REPUBLIC OF AZERBAIJAN

On the rights of the manuscript

ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

FUZZY MODELING OF SOCIO-LEGAL EVENTS AND PROCESSES IN PROCEDURAL LAW

Specialty: 3338.01 – "System analysis, control and
                         information processing"

Field of science: Technical sciences

Plaintiff: **Agayev Faig Bahadur**

Baku – 2021

The work was performed at the Institute of Control Systems of the Azerbaijan National Academy of Sciences.

Scientific supervisor (consultant):   doctor of technical sciences, professor **Ramin Rza Rzayev**

Official opponents: doctor of technical sciences, professor **Cavanshir Firudun Mammadov**

doctor of technical sciences, dosent **Mehriban Isa Fattahova**

PhD in technique **Hanmurad Hanbala Abdullayev**

Dissertation council ED 1.20 of Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at the Institute of Control Systems of the Azerbaijan National Academy of Sciences

Chairman of the Dissertation council:

academian of ANAS, doctor of technical sciences, professor **Ali Mamed Abbasov**

_____

Scientific secretary of the Dissertation council:

doctor of technical sciences, professor **Naila Fuad Musayeva**

_____

Chairman of the scientific seminar:

doctor of technical sciences, dosent **Fahrad Haydar Pashayev**

_____

GENERAL CHARACTERISTICS OF WORK

Relevance of the work. Hundreds of cases of use of assessment concepts can be observed in the procedural law of any country, in its legal norms. Each concept of assessment is unique in its own way, because it has its own history of creation and evolution, periodic repetition of its application, analogues in the legal norms of foreign countries, and its own special allocation.

Assessment terms used in legal norms governing procedural legal relations reflect fuzzy concepts. In the legal doctrine of any state, they are called assessment concepts. Thus, during the correct application and interpretation, they allow achieving the effectiveness of lawmaking and law enforcement, the unequivocal clarification of the rights and responsibilities of citizens, the interference of moral ideas in the legislative and legislative process. With their help, it is possible to amortize the contradictions between the formal definition of the rule of law and the flexibility of the dynamics of public life. However, in practice, there are very difficult but completely justified complications in the use of assessment concepts. First, this is due to the fact that in most cases it is impossible to replace the concepts of assessment with formally defined expressions, i.e. formalisms, although in some cases it is not appropriate for this purpose. Therefore, if necessary, there is a great need to replace the concepts of assessment with appropriate formalisms and to carry out the process of alternative law regulation (application of law) on their basis with the application of full scientific justification. Here, we should bear in mind that any concept of assessment must be present in the expression of legal norms in an accessible and clear form of natural language for a wide range of the population. However, most words in the natural language of communication reflecting these and other concepts have semantic uncertainty, or, to put it simply, fuzzy.

This is explained by the fact that human nature, by its very nature, is fuzzy at all its levels, whether scientific or domestic, and it is impossible to describe it by traditional classical mathematical methods

when necessary. It is the semantic uncertainty that assessment concepts carry that becomes a "headache" for legislators and law enforcers in the first place.

The problem of semantic uncertainty in fuzzy assessment concepts is not only a legal but also a general scientific problem. Representatives of both the humanities and the exact sciences are engaged in its elimination. The term "concept of assessment" was first coined in 1956 by S.I. Vilyansky in the post-Soviet space. Over the following decades, important research in the field of legal aspects of assessment concepts was carried out in the fundamental works of T.V. Kashanina and D.N. Levi on the general theory of law; on criminal law of R.S. Jinjolia and others; on Civil Law of D.A. Garaymovich; also on criminal process of S.S. Bezrukov; on labor law of Y.A. Stepanova; on administrative law of V.V. Ignatenko; on suffrage of A.V. Mironov. Nevertheless, the logical (sometimes decisive) significance of the concepts of assessment in the process of law-making and application still remains poorly understood. R.M. Nigmatdinov's monograph on the conceptual apparatus of civil procedural law in the Russian-speaking environment and V.V. Yarkov's scientific work on the application of the concepts of arbitration and assessment in civil procedural law can also be mentioned.

It is also worth noting in the field the services of J. Karimov, the world-class Azerbaijani scientist in legal cybernetics, corresponding member of the Russian Academy of Sciences, Academician of ANAS (since 1967), Serbian Academy of Sciences and Arts, Finnish Academy of Sciences and Letters, Montenegrin Academy of Sciences and Arts, Russian Academy Sciences' Institute of Social Sciences, also of the International Academy of Information Processes and Technologies, the Academy of Political Sciences of the Russian Federation, International Informatization Academy and Honored Scientist of the Russian Federation. Synthesizing legal science with information, Karimov is the first legal scientist in the USSR to deal with legal cybernetics. Among his numerous scientific works are the

books "Philosophical Problems of Law" (1972) and "Methodology of Law" (2008).

Thus, the abovementioned considerations prove the relevance of the topic and essence of the existing dissertation research.

The purpose of the work. The main purpose of the dissertation is to eliminate the semantic uncertainty of the assessment concepts used in procedural law, to reveal the interpretive features of their interpretation through fuzzy modeling of legal norms and on this basis to develop a methodology of information support of procedural decision-making process (PDMP); to develop a methodology for information support of the decision-making process in the framework of legal regulation of procedural legal relations

In order to achieve this goal, it was proposed to address the following issues:

❑ Disclosure of the logical and legal essence and content of fuzzy concepts of law;
❑ Study of the logical structural model of the legal norm;
❑ Fuzzy modeling of the legal norm, taking into account the existence of semantic uncertainty in the concepts of assessment;
❑ Classification and assessment of violations, taking into account the existence of semantic uncertainty in the concepts of assessment;
❑ Development and simulation of the concept of the information system supporting the decision-making process.
❑ Characteristics of social and legal events, procedural rights, norms and relations of criminal procedure law.

Object and content of the research. The object of scientific research carried out within the dissertation is the articles of the Criminal Code of the Republic of Azerbaijan, the corresponding legal doctrines, as well as public relations related to criminal cases on the basis of Article 165 ("Infringement of copyright or related rights").

The content of the research of the dissertation is the assessment concepts of procedural law, which determine the amount of pecuniary damage and, at the time of its application, generally reflect the legitimacy and nature of the genesis.

Methodological bases of research. The current research methodology is based on the methods of control technologies using elements of artificial intelligence, as well as fuzzy logic and neural networks that successfully reflect themselves in decision-making processes in uncertainty environment. For example, the assessment used in procedural law allows the development of a formal apparatus that does not require complex mathematical calculations to describe the legal norms of the application of fuzzy logic in the elimination of semantic uncertainty of concepts. In addition, the mathematical apparatus of fuzzy set theory allows the processing of unmeasured data as well as measured data.

Hybrid (*neural-fuzzy*) method is also used in the dissertation. It became clear on the basis of the application of this method in a special example of procedural law and law enforcement that during the application of the law, in the presence of semantic uncertainty in the concepts of assessment, it is possible to create fundamentally new hardware and software tools that can provide information support to the decision-making process.

Scientific results. The main results obtained in defense are expressed as follows:

❑ Clarification of the logical-legal essence and content of the concepts of fuzzy assessment of law;
❑ Study of the formal model of the logical structure of the legal norm;
❑ Development of a fuzzy model of the legal norm, taking into account the existence of semantic uncertainty in the concepts of assessment;
❑ Assessment and classification of violations of the law, taking into account the existence of semantic uncertainty in the concepts of assessment;
❑ Development and simulation of the concept of information support system of procedural decision-making process.

Theoretical and normative bases of research. The theoretical basis of the research is the field knowledge acquired by the plaintiff in law, as well as the combined knowledge that is inextricably linked

with them, and events in the field of lawmaking and law enforcement. The plaintiff tried to understand critically and to initiate the development of the theoretical potential of formal logic based on the mathematical apparatus of fuzzy logic in terms of the study of the concepts of assessment in the legal norms of procedural law. The normative bases of the scientific research carried out within the dissertation work are the sources of the legislation on civil and administrative methods of judgment, in particular, the articles of the Criminal and Criminal-Procedural Codes of the Republic of Azerbaijan.

Scientific novelty of the research and its provisions put forward for defense. The novelty of the research conducted in the framework of the dissertation is reflected in the formulation and expression of vague approaches to the formalism of the legal norms as a whole, and in particular to the concept of evaluation. Based on the existing approach, the concept and methodology of developing an information support system for procedural decision-making with the application of a neural-fuzzy (hybrid) modeling system were expressed.

The dissertation is an uncompleted individual research work. The results of the analysis of semantic uncertainty in the assessment concepts of procedural law were also reflected here. Within the framework of the research, the author's interpretation of the logical structure of the legal norm was expressed and substantiated in the sense that its content was expressed in the form of cause-and-effect relationships through the rules of implication.

Thus, for the first time, the assessment concepts set forth in the norms of the procedural law of the Republic of Azerbaijan, reflecting the amount of damage, are considered in the complex - in the process of application of the law in the form of fuzzy formalisms during the period of their existence and development. The complex approach is reflected in the fact that these concepts of assessment are analyzed and studied from both the semantic and formal (fuzzy) point of view of the doctrine of law.

According to the results of the scientific research carried out within the dissertation, the applicant defended the following provisions:

❑ The concept of semantic uncertainty was expressed and applied in the assessment concepts that can be used in jurisprudence: thus, semantic uncertainty in the concept of assessment is an integral part of the legal norm. It entrusts the law enforcement officer with the choice of a free, intellectually willed and morally justified procedural decision.

❑ The semantic nature of the concept of eassessment was analyzed in a new way. It was determined that the distinguishing feature of the concept of assessment in the legal norm is not related to the obvious nature of its logical structure. It is due to the ambiguity of the semantic content of the legal norm.

❑ In the example of the concept of the amount of material damage, the definition of the concept of assessment of procedural law was given from a formal point of view: as a fuzzy concept that regulates the judicial process and carries additional information in a specific court case for the law enforcement within the fuzzy extract system.

❑ Given the presence of semantic uncertainty in the assessment concepts, a fuzzy model of the rule of law has been developed.

❑ Given the existence of semantic uncertainty in assessment concepts, fuzzy methods for classifying and assessing violations have been developed and articulated.

❑ The concept of an information system supporting the decision-making process based on a fuzzy logic output system implemented on a neural network basis was expressed, and a simulation was performed on a specific example.

Theoretical and practical significance of the dissertation. The practical significance of the dissertation is that the results obtained can be applied in court practice, for example: in the interpretation of assessment concepts by law enforcers (law enforcement officers), in the interpretation of court decisions of all instances, in lawmaking - in the improvement of legislation and legal norms that include assessment concepts. In addition, due to the use of a large number of assessment concepts in legal documents, it would be appropriate to include in the

curricula of higher education law specialization "Procedural law assessment concepts" subject.

Approbation of the obtained results. The dissertation was developed in the laboratory "Methods of signal recognition and technical diagnostic systems" of the Institute of Control Systems of the Azerbaijan National Academy of Sciences and was discussed in the laboratory and general institute seminars. The main provisions of the dissertation were published in eight scientific articles and commented on in September 2016 at the International Scientific Conference on Application of Fuzzy Systems and Soft Computing (ICAFS).

Structure and volume of work. The dissertation consists of introduction, four chapters, results and a list of 75 literary sources. Without the table, figures and the list of the literatures the volume of the main content of the dissertation consists of 204500 characters, including: introduction - 15216 characters, Chapter I – 65900 characters, Chapter II - 42282 characters, Chapter III – 44562 characters, Chapter IV - 34728, Results - 1812 characters.

CONTENT OF THE DISSERTATION

The **Introduction** explained the relevance of the dissertation, emphasized the basics of research, reflected the scientific novelty and theoretical and practical significance of the work, outlined the provisions to be defended with the purpose to achieve the goals of the dissertation, and described the content and structure of the work, including the results sought.

The **First Chapter** is devoted to the problems of semantic uncertainty in the assessment concepts of law, and in this chapter, the essence of the existing assessment concepts in jurisprudence is considered. It is noted that the problem of assessment concepts is not sufficiently developed as part of the general problem of uncertainty in the legal doctrine of the state. According to these views, the main issue of the scientific research carried out within the dissertation was stated. The research question in the chapter is expressed as the need to develop a mechanism designing an information support system for the

PDMP, provided that semantic uncertainty in the assessment of legal norms is eliminated.

The problem of exempting legal norms and assessment concepts from fuzzy as one of the factors of uncertainty inherent in the natural language system, for example, is even more acute. Such uncertainty can be overcome through the context of the "fuzzy word." However, this is not always possible, because the technique of describing law is not perfect and cannot be a priori perfect. Take, for example, the terms of assessment that are common in legislation, such as "honest", "difficult", 'immediate', "basic", "special", and "obvious", etc. In jurisprudence, they are given the same meanings as the corresponding words of natural language. Even in the use of ordinary words (for example, household), their content is often blurred and their very meaningful interpretation is also allowed.

However, the use of the above-mentioned concepts of assessment of legal norms in the legislation does not mean that there is a sloppiness of the legislative person, in particular, the ambiguity of the content of legal norms is justified in some cases, because it acquires the necessary flexibility in the expression of law.

Thus, the current chapter examines the problem of uncertainty in procedural law. Take, for example, the concepts of assessment that are common in legislation, such as "real", "secret", "short-term", "basic", and "obvious", etc. In law, they are given meanings that apply to the relevant words of the natural language. Even in the development of the word household, their content is often vague and allows for ambiguous interpretation.

The **Second Chapter** is devoted to the process of decision-making based on the methods of fuzzy logic and the study of methods of applying hybrid systems, and in this chapter, the methods of overcoming semantic uncertainties inherent in the natural language system are considered as well. For example, methods of neural-fuzzy modeling and fuzzy set theory were applied as means of informatization of weakly structured objects of the conceptual types of assessment of legal norms.

The main point of the chapter is the analysis of multivariate selection methods among fuzzy alternatives based on the point assessment and intersection of fuzzy sets. In addition, the implementation of the fuzzy

extraction mechanism on the logical basis of neural networks is explained in detail here. Artificial neural networks were dynamic systems capable of learning. They are resistant to noise and have a wide range of properties. A neural network consists of numerous processor elements (artificial neurons) that interact. These neurons differ in their teaching characteristics and are generated based on examples and data.

Figure 1 presents a model of a five-layer feed forward-type neural network.
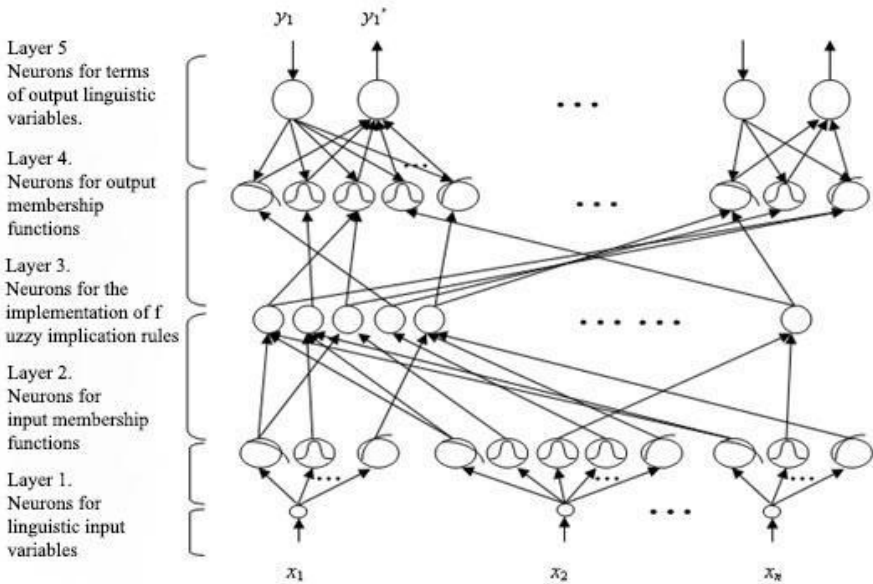
Fig. 1. Fuzzy extraction mechanism in the logical basis of the neural network

Due to its own structural and parametric learning ability this network implements an autonomous system of fuzzy logic that supports the decision-making process in the environment of uncertainty.

The **Third Chapter** proposes a new method that eliminates semantic uncertainty in the concepts of assessment in procedural law. In this chapter, Article 165 of the Criminal Code of the Republic of Azerbaijan

(Infringement of author's or adjacent rights) was taken as an example, and the formalism of the notion of "significant damage" assessment was proposed, provided that it was harmonized with the sanction applied on its basis.

In order to provide an adequate punishment for the notion of assessment, a gradation scale of possible sanctions obtained on the basis of the description of the relevant legal norm in terms of fuzzy implicative rules is proposed. Here we understand the following formalism under the name of a logical structure that reflects the essence of the concept of assessment as a starting condition:

$$C = x_1 \backslash x_2 \backslash \ldots \backslash x_n \backslash y_1 \backslash y_2 \backslash \ldots \backslash y_m. \tag{1}$$

Here, C is the content of the assessment concept; x_i $(i=1 \div n)$ are signs of this content known to the person applying the right; y_j $(j=1 \div m)$ are features added to the definition of assessment defined in the process of law enforcement. That is determined as a result of such analysis that under the name of the logical structure of the legal norm, they understand the topological set (or unity) of three dialectically interrelated elements: *hypothesis*, *disposition* and *sanction*. These elements support the functional autonomy of this collection. As a result, the logical structure of the legal norm is described as follows.
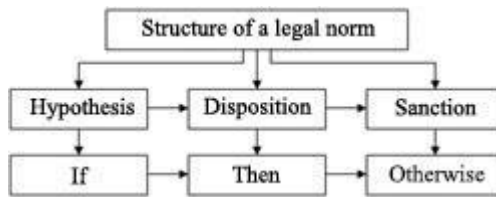
Fig. 2. The logical structure of the legal norm

The nature and means of the interaction of the legal norm elements are determined by the existing public relations, as well as by the specific features of the elements themselves. It is impossible not to take into account the existence of the human factor in the personality of the legislator because the legislator, by his voluntary decision, forms the content of all elements of the legal norm and connects them

with other legal factors. From a formal (mathematical) point of view, the norm of law N is usually described in the following implicative way, i.e. in the form of a logical statement:

$$N = ((C \Rightarrow E) \wedge (C \wedge \overline{E})) \Rightarrow S$$

(2)

Here C - indicates the conditions (legal situation) for the implementation of the legal norm; E - is a legal instruction; S is a sanction. The implication of *SE*, the core of the rule of law, creates a cause-and-effect relationship between a specific legal situation and a sanction. In this case, the existence of a violation is the result of the appropriate *S* sanction.

According to the principle (1), the structure of any legal norm can be formalism. However, it is possible to be satisfied with simplified expressions in specific cases. For example, suppose that the act of breaking any law is symbolized by A, and B symbolizes the signs of the act of breaking this law. If an equivalent relationship is established between them, then the S sanction is applied. In other words, the following implicative rule exists:

$$(A \approx B) \Rightarrow S$$

(3)

In fact, this rule reflects the following idea: the presence of a certain component (A) of the offense characterized by certain features (B) leads to the application of the relevant sanction (S). Assessment can be specified by changing the symbols (3) with the help of the necessary formulas that reflect the structure of the concepts. As a result, it is possible to obtain more complex configurations of legal norms.

Take, for example, Article 165 of the Criminal Code of the Republic of Azerbaijan, entitled (Infringement of author's or adjacent rights). This article is expressed as follows:

165.1. Illegal use of author's or adjacent rights objects, that is edition under a name or different way in assignment of authorship of another's scientific, literary, art or other product, its illegal reprinting or distribution, as well as compulsion to co-authorship and as a result of these acts damage caused was in significant size - is punished by the fine at a rate from 1000 up to 2000 manats or public labor for the term from three hundred and twenty up to four hundred eighty hours.

165.2. The same acts committed:

165.2.1. repeatedly;

165.2.2. on preliminary arrangement by group of persons and by organized group — is punished by a fine at a rate of 2,000 to 4,000 manats, or correctional labor for the term up to 2 years, or restriction of liberty for up to 2 years, or imprisonment for up to 2 years.

Taking into account the accepted signs, the existing legal norm can be described as follows:

$$\begin{cases} (A \approx B_1) \Rightarrow S_1, \\ (A \approx (B_1 \wedge B_2)) \Rightarrow S_2. \end{cases}$$

$$(4)$$

At first glance, everything is quite clear and concisely described by the expression of the existing legal norm and its kind of logical formalism (3.4). But this only seems so at first glance. This includes the notion of "significant harm" assessment as an obstacle, or more precisely, its semantic uncertainty. Along with other terms such as "insignificant damage", "large amounts of damage", "a very large amount of damage", "significant damage", etc., the linguistic variable *"amount of damage"* has an important place in the interpretation of the law and in the law enforcement process.

The point is that an improperly thought out assessment of the amount of damage can lead, on the one hand, to incomplete protection of copyright and related rights, and, on the other hand - to an unjustified extension of the sanction. In addition, the terms of the linguistic variable "*amount of damage*" can be interpreted differently in different situations. Therefore, it is necessary to develop an appropriate gradation scale for each specific case or event.

For example, the following five assessment concepts were selected to assess the violation and to express the appropriate sanction: u_1 – "Small amount of material damage"; u_2 – "significant material damage"; u_3 – "great material damage"; u_4 – "significant damage'; u_5 – "significant damage". Simply put, under the name of $C=(u_1, u_2, u_3, u_4, u_5)$ plurality we understand a set of signs that classify sanctions. Then, if we consider the criteria used in the legal norm as fuzzy sets, then perform the assessment of the offense with the application of a sufficient set of fuzzy implicative rules of the type "<If ..., then ....>"

and an appropriate gradation scale of possible sanctions is drawn up on its basis. Thus, the main points of Article 165 of the Criminal Code of the Republic of Azerbaijan are expressed differently as follows:

e_1: "If there is a publication of another's scientific, literary, artistic or other work in one's own name, or another misappropriation of another's authorship, as well as coercion to co-authorship, a minimum fine (from 1,000 to 2,000 manats) is imposed.";

e_2: "If, in addition to the above, there is an illegal reprint or distribution of such work, a fine of more than the minimum (three hundred and twenty to four hundred and eighty hours of public labor) is imposed.";

e_3: "If, in addition to the terms of e_2 the same acts are committed repeatedly or by a group of persons or an organized group in collusion, then the maximum penalty (fine of 2000 to 4000 manats or correctional labor for up to two years or restriction of liberty for up to two years or imprisonment for up to two years) is imposed";

e_4: "If the case in question contains all the features listed in order e_2, but the damage is caused by the repetition of the same acts by only one person, except for a group of persons previously involved in the crime, then the average penalty (in the amount of 2000 to 4000 manats) is imposed";

e_5: "If there is coercion to co-authorship, but the publication of another's scientific, literary, artistic, or other work under his own name has not been proven to have been committed by a group of persons or an organized group with prior connivance, then the average penalty (in the amount of 1000 to 2000 manats) is imposed";

e_6: "If there is no publication of another's scientific, literary, artistic or other work in one's own name, and if the coercion of co-authorship is not confirmed, then there is no criminal liability.".

As a result of the implementation of these rules, a general functional solution to the problem was found in the form of the following matrix:

$$R = \begin{bmatrix} & 0 & 0.1 & 0.2 & 0.3 & 0.4 & 0.5 & 0.6 & 0.7 & 0.8 & 0.9 & 1 \\ u_1 & 0.9917 & 0.9987 & 0.9987 & 0.9492 & 0.8792 & 0.7892 & 0.6792 & 0.5492 & 0.3992 & 0.2292 & 0.0392 \\ u_2 & 0.9111 & 0.9817 & 0.9817 & 0.9817 & 0.9809 & 0.8909 & 0.7809 & 0.6509 & 0.5009 & 0.3309 & 0.1409 \\ u_3 & 0.7009 & 0.8009 & 0.8701 & 0.8701 & 0.8701 & 0.8701 & 0.8701 & 0.8701 & 0.7279 & 0.5579 & 0.3679 \\ u_4 & 0.3588 & 0.4588 & 0.5203 & 0.5203 & 0.5203 & 0.5203 & 0.5203 & 0.5203 & 0.5203 & 0.5203 & 0.6977 \\ u_5 & 0.0482 & 0.0784 & 0.0784 & 0.0784 & 0.0784 & 0.0784 & 0.0784 & 0.0784 & 0.0784 & 0.0784 & 0.9608 \end{bmatrix}$$

Line k of this matrix represents a fuzzy statement about the level of appropriate sanction being enforced. The final scale for assessing and selecting the appropriate sanction for a copyright infringement case within the accepted hypotheses is described as in Figure 3. Let's use the gradation obtained from the "*Level of Damage*" assessment concepts used in the application of the law with regard the infringement of author's or adjacent rights to classify sanctions according to the nature of the infringement. As a result, this classification (on the example of Article 165 of the Criminal Code) will be described as Table 1.

Insignificant damage - significant damage - large amounts of damage - quite a large amount of damage – a large amount of damage
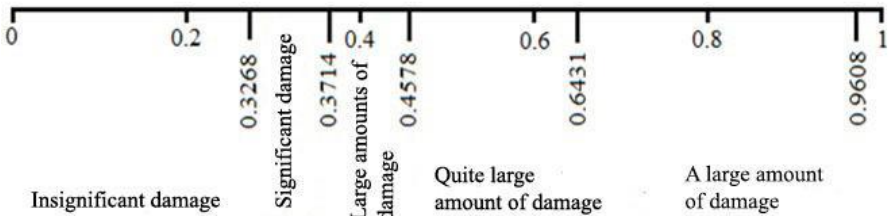
Fig. 3. Sanctions selection scale based on possible damage levels

**Table 1.** Classification of sanctions for violations of the law

Sanction	Comment	The concept of evaluation	Interval
Not guilty	There is no criminal liability	A small amount of damage	[0, 0.3268]

16

Minimal	Fine in the amount of 1000-2000 manats	Significant material damage	(0.3268, 0.3714]
Above the minimum	Imposing public works from 320 to 480 hours	Great material damage	(0.3714, 0.4578]
Medium heavy	Fine in the amount of 2000-4000 manats	Very significant damage	(0.4578, 0.6431]
Maximum	imprisonment for up to two years	Significant damage	(0.6431, 0.9608]

A special case has been considered. For example, let's consider a case of copyright infringement committed by a person for the first time and with a loss of 1,500 manats. Assume that the amount of damage shown corresponds to the interval u_2 or [0.2; 0.4] in our special case. At the MATLAB/Fuzzy Sets Toolbox (Figure 4) notation, the score was 0.38. This shows that the minimum sanction for the gradation of the obtained sanctions, i.e. 160 to 240 hours of public works. Thus, in the context of the disclosure and assessment of the methodological essence of fuzzy logic in lawmaking and law enforcement, a suggestion has been made to eliminate the semantic uncertainty in the assessment concepts of procedural law. The fuzzy implementation of Article 165 of the Criminal Code of the Republic of Azerbaijan "Infringement of author's or adjacent rights" proposed in this chapter reflects the cause-and-effect relationship between the concepts of assessment on the one hand, and the sanctions imposed on the other.

In other words, a vague analogue of a possible sanction, such as a sanction corresponding to the notion of "significant loss", was obtained on the basis of existing assessment concepts in the form of terms of the linguistic variable "amount of damage".
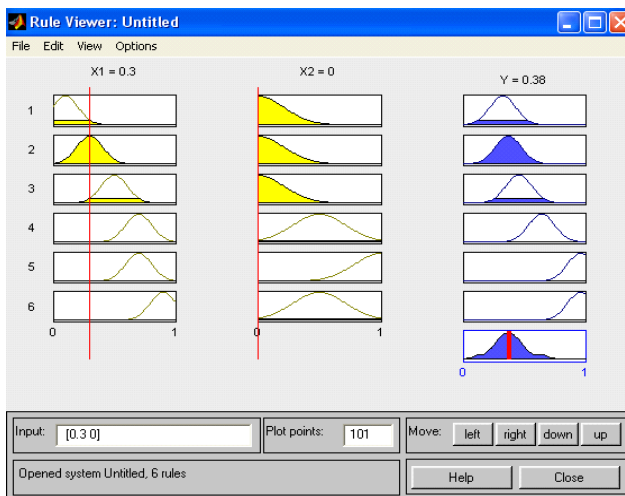
Fig. 4. Determining the level of sanction for infringement of copyright or related rights in the notation of the application package MATLAB

The Fourth Chapter proposes a means of implementing a fuzzy logic system (FLS) based on the generalized neural network model described in Chapter 2, or in other words, its logical basis, which supports the procedural decision-making process. As it was mentioned above, the connectivity model, presented in the form of a *feed-forward* multi-layered neural network, supports the ideology of fuzzy logical control at the logical basis of neural networks. Here, PDMP FLS training is automatically generated through the implementation of training and pilot activities based on relevant sets of input-output data. As an example, Article 165 of the Criminal Code, which is expressed in the Fourth Chapter in the form of six fuzzy implicative rules, was chosen. The development of these rules through the Mamdani-type FIS editor of the MATLAB package has made it possible to establish the majority of training pairs required to establish a fuzzy logic system that supports the procedural decision-making process (Fig.5) and it formed the basis for the development of an information system that supported the procedural decision-making process.

The structure of the Sugena-type FIS fuzzy extraction system is generated. This structure is a model of a hybrid network in the MATLAB package. To do this, we activate the Gaussian membership function to describe the terms of input and output linguistic data through fuzzy sets through a dialog box. After the generation of the hybrid network, it is possible to visualize the structure of the PQQE FLS in the notation of the five-layer neural network. In other words, after the generation of the hybrid neural-fuzzy system, the structure of the fuzzy logic system supporting the decision-making process was visualized as in Figure 6 in the logic base of a 5-layer neural network.
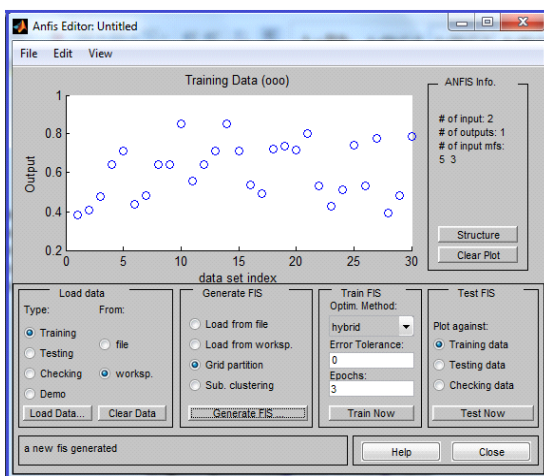

Fig. 5. Graphical interface of ANFIS editor
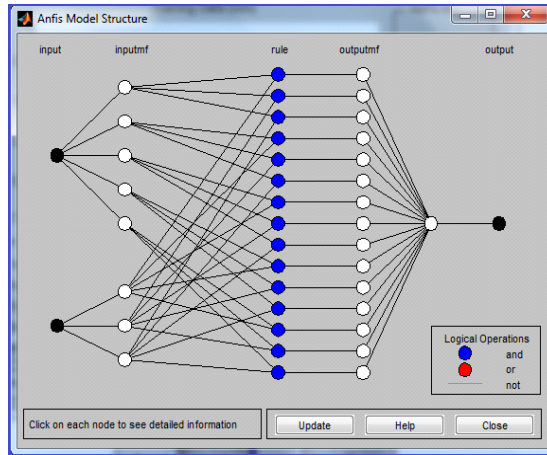
Fig. 6. The structure of the neural network in the logical basis of the Fuzzy extract system

Further adjustment of the parameters of the installed and trained PQQE FLS can be done using the standard graphics tools of the Fuzzy Logic Toolbox. As a result of the learning process, the input properties of the hybrid system were optimized. Thus, as shown in Figure 7, the parameters of the Gaussian-type membership functions of fuzzy sets representing the terms of the linguistic variables x1 and x2 are optimized.
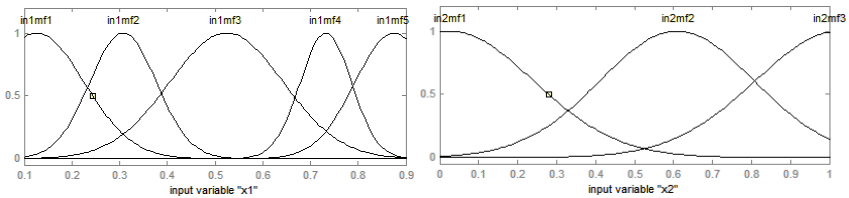
Fig. 7. Optimized affiliation functions on inputs

Table 2 simplifies the "taught" fuzzy implicative rules. For example, one of the regulated rules is interpreted as follows:

"**if** $x_1 - X_{12}$=is important (i.e. o $x_{12}(u)$=exp$\{-(u-0.3075)^2/0.0703^2\}$ if it is a fuzzy set recoverable by Gauss membership function) **and** $x_2 -$

X_{21}=happened for the first time(i.e. o $x_{21}(u)=\exp\{-(u-0.6090)^2/0.1983^2\}$ if it is a fuzzy set recoverable by Gauss membership function), **then** y Y_2=payment of the fine(From 1000 to 2000 manats)".

**Table 2.** Logical rules regulated by a hybrid learning algorithm

№	Input		Output	
	x_1	x_2	Defasited prices	Assessment of violations (sanctions)
1	X_{11}	X_{21}	0.3859	Y_1 – no criminal liability
2	X_{11}	X_{22}	0.4334	Y_2 – Fine in the amount of 1000 to 2000 manats
3	X_{11}	X_{23}	0.5678	Y_3 – three hundred and twenty to four hundred and eighty hours of public work
4	X_{12}	X_{21}	0.4005	Y_2 – Fine in the amount of 1000 to 2000 manats
5	X_{12}	X_{22}	0.4453	Y_2 – Fine in the amount of 1000 to 2000 manats
6	X_{12}	X_{23}	0.6503	Y_3 – three hundred and twenty to four hundred and eighty hours of public work
7	X_{13}	X_{21}	0.4704	Y_2 – Fine in the amount of 1000 to 2000 manats
8	X_{13}	X_{22}	0.6572	Y_3 – three hundred and twenty to four hundred and eighty hours of public work
9	X_{13}	X_{23}	0.7226	Y_4 – Fine in the amount of 1000 to 4000 manats
10	X_{14}	X_{21}	0.7302	Y_4 – Fine in the amount of 1000 to 4000 manats
11	X_{14}	X_{22}	0.5859	Y_3 – three hundred and twenty to four hundred and eighty hours of public work
12	X_{14}	X_{23}	0.9796	Y_5 – imprisonment for up to two years
13	X_{15}	X_{21}	0.7242	Y_4 – Fine in the amount of 1000 to 4000 manats
14	X_{15}	X_{22}	0.8815	Y_5 – imprisonment for up to two years
15	X_{15}	X_{23}	0.6810	Y_3 – three hundred and twenty to four hundred and eighty hours of public work

Figure 8 shows the distribution of the parameters of the adapted Fuzzy Inference System outputs. This is a very result of this that five clusters y were assigned intervals for the default values of fuzzy outputs, means: [0; 0.4], [0.4; 0.55], [0.55; 0.7], [0.7; 0.85] və [0.85; 1].
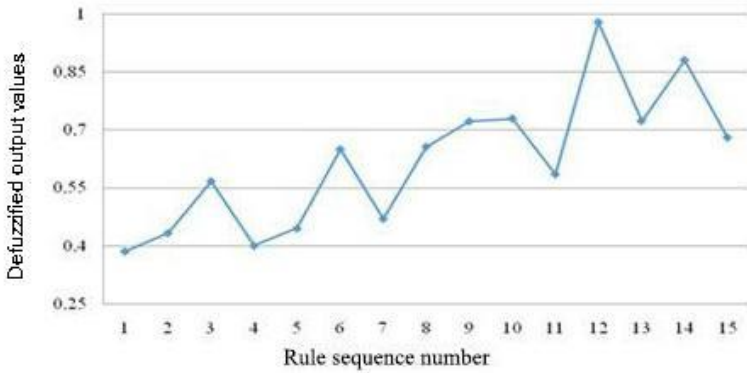
Figure 8. Aggregate parameters of Sugeno type ANFIS outputs

During the FLS simulation process, the PQQE used three assessment criteria for the composition of the offense. Based on them, it was possible to establish and study the cause-and-effect relationship between the properties of the offense and the consequences of law enforcement through the Sugeno-type adapted Fuzzy Inference System editor. (Fig.9).
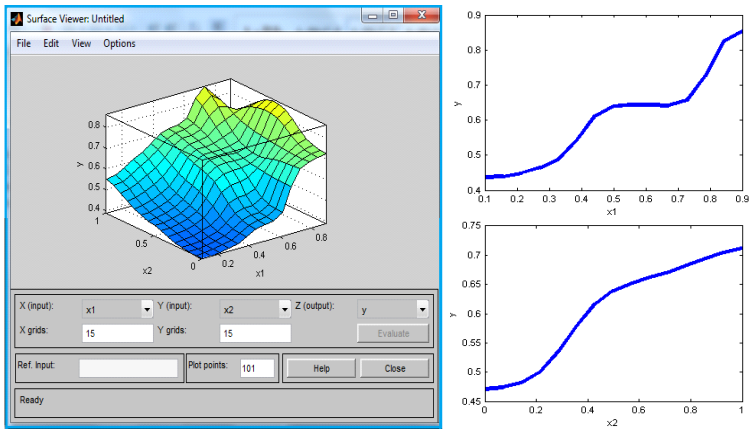
Figure 9. Dependence of a sanction depending on the nature of the violation

22

Numerical interpretation of the degree of violation and, consequently, if the level of the sanction is the maximum unit does not exceed 0.85; increases relatively steadily with increasing x_2 and increases sharply with increasing x_1. The proposed PQQE FLS system has the ability to quickly and relatively simply diversify its functions to other types of offenses. This requires formalizing the relevant legal norms and obtaining sufficient statistics for the assessment of violations in different scenarios. In the future, such a system may operate autonomously, as it is sufficient to involve existing heuristic knowledge in the field of law enforcement during its development and adaptation.

As a result of the experiments, it can be seen that the ANFIS tool used to simulate the PDMP FLS showed that the efforts to develop the perfect (full-value) software for an autonomous information system that supports procedural decision-making are very promising. The only drawback of the hybrid modeling of PDMP FLS is that the learning element is interfered with during its simulation period, and its quality, therefore the quality of the results depends on the accuracy and adequacy of the experimental data (i.e. training pairs). That is why the choice of teaching sets in the development of such systems is a very important process. To do this, you need to take into account the following.

When constructing and simulating a fuzzy output system on the logical basis of a neural network, it is not possible to determine unambiguously in advance: how much and what input data should be used to teach the neural network. For example, due to the lack of training pairs, the neural network will not be fully trained to solve the problem. In addition, in most weakly formalized areas of human activity, such as lawmaking and law enforcement, legislators and/or law enforcement officials often fail to provide an accurate answer: what elements of the crime are more important from the point of view of the law in order to make well-founded procedural decisions. Therefore, at the entrance to the neural network, users usually transmit a large amount of data, which in itself is not true. At the same time, in order to reduce the training time of the neural network and improve the quality of its operation, it is necessary to determine: what data is required to solve this or that application

problem? In the context of addressing this issue, experts in existing fields should also determine the importance of input signals.

Thus, when selecting training pairs, the user must take into account the following factors for effective structural and parametric regulation of the neural network, which performs a fuzzy output mechanism:

• At the initial stage of the neural network modeling process, it is necessary to select a large number of teaching examples, because when solving poorly structured problems with the help of neuro-fuzzy hybrid systems, this is impossible to predict the cause-and-effect relationship between the output property of the model and the existing input data.

• The input properties of the future model should not be correlated with each other, because the existence of a correlation between them does not allow them to perform the ranking. Otherwise, it becomes impossible to use the usual algorithm due to its importance.

• Before deleting teaching samples, make sure that they do not contain important information.

CONCLUSION

The concept of semantic uncertainty was expressed and applied in the assessment concepts that can be used in legal science: thus, semantic uncertainty in the concept of assessment is an integral part of the legal norm. Within its framework, the responsible person executing the law is entrusted with the choice of a free, intellectually willed, and morally grounded procedural decision.

❑ The semantic nature of the concept of evaluation was analyzed in a new manner: It was established that the distinguishing feature of the assessment concept in the legal norm is not related to the obvious nature of its logical structure. It is due to the ambiguity of the semantic content of the legal norm.

❑ In the example of the concept of the amount of material damage, the definition of the assessment concept of

procedural law was given from a formal standpoint: as a fuzzy concept that regulates litigation and carries additional information in a specific court case for a law enforcer within a fuzzy extract system.

❑ Given the existence of semantic uncertainty in the assessment concepts, a fuzzy model of the rule of law has been developed.

❑ Given the existence of semantic uncertainty in assessment concepts, fuzzy methods for classifying and assessing violations have been developed and articulated.

❑ The concept of an information system that supports the process of making procedural decisions based on a fuzzy logic output system implemented in the logical basis of the neural network was expressed and a software simulation was performed on a specific example.

❑ Social events regulated by law can be considered socio-legal events. Both the crime itself and the process of prosecuting this crime (the perpetrator) can be seen as a type of socio-legal event.

The main results of the dissertation were published in the following scientific works:

1. F.B. Ağayev. Beynəlxalq və milli səviyyədə uşaq hüquqlarının müdafiə mexanizmləri // "Hüquq düşüncəsi və elm" elmi-nəzəri jurnal, 2011, №3, səh. 14-18.

2. F.B. Ağayev. Beynəlxalq və milli hüquqda uşaq əməyinin istismarının yolverilməzliyi // "Qanun" elmi hüquq jurnalı, 2011, №08 (208), səh. 65-71

3. F.B. Ağayev. Azərbaycanda Ombudsman təsisatı: yeni səlahiyyətlər və vəzifələr // Gənc Alimlərin Əsərləri, 2013, №8, səh. 287-292.

4. Ф.Б. Агаев. Процесс миграции и защита прав мигрантов // Межд. научно-практ. Конф., посвященная 20-летию

Конституции Российской Федерации, Кемерово, 2013, 12 декабря, с. 157-162

5. F.B. Ağayev. Hüquq mədəniyyətinin və düşüncəsinin inkişafında Ombudsman təsisatının rolu // Gənc Alimlərin Əsərləri, 2014, №9, səh. 248-257

6. F.B. Ağayev. Aliment: qanunvericilik və mövcud problemlər // "Azərbaycanda Hüquqi dövlət quruculuğunun aktual problemləri" II Beyn. Elmi Konf. Mater. 2014, səh. 93-96.

7. Р.Р. Рзаев, Ф.Б. Агаев, М.А.Агамалыев. Об одном подходе к преодолению семантической неопределённости в оценочных понятиях процессуального права // Azərbaycan Milli Elmlər Akademiyasının Xəbərləri, Fizika-Texnika və Riyaziyyat Elmlər Seriyası, İnformasiya və İdarəetmə Problemləri, Bakı, 2014, Cild 34, №3, səh. 49-61.

8. R.R. Rzayev, F.B. Agayev, M.A. Agamaliyev. Fuzzy Approach to Overcoming of Semantic Uncertainty in Criterion Concepts of a Procedural Law // Journal of Next Generation Information Technology, South Korea, 2014, Vol. 5, No. 4, pp. 11-25.

9. Р.Р. Рзаев, Г.М. Шихалиева, З.Р. Джамалов, Ф.Б. Агаев. Об одном подходе к дефаззификации выходов нечётких моделей временного ряда // Математичні машини і системи, Институт Проблем Математических Машин и Систем, Киев, 2015, № 1, стр. 96-110.

10. Р.Р. Рзаев, Ф.Б. Агаев, Н.А. Умарова, И.Р. Рзаева. Нечёткая логико-лексикологическая поддержка создания терминологического словаря промежуточного языка в билингвальном обучении // Gənc Alimlərin Əsərləri, Bakı, 2015, №11, səh. 14-25.

11. Р.Р. Рзаев, Ф.Б. Агаев, З.Р.Джамалов, В.И. Гасанов. Поддержка принятия процессуальных решений на основе применения нейро-нечёткого метода многокритериальной оценки // Gənc Alimlərin Əsərləri, Bakı, 2015, №12, səh. 5-20.

12. F.B. Ağayev. Erkən nikahların qarşısının alınması üzrə imkanların gücləndirilməsi // "Ailə-məişət zorakılığının sosial-psixoloji, cinayət-hüquqi və kriminoloji problemləri" mövzusunda

Beynəlxalq elmi-praktik konfransın materialları, 2016, səh. 386-390.

13. Р.Р. Рзаев, Ф.Б. Агаев, З.Р.Джамалов, А.И.Гоюшов. Информационная Система Поддержки Принятия Процессуальных Решений // Системы и средства информатики, Москва, 2016, Т.26, №1, с. 182-196.

14. R.R. Rzayev, F.B. Agayev, M.A. Agamaliyev, V.I. Hasanov. Overcoming of semantic uncertainty in criterion concepts of a procedural law based on using fuzzy inferences // 12th International Conference on Application of Fuzzy Systems and Soft Computing – ICAFS-2016, Procedia Computer Science, Published by Elsevier, Vienna, Austria, 2016, Vol. 102, pp. 209-216.

15. F.B. Agayev. Modeling of legal norms with the using of fuzzy reference method **//** Proceeding of young scientists, Baku, 2016, No. 14, pp. 5-15.

16. F.B. Ağayev. Cinayət-prosessual hüquq normaları və bu normalarla tənzim edilən hüquq münasibətləri haqqında // "Qanun" elmi hüquq jurnalı, 2018, 08 (268), səh. 71-77.

17. F.B. Ağayev. Azərbaycan Respublikasının İnsan Hüquqları üzrə Müvəkkilinin elmi-analitik və hüquqi maarifləndirmə sferalarında fəaliyyəti hüquq elminin inkişafı kontekstində // İnsan hüquqları və informasiya hüququ (elmi məqalələr toplusu), 2018, №1 (1), səh. 37-42.

18. F.B. Ağayev. Cinayət-prosessual hüquq normaları ilə tənzim edilən münasibətlərin xüsusiyyətləri // "Azərbaycanda hüquq elminin müasir inkişaf istiqamətləri və tendensiyaları" mövzusunda beynəlxalq elmi-praktiki konfransın materialları, 2018, səh. 427-431.

19. F.B. Agayev. Analytical support of the procedural decision-making process // Mathematical Machines and System, Ukrainian, 2020, No. 4, pp. 20-32.

The personal role of the applicant in the jointly published scientific works: [7], [8], [11], [13] and [14] the co-authors participated only in discussions and calculations. In [9] and [10], it is up to the plaintiff to develop the conceptual models applied therein.

The defense will be held on 11 February 2022 at 14^{00} at the meeting of the Dissertation council ED 1.20 of Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at Institute of Control Systems of the Azerbaijan National Academy of Sciences.

Address: 68 B. Vahabzade Str., Baku AZ1141

Dissertation is accessible at the Library of the Institute of Control Systems of the Azerbaijan National Academy of Sciences.

Electronic versions of dissertation and its abstract are available on the official website (https://www.isi.az) of the Institute of Control Systems of the Azerbaijan National Academy of Sciences.

Abstract was sent to the required addresses on 07 January 2022.