УДК 004.8

05.13.18 - Математическое моделирование, численные методы и комплексы программ (технические науки)

АВТОМАТИЗИРОВАННЫЙ СИСТЕМНО-КОГНИТИВНЫЙ АНАЛИЗ УРОВНЯ СИСТЕМНОСТИ НАТУРАЛЬНЫХ ЧИСЕЛ, КАК СИСТЕМ ПРОСТЫХ МНОЖИТЕЛЕЙ

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Данная работа является продолжением серии работ автора по применению систем искусственного интеллекта для исследований в области теории чисел (высшей арифметики) и статистики. В работе решается задача изучения зависимости уровня системности натуральных чисел, как систем простых множителей, от величины числа, его простых множителей, логарифма числа, рекурсивной суммы его цифр и того какие цифры расположены в различных позициях записи числа. Для количественной оценки уровня системности натуральных чисел используется коэффициент эмерджентности, предложенный автором в 2002 году и названый им в честь одного из основателей научной теории информации Р.Хартли. Для построения и моделей и их анализа используется автоматизированный системно-когнитивный анализ (АСК-анализ) и его программный инструментарий – интеллектуальная система «Эйдос». Дается краткое описание АСК-анализа и системы «Эйдос». Приводится подробный численный пример, в котором продемонстрировано применение АСК-анализа для решения ряда задач. Задача-1. Когнитивная структуризация предметной области. Задача-2. Формализация предметной области. Задача-3. Синтез статистических и системно-когнитивных моделей. Многопараметрическая типизация и частные критерии знаний. Задача-4. Верификация моделей. Задача-5. Выбор наиболее достоверной модели. Задача-6. Системная идентификация и прогнозирование. Интегральные критерии. Задача-7. Поддержка принятия решений. Задача-8. Исследование объекта моделирования путем исследования его модели. Работа может быть основой для лабораторных работ по применению интеллектуальных технологий в высшей арифметике (теории чисел)

Ключевые слова: АВТОМАТИЗИРОВАННЫЙ СИСТЕМНО-КОГНИТИВНЫЙ АНАЛИЗ, КОЭФФИЦЕНТЫ ЭМЕРДЕЖНТНОСТИ ПРОФ.Е.В.ЛУЦЕНКО, АСК-АНАЛИЗ, ИНТЕЛЛЕКТУАЛЬНАЯ СИСТЕМА «ЭЙДОС»

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05.13.18 - Mathematical modeling, numerical methods and software packages (technical sciences)

AUTOMATED SYSTEM-COGNITIVE ANALYSIS OF THE LEVEL OF CONSISTENCY OF NATURAL NUMBERS AS SYSTEMS OF PRIME FACTORS

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This work is a continuation of the author's series of works on the use of artificial intelligence systems for research in the field of number theory (higher arithmetic) and statistics. The paper solves the problem of studying the dependence of the level of consistency of natural numbers, as systems of prime factors, on the magnitude of the number, its prime factors, the logarithm of the number, the recursive sum of its digits and which digits are located in different positions of the number entry. To quantify the level of consistency of natural numbers, the emergence coefficient is used, proposed by the author in 2002 and named by him in honor of one of the founders of the scientific theory of information, R. Hartley. Automated system-cognitive analysis (ASC-analysis) and its software tools – the intelligent system "Eidos" are used to build and analyze models and their analysis. A brief description of the ASC- analysis and the "Eidos" system is given. A detailed numerical example is given, which demonstrates the application of ASC-analysis to solve a number of problems. Task-1. Cognitive structuring of the subject area. Task-2. Formalization of the subject area. Task-3. Synthesis of statistical and system-cognitive models. Multiparametric typing and particular criteria of knowledge. Task-4. Verification of models. Task-5. Choosing the most reliable model. Task-6. System identification and forecasting. Integral criteria. Task-7. Decision support. Task-8. The study of a modeling object by examining its model. The work can be the basis for laboratory work on the application of intelligent technologies in higher arithmetic (number theory)

Keywords: AUTOMATED SYSTEM-COGNITIVE ANALYSIS, FORMALIZED COGNITIVE CONCEPT, ASC-ANALYSIS, INTELLECTUAL SYSTEM "EIDOS", TOOLS OF COGNITION, BASIC COGNITIVE OPERATIONS

CONTENTS

1. INTRODUCTION

1.1. Description of the subject area under study

This work is a continuation of the author's series of works on the application of information theory, artificial intelligence systems and cognitive technologies for conducting research in the field of number theory (higher arithmetic) and statistics [1-52].

"Number theory or higher arithmetic is a section of mathematics that originally studied the properties of integers. In modern number theory, other types of numbers are also considered - for example, algebraic and transcendent, as well as functions of various origins that are associated with the arithmetic of integers and their generalizations.

In studies on number theory, along with arithmetic and algebra, geometric and analytical methods, as well as ***methods of probability theory***, are used. [1]"

In this work, the problem of studying the dependence ***of the level of systematality of natural numbers, as systems of prime factors,*** on the properties of natural numbers is solved. This property of natural numbers is little studied and little known to a wide range of specialists, since quantitative ***information measures of the level of systemicity***, called by the author the coefficients of emergence, are proposed and investigated only in the author's works [1-52].

Initial data include 65,535 natural numbers described by observations of 9 properties. This number of studied natural numbers can be easily increased to tens and even hundreds of millions, but this was not done in this work due to the limitation on the size of the work.

1.2. Object and subject of study

The object of study in this work is natural numbers and their properties.

The subject of research in the work is the study of the dependence of the level of systematality of natural numbers, as systems of prime factors, on the properties of natural numbers.

1.3. The problem to be solved in the work and its relevance. The idea of solving the problem

Traditionally, the study of the properties of natural numbers is carried out as at the theoretical level of cognition. But there are quite numerous empirical studies carried out through numerical experiments.

These numerical experiments usually require special computational resources and time-efficient numerical methods and often use calculations on supercomputers or graphics processors of powerful video cards.

[1] https://kartaslov.ru/карта-знаний/Теория+чисел

However, these methods and techniques are relatively inaccessible. The development of such technology is very **relevant**.

Thus, there is a problem solved in this work **that** the technologies of empirical research in the field of number theory (higher arithmetic) by conducting numerical experiments exist, but require huge computational resources and time and are very inaccessible. Therefore, there is a need to develop a highly efficient and accessible technology of empirical research (numerical experiments) in the field of number theory.

1.4. The idea of solving the problem

The idea of solving the problem posed is ***to apply information theory, intellectual and cognitive technologies to study*** the properties of numbers. This idea was realized and specified by the author and co-authors in numerous empirical studies in the field of number theory [1-52].

1.5. Purpose and objectives of the work

The purpose of the work is to solve the above problem by ***decomposing*** the goal into the following sequence of tasks, the solution **of** which is the stages of achieving ***the*** goal:

Task-1. Cognitive structuring of the subject area. Two interpretations of classification and descriptive scales and gradations.

Task-2. Formalization of the subject area.

Task-3. Synthesis of statistical and system-cognitive models. Multivariable typing and private knowledge criteria.

Task-4. Model verification.

Task-5. Select the most reliable model.

Task-6. System identification and forecasting.

Task-7. Decision Support (Simplified Decision Making as Inverse Prediction Task, Positive and Negative Class Information Portraits, SWOT Analysis; Developed decision-making algorithm in ASK analysis).

Task-8. Study of a modeling object by examining its model (Inverted SWOT charts of descriptive scale values (semantic potentials); Cluster-design analysis of classes; Cluster-design analysis of descriptive scale values; The knowledge model of the Eidos system and non-local neurons; Non-local neural network; 3d-integral cognitive maps; 2d-integral cognitive maps of meaningful class comparison (mediated fuzzy plausible reasoning); 2d-integral cognitive maps of meaningful comparison of factor values (mediated fuzzy plausible reasoning); Cognitive functions; Significance of descriptive scales and their gradations; Degree of determinity of classes and classification scales).

2. METHODS (METHODS)

2.1. Substantiation of requirements for the problem solving method

The method used to solve the problem should ensure the sustainable detection in a comparable form of force and the direction of causal dependencies in incomplete noisy (inaccurate) interdependent (nonlinear) data of very large dimension of numerical and non-numerical nature, measured in various types of scales (nominal, ordinal and numerical) and in different units of measurement (i.e., it should not impose stringent data requirements that cannot be met, but should ensure the processing of those data that really exist). In addition, the method should take into account not only point values in the time series, but also the dynamics and nature, that is, scenarios for their change.

2.2. Literary review of problem-solving methods, their characterization and assessment of compliance with the requirements

A new method of artificial intelligence meets all the requirements formulated above: scripted automated system-cognitive analysis (scripted ASK analysis), which has its own software tools, which currently act as the personal intelligent online environment "Eidos-Xpro."

Below we will briefly consider this method and its software tools.

2.3. Automated system-cognitive analysis (ASK analysis)

Automated system-cognitive analysis (ASK-analysis) proposed *prof. E.V. Lutsenko* in 2002 in a number of articles and a fundamental monograph [1]. *The term itself: "Automated system-cognitive analysis (ASK-analysis)" was proposed by prof. E.V.Lutsenko. At that time, he did not meet at all on the Internet.* Today, upon request, Yandex has 9 million sites with this combination of words[2].

ASK analysis includes:

- theoretical foundations, in particular basic formalized cognitive concept;

- mathematical model based on the system generalization of information theory (CTI);

- methodology of numerical calculations (structures of databases and algorithms of their processing);

- software toolkit, which currently acts as the universal cognitive analytical system "Eidos" (intelligent system "Eidos").

The ASK analysis is described in more detail in works [1, 2, 3] and several others. About half of the more than 662 scientific papers published by

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[2] https://yandex.ru/search/?lr=35&clid=2327117-18&win=360&text=%20360&text=Автоматизированный+системно-когнитивный+анализ + (ASK analysis)

the author are devoted to the theoretical foundations of ASK analysis and its practical applications in a number of subject areas. At the time of writing this work, the author published more than 40 monographs, 27 teaching aids, including 3 teaching aids with the labels of the UMO and the Ministry, received 32 patent of the Russian Federation for artificial intelligence systems, 344 publications in publications included in the list of Higher Attestation Commission of the Russian Federation and equated by him (according to the RSCI), 6 articles in journals included in WoS, 6 publications in journals included inSkopus[3].

Three monographs are included in the collections of the Library of Congress[4].

ASK analysis and the Eidos system were successfully applied in 8 doctoral and 8 candidate dissertations in economic, technical, biological, psychological and medical sciences, several more doctoral and candidate dissertations using ASK analysis at the stage of defense.

The author is the founder of an interdisciplinary scientific school: "Automated system-cognitive analysis." [5]Scientific school: "Automated system-cognitive analysis" is an interdisciplinary scientific direction at the intersection of at least three scientific specialties (according to the recently approved new nomenclature of scientific specialties of the Higher Attestation Commission of the Russian Federation[6]). The main scientific specialties that the scientific school corresponds to:

– 5.12.4. Cognitive modeling;
– 1.2.1. Artificial intelligence and machine learning;
– 2.3.1. System analysis, management and information processing.

Scientific school: "Automated system-cognitive analysis" includes the following interdisciplinary scientific areas:

- Automated system-cognitive analysis of numerical and text tabular data;
- Automated system-cognitive analysis of text data;
- Spectral and contour automated system-cognitive analysis of images;
- Scenario automated system-cognitive analysis of time and dynamic series.

It is hardly advisable to refer here to all these works. Note only that the author has a personal site [4] and a page in ResechGate [5], on which you can get more complete information about the ASK analysis method. Brief information about ASK analysis and the Eidos system is available in the material: http://lc.kubagro.ru/aidos/Presentation_Aidos-online.pdf.

[3]http://lc.kubagro.ru/aidos/Sprab0802.pdf
[4]https://catalog.loc.gov/vwebv/search?searchArg=Lutsenko+E.V. (и кликнуть: “**Search**”)
[5]https://www.famous-scientists.ru/school/1608
[6]https://www.garant.ru/products/ipo/prime/doc/400450248/

2.4. Eidos System - ASK Analysis Tools

There are many artificial intelligence systems. The Eidos universal cognitive analytical system differs from them in the following parameters:

- is universal and can be applied in many subject areas, since it is developed in universal staging, independent of the subject area (http://lc.kubagro.ru/aidos/index.htm) and has 6 automated program interfaces (APIs) for entering data from external data sources of various types: tables, texts and graphics. The Eidos system is an automated system, that is, it involves the direct participation of a person in real time in the process of creating models and using them to solve problems of identification, prediction, decision-making and research of the subject area by studying its model (automatic systems work without such human participation);

- is in full public free access (http://lc.kubagro.ru/aidos/_Aidos-X.htm), and with current source texts (http://lc.kubagro.ru/__AidosALL.txt): open license: CC BY-SA 4.0(https://creativecommons.org/licenses/by-sa/4.0/), and this means that everyone can use it without any additional permission from the primary copyright holder - the author of the Eidos system prof. E.V. Lutsenko (note that the Eidos system was created entirely using only licensed tool software and it has 32 certificates of the Russian Federal Patent);

- is one of the first domestic systems of artificial intelligence of a personal level, i.e. does not require a user special training in the field of artificial intelligence technologies: "has a zero entry threshold" (there is an act of introducing the Eidos system of 1987) (http://lc.kubagro.ru/aidos/aidos02/PR-4.htm);

- realistically works, ensures stable detection in comparable form of force and direction of causal dependencies in incomplete noisy interdependent (nonlinear) data of very large dimension of numerical and not numerical nature, measured in different types of scales (nominal, ordinal and numerical) and in different units of measurement (i.e. does not impose stringent requirements for data that cannot be fulfilled, but processes those data that are);

- has a "zero entry threshold," contains a large number of local (delivered with installation) and cloud educational and scientific Eidos applications (currently there are 31 and 333, respectively: http://aidos.byethost5.com/Source_data_applications/WebAppls.htm) (http://lc.kubagro.ru/aidos/Presentation_Aidos-online.pdf);

- supports on-line knowledge-building and exchange environment, widely used worldwide (http://aidos.byethost5.com/map5.php);

- Provides multilingual interface support in 51 languages. Language bases are included in the installation and can be replenished automatically;

- the most computationally labor-intensive operations of model synthesis and recognition is implemented using a graphics processor (GPU), which on some tasks provides acceleration of solving these problems by several thousand times, which actually provides intelligent processing of large data, large information and great knowledge (the graphics processor should be on the NVIDIA chipset);

- converts the initial empirical data into information, and it is converted into knowledge and solved using this knowledge of classification problems, decision support and research of the subject area by studying its system-cognitive model, while generating a very large number of tabular and graphical output forms (development of cognitive graphics), many of which have no analogues in other systems (examples of forms can be seen in the work: http://lc.kubagro.ru/aidos/aidos18_LLS/aidos18_LLS.pdf);

- well imitates the human style of thinking: gives the results of analysis, understandable to experts on the basis of their experience, intuition and professional competence;

- rather than imposing practical requirements on the source data (like normality of distribution, absolute accuracy and complete repetitions of all combinations of values of factors and their complete independence and additivity) automated system-cognitive analysis (ASK-analysis) suggests without any preliminary processing to understand this data and thereby convert it into information, and then convert this information into knowledge by applying it to achieve goals (i.e., to manage) and solve classification problems, support decision-making and meaningful empirical research of the simulated subject area.

What is the strength of the Aidos approach? The fact is that it implements an approach, the effectiveness of which does not depend on what we think about the subject area and whether we think at all. It builds models directly from empirical data, not from our ideas about the mechanisms of implementing patterns in these data. That is why Eidos models are effective even if our ideas about the subject area are incorrect or absent at all.

In this and the weakness of this approach implemented in the Eidos system. Models of the Eidos system are phenomenological models that reflect empirical laws in the facts of the training sample, i.e. they do not reflect the causal mechanism of determination, but only the fact and nature of determination. A meaningful explanation of these empirical laws is already formulated by experts at the theoretical level of knowledge in meaningful scientific laws7.

In the development of the Eidos system, the following steps were taken:

1st stage, "preparatory": 1979-1992. The mathematical model of the Eidos system was developed in 1979 and first underwent experimental testing in 1981 (the first calculation on a computer based on the model). From 1981 to

[7]Reference to this brief description of the Eidos system in English: http://lc.kubagro.ru/aidos/The_Eidos_en.htm

1992, the Eidos system was repeatedly implemented on the Wang platform (on Wang-2200C computers). In 1987, it was first obtained on one of Implementation Actthe early versions of the Eidos system, implemented in the environment of the Vega-M personal technological system developed by the author (see Act 2).

Stage 2, "IBM PC and MS DOS era": 1992-2012. For IBM-compatible personal computers, the Eidos system was first implemented in the CLIPPER-87 and CLIPPER-5.01 (5.02) languages in 1992, and in 1994 the RosPatent certificatesfirst ones in the Krasnodar Territory and, possibly, in Russia on artificial intelligence systems (on the left there is a title videogram of the final DOS-version of the year "2012. From then until now, the system has been continuously improved on the IBM PC.

Stage 3, "MS Windows xp, 8, 7 era": 2012-2020. From June 2012 to 14.12.2020, the Eidos system developed in Alaska-1.9 + Express++ + library for working with Internet xb2net. The Eidos-X1.9 system worked well on all versions of MS Windows except Windows-10, which required special configuration. The most computationally labor-intensive operations of model synthesis and recognition are implemented using a graphics processor (GPU), which on some tasks allows you to accelerate the solution of these problems by several thousand times, which actually provides intelligent processing of large data, large information and a lot of knowledge (the graphics processor must be on the NVIDIA chipset).

Stage 4, "MS Windows-10 era": 2020-2021. From 13.12.2020 to the present, the Eidos system has been developing in the Alaska-2.0 + Express++ language. The xb2net library is no longer used in it, since all Internet features are included in.basic programming language capabilities

Stage 5, "the era of Big Data, Information and Knowledge": from 2022 to the present. Since 2022, the author and developer of the Eidos system prof. E.V.Lutsenko closely engaged in the development of a professional version of the Aidos system in Alaska + Express, which provides the processing of big data, information and knowledge (Big Data, Big Information, Big Knowledge) using ADS (Advantage Database Server), as well as in C # (Visual Studio). | C

Figure 1 shows the cover videogram of the DOS version of the Eidos system, Figure 2 shows the current version of the Eidos system, and Figure 3 shows the sequence of processing data, information and knowledge in the Eidos system:

Figure 1. Title videogram of the DOS version of the Eidos system (until 2012)[8]

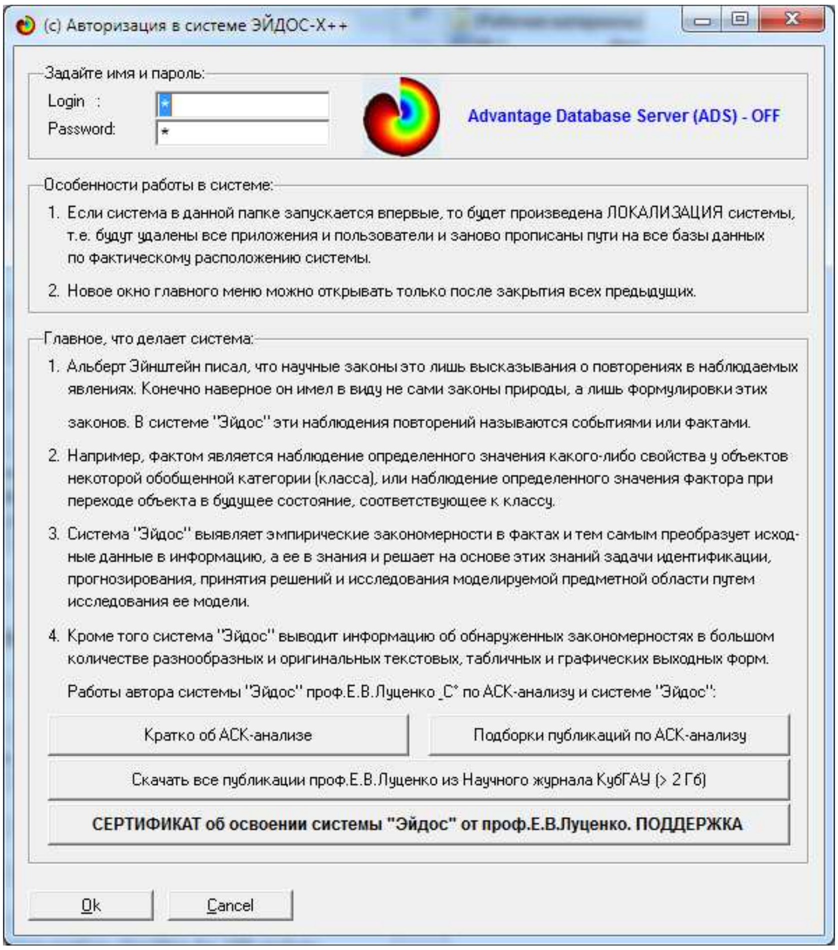


Figure 2. Cover videogram of the current version of "Eidos" system

[8]http://lc.kubagro.ru/pic/aidos_titul.jpg

Последовательность обработки данных, информации и знаний в системе «Эйдос», повышение уровня системности данных, информации и знаний, повышение уровня системности моделей

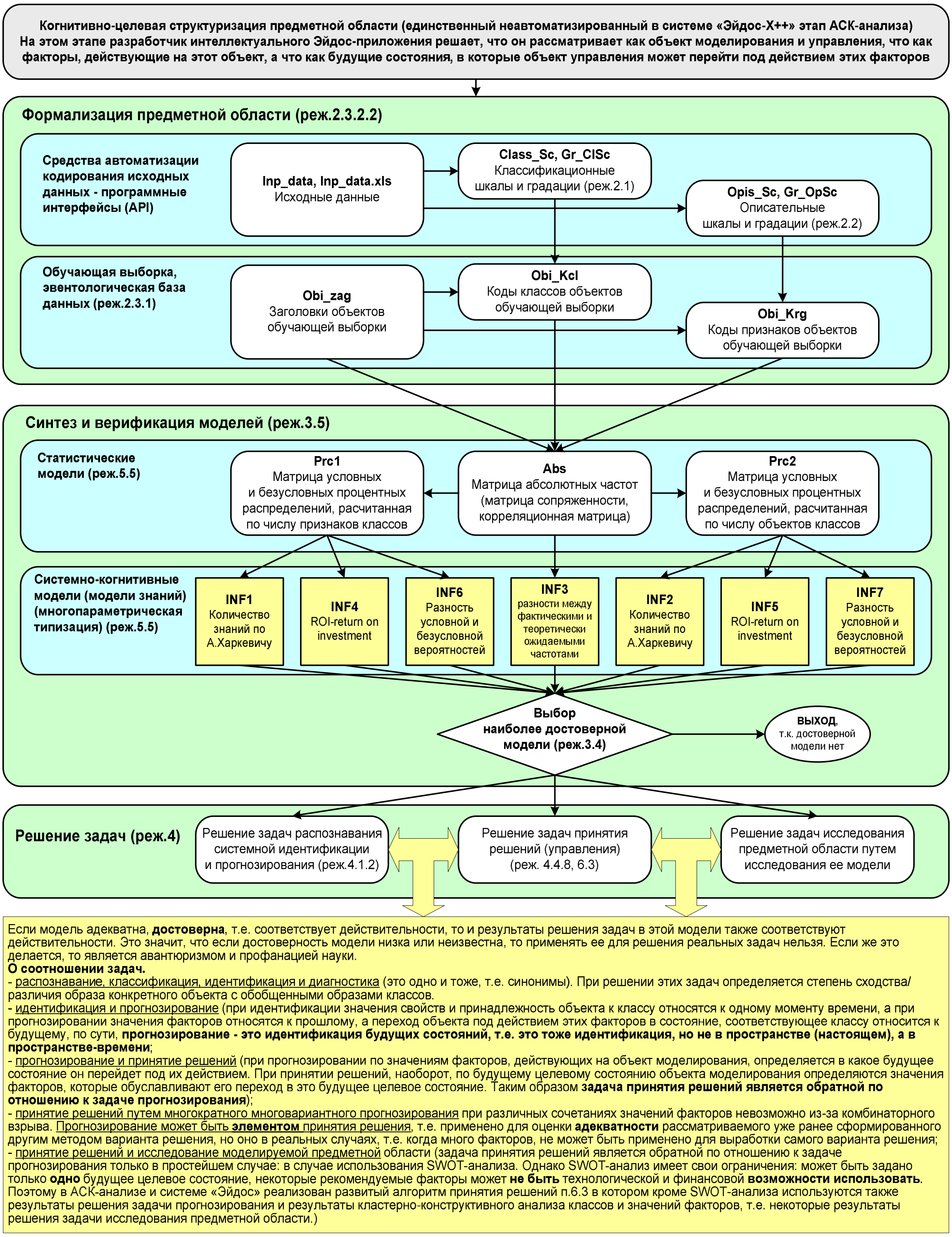


Figure 3. Sequence of data, information and knowledge processing in "Eidos" system

3. RESULTS

3.1. *Task-1.* Cognitive structuring of the subject area. Two interpretations of classification descriptive scales and gradations

The stage of cognitive-targeted structuring of the subject area is the only stage of scenario ASK analysis that is not automated in the Eidos system.

At the stage of cognitive-targeted structuring of the subject area, we decide informalistically at a qualitative level, which we will consider as factors acting on the simulated object (causes), and what as results of the action of these factors (consequences). In fact, this is the setting of the problem to be solved.

Descriptive scales are used to formally describe factors, and classification scales are used to describe the results of their action on the modeling object. The scales can be numeric and textual. Text scales can be nominal and ordinal.

Cognitive structuring of the subject area is the first and only non-automated stage of ASK analysis in the Eidos system, i.e. all subsequent stages of ASK analysis in it are fully automated.

Two interpretations of classification and descriptive scales and gradations are used in ASK analysis and the Eidos system***: static and dynamic*** and corresponding terminology (generalizing, static and dynamic).

Static interpretation and terminology:

- gradations of classification scales - these are generalizing categories of object types (classes);

- descriptive scales - properties of objects, gradations of descriptive scales - values of properties (characteristics) of objects.

Dynamic interpretation and terminology:

- gradations of classification scales - these are generalizing categories of future states of the modeling object (classes);

- descriptive scales - factors acting on the modeling object, gradations of descriptive scales - values of factors acting on the modeling object.

Generalizing terminology:

- classification scales and gradations;
- descriptive scales and gradations.

Gradations of classification scales in ASK analysis are called classes, and gradations of descriptive scales are called signs.

In this work, we will mainly adhere to static interpretation and terminology.

As a result of the stage of cognitive-targeted structuring of the subject area:

- as a **modeling object**, we will choose natural numbers from 1 to 65535, which we will consider as systems of simple multipliers;
- as factors affecting the system level of the simulation object, let us select the values of the number, its prime factors, the logarithm of the number, the recursive sum of its digits and which digits are located in various positions of the number record (Table 1);
- as the results of the influence of factors on the modeling object, we will choose the levels of systemicity of natural numbers (Table 2).

To quantify the level of systemicity of natural numbers, the emergence coefficient proposed by the author in 2002 and named after one of the founders of the scientific theory of information R. Hartli is used.

Table 1- Factors affecting the system level of the simulation object (descriptive scales)

KOD_OPSC	NAME_OPSC
1	NUMBER
2	PRIMFACTRS
3	LOGNUMBER
4	CONVOLUTIO
5	E4
6	E3
7	E2
8	E1
9	E0

Table 2- Results of factors influence on the simulation object (classification scales)

KOD_CLSC	NAME_CLSC
1	LEVELCONS

3.2. *Task-2.* Formalization of the subject area

At the stage of formalization of the subject area classification and descriptive scales and gradations are developed, and then the initial data are encoded using them, as a result of which a training sample is obtained. The training sample is essentially the original data *normalized* with classification and descriptive scales and gradations.

The Eidos system has a large number of various automated software interfaces (APIs) that provide input to the system of external data of various types: text, table and graphic, as well as others that can be presented in this form, for example, audio or electroencephalogram (ETG) or cardiogram (ECG) data.

This ensures the possibility of a user-friendly application of the Eidos system for conducting scientific research in a variety of areas of science and solving practical problems in a variety of subject areas, almost everywhere a person uses natural intelligence.

In this work, tables of natural numbers and their properties, generated by a program specially developed by the author for conducting this study, are used as initial data.

Figure 4 shows the screen forms of this program, in Table 3 a fragment of the source data generated by it, and then ***a main*** fragment of the source text of this program:

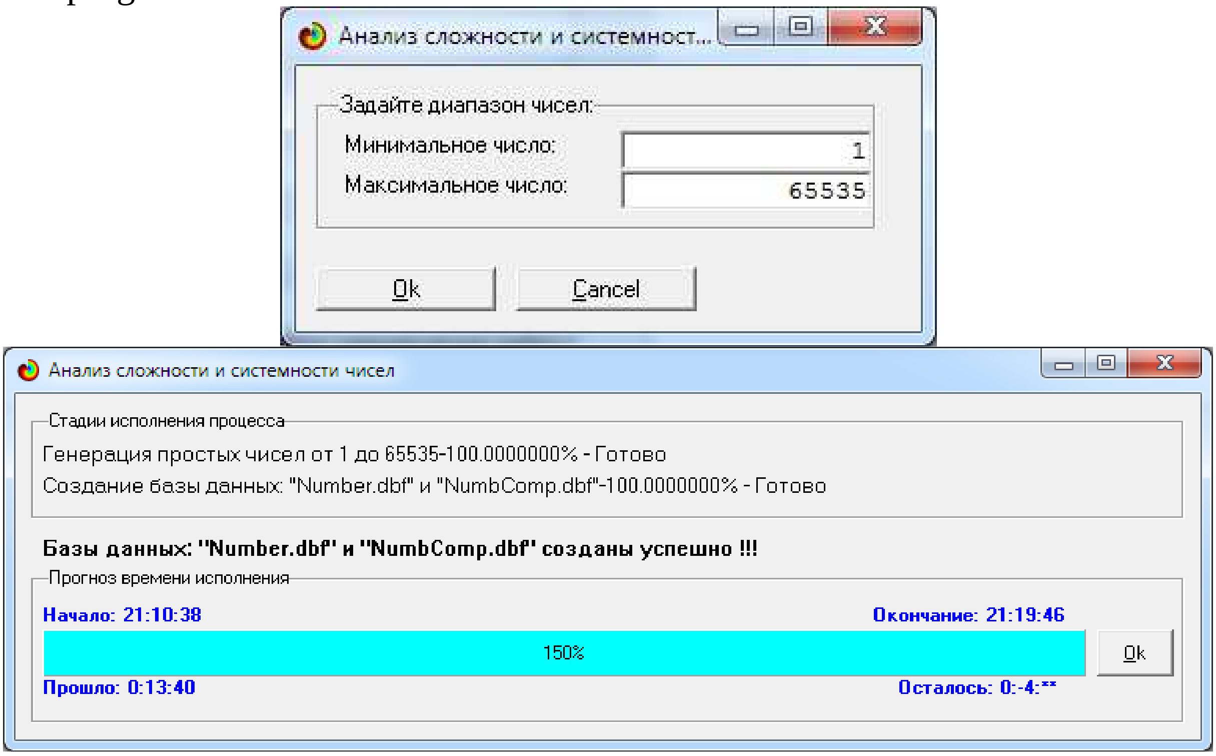


Figure 4. Screen forms of the source data generation program

In full working form, this program is available on the ResechGate website at: https://www.researchgate.net/publication/360224846.

```
/*
     *** (C) д.э.н., к.т.н., профессор Луценко Евгений Вениаминович, Россия, Краснодар.
     *** 1:07 20.04.2022.    Анализ сложности и системности чисел
*/
***
********************************************************************************
     FUNCTION Main()

     LOCAL GetOptions, nColor, oMessageBox, oMenuWords, oDlg, n := 0, oPrinter, cOutString
     LOCAL Getlist := {}, oProgress, oDialog
     LOCAL Mess97, Mess98, Mess99             // Массив сообщений отображаемых стадий исполнения (до 30 на экране)
     PUBLIC aSay[30], mNumPP := 0

        DC_IconDefault(1000)

        SET DECIMALS TO 15
        SET DATE GERMAN
        SET ESCAPE On

********************************************************************
mMinNumb  = 1
mMaxNumb  = 10000

@1,1  DCGROUP oGroup1 CAPTION 'Задайте диапазон чисел:' SIZE 40.0, 3.5

@1,2  DCSAY "Минимальное число:"                        PARENT oGroup1
@1,20 DCSAY "" GET mMinNumb PICTURE "###############" PARENT oGroup1

@2,2  DCSAY "Максимальное число:"                       PARENT oGroup1
@2,20 DCSAY "" GET mMaxNumb PICTURE "###############" PARENT oGroup1
```

```
DCREAD GUI;
      TO lExit ;
      FIT;
      ADDBUTTONS;
      MODAL;
      TITLE 'Анализ сложности и системности чисел'
      IF lExit
         ** Button Ok
      ELSE
         QUIT
      ENDIF
*********************************************************************

   mLenMaxNumb   = LEN(ALLTRIM(STR(mMaxNumb)))

   Wsego = mMaxNumb + ( mMaxNumb - mMinNumb + 1 )

   // Отображение стадии исполнения. Будет написано прямо в окне Progress-bar
   @ 0,0 DCGROUP oGroup1 CAPTION 'Стадии исполнения процесса' FONT "6.Helv" SIZE 105, 3.5 PARENT oTabPage1
   @ 5,0 DCGROUP oGroup2 CAPTION 'Прогноз времени исполнения' FONT "6.Helv" SIZE 105, 5.0 PARENT oTabPage2
   s = 1
   @s++,1 DCSAY " " SAYSIZE 100 SAYOBJECT aSay[ 1] FONT "10.Helv"  // 1
   @s++,1 DCSAY " " SAYSIZE 100 SAYOBJECT aSay[ 2] FONT "10.Helv"  // 2
    s++
   @s++,1 DCSAY " " SAYSIZE 100 SAYOBJECT oSay97 FONT "10.HelvBold"
    s++
   @0.2+s++,1 DCSAY " " SAYSIZE 100 SAYOBJECT oSay98 FONT "9.Helv Bold" COLOR GRA_CLR_BLUE
   @1.5+s  ,1 DCSAY " " SAYSIZE 100 SAYOBJECT oSay99 FONT "9.Helv Bold" COLOR GRA_CLR_BLUE

   @s  ,1 DCPROGRESS oProgress ;
          SIZE 95,1.5 ;
          PERCENT ;
          EVERY 1;                          // Кол-во обновлений изображения
          MAXCOUNT Wsego;
          COLOR GRA_CLR_CYAN                // Цвет полосы
   @s++,97 DCPUSHBUTTON  CAPTION '&Cancel' ;
          ACTION {||lOk:=.T.} OBJECT oButton ;
          SIZE 7,1.5
   DCREAD GUI ;
          TITLE 'Анализ сложности и системности чисел' ;
          PARENT @oDialog  ;
          FIT ;
          EXIT ;
          MODAL

   oDialog:alwaysOnTop = .T.       // Окно открывается на переднем плане
   oDialog:show()
*************************************************************************

   aStructure := { { "Num"        , "N", 19, 0},;     // Число
                   { "NPrmFactrs", "N", 19, 0},;      // Сложность   числа = количество простых множителей
                   { "LevelCons" , "N", 19,13},;      // Системность числа = коэфф.эмердж.Хартли
                   { "Number"    , "N", 19, 0},;      // Число
                   { "PrimFactrs", "C",255, 0},;      // Простые множители через пробел
                   { "LogNumber" , "N", 19, 7},;      // Логарифм числа (по основанию 2)
                   { "Convolutio", "C",   3, 0} }     // Свертка (рекурсивная сумма всех цифр)

   FOR j = mLenMaxNumb TO 1 STEP -1                   // Число разрядов
       FieldName = "E"+ALLTRIM(STR(j-1,19))
       AADD(aStructure, { FieldName  , "C", 3, 0 })
   NEXT

   DbCreate( "Number", aStructure )

   // Начало отсчета времени для прогнозирования длительности исполнения
   Time_progress = 0
   // Прошло секунд с начала процесса
   // Процесс может идти больше суток, поэтому для определения
   // во всех случаях вычисляется время, прошедшее с начала года
      T_Mess1     = "Начало:"+" "+TIME()           // Начало
      Sec_1       = (DOY(DATE())-1)*86400+SECONDS()
      PUBLIC T1 := (DOY(DATE())-1)*86400+SECONDS()        // Время предыдущей индикации процесса исполнения
      PUBLIC T2 := (DOY(DATE())-1)*86400+SECONDS()+1      // Текущее время (1-й раз оно заметно больше T1 чтобы было
отображение)
      PUBLIC T1tp := T1
      PUBLIC T2tp := T2
   *********************************************************************************

*  aSay[ 1]:SetCaption('Генерация простых чисел от 1 до '+ALLTRIM(STR(mMaxNumb)))
   mMess = 'Генерация простых чисел от 1 до '+ALLTRIM(STR(mMaxNumb))
   mNumPP := 0

   USE Number EXCLUSIVE NEW

   ***** Найти все простые числа меньшие mMaxNumb, включая 1 и допуская mNumb=1

   aPrCh := {}   // Массив простых чисел

   IF mMaxNumb = 1
      AADD(aPrCh, 1)
   ELSE
```

```
      FOR j = 1 TO mMaxNumb

         PercTimeVisio(1, mMess, mMaxNumb)

         **** Проверка, является ли j простым числом
         mFlag = .T.
         FOR i=2 TO j-1
             IF j=i*INT(j/i)  // Делится ли j на i нацело?
                mFlag = .F.
                EXIT
             ENDIF
         NEXT
         IF mFlag
            AADD(aPrCh, j)
         ENDIF
         lOk = Time_Progress (++Time_Progress, Wsego, oProgress, lOk )
      NEXT
   ENDIF
   ASORT(aPrCh)
   mLenPrCh = LEN(ALLTRIM(STR(aPrCh[LEN(aPrCh)])))   // Максимальная длина простого числа в занках

   aSay[ 1]:SetCaption(aSay[1]:caption+' - Готово ')
*  aSay[ 2]:SetCaption('Создание базы данных: "Number.dbf" и "NumbComp.dbf"')
   mMess = 'Создание базы данных: "Number.dbf" и "NumbComp.dbf"'
   mNumPP := 0

   NPrmFactrsMax = -99999999

   FOR mNumb = mMinNumb TO mMaxNumb

       PercTimeVisio(2, mMess, mMaxNumb-mMinNumb+1)

       ***** Разложить число mNumb на простые множители

       aPrMn := {}           // Массив простых множителей числа: mNumb
       Chislo = mNumb
       IF Chislo = 1
          AADD(aPrMn,1)
       ELSE
          mFlag = .T.
          DO WHILE mFlag
             FOR j=2 TO LEN(aPrCh)
                 **** Проверка, делится ли Chislo на простое число из массива aPrCh
                 mFlag = .F.
                 IF Chislo = aPrCh[j] * INT(Chislo/aPrCh[j])
                    AADD(aPrMn,aPrCh[j])
                    Chislo = Chislo/aPrCh[j]
                    mFlag = .T.
                    EXIT
                 ENDIF
             NEXT
          ENDDO
       ENDIF

       mPrimFactrs = ''
       FOR j=1 TO LEN(aPrMn)
           mPrimFactrs = mPrimFactrs + ' ' + STRTRAN(STR(aPrMn[j], mLenPrCh),' ','0')
       NEXT

       mNPrmFactrs   = LEN(aPrMn)                      // Сложность числа = количество простых множителей

       NPrmFactrsMax = MAX(NPrmFactrsMax, mNPrmFactrs)  // Максимальная сложность числа

       mConvolutio = 0
       mNumbConvol = mNumb

       DO WHILE .T.                                  // Расчет свертки (рекурсивная сумма всех цифр числа)
          FOR j=1 TO LEN(ALLTRIM(STR(mNumb)))
              mConvolutio = mConvolutio + VAL(SUBSTR(ALLTRIM(STR(mNumbConvol)),j,1))
          NEXT
          IF LEN(ALLTRIM(STR(mConvolutio))) = 1
             EXIT
          ELSE
             mNumbConvol = mConvolutio
             mConvolutio = 0
          ENDIF
       ENDDO

       APPEND BLANK
       REPLACE Num         WITH mNumb                                                   // Число
       REPLACE NPrmFactrs WITH LEN(aPrMn)                                               // Сложность   числа =
количество простых множителей
       REPLACE LevelCons  WITH LOG(Summa_Cnm(mNPrmFactrs, mNPrmFactrs))/LOG(mNPrmFactrs)      // Системность числа =
коэфф.эмердж.Хартли
       REPLACE Number     WITH mNumb                                                    // Число
       REPLACE PrimFactrs WITH mPrimFactrs                                                // Простые множители
через пробел
       REPLACE LogNumber  WITH LOG(mNumb)/LOG(2)                                         // Логарифм числа (по
основанию 2)
       REPLACE Convolutio WITH '"'+ALLTRIM(STR(mConvolutio))+'"'                                   // Свертка
(рекурсивная сумма всех цифр)
```

```
      mChislo = STRTRAN(STR(mNumb,mLenMaxNumb),' ','0')                                 // Число с ведущими
нулями
      FOR j = 1 TO mLenMaxNumb                                                        // Число разрядов
          FieldName = "E"+ALLTRIM(STR(mLenMaxNumb-j,19))
          REPLACE &FieldName WITH '"'+SUBSTR(mChislo,j,1)+'"'                            // Кол-во единиц,
десятков, сотен, тысяч, десятков тысяч, сотен тысяч, миллионов, десятков миллионов и т.д. в числе
      NEXT

      lOk = Time_Progress (++Time_Progress, Wsego, oProgress, lOk )

   NEXT

   aSay[ 2]:SetCaption(aSay[2]:caption+' - Готово ')
   CLOSE ALL

   aStructure := { { "Comp1"  , "N", 19, 0} }
   FOR j=2 TO NPrmFactrsMax
       FieldName = "Comp"+ALLTRIM(STR(j,19))
       AADD(aStructure, { FieldName  , "N", 19, 0 })
   NEXT
   DbCreate( "NumbComp", aStructure )

   PRIVATE aRecNumb[NPrmFactrsMax]    // Массив количества чисел сложности Comp###
   AFILL(aRecNumb, 0)

   USE NumbComp EXCLUSIVE NEW
   USE Number   EXCLUSIVE NEW

   SELECT Number

   mNRec = RECCOUNT()

   DBGOTOP()
   DO WHILE .NOT. EOF()

      mNumber      = Number                               // Число
      mNPrmFactrs = NPrmFactrs                            // Сложность   числа = количество простых множителей
      aRecNumb[mNPrmFactrs] = aRecNumb[mNPrmFactrs] + 1   // Количества чисел сложности mNPrmFactrs###

      SELECT NumbComp
      IF RECCOUNT() < aRecNumb[mNPrmFactrs]
         APPEND BLANK
      ENDIF

      DBGOTO(aRecNumb[mNPrmFactrs])
      FIELDPUT(mNPrmFactrs, mNumber)

      lOk = Time_Progress (++Time_Progress, Wsego, oProgress, lOk )

      SELECT Number
      DBSKIP(1)
   ENDDO

   CLOSE ALL

   oSay97:SetCaption('Базы данных: "Number.dbf" и "NumbComp.dbf" созданы успешно !!!')
   oSay97:SetCaption(oSay97:caption)
   oButton:SetCaption('&Ok')          // Деструктурирование окна отображения графического Progress-bar
   oButton:activate := {||PostAppEvent(xbeP_Close,,,oDialog)}  //<<<<<< Add This
   DC_AppEvent( @lOk )
*  PostAppEvent(xbeP_Activate,,,DC_GetObject(GetList,'DCGUI_BUTTON_OK'))       // Роджер
   oDialog:Destroy()

*  aMess := {}
*  AADD(aMess, 'Базы данных: "Number.dbf" и "NumbComp.dbf" созданы успешно !!!')
*  LB_Warning(aMess, 'Сложность и системность чисел')

   RETURN NIL

*************************************************************************************************************
```

To develop this program, the author used the programming language xBase++ & eXpress++(Alaska):

- https://www.alaska-software.com/
- http://bb.donnay-software.com/donnay/phpbb3/viewforum.php?f=2
- https://www.xbaseforum.de/

Table 3- Initial data (fragment)

NUM	NPRMFACTRS	LEVELCONS	NUMBER	PRIMFACTRS	LOGNUMBER	CONVOLUTIO	E4	E3	E2	E1	E0
1	1	0,0000000000000	1	00001	0,0000000	"1"	"0"	"0"	"0"	"0"	"1"
2	1	0,0000000000000	2	00002	1,0000000	"2"	"0"	"0"	"0"	"0"	"2"
3	1	0,0000000000000	3	00003	1,5849625	"3"	"0"	"0"	"0"	"0"	"3"
4	2	1,5849625007212	4	00002 00002	2,0000000	"4"	"0"	"0"	"0"	"0"	"4"
5	1	0,0000000000000	5	00005	2,3219281	"5"	"0"	"0"	"0"	"0"	"5"
6	2	1,5849625007212	6	00002 00003	2,5849625	"6"	"0"	"0"	"0"	"0"	"6"
7	1	0,0000000000000	7	00007	2,8073549	"7"	"0"	"0"	"0"	"0"	"7"
8	3	1,7712437491614	8	00002 00002 00002	3,0000000	"8"	"0"	"0"	"0"	"0"	"8"
9	2	1,5849625007212	9	00003 00003	3,1699250	"9"	"0"	"0"	"0"	"0"	"9"
10	2	1,5849625007212	10	00002 00005	3,3219281	"1"	"0"	"0"	"0"	"1"	"0"
11	1	0,0000000000000	11	00011	3,4594316	"2"	"0"	"0"	"0"	"1"	"1"
12	3	1,7712437491614	12	00002 00002 00003	3,5849625	"3"	"0"	"0"	"0"	"1"	"2"
13	1	0,0000000000000	13	00013	3,7004397	"4"	"0"	"0"	"0"	"1"	"3"
14	2	1,5849625007212	14	00002 00007	3,8073549	"5"	"0"	"0"	"0"	"1"	"4"
15	2	1,5849625007212	15	00003 00005	3,9068906	"6"	"0"	"0"	"0"	"1"	"5"
16	4	1,9534452978043	16	00002 00002 00002 00002	4,0000000	"7"	"0"	"0"	"0"	"1"	"6"
17	1	0,0000000000000	17	00017	4,0874628	"8"	"0"	"0"	"0"	"1"	"7"
18	3	1,7712437491614	18	00002 00003 00003	4,1699250	"9"	"0"	"0"	"0"	"1"	"8"
19	1	0,0000000000000	19	00019	4,2479275	"1"	"0"	"0"	"0"	"1"	"9"
20	3	1,7712437491614	20	00002 00002 00005	4,3219281	"2"	"0"	"0"	"0"	"2"	"0"
21	2	1,5849625007212	21	00003 00007	4,3923174	"3"	"0"	"0"	"0"	"2"	"1"
22	2	1,5849625007212	22	00002 00011	4,4594316	"4"	"0"	"0"	"0"	"2"	"2"
23	1	0,0000000000000	23	00023	4,5235620	"5"	"0"	"0"	"0"	"2"	"3"
24	4	1,9534452978043	24	00002 00002 00002 00003	4,5849625	"6"	"0"	"0"	"0"	"2"	"4"
25	2	1,5849625007212	25	00005 00005	4,6438562	"7"	"0"	"0"	"0"	"2"	"5"
26	2	1,5849625007212	26	00002 00013	4,7004397	"8"	"0"	"0"	"0"	"2"	"6"
27	3	1,7712437491614	27	00003 00003 00003	4,7548875	"9"	"0"	"0"	"0"	"2"	"7"
28	3	1,7712437491614	28	00002 00002 00007	4,8073549	"1"	"0"	"0"	"0"	"2"	"8"
29	1	0,0000000000000	29	00029	4,8579810	"2"	"0"	"0"	"0"	"2"	"9"
30	3	1,7712437491614	30	00002 00003 00005	4,9068906	"3"	"0"	"0"	"0"	"3"	"0"
31	1	0,0000000000000	31	00031	4,9541963	"4"	"0"	"0"	"0"	"3"	"1"
32	5	2,1336562149773	32	00002 00002 00002 00002 00002	5,0000000	"5"	"0"	"0"	"0"	"3"	"2"
33	2	1,5849625007212	33	00003 00011	5,0443941	"6"	"0"	"0"	"0"	"3"	"3"
34	2	1,5849625007212	34	00002 00017	5,0874628	"7"	"0"	"0"	"0"	"3"	"4"
35	2	1,5849625007212	35	00005 00007	5,1292830	"8"	"0"	"0"	"0"	"3"	"5"
36	4	1,9534452978043	36	00002 00002 00003 00003	5,1699250	"9"	"0"	"0"	"0"	"3"	"6"
37	1	0,0000000000000	37	00037	5,2094534	"1"	"0"	"0"	"0"	"3"	"7"
38	2	1,5849625007212	38	00002 00019	5,2479275	"2"	"0"	"0"	"0"	"3"	"8"
39	2	1,5849625007212	39	00003 00013	5,2854022	"3"	"0"	"0"	"0"	"3"	"9"
40	4	1,9534452978043	40	00002 00002 00002 00005	5,3219281	"4"	"0"	"0"	"0"	"4"	"0"
41	1	0,0000000000000	41	00041	5,3575520	"5"	"0"	"0"	"0"	"4"	"1"
42	3	1,7712437491614	42	00002 00003 00007	5,3923174	"6"	"0"	"0"	"0"	"4"	"2"
43	1	0,0000000000000	43	00043	5,4262648	"7"	"0"	"0"	"0"	"4"	"3"
44	3	1,7712437491614	44	00002 00002 00011	5,4594316	"8"	"0"	"0"	"0"	"4"	"4"
45	3	1,7712437491614	45	00003 00003 00005	5,4918531	"9"	"0"	"0"	"0"	"4"	"5"
46	2	1,5849625007212	46	00002 00023	5,5235620	"1"	"0"	"0"	"0"	"4"	"6"
47	1	0,0000000000000	47	00047	5,5545889	"2"	"0"	"0"	"0"	"4"	"7"
48	5	2,1336562149773	48	00002 00002 00002 00002 00003	5,5849625	"3"	"0"	"0"	"0"	"4"	"8"
49	2	1,5849625007212	49	00007 00007	5,6147098	"4"	"0"	"0"	"0"	"4"	"9"
50	3	1,7712437491614	50	00002 00005 00005	5,6438562	"5"	"0"	"0"	"0"	"5"	"0"
51	2	1,5849625007212	51	00003 00017	5,6724253	"6"	"0"	"0"	"0"	"5"	"1"
52	3	1,7712437491614	52	00002 00002 00013	5,7004397	"7"	"0"	"0"	"0"	"5"	"2"
53	1	0,0000000000000	53	00053	5,7279205	"8"	"0"	"0"	"0"	"5"	"3"
54	4	1,9534452978043	54	00002 00003 00003 00003	5,7548875	"9"	"0"	"0"	"0"	"5"	"4"
55	2	1,5849625007212	55	00005 00011	5,7813597	"1"	"0"	"0"	"0"	"5"	"5"
56	4	1,9534452978043	56	00002 00002 00002 00007	5,8073549	"2"	"0"	"0"	"0"	"5"	"6"
57	2	1,5849625007212	57	00003 00019	5,8328900	"3"	"0"	"0"	"0"	"5"	"7"
58	2	1,5849625007212	58	00002 00029	5,8579810	"4"	"0"	"0"	"0"	"5"	"8"
59	1	0,0000000000000	59	00059	5,8826430	"5"	"0"	"0"	"0"	"5"	"9"
60	4	1,9534452978043	60	00002 00002 00003 00005	5,9068906	"6"	"0"	"0"	"0"	"6"	"0"
61	1	0,0000000000000	61	00061	5,9307373	"7"	"0"	"0"	"0"	"6"	"1"
62	2	1,5849625007212	62	00002 00031	5,9541963	"8"	"0"	"0"	"0"	"6"	"2"
63	3	1,7712437491614	63	00003 00003 00007	5,9772799	"9"	"0"	"0"	"0"	"6"	"3"
64	6	2,3123275180326	64	00002 00002 00002 00002 00002 00002	6,0000000	"1"	"0"	"0"	"0"	"6"	"4"
65	2	1,5849625007212	65	00005 00013	6,0223678	"2"	"0"	"0"	"0"	"6"	"5"
66	3	1,7712437491614	66	00002 00003 00011	6,0443941	"3"	"0"	"0"	"0"	"6"	"6"
67	1	0,0000000000000	67	00067	6,0660892	"4"	"0"	"0"	"0"	"6"	"7"
68	3	1,7712437491614	68	00002 00002 00017	6,0874628	"5"	"0"	"0"	"0"	"6"	"8"
69	2	1,5849625007212	69	00003 00023	6,1085245	"6"	"0"	"0"	"0"	"6"	"9"
70	3	1,7712437491614	70	00002 00005 00007	6,1292830	"7"	"0"	"0"	"0"	"7"	"0"
71	1	0,0000000000000	71	00071	6,1497471	"8"	"0"	"0"	"0"	"7"	"1"
72	5	2,1336562149773	72	00002 00002 00002 00003 00003	6,1699250	"9"	"0"	"0"	"0"	"7"	"2"
73	1	0,0000000000000	73	00073	6,1898246	"1"	"0"	"0"	"0"	"7"	"3"
74	2	1,5849625007212	74	00002 00037	6,2094534	"2"	"0"	"0"	"0"	"7"	"4"
75	3	1,7712437491614	75	00003 00005 00005	6,2288187	"3"	"0"	"0"	"0"	"7"	"5"
76	3	1,7712437491614	76	00002 00002 00019	6,2479275	"4"	"0"	"0"	"0"	"7"	"6"
77	2	1,5849625007212	77	00007 00011	6,2667865	"5"	"0"	"0"	"0"	"7"	"7"
78	3	1,7712437491614	78	00002 00003 00013	6,2854022	"6"	"0"	"0"	"0"	"7"	"8"
79	1	0,0000000000000	79	00079	6,3037807	"7"	"0"	"0"	"0"	"7"	"9"
80	5	2,1336562149773	80	00002 00002 00002 00002 00005	6,3219281	"8"	"0"	"0"	"0"	"8"	"0"

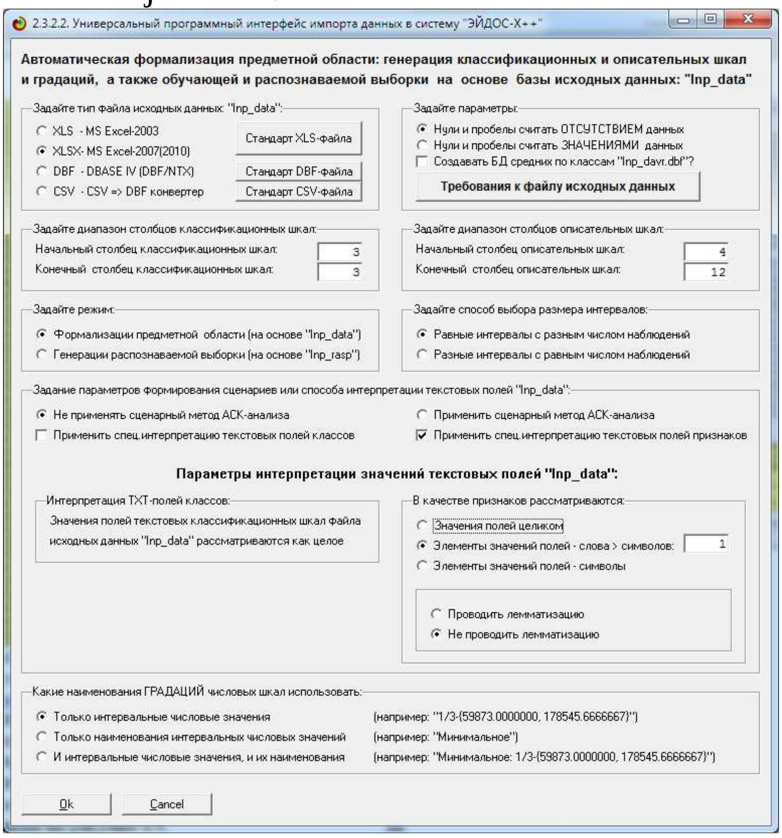
The correspondence of the field names of Table 3 and their meaning is given below:

– Num: Number;
– NPrmFactrs: Number complexity = number of prime multipliers;
– LevelCons: Number Systematality = Hartley Emergence Coefficient;
– Number: Number;
– PrimFactrs: Simple factors across a space;
– LogNumber: Logarithm of the number (by base 2);
– Convolutio: Convolution (recursive sum of all digits).

In full form, the Excel source data table is in full public free access in the Eidos Cloud by direct link: http://aidos.byethost5.com/Source_data_applications/Applications-000333/Inp_data.xlsx. In addition, it can be calculated by itself using the program: https://www.researchgate.net/publication/360224846 at any given parameters.

We will not describe the systemic level of the natural number as a system of simple multipliers in this work, since a large number of works by the author are devoted to this issue [29-56].

In this work, API-2.3.2.2 universal automated program interface with the parameters given in Figure 5 was used for input of initial data (Table 3) into the Eidos system and automated development of classification and descriptive scales and gradations and training sampling (Tables 4, 5, 6), i.e. for automated formalization of the subject area:



Помощь по режиму 2.3.2.2 для случая Excel-файлов исходных данных

Режим 2.3.2.2: Универсальный программный интерфейс импорта данных из внешней базы данных "Inp_data.xls" в систему "Эйдос-Х++" и формализации предметной области.
- Данный программный интерфейс обеспечивает формализацию предметной области, т.е. анализ файла исходных данных Inp_data.xls(x), формирование классификационных и описательных шкал и градаций, а затем кодирование файла исходных с их использованием.
- Файл исходных данных должен иметь имя: Inp_data.xls(x), а файл распознаваемой выборки имя: Inp_rasp.xls(x). Файлы Inp_data.xls(x) и Inp_rasp.xls(x) должны находиться в папке ../AIDOS-X/AID_DATA/Inp_data/. Эти файлы имеют совершенно одинаковую структуру.
- 1-я строка этого файла должна содержать наименования колонок на любом языке, в т.ч. и русском. Эти наименования должны быть во всех колонках, при этом переносы по словам разрешены, а объединение ячеек, разрыв строки знак абзаца не допускаются. Эти наименования должны быть короткими, но понятными, т.к.они будут в выходных формах, а к ним еще будут добавляться наименования градаций. В числовых шкалах надо ОБЯЗАТЕЛЬНО указывать единицы измерения и число знаков после запятой в колонке должно быть ОДИНАКОВОЕ.
- 1-я колонка содержит наименование объекта обучающей выборки или наименование наблюдения. Оно может быть длинным: до 255 символов.
- Каждая строка этого файла, начиная со 2-й, содержит данные об одном объекте обучающей выборки или одном наблюдении. В MS Excel-2003 в листе может быть до 65536 строк и до 256 колонок. В листе MS Excel-2010 и более поздних возможно до 1048576 строк и 16384 колонок.
- Столбцы, начиная со 2-го, являются классификационными и описательными шкалами и могут быть текстового (номинального / порядкового) или числового типа (с десятичными знаками после запятой).
- Столбцу присваивается числовой тип, если все значения его ячеек числового типа. Если хотя бы одно значение является текстовым (не числом, в т.ч. пробелом), то столбцу присваивается текстовый тип. Это означает, что нули должны быть указаны нулями, а не пробелами.
- Столбцы со 2-го по N-й являются классификационными шкалами (выходными параметрами) и содержат данные о классах (будущих состояниях объекта управления), к которым принадлежат объекты обучающей выборки.
- Столбцы с N+1 по последний являются описательными шкалами (свойствами или факторами) и содержат данные о признаках (т.е. значениях свойств или значениях факторов), характеризующих объекты обучающей выборки.
- В результате работы режима формируется файл INP_NAME.TXT стандарта MS DOS (кириллица), в котором наименования классификационных и описательных шкал являются СТРОКАМИ. Система формирует классификационные и описательные шкалы и градации. Для этого в каждом числовом столбце система находит минимальное и максимальное числовые значения и формирует заданное количество числовых интервалов, после чего числовые значения заменяются их интервальными значениями. В текстовых столбцах система находит уникальные текстовые значения. Каждое УНИКАЛЬНОЕ интервальное числовое или текстовое значение считается градацией классификационной или описательной шкалы, характеризующей объект. В каждой шкале ее градации сортируются по алфавиту. С использованием шкал и градаций кодируются исходные данные в результате чего генерируется обучающая выборка, каждый объект которой соответствует одной строке файла исходных данных NP_DATA и содержит коды классов, соответствующие фактам совпадения числовых или уникальных текстовых значений классов с градациями классификационных шкал и коды признаков, соответствующие фактам совпадения числовых или уникальных текстовых значений признаков с градациями описательных шкал
- Распознаваемая выборка формируется на основе файла INP_RASP аналогично, за исключением того, что классификационные и описательные шкалы и градации не создаются, а используются ранее созданные в модели, и базы распознаваемой выборки могут не включать коды классов, если столбцы классов в файле INP_RASP были пустыми. Структура файла INP_RASP должна быть такая же, как INP_DATA, т.е. они должны ПОЛНОСТЬЮ совпадать по наименованиям столбцов, но могут иметь разное количество строк с разными значениями в них.

Принцип организации таблицы исходных данных:

Наименование объекта обучающей выборки	Наименование 1-й классификационной шкалы	Наименование 2-й классификационной шкалы	...	Наименование 1-й описательной шкалы	Наименование 2-й описательной шкалы	...
1-й объект обучающей выборки (1-е наблюдение)	Значение шкалы	Значение шкалы	...	Значение шкалы	Значение шкалы	...
2-й объект обучающей выборки (2-е наблюдение)	Значение шкалы	Значение шкалы	...	Значение шкалы	Значение шкалы	...
...	...	...	...	...	...	...

Определения основных терминов и профилактика типичных ошибок при подготовке Excel-файла исходных данных

Помощь по режиму 2.3.2.2 для случая Excel-файлов исходных данных

Режим 2.3.2.2: Универсальный программный интерфейс импорта данных из внешней базы данных "Inp_data.xls(x)" в систему "Эйдос-Х++"
ТЕРМИНЫ АСК-АНАЛИЗА И СИСТЕМЫ "ЭЙДОС":
Шкала представляет собой способ формализации предметной области. Используется числовые и текстовые шкалы, при этом текстовые могут быть номинальными и порядковыми. На номинальных шкалах есть только отношения эквивалентности и неэквивалентности, на порядковых,кроме того еще отношения "больше", "меньше", а на числовых - кроме того могут выполняться все арифметические операции. Каждый объект выборки (наблюдение) описан с одной стороны своими признаками, а с другой -принадлежностью к некоторым обобщающим категориям (классам). Такая структура описания называется онтологией или фреймом экземпляром и является базовой для всех моделей представления знаний.
В АСК-анализе и системе "Эйдос" используется три интерпретации шкал и градаций: универсальная, статическая и динамическая:
- в универсальной интерпретации: признаки - это градации описательных шкал;
- в статической интерпретации: описательная шкала - это свойство, а градация (признак) - это степень выраженности этого свойства;
- в динамической интерпретации: описательная шкала - это фактор, а градация (признак) - это значение фактора;
- в универсальной интерпретации: классы - это градации классификационных шкал;
- в статической интерпретации: классификационная шкала - способ классификации обобщающих категорий (классов), к которым в настоящем времени по отношению к признакам относятся состояния объекта моделирования;
- в динамической интерпретации: классификационная шкала - способ классификации обобщающих категорий (классов), к которым в будущем времени по отношению к признакам относятся состояния объекта прогнозирования или управления;
ПРОФИЛАКТИКА ОШИБОК В ФАЙЛЕ ИСХОДНЫХ ДАННЫХ:
- 1-я строка файла "Inp_data.xls(x)" должна содержать наименования колонок. Эти наименования должны быть во всех колонках, при этом переносы по словам разрешены, а объединение ячеек, разрыв строки знак абзаца и неалфавитные символы не допускаются. Эти наименования должны быть короткими, но понятными, т.к.они будут в выходных формах, а к ним еще будут добавляться наименования градаций. В числовых шкалах надо обязательно указывать единицы измерения. Число знаков после запятой в числовой колонке должно быть одинаковым.
- 1-я колонка содержит наименование объекта обучающей выборки или наименование наблюдения. Оно может быть длинным: до 255 символов.
- Столбцы, начиная со 2-го, являются классификационными и описательными шкалами и могут быть текстового (номинального / порядкового) или числового типа (со знаками после запятой). Чтобы текстовая шкала была порядковой, нужно чтобы при сортировке по алфавиту градации этой шкалы образовывали осмысленную последовательность от минимального значения до максимального. Например, текстовая шкала "Размер" с градациями: "очень малое", "малое", "среднее", "большое", "очень большое", будет номинальной шкалой, т.к.при сортировке по алфавиту они расположатся в порядке: "большое", "малое", "очень большое", "очень малое", "среднее".Чтобы шкала "Размер" стала порядковой нужно в этим градациям присвоить следующие значения: "1/5-очень малое", "2/5-малое", "3/5-среднее", "4/5-большое", "5/5-очень большое".
- Столбцу присваивается числовой тип, если все значения его ячеек числового типа. Если хотя бы одно значение является текстовым (не числом, в т.ч. пробелом), то столбцу присваивается текстовый тип. Это означает, что нули должны быть указаны нулями, а не пробелами.
Если в системе "Эйдос" в режимах 2.1, 2.2 посмотреть на градации классификационных и описательных шкал, которые должны быть числовыми, то сразу будет видно, в какой форме представлены числа: числовыми диапазонами или прямо числами. Если числовыми диапазонами, значит в файле исходных данных в этом отношении все правильно, если же числами, то возможно в Excel-файле нужно заменить десятичные точки на запятые, а также найти и исправить нечисловые данные в числовых по смыслу колонках. Быстро найти их можно перейдя на последнюю строку файла исходных данных и задав расчет суммы колонки. В формуле будет видно с какой строки идет расчет суммы. Если со 2-й, то значит все верно, иначе будет указана строка, в которой находится нечисловое значение.
- Система "Эйдос" работает с областью данных файла исходных данных, которую можно выделить блоком, поставив курсор в ячейку A1, нажав Ctrl+Home, а затем зажав клавиши Shift+Ctrl нажать End. Если этот блок выходит за пределы области таблицы, фактически занятой данными надо скопировать эту фактическую область данных в буфер обмена, создать новый лист и скопировать в него, а исходный лист удалить.
- Иногда бывает полезно сбросить все форматирование Excel-таблицы исходных данных. Это можно сделать в MS Excel. А можно скопировать таблицу в MS Word, а потом обратно в MS Excel.

Принцип организации таблицы исходных данных:

Наименование объекта обучающей выборки	Наименование 1-й классификационной шкалы	Наименование 2-й классификационной шкалы	...	Наименование 1-й описательной шкалы	Наименование 2-й описательной шкалы	...
1-й объект обучающей выборки (1-е наблюдение)	Значение шкалы	Значение шкалы	...	Значение шкалы	Значение шкалы	...
2-й объект обучающей выборки (2-е наблюдение)	Значение шкалы	Значение шкалы	...	Значение шкалы	Значение шкалы	...
...	...	...	...	...	...	...

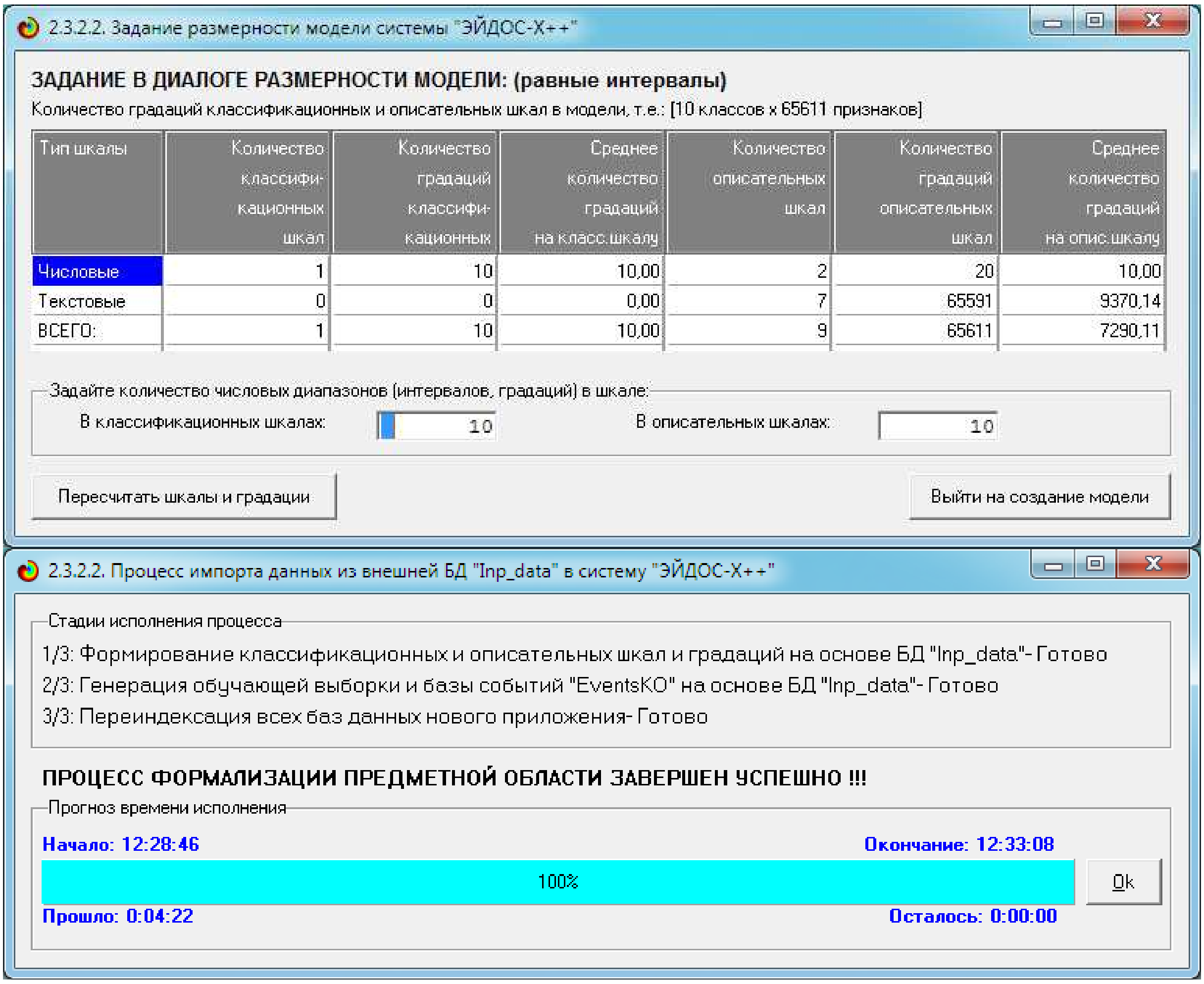


Figure 5. Screen forms of universal automated software interface API-2.3.2.2 of "Eidos" system

The API-2.3.2.2 results in classification and descriptive scales and gradations (Tables 4 and 5).

Table 4- Classification scales and gradations (complete)

KOD_CLS	NAME_CLS
1	LEVELCONS-1/10-{1.6, 1.8}
2	LEVELCONS-2/10-{1.8, 2.0}
3	LEVELCONS-3/10-{2.0, 2.3}
4	LEVELCONS-4/10-{2.3, 2.5}
5	LEVELCONS-5/10-{2.5, 2.7}
6	LEVELCONS-6/10-{2.7, 2.9}
7	LEVELCONS-7/10-{2.9, 3.2}
8	LEVELCONS-8/10-{3.2, 3.4}
9	LEVELCONS-9/10-{3.4, 3.6}
10	LEVELCONS-10/10-{3.6, 3.8}

Table 5- Descriptive scales and gradations (fragment)

KOD_ATR	NAME_ATR
1	NUMBER-1/10-{1.0000000, 6554.4000000}
2	NUMBER-2/10-{6554.4000000, 13107.8000000}
3	NUMBER-3/10-{13107.8000000, 19661.2000000}
4	NUMBER-4/10-{19661.2000000, 26214.6000000}
5	NUMBER-5/10-{26214.6000000, 32768.0000000}
6	NUMBER-6/10-{32768.0000000, 39321.4000000}
7	NUMBER-7/10-{39321.4000000, 45874.8000000}
8	NUMBER-8/10-{45874.8000000, 52428.2000000}
9	NUMBER-9/10-{52428.2000000, 58981.6000000}
10	NUMBER-10/10-{58981.6000000, 65535.0000000}
11	PRIMFACTRS-00001
12	PRIMFACTRS-00002
13	PRIMFACTRS-00003
14	PRIMFACTRS-00005
15	PRIMFACTRS-00007
16	PRIMFACTRS-00011
17	PRIMFACTRS-00013
18	PRIMFACTRS-00017
19	PRIMFACTRS-00019
20	PRIMFACTRS-00023
21	PRIMFACTRS-00029
22	PRIMFACTRS-00031
23	PRIMFACTRS-00037
24	PRIMFACTRS-00041
25	PRIMFACTRS-00043
26	PRIMFACTRS-00047
***	***
6550	PRIMFACTRS-65479
6551	PRIMFACTRS-65497
6552	PRIMFACTRS-65519
6553	PRIMFACTRS-65521
6554	LOGNUMBER-1/10-{1.0000000, 2.4999978}
6555	LOGNUMBER-2/10-{2.4999978, 3.9999956}
6556	LOGNUMBER-3/10-{3.9999956, 5.4999934}
6557	LOGNUMBER-4/10-{5.4999934, 6.9999912}
6558	LOGNUMBER-5/10-{6.9999912, 8.4999890}
6559	LOGNUMBER-6/10-{8.4999890, 9.9999868}
6560	LOGNUMBER-7/10-{9.9999868, 11.4999846}
6561	LOGNUMBER-8/10-{11.4999846, 12.9999824}
6562	LOGNUMBER-9/10-{12.9999824, 14.4999802}
6563	LOGNUMBER-10/10-{14.4999802, 15.9999780}
6564	CONVOLUTIO-"1"
6565	CONVOLUTIO-"2"
6566	CONVOLUTIO-"3"
6567	CONVOLUTIO-"4"
6568	CONVOLUTIO-"5"
6569	CONVOLUTIO-"6"
6570	CONVOLUTIO-"7"
6571	CONVOLUTIO-"8"
6572	CONVOLUTIO-"9"
6573	E4-"0"
6574	E4-"1"
6575	E4-"2"
6576	E4-"3"
6577	E4-"4"
6578	E4-"5"
6579	E4-"6"
6580	E3-"0"
6581	E3-"1"
6582	E3-"2"
6583	E3-"3"
6584	E3-"4"
6585	E3-"5"
6586	E3-"6"
6587	E3-"7"
6588	E3-"8"
6589	E3-"9"
6590	E2-"0"
6591	E2-"1"
6592	E2-"2"
6593	E2-"3"
6594	E2-"4"
6595	E2-"5"
6596	E2-"6"
6597	E2-"7"
6598	E2-"8"
6599	E2-"9"
6600	E1-"0"
6601	E1-"1"
6602	E1-"2"
6603	E1-"3"
6604	E1-"4"
6605	E1-"5"
6606	E1-"6"
6607	E1-"7"
6608	E1-"8"
6609	E1-"9"
6610	E0-"0"
6611	E0-"1"
6612	E0-"2"
6613	E0-"3"
6614	E0-"4"
6615	E0-"5"
6616	E0-"6"
6617	E0-"7"
6618	E0-"8"
6619	E0-"9"

In the process of formalization of the subject area using API-2.3.2.2, the initial data (Table 3) were encoded using classification and descriptive scales and gradations (Tables 4 and 5), as a result of which a training sample was obtained (Table 6), which is essentially normalized using these directories.

Table 6- Training sample (fragment)

NAME_OBJ	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
1			1	11		6564	6573	6580	6590	6600	6611
2			1	12	6554	6565	6573	6580	6590	6600	6612
3			1	13	6554	6566	6573	6580	6590	6600	6613
4		1	1	12	6554	6567	6573	6580	6590	6600	6614
5			1	14	6554	6568	6573	6580	6590	6600	6615
6		1	1	13	6555	6569	6573	6580	6590	6600	6616
7			1	15	6555	6570	6573	6580	6590	6600	6617
8		1	1	12	6555	6571	6573	6580	6590	6600	6618
9		1	1	13	6555	6572	6573	6580	6590	6600	6619
10		1	1	14	6555	6564	6573	6580	6590	6601	6610
11			1	16	6555	6565	6573	6580	6590	6601	6611
12		1	1	13	6555	6566	6573	6580	6590	6601	6612
13			1	17	6555	6567	6573	6580	6590	6601	6613
14		1	1	15	6555	6568	6573	6580	6590	6601	6614
15		1	1	14	6555	6569	6573	6580	6590	6601	6615
16		2	1	12	6556	6570	6573	6580	6590	6601	6616
17			1	18	6556	6571	6573	6580	6590	6601	6617
18		1	1	13	6556	6572	6573	6580	6590	6601	6618
19			1	19	6556	6564	6573	6580	6590	6601	6619
20		1	1	14	6556	6565	6573	6580	6590	6602	6610
21		1	1	15	6556	6566	6573	6580	6590	6602	6611
22		1	1	16	6556	6567	6573	6580	6590	6602	6612
23			1	20	6556	6568	6573	6580	6590	6602	6613
24		2	1	13	6556	6569	6573	6580	6590	6602	6614
25		1	1	14	6556	6570	6573	6580	6590	6602	6615
26		1	1	17	6556	6571	6573	6580	6590	6602	6616
27		1	1	13	6556	6572	6573	6580	6590	6602	6617
28		1	1	15	6556	6564	6573	6580	6590	6602	6618
29			1	21	6556	6565	6573	6580	6590	6602	6619
30		1	1	14	6556	6566	6573	6580	6590	6603	6610
31			1	22	6556	6567	6573	6580	6590	6603	6611
32		3	1	12	6556	6568	6573	6580	6590	6603	6612
33		1	1	16	6556	6569	6573	6580	6590	6603	6613
34		1	1	18	6556	6570	6573	6580	6590	6603	6614
35		1	1	15	6556	6571	6573	6580	6590	6603	6615
36		2	1	13	6556	6572	6573	6580	6590	6603	6616
37			1	23	6556	6564	6573	6580	6590	6603	6617
38		1	1	19	6556	6565	6573	6580	6590	6603	6618
39		1	1	17	6556	6566	6573	6580	6590	6603	6619
40		2	1	14	6556	6567	6573	6580	6590	6604	6610
41			1	24	6556	6568	6573	6580	6590	6604	6611
42		1	1	15	6556	6569	6573	6580	6590	6604	6612
43			1	25	6556	6570	6573	6580	6590	6604	6613
44		1	1	16	6556	6571	6573	6580	6590	6604	6614
45		1	1	14	6556	6572	6573	6580	6590	6604	6615
46		1	1	20	6557	6564	6573	6580	6590	6604	6616
47			1	26	6557	6565	6573	6580	6590	6604	6617
48		3	1	13	6557	6566	6573	6580	6590	6604	6618
49		1	1	15	6557	6567	6573	6580	6590	6604	6619
50		1	1	14	6557	6568	6573	6580	6590	6605	6610
51		1	1	18	6557	6569	6573	6580	6590	6605	6611
52		1	1	17	6557	6570	6573	6580	6590	6605	6612
53			1	27	6557	6571	6573	6580	6590	6605	6613
54		2	1	13	6557	6572	6573	6580	6590	6605	6614
55		1	1	16	6557	6564	6573	6580	6590	6605	6615
56		2	1	15	6557	6565	6573	6580	6590	6605	6616
57		1	1	19	6557	6566	6573	6580	6590	6605	6617
58		1	1	21	6557	6567	6573	6580	6590	6605	6618
59			1	28	6557	6568	6573	6580	6590	6605	6619
60		2	1	14	6557	6569	6573	6580	6590	6606	6610
61			1	29	6557	6570	6573	6580	6590	6606	6611
62		1	1	22	6557	6571	6573	6580	6590	6606	6612
63		1	1	15	6557	6572	6573	6580	6590	6606	6613
64		4	1	12	6557	6564	6573	6580	6590	6606	6614
65		1	1	17	6557	6565	6573	6580	6590	6606	6615
66		1	1	16	6557	6566	6573	6580	6590	6606	6616
67			1	30	6557	6567	6573	6580	6590	6606	6617

Figure 6 shows the screen form with a fragment of the training sample:

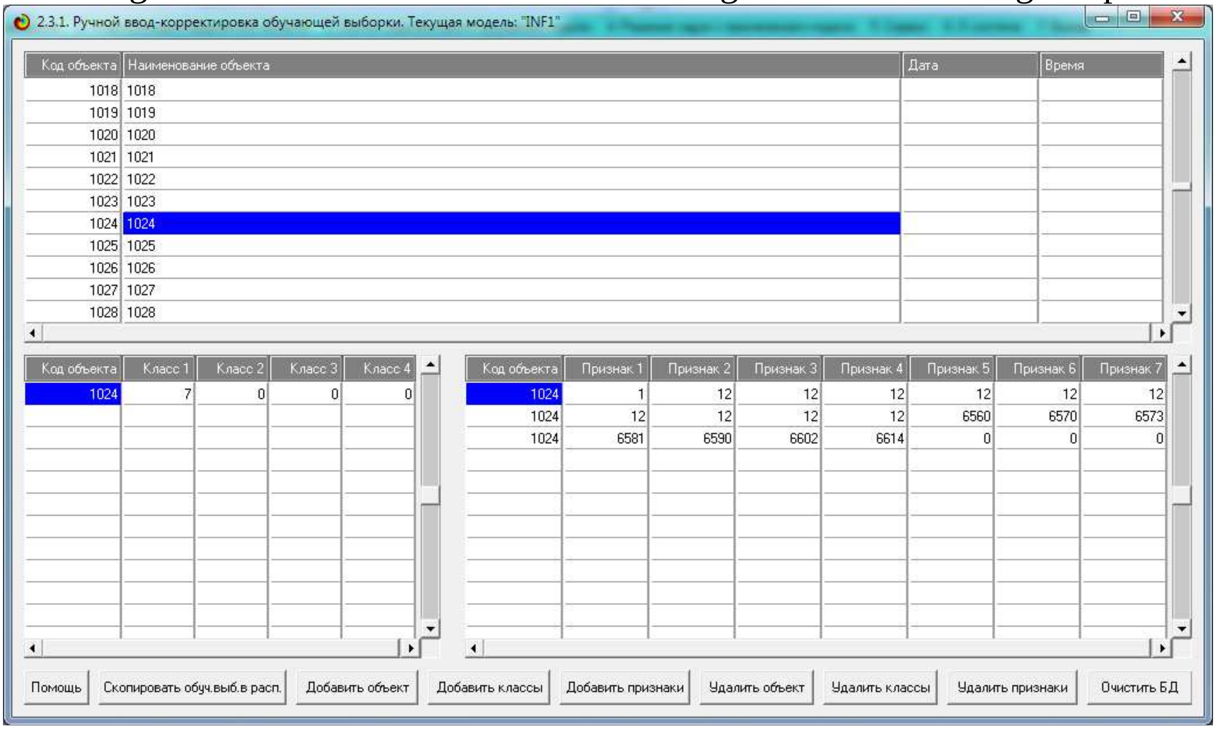


Figure 6. Training sample (fragment)

The full training sample is not given due to its very large volume: 65535 objects of the training sample.

3.3. *Task-3.* Synthesis of statistical and system-cognitive models. Multivariable typing and private knowledge criteria

Synthesis and verification of statistical and system-cognitive models (SC-models) of models is carried out in mode 3.5 of the Eidos system. Mathematical models, on the basis of which statistical and SC models are calculated, are described in detail in a number of monographs and articles by the author. Therefore, in this work we will look at these issues very briefly. Note only that the models of the Eidos system are based on a matrix of absolute frequencies, reflecting the number of meetings of gradations of descriptive scales according to gradations of classification scales (facts). But to solve all problems, not this matrix itself is used, but matrices of conditional and unconditional percentage distributions and system-cognitive models, which are calculated on its basis and reflect how much information is contained in the fact of observing a certain gradation of the descriptive scale that the modeling object will go into a state corresponding to a certain gradation of the classification scale (class) (Figure 3).

The mathematical model of ASK analysis and the Eidos system is based on system fuzzy interval mathematics [7, 14, 18, 50] and provides comparable processing of large volumes of fragmented and noisy interdependent data presented in various types of scales (nominal, ordinal and numerical) and various units.

The essence of the mathematical model of ASK analysis is as follows. The absolute frequency matrix (Table 7) is calculated directly from empirical data (see Help mode 2.3.2.2).

Table 7- Absolute Frequency Matrix (ABS Statistical Model)

		Classes					Sum
		1	...	*j*	...	*W*	
Values of factors	*1*	N_{11}		N_{1j}		N_{1W}	
	...						
	i	N_{i1}		N_{ij}		N_{iW}	$N_{i\Sigma}=\sum_{j=1}^{W} N_{ij}$
	...						
	M	N_{M1}		N_{Mj}		N_{MW}	
Total number of signs by class				$N_{\Sigma j}=\sum_{i=1}^{M} N_{ij}$			$N_{\Sigma\Sigma}=\sum_{i=1}^{W}\sum_{j=1}^{M} N_{ij}$
Total number of training objects by class				$N_{\Sigma j}$			$N_{\Sigma\Sigma}=\sum_{j=1}^{W} N_{\Sigma j}$

Based on it, matrices of conditional and unconditional interest distributions are calculated (Table 8).

Note that in ASK analysis and its software toolkit, the Eidos intelligent system uses two methods of calculating matrices of conditional and unconditional percentage distributions:

1st method: the total number of characteristics by class $N_{\Sigma j}$ is used as a

2nd method: the total number of objects of the class training selection $N_{\Sigma j}$ is used as a class.

Table 8- Matrix of conditional and unconditional percentage distributions (statistical models PRC1 and PRC2)

		Classes					Bezuslovnayaveroyatnostpriznaka
		1	...	*j*	...	*W*	
Values of factors	*1*	P_{11}		P_{1j}		P_{1W}	
	...						
	i	P_{i1}		$P_{ij} = \frac{N_{ij}}{N_{\Sigma j}}$		P_{iW}	$P_{i\Sigma} = \frac{N_{i\Sigma}}{N_{\Sigma\Sigma}}$
	...						
	M	P_{M1}		P_{Mj}		P_{MW}	
Bezuslovnayaveroyatnostklassa				$P_{\Sigma j}$			

In practice, there is often a significant ***data imbalance***, which means ***a very different number of learning objects belonging to different classes***. Therefore, solving the problem on the basis of the absolute frequency matrix itself (Table 7) would be very unreasonable and the transition from absolute frequencies to conditional and unconditional relative frequencies (frequencies) is very reasonable and logical.

This transition completely eliminates the ***problem*** of data ***imbalance***, since the subsequent analysis uses not a matrix of absolute frequencies, but matrices of conditional and unconditional percentage distributions and matrices of system-cognitive models (SC-models, Table 8), in particular an information matrix.

This approach also eliminates the problem of ensuring ***comparability*** of processing in one model of initial data presented in different types of scales (nominal, ordinal and numerical) and in different units of measure [6].

In the Eidos system, all this ***is always*** done when solving ***any tasks***, regardless of whether the initial data is balanced and comparable or not.

The matrices of the system-cognitive models (Table 10) are then calculated from Table 8 using the particular criteria, knowledge given in Table 9.

Table 9- Various analytical forms of private knowledge criteria used in ASK analysis and Eidos system

<table>
<tr><th rowspan="2">Name of the knowledge model private criterion</th><th colspan="2">Expression for private criterion</th></tr>
<tr><th>through relative frequencies</th><th>through absolute frequencies</th></tr>
<tr><td>ABS, matrix of absolute frequencies, N_{ij} - the actual number of meetings of the i-th characteristic for objects of the j-th class; $\overline{N}_{ij}$ - the theoretical number of meetings of the i-th characteristic for objects of the j-th class; N_i - total number of characteristics in the i-th line; N_j is the total number of features or objects of the training sample in the j-th class; N is the total number of characteristics across the sample (Table 1)</td><td colspan="2">$N_i = \sum_{j=1}^{W} N_{ij};\ N_j = \sum_{i=1}^{M} N_{ij};\ N = \sum_{i=1}^{W} \sum_{j=1}^{M} N_{ij};$
N_{ij} $-$ фактическая частота;
$\overline{N}_{ij} = \frac{N_i N_j}{N}$ $-$ теоретическая частота.</td></tr>
<tr><td>PRC1, the matrix of conditional P_{ij} and unconditional P_i percentage distributions, the total number of characteristics by class is used as N_j</td><td rowspan="2">---</td><td rowspan="2">$P_{ij} = \frac{N_{ij}}{N_j};\ P_i = \frac{N_i}{N}$</td></tr>
<tr><td>PRC2, a matrix of conditional P_{ij} and unconditional P_i percentage distributions, the total number of learning objects by class is used as N_j</td></tr>
<tr><td>INF1, a particular criterion: the amount of knowledge according to A. Harkevich, the 1st version of probability calculation: Nj - the total number of signs according to the j-th class. The probability that if an object of the j-th class has a characteristic, then this is the i-th characteristic</td><td rowspan="2">$I_{ij} = \Psi \times Log_2 \frac{P_{ij}}{P_i}$</td><td rowspan="2">$I_{ij} = \Psi \times Log_2 \frac{N_{ij}}{\overline{N}_{ij}} = \Psi \times Log_2 \frac{N_{ij} N}{N_i N_j}$</td></tr>
<tr><td>INF2, a particular criterion: the amount of knowledge according to A. Harkevich, the 2nd version of probability calculation: Nj - the total number of objects according to the j-th class. The probability that if an object of the j-th class is presented, then it will have the i-th sign.</td></tr>
<tr><td>INF3, partial criterion: Chi-square: differences between actual and theoretically expected absolute frequencies</td><td>---</td><td>$I_{ij} = N_{ij} - \overline{N}_{ij} = N_{ij} - \frac{N_i N_j}{N}$</td></tr>
<tr><td>INF4, private criterion: ROI - Return On Investment, 1st variant of probability calculation: Nj - total number of characteristics by j-th class</td><td rowspan="2">$I_{ij} = \frac{P_{ij}}{P_i} - 1 = \frac{P_{ij} - P_i}{P_i}$</td><td rowspan="2">$I_{ij} = \frac{N_{ij}}{\overline{N}_{ij}} - 1 = \frac{N_{ij} N}{N_i N_j} - 1$</td></tr>
<tr><td>INF5, private criterion: ROI - Return On Investment, 2nd variant of probability calculation: Nj - total number of objects by j-th class</td></tr>
<tr><td>INF6, partial criterion: difference of conditional and unconditional probabilities, 1st variant of probability calculation: Nj - total number of signs by j-th class</td><td rowspan="2">$I_{ij} = P_{ij} - P_i$</td><td rowspan="2">$I_{ij} = \frac{N_{ij}}{N_j} - \frac{N_i}{N}$</td></tr>
<tr><td>INF7, partial criterion: difference of conditional and unconditional probabilities, 2nd variant of probability calculation: Nj - total number of objects by j-th class</td></tr>
</table>

Symbols for Table 3:
i is the value of the previous parameter;
j - value of future parameter;
N_{ij} - number of meetings of j-th value of future parameter at i-th value of previous parameter;
M is the total number of values of all past parameters;
W is the total number of values of all future parameters.
N_i is the number of meetings of the ith value of the past parameter over the entire sample;
N_j is the number of meetings of the j-th value of the future parameter over the entire sample;
N is the number of meetings of the j-th value of the future parameter at the i-th value of the previous parameter over the entire sample.
I_{ij} - a particular knowledge criterion: the amount of knowledge in the fact of observing the i-th value of the previous parameter that the object will transition to the state corresponding to the j-th value of the future parameter;
Sound- normalization coefficient (E.V. Lutsenko, 2002), which converts the amount of information in the A. Harkevich formula into bits and ensures that it complies with the principle of conformity with the R. Hartley formula;
P_i is the unconditional relative frequency of the ith value of the past parameter in the training sample;
P_{ij} is the conditional relative frequency of meeting the i-th value of the previous parameter at the j-th value of the future parameter.

Table 9 shows the formulas:

- for comparison of **actual and theoretical absolute frequencies**;
- for comparison **of conditional and unconditional relative frequencies** ("probabilities").

And this comparison in Table 8 is made in two possible ways: by **subtraction** and by **division**.

Number of private knowledge criteria and system-cognitive models based on them (Tables 9 and 10), currently used in the Eidos system, equal **to 7** is determined by the fact that they are obtained by **all possible options for** comparing **actual and theoretical absolute frequencies, conditional and unconditional relative frequencies** by **subtraction** and **division**, and Nj is considered as the total number of either **features** or objects of the training sample in the j-th class, and **normalization to zero** (for additive integral criteria), if there is no connection between the presence of the characteristic and the belonging of the object to the class, it is carried out either **by logarithming** or **subtracting the unit**.

When we compare the actual and theoretical absolute frequencies by subtraction at us the private criterion of knowledge turns out: "chi-square" (INF3 SK-model) when we compare them by division, at us the private criterion turns out: "amount of information according to A. Harkevich" (INF1, INF2 SK-model) or "coefficient of return of investments of ROI" - Return On Investment (INF4, INF5 SK-model) depending on a way of a normalization.

When we compare conditional and unconditional relative frequencies by subtraction, we obtain a partial knowledge criterion: "relationship coefficient" (CK-models INF6, INF7), when we compare them by division, then we obtain a partial criterion: "amount of information according to A. Harkevich" (CK-models INF1, INF2).

Thus, we see that **all private knowledge criteria are closely interconnected**. Particularly interesting is the connection of the famous Pearson chi-square criterion with a remarkable measure of the amount of information by A. Harkevich and with the ROI coefficient known in economics.

Table 10- System-cognitive model matrix

		Classes					Znachimostfaktora
		1	...	j	...	W	
Values of factors	1	I_{11}		I_{1j}		I_{1W}	$\sigma_{1\Sigma} = \sqrt[2]{\frac{1}{W-1}\sum_{j=1}^{W}\left(I_{1j}-\bar{I}_1\right)^2}$
	...						
	i	I_{i1}		I_{ij}		I_{iW}	$\sigma_{i\Sigma} = \sqrt[2]{\frac{1}{W-1}\sum_{j=1}^{W}\left(I_{ij}-\bar{I}_i\right)^2}$
	...						
	M	I_{M1}		I_{Mj}		I_{MW}	$\sigma_{M\Sigma} = \sqrt[2]{\frac{1}{W-1}\sum_{j=1}^{W}\left(I_{Mj}-\bar{I}_M\right)^2}$
Stepenreduktsiiklassa		$\sigma_{\Sigma 1}$		$\sigma_{\Sigma j}$		$\sigma_{\Sigma W}$	$H = \sqrt[2]{\frac{1}{(W \cdot M-1)}\sum_{j=1}^{W}\sum_{i=1}^{M}\left(I_{ij}-\bar{I}\right)^2}$

Probability is considered as the limit to which the relative frequency tends (the ratio of the number of favorable outcomes to the number of tests) with **an unlimited** increase in the number of tests. It is clear that probability is a mathematical abstraction that never occurs in practice (as well as other mathematical and physical abstractions, such as a mathematical point, a material point, infinitesimal, etc.). In practice, only relative frequency occurs. But it can be very close to probability. For example, with 480 observations, the difference between relative frequency and probability (error) is about 5%, with 1250 observations - about 2.5%, with 10,000 observations - 1%.

The essence of these methods is that the amount of information in the value of the factor that the modeling object will transition under its action to a certain state corresponding to the class is calculated. This enables comparable and correct processing of heterogeneous information on observations of the simulation object, presented in different types of measurement scales and different units of measurement [6].

On the basis of the system-cognitive models presented in Table 10 (differ by the frequent criteria given in Table 9), the problems of identification (classification, recognition, diagnosis, prediction), decision support (reverse prediction problem), as well as the task of studying the simulated subject area by studying its system-cognitive model [10-64] are solved.

Note that as the significance of the value of the factor, the degree of determinicity of the class and the value or quality of the model in the ASK analysis, the variability of the values of the partial criteria of this value of the factor, class or model as a whole is considered (Table 10).

Numerically, this variability can be measured in various ways, for example, by the average deviation of the modules of the partial criteria from the average, by the variance or the mean square deviation or its square. In the "Eidos" system, the last version is adopted, since this value coincides with ***the signal power****, in particular* ***the information power****, and in the ASK analysis all models are considered as a source of information about the modeling object.*

Therefore, there is every reason to clarify the traditional terminology of ASK analysis (Table 11):

Table 11- Clarification of ASK analysis terminology

№	Traditional terms (synonyms)	New term	Formula
1	1. Significance of the value of the factor (characteristic). 2. Differentiating power of factor value (characteristic). 3. Value of factor value for identification and other tasks	Root from information power of factor value	$\sigma_{i\Sigma} = \sqrt[2]{\frac{1}{W-1}\sum_{j=1}^{W}\left(I_{ij} - \bar{I}_i\right)^2}$
2	1. Degree of class determinity. 2. Degree of class conditionality.	Root from Class Information Capacity	$\sigma_{\Sigma j} = \sqrt[2]{\frac{1}{M-1}\sum_{i=1}^{M}\left(I_{ij} - \bar{I}_j\right)^2}$
3	1. Model quality. 2. The value of the model. 3. The degree to which the model is formed. 4. Quantitative measure of degree of regularity in the simulated subject area	Root from Model Information Capacity	$H = \sqrt[2]{\frac{1}{(W \cdot M - 1)}\sum_{j=1}^{W}\sum_{i=1}^{M}\left(I_{ij} - \bar{I}\right)^2}$

All calculations given above are performed in mode 3.5 of "Eidos" system. The screen forms of this mode with the parameters actually used in this work are given in Figures 7:

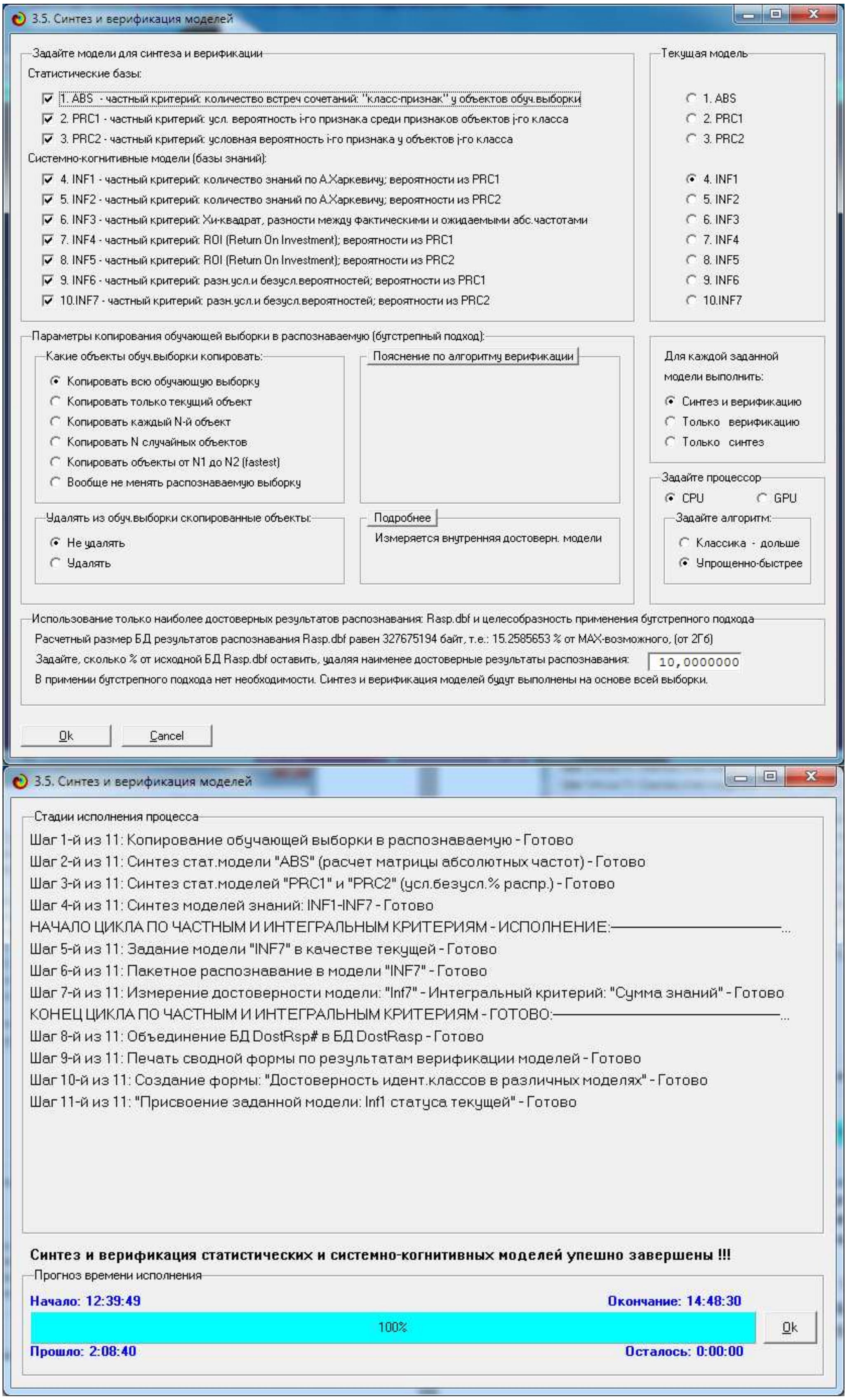


Figure 7. Screen forms of mode 3.5 of "Eidos" system, in which synthesis and verification of 3 statistical and 7 system-cognitive models is carried out

Figures 8 show the screen forms of 5.5 mode. "Eidos" systems, which show fragments of statistical and system-cognitive models created in mode 3.5:

5.5. Модель: "1. ABS - частный критерий: количество встреч сочетаний: "Класс-признак" у объектов обуч.выборки"

Код признака	Наименование описательной шкалы и градации	1. LEVELCONS 1/10 {1.6, 1.8}	2. LEVELCONS 2/10 {1.8, 2.0}	3. LEVELCONS 3/10 {2.0, 2.3}	4. LEVELCONS 4/10 {2.3, 2.5}	5. LEVELCONS 5/10 {2.5, 2.7}	6. LEVELCONS 6/10 {2.7, 2.9}	7. LEVELCONS 7/10 {2.9, 3.2}	8. LEVELCONS 8/10 {3.2, 3.4}	9. LEVELCONS 9/10 {3.4, 3.6}	10. LEVELCONS 10/10 {3.6, 3.8}	Сумма	Среднее	Средн. квадр. откл.
1	NUMBER-1/10-{1.0000000, 6554.4000000}	3444	1093	615	301	206	29	12	6			5706	570.60	10
2	NUMBER-2/10-{6554.4000000, 13107.8000000}	3313	1198	656	361	250	34	17	10	2		5841	584.10	10
3	NUMBER-3/10-{13107.8000000, 19661.2000000}	3273	1213	698	365	268	39	17	12	1	1	5887	588.70	10
4	NUMBER-4/10-{19661.2000000, 26214.6000000}	3253	1191	741	357	280	44	17	13	1	1	5898	589.80	10
5	NUMBER-5/10-{26214.6000000, 32768.0000000}	3228	1236	700	406	277	40	21	11	3	1	5923	592.30	10
6	NUMBER-6/10-{32768.0000000, 39321.4000000}	3212	1209	767	361	295	48	18	15		1	5926	592.60	10
7	NUMBER-7/10-{39321.4000000, 45874.8000000}	3182	1261	713	416	285	44	23	12	3	1	5940	594.00	9
8	NUMBER-8/10-{45874.8000000, 52428.2000000}	3188	1235	754	401	294	42	21	13	2	1	5951	595.10	9
9	NUMBER-9/10-{52428.2000000, 58981.6000000}	3177	1226	765	385	307	48	22	14	1	2	5947	594.70	9
10	NUMBER-10/10-{58981.6000000, 65535.0000000}	3159	1277	741	404	305	50	19	15	2	1	5973	597.30	9
11	PRIMFACTRS-00001													
12	PRIMFACTRS-00002	13524	13622	12896	9792	10701	2372	1289	1041	164	117	65518	6551.80	60
13	PRIMFACTRS-00003	8896	7918	6567	4370	3850	657	295	179	21	8	32761	3276.10	35
14	PRIMFACTRS-00005	5338	4206	3142	1856	1467	213	94	56	5	2	16379	1637.90	19
15	PRIMFACTRS-00007	3849	2833	2001	1166	857	128	50	31	3	1	10919	1091.90	13
16	PRIMFACTRS-00011	2490	1708	1149	634	460	66	26	16	1		6550	655.00	8
17	PRIMFACTRS-00013	2126	1418	943	516	368	52	24	10	1		5458	545.80	7
18	PRIMFACTRS-00017	1650	1063	685	373	263	37	13	9			4093	409.30	5
19	PRIMFACTRS-00019	1493	933	608	321	233	31	13	6			3638	363.80	5
20	PRIMFACTRS-00023	1239	776	483	257	184	22	10	5			2976	297.60	4
21	PRIMFACTRS-00029	1006	593	379	193	137	19	7	3			2337	233.70	3
22	PRIMFACTRS-00031	944	558	348	180	127	16	7	3			2183	218.30	3
23	PRIMFACTRS-00037	802	462	281	155	98	13	5	2			1818	181.80	2
24	PRIMFACTRS-00041	726	418	253	131	90	11	4	2			1635	163.50	2

5.5. Модель: "1. ABS - частный критерий: количество встреч сочетаний: "Класс-признак" у объектов обуч.выборки"

Код признака	Наименование описательной шкалы и градации	1. LEVELCONS 1/10 {1.6, 1.8}	2. LEVELCONS 2/10 {1.8, 2.0}	3. LEVELCONS 3/10 {2.0, 2.3}	4. LEVELCONS 4/10 {2.3, 2.5}	5. LEVELCONS 5/10 {2.5, 2.7}	6. LEVELCONS 6/10 {2.7, 2.9}	7. LEVELCONS 7/10 {2.9, 3.2}	8. LEVELCONS 8/10 {3.2, 3.4}	9. LEVELCONS 9/10 {3.4, 3.6}	10. LEVELCONS 10/10 {3.6, 3.8}	Сумма	Среднее	Средн. квадр. откл.
6601	E1-"1"	3410	1290	659	280	207	24	14	9	1		5894	589.40	10
6602	E1-"2"	2941	1239	855	424	344	56	15	22	1		5897	589.70	9
6603	E1-"3"	3431	1275	657	298	186	30	12	8	1		5898	589.80	10
6604	E1-"4"	3230	1122	720	422	327	45	29	12	2	2	5911	591.10	10
6605	E1-"5"	3213	1206	793	392	228	29	10	9	1	1	5882	588.20	10
6606	E1-"6"	3211	1158	706	431	322	40	33	12		3	5916	591.60	9
6607	E1-"7"	3155	1424	745	327	206	32	14	5	2	1	5911	591.10	10
6608	E1-"8"	3206	1123	731	419	314	62	14	17	3	1	5890	589.00	9
6609	E1-"9"	3401	1295	641	301	197	23	11	9	1	1	5880	588.00	10
6610	E0-"0"	848	1763	1680	1093	916	143	63	41	4	2	6553	655.30	7
6611	E0-"1"	4174	554	140	47	13						4928	492.80	13
6612	E0-"2"	2700	1644	1084	555	443	75	24	22	5	1	6553	655.30	9
6613	E0-"3"	4171	524	159	40	13	1					4908	490.80	13
6614	E0-"4"	2683	1678	1044	603	428	58	39	18		3	6554	655.40	9
6615	E0-"5"	4107	1598	611	178	57	2					6553	655.30	13
6616	E0-"6"	2684	1686	1029	606	431	58	38	18	1	2	6553	655.30	9
6617	E0-"7"	4169	525	159	37	15	1					4906	490.60	13
6618	E0-"8"	2707	1630	1094	553	439	80	22	22	5	1	6553	655.30	9
6619	E0-"9"	4186	537	150	45	12		1				4931	493.10	13
	Сумма числа признаков	341061	145668	92950	52598	42392	7106	3366	2336	315	200	687992		
	Среднее	52	22	14	8	6	1	1	0				10.39	
	Среднеквадратичное отклонение	495	266	211	146	147	31	17	13	2	1			2
	Сумма числа объектов обуч.выборки	32429	12139	7150	3757	2767	418	187	121	15	9	58992		

5.5. Модель: "2. PRC1 - частный критерий: усл. вероятность i-го признака среди признаков объектов j-го класса"

Код признака	Наименование описательной шкалы и градации	1. LEVELCO... 1/10 {1.6, 1.8}	2. LEVELCO... 2/10 {1.8, 2.0}	3. LEVELCO... 3/10 {2.0, 2.3}	4. LEVELCO... 4/10 {2.3, 2.5}	5. LEVELCO... 5/10 {2.5, 2.7}	6. LEVELCO... 6/10 {2.7, 2.9}	7. LEVELCO... 7/10 {2.9, 3.2}	8. LEVELCO... 8/10 {3.2, 3.4}	9. LEVELCO... 9/10 {3.4, 3.6}	10. LEVELCO... 10/10 {3.6, 3.8}	Безусл. вероятн.	Среднее	Средн. квадр. откл.
1	NUMBER-1/10-{1.0000000, 6554.4000000}	1.010	0.750	0.662	0.572	0.486	0.408	0.357	0.257			0.829	0.450	0.319
2	NUMBER-2/10-{6554.4000000, 13107.8000000}	0.971	0.822	0.706	0.686	0.590	0.478	0.505	0.428	0.635		0.849	0.582	0.262
3	NUMBER-3/10-{13107.8000000, 19661.2000000}	0.960	0.833	0.751	0.694	0.632	0.549	0.505	0.514	0.317	0.500	0.856	0.625	0.188
4	NUMBER-4/10-{19661.2000000, 26214.6000000}	0.954	0.818	0.797	0.679	0.661	0.619	0.505	0.557	0.317	0.500	0.857	0.641	0.184
5	NUMBER-5/10-{26214.6000000, 32768.0000000}	0.946	0.849	0.753	0.772	0.653	0.563	0.624	0.471	0.952	0.500	0.861	0.708	0.174
6	NUMBER-6/10-{32768.0000000, 39321.4000000}	0.942	0.830	0.825	0.686	0.696	0.675	0.535	0.642		0.500	0.861	0.633	0.260
7	NUMBER-7/10-{39321.4000000, 45874.8000000}	0.933	0.866	0.767	0.791	0.672	0.619	0.683	0.514	0.952	0.500	0.863	0.730	0.160
8	NUMBER-8/10-{45874.8000000, 52428.2000000}	0.935	0.848	0.811	0.762	0.694	0.591	0.624	0.557	0.635	0.500	0.865	0.696	0.140
9	NUMBER-9/10-{52428.2000000, 58981.6000000}	0.932	0.842	0.823	0.732	0.724	0.675	0.654	0.599	0.317	1.000	0.864	0.730	0.192
10	NUMBER-10/10-{58981.6000000, 65535.0000000}	0.926	0.877	0.797	0.768	0.719	0.704	0.564	0.642	0.635	0.500	0.868	0.713	0.134
11	PRIMFACTRS-00001													
12	PRIMFACTRS-00002	3.965	9.351	13.874	18.617	25.243	33.380	38.295	44.563	52.063	58.500	9.523	29.785	18.581
13	PRIMFACTRS-00003	2.608	5.436	7.065	8.308	9.082	9.246	8.764	7.663	6.667	4.000	4.762	6.884	2.245
14	PRIMFACTRS-00005	1.565	2.887	3.380	3.529	3.461	2.997	2.793	2.397	1.587	1.000	2.381	2.560	0.893
15	PRIMFACTRS-00007	1.129	1.945	2.153	2.217	2.022	1.801	1.485	1.327	0.952	0.500	1.587	1.553	0.572
16	PRIMFACTRS-00011	0.730	1.173	1.236	1.205	1.085	0.929	0.772	0.685	0.317		0.952	0.813	0.406
17	PRIMFACTRS-00013	0.623	0.973	1.015	0.981	0.868	0.732	0.713	0.428	0.317		0.793	0.665	0.331
18	PRIMFACTRS-00017	0.484	0.730	0.737	0.709	0.620	0.521	0.386	0.385			0.595	0.457	0.274
19	PRIMFACTRS-00019	0.438	0.640	0.654	0.610	0.550	0.436	0.386	0.257			0.529	0.397	0.243
20	PRIMFACTRS-00023	0.363	0.533	0.520	0.489	0.434	0.310	0.297	0.214			0.433	0.316	0.196
21	PRIMFACTRS-00029	0.295	0.407	0.408	0.367	0.323	0.267	0.208	0.128			0.340	0.240	0.153
22	PRIMFACTRS-00031	0.277	0.383	0.374	0.342	0.300	0.225	0.208	0.128			0.317	0.224	0.141
23	PRIMFACTRS-00037	0.235	0.317	0.302	0.295	0.231	0.183	0.149	0.086			0.264	0.180	0.119
24	PRIMFACTRS-00041	0.213	0.287	0.272	0.249	0.212	0.155	0.119	0.086			0.238	0.159	0.106

5.5. Модель: "4. INF1 - частный критерий: количество знаний по А.Харкевичу; вероятности из PRC1"

Код признака	Наименование описательной шкалы и градации	1. LEVELCONS 1/10 {1.6, 1.8}	2. LEVELCONS 2/10 {1.8, 2.0}	3. LEVELCONS 3/10 {2.0, 2.3}	4. LEVELCONS 4/10 {2.3, 2.5}	5. LEVELCONS 5/10 {2.5, 2.7}	6. LEVELCONS 6/10 {2.7, 2.9}	7. LEVELCONS 7/10 {2.9, 3.2}	8. LEVELCONS 8/10 {3.2, 3.4}	9. LEVELCONS 9/10 {3.4, 3.6}	10. LEVELCONS 10/10 {3.6, 3.8}	Сумма	Среднее
1	NUMBER-1/10-{1.0000000, 6554.4000000}	0.049	-0.025	-0.056	-0.092	-0.132	-0.175	-0.209	-0.290			-0.929	
2	NUMBER-2/10-{6554.4000000, 13107.8000000}	0.033	-0.008	-0.046	-0.053	-0.090	-0.142	-0.128	-0.169	-0.072		-0.674	
3	NUMBER-3/10-{13107.8000000, 19661.2000000}	0.028	-0.007	-0.032	-0.052	-0.075	-0.110	-0.130	-0.126	-0.245	-0.133	-0.881	
4	NUMBER-4/10-{19661.2000000, 26214.6000000}	0.026	-0.012	-0.018	-0.058	-0.064	-0.080	-0.131	-0.107	-0.246	-0.133	-0.822	
5	NUMBER-5/10-{26214.6000000, 32768.0000000}	0.023	-0.004	-0.033	-0.027	-0.068	-0.105	-0.080	-0.149	0.025	-0.134	-0.551	
6	NUMBER-6/10-{32768.0000000, 39321.4000000}	0.022	-0.009	-0.011	-0.056	-0.053	-0.060	-0.118	-0.073		-0.134	-0.491	
7	NUMBER-7/10-{39321.4000000, 45874.8000000}	0.019	0.001	-0.029	-0.022	-0.062	-0.082	-0.058	-0.128	0.024	-0.135	-0.472	
8	NUMBER-8/10-{45874.8000000, 52428.2000000}	0.019	-0.005	-0.016	-0.031	-0.055	-0.094	-0.081	-0.109	-0.076	-0.135	-0.583	
9	NUMBER-9/10-{52428.2000000, 58981.6000000}	0.018	-0.007	-0.012	-0.041	-0.044	-0.061	-0.069	-0.091	-0.248	0.036	-0.517	
10	NUMBER-10/10-{58981.6000000, 65535.0000000}	0.016	0.002	-0.021	-0.030	-0.046	-0.052	-0.106	-0.075	-0.077	-0.136	-0.526	
11	PRIMFACTRS-00001												
12	PRIMFACTRS-00002	-0.217	-0.004	0.093	0.166	0.241	0.310	0.344	0.381	0.420	0.449	2.182	
13	PRIMFACTRS-00003	-0.149	0.033	0.098	0.138	0.160	0.164	0.151	0.118	0.083	-0.043	0.751	
14	PRIMFACTRS-00005	-0.104	0.048	0.087	0.097	0.092	0.057	0.039	0.002	-0.100	-0.214	0.004	
15	PRIMFACTRS-00007	-0.084	0.050	0.075	0.083	0.060	0.031	-0.016	-0.044	-0.126	-0.285	-0.257	
16	PRIMFACTRS-00011	-0.066	0.051	0.065	0.058	0.032	-0.006	-0.052	-0.081	-0.271		-0.270	
17	PRIMFACTRS-00013	-0.060	0.051	0.061	0.052	0.022	-0.020	-0.026	-0.152	-0.226		-0.299	
18	PRIMFACTRS-00017	-0.051	0.050	0.053	0.043	0.010	-0.033	-0.107	-0.107			-0.141	
19	PRIMFACTRS-00019	-0.047	0.047	0.053	0.035	0.010	-0.048	-0.078	-0.178			-0.205	
20	PRIMFACTRS-00023	-0.043	0.051	0.045	0.030	0.001	-0.083	-0.093	-0.174			-0.265	
21	PRIMFACTRS-00029	-0.035	0.045	0.045	0.019	-0.012	-0.059	-0.121	-0.240			-0.359	
22	PRIMFACTRS-00031	-0.034	0.047	0.041	0.019	-0.014	-0.085	-0.104	-0.224			-0.355	
23	PRIMFACTRS-00037	-0.029	0.045	0.033	0.027	-0.033	-0.091	-0.142	-0.279			-0.468	
24	PRIMFACTRS-00041	-0.027	0.047	0.034	0.012	-0.028	-0.106	-0.171	-0.252			-0.493	

5.5. Модель: "6. INF3 - частный критерий: Хи-квадрат, разности между фактическими и ожидаемыми абс.частотами"

Код признака	Наименование описательной шкалы и градации	1. LEVELCONS 1/10 {1.6, 1.8}	2. LEVELCONS 2/10 {1.8, 2.0}	3. LEVELCONS 3/10 {2.0, 2.3}	4. LEVELCONS 4/10 {2.3, 2.5}	5. LEVELCONS 5/10 {2.5, 2.7}	6. LEVELCONS 6/10 {2.7, 2.9}	7. LEVELCONS 7/10 {2.9, 3.2}	8. LEVELCONS 8/10 {3.2, 3.4}	9. LEVELCONS 9/10 {3.4, 3.6}	10. LEVELCONS 10/10 {3.6, 3.8}	Сумма	Среднее
1	NUMBER-1/10-{1.0000000, 6554.4000000}	615.342	-115.127	-155.900	-135.232	-145.587	-29.935	-15.917	-13.374	-2.613	-1.659		
2	NUMBER-2/10-{6554.4000000, 13107.8000000}	417.418	-38.710	-133.138	-85.553	-109.905	-26.329	-11.577	-9.832	-0.674	-1.698		
3	NUMBER-3/10-{13107.8000000, 19661.2000000}	354.614	-33.450	-97.353	-85.070	-94.739	-21.805	-11.802	-7.989	-1.695	-0.711		
4	NUMBER-4/10-{19661.2000000, 26214.6000000}	329.161	-57.779	-55.839	-93.911	-83.417	-16.918	-11.856	-7.026	-1.700	-0.715		
5	NUMBER-5/10-{26214.6000000, 32768.0000000}	291.768	-18.072	-100.217	-46.822	-87.957	-21.176	-7.978	-9.111	0.288	-0.722		
6	NUMBER-6/10-{32768.0000000, 39321.4000000}	274.281	-45.707	-33.622	-92.051	-70.142	-13.207	-10.993	-5.121	-2.713	-0.723		
7	NUMBER-7/10-{39321.4000000, 45874.8000000}	237.340	3.329	-89.514	-38.122	-81.005	-17.352	-6.061	-8.169	0.280	-0.727		
8	NUMBER-8/10-{45874.8000000, 52428.2000000}	237.887	-25.001	-50.000	-53.963	-72.683	-19.466	-8.115	-7.206	-0.725	-0.730		
9	NUMBER-9/10-{52428.2000000, 58981.6000000}	228.870	-33.154	-38.459	-69.657	-59.436	-13.424	-7.096	-6.192	-1.723	0.271		
10	NUMBER-10/10-{58981.6000000, 65535.0000000}	197.981	12.341	-65.972	-52.645	-63.038	-11.693	-10.223	-5.281	-0.735	-0.736		
11	PRIMFACTRS-00001												
12	PRIMFACTRS-00002	-18955.498	-250.074	4044.301	4783.053	6663.978	1695.290	968.453	818.541	134.002	97.954		
13	PRIMFACTRS-00003	-7344.740	981.539	2140.880	1865.373	1831.366	318.624	134.717	67.764	6.000	-1.524		
14	PRIMFACTRS-00005	-2781.627	738.087	929.143	603.801	457.775	43.828	13.866	0.387	-2.499	-2.761		
15	PRIMFACTRS-00007	-1563.919	521.129	525.807	331.226	184.204	15.222	-3.421	-6.074	-1.999	-2.174		
16	PRIMFACTRS-00011	-757.057	321.174	264.073	133.243	56.409	-1.652	-6.046	-6.240	-1.999	-1.904		
17	PRIMFACTRS-00013	-579.716	262.382	205.606	98.728	31.694	-4.374	-2.703	-8.532	-1.499	-1.587		
18	PRIMFACTRS-00017	-379.039	196.392	132.022	60.084	10.802	-5.275	-7.025	-4.897	-1.874	-1.190		
19	PRIMFACTRS-00019	-310.480	162.729	116.494	42.870	8.837	-6.575	-4.799	-6.352	-1.666	-1.058		
20	PRIMFACTRS-00023	-236.304	145.894	80.933	29.480	0.628	-8.738	-4.560	-5.105	-1.363	-0.865		
21	PRIMFACTRS-00029	-152.530	98.189	63.264	14.333	-6.999	-5.138	-4.434	-4.935	-1.070	-0.679		
22	PRIMFACTRS-00031	-138.187	95.795	53.069	13.106	-7.510	-6.547	-3.680	-4.412	-0.999	-0.635		
23	PRIMFACTRS-00037	-99.244	77.076	35.382	16.011	-14.020	-5.777	-3.895	-4.173	-0.832	-0.528		
24	PRIMFACTRS-00041	-84.525	71.823	32.106	6.002	-10.744	-5.887	-3.999	-3.551	-0.749	-0.475		

Figure 8. Screen forms of mode 5.5 of "Eidos" system, with fragments of statistical system-cognitive models created in mode 3.5

Turning to the second figure 8, we see that in the studied range of natural numbers: {1-65535} different number of numbers with different levels of systemicity.

Table 12, formed by the https://www.researchgate.net/publication/360224846 program, shows natural numbers of varying complexity.

The complexity of a number is the number of prime factors on which it is spread.

For primes, the complexity is 1, they are given in the 1st column of Table 12.

Table 12- Natural numbers of different level of systemicity from the range: {1-65535} (fragment)

COMP1	COMP2	COMP3	COMP4	COMP5	COMP6	COMP7	COMP8	COMP9	COMP10	COMP11	COMP12	COMP13	COMP14	COMP15
1	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768
2	6	12	24	48	96	192	384	768	1536	3072	6144	12288	24576	49152
3	9	18	36	72	144	288	576	1152	2304	4608	9216	18432	36864	
5	10	20	40	80	160	320	640	1280	2560	5120	10240	20480	40960	
7	14	27	54	108	216	432	864	1728	3456	6912	13824	27648	55296	
11	15	28	56	112	224	448	896	1792	3584	7168	14336	28672	57344	
13	21	30	60	120	240	480	960	1920	3840	7680	15360	30720	61440	
17	22	42	81	162	324	648	1296	2592	5184	10368	20736	41472		
19	25	44	84	168	336	672	1344	2688	5376	10752	21504	43008		
23	26	45	88	176	352	704	1408	2816	5632	11264	22528	45056		
29	33	50	90	180	360	720	1440	2880	5760	11520	23040	46080		
31	34	52	100	200	400	800	1600	3200	6400	12800	25600	51200		
37	35	63	104	208	416	832	1664	3328	6656	13312	26624	53248		
41	38	66	126	243	486	972	1944	3888	7776	15552	31104	62208		
43	39	68	132	252	504	1008	2016	4032	8064	16128	32256	64512		
47	46	70	135	264	528	1056	2112	4224	8448	16896	33792			
53	49	75	136	270	540	1080	2160	4320	8640	17280	34560			
59	51	76	140	272	544	1088	2176	4352	8704	17408	34816			
61	55	78	150	280	560	1120	2240	4480	8960	17920	35840			
67	57	92	152	300	600	1200	2400	4800	9600	19200	38400			
71	58	98	156	304	608	1216	2432	4864	9728	19456	38912			
73	62	99	184	312	624	1248	2496	4992	9984	19968	39936			
79	65	102	189	368	729	1458	2916	5832	11664	23328	46656			
83	69	105	196	378	736	1472	2944	5888	11776	23552	47104			
89	74	110	198	392	756	1512	3024	6048	12096	24192	48384			
97	77	114	204	396	784	1568	3136	6272	12544	25088	50176			
101	82	116	210	405	792	1584	3168	6336	12672	25344	50688			
103	85	117	220	408	810	1620	3240	6480	12960	25920	51840			
107	86	124	225	420	816	1632	3264	6528	13056	26112	52224			
109	87	125	228	440	840	1680	3360	6720	13440	26880	53760			
113	91	130	232	450	880	1760	3520	7040	14080	28160	56320			
127	93	138	234	456	900	1800	3600	7200	14400	28800	57600			
131	94	147	248	464	912	1824	3648	7296	14592	29184	58368			
137	95	148	250	468	928	1856	3712	7424	14848	29696	59392			
139	106	153	260	496	936	1872	3744	7488	14976	29952	59904			
149	111	154	276	500	992	1984	3968	7936	15872	31744	63488			
151	115	164	294	520	1000	2000	4000	8000	16000	32000	64000			
157	118	165	296	552	1040	2080	4160	8320	16640	33280				
163	119	170	297	567	1104	2187	4374	8748	17496	34992				
167	121	171	306	588	1134	2208	4416	8832	17664	35328				
173	122	172	308	592	1176	2268	4536	9072	18144	36288				
179	123	174	315	594	1184	2352	4704	9408	18816	37632				
181	129	175	328	612	1188	2368	4736	9472	18944	37888				

3.4. _Task-4._ Model Verification

Evaluation of validity of models in the "Eidos" system is carried out by solving the problem of classifying objects of the training sample according to generalized class images and counting the number of true and false positive and negative solutions according to Van Riesbergen's F-measure, as well as according to the criteria L1- L2-measures prof. E. V. Lutsenko, which are proposed in order to mitigate or completely overcome some of the shortcomings of the F-measure [8].

The validity of models can also be assessed by solving other problems, for example, forecasting problems, generating control solutions, studying the modeling object by studying its model. But this is more laborious and even always possible, especially on economic and political models.

In mode 3.4 of the Eidos system and a number of others, the validity of each private model is studied in accordance with these confidence measures (Figures 9).

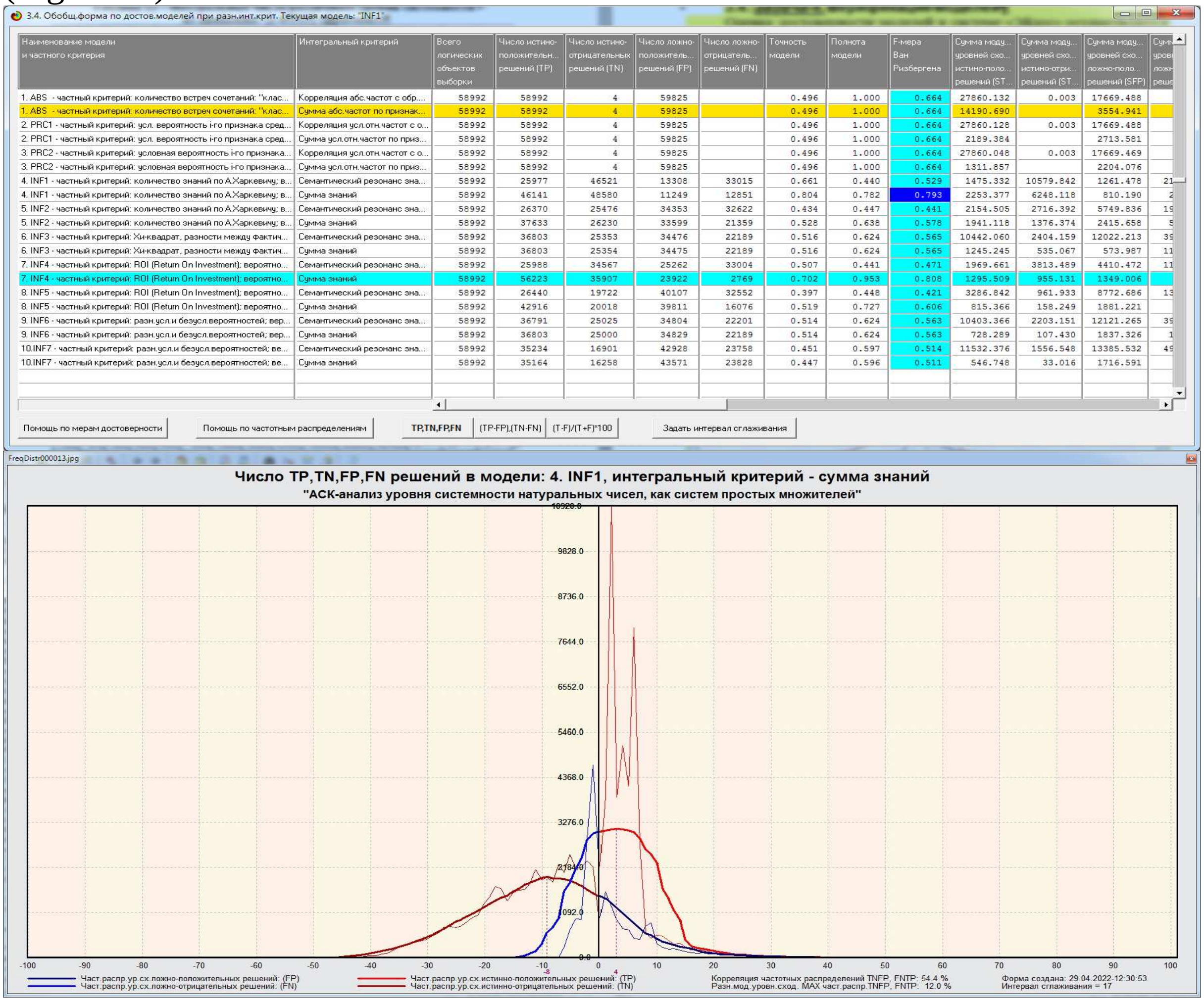


Figure 9. Screen forms of mode 3.4 of "Eidos" system, with information on results of evaluation of validity of statistical and system-cognitive models created in mode 3.5

Figures 10 show screen forms with helps of mode 3.4:

Помощь по режимам: 3.4, 4.1.3.#: Виды прогнозов и меры достоверности моделей в системе "Эйдос-Х++"

Помощь по режимам: 3.4, 4.1.3.6, 4.1.3.7, 4.1.3.8, 4.1.3.10: Виды прогнозов и меры достоверности моделей в системе "Эйдос-Х++".

ПОЛОЖИТЕЛЬНЫЙ ПСЕВДОПРОГНОЗ.

Предположим, модель дает такой прогноз, что выпадет все: и 1, и 2, и 3, и 4, и 5, и 6. Понятно, что из всего этого выпадет лишь что-то одно. В этом случае модель не предскажет, что не выпадет, но зато она обязательно предскажет, что выпадет. Однако при этом очень много объектов будет отнесено к классам, к которым они не относятся. Тогда вероятность истинно-положительных решений у модели будет 1/6, а вероятность ложно-положительных решений - 5/6. Ясно, что такой прогноз бесполезен, поэтому он и назван мной псевдопрогнозом.

ОТРИЦАТЕЛЬНЫЙ ПСЕВДОПРОГНОЗ.

Представим себе, что мы выбрасываем кубик с 6 гранями, и модель предсказывает, что ничего не выпадет, т.е. не выпадет ни 1, ни 2, ни 3, ни 4, ни 5, ни 6, но что-то из этого, естественно, обязательно выпадет. Конечно, модель не предсказала, что выпадет, зато она очень хорошо предсказала, что не выпадет. Вероятность истинно-отрицательных решений у модели будет 5/6, а вероятность ложно-отрицательных решений - 1/6. Такой прогноз гораздо достовернее, чем положительный псевдопрогноз, но тоже бесполезен.

ИДЕАЛЬНЫЙ ПРОГНОЗ.

Если в случае с кубиком мы прогнозируем, что выпадет, например 1, и соответственно прогнозируем, что не выпадет 2, 3, 4, 5, и 6, то это идеальный прогноз, имеющий, если он осуществляется, 100% достоверность идентификации и не идентификации. Идеальный прогноз, который полностью снимает неопределенность о будущем состоянии объекта прогнозирования, на практике удается получить крайне редко и обычно мы имеем дело с реальным прогнозом.

РЕАЛЬНЫЙ ПРОГНОЗ.

На практике мы чаще всего сталкиваемся именно с этим видом прогноза. Реальный прогноз уменьшает неопределенность о будущем состоянии объекта прогнозирования, но не полностью, как идеальный прогноз, а оставляет некоторую неопределенность не снятой. Например, для игрального кубика делается такой прогноз: выпадет 1 или 2, и, соответственно, не выпадет 3, 4, 5 или 6. Понятно, что полностью на практике такой прогноз не может осуществиться, т.к. варианты выпадения кубика альтернативны, т.е. не может выпасть одновременно и 1, и 2. Поэтому у реального прогноза всегда будет определенная ошибка идентификации. Соответственно, если не осуществится один или несколько из прогнозируемых вариантов, то возникнет и ошибка не идентификации, т.к. это не прогнозировалось моделью. Теперь представите себе, что у Вас не 1 кубик и прогноз его поведения, а тысячи. Тогда можно посчитать средневзвешенные характеристики всех этих видов прогнозов.

Таким образом, если просуммировать число верно идентифицированных и не идентифицированных объектов и вычесть число ошибочно идентифицированных и не идентифицированных объектов, а затем разделить на число всех объектов то это и будет критерий качества модели (классификатора), учитывающий как ее способность верно относить объекты к классам, которым они относятся, так и ее способность верно не относить объекты к тем классам, к которым они не относятся. Этот критерий предложен и реализован в системе "Эйдос" проф. Е.В.Луценко в 1994 году. Эта мера достоверности модели предполагает два варианта нормировки: {-1, +1} и {0, 1}:

La = (TP + TN - FP - FN) / (TP + TN + FP + FN) (нормировка: {-1,+1})

Lb = (1 + (TP + TN - FP - FN) / (TP + TN + FP + FN)) / 2 (нормировка: { 0, 1})

где количество: TP - истинно-положительных решений; TN - истинно-отрицательных решений; FP - ложно-положительных решений; FN - ложно-отрицательных решений;

Классическая F-мера достоверности моделей Ван Ризбергена (колонка выделена ярко-голубым фоном):

F-mera = 2*(Precision*Recall)/(Precision+Recall) - достоверность модели

Precision = TP/(TP+FP) - точность модели;

Recall = TP/(TP+FN) - полнота модели;

L1-мера проф.Е.В.Луценко - нечеткое мультиклассовое обобщение классической F-меры с учетом СУММ уровней сходства (колонка выделена ярко-зеленым фоном):

L1-mera = 2*(SPrecision*SRecall)/(SPrecision+SRecall)

SPrecision = STP/(STP+SFP) - точность с учетом сумм уровней сходства;

SRecall = STP/(STP+SFN) - полнота с учетом сумм уровней сходства;

STP - Сумма модулей сходства истинно-положительных решений; STN - Сумма модулей сходства истинно-отрицательных решений;

SFP - Сумма модулей сходства ложно-положительных решений; SFN - Сумма модулей сходства ложно-отрицательных решений.

L2-мера проф.Е.В.Луценко - нечеткое мультиклассовое обобщение классической F-меры с учетом СРЕДНИХ уровней сходства (колонка выделена желтым фоном):

L2-mera = 2*(APrecision*ARecall)/(APrecision+ARecall)

APrecision = ATP/(ATP+AFP) - точность с учетом средних уровней сходства;

ARecall = ATP/(ATP+AFN) - полнота с учетом средних уровней сходства;

ATP=STP/TP - Среднее модулей сходства истинно-положительных решений; AFN=SFN/FN - Среднее модулей сходства истинно-отрицательных решений;

AFP=SFP/FP - Среднее модулей сходства ложно-положительных решений; AFN=SFN/FN - Среднее модулей сходства ложно-отрицательных решений.

Строки с максимальными значениями F-меры, L1-меры и L2-меры выделены фоном цвета, соответствующего колонке.

Из графиков частотных распределений истинно-положительных, истинно-отрицательных, ложно-положительных и ложно-отрицательных решений видно, что чем выше модуль уровня сходства, тем больше доля истинных решений. Это значит, что модуль уровня сходства является адекватной мерой степени истинности решения и степени уверенности системы в этом решении. Поэтому система "Эйдос" имеет адекватный критерий достоверности собственных решений, с помощью которого она может отфильтровать заведомо ложные решения.

Луценко Е.В. Инвариантное относительно объемов данных нечеткое мультиклассовое обобщение F-меры достоверности моделей Ван Ризбергена в АСК-анализе и системе "Эйдос" / Е.В. Луценко // Политематический сетевой электронный научный журнал Кубанского государственного аграрного университета (Научный журнал КубГАУ) [Электронный ресурс]. - Краснодар: КубГАУ, 2017. - №02(126). С. 1 - 32. - IDA [article ID]: 1261702001. - Режим доступа: http://ej.kubagro.ru/2017/02/pdf/01.pdf, 2 у.п.л.

Помощь по режиму 3.4. (С) Система "ЭЙДОС-Х++"

Режим: 4.1.3.11. РАСЧЕТ И ГРАФИЧЕСКАЯ ВИЗУАЛИЗАЦИЯ ЧАСТОТНЫХ РАСПРЕДЕЛЕНИЙ УРОВНЕЙ СХОДСТВА:

По нажатию кнопок: [TP,TN,FP,FN], [(TP-FP),(TN-FN)], [(T-F)/(T+F)*100] отображаются графики частотных распределений для модели и интегрального критерия той строки, на которой в экранной форме 3.4 стоит курсор. По клику на кнопке: [(T-F)/(T+F)*100] выводятся графики частотных распределений: (TP-FP)/(TP+FP)*100 и (TN-FN)/(TN+FN)*100.

где:

TP-True-Positive; TN-True-Negative; FP-False Positive; FN-False-Negative, количество истинных и ложных положительных и отрицательных решений.

Луценко Е.В. Инвариантное относительно объемов данных нечеткое мультиклассовое обобщение F-меры достоверности моделей Ван Ризбергена в АСК-анализе и системе "Эйдос" / Е.В. Луценко // Политематический сетевой электронный научный журнал Кубанского государственного аграрного университета (Научный журнал КубГАУ) [Электронный ресурс]. - Краснодар: КубГАУ, 2017. - №02(126). С. 1 - 32. -IDA [article ID]: 1261702001. -Режим доступа: http://ej.kubagro.ru/2017/02/pdf/01.pdf, 2 у.п.л.

Примерные графики TP,TN,FP,FN, а также F-меры и критериев L1, L2 при увеличении объема выборки:

Figure 10. Screen forms of mode 3.4 of "Eidos" system

From the screen forms presented in Figures 9, it can be seen that when solving the problem of identifying the level of systemicity of a natural number by its properties, good results were obtained, which indicate the presence of sufficiently strong and pronounced laws and the relationships between the properties of natural numbers on the one hand and the level of systematality of these numbers, on the other hand: the reliability of the INF4 model by Van Riesbergen F-measure is 0.808. Only 0.015 less reliability of the INF1 model: 0.793, which demonstrates the most reasonable type of frequency distributions of the number of true and false, positive and negative solutions:

- *for positive solutions* at all values of the level of similarity, the number of true solutions significantly exceeds the number of false solutions;

- *for negative solutions* at all values of the difference level module 3% and higher, the number of true solutions significantly exceeds the number of false solutions.

3.5. *Task-5.* Select the Most Reliable Model

All subsequent problems are solved in the most reliable model.

The reasons for this are simple. If the model is valid, then:

- *the identification* of an object with a class is valid, i.e. the model classifies the objects to which they actually belong;

- *forecasting* is reliable, i.e. the events that are predicted actually occur;

- *making decisions* adequately (reliably), i.e., after implementation of the adopted control decisions, the control object really transitions to the target future states;

- *The study* is reliable, i.e. the conclusions obtained as a result of the study of the model of the modeling object can be rightly attributed to the modeling object.

Technically, the selection of the most reliable model is carried out in the 5.6 mode of the Eidos system and passes quickly (Figure 11). This is only necessary to solve the problem of identification and prediction (in mode 4.1.2), which requires the most computational resources and therefore is solved only for the model specified by the current one. All other calculations are carried out in the Eidos system in all models at once.

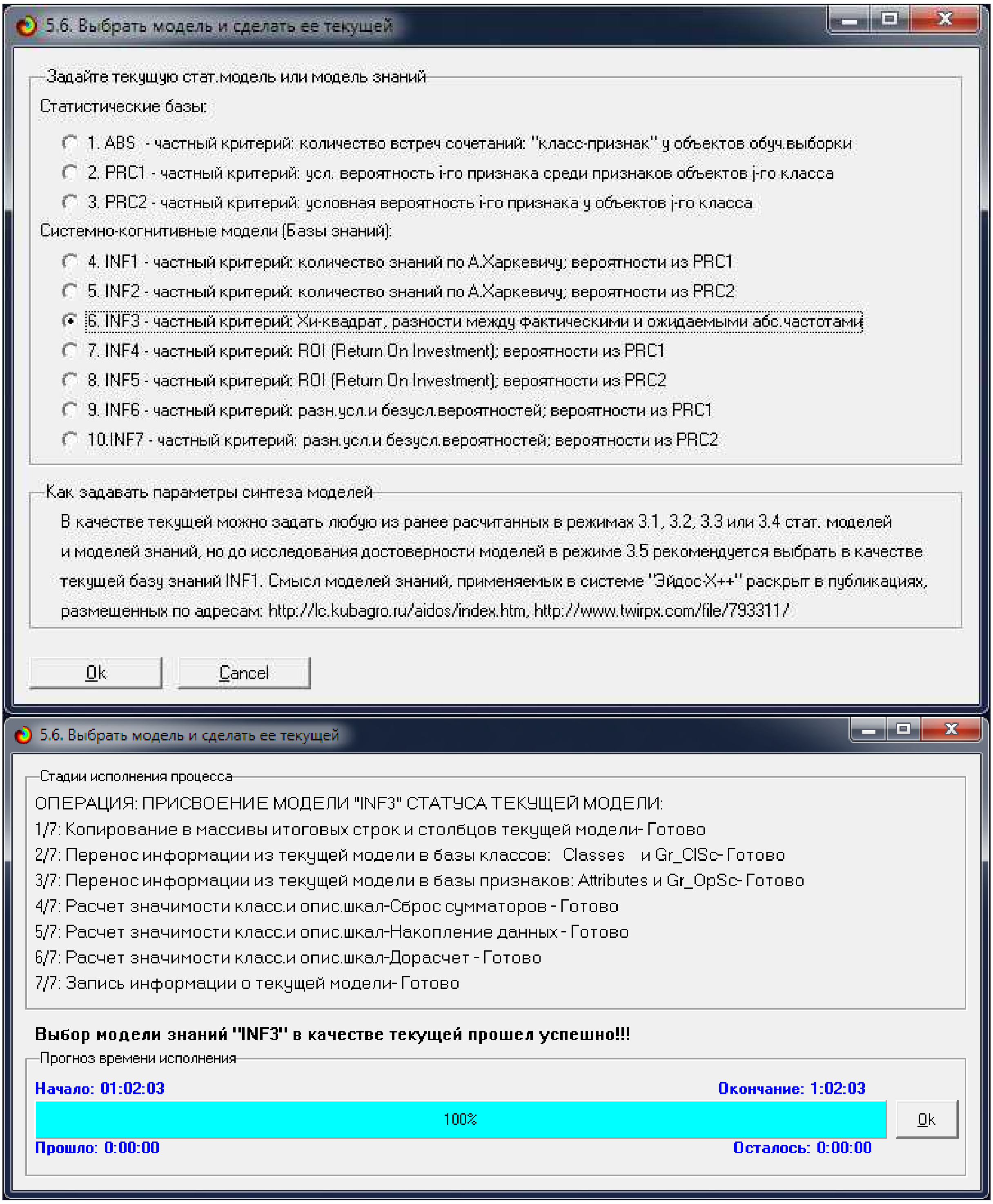


Figure 11. Screen forms of mode 5.6 of "Eidos" system:
To Set the Current Model

3.6. *Task-6.* System identification and forecasting. Integral criteria

When solving *the problem of identification*, each object of the recognized sample is compared by all its features with each of the generalized class images. The point of solving the identification problem is that when determining the belonging of a particular object to a generalized image of a class, *everything that is known about objects of this class, at least the most significant about them, that is, how they differ from objects of other classes, becomes known by **analogy.***

Identification and prediction tasks are interrelated and differ little from each other. The main difference between them is that when identifying the values of properties and the belonging of the object to the class belong to one point in time, and when predicting the values of factors relate to the past, and the transition of the object under the influence of these factors to the state corresponding to the class belongs to the future (Figure 3).

The problem is solved in the model specified as current, since it is very time consuming in computational terms. True, using a graphics processor (GPU) for calculations, this problem has practically been removed.

The comparison is carried out by applying *non-metric integral criteria*, which are currently used in the Eidos system. These integral criteria are interesting in that they are correct [9]in non-orthonormal spaces, which are always found in practice, and are noise cancellation filters.

3.6.1. Integral criterion "Sum of knowledge"

The integral criterion "Sum of knowledge" is the total amount of knowledge contained in the system of factors of various nature that characterize the control object itself, control factors and the environment, about the transition of the object to future target or undesirable states.

The integral criterion is an additive function of the particular knowledge criteria presented in help mode 5.5:

$$I_j = (\vec{I}_{ij}, \vec{L}_i).$$

In the expression, a scalar product is indicated in parentheses. In coordinate form, this expression has the form:

$$I_j = \sum_{i=1}^{M} I_{ij} L_i, ,$$

where: M is the number of gradations of descriptive scales (features);

$\vec{I}_{ij} = \{I_{ij}\}$ - jth class state vector;

$\vec{L}_i = \{L_i\}$ - a vector of the state of the recognized object, including all types of factors characterizing the object itself, controlling impacts and the environment (array-locator), i.e.:

[9]Unlike Euclidean distance, which is used for such purposes most often

$$\vec{L}_i = \begin{cases} 1, \textit{если } i - \textit{й фактор действует}; \\ n, \textit{где}: n > 0, \textit{если } i - \textit{й фактор действует с истинностью } n; \\ 0, \textit{если } i - \textit{й фактор не действует}. \end{cases}$$

In the current version of the Eidos-X + + system, the coordinate values of the state vector of the recognized object were taken to be either 0 if there is no sign, or n if it is present in an object with intensity n, i.e. it is represented n times (for example, the letter "o" in the word "milk" is represented 3 times, and the letter "m" - once).

3.6.2. Integral criterion "Semantic resonance of knowledge"

The integral criterion "Semantic resonance of knowledge" is the *normalized* total amount of knowledge contained in the system of factors of various nature that characterize the control object itself, control factors and the environment, about the transition of the object to future target or undesirable states.

The integral criterion is an additive function of the particular knowledge criteria presented in help mode 3.3 and has the form:

$$I_j = \frac{1}{\sigma_j \sigma_l M} \sum_{i=1}^{M} \left(I_{ij} - \bar{I}_j\right)\left(L_i - \bar{L}\right),$$

where:

M -number of gradations of descriptive scales (features); - $\bar{I}_j$ average informativity by class vector; - $\bar{L}$ average by object vector;

σ_j is the standard deviation of the partial knowledge criteria of the class vector; σ_l isthe standard deviation of the vector of the object being recognized.

$\vec{I}_{ij} = \{I_{ij}\}$ - a vector of the state of the j-th class; - $\vec{L}_i = \{L_i\}$ a vector of the state of the recognized object (state or phenomenon), including all types of factors characterizing the object itself, controlling impacts and the environment (array-locator), i.e.:

$$\vec{L}_i = \begin{cases} 1, \textit{если } i - \textit{й фактор действует}; \\ n, \textit{где}: n > 0, \textit{если } i - \textit{й фактор действует с истинностью } n; \\ 0, \textit{если } i - \textit{й фактор не действует}. \end{cases}$$

In the current version of the Eidos-X + + system, the coordinate values of the state vector of the recognized object were taken to be either 0 if there is no sign, or n if it is present in an object with intensity n, i.e. it is represented n times (for example, the letter "o" in the word "milk" is represented 3 times, and the letter "m" - once).

The given expression for the integral criterion "Semantic resonance of knowledge" is obtained directly from the expression for the criterion "Sum of knowledge" after replacing the coordinates of multiplied vectors with their standardized values: $I_{ij} \to \frac{I_{ij} - \bar{I}_j}{\sigma_j}$, $L_i \to \frac{L_i - \bar{L}}{\sigma_l}$. Therefore, in essence, it is also a scalar product of two standardized (unit) vectors of class and object. There are many other methods of rationing, for example, by using splines, in particular linear interpolation: $I_{ij} \to \frac{I_{ij} - I_j^{\min}}{I_j^{\max} - I_j^{\min}}$, $L_i \to \frac{L_i - L^{\min}}{L^{\max} - L^{\min}}$, This allows you to propose other types of integral criteria. But they are not currently implemented in the Eidos system.

3.6.3. Important mathematical properties of integral criteria

These integral criteria have very interesting ***mathematical properties that*** provide him with important advantages:

First, the integral criterion has **a non-metric** nature, i.e. it is a measure of the similarity of the class vectors and the object, but not the distance between them, but the cosine of the angle between them, i.e. it is an inter-vector or information distance. Therefore, its application is correct in **non-orthonormal** spaces, which, as a rule, are found in practice and in which the application of the Euclidean distance (Pythagorean theorem) is incorrect.

Secondly, this integral criterion is a white **noise** suppressing **filter**, which is always present in empirical raw data and in models based on them. This property of suppressing white noise appears in this criterion the brighter the more descriptive scales in the gradation model.

Thirdly, the integral similarity criterion is a quantitative measure of the similarity/difference of a particular object with a generalized class image and has the same meaning as the **function of belonging** of an element to a set in fuzzy Lotfi Zade logic**. However**, in fuzzy logic, this function is given a priori by the researcher by choosing from several possible options, and in ASK analysis and its software toolkit, the Eidos intelligent system, it is calculated in accordance with a well-founded mathematical model directly based on empirical data.

Fourth, the value of the integral similarity criterion is an adequate self-assessment of **the degree of confidence** of the system in a positive or negative decision about the belonging/non-belonging of the object to the class or **the risk of error** in such a decision.

Fifth, in fact, the recognition calculates the coefficients I_j of decomposition of the function of the object L_i into a series according to the functions of classes I_{ij}, that is**, the weight** of each generalized class image in the object image is determined, as described in more detail in monographs [46, 50].

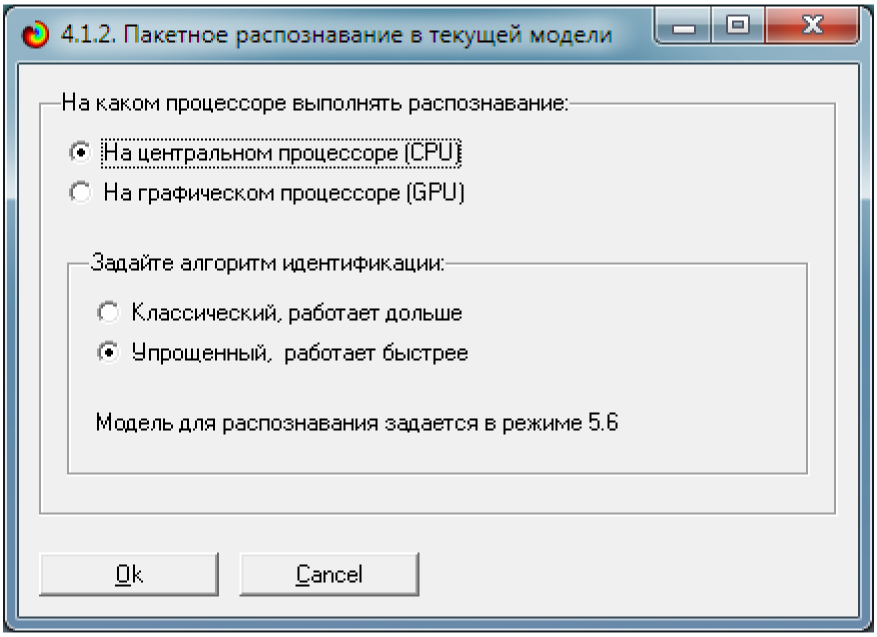
3.6.4. Output forms based on identification and forecasting results

Figures 12 show the screen forms of 4.1.2 Eidos identification and prediction mode:

- on the *first* screen form, the processor type and algorithm for calculation are set;

- the *second* screen form shows the execution stages and the forecast of the end time;

- the *third* screen form shows a fragment of the main menu of the system (subsystem 4.1.3.), Which shows various output forms based on the results of recognition.



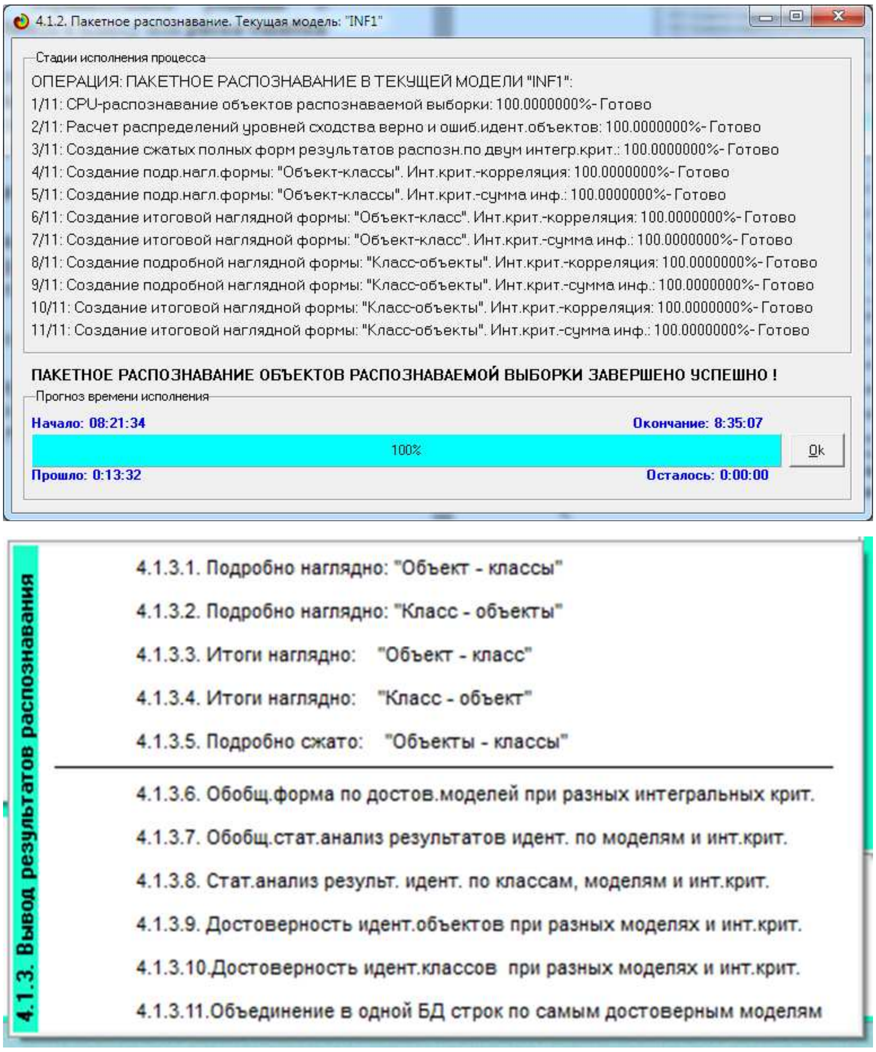


Figure 12. Screen forms of identification and forecasting mode 4.1.2 of "Eidos" system

3.7. *Task-7.* Decision Support

3.7.1. Simplified decision making as inverse prediction task, positive and negative information portraits of classes, SWOT analysis

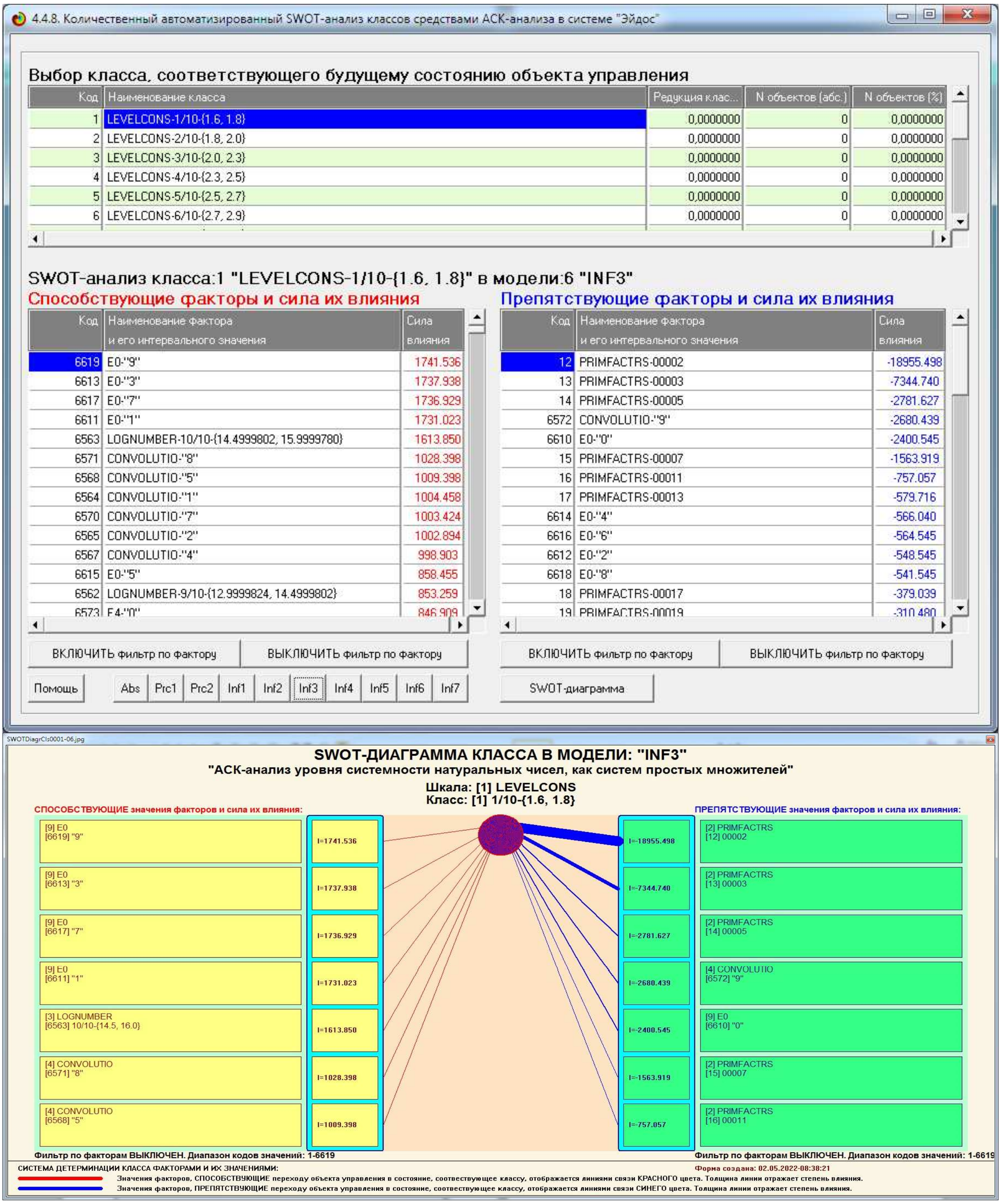
Predictive and decision-making tasks refer to each other as direct and ***inverse*** problems:

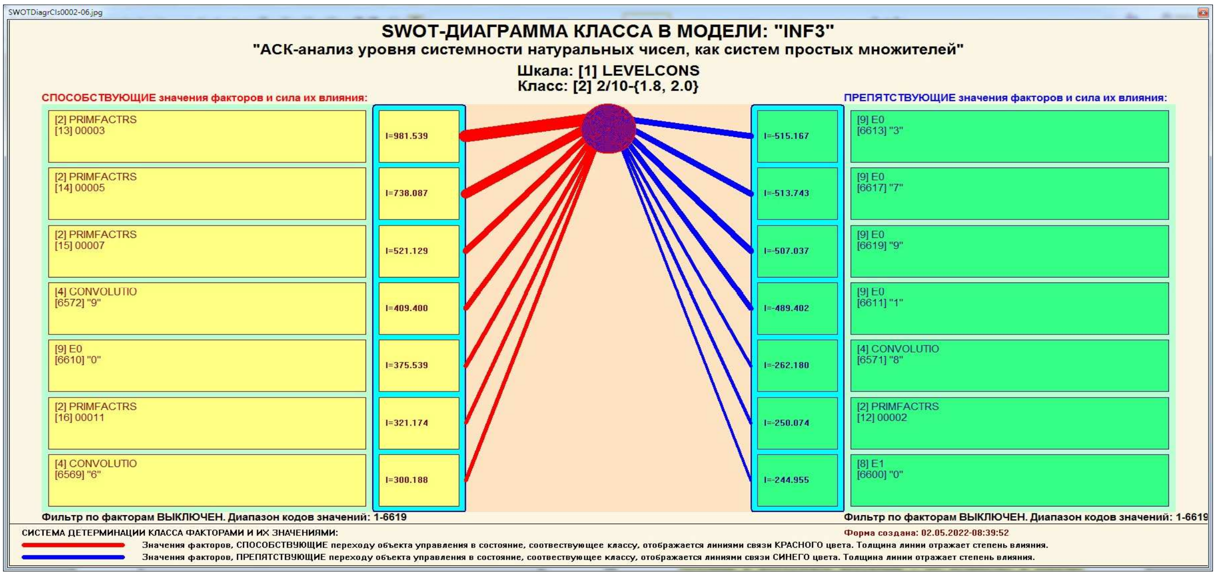
- when predicting by the values of factors acting on the modeling object, it is determined which future state it will pass under their action;

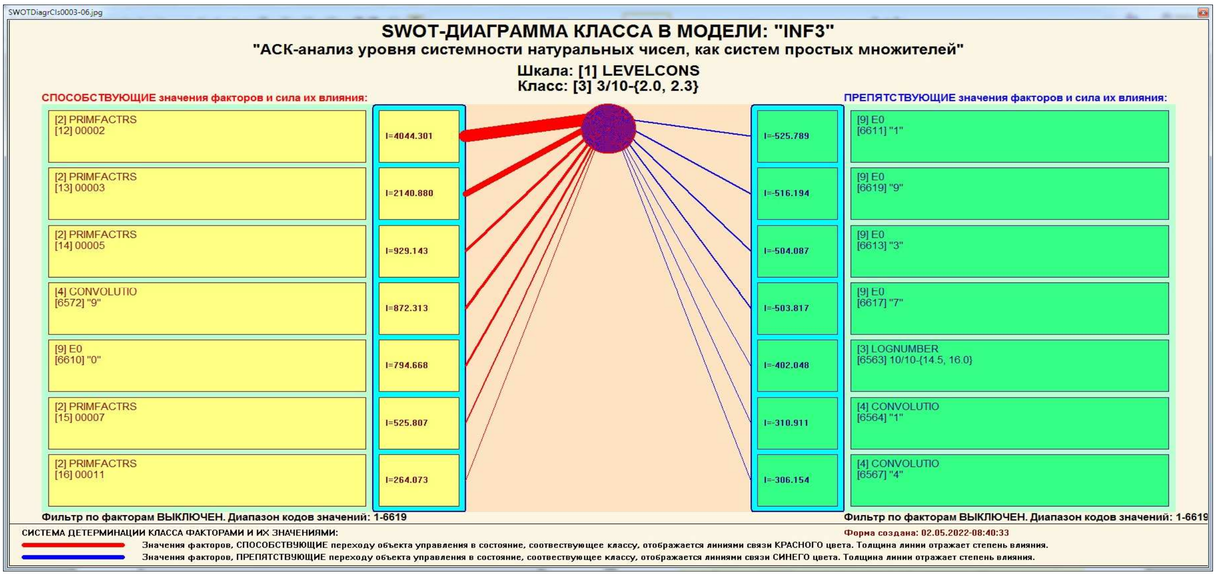
- when making decisions, on the contrary, according to the future target state of the modeling object, the values of factors that determine its transition to this future target state are determined.

Thus, the decision task is inverse to the prediction task. But this is so only in the simplest case: in the case of using SWOT analysis (mode 4.4.8 of the Eidos system) [9].

Figures 13 show the screen forms of SWOT-analysis mode 4.4.8 of "Eidos" system:




SWOT-ДИАГРАММА КЛАССА В МОДЕЛИ: "INF3"
"АСК-анализ уровня системности натуральных чисел, как систем простых множителей"
Шкала: [1] LEVELCONS
Класс: [2] 2/10-{1.8, 2.0}
СПОСОБСТВУЮЩИЕ значения факторов и сила их влияния:
ПРЕПЯТСТВУЮЩИЕ значения факторов и сила их влияния:
[2] PRIMFACTRS [13] 00003
I=981.539
[2] PRIMFACTRS [14] 00005
I=738.087
[2] PRIMFACTRS [15] 00007
I=521.129
[4] CONVOLUTIO [6572] "9"
I=409.400
[9] E0 [6610] "0"
I=375.539
[2] PRIMFACTRS [16] 00011
I=321.174
[4] CONVOLUTIO [6569] "6"
I=300.188
I=515.167
[9] E0 [6613] "3"
I=513.743
[9] E0 [6617] "7"
I=507.037
[9] E0 [6619] "9"
I=489.402
[9] E0 [6611] "1"
I=262.180
[4] CONVOLUTIO [6571] "8"
I=250.074
[2] PRIMFACTRS [12] 00002
I=244.955
[8] E1 [6600] "0"
Фильтр по факторам ВЫКЛЮЧЕН. Диапазон кодов значений: 1-6619
Фильтр по факторам ВЫКЛЮЧЕН. Диапазон кодов значений: 1-6619
СИСТЕМА ДЕТЕРМИНАЦИИ КЛАССА ФАКТОРАМИ И ИХ ЗНАЧЕНИЯМИ:
Форма создана: 02.05.2022-08:39:52
Значения факторов, СПОСОБСТВУЮЩИЕ переходу объекта управления в состояние, соответствующее классу, отображается линиями связи КРАСНОГО цвета. Толщина линии отражает степень влияния.
Значения факторов, ПРЕПЯТСТВУЮЩИЕ переходу объекта управления в состояние, соответствующее классу, отображается линиями связи СИНЕГО цвета. Толщина линии отражает степень влияния.


SWOT-ДИАГРАММА КЛАССА В МОДЕЛИ: "INF3"
"АСК-анализ уровня системности натуральных чисел, как систем простых множителей"
Шкала: [1] LEVELCONS
Класс: [3] 3/10-{2.0, 2.3}
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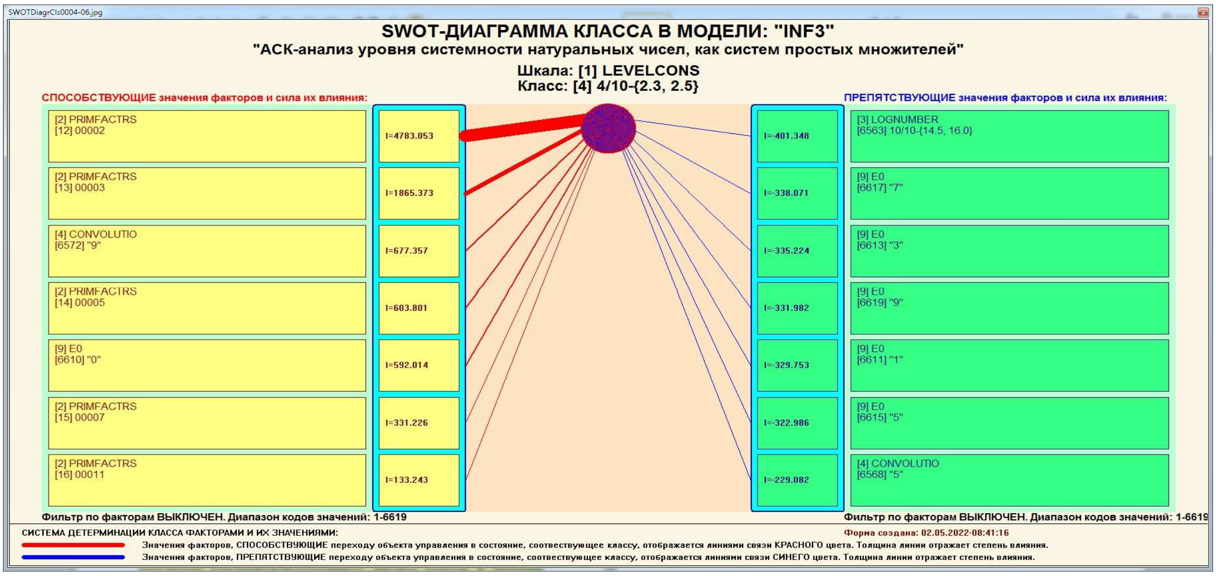
SWOT-ДИАГРАММА КЛАССА В МОДЕЛИ: "INF3"
"АСК-анализ уровня системности натуральных чисел, как систем простых множителей"
Шкала: [1] LEVELCONS
Класс: [4] 4/10-{2.3, 2.5}
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Фильтр по факторам ВЫКЛЮЧЕН. Диапазон кодов значений: 1-6619
СИСТЕМА ДЕТЕРМИНАЦИИ КЛАССА ФАКТОРАМИ И ИХ ЗНАЧЕНИЯМИ:
Форма создана: 02.05.2022-08:41:16
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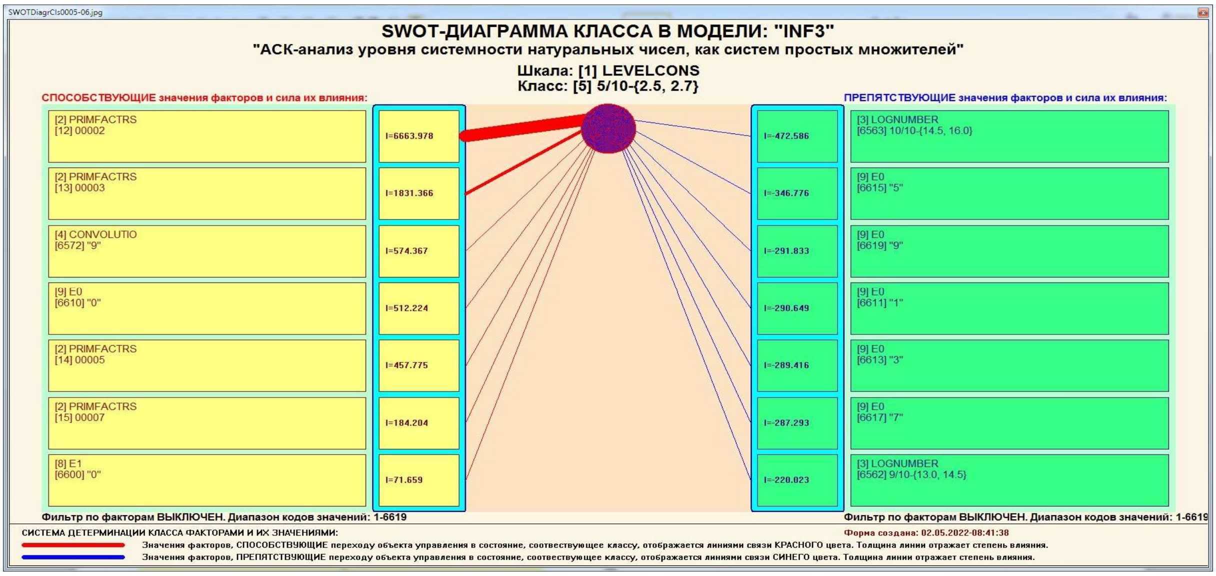
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"АСК-анализ уровня системности натуральных чисел, как систем простых множителей"
Шкала: [1] LEVELCONS
Класс: [5] 5/10-{2.5, 2.7}
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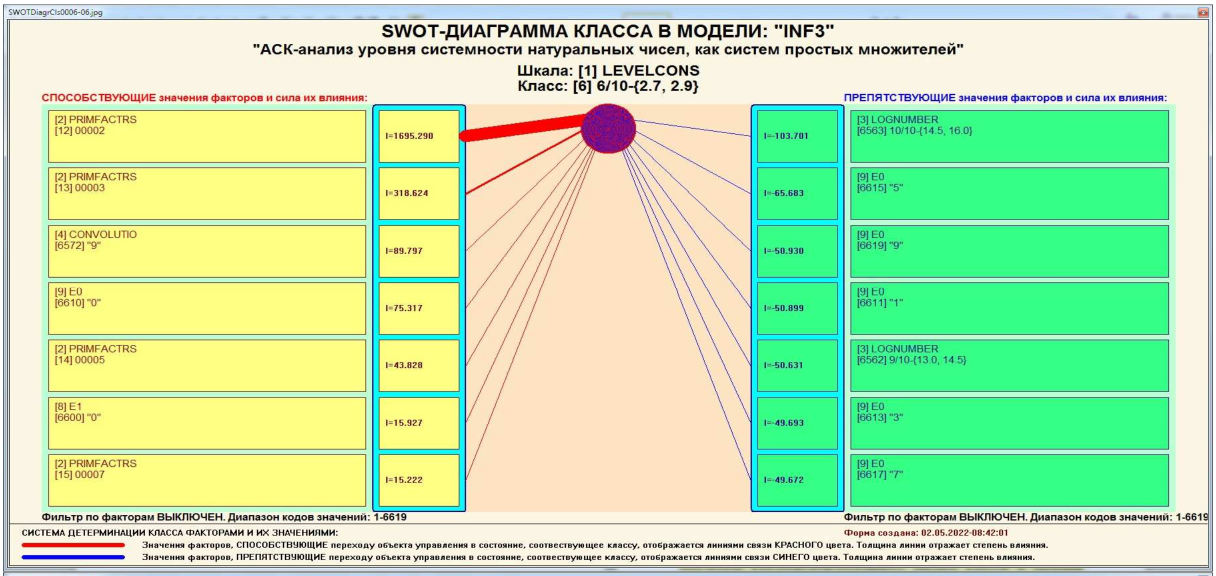
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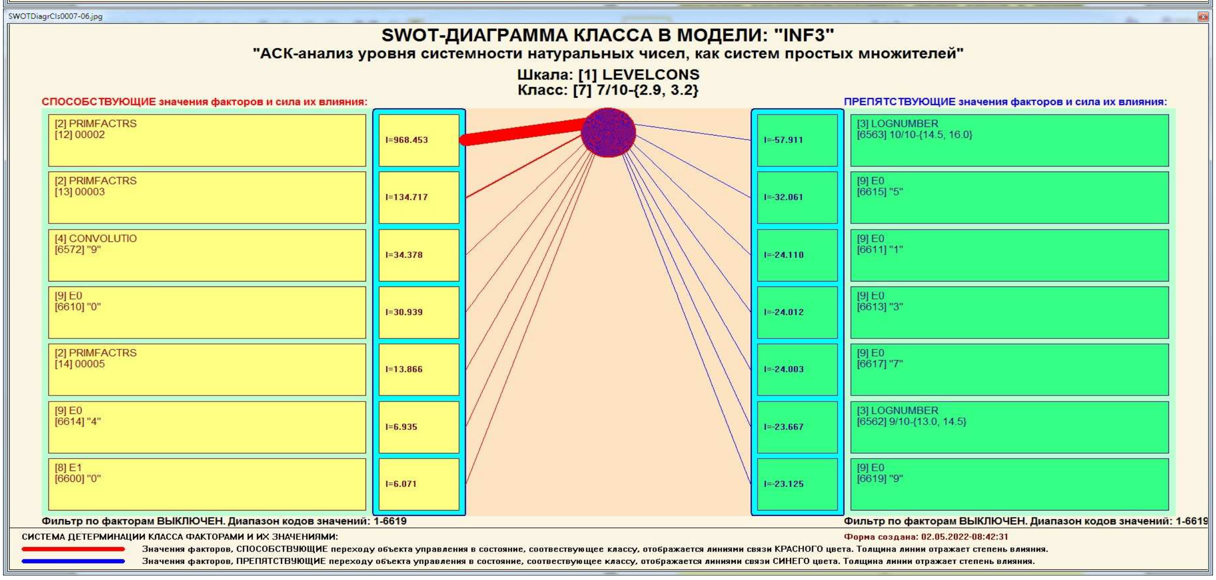
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"АСК-анализ уровня системности натуральных чисел, как систем простых множителей"
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Класс: [7] 7/10-{2.9, 3.2}
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СИСТЕМА ДЕТЕРМИНАЦИИ КЛАССА ФАКТОРАМИ И ИХ ЗНАЧЕНИЯМИ:
Форма создана: 02.05.2022-08:42:31
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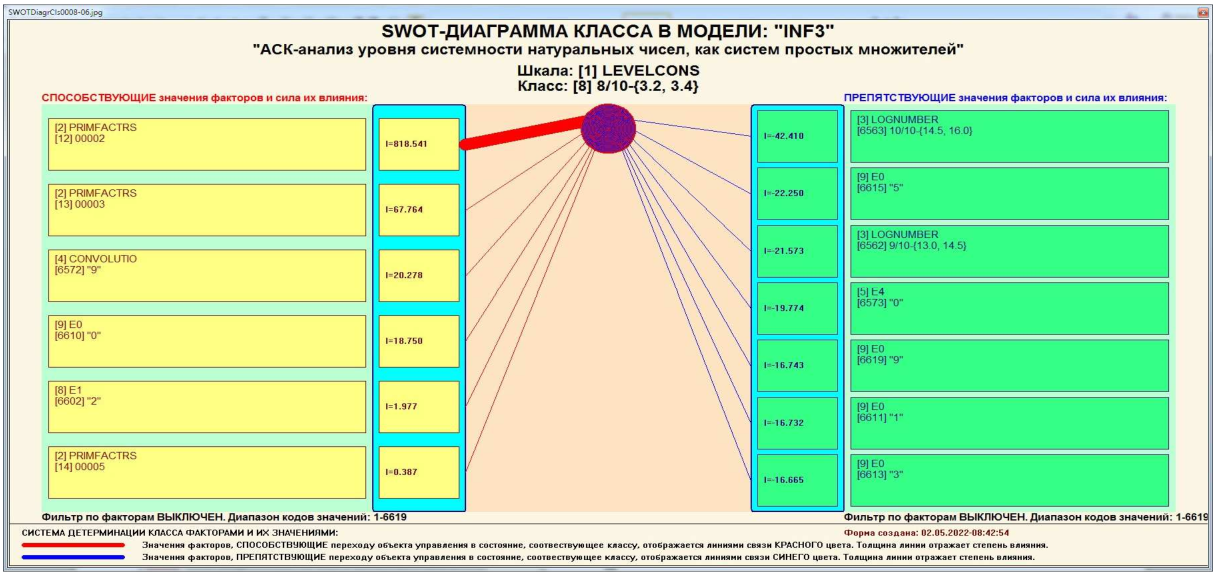
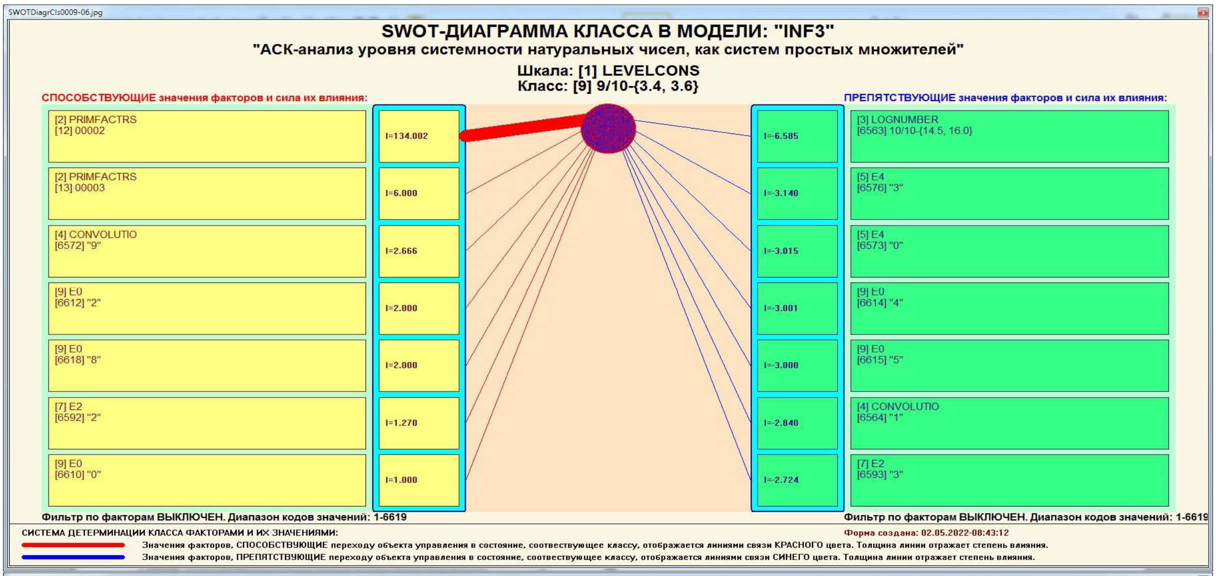
Значения факторов, ПРЕПЯТСТВУЮЩИЕ переходу объекта управления в состояние, соответствующее классу, отображается линиями связи СИНЕГО цвета. Толщина линии отражает степень влияния.





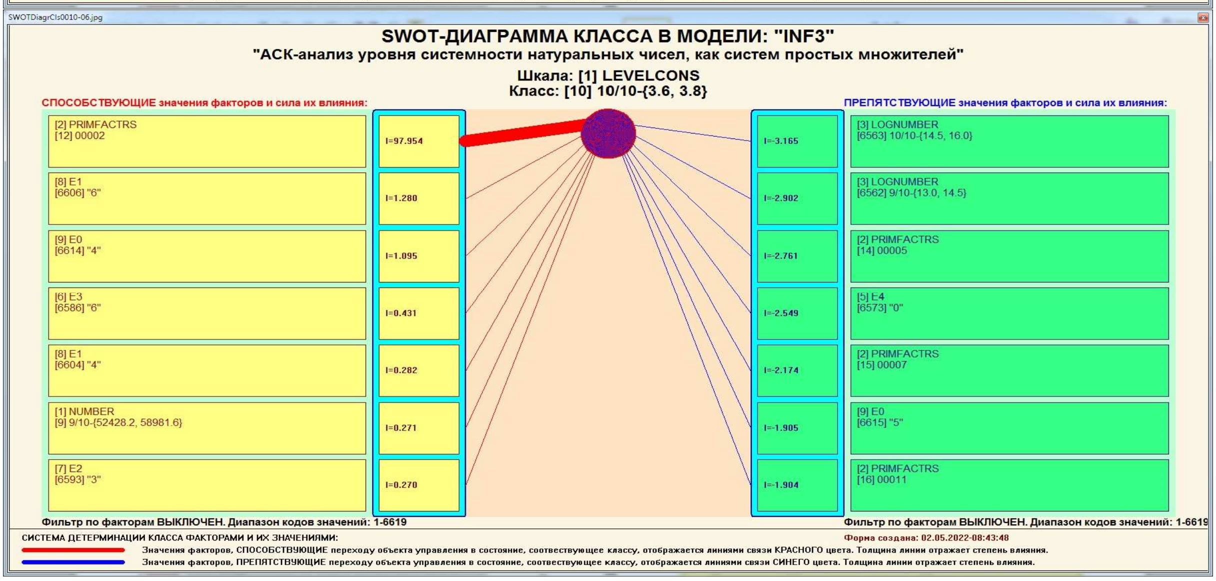


Figure 13. Screen forms of SWOT analysis mode 4.4.8 of "Eidos" system

From the diagrams given by SWOT, it is clear which properties of natural numbers are to what degree characters6 and to what extent uncharacteristic of numbers, different levels of systemicity.

3.7.2. Advanced decision-making algorithm in ASK analysis

However, SWOT analysis (mode 4.4.8 of the Eidos system) has its limitations: only one future target state can be set, some recommended factors may not be technological and financial ability to use.

Therefore, in the ASK analysis and the Eidos system, a developed decision-making algorithm is implemented (mode 6.3) in which, in addition to SWOT analysis, the results of solving the prediction problem and the results of cluster-structural analysis of classes and values of factors, i.e., some results of solving the problem of studying the subject area, are also used. This algorithm is described in operation [10] and a number of subsequent works (Figure 14).

Step 1. Management sets management **goals,** that is, determines the future target states of the management object. Usually, target states in kind are the quantity and quality of products, and in value terms, profit and profitability. The control object as a system, the efficiency of the control object as **a system property**, increasing the system level of the control object as a control target (nonlinearity). The model reflects a certain level of technology, so target states that are not achievable in one model can be achievable in another with a large number of factors.

Step 2 (see mode 6.4). Cognitive-targeted structuring and formalization of the subject area (regime .2.3.2.2), synthesis and verification of models (regime .3.5), we determine the most reliable of them by Van Riesbergen's F-criterion and the L1 and L2 criteria prof. E.V. Lutsenko (cut. 3.4). Increase the level of systematics and adequacy of the control object model (William Ross Ashby principle).

Step 3. If the target state is one, then we go to step 6, and otherwise to step 4.

Step 4. Otherwise, we evaluate **the correctness of** the set goals by comparing the determination system of target states by **cognitive clustering** (4.2.2.3) or based on the similarity matrix (4.2.2.1), i.e., we determine whether the target states are compatible, i.e., achievable simultaneously, by the factors that determine them, or they are mutually exclusive (alternative) according to the determination system and simultaneously unattainable.

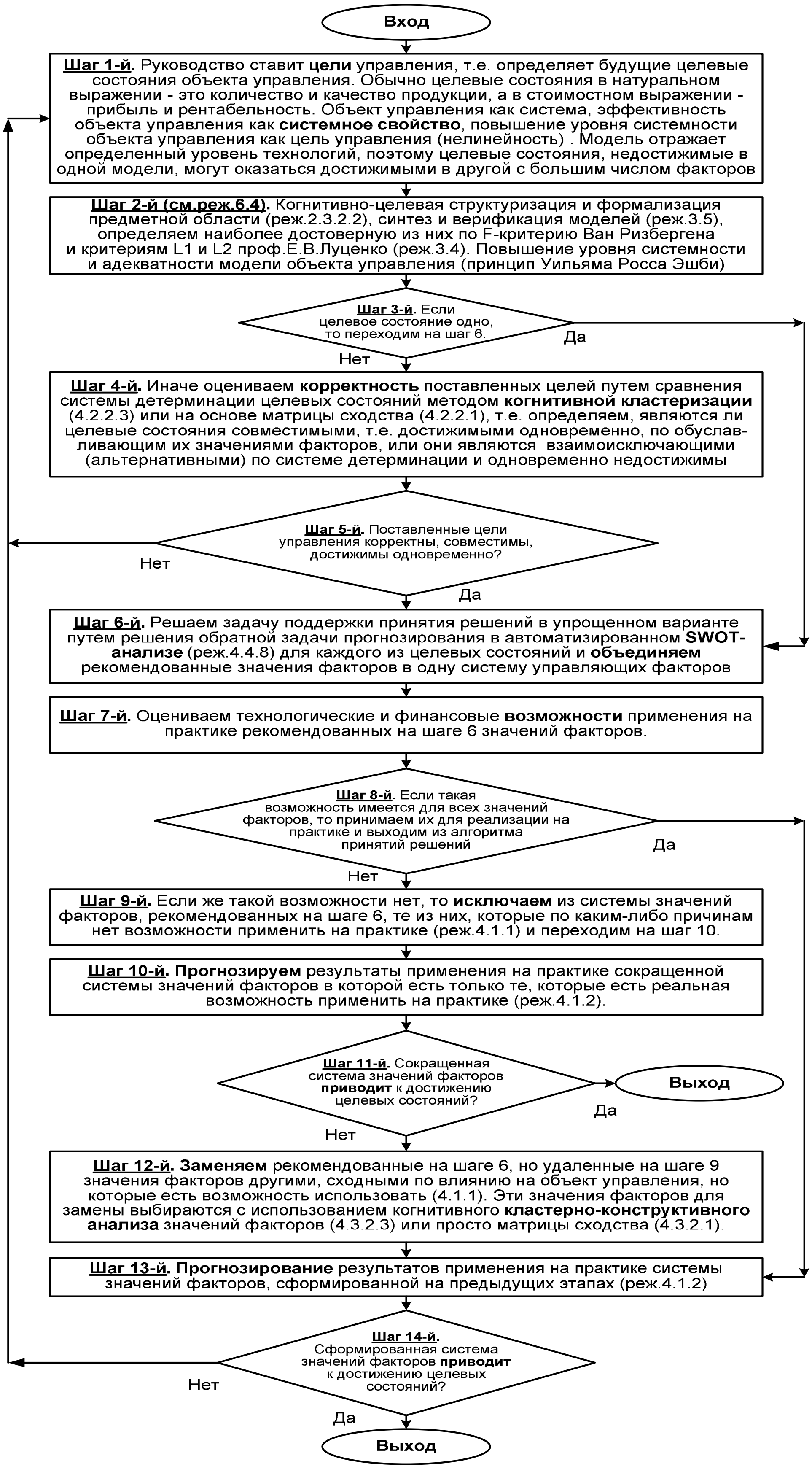


Figure 14. Advanced decision-making algorithm in intelligent control systems based on ASK analysis and the Eidos system

Step 5. Are the set management goals correct, compatible, achievable at the same time? If yes, go to step 6, or step 1.

Step 6. We solve the problem of supporting decision making in a simplified version by solving the inverse prediction problem in the automated **SWOT analysis** (mode 4.4.8) for each of the target states and **combine** the recommended values of factors into one system of control factors.

Step 7. We evaluate the technological and financial **feasibility** of applying the factors recommended in step 6.

Step 8. If this is possible for all values of factors, then we take them for implementation and go to step 13 to test the effectiveness of the decisions made, and otherwise we go to step 9.

Step 9. If there is no such possibility**, then we exclude** from the system the values of the factors recommended in step 6, those that for some reason cannot be applied in practice (mode 4.1.1) and go to step 10.

Step 10. We predict the results of applying in practice a reduced system of values of factors in which there are only those that there is a real opportunity to apply in practice (mode 4.1.2).

Step 11. A reduced system of factor values **leads** to the achievement of target states? If yes, then exit the decision algorithm, and otherwise go to step 12.

Step 12. We replace the values of factors recommended in step 6, but deleted in step 9 with other values similar in effect to the control object, but which can be used (4.1.1). These factor values for replacement are selected using **cognitive cluster design analysis** of factor values (4.3.2.3) or simply a similarity matrix (4.3.2.1).

Step 13. Prediction of results of application in practice of system of values of factors formed at previous stages (mode 4.1.2)

Step 14. The formed system of values of factors **leads** to the achievement of target states? If yes, then exit the decision algorithm, and otherwise go to step 1.

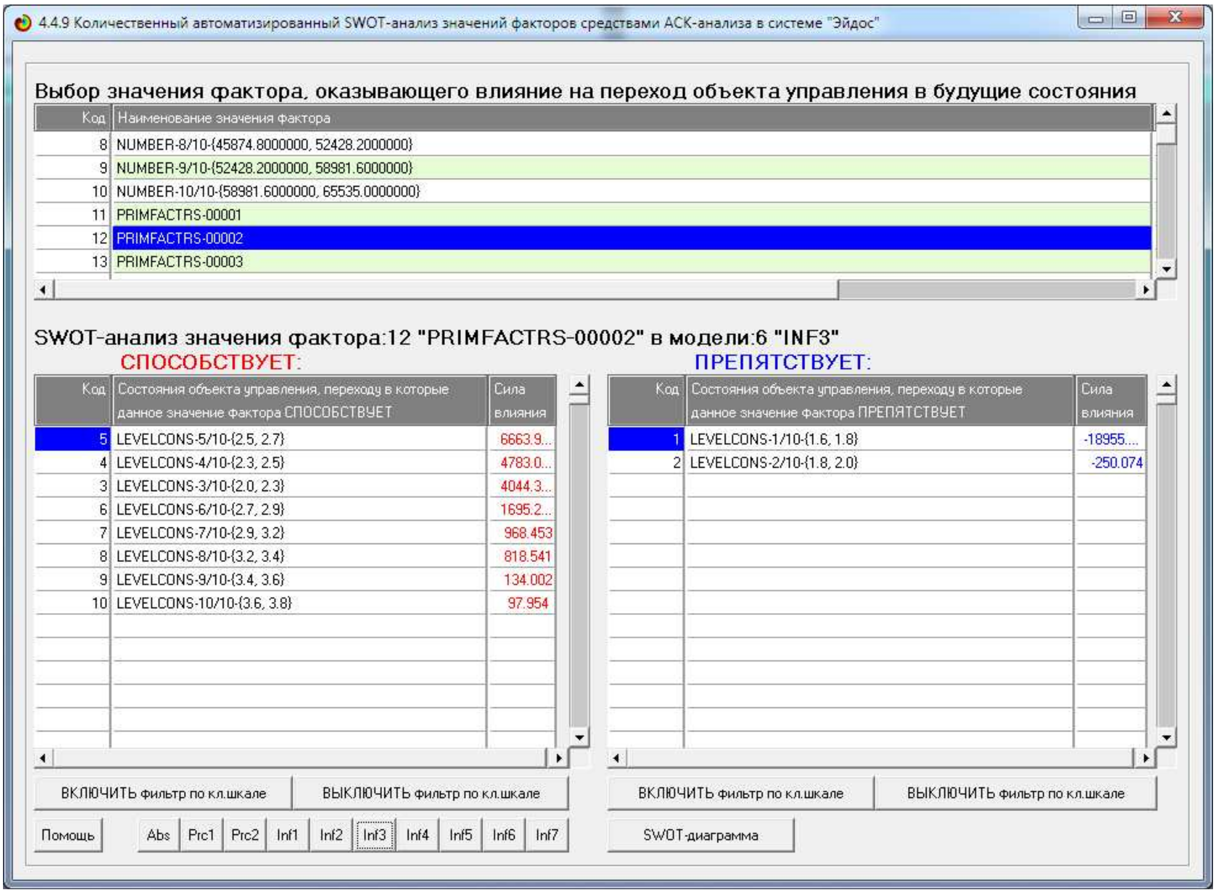
As we see in the developed decision-making algorithm, the results of solving various problems are widely used: both prediction problems and some problems of studying the modeling object by studying its model. It should be emphasized that all these tasks are solved in the Eidos system.

Therefore, below we will briefly consider the solution of these problems. In addition, the solution of these problems is also of independent interest.

3.8. _*Task-8.*_ Research on a modeling object by examining its model

3.8.1. Inverted SWOT charts of descriptive scale values (semantic potentials)

Inverted SWOT-diagrams (proposed by the author in work [9]) reflect the force and direction of influence of a specific gradation of the descriptive scale on transition of the modeling object to states corresponding to gradations of classification scales (classes). This is the ***meaning*** (semantic potential) of this grading of the descriptive scale. Inverted SWOT diagrams are output in mode 4.4.9 of "Eidos" system (Figure 15).



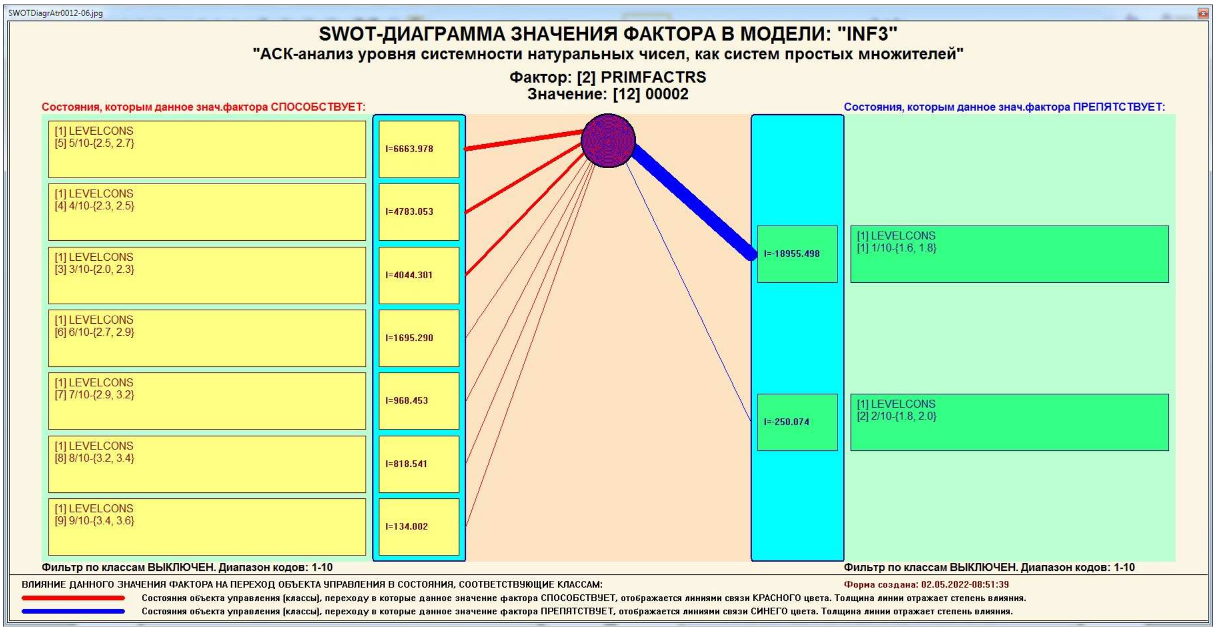


Figure 15. Screen forms of SWOT-analysis mode 4.4.9 of "Eidos" system

The forms in Figure 15 show which levels of systemicity and to what extent, both positive and negative, determine which properties of natural numbers.

3.8.2. Cluster Design Class Analysis

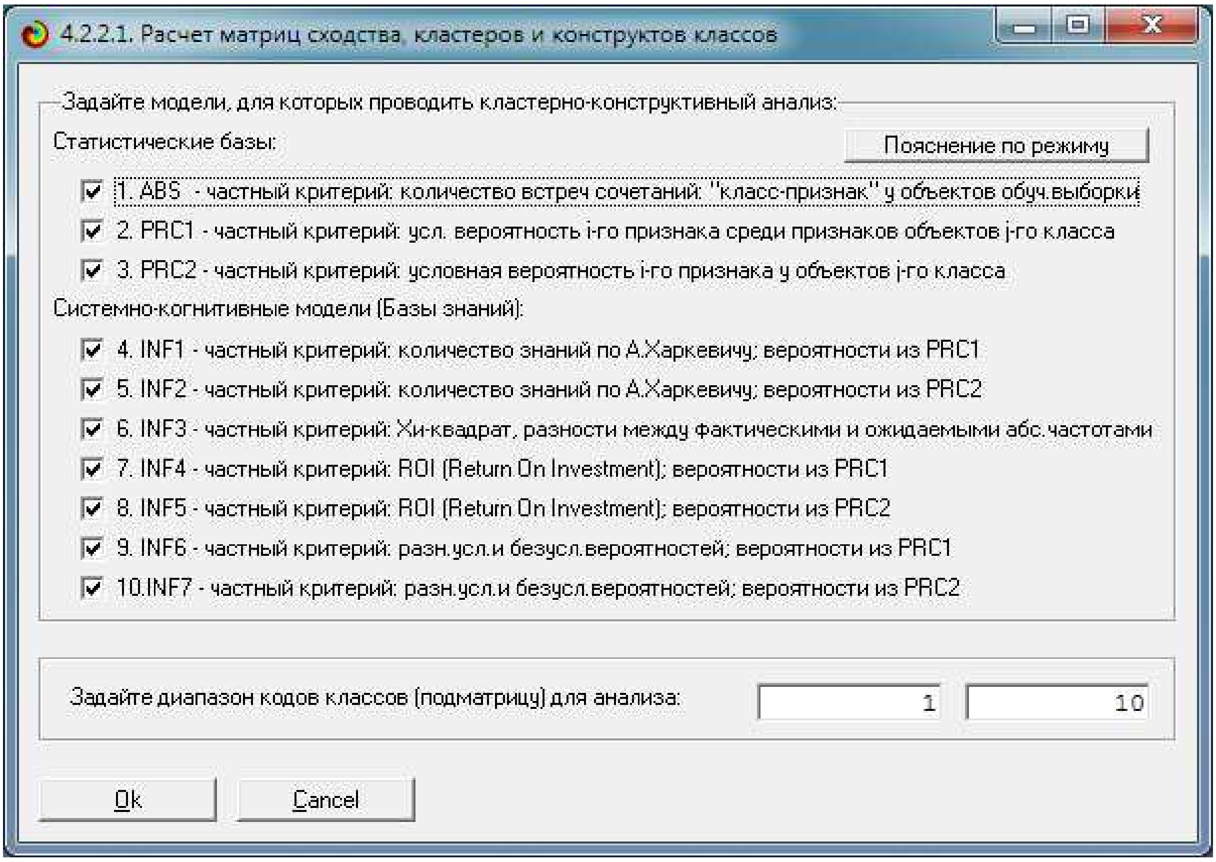
In the "Eidos" system (in mode 4.2.2.1), a matrix of class similarities is calculated according to the system of their determination and four main forms are calculated and output on the basis of this matrix (Figures 16):

- circular 2D cognitive diagram of classes (mode 4.2.2.2);

- agglomerative dendrograms obtained as a result ***of cognitive (true) clustering of classes*** (proposed by the author in 2011 in work [11]) (mode 4.2.2.3);

- schedule of change of inter-cluster distances (mode 4.2.2.3);

- 3D cognitive diagram of classes and features (mode 4.4.12).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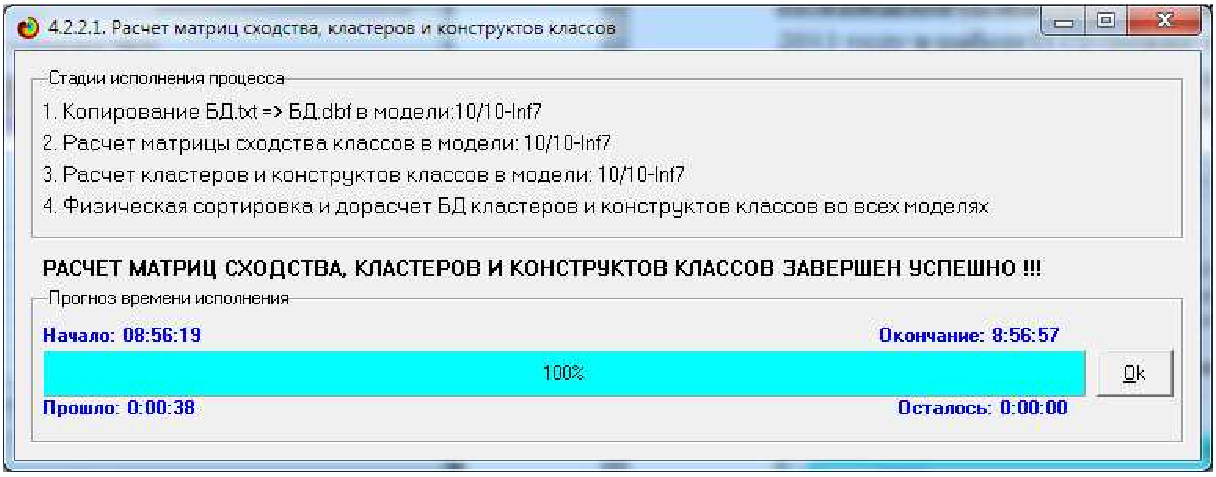
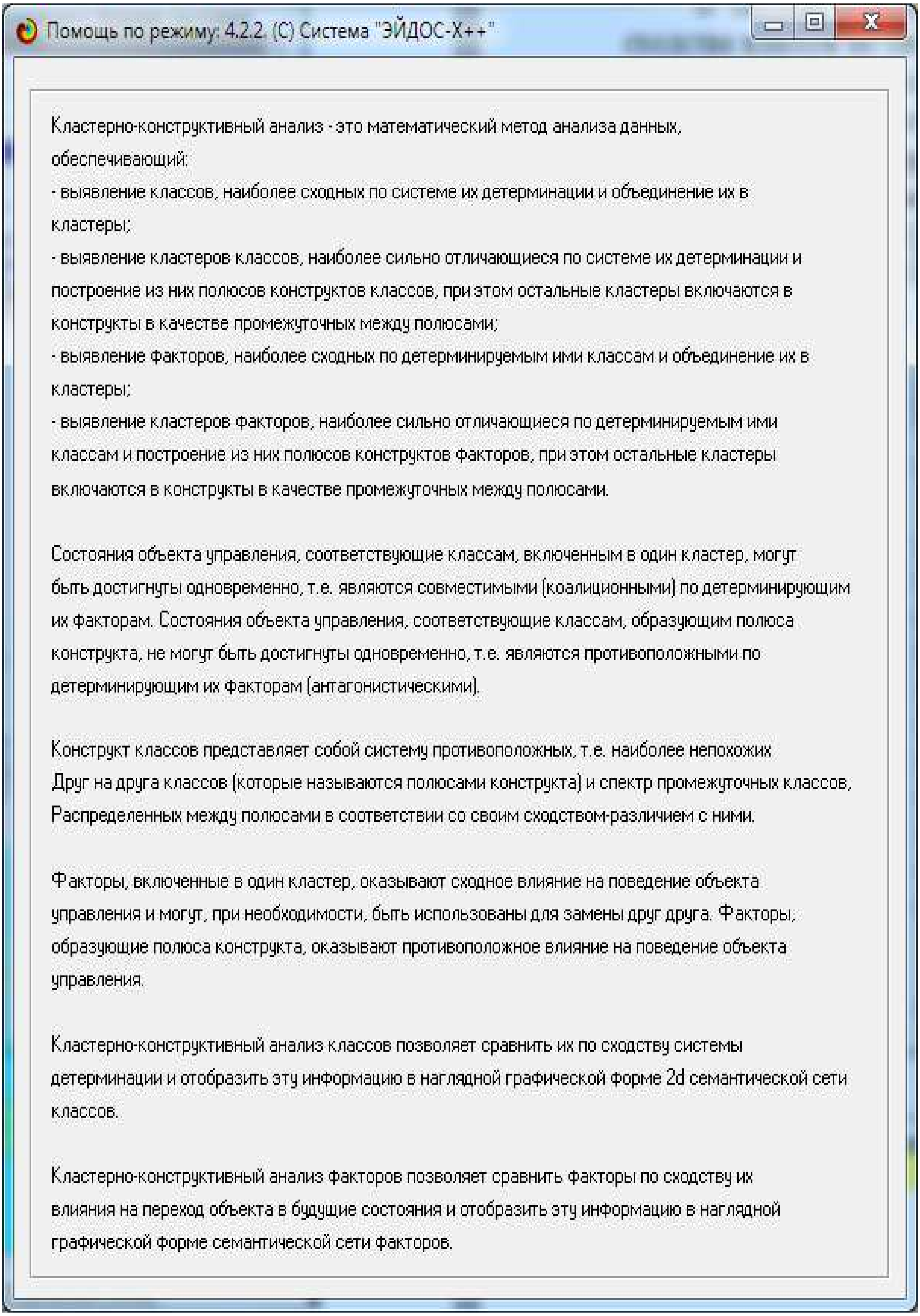
Задайте модели, для которых проводить кластерно-конструктивный анализ:
Статистические базы:
Пояснение по режиму
1. ABS - частный критерий: количество встреч сочетаний: "класс-признак" у объектов обуч.выборки
2. PRC1 - частный критерий: усл. вероятность i-го признака среди признаков объектов j-го класса
3. PRC2 - частный критерий: условная вероятность i-го признака у объектов j-го класса
Системно-когнитивные модели (Базы знаний):
4. INF1 - частный критерий: количество знаний по А.Харкевичу; вероятности из PRC1
5. INF2 - частный критерий: количество знаний по А.Харкевичу; вероятности из PRC2
6. INF3 - частный критерий: Хи-квадрат, разности между фактическими и ожидаемыми абс.частотами
7. INF4 - частный критерий: ROI (Return On Investment); вероятности из PRC1
8. INF5 - частный критерий: ROI (Return On Investment); вероятности из PRC2
9. INF6 - частный критерий: разн.усл.и безусл.вероятностей; вероятности из PRC1
10.INF7 - частный критерий: разн.усл.и безусл.вероятностей; вероятности из PRC2
Задайте диапазон кодов классов (подматрицу) для анализа:
1
10
Ok
Cancel


4.2.2.1. Расчет матриц сходства, кластеров и конструктов классов
Стадии исполнения процесса
1. Копирование БД.txt => БД.dbf в модели:10/10-Inf7
2. Расчет матрицы сходства классов в модели: 10/10-Inf7
3. Расчет кластеров и конструктов классов в модели: 10/10-Inf7
4. Физическая сортировка и дорасчет БД кластеров и конструктов классов во всех моделях
РАСЧЕТ МАТРИЦ СХОДСТВА, КЛАСТЕРОВ И КОНСТРУКТОВ КЛАССОВ ЗАВЕРШЕН УСПЕШНО !!!
Прогноз времени исполнения
Начало: 08:56:19
Окончание: 8:56:57
100%
Ok
Прошло: 0:00:38
Осталось: 0:00:00



Помощь по режиму: 4.2.2. (С) Система "ЭЙДОС-Х++"

Кластерно-конструктивный анализ - это математический метод анализа данных, обеспечивающий:
- выявление классов, наиболее сходных по системе их детерминации и объединение их в кластеры;
- выявление кластеров классов, наиболее сильно отличающиеся по системе их детерминации и построение из них полюсов конструктов классов, при этом остальные кластеры включаются в конструкты в качестве промежуточных между полюсами;
- выявление факторов, наиболее сходных по детерминируемым ими классам и объединение их в кластеры;
- выявление кластеров факторов, наиболее сильно отличающиеся по детерминируемым ими классам и построение из них полюсов конструктов факторов, при этом остальные кластеры включаются в конструкты в качестве промежуточных между полюсами.

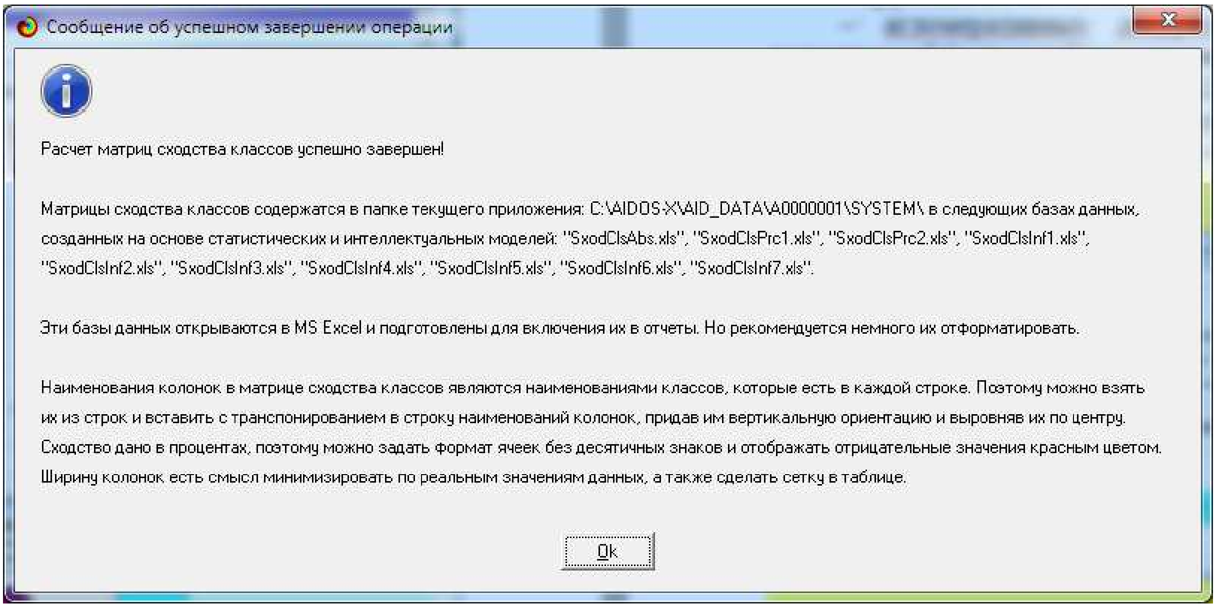
Состояния объекта управления, соответствующие классам, включенным в один кластер, могут быть достигнуты одновременно, т.е. являются совместимыми (коалиционными) по детерминирующим их факторам. Состояния объекта управления, соответствующие классам, образующим полюса конструкта, не могут быть достигнуты одновременно, т.е. являются противоположными по детерминирующим их факторам (антагонистическими).

Конструкт классов представляет собой систему противоположных, т.е. наиболее непохожих Друг на друга классов (которые называются полюсами конструкта) и спектр промежуточных классов, Распределенных между полюсами в соответствии со своим сходством-различием с ними.

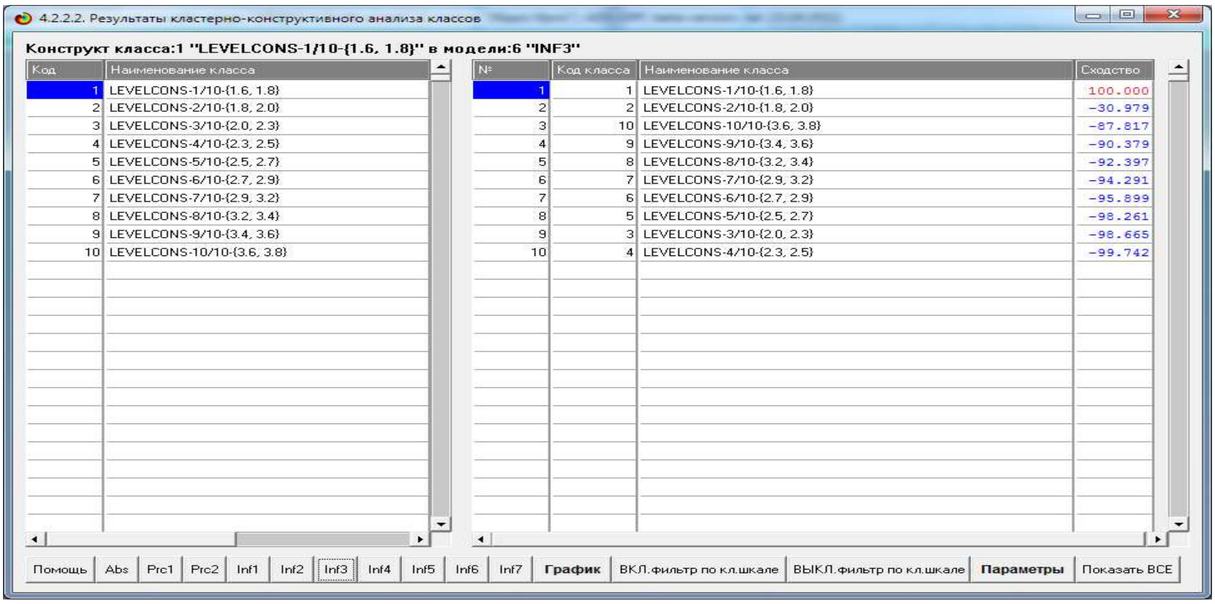
Факторы, включенные в один кластер, оказывают сходное влияние на поведение объекта управления и могут, при необходимости, быть использованы для замены друг друга. Факторы, образующие полюса конструкта, оказывают противоположное влияние на поведение объекта управления.

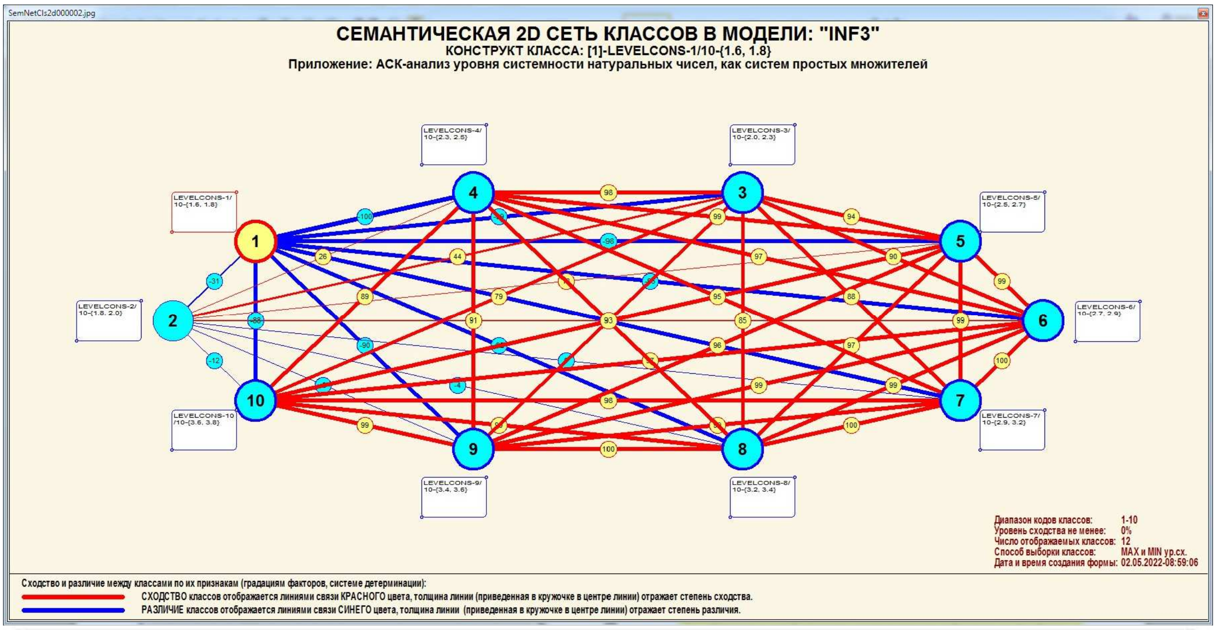
Кластерно-конструктивный анализ классов позволяет сравнить их по сходству системы детерминации и отобразить эту информацию в наглядной графической форме 2d семантической сети классов.

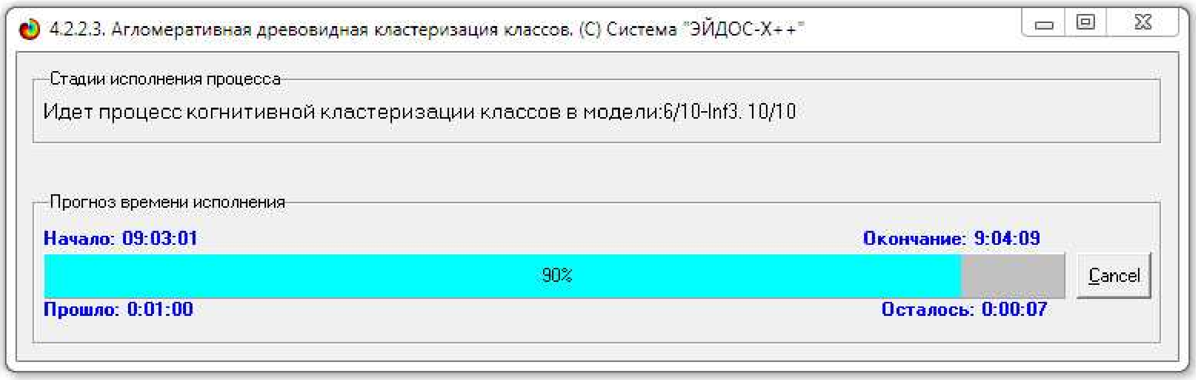
Кластерно-конструктивный анализ факторов позволяет сравнить факторы по сходству их влияния на переход объекта в будущие состояния и отобразить эту информацию в наглядной графической форме семантической сети факторов.

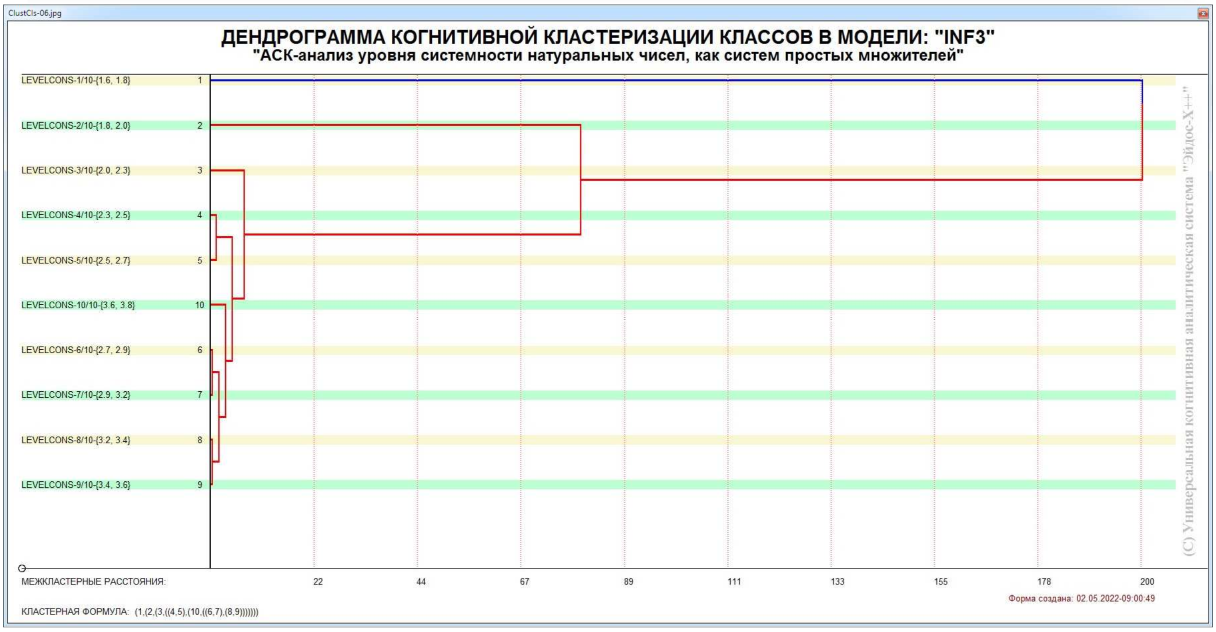


Код	Уровень системности	LEVELCONS-1/10-{1.6, 1.8}	LEVELCONS-2/10-{1.8, 2.0}	LEVELCONS-3/10-{2.0, 2.3}	LEVELCONS-4/10-{2.3, 2.5}	LEVELCONS-5/10-{2.5, 2.7}	LEVELCONS-6/10-{2.7, 2.9}	LEVELCONS-7/10-{2.9, 3.2}	LEVELCONS-8/10-{3.2, 3.4}	LEVELCONS-9/10-{3.4, 3.6}	LEVELCONS-10/10-{3.6, 3.8}
1	LEVELCONS-1/10-{1.6, 1.8}	100,000	-30,979	-98,665	-99,742	-98,261	-95,899	-94,291	-92,397	-90,379	-87,817
2	LEVELCONS-2/10-{1.8, 2.0}	-30,979	100,000	43,704	25,864	13,015	4,103	-0,040	-4,330	-8,003	-11,981
3	LEVELCONS-3/10-{2.0, 2.3}	-98,665	43,704	100,000	97,933	94,182	90,223	87,759	85,208	82,507	79,274
4	LEVELCONS-4/10-{2.3, 2.5}	-99,742	25,864	97,933	100,000	98,881	96,709	95,204	93,299	91,362	88,804
5	LEVELCONS-5/10-{2.5, 2.7}	-98,261	13,015	94,182	98,881	100,000	99,385	98,599	97,497	96,168	94,318
6	LEVELCONS-6/10-{2.7, 2.9}	-95,899	4,103	90,223	96,709	99,385	100,000	99,732	99,278	98,515	97,189
7	LEVELCONS-7/10-{2.9, 3.2}	-94,291	-0,040	87,759	95,204	98,599	99,732	100,000	99,708	99,135	98,371
8	LEVELCONS-8/10-{3.2, 3.4}	-92,397	-4,330	85,208	93,299	97,497	99,278	99,708	100,000	99,658	99,204
9	LEVELCONS-9/10-{3.4, 3.6}	-90,379	-8,003	82,507	91,362	96,168	98,515	99,135	99,658	100,000	99,308
10	LEVELCONS-10/10-{3.6, 3.8}	-87,817	-11,981	79,274	88,804	94,318	97,189	98,371	99,204	99,308	100,000




СЕМАНТИЧЕСКАЯ 2D СЕТЬ КЛАССОВ В МОДЕЛИ: "INF3"
КОНСТРУКТ КЛАССА: [1]-LEVELCONS-1/10-{1.6, 1.8}
Приложение: АСК-анализ уровня системности натуральных чисел, как систем простых множителей
Сходство и различие между классами по их признакам (градациям факторов, системе детерминации):
СХОДСТВО классов отображается линиями связи КРАСНОГО цвета, толщина линии (приведенная в кружочке в центре линии) отражает степень сходства.
РАЗЛИЧИЕ классов отображается линиями связи СИНЕГО цвета, толщина линии (приведенная в кружочке в центре линии) отражает степень различия.


4.2.2.3. Агломеративная древовидная кластеризация классов. (С) Система "ЭЙДОС-Х++"
Стадии исполнения процесса
Идет процесс когнитивной кластеризации классов в модели:6/10-Inf3. 10/10
Прогноз времени исполнения
Начало: 09:03:01
Окончание: 9:04:09
90%
Cancel
Прошло: 0:01:00
Осталось: 0:00:07


ДЕНДРОГРАММА КОГНИТИВНОЙ КЛАСТЕРИЗАЦИИ КЛАССОВ В МОДЕЛИ: "INF3"
"АСК-анализ уровня системности натуральных чисел, как систем простых множителей"
МЕЖКЛАСТЕРНЫЕ РАССТОЯНИЯ:
22
44
67
89
111
133
155
178
200
КЛАСТЕРНАЯ ФОРМУЛА: (1,(2,(3,((4,5),(10,((6,7),(8,9)))))))

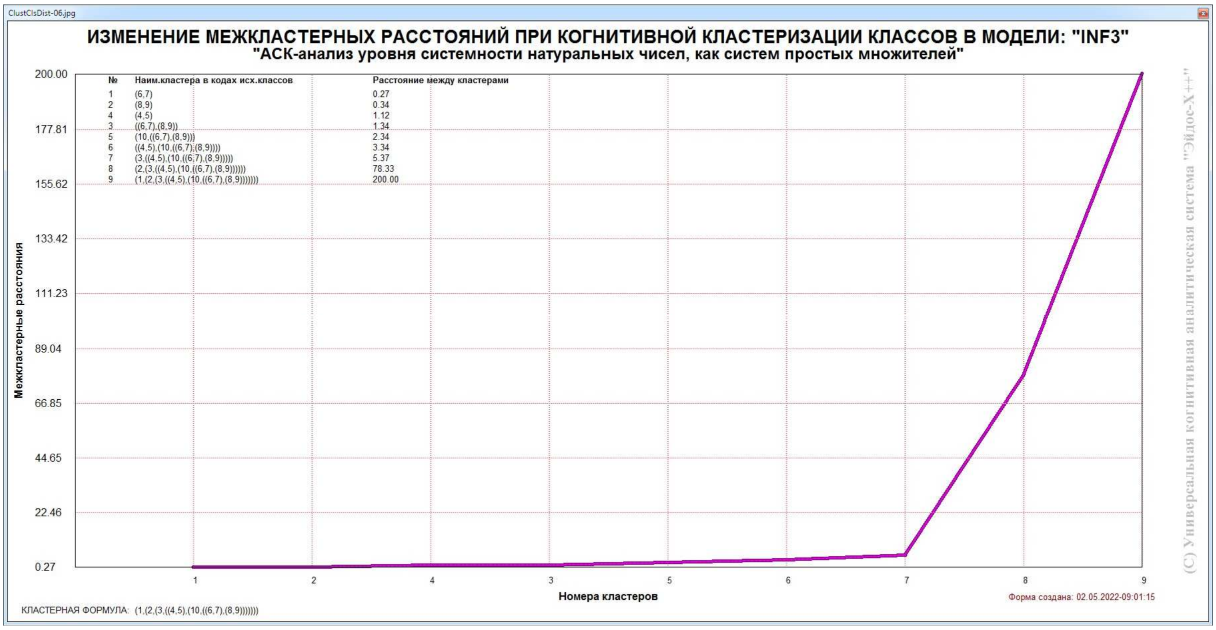


Figure 16. On-screen forms of subsystem 4.2.2: "Cluster-structural analysis of classes"

From the screen forms given in Figure 16, one can draw reasonable conclusions presented in the following algorithm:

1. *cycle start.* Natural numbers with the lowest level of systemicity, i.e. prime numbers, differ most significantly in their properties from other natural numbers.

2. *the body of the cycle.* If the numbers discussed in the preceding paragraph are excluded, then the natural numbers with the lowest level of systemicity of the remaining ones differ most significantly in their properties from other natural numbers.

3. *end of cycle.* Are all levels of systemicity of natural numbers considered? If yes, then exit, otherwise change to item 2.

3.8.3. Cluster-design analysis of descriptive scale values

In the "Eidos" system (in mode 4.3.2.1), a matrix of similarity of characteristics according to the system of their meaning is calculated and three main forms are calculated and displayed on the basis of this matrix:

- circular 2D cognitive diagram of features (mode 4.3.2.2);
- agglomerative dendrograms obtained as a result ***of cognitive (true) clustering of features*** (proposed by the author in 2011 in work [11]) (mode 4.3.2.3);
- diagram of change of inter-cluster distances (mode 4.3.2.3);
- 3D cognitive diagram of classes and features (mode 4.4.12).

In this work, these output forms were not calculated, since the number of gradations of descriptive scales (Table 5) is too large (6616) to be possible.

3.8.4. Eidos System Knowledge Model and Non-Local Neurons

The knowledge model of the Eidos system refers to ***fuzzy declarative*** hybrid models and combines some positive features of neural network and frame models of knowledge representation.

Classes in this model correspond to neurons and frames, and signs of receptors and spades (descriptive scales - slots).

The Eidos system model *differs from* the knowledge representation *frame model* in its effective and simple software implementation, obtained due to the fact that different frames differ from each other not by a set of slots and frames, but only by information in them. *Therefore, in the Aidos system, as the number of frames increases, the number of databases itself does not increase, but only their dimension increases*. This is a very important property of the models of the Eidos system, which significantly facilitates and simplifies software implementations.

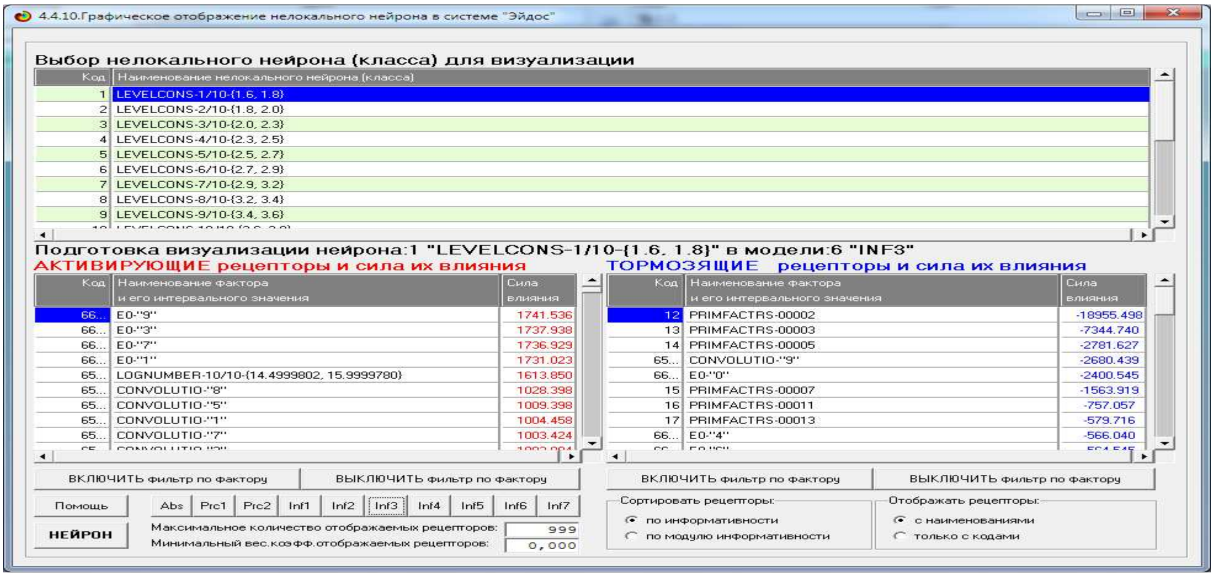
The model of the Eidos system differs *from the neural network model* of knowledge representation in that [12]:

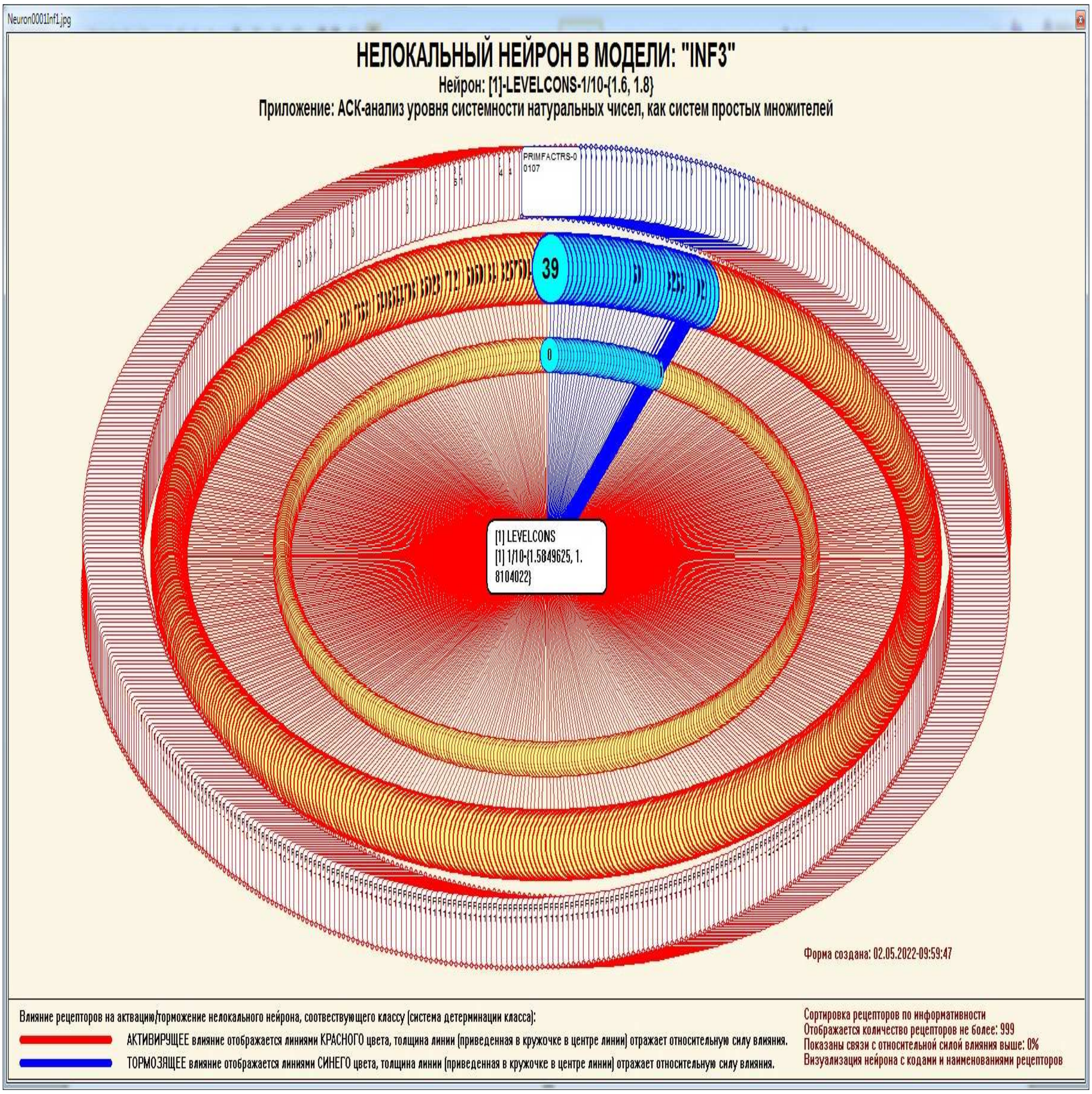
1) weight coefficients on receptors are not selected by the iterative method of reverse error propagation, but are calculated by the direct counting method on the basis of a well-theoretically justified model based on ***information theory*** (this resembles Bayesian networks);

2) weight coefficients have a well-theoretically justified ***meaningful interpretation*** based on information theory;

3) the neural network is ***non-local***, as they now say "fully connected."

In the Eidos system, non-local neurons are visualized (mode 4.4.10 of the Eidos system) in the form of special graphic forms in which the force and direction of the influence of neuron receptors on the degree of its activation/inhibition is displayed in the form of color and thickness of the dendrite (Figure 17). The number of receptors displayed in the diagram is set in the imaging parameters (Figure 17).


4.4.10.Графическое отображение нелокального нейрона в системе "Эйдос"
Выбор нелокального нейрона (класса) для визуализации
Код
Наименование нелокального нейрона (класса)
1 LEVELCONS-1/10-{1.6, 1.8}
2 LEVELCONS-2/10-{1.8, 2.0}
3 LEVELCONS-3/10-{2.0, 2.3}
4 LEVELCONS-4/10-{2.3, 2.5}
5 LEVELCONS-5/10-{2.5, 2.7}
6 LEVELCONS-6/10-{2.7, 2.9}
7 LEVELCONS-7/10-{2.9, 3.2}
8 LEVELCONS-8/10-{3.2, 3.4}
9 LEVELCONS-9/10-{3.4, 3.6}
Подготовка визуализации нейрона:1 "LEVELCONS-1/10-{1.6, 1.8}" в модели:6 "INF3"
АКТИВИРУЮЩИЕ рецепторы и сила их влияния
ТОРМОЗЯЩИЕ рецепторы и сила их влияния
Код
Наименование фактора и его интервального значения
Сила влияния
66... E0-"9" 1741.536
66... E0-"3" 1737.938
66... E0-"7" 1736.929
66... E0-"1" 1731.023
65... LOGNUMBER-10/10-{14.4999802, 15.9999780} 1613.850
65... CONVOLUTIO-"8" 1028.398
65... CONVOLUTIO-"5" 1009.398
65... CONVOLUTIO-"1" 1004.458
65... CONVOLUTIO-"7" 1003.424
12 PRIMFACTRS-00002 -18955.498
13 PRIMFACTRS-00003 -7344.740
14 PRIMFACTRS-00005 -2781.627
65... CONVOLUTIO-"9" -2680.439
66... E0-"0" -2400.545
15 PRIMFACTRS-00007 -1563.919
16 PRIMFACTRS-00011 -757.057
17 PRIMFACTRS-00013 -579.716
66... E0-"4" -566.040
ВКЛЮЧИТЬ фильтр по фактору
ВЫКЛЮЧИТЬ фильтр по фактору
Помощь
Abs Prc1 Prc2 Inf1 Inf2 Inf3 Inf4 Inf5 Inf6 Inf7
НЕЙРОН
Максимальное количество отображаемых рецепторов: 999
Минимальный вес.коэфф.отображаемых рецепторов: 0,000
Сортировать рецепторы:
по информативности
по модулю информативности
Отображать рецепторы:
с наименованиями
только с кодами


Neuron0001Inf1.jpg
НЕЛОКАЛЬНЫЙ НЕЙРОН В МОДЕЛИ: "INF3"
Нейрон: [1]-LEVELCONS-1/10-{1.6, 1.8}
Приложение: АСК-анализ уровня системности натуральных чисел, как систем простых множителей
39
0
[1] LEVELCONS
[1] 1/10-{1.5849625, 1.8104022}
Форма создана: 02.05.2022-09:59:47
Влияние рецепторов на активацию/торможение нелокального нейрона, соответствующего классу (система детерминации класса):
АКТИВИРУЩЕЕ влияние отображается линиями КРАСНОГО цвета, толщина линии (приведенная в кружочке в центре линии) отражает относительную силу влияния.
ТОРМОЗЯЩЕЕ влияние отображается линиями СИНЕГО цвета, толщина линии (приведенная в кружочке в центре линии) отражает относительную силу влияния.
Сортировка рецепторов по информативности
Отображается количество рецепторов не более: 999
Показаны связи с относительной силой влияния выше: 0%
Визуализация нейрона с кодами и наименованиями рецепторов

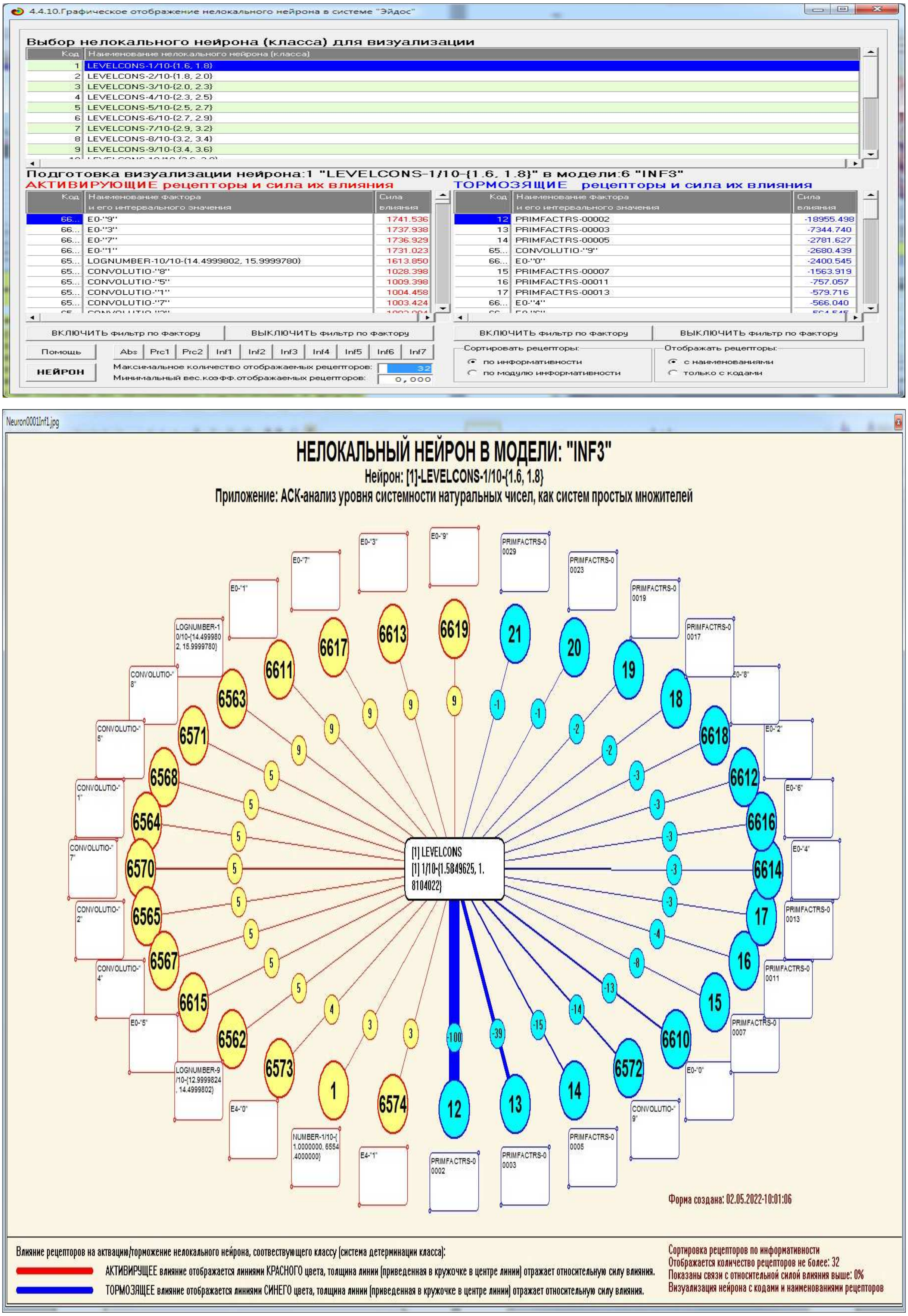


Figure 17. Screen forms of subsystem 4.4.8 of "Eidos" system

3.8.5. Non-local neural network

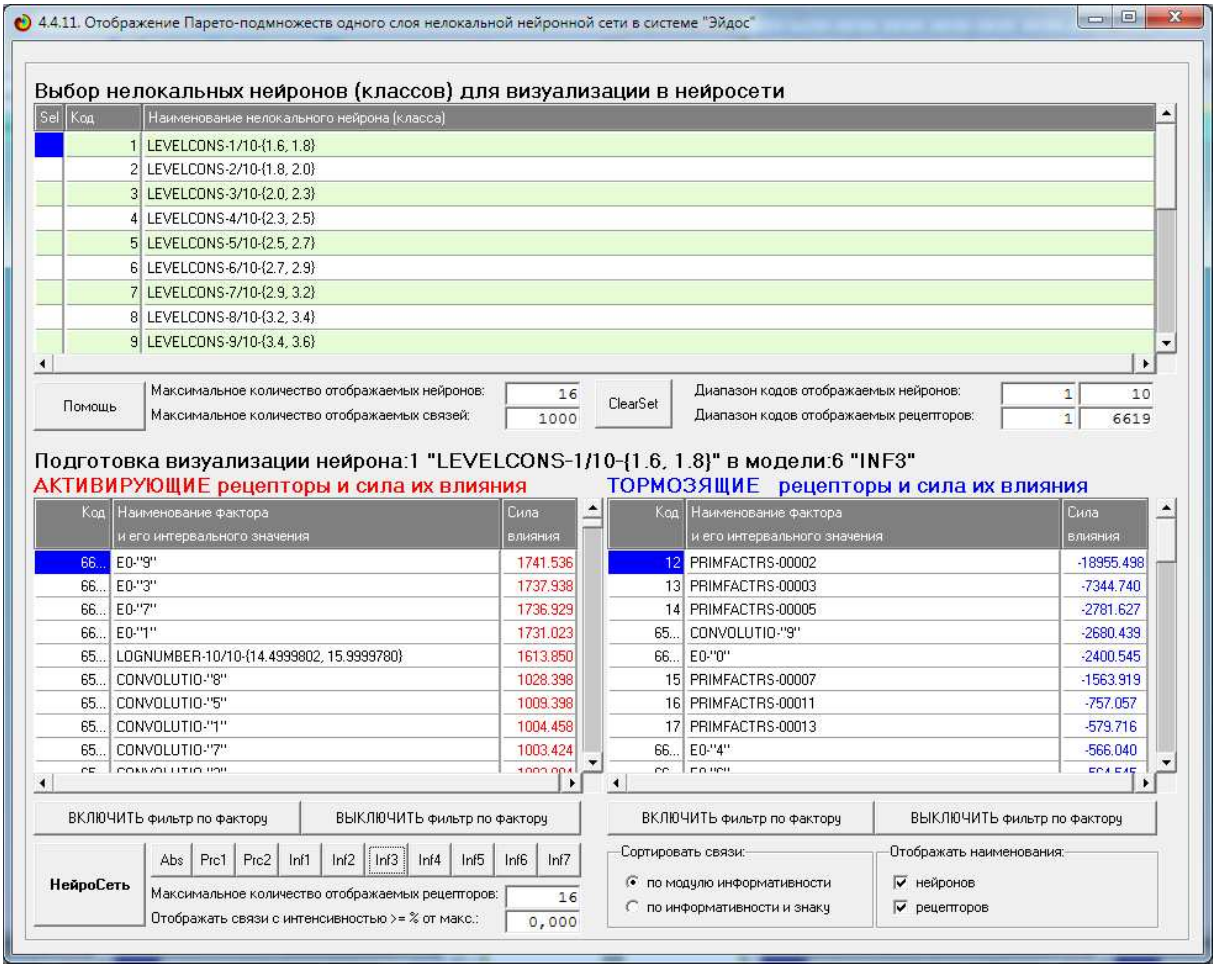
In the Eidos system, it is possible to build models corresponding to multilayer neural networks [12].

It is also possible to visualize any one layer of a non-local neural network (mode 4.4.11 of the Eidos system).

Such a layer clearly reflects the strength and direction of the effect of the receptors of a number of neurons on the degree of their activation/inhibition in the form of color and thickness of dendrites.

Neurons on the image of the layer of the neural network are located from left to right in descending order of the modulus of the total force of their determination by receptors, i.e. on the left are the results most strictly determined by the values of factors acting on them, and on the right are less rigidly determined.

Figures 18 show small fragments of one layer of the neural network at different visualization parameters (given in the lower right part of the graphic form) and the screen form for setting the values of its visualization parameters:



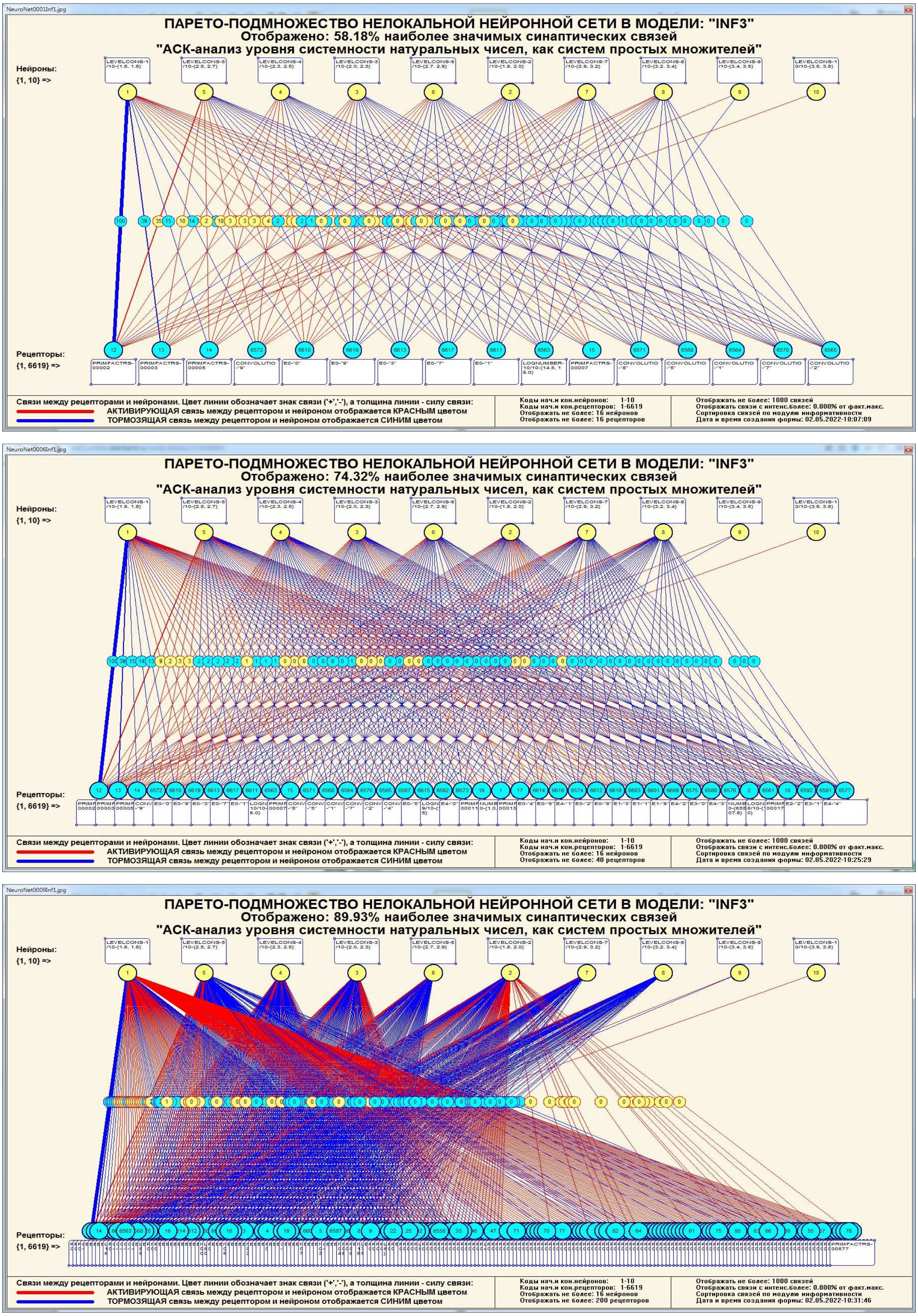


Figure 18. Screen forms of subsystem 4.4.11 of "Eidos" system

3.8.6. 3D Integral Cognitive Maps

3d-integral cognitive map is a display in one figure of cognitive diagrams of classes and values of factors at the top and bottom, respectively, and one layer of the neural network (mode 4.4.12 of the Eidos system).

In this work, the similarities of the factor values were not calculated, since the number of gradations of the descriptive scales (Table 5) is too large (6616) to be possible to do this. Therefore, 3D-integral cognitive maps were not formed.

3.8.7. 2D-integral cognitive maps of meaningful class comparison (mediated fuzzy plausible reasoning)

In 2D cognitive diagrams of class comparisons according to their determination system, one can see how similar or how different classes are from each other in terms of the values of the factors driving them.

However, we do not see from this diagram what exactly are similar and how exactly these classes differ in the values of the factors that determine them.

We can see this from the cognitive chart of the meaningful comparison of classes, which is displayed in mode 4.2.3 of the Eidos system.

2D-integral cognitive maps of meaningful class comparison are examples of mediated fuzzy plausible logical conclusions, about which Dierdi Poia may be the first to write [13]. For the first time about the automated implementation of this type of reasoning in the intelligent system "Eidos" was written in 2002 in the work [1] on page 521. [10]Later, this was written in the work [7] [11]and a number of other works of the author, so it is impractical to consider this issue in more detail.

<u>For example</u>, we know that one person has blue eyes and the other has black hair. Is it asked whether these traits contribute to the similarity or to the difference between the two people? In ASK analysis and the Eidos system, this issue is resolved in this way. In the model, based on cluster design analysis of classes and values of factors (features), it is known how similar or different certain features are or differ in their effect on the modeling object. Therefore, it is clear that a person with blue eyes is most likely blond, and a brunette most likely has dark eyes. So it is clear that these features contribute to the difference between the two people.

In this work, the similarities of the factor values were not calculated, since the number of gradations of the descriptive scales (Table 5) is too large (6616) to be possible to do this. Therefore, 2D-integral cognitive maps of

[10]https://www.elibrary.ru/download/elibrary_18632909_64818704.pdf, Table 7. 17, p. 521
[11]http://ej.kubagro.ru/2013/07/pdf/15.pdf, стр.44.

meaningful class comparison (mediated fuzzy plausible reasoning) were not formed.

3.8.8. 2D integral cognitive maps of meaningful comparison of factor values (mediated fuzzy plausible reasoning)

From 2D-cognitive diagrams of comparing the values of factors by their influence on the modeling object, i.e. on its transitions to states corresponding to classes, it is quite clear how similar or different any two values of factors are in their meaning.

Recall that the meaning, according to the Schenk-Abelson concept of meaning used in ASK analysis, is to know the causes and consequences [14]. However, this chart does not show exactly how the meanings of factors in their meaning are similar or different. This can be seen from cognitive diagrams that can be obtained in mode 4.3.3 of the Eidos system.

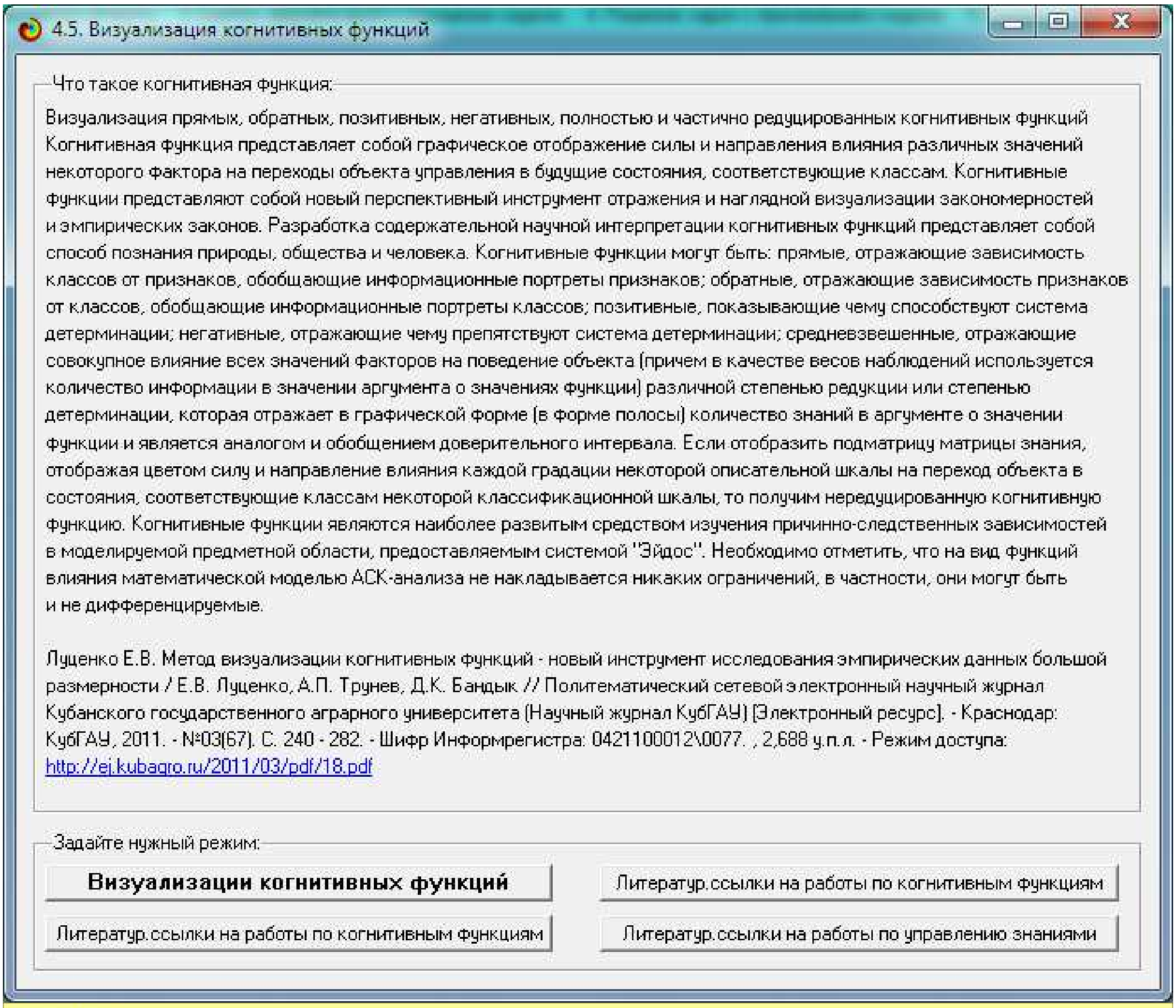
In this work, the similarities of the factor values were not calculated, since the number of gradations of the descriptive scales (Table 5) is too large (6616) to be possible to do this. Therefore, 2D-integral cognitive maps of meaningful comparison of factor values (mediated fuzzy plausible reasoning) were not formed.

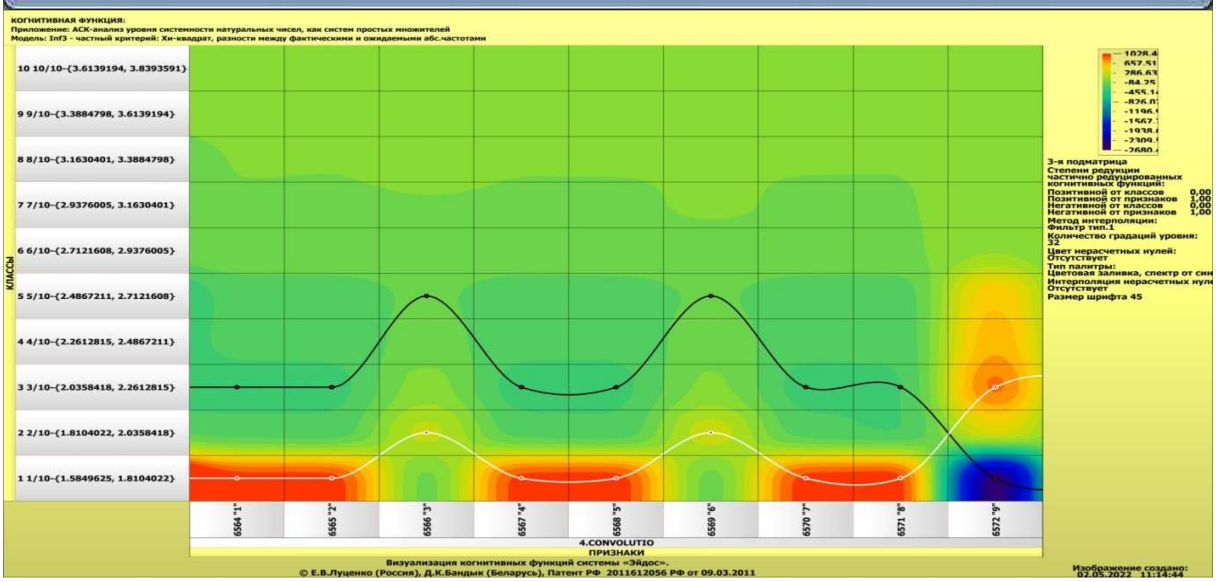
3.8.9. Cognitive functions

Cognitive functions are a generalization of the classical mathematical concept of function based on the system theory of information and were proposed by E.V. Lutsenko in 2005 [7, 15-22].

Cognitive functions display how much information is contained in the gradations of the descriptive scale about the transition of the modeling object to states corresponding to gradations of the classification scale. At the same time, statistical and system-cognitive models in each gradation of the descriptive scale contain information on all gradations of the classification scale, i.e***., all values of the function correspond to each value of the argument, but correspond to different degrees, both positive and negative, which is displayed in color***.

In the Eidos system, cognitive functions are displayed in mode 4.5 (Figures 19).


4.5. Визуализация когнитивных функций
Что такое когнитивная функция:
Визуализация прямых, обратных, позитивных, негативных, полностью и частично редуцированных когнитивных функций
Когнитивная функция представляет собой графическое отображение силы и направления влияния различных значений некоторого фактора на переходы объекта управления в будущие состояния, соответствующие классам. Когнитивные функции представляют собой новый перспективный инструмент отражения и наглядной визуализации закономерностей и эмпирических законов. Разработка содержательной научной интерпретации когнитивных функций представляет собой способ познания природы, общества и человека. Когнитивные функции могут быть: прямые, отражающие зависимость классов от признаков, обобщающие информационные портреты признаков; обратные, отражающие зависимость признаков от классов, обобщающие информационные портреты классов; позитивные, показывающие чему способствуют система детерминации; негативные, отражающие чему препятствуют система детерминации; средневзвешенные, отражающие совокупное влияние всех значений факторов на поведение объекта (причем в качестве весов наблюдений используется количество информации в значении аргумента о значениях функции) различной степенью редукции или степенью детерминации, которая отражает в графической форме (в форме полосы) количество знаний в аргументе о значении функции и является аналогом и обобщением доверительного интервала. Если отобразить подматрицу матрицы знания, отображая цветом силу и направление влияния каждой градации некоторой описательной шкалы на переход объекта в состояния, соответствующие классам некоторой классификационной шкалы, то получим нередуцированную когнитивную функцию. Когнитивные функции являются наиболее развитым средством изучения причинно-следственных зависимостей в моделируемой предметной области, предоставляемым системой "Эйдос". Необходимо отметить, что на вид функций влияния математической моделью АСК-анализа не накладывается никаких ограничений, в частности, они могут быть и не дифференцируемые.
Луценко Е.В. Метод визуализации когнитивных функций - новый инструмент исследования эмпирических данных большой размерности / Е.В. Луценко, А.П. Трунев, Д.К. Бандык // Политематический сетевой электронный научный журнал Кубанского государственного аграрного университета (Научный журнал КубГАУ) [Электронный ресурс]. - Краснодар: КубГАУ, 2011. - №03(67). С. 240 - 282. - Шифр Информрегистра: 0421100012\0077. , 2,688 у.п.л. - Режим доступа: http://ej.kubagro.ru/2011/03/pdf/18.pdf
Задайте нужный режим:
Визуализации когнитивных функций
Литератур.ссылки на работы по когнитивным функциям
Литератур.ссылки на работы по когнитивным функциям
Литератур.ссылки на работы по управлению знаниями


КОГНИТИВНАЯ ФУНКЦИЯ:
Приложение: АСК-анализ уровня системности натуральных чисел, как систем простых множителей
Модель: Inf3 - частный критерий: Хи-квадрат, разности между фактическими и ожидаемыми абс.частотами
КЛАССЫ
10 10/10-{3.6139194, 3.8393591}
9 9/10-{3.3884798, 3.6139194}
8 8/10-{3.1630401, 3.3884798}
7 7/10-{2.9376005, 3.1630401}
6 6/10-{2.7121608, 2.9376005}
5 5/10-{2.4867211, 2.7121608}
4 4/10-{2.2612815, 2.4867211}
3 3/10-{2.0358418, 2.2612815}
2 2/10-{1.8104022, 2.0358418}
1 1/10-{1.5849625, 1.8104022}
6564 "1"
6565 "2"
6566 "3"
6567 "4"
6568 "5"
6569 "6"
6570 "7"
6571 "8"
6572 "9"
4.CONVOLUTIO
ПРИЗНАКИ
3-я подматрица
Степени редукции частично редуцированных когнитивных функций:
Позитивной от классов 0,00
Позитивной от признаков 1,00
Негативной от классов 0,00
Негативной от признаков 1,00
Метод интерполяции: Фильтр тип.1
Количество градаций уровня: 32
Цвет нерасчетных нулей: Отсутствует
Тип палитры:
Интерполяция нерасчетных нулей
Отсутствует
Размер шрифта 45
Визуализация когнитивных функций системы «Эйдос».
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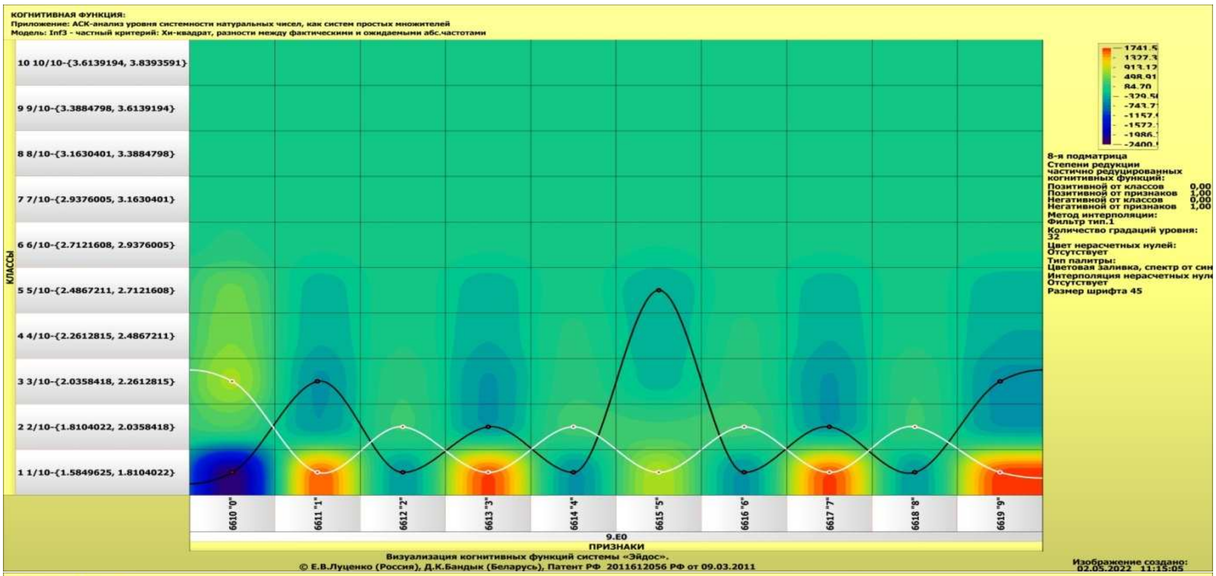
Изображение создано: 02.05.2022 11:14:44


КОГНИТИВНАЯ ФУНКЦИЯ:
Приложение: АСК-анализ уровня системности натуральных чисел, как систем простых множителей
Модель: Inf3 - частный критерий: Хи-квадрат, разности между фактическими и ожидаемыми абс.частотами
10 10/10-{3.6139194, 3.8393591}
9 9/10-{3.3884798, 3.6139194}
8 8/10-{3.1630401, 3.3884798}
7 7/10-{2.9376005, 3.1630401}
6 6/10-{2.7121608, 2.9376005}
5 5/10-{2.4867211, 2.7121608}
4 4/10-{2.2612815, 2.4867211}
3 3/10-{2.0358418, 2.2612815}
2 2/10-{1.8104022, 2.0358418}
1 1/10-{1.5849625, 1.8104022}
КЛАССЫ
9.EO
ПРИЗНАКИ
Визуализация когнитивных функций системы «Эйдос».
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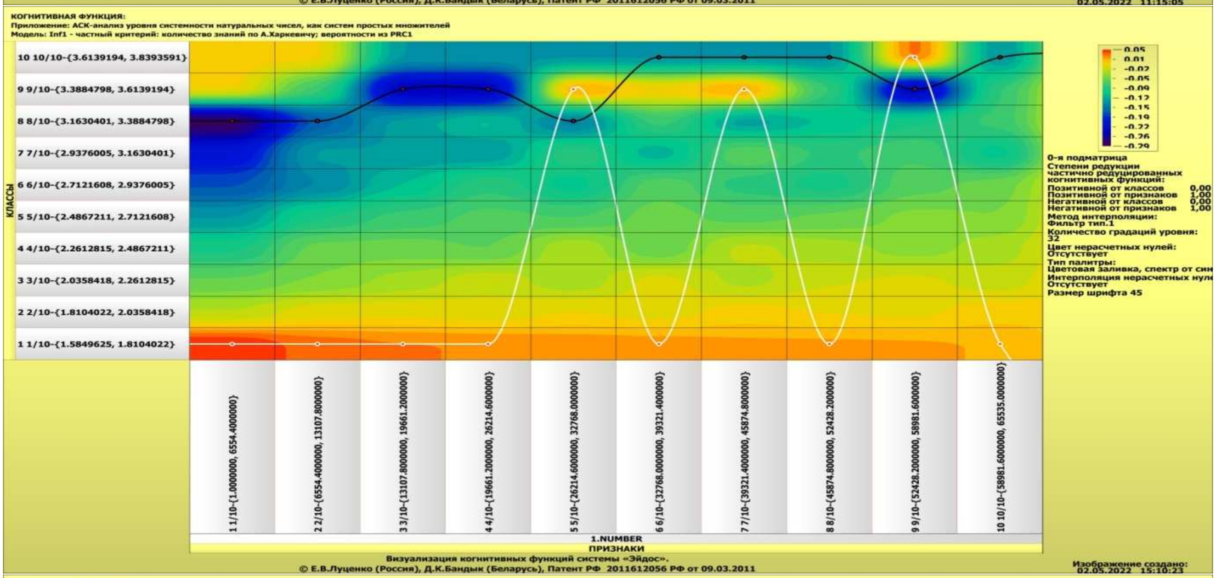
КОГНИТИВНАЯ ФУНКЦИЯ:
Модель: Inf1 - частный критерий: количество знаний по А.Харкевичу; вероятности из PRC1
КЛАССЫ
1.NUMBER
ПРИЗНАКИ
Визуализация когнитивных функций системы «Эйдос».
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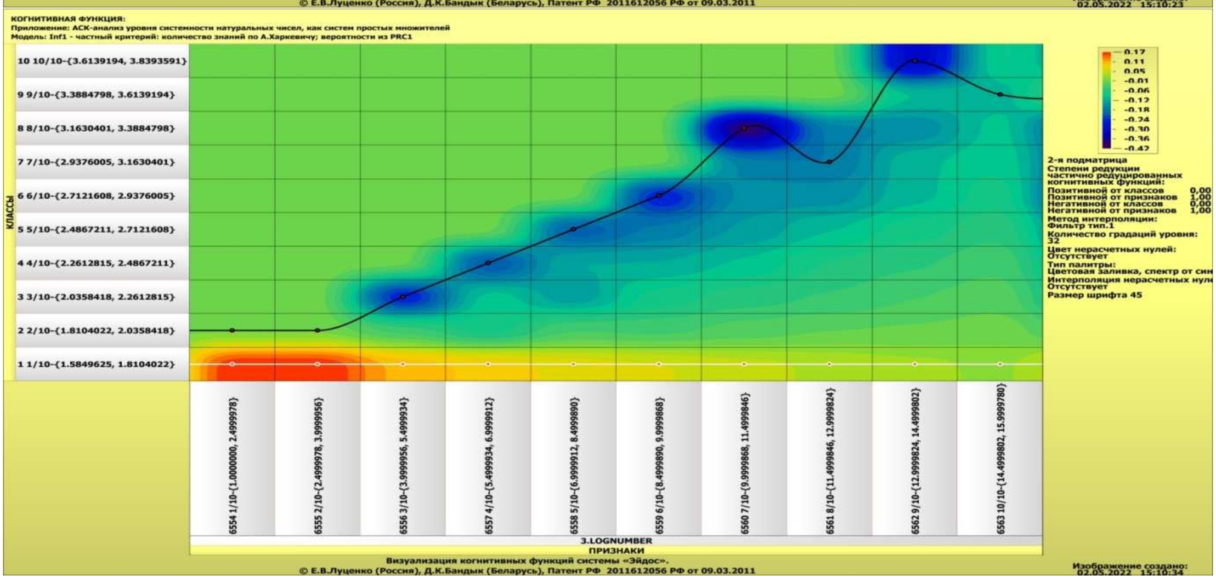
КОГНИТИВНАЯ ФУНКЦИЯ:
Модель: Inf1 - частный критерий: количество знаний по А.Харкевичу; вероятности из PRC1
КЛАССЫ
3.LOGNUMBER
ПРИЗНАКИ
Визуализация когнитивных функций системы «Эйдос».
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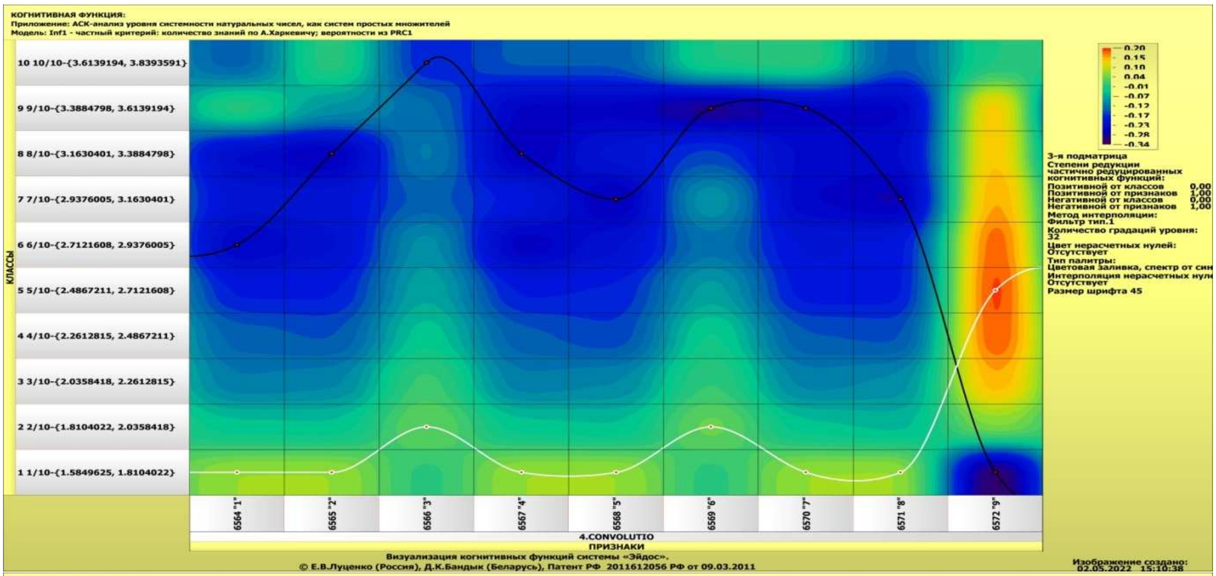
КОГНИТИВНАЯ ФУНКЦИЯ:
Приложение: АСК-анализ уровня системности натуральных чисел, как систем простых множителей
Модель: Inf1 - частный критерий: количество знаний по А.Харкевичу; вероятности из PRC1
10 10/10-{3.6139194, 3.8393591}
9 9/10-{3.3884798, 3.6139194}
8 8/10-{3.1630401, 3.3884798}
7 7/10-{2.9376005, 3.1630401}
6 6/10-{2.7121608, 2.9376005}
5 5/10-{2.4867211, 2.7121608}
4 4/10-{2.2612815, 2.4867211}
3 3/10-{2.0358418, 2.2612815}
2 2/10-{1.8104022, 2.0358418}
1 1/10-{1.5849625, 1.8104022}
КЛАССЫ
6564 "1"
6565 "2"
6566 "3"
6567 "4"
6568 "5"
6569 "6"
6570 "7"
6571 "8"
6572 "9"
4.CONVOLUTIO
ПРИЗНАКИ
3-я подматрица
Визуализация когнитивных функций системы «Эйдос».
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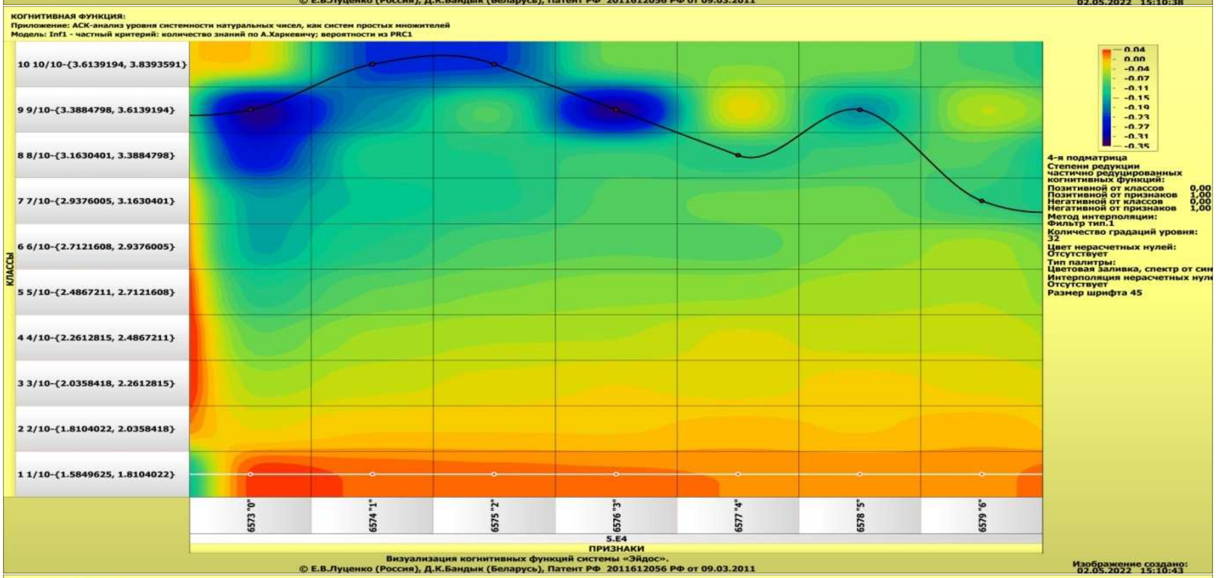
КОГНИТИВНАЯ ФУНКЦИЯ:
Приложение: АСК-анализ уровня системности натуральных чисел, как систем простых множителей
Модель: Inf1 - частный критерий: количество знаний по А.Харкевичу; вероятности из PRC1
10 10/10-{3.6139194, 3.8393591}
9 9/10-{3.3884798, 3.6139194}
8 8/10-{3.1630401, 3.3884798}
7 7/10-{2.9376005, 3.1630401}
6 6/10-{2.7121608, 2.9376005}
5 5/10-{2.4867211, 2.7121608}
4 4/10-{2.2612815, 2.4867211}
3 3/10-{2.0358418, 2.2612815}
2 2/10-{1.8104022, 2.0358418}
1 1/10-{1.5849625, 1.8104022}
КЛАССЫ
6573 "0"
6574 "1"
6575 "2"
6576 "3"
6577 "4"
6578 "5"
6579 "6"
5.E4
ПРИЗНАКИ
4-я подматрица
Визуализация когнитивных функций системы «Эйдос».
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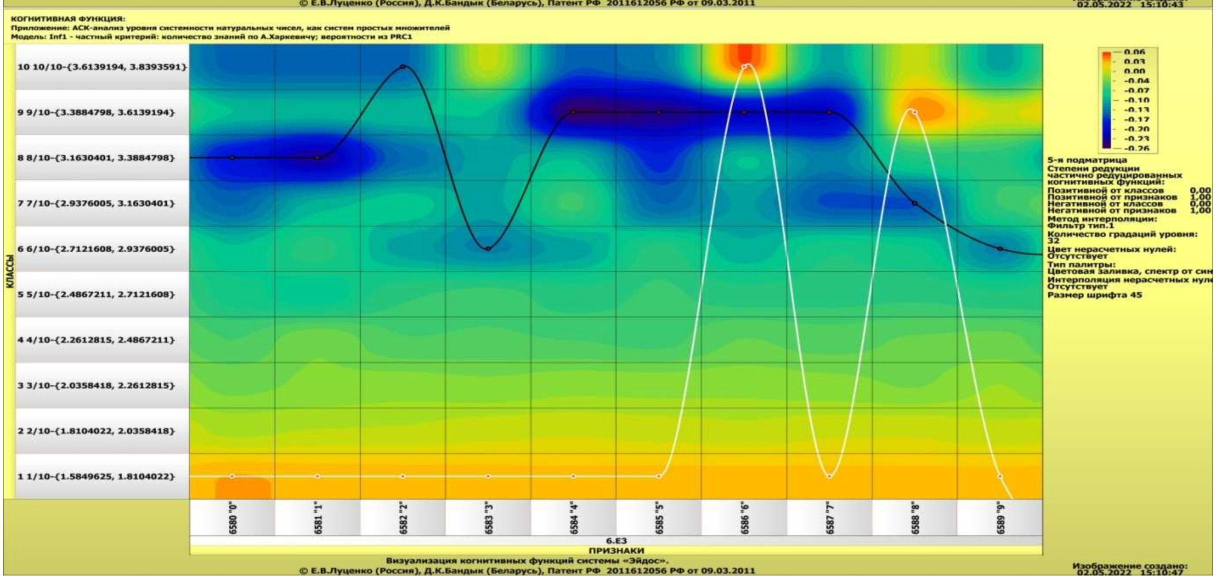
КОГНИТИВНАЯ ФУНКЦИЯ:
Приложение: АСК-анализ уровня системности натуральных чисел, как систем простых множителей
Модель: Inf1 - частный критерий: количество знаний по А.Харкевичу; вероятности из PRC1
10 10/10-{3.6139194, 3.8393591}
9 9/10-{3.3884798, 3.6139194}
8 8/10-{3.1630401, 3.3884798}
7 7/10-{2.9376005, 3.1630401}
6 6/10-{2.7121608, 2.9376005}
5 5/10-{2.4867211, 2.7121608}
4 4/10-{2.2612815, 2.4867211}
3 3/10-{2.0358418, 2.2612815}
2 2/10-{1.8104022, 2.0358418}
1 1/10-{1.5849625, 1.8104022}
КЛАССЫ
6580 "0"
6581 "1"
6582 "2"
6583 "3"
6584 "4"
6585 "5"
6586 "6"
6587 "7"
6588 "8"
6589 "9"
6.E3
ПРИЗНАКИ
5-я подматрица
Визуализация когнитивных функций системы «Эйдос».
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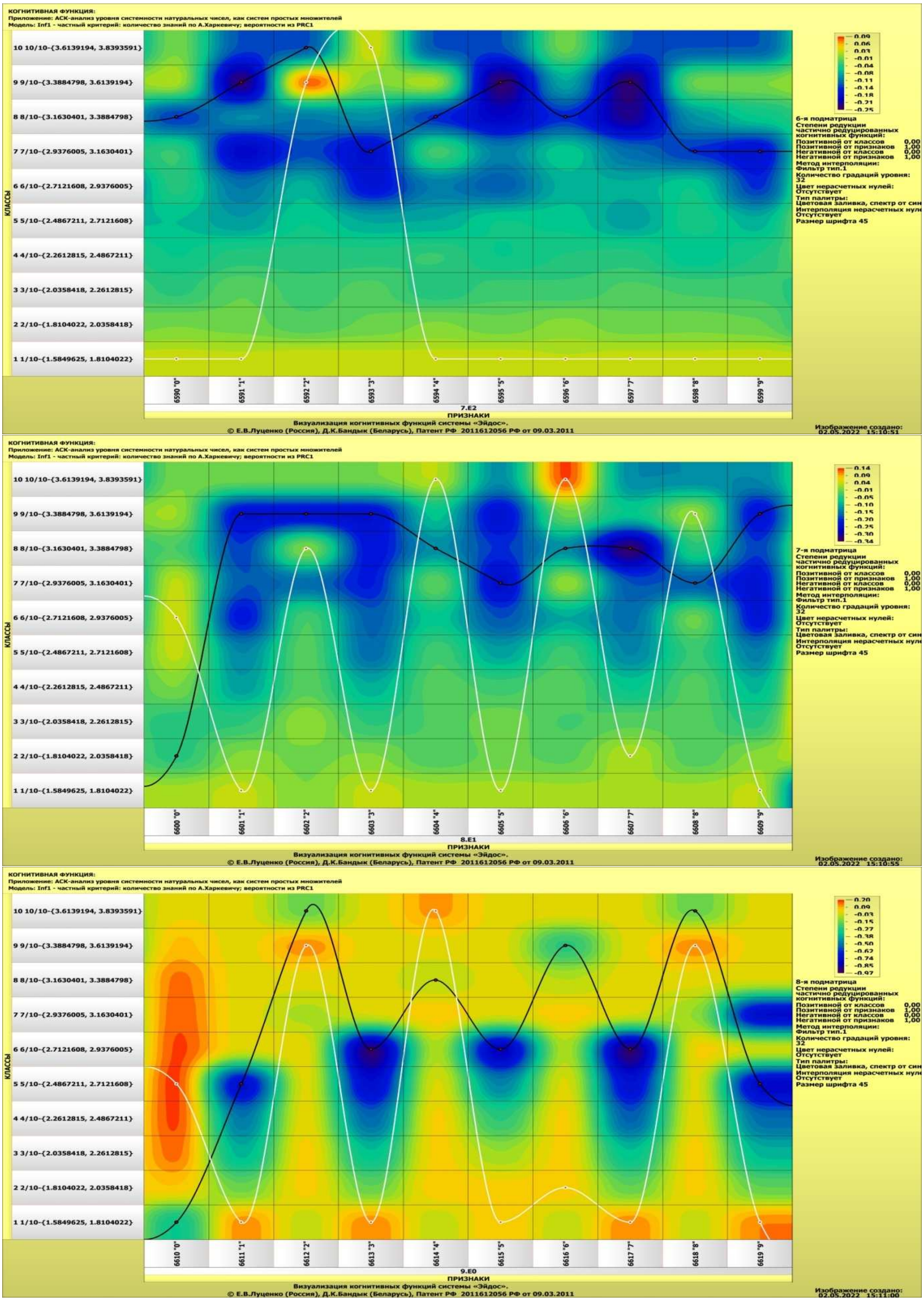

Figure 19. Screen forms of mode 4.5 of the "Eidos" system: some Cognitive functions in models INF3 and INF1

Among the cognitive functions given, there are interesting patterns in the simulated subject area. But a meaningful interpretation of these laws is the business of experts in the field of number theory.

3.8.10. Significance of descriptive scales and their gradations

In the ASK analysis, all factors are considered from one single point of view: how much information is contained in their values about the transition of the modeling and control object on which they act to a certain future state described by the class (classification scale gradation), and at the same time the force and direction of influence of all values of factors on the object is measured in the same units of measurement common to all factors: units of information quantity [6].

The significance (selective strength) of gradations of descriptive scales in ASK analysis is the variability of private criteria in statistical and system-cognitive models, for example, in the Inf1 model, this is the variability of information properties (mode 3.7.5 of the Eidos system).

The significance of the entire descriptive scale is the average of the significance of its gradations (mode 3.7.4 of the Eidos system).

If you sort all the gradations of factors (features) in descending order of the selective force and obtain the sum of the selective force of the system of factor values by the cumulative result, then we get the Pareto-curve shown in Figure 20.

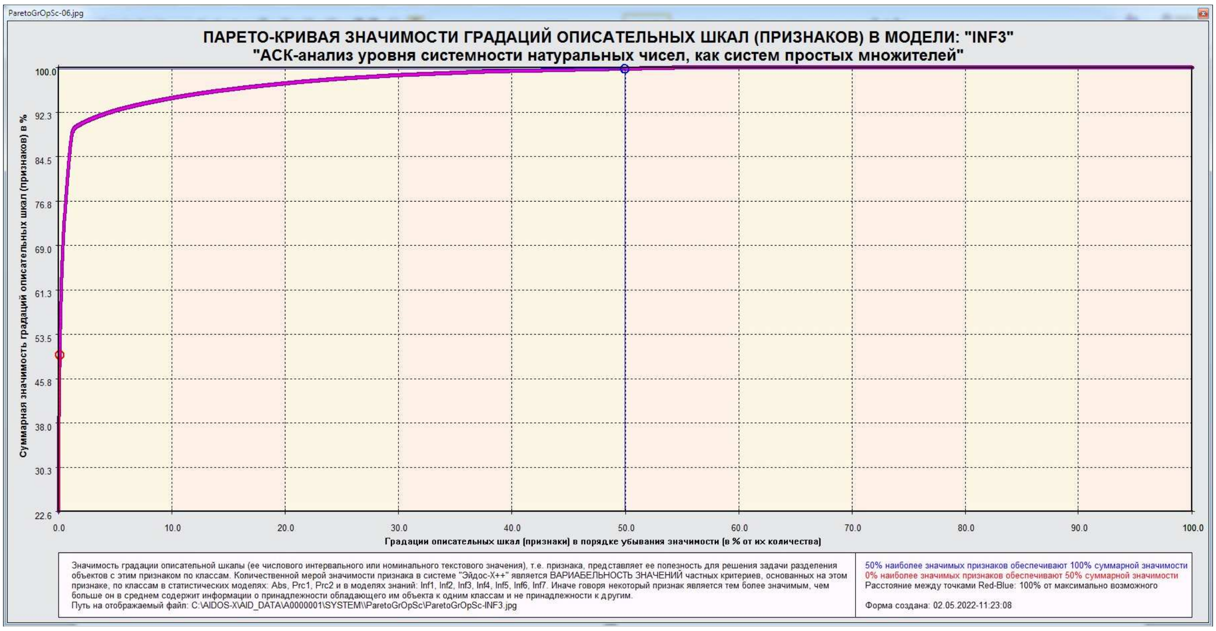

Figure 20. Significance of the cumulative factor values: mode 3.75 of "Eidos" system

The names of Excel tables with information, on the basis of which Figure 20 is built, are given in Figure 21:

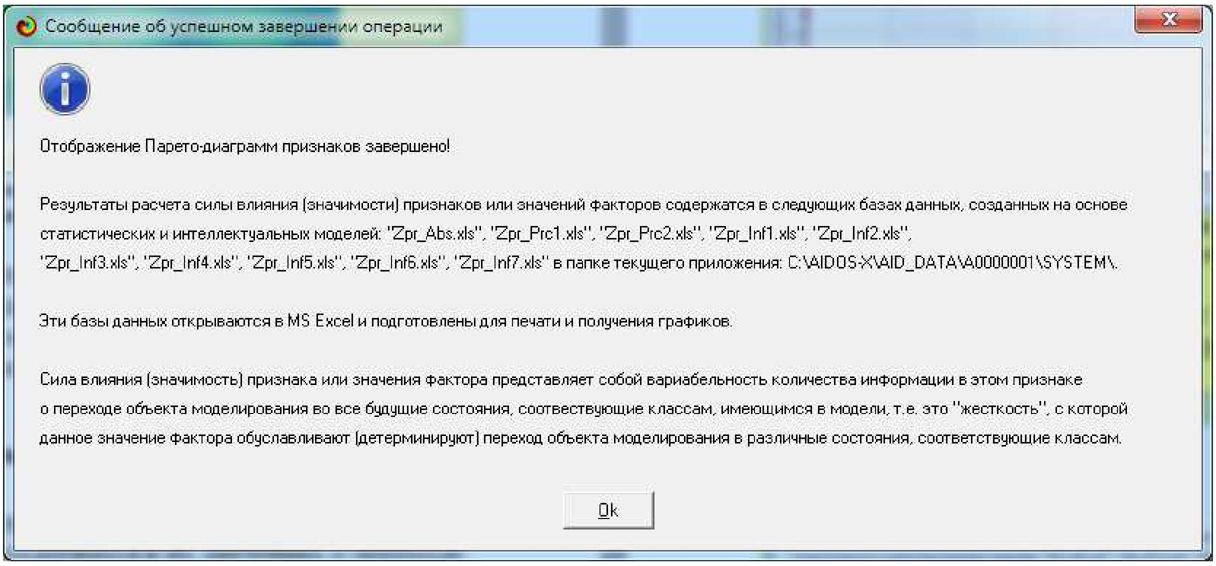

Figure 21. Names of Excel tables with information, on the basis of which Figure 25 is built

Table 13 provides information on the value of the property values of natural numbers to determine their levels of systemicity as a cumulative result:

Table 13- Value of property values of natural numbers in model INF3 (fragment)

№	№%	Factor Value Code	Name of factor value	Factor Code	Significance of factor value,%	Significance of factor value,% cumulative
1	0,015	12	PRIMFACTRS-00002	2	22,551	22,551
2	0,030	13	PRIMFACTRS-00003	2	8,690	31,240
3	0,045	14	PRIMFACTRS-00005	2	3,324	34,564
4	0,060	6572	CONVOLUTIO-"9"	4	3,182	37,746
5	0,076	6610	E0-"0"	9	2,851	40,598
6	0,091	6619	E0-"9"	9	2,066	42,664
7	0,106	6613	E0-"3"	9	2,061	44,725
8	0,121	6617	E0-"7"	9	2,060	46,785
9	0,136	6611	E0-"1"	9	2,053	48,838
10	**0,151**	**6563**	**LOGNUMBER-10/10-{14.4999802, 15.9999780}**	**3**	**1,902**	**50,740**
11	0,166	15	PRIMFACTRS-00007	2	1,888	52,628
12	0,181	6571	CONVOLUTIO-"8"	4	1,211	53,839
13	0,196	6568	CONVOLUTIO-"5"	4	1,189	55,028
14	0,212	6564	CONVOLUTIO-"1"	4	1,185	56,213
15	0,227	6570	CONVOLUTIO-"7"	4	1,183	57,396
16	0,242	6565	CONVOLUTIO-"2"	4	1,182	58,577
17	0,257	6567	CONVOLUTIO-"4"	4	1,178	59,755
18	0,272	6615	E0-"5"	9	1,111	60,867
19	0,287	6562	LOGNUMBER-9/10-{12.9999824, 14.4999802}	3	1,000	61,867
20	0,302	6573	E4-"0"	5	0,992	62,859
21	0,317	16	PRIMFACTRS-00011	2	0,934	63,793
22	0,332	17	PRIMFACTRS-00013	2	0,721	64,514
23	0,347	1	NUMBER-1/10-{1.0000000, 6554.4000000}	1	0,721	65,235
24	0,363	6614	E0-"4"	9	0,708	65,943

25	0,378	6616	E0-"6"	9	0,707	66,650
26	0,393	6612	E0-"2"	9	0,683	67,334
27	0,408	6618	E0-"8"	9	0,674	68,008
28	0,423	6574	E4-"1"	5	0,660	68,667
29	0,438	6603	E1-"3"	8	0,616	69,283
30	0,453	6601	E1-"1"	8	0,597	69,880
31	0,468	6609	E1-"9"	8	0,597	70,477
32	0,483	6575	E4-"2"	5	0,559	71,036
33	0,499	6580	E3-"0"	6	0,497	71,534
34	0,514	6576	E4-"3"	5	0,493	72,027
35	0,529	2	NUMBER-2/10-{6554.4000000, 13107.8000000}	1	0,493	72,520
36	0,544	18	PRIMFACTRS-00017	2	0,481	73,000
37	0,559	6561	LOGNUMBER-8/10-{11.4999846, 12.9999824}	3	0,467	73,467
38	0,574	6600	E1-"0"	8	0,452	73,919
39	0,589	6577	E4-"4"	5	0,430	74,349
40	0,604	6592	E2-"2"	7	0,430	74,779
41	0,619	6581	E3-"1"	6	0,429	75,208
42	0,635	3	NUMBER-3/10-{13107.8000000, 19661.2000000}	1	0,417	75,625
43	0,650	6578	E4-"5"	5	0,413	76,038
44	0,665	6582	E3-"2"	6	0,410	76,448
45	0,680	6599	E2-"9"	7	0,404	76,852
46	0,695	19	PRIMFACTRS-00019	2	0,397	77,249
47	0,710	6595	E2-"5"	7	0,395	77,644
48	0,725	6590	E2-"0"	7	0,391	78,035
49	0,740	6583	E3-"3"	6	0,388	78,422
50	0,755	4	NUMBER-4/10-{19661.2000000, 26214.6000000}	1	0,386	78,808
51	0,771	6593	E2-"3"	7	0,383	79,191
52	0,786	6594	E2-"4"	7	0,378	79,569
53	0,801	6607	E1-"7"	8	0,377	79,946
54	0,816	6584	E3-"4"	6	0,371	80,317
55	0,831	6597	E2-"7"	7	0,369	80,686
56	0,846	6569	CONVOLUTIO-"6"	4	0,364	81,050
57	0,861	6585	E3-"5"	6	0,364	81,414
58	0,876	6598	E2-"8"	7	0,362	81,776
59	0,891	6604	E1-"4"	8	0,362	82,138
60	0,906	6605	E1-"5"	8	0,358	82,496
61	0,922	6591	E2-"1"	7	0,348	82,844
62	0,937	5	NUMBER-5/10-{26214.6000000, 32768.0000000}	1	0,347	83,191
63	0,952	6608	E1-"8"	8	0,346	83,536
64	0,967	6566	CONVOLUTIO-"3"	4	0,339	83,875
65	0,982	6606	E1-"6"	8	0,333	84,208
66	0,997	6586	E3-"6"	6	0,328	84,537
67	1,012	6587	E3-"7"	6	0,325	84,861
68	1,027	6	NUMBER-6/10-{32768.0000000, 39321.4000000}	1	0,324	85,185
69	1,042	6588	E3-"8"	6	0,322	85,507
70	1,058	6589	E3-"9"	6	0,316	85,823
71	1,073	6596	E2-"6"	7	0,314	86,137
72	1,088	20	PRIMFACTRS-00023	2	0,310	86,447
73	1,103	7	NUMBER-7/10-{39321.4000000, 45874.8000000}	1	0,288	86,735
74	1,118	8	NUMBER-8/10-{45874.8000000, 52428.2000000}	1	0,279	87,014
75	1,133	9	NUMBER-9/10-{52428.2000000, 58981.6000000}	1	0,269	87,283
76	1,148	10	NUMBER-10/10-{58981.6000000, 65535.0000000}	1	0,240	87,523
77	1,163	6560	LOGNUMBER-7/10-{9.9999868, 11.4999846}	3	0,213	87,735
78	1,178	21	PRIMFACTRS-00029	2	0,206	87,941
79	1,194	6579	E4-"6"	5	0,205	88,146
***	***	***	***	***	***	***
3307	49,962	3243	PRIMFACTRS-29837	2	0,001	99,829
3308	49,977	3244	PRIMFACTRS-29851	2	0,001	99,829
3309	49,992	3245	PRIMFACTRS-29863	2	0,001	99,830
3310	50,008	3246	PRIMFACTRS-29867	2	0,001	99,830
3311	50,023	3247	PRIMFACTRS-29873	2	0,001	99,831
3312	50,038	3248	PRIMFACTRS-29879	2	0,001	99,832
3313	50,053	3249	PRIMFACTRS-29881	2	0,001	99,832

From Figure 20 and Table 13, we see that only 0.151% of the factor values provide 50% of their total significance, and 50% of the factor values provide almost 99.830% of the total significance.

Figure 22 shows a screen form with the names of Excel tables containing information on the significance of climatic factors for forecasting in different models. Table 14 shows such a table in model INF3.

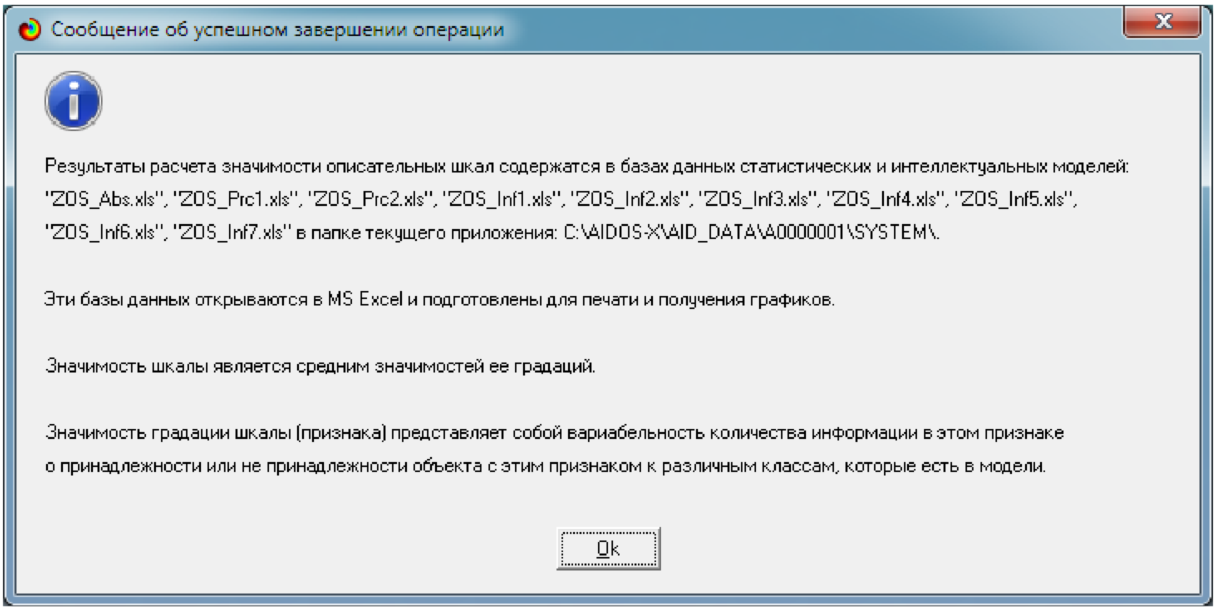

Figure 22. Names of Excel tables with information on the significance of climatic factors

Table 14- Value of properties of natural numbers for quantification of their level of systemicity in INF3 model

№	№%	Code	Factor name	Significance,%	Significance, %, cumulative
1	11,111	9	E0	28,914	28,914
2	22,222	4	CONVOLUTIO	23,624	52,538
3	33,333	5	E4	10,350	62,888
4	44,444	8	E1	7,943	70,831
5	55,556	7	E2	7,284	78,115
6	66,667	1	NUMBER	7,265	85,380
7	77,778	6	E3	7,240	92,620
8	88,889	3	LOGNUMBER	7,229	99,849
9	100,000	2	PRIMFACTRS	0,151	100,000

From Table 14 and the graph based on it in Figure 23, we see that the following climatic factors are most valuable for quantifying the level of systemicity of natural numbers:

- E0;
- CONVOLUTIO;
- E4.

And the least significant:

- E1;
- E2;
- NUMBER;
- E3;
- LOGNUMBER;
- PRIMFACTRS.

The significance of the most and least significant climatic indicators differs by about 191 times, which is very, very significant.

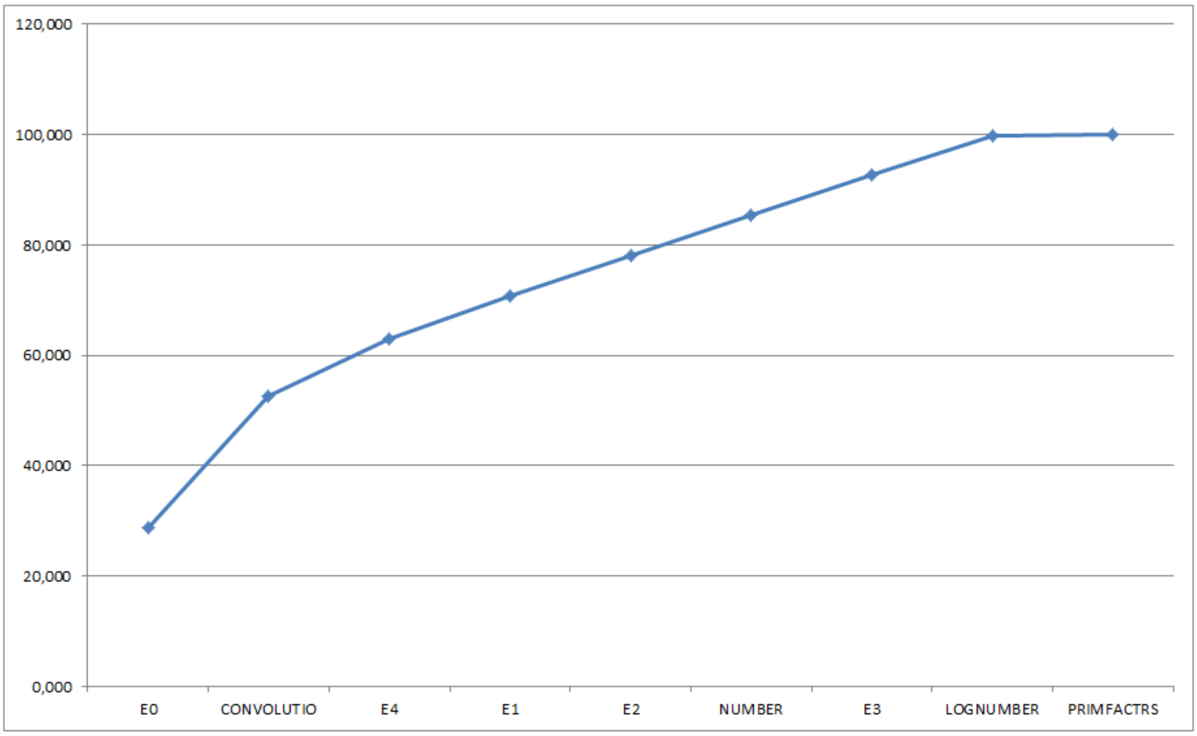

Figure 23. The value of the properties of natural numbers for quantifying their level of systemicity in the INF3 model

3.8.11. Degree of Determinity of Classification Scale Classes

The degree of determinicity (conditionality) of the class in the Eidos system is quantified by the ***degree of variability of the values of factors*** (gradations of descriptive scales) in the column of the model matrix corresponding to this class.

The higher the degree of determinicity of the class, the more reliably it is predicted by the values of factors.

The degree of determinity (conditionality) of the entire classification scale is the average of the degree of determinicity of its gradations, i.e. classes (mode 3.7.2 of the Eidos system).

If you sort all classes in descending order of the selective force and get the sum of the selective force of the class system by the cumulative total (cumulatively), then we get the Pareto curve shown in Figure 24.

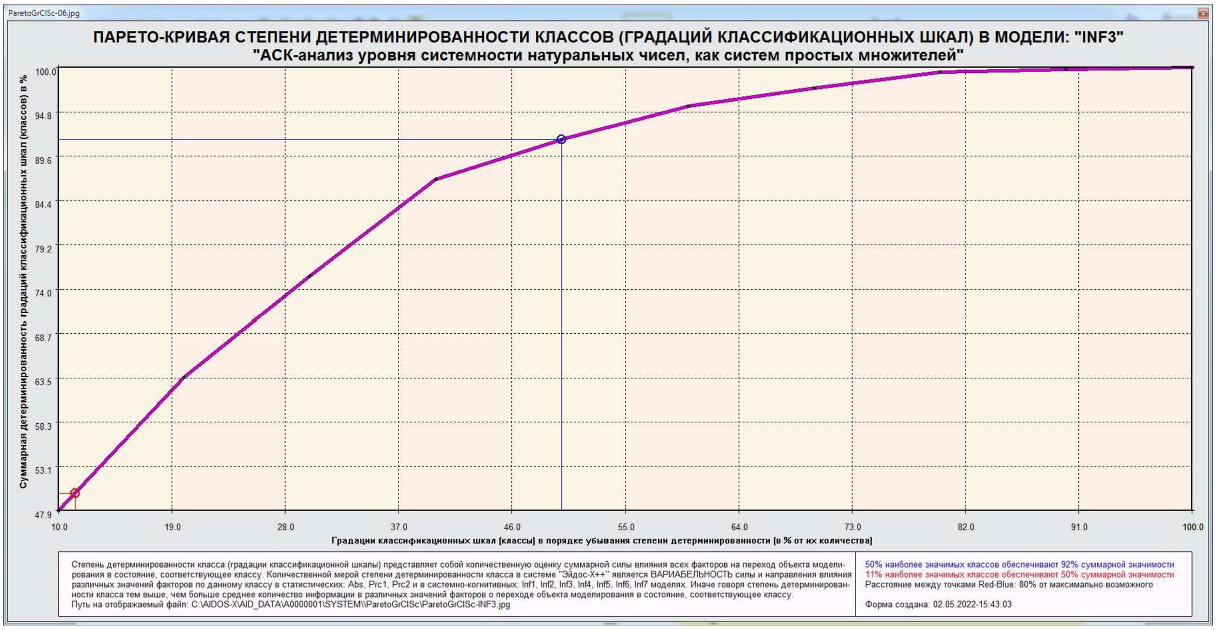

Figure 24. The degree of determinity of classes with a cumulative result: mode 3.73 of "Eidos" system

The names of Excel tables with information, on the basis of which Figure 24 is built, are given in Figure 35:

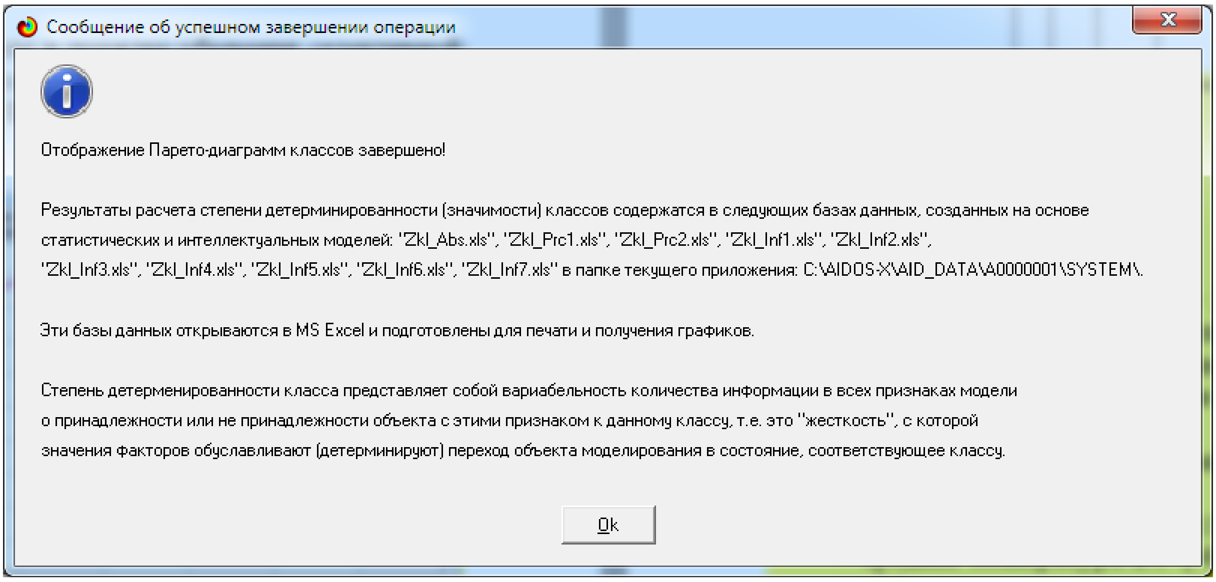

Figure 25. Names of Excel tables with information, on the basis of which Figure 29 is built

Table 15 shows information on degree of determinity of classes corresponding to future values of climatic indicators values, cumulative total:

Table 15- Degree of Class Determinity in INF3 Model

№	№%	Class Code	Class name	Degree of determinity ,%	Degree of determinity ,%, cumulative
1	10,000	1	LEVELCONS-1/10-{1.6, 1.8}	47,900	47,900
2	20,000	5	LEVELCONS-5/10-{2.5, 2.7}	15,684	63,584
3	30,000	4	LEVELCONS-4/10-{2.3, 2.5}	11,956	75,540
4	40,000	3	LEVELCONS-3/10-{2.0, 2.3}	11,315	86,856
5	50,000	2	LEVELCONS-2/10-{1.8, 2.0}	4,732	91,587
6	60,000	6	LEVELCONS-6/10-{2.7, 2.9}	3,873	95,460
7	70,000	7	LEVELCONS-7/10-{2.9, 3.2}	2,188	97,648
8	80,000	8	LEVELCONS-8/10-{3.2, 3.4}	1,834	99,482
9	90,000	9	LEVELCONS-9/10-{3.4, 3.6}	0,300	99,782
10	100,000	10	LEVELCONS-10/10-{3.6, 3.8}	0,218	100,000

From Table 15 and Figure 24, it can be seen that about 10% of the most deterministic classes provide about 50% of the total determinity of the system level of natural numbers, and 50% of the most strongly deterministic classes provide about 92% of the total determinity of the system level.

The following levels of systemicity of natural numbers are most strictly determined:

– LEVELCONS-1/10-{1.6, 1.8};
– LEVELCONS-5/10-{2.5, 2.7};
– LEVELCONS-4/10-{2.3, 2.5};
– LEVELCONS-3/10-{2.0, 2.3}.

The system level values at the end of Table 13 are the weakest deterministic.

– LEVELCONS-2/10-{1.8, 2.0};
– LEVELCONS-6/10-{2.7, 2.9};
– LEVELCONS-7/10-{2.9, 3.2};
– LEVELCONS-8/10-{3.2, 3.4};
– LEVELCONS-9/10-{3.4, 3.6};
– LEVELCONS-10/10-{3.6, 3.8}.

4. DISCUSSION

So, we conducted an automated system-cognitive analysis of the dependence of the level of systemicity of natural numbers on their properties.

Thus, this work implements the idea of applying ***information theory, intellectual and cognitive technologies to study the properties of numbers***. This idea was realized and specified by the author and co-authors in numerous empirical studies in the field of number theory [1-53].

When solving the problem of identifying the level of systematality of a natural number by its properties, good results were obtained, which indicate the presence of fairly strong and pronounced laws and relationships between the properties of natural numbers on the one hand and the level of systematality of these numbers, on the other hand: the reliability of the INF4 model by Van Riesbergen's F-measure is 0.808. Only 0.015 less reliability of the INF1 model: 0.793, which demonstrates the most reasonable type of frequency distributions of the number of true and false, positive and negative solutions:

- *for positive solutions* at all values of the level of similarity, the number of true solutions significantly exceeds the number of false solutions;

- *for negative solutions* at all values of the difference level module 3% and higher, the number of true solutions significantly exceeds the number of false solutions.

This means that the created system-cognitive models in general correctly reflect the simulated subject area and they can reasonably be used to solve various problems of identification, prediction, decision-making and research of the simulated subject area by studying its model, which is done in this work.

In particular:

- system-cognitive models INF1 and INF3 can reasonably be used to solve various problems;

- the researcher has an adequate criterion for evaluating the results of the identification problem: this is the level of similarity (i.e., the value of the integral criterion) of the object with the class.

It should be noted that models of the Eidos system are phenomenological models that reflect empirical laws in the facts of the training sample, that is, they do not reflect ***the mechanism*** of causal determination, but only the fact and nature of determination. A meaningful explanation of these empirical laws is already formulated by experts at the theoretical level of knowledge in meaningful scientific laws [52].

5. CONCLUSIONS

Based on the analysis, we can make a reasonable ***conclusion*** that when solving the problem set forth in this work of identifying and investigating the dependence of the level of systematality of natural numbers on their properties, Automated system-cognitive analysis is an adequate tool, both according to its mathematical model and according to the software tools implementing it, which is currently the Eidos intelligent system.

The problem posed in the work **has been solved, the goal** of the work **has been achieved**.

You can personally get acquainted with the proposed solution by downloading to the address: http://lc.kubagro.ru/aidos/_Aidos-X.htm and installing the Eidos system on your computer, and then installing the intelligent cloud Eidos application **No. 33**3 in the application manager (mode 1.3).

As a ***perspective***, in the future it is planned to use ASK analysis and its software tools - the Eidos intelligent system for studying other properties of natural numbers studied in number theory, as well as ASK analysis of magic squares.

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