Eidos System Prediction of Myopia in Children in Early Education Stages

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ABSTRACT

This study used a database containing factors that, when processed using the Eidos intellectual system, detect myopia in children of primary school age. The database includes parameters that take into account the properties of the visual system, as well as factors that determine the duration of the performance of the main functions of the cognitive and entertaining nature of the students. The results obtained allow us to determine those factors that are more conducive to the appearance of myopia. The negative impact of some factors that cause myopia can be removed, such as, limiting the screen time spent, increasing outdoor activities/sports. A retrospective training sample can be used for automated processing using the Eidos intellectual system of the results obtained during the preventive examination of schoolchildren by an ophthalmologist. Early intervention towards myopia management in students, improves the chances of maintaining vision and slows myopia progression. The contribution of this research includes factors of a social nature that could be influenced at school in the process of education, increasing the attention towards chlident, awareness of maintaining vision and slows down the progression of myopia.

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1. INTRODUCTION

According to the World Health Organization, by 2050 in 57% of the world, the prevalence of myopia will exceed 50%. Therefore, this global visual pandemic warrants early recognition and intervention [1]. Axial myopia occurs when the eye is disproportionately elongated, the lens focuses light, but the retina is further away than the focused image [2]. The cause of refractive myopia is an increase in the refractive power of the optical lens of the eye [3]. Timely screening and diagnosis of myopia can activate measures in advance that prevent its progression [4]. Linear regression, support vector machines, decision trees, and other methods are being widely used to diagnose myopia [5]–[7]. Sports activities, outdoor walks, reduced hours of TV, large/small screen display viewing and playing computer games are significant factors that reduce the risk of myopia [8]. However, there are no artificial intelligence (AI) systems in schools that make it possible to visually demonstrate to schoolchildren the perniciousness of bad habits and the need for sports and outdoor walks. The fact that the appearance of myopia is numerical and textual, makes it difficult to develop a system-cognitive model based on a systemic generalization of information necessary to detect myopia [9].

Furthermore, with rapid adoption of technology in education, students at early level of education could become addicted to electronical devices and this casues them illness including myopia [10], [11]. Regardless positive impact of technology and internet usage, schools and families are in charge of controlling usage among children [12]. There are some researches have confirmed the negative impact of using interent and cellphones among children in early stages [13]–[15]. In addition, Studies have shown that children's exposure to telephone and computer screens causes many visual diseases [16]. Recently, when all the world was affected by Covid-19 pandemic, the usage of internet and electronic devices became compulsory [17]–[18]. Students at easly stages of education were encouraged to use computers, cellphones and tablets to continue their education [19] where they have spent longer time (learning hours) using these devices daily.

2. METHODS

This study is devoted to the detection of myopia in primary school children. Fig.1 illustrates the stages of data collection and diagnosis of myopia in children.

2.1. Data Description

The dataset for this study analyses records of 618 (302 girls, 316 boys) school-age children aged 5 to 9 years [20]. The following factors were used to predict the onset of myopia:

- AGE: Age at first visit, Numeric;
- GENDER: Boolean (0: M/1: F);
- SPHEQL: Spherical Equivalent Refraction, a measure of the eye's effective focusing power, Float;
- AL: Axial Length, the length of eye from front to back, Numeric (mm);
- ACD: Anterior Chamber Depth, the length from front to back of the aqueous-containing space of the eye between the cornea and the iris, Numeric (mm);
- LT: Lens Thickness, the length from front to back of the crystalline lens, Numeric (mm);
- VCD: Vitreous Chamber Depth, the length from front to back of the aqueous-containing space of the eye in front of the retina, Numeric (mm);
- SPORTHR: How many hours per week outside of school the child spent participating in sports/outdoor activities, Numeric;
- READHR: How many hours per week outside of school the child spent reading for pleasure, Numeric;
- COMPHR: How many hours per week outside of school the child spent playing video/computer games or working on the computer, Numeric
- STUDYHR: How many hours per week outside of school the child spent reading or studying for school assignments, Numeric;
- TVHR: How many hours per week outside of school the child spent watching television, Numeric;
- DIOPTERHR" Composite of near-work activities defined as DIOPTERHR = 3× (READHR + STUDYHR) + 2× COMPHR + TVHR, Numeric;
- MOMMY: Was the case's mother myopic? Boolean (0: No /1: YES);
- DADMY: Was the case's father myopic? Boolean (0: No /1: YES).

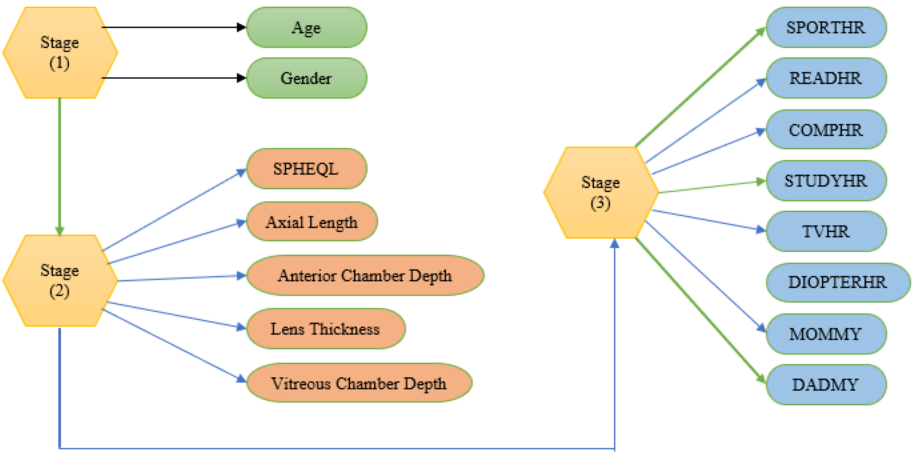


Fig. 1. Stages of diagnosis Myopia

2.2. Research tool

To solve the problem posed in this work, an automated system-cognitive analysis (ASC-analysis) and its software tools - the Eidos intellectual system - were used. ASC analysis was proposed by Professor Lutsenko E.V. in 2002 in a number of articles and a fundamental monograph [21]. Mathematical models of ASC-analysis of the intellectual system Eidos are based on system fuzzy interval mathematics and provide comparable processing of large volumes of fragmented and noisy interdependent data presented in various types of scales: nominal, ordinal and numerical and various units of measurement [22]. The system-cognitive models of the

Eidos system reflect patterns in the training sample database, i.e. fix the facts and the nature of their determination [23]. This important feature of the Eidos system models allows it to be used to detect myopia in children of primary school age. The Eidos system differs from other AI systems [24] as it was developed in a universal setting, independent of the subject area, therefore, it can be used in many subject areas. It is freely available with up-to-date source texts and does not require special user training in the field of AI technologies. Eidos system also provides a stable identification of causal relationships in incomplete noisy data of a very large dimension of numerical and non-numerical nature. It contains a large number of cloud-based educational and scientific applications (currently 31 and 295 respectively) and supports online knowledge accumulation environment. Since it provides multilingual interface support in 51 languages, it is widely used all over the world. Additionally, even the most time-consuming computational operations are implemented using a graphics processor (GPU).

2.3. Data collection and analysis tool

The Orindsky Longitudinal Myopia Study (OLMS), which collected data for the risk factors for myopia in children, was assessed for the current study. Data collection began in the 1989-1990 school year and continued annually until the 2000-2001 school year. (https://www.kaggle.com/datasets/mscgeorges/myopia-study). However, the factors of the training data set have been significantly refined to reflect the knowledge of an experienced ophthalmologist [25].

Directly on the basis of the edited data, after their formalization, a table of absolute frequencies was calculated. In this table, the rows corresponded to the gradations of the descriptive scales (factor values), and the columns corresponded to the classes, that is, the gradations of the classification scales. At their intersection was the number of cases (facts) of observing a certain feature value in objects of a certain class. The transition of the simulation object to a certain future state was also observed if it was affected by the value of some factor. To establish a fact, it was necessary to obtain information about the features of an object, create an image of the object on its basis and identify this specific image, that is, compare it with generalized images and determine the degree of their similarity [26].

When performing automated system-cognitive analysis, the following tasks were solved:

[1]. cognitive structuring subject areas
[2]. preparation of initial data and formalization of the subject area
[3]. synthesis and verification of statistical and system-cognitive models and selection of the most reliable model
[4]. solving various problems in the most reliable model:
   - subtask 4.1. Forecasting (diagnostics, classification, recognition, identification);
   - subtask 4.2. Decision support;
   - subtask 4.3. The study of the modeled subject area by forming cognitive diagrams of classes and values of factors, non-local neurons and neural networks, 3 d -integrated cognitive maps.

As an INF3 model, the partial knowledge criterion χ^2 " chi-square " is calculated:

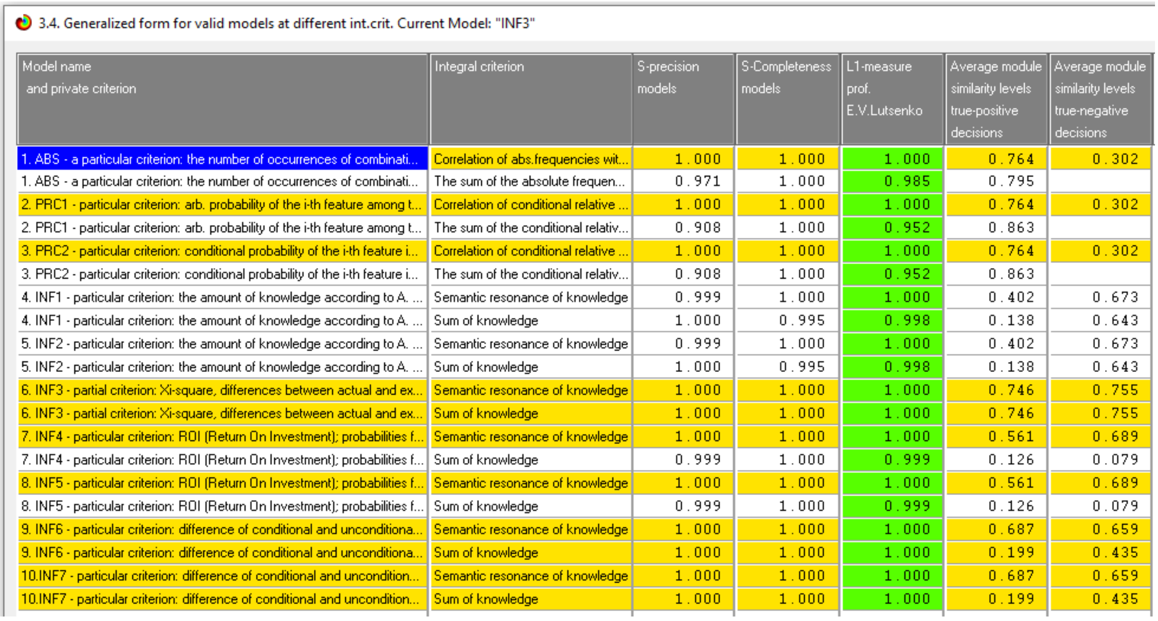
$$Iij = Nij - \bar{N}ij = Nij - \frac{Ni\,Nj}{N} \tag{1}$$

where N_{ij} is the actual number of occurrences of the i-th feature in objects of the j-th class. $\bar{N}_{ij}$ is the theoretical number of occurrences of the i-th feature in objects of the j-th class. *Ni* is the total number of features in the i-th row. *Nj* is the total number of features or objects of the training sample in the j-th class. *N* is the total number of features in the entire sample.

Thus, the amount of information in the value of the factor is calculated that the modeling object will pass under its action to a certain state corresponding to the class. This allows for comparable and correct processing of heterogeneous information about the observations of the simulation object, presented in different types of measuring scales and different units of measurement. The principles of using automated system-cognitive analysis for the diagnosis of human diseases are disclosed in presentations with sound in English, which are posted on the site https://www.patreon.com/user?u=87599532 [27].

3. RESULTS AND DISCUSSION

In the Eidos system, 10 models were automatically generated, the INF 3 model turned out to be the most applicable, Fig. 2. The mean value of similarity in recognizing the presence of myopia in children was 0.746. The mean similarity value for recognizing the absence of myopia in children was 0.755. An example of myopia recognition in several children is shown in Fig. 3.



3.4. Generalized form for valid models at different int.crit. Current Model: "INF3"

Model name and private criterion	Integral criterion	S-precision models	S-Completeness models	L1-measure prof. E.V.Lutsenko	Average module similarity levels true-positive decisions	Average module similarity levels true-negative decisions
1. ABS - a particular criterion: the number of occurrences of combinati...	Correlation of abs.frequencies wit...	1.000	1.000	1.000	0.764	0.302
1. ABS - a particular criterion: the number of occurrences of combinati...	The sum of the absolute frequen...	0.971	1.000	0.985	0.795	
2. PRC1 - particular criterion: arb. probability of the i-th feature among t...	Correlation of conditional relative ...	1.000	1.000	1.000	0.764	0.302
2. PRC1 - particular criterion: arb. probability of the i-th feature among t...	The sum of the conditional relativ...	0.908	1.000	0.952	0.863	
3. PRC2 - particular criterion: conditional probability of the i-th feature i...	Correlation of conditional relative ...	1.000	1.000	1.000	0.764	0.302
3. PRC2 - particular criterion: conditional probability of the i-th feature i...	The sum of the conditional relativ...	0.908	1.000	0.952	0.863	
4. INF1 - particular criterion: the amount of knowledge according to A. ...	Semantic resonance of knowledge	0.999	1.000	1.000	0.402	0.673
4. INF1 - particular criterion: the amount of knowledge according to A. ...	Sum of knowledge	1.000	0.995	0.998	0.138	0.643
5. INF2 - particular criterion: the amount of knowledge according to A. ...	Semantic resonance of knowledge	0.999	1.000	1.000	0.402	0.673
5. INF2 - particular criterion: the amount of knowledge according to A. ...	Sum of knowledge	1.000	0.995	0.998	0.138	0.643
6. INF3 - partial criterion: Xi-square, differences between actual and ex...	Semantic resonance of knowledge	1.000	1.000	1.000	0.746	0.755
6. INF3 - partial criterion: Xi-square, differences between actual and ex...	Sum of knowledge	1.000	1.000	1.000	0.746	0.755
7. INF4 - particular criterion: ROI (Return On Investment); probabilities f...	Semantic resonance of knowledge	1.000	1.000	1.000	0.561	0.689
7. INF4 - particular criterion: ROI (Return On Investment); probabilities f...	Sum of knowledge	0.999	1.000	0.999	0.126	0.079
8. INF5 - particular criterion: ROI (Return On Investment); probabilities f...	Semantic resonance of knowledge	1.000	1.000	1.000	0.561	0.689
8. INF5 - particular criterion: ROI (Return On Investment); probabilities f...	Sum of knowledge	0.999	1.000	0.999	0.126	0.079
9. INF6 - particular criterion: difference of conditional and unconditiona...	Semantic resonance of knowledge	1.000	1.000	1.000	0.687	0.659
9. INF6 - particular criterion: difference of conditional and unconditiona...	Sum of knowledge	1.000	1.000	1.000	0.199	0.435
10.INF7 - particular criterion: difference of conditional and uncondition...	Semantic resonance of knowledge	1.000	1.000	1.000	0.687	0.659
10.INF7 - particular criterion: difference of conditional and uncondition...	Sum of knowledge	1.000	1.000	1.000	0.199	0.435

Fig. 2. Generalized form of model reliability

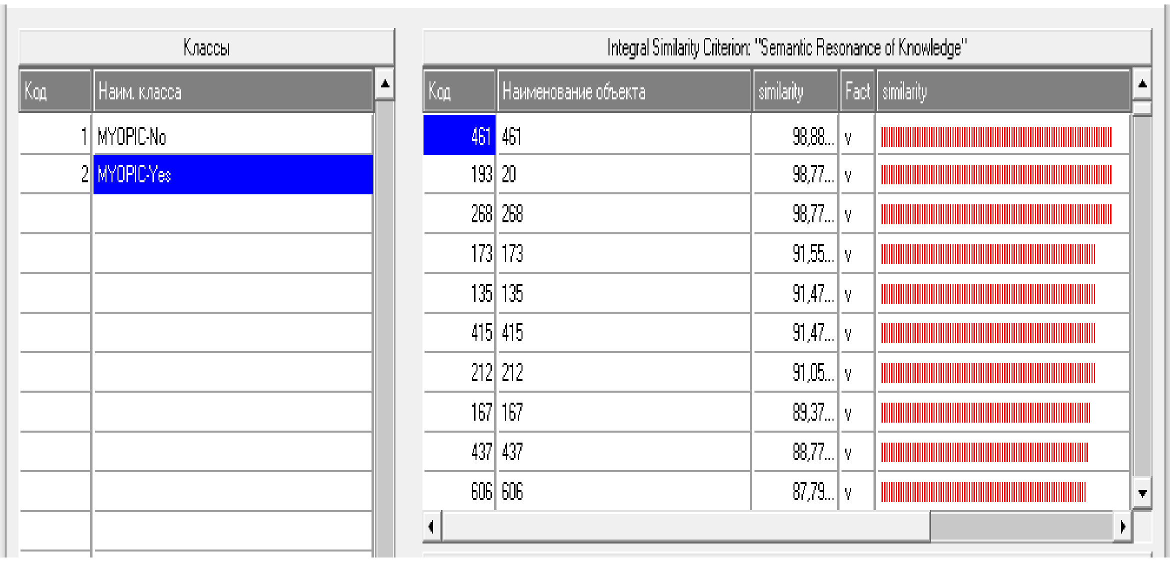
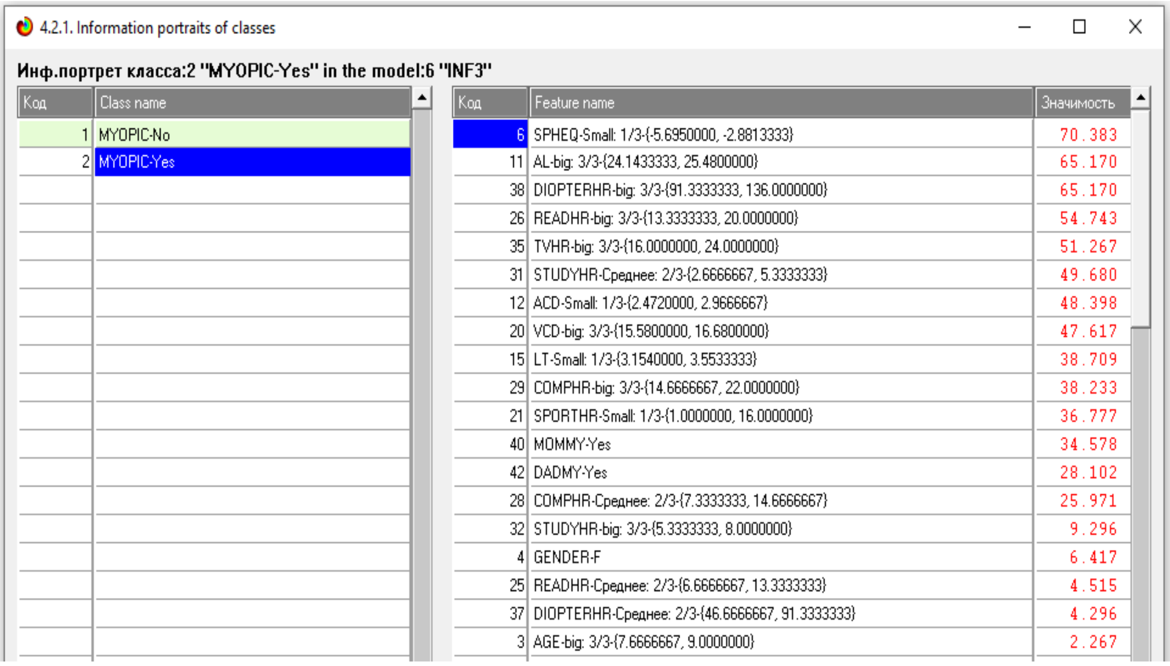


Fig. 3. Recognition of myopia in several children

Informational portrait of the myopia recognition class shown in Fig. 3 showed the informational contribution of each feature to the total amount of information contained in the generalized image of this class.

Fig. 4 shows the information portrait of a class in a list of factors ranked in descending order of their influence on the transition of the control object to the state corresponding to the given class. Note, that in models the degree of expression of various properties of objects of observation was considered from a single point of view: from the point of view of how much information they contain about which classes these objects will or will not belong to. Therefore, it dd not matter in what units of measurement certain properties of the objects of observation were measured, and in what units the results of the influence of these properties were measured, natural, percentage or cost.

An information portrait of the MYOPIC - No class is shown in Fig. 4. When making decisions, the strength and direction of the influence of the values of the factors on the belonging of the states of the modeling object to one or another class corresponding to various future states is determined. In the simplest version, decision making is, in fact, a solution to the problem of SWOT analysis.



4.2.1. Information portraits of classes

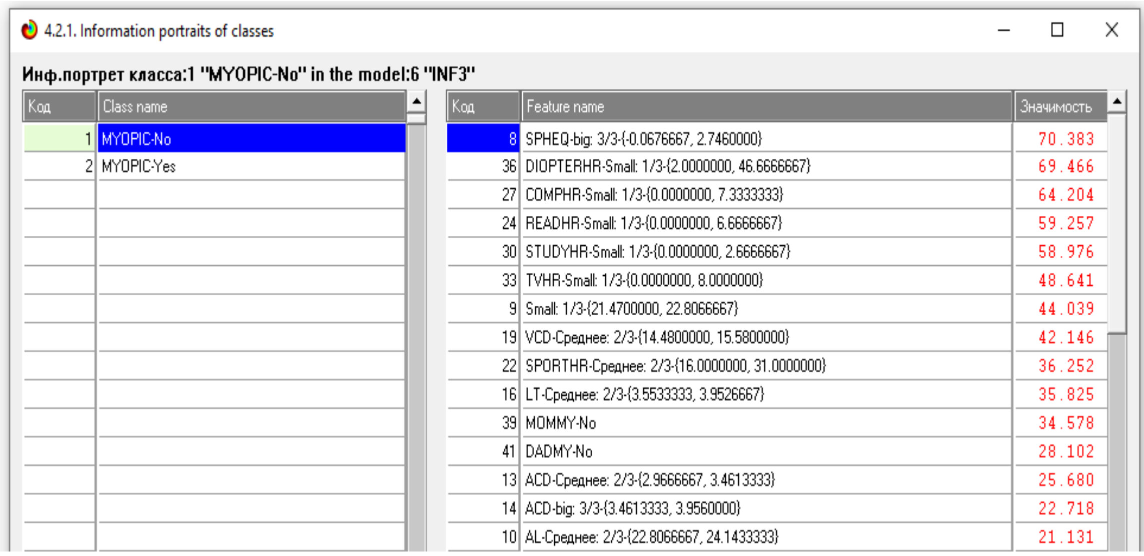
Инф.портрет класса:2 "MYOPIC-Yes" in the model:6 "INF3"

Код	Class name
1	MYOPIC-No
2	MYOPIC-Yes

Код	Feature name	Значимость
6	SPHEQ-Small: 1/3-{-5.6950000, -2.8813333}	70.383
11	AL-big: 3/3-{24.1433333, 25.4800000}	65.170
38	DIOPTERHR-big: 3/3-{91.3333333, 136.0000000}	65.170
26	READHR-big: 3/3-{13.3333333, 20.0000000}	54.743
35	TVHR-big: 3/3-{16.0000000, 24.0000000}	51.267
31	STUDYHR-Среднее: 2/3-{2.6666667, 5.3333333}	49.680
12	ACD-Small: 1/3-{2.4720000, 2.9666667}	48.398
20	VCD-big: 3/3-{15.5800000, 16.6800000}	47.617
15	LT-Small: 1/3-{3.1540000, 3.5533333}	38.709
29	COMPHR-big: 3/3-{14.6666667, 22.0000000}	38.233
21	SPORTHR-Small: 1/3-{1.0000000, 16.0000000}	36.777
40	MOMMY-Yes	34.578
42	DADMY-Yes	28.102
28	COMPHR-Среднее: 2/3-{7.3333333, 14.6666667}	25.971
32	STUDYHR-big: 3/3-{5.3333333, 8.0000000}	9.296
4	GENDER-F	6.417
25	READHR-Среднее: 2/3-{6.6666667, 13.3333333}	4.515
37	DIOPTERHR-Среднее: 2/3-{46.6666667, 91.3333333}	4.296
3	AGE-big: 3/3-{7.6666667, 9.0000000}	2.267

Fig. 4. Information portrait of the MYOPIC class – Yes

Quantitative SWOT analysis of classes provided the construction of a SWOT matrix for a given class indicating the strength of the influence of facilitating and hindering factors directly based on empirical data and therefore is a tool for automated quantitative SWOT analysis. At the beginning of the information portrait of the class, there were factors that positively affected the transition of the control object to a given state, then factors that did not have a significant effect on this, and then preventing the transition of the control object to this state. The SWOT-diagram of the MYOPIC - No class is shown in Fig. 5 and SWOT-diagram of class MYOPIC - Yes - in Fig. 6. Fig. 7 illustrates the SWOT charts displayed the 16 most significant links, with the sign of the link displayed in color (red +, blue -), and the value was set by the thickness of the line. It was possible to display diagrams with only positive or only negative links.



4.2.1. Information portraits of classes

Инф.портрет класса:1 "MYOPIC-No" in the model:6 "INF3"

Код	Class name
1	MYOPIC-No
2	MYOPIC-Yes

Код	Feature name	Значимость
8	SPHEQ-big: 3/3-{-0.0676667, 2.7460000}	70.383
36	DIOPTERHR-Small: 1/3-{2.0000000, 46.6666667}	69.466
27	COMPHR-Small: 1/3-{0.0000000, 7.3333333}	64.204
24	READHR-Small: 1/3-{0.0000000, 6.6666667}	59.257
30	STUDYHR-Small: 1/3-{0.0000000, 2.6666667}	58.976
33	TVHR-Small: 1/3-{0.0000000, 8.0000000}	48.641
9	Small: 1/3-{21.4700000, 22.8066667}	44.039
19	VCD-Среднее: 2/3-{14.4800000, 15.5800000}	42.146
22	SPORTHR-Среднее: 2/3-{16.0000000, 31.0000000}	36.252
16	LT-Среднее: 2/3-{3.5533333, 3.9526667}	35.825
39	MOMMY-No	34.578
41	DADMY-No	28.102
13	ACD-Среднее: 2/3-{2.9666667, 3.4613333}	25.680
14	ACD-big: 3/3-{3.4613333, 3.9560000}	22.718
10	AL-Среднее: 2/3-{22.8066667, 24.1433333}	21.131

Fig. 5. Information portrait of the MYOPIC class – No

Recent studies have examined the efficacy of different myopia control interventions in children [28]–[31]. Orthokeratology (OK) and multifocal soft contact lenses (SCL) have emerged as two effective options for slowing down the progression of myopia in children [32]. More studies found that OK was more effective than SCL in reducing axial elongation, which is a major factor contributing to myopia progression [33], [34]. However, other research has shown that both OK and SCL are equally effective in slowing down myopia progression over a two-year period [35], [36]. Additionally, atropine eye drops have also been found to effectively slow down the progression of myopia [37]. While further research is needed to fully understand the long-term effects of these interventions, it is clear that they provide effective options for managing myopia in children.

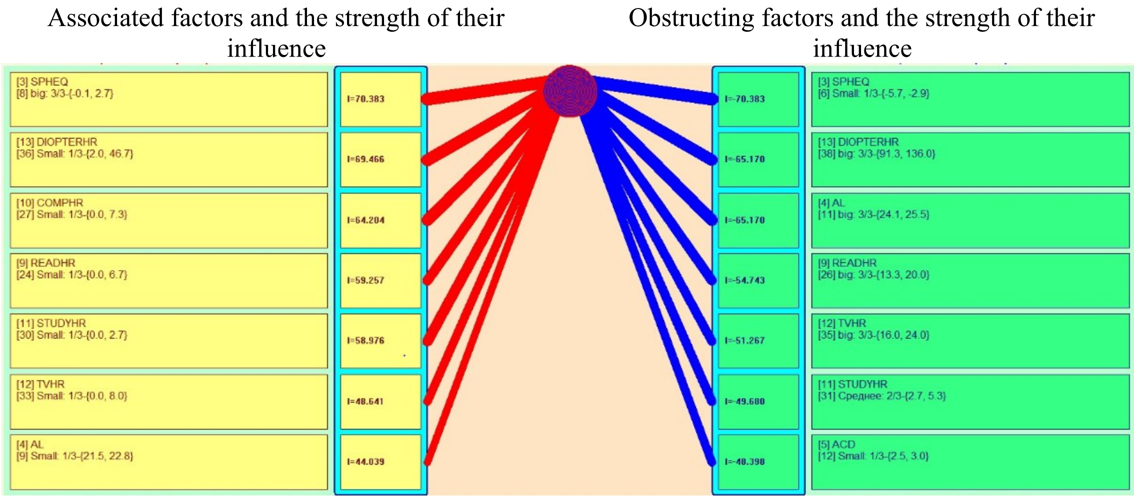


Fig. 6. SWOT -diagram of the MYOPIC class – No

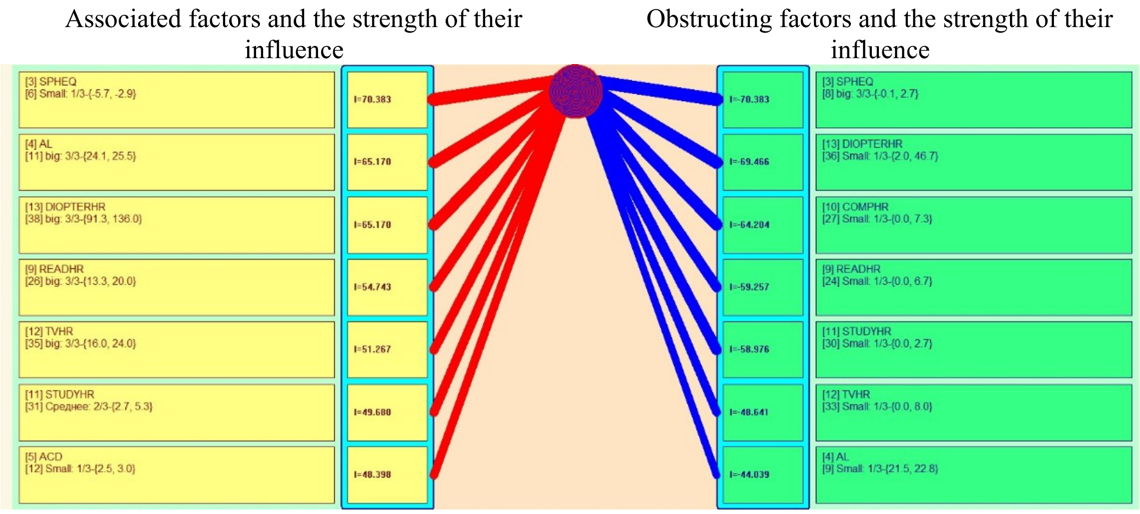


Fig. 7. SWOT-diagram of class MYOPIC – Yes

In schools, it is necessary not only to teach children, but also to monitor their health [38]. Regular preventive measures related to the vision of schoolchildren should be carried out at school. Otherwise, after graduation from school, children will be left with damaged eyesight [39]–[41]. Early intervention in the management of students' myopia improves the chances of maintaining vision and slows down the progression of myopia. Although myopia cannot be eliminated, it must be prevented from worsening it [42]. This may protect the health of the child's eyes in the future, despite the need to wear glasses or contact lenses, which are also effective in slowing the progression of myopia and axial lengthening of the eye in children [43].

4. CONCLUSION

Myopia in schoolchildren will appear if their SPHED factor has a low value in the range from -5.695 to -2.88, they play computer games for too long, read a lot, prepare their lessons for too long, watch TV for a long time, play little sports and their parents have myopia. It has been already shown that each hour increases in outdoor activity per day had a negative effect on the change of SE by 0.06 D on a subsequent visit, as compared with the previous visit. Outdoor activity is usually associated with exposure to bright sunlight which results in release of dopamine from the retina and increased dopamine release inhibits axial elongation of the eyeball.

The Eidos system is distributed free of charge on the Internet, it can be installed on school computers in order to demonstrate the strength and direction of the influence of the factors taken into account in the simulation, which will help convince schoolchildren not to get carried away with long studies and help them save their eyesight.

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