievement of conflicting goals, namely, improving the accuracy of output while reducing the complexity of the system. The automated Neuro-Adaptive Learning ANFIS in MATLAB system was used to test possible approaches to performing the tasks of the fuzzy output production system optimization and optimization process [7].

In this work attention is focused on the last two stages and demonstration of possibilities of the formalization method of Ukrainian-language content for creation of a fuzzy production system on the basis of initialized input vectors.

3 Our Approach for Evaluating Variables Contained in Ukrainian-Language Content

Further studies allowed to apply the results obtained in [11] to construct a method for initializing the input vectors of a fuzzy production system, which allows to formalize the information contained in textual form and to adjust the system itself. The method consists of four steps: modeling information of Ukrainian-language content in the form of digraphs; building order relations on the elements of this model; initialization of input vectors; fuzzy production system setup.

In the setup of fuzzy production system, we will understand the definition of membership functions for fuzzy sets of terms of linguistic input variable information, production rules, and accurate output estimation by the Sugeno fuzzy output method.

Initialization variables must be defined for the vector of input variables. Assume that the variable α contains an estimate of certain text information $Input$ that is put to the product system input.

The first step of the method is the modeling of ontology concepts [9] in the form of a digraph H in Fig. 2 [14].

Assume that the variable α is characterized by n nonmetric features $P_i, i = \overline{1, n}$ forming the set P, $|P| = n$. Each feature P_i can take k_i values p_{ij}, $j = \overline{1, k_i}$. Each branch of the order H defines a specific feature $P_i, i = \overline{1, n}$. The vertexes corresponding to the features $P_i, i = \overline{1, n}$ form the first tier. The second tier consists of the leaves of the order H, which are possible values p_{ij} of the feature P_i.

To determine the set of features P and the possible meanings of these features, a semantic analysis of textual information is required [14].

The second step of the method is to build the order of the plural order X.
The domain of the variable definition α is determined by the Cartesian product of non-metric features $X = P_1 \times P_2 \times ... \times P_n$, $|X| = \prod_{i=1}^{n} k_i$: $X = \left\{ x_s \middle| x_s = \left(p_{1 j_{s1}}, p_{2 j_{s2}}, ..., p_{n j_{sn}}\right), 1 \le j_{si} \le k_i, i = \overline{1, n} \right\}$.
The problem is that the arbitrary positioning of the value x_s on the abscissa does not allow to build an initialization function $f(x_s)$ with predefined properties. Therefore, it is necessary to define a bijective mapping $f : X \to R$ that meets two requirements:

1. the reproduction of a binary order ρ that corresponds to the natural ordering x_s of a certain quality criterion, and
2. fulfillment of conditions of monotonicity of the initialization function $f(x_s)$.

The theoretical basis of the ordering of the set X is given in [11].

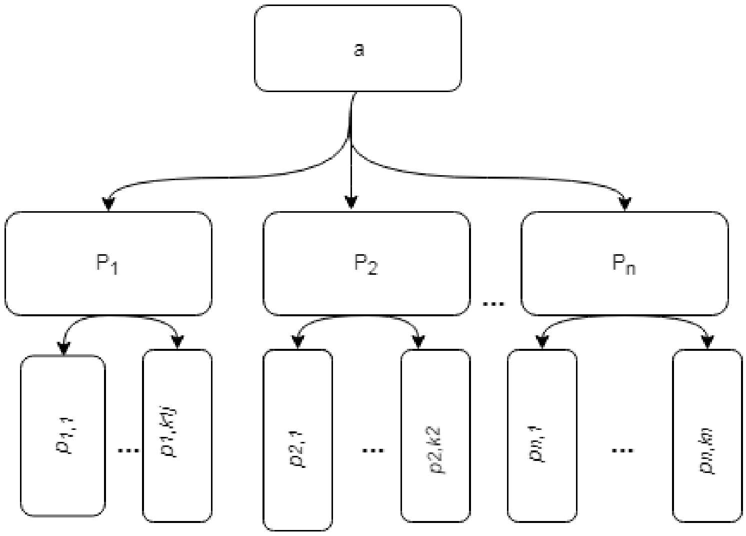


Fig. 2. Model of the concept of ontology (variable α) in the form of a digraph H .

The result of the method's second step is an ordered set of feature values, which enables the ordered arrangement of the abscissa of the vectors set $X = \left\{x_s \middle| x_s = \left(p_{1j_{s1}}, p_{2j_{s2}}, \ldots, p_{nj_{sn}}\right), 1 \leq j_{si} \leq k_i, i = \overline{1,n}\right\}$.

The third step is to define the initialization functions for the variable α .

To determine the identifier x_s, we apply positional numeral system with base, in which the digit 10^{n-i+1} is determined by the sequence number of the vertex describing the feature P_i in the strict order column and the digit j_{si} - the sequence number of the value $p_{ij_{si}}$ for the feature P_i, which was implemented in the vector x_s. Let denote the absence of a value for a particular sign as "0". Place the vectors of the values P of the traits on the abscissa axis according to the defined order $\langle\{p\},\pi\rangle$.

At the fourth step, to set up a fuzzy product system, it is needed to build the vectors of the input $x_s = \left(p_{1j_{s1}}, p_{2j_{s2}}, \ldots, p_{nj_{sn}}\right), 1 \leq j_{si} \leq k_i, i = \overline{1,n}$, $x_s \in X$, and output data. Functional dependency views $f(x_s)$ should reproduce the intuitively expected evaluation of an object α , that is, fit the order ρ and provide general requirements for the monotony of the function.

For large values $k_i, i = \overline{1,n}$ and n, the number of vectors $|X|$ is too large for the expert definition of the initialization function. Therefore, it is advisable to automate the initialization functions' construction, which further will be used to train the fuzzy production system on the values of the input and output variables.

The following types of formulas are offered to determine the initialization function $f(x_s)$, where β_r, $r=\overline{1,2}$ - parameters:

$$f(x_s)=\beta_1+\beta_2*\sum_{i=1}^{n} j_{si}*base^{-i}\ ,0\le j_{si}\le k_i \tag{2}$$

One of definition variant is $base=10$. It is also advisable to determine the basis of the calculation system $base$, where $base=1\text{mod}(\max j_i)$. Another way to define the initialization function as linear:

$$f(x_s)=\beta_3+\beta_4*num(x_s) \tag{3}$$

where $num(x_s)$ is the sequence number of the vector x_s in order ρ.

4 Experiments

The authors aimed to conduct an experiment to investigate the effectiveness of applying formula (2) with different bases of the calculation system and formula (3) to build estimates of the input vectors of a fuzzy production system.

To achieve this aim, the capabilities of the automated system Neuro-Adaptive Learning ANFIS in MATLAB were used [7]. To train the fuzzy system with the neuroadaptive methods' help, matrix is formed from the input and output experiments' data. In order to form a fuzzy output system, which works with neuro-adaptive methods and satisfies the output quality requirements, ANFIS training should be conducted on a sample data that fully reflects the features of the simulation data.

According to Art. 65, 66, 67 of the Criminal Code of Ukraine [12], as in previous works [9, 10], the following methods were chosen by the method of direct logical deduction by input linguistic variables: *Severity* - severity of the crime committed; *Personality* - characteristic of the person of the offender which takes value from the term-set {negative, neutral, positive}; *Mitigation* - an assessment of the judge's ability to consider the amount of mitigating circumstances to the crime; *Burden* - assessment of the judge's ability of taking into account the number of burden circumstances; *Lawyer* characterizes the level of neutrality of the judge and takes the value from the term-set {loyal, neutral, strict}. We will assume that the judge is "neutral".

The analysis of the verdicts in court cases showed that there was another element that influenced the court's decision. This is the plaintiff. Therefore, the model (1) presented in [10] is supplemented by the linguistic variable *Plaintiff*, which takes the value from the term {adjusting to mitigation, neutral, not adjusting to mitigation}.

The following general model of DSS is proposed in court:

(Fine, Years, RF, Public Works, Condition) = F (Severity, Lawyer, Personality, Plaintiff, Mitigation, Burden), (4)

where *F* is the corresponding fuzzy inference algorithm.

For the experiment were selected part 3 Art. 185 of the Criminal Code of Ukraine on theft and part 2 Art. 240 "Violation of the rules of protection or use of subsoil" [12].

The experiments were performed to construct a fuzzy inference system by the Sugeno algorithm. The mathematical model of DSS was adopted in accordance with the selected articles in court:

$$(Years) = SUGENO(Personality, Plaintiff, Mitigation, Burden) \tag{5}$$

The models' simplification with relation to the general (4) was made in view of the fact that the gravity of the crime is unchanged within the scope of a specific article of the Criminal Code. The automatic implementation of Sugeno output with Neuro-Adaptive Learning ANFIS in MATLAB allows to get the only one output that was chosen *Years* or *Fine*.

4.1 An Example of Production System Construction According to Part 385 of the Criminal Code of Ukraine

The first step: modeling ontology concepts in the form of digraphs.

For its realization it is necessary to select information concerning variables: *Personality, Mitigation, Burden, Plaintiff,* which are defined in (4). The collection of documents consisted of 25 court sentences under part 385 of the Criminal Code of Ukraine. The documents were obtained from the Unified Register in accordance with the rules for using this electronic resource containing certain restrictions for access [13]. The statutory form of the court decision contains an introductory, motivating and resolutive part. The information about the offender is contained in the introductory part, in the explanatory part the court indicates what information about the person of the defendant is taken into account when determining his sentence, circumstances that mitigate or burden the sentence. The resolution section contains the court's decision on sanctions.

The study used the methods of semantic analysis [15, 16]: the signal words in the HTML document highlighted the necessary paragraphs of the motivation part, which built the libraries, removed the stop words from the Unified Register of court sentences, stamming, calculation of term-document matrices with TF-IDF weight index use.

The categories of terms and words corresponding to the terms of the ontologies concepts were distinguished: the person of the guilty; the plaintiff; the mitigating and burdening circumstances. Synonyms for each concept were expertly created from the chosen terms. Models are represented by digraphs in Fig. 3 and Fig. 4.

For example, let's look at many of the features for Personality in Ukrainian, in courts' decision language:

$P^1_{\text{Personality}}$ = *{працевлаштування, сімейний стан, проживання, реєстрація, характеристика, перебування на обліку, наявність зв'язків, кримінальна відповідальність, судимість},* $|P| = 9$.

In the second step we will define the area of definition of variables Personality and Plaintiff.

Therefore, the domain of the variable X definition is a Cartesian product of the features $X = P_1 \times P_2 \times ... \times P_9$, whose power $|X| = 1728$. The digraph in Fig. 3 reflects the expertly defined order of characteristics relative to the term "positive person". This makes it possible to arrange 1728 plural elements X.

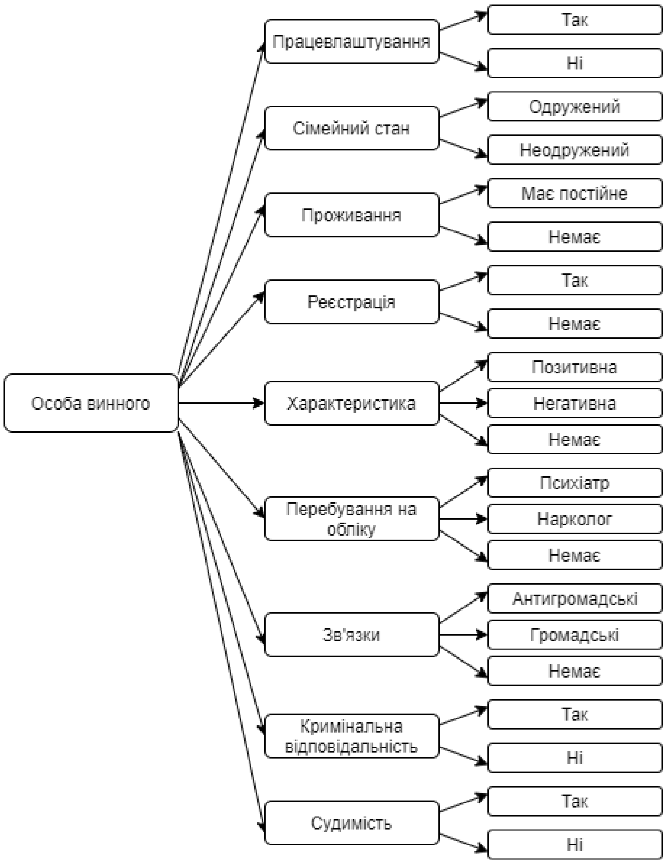


Fig. 3. Model of the Personality ontology concept

In the third step, we calculate the normalized values of the estimates based on the formula (2) with $base = 10$, $base = 4$ and on the formula (3) (Fig. 5 a)).

Similar actions are performed for the Plaintiff model.

$P^1_{plaintiff}$ *={відшкодування отримав, моральні збитки, просить пом'якшення}*, $|P| = 3$.

Therefore, the domain of the variable X definition is a Cartesian product of the features $X = P_1 \times P_2 \times P_3$, whose power $|X| = 8$. The digraph displays an expertly defined order of characteristics with respect to the term "Adjusting to mitigation".

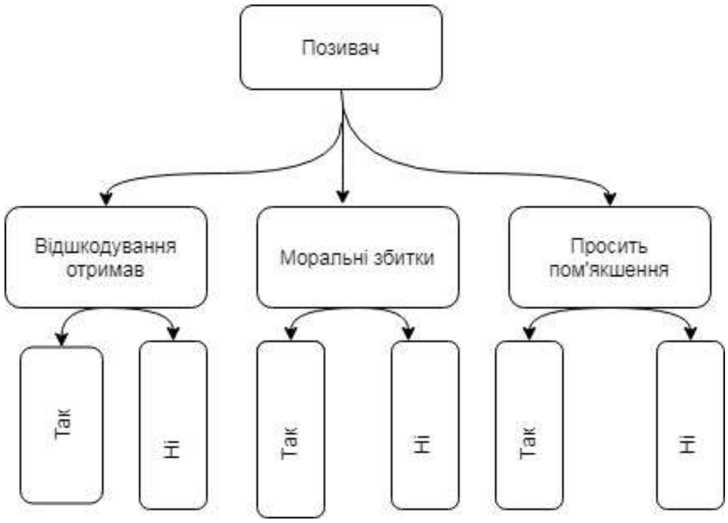
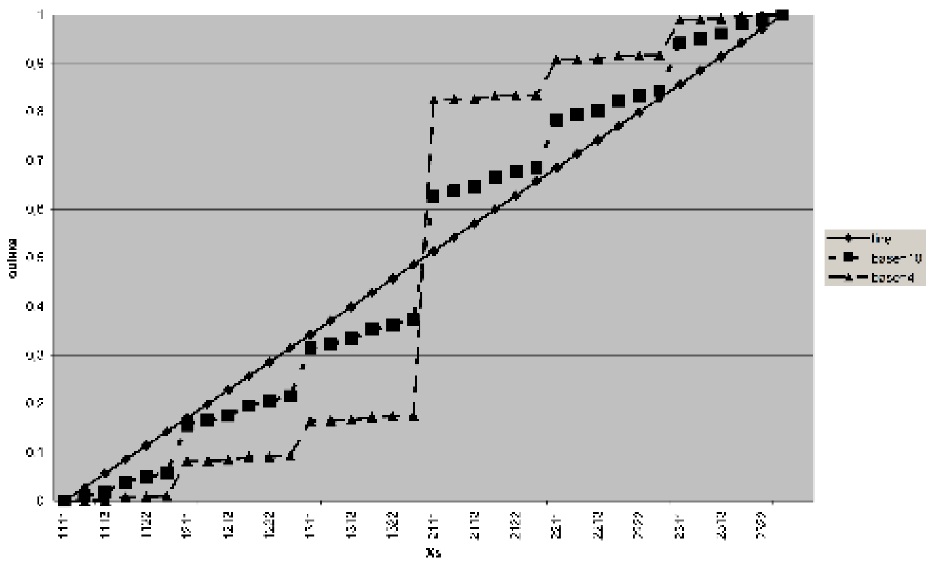


Fig. 4. Model of the Plaintiff ontology concept for Art.185

For variables *Personality* and *Plaintiff* initialization functions were built. In formulas (2) - (3) assume that β_k, $k = \overline{1,7}$. Normalized initialization functions for variable *Personality* are presented in Fig. 5 a), for variable *Plaintiff* in Fig. 5 b).

The fourth step, namely the definition of a linguistic variable based on the model created and the fuzzy production system setup, was carried out using the automated ANFIS in MATLAB system. The network learning method is a hybrid, which is a combination of the least-squares method and the inverse gradient reduction method.

a)



b)

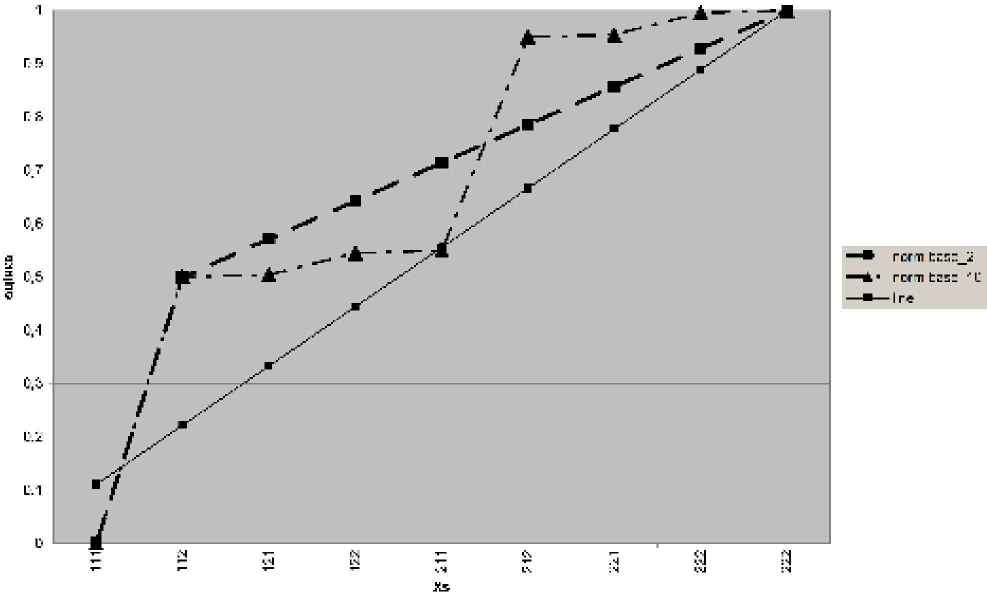


Fig. 5. Normalized initialization functions a) variable *Personality* , b) variable *Plaintiff*.

In Fig. 6 shown the structure of the neuro-fuzzy system. The system consists of 4 layers. On the first layer put the numerical values of the input vector. The second layer is a phase layer in which the modules reproduce a fuzzy membership function to represent the input values in a fuzzy set. Each module at this level corresponds to a certain fuzzy set. The next layer defines the fuzzy rules. Each module at this level meets certain rules. Each node connects to those nodes of the first layer that form the preconditions of the corresponding rule. The modules implement operations "AND" with a minimum in the t-norm form [16]. The fourth layer implements an output device, one for each output.

The input vectors are initialized by function (2) with the basis either $base = 10$, or $base = 4$ for *Personality* and $base = 2$ for *Plaintiff*, or (3) with normalization and without normalization. The experiment results showed that the best accuracy was obtained with the normalized initialization functions (2) $base = 4$ for *Personality* and $base = 2$ for *Plaintiff*. The biggest error is given by function (3).

a)

b)

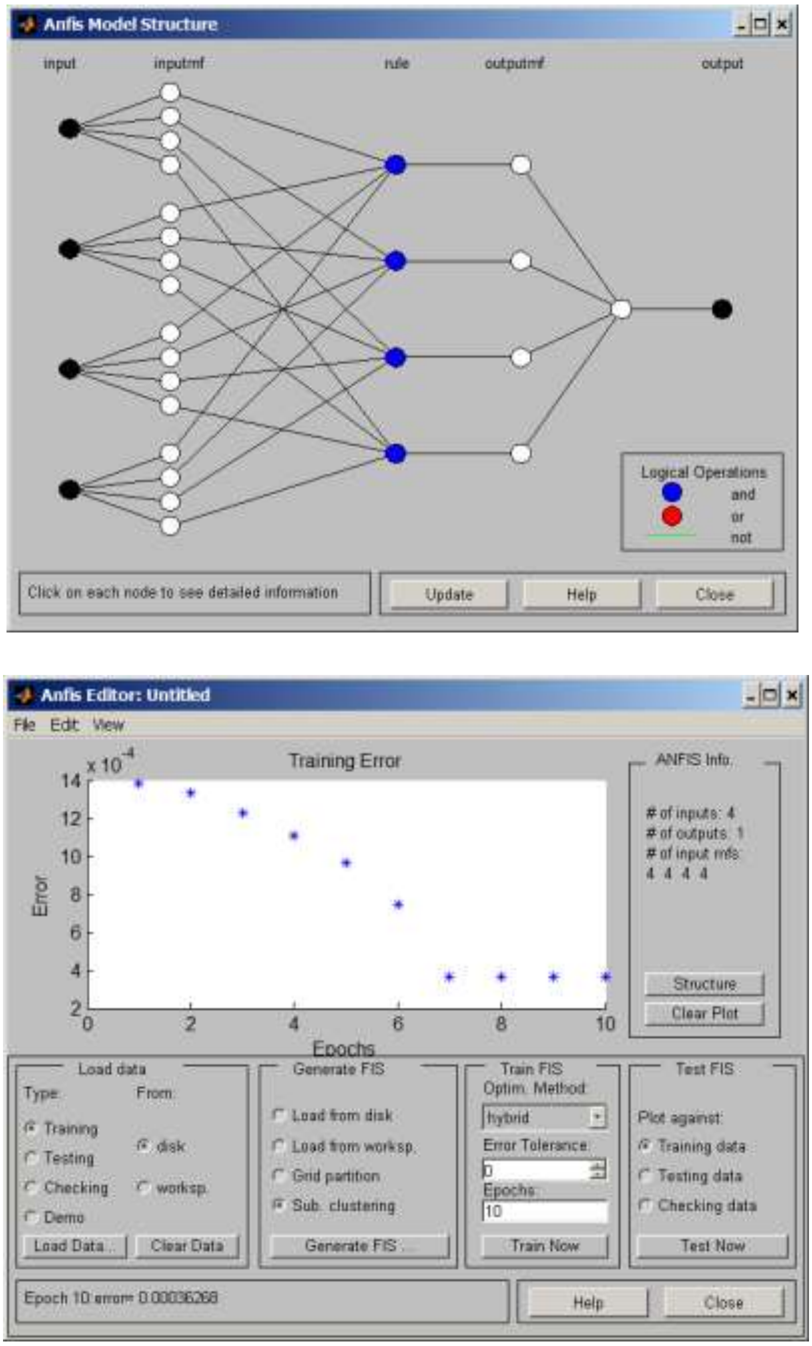


Fig. 6. A neuro-fuzzy system built on normalized data that is initialized by function (2) $base = 4$ for *Personality* and $base = 2$ for *Plaintiff* a) neural network, b) learning error.

4.2 An Example of Building Production System under Part 2 of Art. 240 of the Criminal Code of Ukraine

The variable model *Personality* is the same as the previous example. The *Plaintiff* in Article 240 is considered the state. The state's mitigation of the sentence is provided by the Law of Ukraine on the Use of Amnesty in Ukraine [18]. Therefore, the model of the *Plaintiff* variable is represented in relation to the effect of this law, and the ordering is made in relation to the term "Adjusting to mitigation".

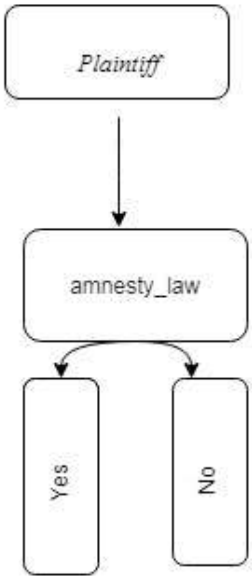


Fig. 7. Plaintiff Ontology Concept Model for Art. 240

$P^2_{plaintif} = \{$ amnesty_law $\}$, $|P^2_{plaintif}| = 1$. Therefore, the variable definition area $P^2_{plaintif}$ has power $|X^2_{plaintif}| = 2$. The digraph in Fig. 7 reflects the expertly defined order of characteristics. In the third step, we calculate the normalized values of the estimates based on the formula (2) with $base = 10$ or $base = 4$ for $Personality$ and $base = 2$ for *Plaintiff*, or (3) with normalization and without normalization (Fig. 5 a)).

Several experiments were performed for the selected sentence collection: for sentences containing fines; for sentences containing years of imprisonment and restriction of freedom, and for the general sample with pre-coding of sentences according to the severity of the sentence. Construction and training of fuzzy inference systems were performed. Experiments were conducted with variants of forming an input vector similar to Example 1. The conclusions were obtained similar to Example 1.

5 Discussions and Further Researches

In practical application of the initialization functions (2) - (3), some certain features must be considered.

The estimates (2) need normalization, to provide a global scale when not all attributes of a qualitative variable α have their characteristics.

The initialization functions are discrete, which makes it possible to obtain a finite set of evaluation values.

For the adopted method, not all values of the abscissa axis are implemented in vectors x_s . Entering an identifier corresponding to the number of possible values $k_i, i = \overline{1, n}$ for each trait will eliminate the redundancy.

With many features, there are limitations in the accuracy of the calculations. In this case, it would be appropriate to break the set of features into subsets, with their further implementation in separate product rules.

In terms of further research, methods of distinguishing the terms of the concepts of the ontology of the court decision need to be developed. It is necessary to build sufficiently exact ‘fine’ algorithms for recognition of the semantics of court sentences, because the vocabulary contains antonymic pairs, differing in the proportion "no", homonyms, the same keywords for different classes of information.

6 Conclusions and Acknowledgment

Scientific novelty is determined by firstly developed common Sentence Knowledge Base based on the method of formalizing Ukrainian-language content for fuzzy output production systems. The structure of the information contained in the court sentence is based on a combination of different crime circumstances reflected in the court's DSS model and ways of formalizing it as input to the fuzzy output system.

The development will allow the processing of large volumes of court sentences as training samples for fuzzy inference systems.

The work was carried out as the part of the research work «Mathematical modeling of socio-economic processes and systems», the registration number DB05038, at the Department of System Analysis and Computational Mathematics of "Zaporizhzhia Polytechnic" National University.

7 References

1. Von, D., Zareczka, I., Suchenko, S. et al. Yevropejs`ki ta mizhnarodni standarty u sferi sudochynstva [European and international standards in the field of justice] Madoyan, Kyiv (2015) (In Ukr.).
2. Bryntsev, O. “Elektronnyi sud” v Ukraini. Dosvid ta perspektyvy [“E-court” in Ukraine. Experience and perspectives] Pravo, Kharkiv (2016) (In Ukr.).
3. Tobota, Yu. Poniattia ta kryterii «spravedlyvoho sudovoho rozghliadu» u rishenniakh yevropeiskoho sudu z prav liudyny [Conception and criteria of «fair legal process» in judgements

of European Court of human rights]. Visnyk Kharkivskoho natsionalnoho universytetu imeni V. N. Karazina **1086**, 65-68 (2013) (In Ukr.).
4. Lytvyn, V., Vysotska, V., Hrendus, M. Method of data expression from the ukrainian content based on the ontological approach. Radioelektronika, informatika, upravlinnya **30**, 157 (2018).
5. Rakytianska, H. Optymizatsiia spoluchenykh nechitkykh baz znan na pravylakh i vidnoshenniakh [Optimization of complied fuzzy knowledge based on rules and relations]. Informatsiini tekhnolohii ta komp`iuterna inzheneriia **1**, 17-26 (2015) (In Ukr.).
6. Jaafari, A., Zennerb, E., Panahic, M., Shahabid, H. Hybrid artificial intelligence models based on a neuro-fuzzy system and metaheuristic optimization algorithms for spatial prediction of wildfire probability. Agricultural and Forest Meteorology **266-267**, 198-207 (2019).
7. Neuro-Adaptive Learning and ANFIS, https://www.mathworks.com/help/fuzzy/neuro-adaptive-learning-and-anfis.html#responsive_%20offcanvas. Last access 2020/02/28.
8. Valkman, Yu., Hala, E. Proektirovanie ontologii dlya pravovoy predmetnoy oblasti na osnove tekstovogo kontenta s ispolzovaniem nechyotkoy logiki [Designing ontology for a legal subject area based on textual content using fuzzy logic]. Ontologiya proektirovaniya **2(12)**, 19-39 (2014) (In Russian).
9. Bakurova, A., Tereschenko, E., Filei, Y., Pasichnyk, M., Ropalo, H. Modeling of decision making ontology. PROCEEDINGS OF THE 3RD INTERNATIONAL CONFERENCE ON COMPUTATIONAL LINGUISTICS AND INTELLIGENT SYSTEMS (COLINS-2019). Vol.1: Main Conference. http://ceur-ws.org/Vol-2362/paper18.pdf (2019).
10. Bakurova, A., Tereschenko, E., Filei, Y., Pasichnyk, M. Production model for administration of judicial decisions in the case of theft. EXPERIMENTAL ECONOMICS AND MACHINE LEARNING FOR PREDICTION OF EMERGENT ECONOMY DYNAMICS. Proceedings of the Selected Papers of the 8th International Conference on Monitoring, Modeling & Management of Emergent Economy (M3E2-EEMLPEED 2019), vol. 2422, pp.284-296. Odessa, Ukraine. http://ceur-ws.org/Vol-2422 (2019).
11. Bakurova, A., Pasichnyk, M., Tereschenko, E. Fuzzy Modeling of Verbal Information for Production Systems. Innovative Technologies and Scientific Solutions for Industries **4(10)**, 5-13. DOI: https://doi.org/10.30837/2522-9818.2019.10.005 (2019).
12. Kriminalniy kodeks Ukrayiny, (In Ukr.), http://zakon.rada.gov.ua/. Last access 2020/02/28.
13. Court decisions register of Ukraine, (In Ukr.), http://www.reyestr.court.gov.ua. Last access 2020/02/28.
14. Ore, O. Theory of graphs, American Mathematical Society Colloquium Publications vol. 38; 270 (1962).
15. Manning, Ch., Raghavan, P.,Schutze, H. Introduction to Information Retrieval, Cambridge University Press, UK (2008) Online: https://doi.org/10.1017/CBO9780511809071 Last access 2020/02/28.
16. Lande, D. Elementy kompiuternoi linhvistyky v pravovii informatytsi [Elements of computational linguistics in legal informatics]. NDIIPR, Kyiv (2014) (In Ukr.).
17. Novak, V., Perfyleva, Y., Mochkrozh, Y. Matematicheskie principy nechetkoj logiki [Mathematical Principles of Fuzzy Logic]. Fizmatlit, Sankt-Peterburg, (2006) (In Russian).
18. Amnesty Law of Ukraine, (In Ukr.), https://zakon.rada.gov.ua/laws/show/392/96-%D0%B2%D1%80. Last access 2020/02/28.