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Abstract. The article describes the software implementation of a formal evaluation system realised Wölfflin statistical analysis method in the MATLAB program package. To build such a system we used fuzzy logic and rules developed by Heinrich Wölfflin, who offered the research of objectives as an "objective fact". Sets of input parameters were developed based on variables and terms of various objects parameters. Application of the fuzzy sets theory for objects evaluation in order to study the relationships of the used parameters showed convenience and efficiency. Since the fuzzy logic describes nature of human thinking more natively.

1. Introduction

Evaluation in the field of fine arts is one of the most controversial processes, causing a large number of disputes and attempts to bring the assessment approaches to the formal form. Like any science, the theory of art has its own methods. Main of them are iconographic method, Wölfflin method (method of formal stylistic analysis), iconological method, hermeneutics method [1].

The main problem considered by H. Wölfflin in his own system - not “what is pictured”, but “how is it pictured”. He offered a formal stylistic analysis, which approaches the study of works of art as an "objective fact", which should be understood primarily from itself.

Heinrich Wölfflin had several tasks. His main task was to develop a universal analysis language of works of art, using the opposition method. His next task was to prove that this language is universal for all kinds of art (architecture, sculpture, painting). But, along with the main tasks, there were several additional ones. Wölfflin wanted to show that this method is applicable to any historical period of the art development, and also wanted to consciously abandon the personalized approach to the analysis of works of art (impersonal analysis makes it possible to create a “pure” art theory), to establish a pattern of general changes in the human perception of art, putting it in the historical context.

Sufficiently accurate description of the parameters proposed by Wölfflin and the links between them allowed us to proceed to the formalization of the method using a mathematical apparatus based on fuzzy logic.

Fuzzy logic, which serves as a basis for the implementation of fuzzy decision-making methods, more naturally describes the nature of human thinking and the course of his reasoning than traditional formal logical systems [2], [3], [4], [5]. That is why studying and using mathematical tools to represent fuzzy initial information allows us to build models that most adequately reflect various aspects of uncertainty, constantly present in the real world [6], [7], [8].

Thus, it is convenient and effective to use the apparatus of fuzzy set theory to model the methods used in the evaluation of works of art. It allows to describe qualitative characteristics that are difficult or impossible to quantify [9], [10], [11].

Computer modeling of the formal evaluation system of works of fine art is performed in the MATLAB software complex using Fuzzy Logic Toolbox.

2. The formation of rule base system for style development based on the pair criterion of Heinrich Wölfflin

The process of forming the fuzzy inference rule base is a formal representation of the expert's empirical knowledge in a particular problem area. The rule base of the system was compiled together with the teachers of the Krasnoyarsk Art School named after V. I. Surikov, based on experience and knowledge in art history and personal artistic taste. The need to take into account all possible combinations within a subset is dictated by the interface of the MATLAB modeling environment.

Table 1 describes the variables used and the corresponding terms.

Table 1. Variables and terms of the topology of artistic styles

Variables	Terms
Linear and pictorial	Pronounced contour
	Medium contour
	Weakly expressed contour
	Unexpressed contour
Planar and spatial	Weakly expressed depth
	Average depth
	Pronounced depth
Closed and open form	Pronounced symmetry
	Medium to pronounced symmetry
	A slight symmetry
Single and multiple	Single
	Mixed
	Multiple
Clear and obscure	Clear image
	Naturalistic image
	Blurred image

Production rules for five input variables of the system were developed on the basis of variables and terms of various artistic styles. Each production rule is written in the form of "If ... and/or ...then" and is composite, since it has a logical AND/OR. Our system always uses logical AND. For example, the first rule: “If a Pronounced contour and Weakly expressed depth, and Pronounced symmetry, and the image is Single, and a Clear image”, then we will refer the product to the 0 stage of style development by Wölfflin.

3. Modelling of fuzzy system using the Fuzzy Logic Toolbox

Fuzzy Logic Toolbox package editor allows you to manually edit and configure the input and output parameters of the fuzzy system. In our case, there are five input linguistic variables (Linear and pictorial, Planar and spatial, Closed and open form, Single and multiple, Clear and obscure) and one output (stage

of style development by Wölfflin). Figure 1 shows a dialog box for specifying a fuzzy model of formal evaluation of works of fine art.

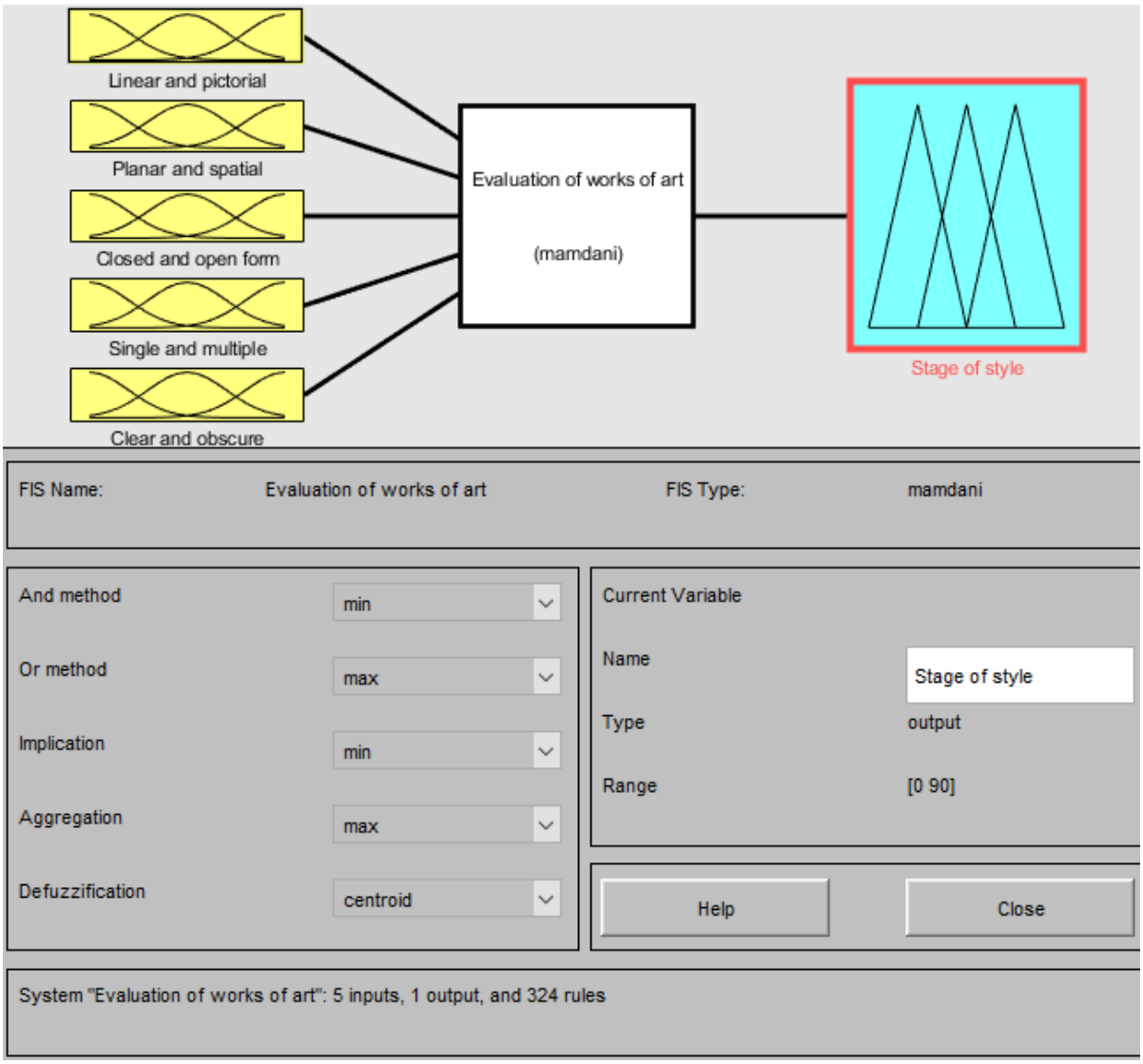

Figure 1. The fuzzy model of the formal assessment.

The dialog box of the produced system rules is shown in figure 2. This editor allows you to set the base of fuzzy rules for the system implementation, set the combination of all modes, applying logical AND/OR, and set the weight of rules to rank rules by their importance.

Each knowledge rule is represented as a series of horizontally arranged rectangles. The first three rectangles display the membership functions of the rule sending terms (If-part of the rule), and the last rectangle corresponds to the membership function of the output term-consequence variable (Then-part of the rule). An empty rectangle in the visualization means that there is no variable sending to this rule, such rules are not presented here. The yellow fill of the membership function graphs of the input variables indicates how much the input values correspond to the terms of this rule.

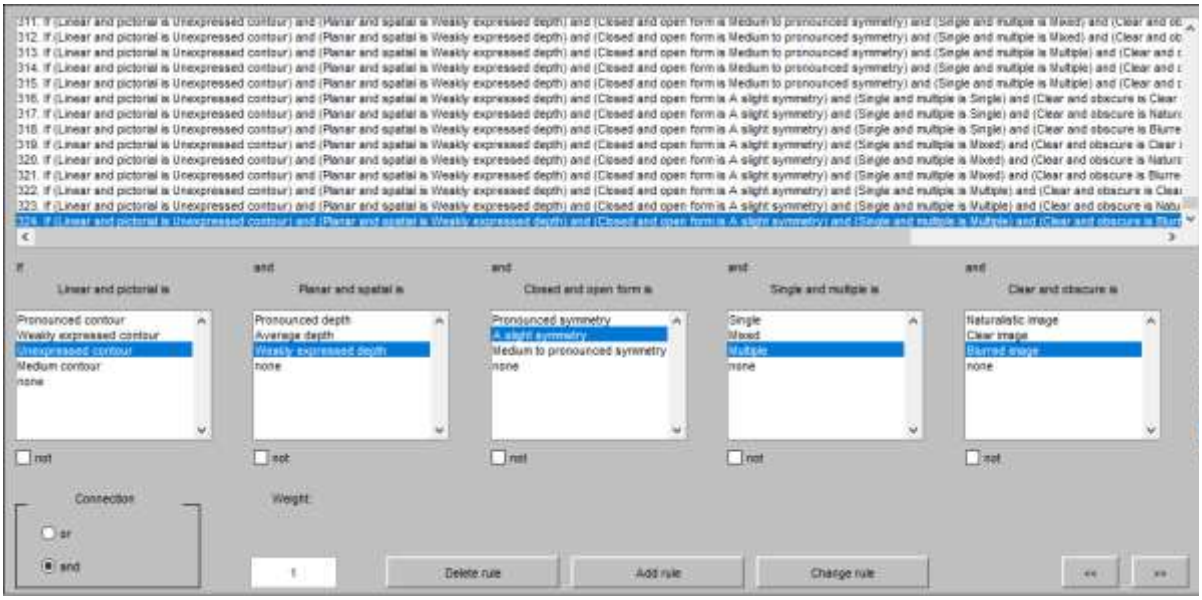

Figure 2. Implementation of the produced rules of the system.

The blue fill of the membership function graphs of the output variables is the result of the logical output in the form of a fuzzy set according to this rule. The resulting fuzzy set corresponding to the logical conclusion of all rules is shown in the bottom rectangle of the last column of the graphic window. In the same rectangle, the red vertical line corresponds to a clear value of the logical output obtained as a result of defuzzification.

Since the fuzzy modeling process involves analyzing the results of fuzzy inference at different values of input variables in order to establish the adequacy of the developed model, let us consider examples. Suppose that the parameter estimate "Linear and pictorial" is equal to 10 (included in the range of "weakly expressed contour"), "Planar and spatial" – 10 (included in the range of "Average expressed depth"), "Closed and open form" – 10 (included in the range of "Medium expressed symmetry").

With these input parameters, the system recommends that we refer the product to the 69.9 stage of style development by Wölfflin.

If we assume that the evaluation of the parameter "Linear and pictorial" is equal to 10 (included in the range of "weakly expressed contour"), "Planar and spatial" – 10 (included in the range of "Average expressed depth") remain the same, and "Closed and open form" will be reduced to 7, the indicator of reference to the stage of development of the style will change significantly and will be equal to 63.8. Moreover, further reduction of the "closed form and open" criterion will decrease the index of the stage, but when it reaches 0, it will not decrease to 0, as other variables play an important role in the system.

Figure 3 shows the conclusion of decision-making with input variables in their different estimates.

For visual comparison, the conclusion of decision-making with input variables is presented: "Linear and pictorial"/"Planar and spatial"/"Closed form and open": 10/10/10 in the upper part, and 7/10/10 in the lower part, respectively.

Visualization of the resulting modeling relationships allows you to see the relationship between the different input and output parameters of the model (figure 4).

In the left part of figure 4, the input variables are "Linear and pictorial" (x) and "Planar and spatial" (y), in the right - "Single and multiple" (x) and "Clear and obscure" (y). The output variable in all cases is the "stage of style development by Wölfflin".

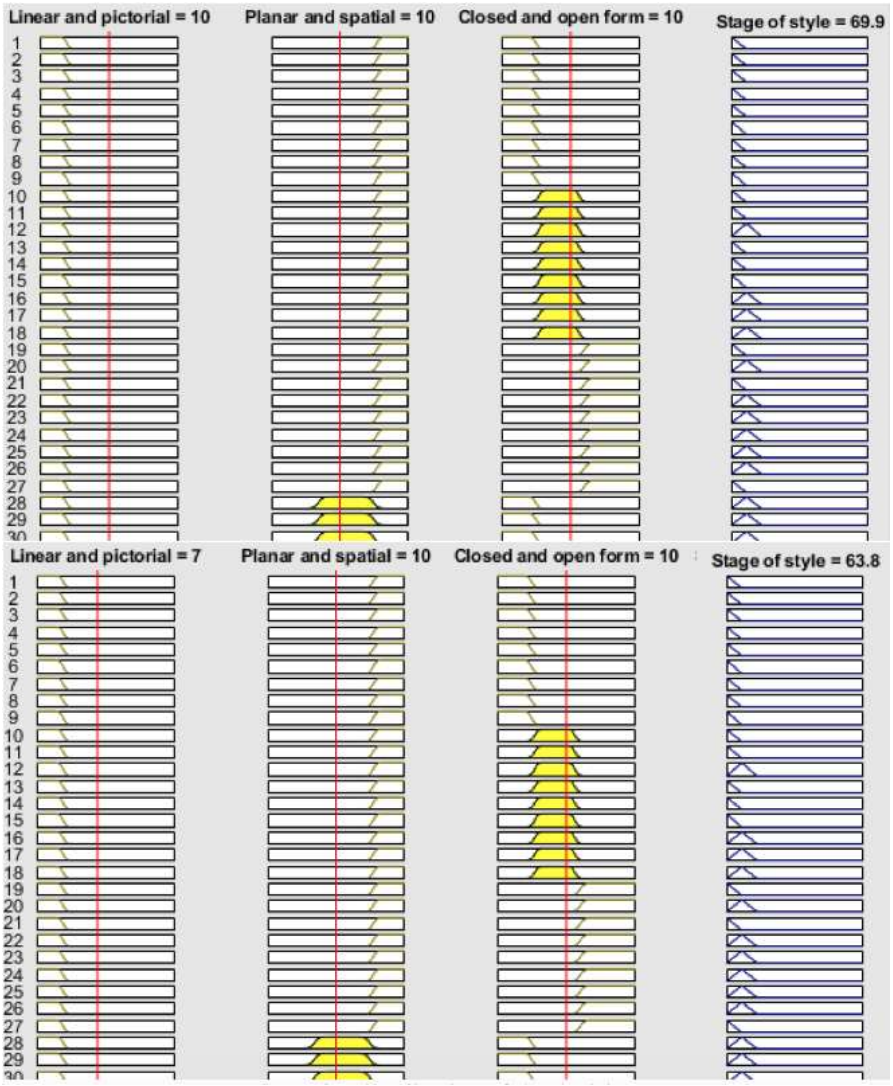

Figure 3. Visualization of the decision.

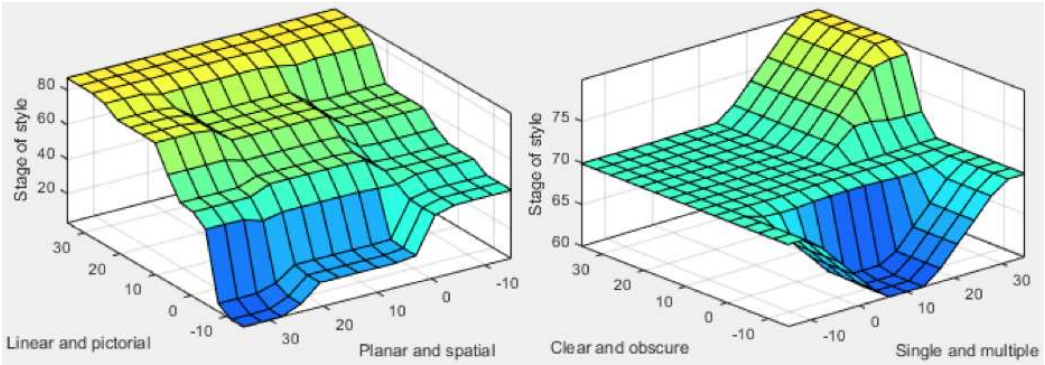

Figure 4. Visualization of input and output variable dependencies.

Figure 5 shows a two-dimensional representation of the dependence on one of the input variables.

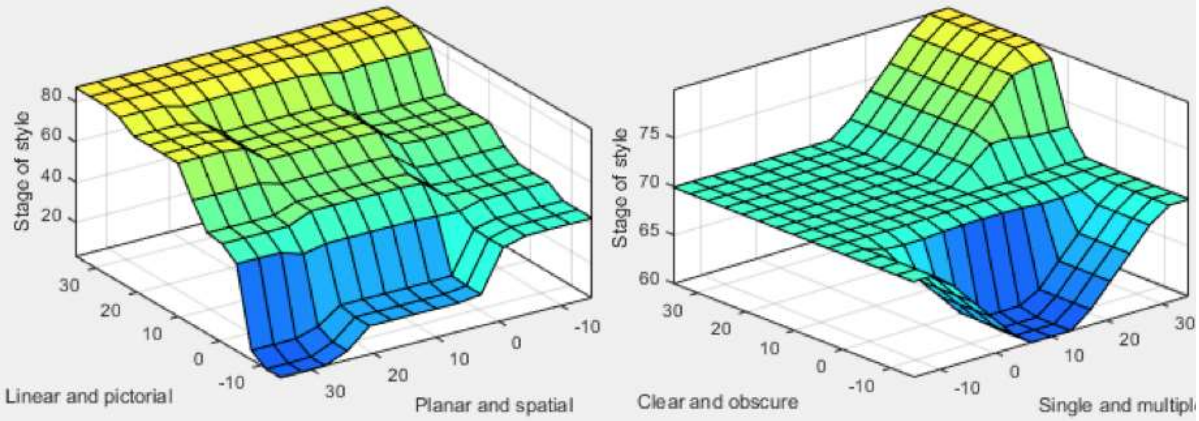

Figure 5. Graph of the stage of style development by Wölfflin from the closeness or openness of the form.

4. Conclusion

When developing a simple fuzzy inference system in interactive mode, it should be noted that this method is most effective for complex fuzzy models with a large number of variables and fuzzy inference rules. In this case, setting variables and membership functions of their terms in the graphical mode, as well as visualization of the rules can significantly reduce the complexity of developing a fuzzy model, reduce the number of possible errors and reduce the total time of fuzzy modeling.

Modeling the formal analysis method of Heinrich Wölfflin using Fuzzy Logic Toolbox package of MATLAB helped to identify impact and dependencies of the different criteria of this method on the style development by Wölfflin.

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References

[1] Bryukhanova E R 2016 System of formal assessment of works of art *International student scientific conference MNSK-2016* 16-19
[2] Terano T, Asai K and Sugeno M 1993 *Applied fuzzy systems* (Moscow, Mir)
[3] Antamoshkin O A, Antamoshkina V O, Zelenkov P V and Kovalev I V 2016 Model and method for optimizing heterogeneous systems *IOP Conference Series: Materials Science and Engineering* **155(1)** 012043
[4] Bukhtoyarov V V, Milov A V, Tynchenko V S, Petrovskiy E A and Tynchenko S V 2019 Intelligently informed control over the process variables of oil and gas equipment maintenance *International Review of Automatic Control* **12(2)** 59-66
[5] Bryukhanova E R 2018 Concept of creating a system of formal evaluation of works of fine art *International scientific conference of students, postgraduates and young scientists Lomonosov* 218-21

[6] Antamoshkin O A, Piatkov A G, Puzanova G A and Saveleva M V 2014 Using fuzzy logic to analyze an organizational measures impact and its tendency *Youth. Society. Modern science, technology and innovation* **13** 206-8
[7] Mahant N 2004 Risk assessment is fuzzy business–Fuzzy logic provides the way to assess off-site risk from industrial installations *Risk* **206** 218-31
[8] Tynchenko V, Milov A, Tynchenko V, Bukhtoyarov V and Antamoshkin O 2018 Application of artificial neural networks for identification of non-normative errors in measuring instruments for controlling the induction soldering process *International Multidisciplinary Scientific GeoConference: SGEM: Surveying Geology & mining Ecology Management* **18** 117-24
[9] Stupina A A, Shigina A A and Shigin A O 2015 Mathematical formulation of technological processes optimization problem *IOP Conference Series: Materials Science and Engineering* **94(1)** 012001
[10] Shigina A, Shigin A, Stupina A, Kurchin G and Kirsanov A 2016 Model of rock drilling process in terms of roller cone bit remaining life *Int. J. of Applied Engineering Research (IJAER)* **11** 9792-9
[11] Tynchenko V S 2019 Intellectualization of the technological processes of permanent joints formation at the rocket-space enterprises *IOP Conference Series: Materials Science and Engineering* **537(3)** 032062