Research Article

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Smart-system of distance learning of visually impaired people based on approaches of artificial intelligence

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Abstract: Research objective is the creation of intellectual innovative technology and information Smart-system of distance learning for visually impaired people. The organization of the available environment for receiving quality education for visually impaired people, their social adaptation in society are important and topical issues of modern education. The proposed Smart-system of distance learning for visually impaired people can significantly improve the efficiency and quality of education of this category of people. The scientific novelty of proposed Smart-system is using intelligent and statistical methods of processing multi-dimensional data, and taking into account psycho-physiological characteristics of perception and awareness learning information by visually impaired people.

Keywords: distance learning, the Smart-system, visually impaired people, approach of artificial intelligence, ontological approach, principal component analysis.

1 Introduction

Recently in education system there is need to increase the efficiency educational process, development of the personal potential of learner and the requirement to creation an intellectual learning environment appears. As a result the traditional education system proceeds to technologies of Smart-education [1] the advantages of these applications are: increase of professional competence, a possibility of the choice of an individual trajectory of learning with innovative educational and methodical complexes, electronic educational resources (for example, Smart-books), creation of uniform educational space in the Internet, successful implementation of research and educational activity. It is a new approach in education providing the high level of development corresponding to tasks and opportunities of the modern world.

Construction and the organization of the high-quality distance learning (DL) is time consuming and difficult process. In this regard special approaches that solve these problems are developed. One of them is the approach based on the ontological models (OM). The ontological model represents hierarchical structure of concepts, objects, definitions, properties and relations of a certain subject domain [2, 3]. Ontological models find active applications in applied areas of the intellectual systems of distance learning connected with construction. Creation of OM for intellectual systems of distance learning allows understanding interrelations and ensures the systematized functioning of the developed intellectual information system, promotes development of the effective software with the convenient interface.

Research objective is development of Smart-technology based on ontological, cognitive approaches, statistical and intelligent methods for distance learning of visually impaired people and the constructing of Smart-system DL for the study of the latest technology in the laboratory of joint use (LJU).

Methods and learning of trajectory VIP discussed in more detail in the article [4], where an example of discipline model "Microprocessor engineering of the Schneider Electric company" presented. It was developed an intellectual system of distance education for learning qualified specialists of technical specialties on the modern equipment in the laboratories of joint use has been developed. Processing of personal data for the purpose of selecting an individual educational plan for each learner is based on the biological approach of artificial immune systems.
2 Literature Review

For the development of distance learning systems various of artificial intelligence methods [5, 6], such as neural networks (NN), fuzzy logic (NL), neuro-fuzzy logic (NNL), genetic algorithms (GA), artificial immune system [7] etc. are widely used.

There are many publications on the subject. In a study [8] proposed the realization of a neural network model predicting the effectiveness of the educational process in DL. The model is based on two parameters: the total combined score (for all modules of the course) and the total time spent on studying the development of the material of all modules. In article [9] features of use of a multi-layered perceptron at the automated control of knowledge are given in electronic learning courses. Modeled multi-layer perceptron to solve the problem of classification test. The model used in the testing stages of e-learning courses for DL the purpose to the individualization of the learning process and improve the objectivity of knowledge assessment. Research objective [10] is the improvement of quality of control of the acquired knowledge learned in DL. Control of knowledge is divided into two independent processes. In the first process transformation of the arrived answer from learned, i.e. the translation from a natural language on formal meta-language is performed. Further, the assessment of correctness of the answer with the use of NN is performed. In article [11] also forecasting of learning progress of learner and DL based on fuzzy logic model are considered. The mathematical model is created using fuzzy logic. For receiving good result of rule of fuzzy logic have been optimized using of genetic algorithm. In research [12] development of mathematical model of forecasting of progress of learner in DL is described. Two fuzzy models are for this purpose constructed: classical and expert. The expert fuzzy model is created using genetic algorithm.

During creation DL on the basis of intellectual methods ontological models are actively used. In article [13] creation of OM based on artificial intelligence and expert systems are suggested. In work [14] use of artificial neural networks for the solution of problems of clustering with use of the self-organized Kohonen’s cards is supposed. In research [15] for creation of OM of mobile learning approach on the basis of Semantic web is used. This system is adaptive, appropriate resources and the approach allows to choose flexibly in learning concrete learner. The cyclic model of quality management of this process based on the use tools of the intellectual analysis is presented. In article [16] authors draw conclusion about need of use of the device of fuzzy logic at design and development of intellectual subsystems for DL technology. The algorithm and an example of use of the device of fuzzy logic are given during creation of elements of expert systems for DL.

At the creation of similar systems for the characterization of learners, the solution of a problem of allocation of informative features is actual. There are various methods and approaches, such as methods of the factorial analysis (PCA – principal component analysis, ICA – independent component analysis [17]), multidimensional scaling, and allocation of informative features on the basis of heuristic algorithms (neural networks, neuro-fuzzy logics [18], genetic algorithms, ant colony optimization, etc.). In article [19] use of principal component analysis for processing of the multidimensional results of rating assessment which are learned is offered. In research [20] the offered scheme of face recognition is based on application of a neural network and principal component analysis. Principal component analysis will transform the number of possibly correlated variables to smaller number of uncorrelated variables.

3 Methods

Learning of visually impaired people and their adaptation in society is one of important questions of modern education. Application of AI methods and ontological approach is actual for creation the Smart-system of DL for VIP. Development of data of systems have the specific features. For the solution of this problem the methods of artificial intelligence, cognitive approach and the combined ontological model are used. Models of ontology allow to create effective intellectual information systems and to carry out interaction between the difficult structured and formalized data. Cognitive approach is applied to detection of the intellectual and personal features, which are trained.

The use intellectual systems is perspective during creation of the latest technologies of DL. The main feature in creation of the intellectual system of DL is need of work with multidimensional inexact data and identification of the hidden knowledge. They have to be adaptive, distributed and ambiguous.

During the development intellectual systems of DL, good result is possible to reach by combination of various statistical and intellectual methods. For allocation of informative features, that characterized of each learner was used principal component analysis (PCA) [21].

\[ \text{Download Date | 6/19/19 9:59 PM} \]
The problem of definition of allocation of informative features in a general view has the following appearance [22]:

\[ a_1, \ldots, a_n \rightarrow z_1, \ldots, z_m, n > m, \]

where \( a_1, \ldots, a_n \) – the initial set of features, \( a_1, \ldots, a_n = \overline{1}, n \);

\( z_1, \ldots, z_m \) – the new set of features, \( z_1, \ldots, z_m = \overline{1}, m \);

\( n \) – dimensionality of the initial feature space;

\( m \) – dimensionality of the new feature space.

The transition from the initial set of features \( a_1, \ldots, a_n \) to the new set of features \( b_1, \ldots, b_m \) implemented with minimal losses of information. The basic is saving the maximum information at the minimum feature set.

Principal component analysis based on finding the eigenvalues and eigenvectors of the correlation matrix. The matrix of principal component analysis has the following appearance [23]:

\[ Z = B(F^T)^{-1}, \]

where \( B \) – the matrix of normalized values; \( F \) – the matrix of factor loadings.

For the solution of this task the initial matrix of data \( A_{ij} \) of dimension (nxm). We will transform matrix to the matrix of normalized values \( B_{ij} \) with elements:

\[ b_{ij} = \frac{a_{ij} - \overline{a_i}}{S_i}, \]

where \( a_{ij} \) - elements of the initial matrix;

\( a_i \) - arithmetic average value;

\( S_i \) – standard deviation of initial elements which is calculated by the formula:

\[ S_i = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (a_i - \overline{a})^2}, \]

\( n \) – the initial set of features.

For the normalized values of the correlation matrix \( R \) is calculated as follows:

\[ R = \frac{1}{n} B^T B, \]

To calculating eigenvalues of matrix \( R \) values considered characteristic equation:

\[ |R - \lambda E| = 0, \]

where \( \lambda \) - own number of \( R \);

\( E \) - identity matrix.

After finding of the decision for \( \lambda \), there is a transformation matrix. The received matrix of transformation initial axes turn so that dispersions were associated with new axes. The calculated coordinates of the data in new system coordinates. Then the features lying closer to the beginning of coordinates are rejected, which are low informative. On the remained informative features the VIP model is construction.

Thus, principal component analysis will transform the number of possibly correlated variables to smaller number of uncorrelated variables [20].

4 Results

During the solution of an objective the integrated block diagram (Fig. 1) of Smart-system of distance learning of VIP is offered, which consists of models and main modules. Smart-system models of DL are included: model of learners with impaired vision, model of learning and model of laboratory of joint use. The main modules of Smart-system of DL consist of: information, intellectual, learning and controlling blocks.

![Smart-system of distance learning VIP](image)

The following algorithm of Smart-system of distance learning of VIP is developed.

**Algorithm.** Smart-system of distance learning of VIP

2. Formation of database and knowledge base for data storage and knowledge of subject domain.
3. Creation of the VIP model taking into account opportunities of sight and development of the database of informative features learned based on cognitive approach (questioning and testing).
4. Preliminary data processing based on a principal component analysis and learning of Smart-system.
5. The choice of the mode of learning taking into account visual impairments (the choice of a background, color schemes, information arrangement on the screen, etc.)
6. Acceptance of inquiries from VIP and data transmission to the interpreter of server scenarios.
7. Creation of model of learning adapted to model learned based on fuzzy logic.
8. The organization of access of VIP to the laboratory of LJU depending on the chosen learning model (from a subject of learning and the learning course).
9. Studying of VIP of theoretical material and performance of practical, laboratory and independent works on the modern equipment in LJU.
10. After studying of a certain course on the chosen level, VIP pass test and the analysis of learning at a neuro-fuzzy logic basis is by results carried out.
11. The system offers three options: further learning, re-learning and end of course.
12. Further learning is chosen in case VIP has shown good results and is ready to development of the following level.
13. End of a course is offered in case VIP has completely mastered all levels of the offered course.
14. On end of course VIP receive the certificate.
15. Relearning of a course is offered if VIP could not master the chosen course level.

For development of the Smart-system of DL of VIP the combined ontological model is offered. Advantage of use of OM is realization of system approach to creation of Smart-system on the basis of methods of artificial intelligence, statistical and cognitive approaches, facilitates writing of Software and the choice of Hardware. This model includes [24] ontological model learner, learning and laboratory of joint use which can be presented as follows:

\[ OM_{COM} = \langle OM_{PVI}, OM_{KN}, OM_{LJU} \rangle, \]

where \( OM_{PVI} \) – ontological model of learner VIP;
\( OM_{KN} \) – ontological model of learning;
\( OM_{LJU} \) – ontological model of laboratory of joint use.

1 Ontological model of learner VIP presented as follows:

\[ OM_{PVI} = \langle VIP_{ID}, VIP_{IH} \rangle, \]

where \( VIP_{ID} \) – identification data of VIP (Name, group, course);
\( VIP_{IH} \) – individual characteristics of VIP.

2 Ontological model of learning model presented as follows:

\[ OM_{KN} = \langle VIP_{DEG}, LN_{SUB}, LN_{IEC}, VIP_{FLR} \rangle, \]

where \( VIP_{DEG} \) – level knowledge of VIP;
\( LN_{SUB} \) – course (disciplines);
\( LN_{IEC} \) – interactive elements of a course (lectures, laboratory works, individual work, practical tasks, forum and others).

VIP\(_{FLR}\) – forecasting of results of learning.

3 The ontological model of laboratory of joint use is presented in the following form:

\[ OM_{LJU} = \langle SC, VM, SW, Int \rangle, \]

where \( SC \) – supercomputer;
\( VM \) – virtual computer;
\( SW \) – software;
\( Int \) – Internet.

The exchange of information is carried out through the Internet network. The considered ontological models supplement each other and are interconnected among themselves.

When developing ontological model the editor of ontology of Protégé (Fig. 2) is applied. The Protégé editor is the freeware program intended for design of ontological structures [25]. It is possible to carry the following to the main features of this editor: openness and expansibility of architecture, language, format, access, collective network remote editing and others. The figure shows the ontological model of Smart-system of distance learning for VIP are implemented in editor of Protégé.

Further according to developed algorithm allocation of informative features by means of a principal component analysis based on a statistical package of the SPSS application programs is carried out.

We will give the following an example. We consider the group of learners of 10 VIP people. Suppose the initial matrix of data \( A = (a_{ij}) \) of dimension (10 × 10) is given in Table 1. Data base features of VIP consists of the following characteristics: age, state health on a visual impair-
### Table 1: The initial data matrix.

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>State health</th>
<th>Visual acuity</th>
<th>Logical thinking</th>
<th>Cognitive activity</th>
<th>Psychological, strong-willed potential</th>
<th>Physiological potential</th>
<th>Motivational potential</th>
<th>Technology of reading</th>
<th>Perception of information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omarova .</td>
<td>25</td>
<td>3.00</td>
<td>6.00</td>
<td>2.00</td>
<td>15</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td>250</td>
<td>3</td>
</tr>
<tr>
<td>Erbolova R.Y.</td>
<td>17</td>
<td>3.00</td>
<td>6.00</td>
<td>2.00</td>
<td>12</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>230</td>
<td>2</td>
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<td>Musina A.K.</td>
<td>30</td>
<td>2.00</td>
<td>1.00</td>
<td>1.00</td>
<td>11</td>
<td>4</td>
<td>5</td>
<td>11</td>
<td>180</td>
<td>1</td>
</tr>
<tr>
<td>Sultangazina N.O.</td>
<td>21</td>
<td>1.00</td>
<td>2.00</td>
<td>2.00</td>
<td>9</td>
<td>6</td>
<td>4</td>
<td>9</td>
<td>190</td>
<td>3</td>
</tr>
<tr>
<td>Junusova G.</td>
<td>23</td>
<td>2.00</td>
<td>1.00</td>
<td>1.00</td>
<td>14</td>
<td>2</td>
<td>3</td>
<td>8</td>
<td>156</td>
<td>2</td>
</tr>
<tr>
<td>Aukarimov N.D.</td>
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<td>3.00</td>
<td>6.00</td>
<td>2.00</td>
<td>13</td>
<td>4</td>
<td>2</td>
<td>12</td>
<td>89</td>
<td>1</td>
</tr>
<tr>
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<td>1.00</td>
<td>2.00</td>
<td>1.00</td>
<td>10</td>
<td>6</td>
<td>6</td>
<td>11</td>
<td>130</td>
<td>3</td>
</tr>
<tr>
<td>Jantasov D.</td>
<td>25</td>
<td>1.00</td>
<td>3.00</td>
<td>1.00</td>
<td>7</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td>40</td>
<td>2</td>
</tr>
<tr>
<td>Jetenova Zh.S.</td>
<td>18</td>
<td>2.00</td>
<td>4.00</td>
<td>2.00</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td>156</td>
<td>1</td>
</tr>
<tr>
<td>Chingisov KH.B.</td>
<td>22</td>
<td>3.00</td>
<td>5.00</td>
<td>2.00</td>
<td>12</td>
<td>6</td>
<td>3</td>
<td>9</td>
<td>180</td>
<td>3</td>
</tr>
</tbody>
</table>

### Table 2: Matrix of standardized data.

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>State health</th>
<th>Visual acuity</th>
<th>Logical thinking</th>
<th>Cognitive activity</th>
<th>Psychological, strong-willed potential</th>
<th>Physiological potential</th>
<th>Motivational potential</th>
<th>Technology of reading</th>
<th>Perception of information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omarova .</td>
<td>0.76</td>
<td>1.02</td>
<td>1.16</td>
<td>0.77</td>
<td>1.49</td>
<td>1.02</td>
<td>1.34</td>
<td>1.26</td>
<td>1.44</td>
<td>1.02</td>
</tr>
<tr>
<td>Erbolova R.Y.</td>
<td>−1.27</td>
<td>1.02</td>
<td>1.16</td>
<td>0.77</td>
<td>0.34</td>
<td>−1.25</td>
<td>−1.34</td>
<td>0.06</td>
<td>1.11</td>
<td>−0.11</td>
</tr>
<tr>
<td>Musina A.K.</td>
<td>2.04</td>
<td>−0.11</td>
<td>−1.25</td>
<td>−1.16</td>
<td>−0.03</td>
<td>−0.11</td>
<td>0.67</td>
<td>0.66</td>
<td>0.31</td>
<td>−1.25</td>
</tr>
<tr>
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<td>−1.25</td>
<td>0.77</td>
<td>0.77</td>
<td>−0.80</td>
<td>1.02</td>
<td>0.00</td>
<td>−0.54</td>
<td>0.47</td>
<td>1.02</td>
</tr>
<tr>
<td>Junusova G.</td>
<td>0.25</td>
<td>−0.11</td>
<td>−1.25</td>
<td>−1.16</td>
<td>1.11</td>
<td>−1.25</td>
<td>−0.67</td>
<td>−1.14</td>
<td>−0.06</td>
<td>−0.11</td>
</tr>
<tr>
<td>Aukarimov N.D.</td>
<td>−0.76</td>
<td>1.02</td>
<td>1.16</td>
<td>0.77</td>
<td>0.73</td>
<td>−0.11</td>
<td>−1.34</td>
<td>1.26</td>
<td>1.13</td>
<td>−1.25</td>
</tr>
<tr>
<td>Nurpeisova S.I.</td>
<td>−0.51</td>
<td>−1.25</td>
<td>−0.77</td>
<td>−1.16</td>
<td>−0.42</td>
<td>1.02</td>
<td>1.34</td>
<td>0.66</td>
<td>−0.48</td>
<td>1.02</td>
</tr>
<tr>
<td>Jantasov D.</td>
<td>0.76</td>
<td>−1.25</td>
<td>−0.29</td>
<td>−1.16</td>
<td>−1.57</td>
<td>−1.25</td>
<td>0.00</td>
<td>0.06</td>
<td>−1.92</td>
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<tr>
<td>Jetenova Zh.S.</td>
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<td>−0.11</td>
<td>0.19</td>
<td>0.77</td>
<td>−1.19</td>
<td>−0.11</td>
<td>0.67</td>
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<td>−1.25</td>
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<tr>
<td>Chingisov KH.B.</td>
<td>0.00</td>
<td>1.02</td>
<td>0.67</td>
<td>0.77</td>
<td>0.34</td>
<td>1.02</td>
<td>−0.67</td>
<td>0.54</td>
<td>0.31</td>
<td>1.02</td>
</tr>
</tbody>
</table>

### Table 3: Matrix of correlation.

<table>
<thead>
<tr>
<th>Features</th>
<th>Age</th>
<th>State health on a visual impairment</th>
<th>Visual acuity</th>
<th>Cognitive activity</th>
<th>Physiological potential</th>
<th>Technology of reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>1.00</td>
<td>0.03</td>
<td>−0.03</td>
<td>0.08</td>
<td>0.40</td>
<td>−0.01</td>
</tr>
<tr>
<td>State health on a visual impairment</td>
<td>0.03</td>
<td>1.00</td>
<td>0.56</td>
<td>0.09</td>
<td>0.51</td>
<td>0.33</td>
</tr>
<tr>
<td>Visual acuity</td>
<td>−0.03</td>
<td>0.56</td>
<td>1.00</td>
<td>0.14</td>
<td>0.25</td>
<td>0.33</td>
</tr>
<tr>
<td>Cognitive activity</td>
<td>0.08</td>
<td>0.09</td>
<td>0.14</td>
<td>1.00</td>
<td>−0.20</td>
<td>0.51</td>
</tr>
<tr>
<td>Physiological potential</td>
<td>0.4</td>
<td>0.51</td>
<td>0.25</td>
<td>−0.20</td>
<td>1.00</td>
<td>0.14</td>
</tr>
<tr>
<td>Technology of reading</td>
<td>−0.01</td>
<td>0.33</td>
<td>0.33</td>
<td>0.51</td>
<td>0.14</td>
<td>1.00</td>
</tr>
</tbody>
</table>
ment, visual acuity, logical thinking, cognitive activity, psychological, strong-willed potential, physiological potential, motivational potential, technology of reading and perception of information. It is necessary to implement a reduction of low informative features for each learner.

The purpose of this article is the compression of a matrix of basic data for receiving optimum quantity of factors. We will receive a matrix of the standardized data of \( B = (b_{ij}) \) of dimension \( 10 \times 10 \) (Table 1) from an initial matrix of \( A = (a_{ij}) \).

Further the correlation coefficients are defined between all variables (Table 2). Allocation of main components and distribution of the corresponding dispersions are given in Table 3. Then the percent of dispersion is calculated and the saved-up percent is calculated. Below is a graph of component of eigenvalues (Figure 3).

![Graph of component of eigenvalues](image)

**Figure 3:** The graph of component of eigenvalues.

After the analysis of Table 3 and Fig. 3 are allocated the most informative features by using the reduction of the low informative features. We group the remained informative features in factors. Essential four factors are allocated.

In order to find the eigenvalues \( \lambda_1=3.422; \lambda_2=2.271; \lambda_3=1.615; \lambda_4=1.001 \) weighted normalized eigenvectors are:

\[
\begin{align*}
z_1 & =(-0.42; 0.21; 0.12; 0.64; -0.39; 0.57); \\
z_2 & =(0.42; 0.79; 0.67; 0.22; 0.74; 0.46); \\
z_3 & =(-0.64; -0.34; -0.36; 0.54; -0.08; -0.04); \\
z_4 & =(-0.13; 0.21; -0.44; -0.27; 0.78; -0.56). \\
\end{align*}
\]

Following the matrix of factorial loadings \( F \) is formed (Table 4). Where rows correspond to informative features, and the columns of the selected factors.

Analyzing of the results of Table 4 it is possible to allocate 3 factors: intellectual potential of learner, the assimilation of information, taking into account peculiari-

Table 4: Allocation main component and distribution of the corresponding dispersions.

<table>
<thead>
<tr>
<th>The eigenvalues</th>
<th>% of dispersion</th>
<th>The saved-up %</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.422</td>
<td>34.219</td>
<td>34.219</td>
</tr>
<tr>
<td>2.271</td>
<td>22.715</td>
<td>56.934</td>
</tr>
<tr>
<td>1.615</td>
<td>16.155</td>
<td>73.088</td>
</tr>
<tr>
<td>1.001</td>
<td>10.010</td>
<td>83.098</td>
</tr>
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<td>0.710</td>
<td>7.103</td>
<td>90.201</td>
</tr>
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<td>0.353</td>
<td>3.534</td>
<td>93.736</td>
</tr>
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<td>0.318</td>
<td>3.184</td>
<td>96.920</td>
</tr>
<tr>
<td>0.238</td>
<td>2.377</td>
<td>99.297</td>
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<tr>
<td>0.070</td>
<td>0.703</td>
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<td>9.859</td>
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</tbody>
</table>

Table 5 shows the scale factor matrix from which it is clear that Nurpeisova S.I. has a good intellectual potential, Sultangazina N. O. and Aukarimova N. D. have assimilation of information taking into account feature of vision, Erbolova R.E., Mussina A.K. and Zhantasov D.T. have high motivation.

The appropriate trajectory of learning and mode of supply of learning material based on the characteristics of each VIP to improve the quality and effectiveness of learning are selected based on these results. Based on the results system select the appropriate trajectory of learning and teaching material supply mode considering the characteristics of each VIP to improve the quality and effectiveness of learning.

Further, the learning model is adapted to model of learner and constructed based on fuzzy logic. The fuzzy logic used in classifying learners by the results of the questionnaire and on the level of knowledge of VIP are selected learning class: entry, mean and continuing levels. The obtained data is recorded in the database. After studying a particular course on the chosen level, VIP passes intermediate test, according to the results of the intermediate testing is carried predicting outcomes based on learning NFL. The system offers three options: further learning, relearning and the completion of the course. If VIP showed good results and ready for the next level of development further learning is selected. The completion of the course is offered if VIP fully has mastered the all the levels proposed course. After completing the course PIV received a certificate. Relearning course is offered if VIP could not master the selected level of course.
5 Discussions

The conducted researches and numerous publications on this subject prove relevance of development of Smart-systems of DL based on modern innovative intellectual technologies.

Development of the combined ontological model for creation of Smart-system of distance learning of visually impaired people using intellectual and statistical methods is perspective direction in the educational environment. This approach helps to systematize and structure functioning of Smart-system of DL, and also allows to use effectively educational resources, to choose an individual trajectory of learning (based on the use of application of a principal component analysis, which helps to take from multidimensional data the main features the characterizing VIP.), to work at convenient speed, promotes the solution of the psycho-physiological problems learners with a visual impairment, lifts temporary and spatial restrictions. The various options of giving learning material that take into account features of sight are offered (the choice of color schemes, information locations on the monitor depending on psycho-physiological features of understanding of information and features of sight, etc.). The distance access of VIP and also the possibility to perform laboratory and practical work on the expensive equipment in LJV are provided.

Table 5: Matrix of factorial loadings.

<table>
<thead>
<tr>
<th>Features</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Age</td>
<td>−0.42</td>
<td>0.42</td>
<td>0.64</td>
<td>−0.13</td>
</tr>
<tr>
<td>2 State health on a visual impairment</td>
<td>0.21</td>
<td>0.79</td>
<td>−0.34</td>
<td>0.21</td>
</tr>
<tr>
<td>3 Visual acuity</td>
<td>0.12</td>
<td>0.67</td>
<td>−0.36</td>
<td>−0.04</td>
</tr>
<tr>
<td>4 Cognitive activity</td>
<td>0.64</td>
<td>0.22</td>
<td>0.54</td>
<td>−0.27</td>
</tr>
<tr>
<td>5 Physiological potential</td>
<td>−0.39</td>
<td>0.74</td>
<td>−0.08</td>
<td>0.07</td>
</tr>
<tr>
<td>6 Technology of reading</td>
<td>0.57</td>
<td>0.46</td>
<td>−0.04</td>
<td>−0.56</td>
</tr>
</tbody>
</table>

6 Conclusions

The offered system is realized using at KazNSTU named after K.I. Satpayeva use of National scientific laboratory of joint information and space technologies and perhaps integrated as a component into the Modular Object-Oriented Dynamic Learning Environment (MOODLE) system.

When the developed software is received the certificate on the state registration of the rights for object of copyright [26].

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