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Contents

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DEVELOPMENT OF DIGITAL LITERACY OF STUDENTS WITH DISABILITIES

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Abstract. The article is devoted to the formation of digital literacy in teaching children with disabilities on the basis of two components: digital user component, digital correction-intellectual component, which are developed by the authors. Discussed the importance of the state program "Digital Kazakhstan" and one of these areas of human capital. Described by the authors created a course on computer science aimed at improving the digital literacy of students with disabilities. The main research methods are the theoretical analysis of educational and methodological, scientific literature and Internet content on digital literacy, and components of digital literacy, generalization of practical experience in the formation and development of digital literacy of students with disabilities. The content of digital literacy of students with disabilities was investigated, the thematic content of the educational sections of the course on the formation and development of digital literacy was substantiated, corresponding to the main components of digital literacy: digital user component, digital correction-intellectual component.

Keywords: education, digital literacy, computer science, students with disabilities, components of digital literacy.

Intoduction

Our world is moving to all new levels of technology development: electrification, informatization, and nowadays digitalization. A lot of analysis of research in the field of digitalization of education shows that the digitalization stage follows the computerization of education system. Digital literacy is a set of knowledge and skills that are necessary for the safe and effective use of digital technologies and Internet resources. Digital literacy is a necessary component of life skills of students in modern life. In modern conditions, information technology and digital transformation are the main factor of technological change and a condition for the provision of digital educational methodological complexes in education. In the Concept of modernization of Kazakhstani education, one of the main tasks of the educational process is the formation of a creative personality, independent in educational, artistic, labor, sports activities, the upbringing of a purposeful, hardworking student who strives for a healthy lifestyle, who knows how to plan his activities and independently acquire knowledge, ready to learning at all levels, with a new type of thinking. To implement this task, it is necessary to purposefully develop the cognitive interests, abilities and capabilities of the student, especially the student with disabilities, as well as develop their digital literacy.

Research

In Kazakhstan, the digitalization of education system is one of the leading trends in the process of its reform. In accordance with the State Program "Digital Kazakhstan" approved by the Decree of the Government of the Republic of Kazakhstan (December 12, 2017), a target indicator is provided to increase the level of digital literacy of the population by 2022 to 83% .2019 - 78.5% 2020 - 80 , 0% 2021 - 81.5%. According to the State Program "Digital Kazakhstan" digital literacy

consists of two group: basic and professional digital skills [1].

The first Basic digital skills include the following five competencies:

Basic digital skills, including confident use of a personal computer and laptop, mobile devices, the Internet, security and data protection;

Skills of using "e-government" and public services, including obtaining the necessary electronic government services "online" without leaving home;

Skills for using Open Government, which includes using the four components of Open Government;

"Electronic commerce" skills, which include the skills of purchasing, selling and promoting goods and services "online";

Information security skills, including the protection of personal data, protection of PCs, tablets, smartphones, etc., protection on the Internet, protection during financial transactions.

The second Professional digital skills include five basic digital skills competencies and:

Media skills - skills in using digital devices (digital cameras, camcorders, etc.);

Professional digital skills - the skills of using software and hardware solutions in professional activities.

One of the direction of development of the state program "Digital Kazakhstan" is the development of human capital. This means that the development of new competencies and digital literacy of the population will be possible thanks to innovations in education. Digital literacy should be developed in connection with the general tasks of education, if the use of ICT was a basic skill, now the formation of digital skills should be included in the school curriculum. It seems that digital literacy has a beneficial effect on the formation of other basic skills and competencies of students with disabilities. In all countries of the world and in all social groups of society, there are people with disabilities. Their number in the world is significant and continues to grow. For example, currently, 139,887 people in Kazakhstan have special educational needs. Of them 37970 - preschoolers, 95497 - students of secondary education, 2900 - recipients of POO, 3520 - students of universities [2]. In the traditional Kazakhstani education system for children with one form or another of disabilities, children with developmental disabilities receive education in special (correctional) educational institutions, at home or in special boarding schools.

In order to form and develop digital literacy of children with disabilities, we must determine the components of digital literacy, taking into account their psychological, pedagogical and physiological abilities. There are different criteria in the components of digital literacy development. For example, renowned media scientist Henry Jenkins believes that digital literacy includes the ability to work with a computer as "hardware", understanding the characteristics of the device and distribution of digital information, understanding the structure of the network community and the characteristics of social media. And also G. Jenkins et al. Believe that digital literacy depends on the formation of three types of skills:

• skills in interacting with a computer and any other devices with which you can go online or create digital artifacts;

• skills of interaction with software, which provide the ability to work with content;

• universal skills in working with digital technologies, including design, development of a digital online or offline environment [3].

Further in the research of the famous scientist in the field of education and in the field of digital literacy Doug Belshaw in his book called "Basic elements of digital literacy" [4], which testifies to the presence of various models of this digital literacy and made eight components as the basis for the qualitative interaction of a person with a digital:

Cultural component;

Cognitive component;

Constructive component;

Communicative component;

Confident use;

Creativity;

Using analytical skills and digital content assessment skills;

Civilian component

The authors of different concepts of digital literacy agree on only one understanding of how digital reality works, can teach a person to control the information environment and make interaction with digital technologies. In addition to the authors, we consider the components of digital literacy from the point of view of world organizations in the field of education (table 1).

Table 1. Comparison of the components of digital literacy according to the some World Organization

JISC - Joint Information Systems Committee	UNESCO - United Nations Educational, Scientific and Cultural Organization	AECT - Association for Educational Communications and Technology
1. Media literacy	1. Access to information	1. Search
2. Communication and collaboration	2. Information management	2. Placement
3. Career and personality management	3. Evaluation of information	3. Accessibility
4. ICT literacy	4. Integration	4. Management
5. Reading skills	5. Formation of new knowledge	5. Integration
6. Digital learning experience	6. Communication	6. Evaluation
7. Information literacy		7. Analysis
		8. Synthesis

Digital literacy: a conceptual framework.

JISC – (Joint Information Systems Committee) has identified that Digital literacy is the capabilities which fit an individual for living, learning and working in a digital society. Digital literacy looks beyond functional IT skills to describe a richer set of digital behaviors', practices and identities. What it means to be digitally literate changes over time and across contexts, so digital literacies are essentially a set of academic and professional situated practices supported by diverse and changing technologies [5].

UNESCO - According to the working definition, agreed at the UNESCO June 2003 Expert Meeting in Paris, "literacy is the ability to identify, understand, interpret, create, communicate, compute and use printed and written materials associated with varying contexts. Literacy involves a continuum of learning in enabling individuals to achieve their goals, to develop their knowledge and potential, and to participate fully in their community and wider society." (UNESCO, 2004) [6].

AECT (Association for Educational Communications and Technology) - has identified that Digital literacy is the use of high technology in everyday life. A digitally literate person may use specific hardware such as a computer, a cell phone, or other digital resource in combination with

communication software, such as the Internet, to interact with society at large, thus becoming a digital citizen or e-citizen and improving social and economic opportunities [7].

Outcomes

In the course of the study, taking into account the author's recommendations of various scientists on the components of digital literacy, we formulated a separate approach to increasing digital literacy in computer science for students with hearing impairment:

Digital user component. In this component students will able to know the Engineering training (ex.: software installation, uninstallation, upgrade, cleaning, etc.);

Digital correction-intellectual component. Improving students' skills: cognitive, logical, critical, creative, systems thinking, memory, imagination, attention, speech, communication through various tasks and programs.

The integration of digital technologies into the educational process distinguishes four levels of such changes in accordance with the SAMR model: Substitution-Augmentation-Modification-Redefinition Model. Bridging the digital divide in education requires moving from digital technologies at the lower levels of the SAMR model (Substitution and Improvement) to digital technologies at the upper levels of this model (Change and Transformation).

In this regard, the strategy for the formation of digital literacy of students with disabilities should include work to reduce inequality in access to digital technologies by developing an information and educational environment.

In the school course, the task of forming and developing digital literacy of students was considered as part of the subject Informatics. The educational process, organized in informatics classes, should ensure the formation of students' readiness for creative self-development and the acquisition of new knowledge. For the development of digital literacy in the subject of computer science, it is important to organize additional courses. Therefore, the authors have compiled their courses in computer science that cover all of the above components of digital literacy. As part of the additional course in Informatics, special attention is paid to the study of issues related to computer graphics, the creation of a 3D model, the development of mobile applications, the creation of projects in the MS Project environment, as well as the configuration and settings of a computer, work in different programs, work with information resources of the network, application Internet services. So, our course was developed on the basis of modular technologies and is divided into four main modules (table 2).

Table 2. Course module

Module	Description	Teaching methods
1. Engineering and technical training	Installing, starting, removing, updating programs. Installing the operating system. Increase the speed of a computer. Working with drivers and peripheral devices. Remote computer control	method for solving engineering and design problems
2. Computer graphics and 3D modeling	Explanation of the concept of computer graphics. Types. Areas of application. Significance. Software for working with computer graphics. Description of 3D modeling. Examples.	Creation and design of objects
3. Creating a mobile application	Origin, history, interesting facts about mobile technologies and applications. Ways to create mobile applications.	Method of projects
4. Digital research project	Students use computer programs on a variety of topics and develop projects using different methods.	Individual, group work

Moreover, methodological support for the development of students' cognitive capabilities has been developed such as: collections of practical tasks, lesson materials, lesson scenes, presentations, videos, a set of materials for self-examination, guidelines for work and other materials. When developing the course, new educational methods and technologies were used: Information and communication technology, Project technology, Technology for the development of critical thinking.

For example using the Project technology students make practical creative tasks that require students to use them to solve problematic tasks, knowledge of the material at this stage.

The topics of this course are fully focused on the formation of the personal characteristics of a graduate who owns the basics of scientific methods of knowing the world around him, motivated to be creative and innovative, gaining new knowledge, willingness to cooperate in any situations, able to carry out educational research, design and information and cognitive activities ; realizing himself as a person, a socially active citizen of the country.

We use Marzano's taxonomy to describe and evaluate learning outcomes. Currently there are different types of taxonomy for assessing educational outcomes, such as Bloom, Marzano, Fink, SOLO etc. For example we will discuss the Taxonomy Robert Marzano, developed the "New Taxonomy of Educational Objectives". Designed specifically to overcome the shortcomings of the widely used Bloom's Taxonomy and the current state of teaching in accordance with educational standards, Marzano's Thinking Model includes a variety of factors that influence the way students think and is a scientifically based theory designed to educate students. Marzano's taxonomy includes three systems: 1) Self-system. 2) The system of metacognition. 3) The cognitive system. Several operations are presented in the cognitive system of Marzano. In a situation where a new opportunity arises, the self-system decides whether it needs to continue the current line of behavior or start a new activity. The metacognition system sets goals and tracks how they are achieved, the cognitive system processes all the necessary information, the Knowledge Area contains the necessary content[8]. Marzano's taxonomy usually focuses on how students begin to learn new materials, how they begin the process of understanding, learning. Marzano's taxonomy is very useful in the development of new educational programs of study and for setting achievable goals in the development of new knowledge. In general, the ideas of the New Taxonomy are based on theories of cognitive skills and are judged to be more reliable and consumable than the old taxonomies.

Conclusion

The results of this study can be understood as the formation of digital literacy in teaching children with disabilities based on two components: a digital user component, a digital correctional and intellectual component. With the help of an additional course in informatics, which were developed by the authors of the article, aimed at increasing the digital literacy of students with disabilities, the thematic content of the educational sections of the course is substantiated. In the Digital user component, students will be able to learn about engineering training. For example: software installation, uninstallation, upgrade, cleaning, etc. In the Digital correction-intellectual component students will be able to improve their skills: cognitive, logical, critical, creative, systems thinking, memory, imagination, attention, speech, communication through various tasks and programs. For the development of digital literacy in the subject of computer science, it is important to organize additional courses. Therefore, the authors have compiled their courses in computer science that cover all of the above components of digital literacy. As part of the additional course in Informatics, special attention is paid to the study of issues related to computer graphics, the creation of a 3D model, the development of mobile applications, the creation of projects in the MS Project environment, as well as the configuration and settings of a computer, work in different programs, work with information resources of the network, application Internet services. So, our course was developed on the basis of modular technologies and is divided into four main modules: engineering and technical training, computer graphics and 3D modeling, creating a mobile application, digital research project. Overall, our results demonstrate a strong impact on the development of digital literacy for students with disabilities.

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STABILIZATION AND OPTIMUM CONTROL OF TWO-MACHINE SYSTEM

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Abstract. The article deals with the problem of optimal motion control of a two-machine system. The problems of stabilization and control of a two-machine system are described by nonlinear differential equations. These mathematical models describe the processes in complex systems consisting of many turbines and generators, and are used to analyze them. The relevance of these models lies in the fact that they allow you to model various pre-emergency, emergency and post-emergency situations. The stability of the synthesized system is checked by the Lyapunov function method. The correctness of the solutions found is verified by the numerical solution of the considered and given example.

The controllability of the model under consideration is determined by the study of the global asymptotic stability of dynamical systems in cylindrical phase systems. The results obtained are demonstrated by a numerical example.

Keywords: phase system, synchronous generator, steam turbine, Euler's method, optimal control, stability, method of Lyapunov function, numerical method.

Introduction

Consider a simplified model of the "synchronous generator – steam turbine" system described by differential equations of the form for the two-machine case:

$$\frac{d\delta_i}{dt} = S_i$$

$$T_{ji}\frac{dS_i}{dt} = P_{Ti} - K_i S_i - \left[\frac{E^2}{z_{11}}\sin\alpha_{11i} + \frac{EU_i}{z_{12}}\sin(\delta_i - \alpha_{12i})\right]$$

$$T_{Pi}\frac{dP_{Ti}}{dt} = -P_{Ti} + \rho_{0i}P_{0i} - \frac{P_{0i}}{\sigma_{0i}}S_i + u.$$

P_{Ti} – steam turbine power; T_{Pi} – time constant of the control cycle of the steam turbine; ρ_{0i}, P_{0i} – given constant values; σ_{0i} – statism of ASC (automatic speed controller); δ_i – EMF angle of the generator; S_i – generator slip; T_i – constant inertia of moving masses; $K_i > 0$ – damping coefficient; E_i – calculated EMF of the generator; U_i – voltage on tires of infinite power; z_{11i} – intrinsic resistance of the generator; z_{12i} – mutual resistance between the generator and tires; α_{11i} – additional angle of intrinsic resistance; α_{12i} – additional angle of mutual resistance.

Let the following parameters of the steam turbine control system be given:

$T_p = 251.2$, $\rho_0 = 0.994$, $P_0 = 10420$, $\sigma_0 = 0.06$

Carrying out the transfer of the origin of coordinates to the equilibrium position $(\sigma, S, P_T) = (0.686, 0, 10357.48)$, we pass to the system of equations of the perturbed motion:

$$\begin{aligned} &\frac{d\delta_1}{dt} = S_1, \quad \frac{d\delta_2}{dt} = S_2 \\ &\frac{dS_1}{dt} = C_1 P_1 - K_1 S_1 - \bar{f}_1(\delta_1) \\ &\frac{dS_2}{dt} = C_2 P_2 - K_2 S_2 - \bar{f}_2(\delta_2) \\ &\frac{dP_1}{dt} = -\bar{A}_1 P_1 + u_1, \quad \frac{dP_2}{dt} = -\bar{A}_2 P_2 + u_2. \end{aligned} \tag{1}$$

where $C_1 = 4.167 * 10^{-8}$, $C_2 = 4.167 * 10^{-8}$, $K_1 = 66.7 * 10^{-4}$, $K_2 = 66.7 * 10^{-4}$, $f_0 = 1.513 * 10^{-4}$, $\theta_0 = 0.3562$, $A_1 = 39.81 * 10^{-4}$, $A_2 = 39.81 * 10^{-4}$, $f_i(\delta_i) = f_0\left[\sin(\delta_i + \theta_0) - \sin\theta_0\right]$.

System (1) can be rewritten as:

$$\frac{dx}{dt} = A(t)x + B(t)u + f(t,u,x), \quad t \in [t_0, t_1], \quad x(t_0) = x_0.$$

where

$$A(t) = A = \begin{vmatrix} 0 & 1 & 0 \\ 0 & -K & C \\ 0 & 0 & \bar{A} \end{vmatrix}, \quad B(t) = B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix},$$

$$x(t) = \begin{bmatrix} \delta(t) \\ S(t) \\ P_T(t) \end{bmatrix}, \quad f(x,u,t) = f(x) = \begin{bmatrix} 0 \\ -\bar{f}(\delta) \\ 0 \end{bmatrix}.$$

as

$$\left|\bar{f}(\delta') - \bar{f}(\delta'')\right| - f_0\left|\sin(\delta' + \theta_0) - \sin(\delta'' + \theta_0)\right| \le f_0\left|\delta' - \delta''\right|,$$

then the function f(x) satisfies the Lipschitz condition:

$$\left|f(t,u^1,x^1) - f(t,u^2,x^2)\right| \le L_1\left|u^1 - u^2\right| + L_2\left|x^1 - x^2\right|,$$
$$\left(\forall u^1, u^2 \in \Omega \subseteq R^r, \forall x^1, x^2 \in G \subseteq R^n\right)$$

where $L_1 = 0, L_2 = 2f_0$. Linear stationary system:

$$\frac{dy}{dt} = Ay + Bv, \quad t \in [t_0, t_1], \quad y(t_0) = x_0, \quad (y \in R^n, v \in R^r) \tag{2}$$

completely controllable as the rank of the Kalman matrix

$$U = \left(B, AB, A^2B\right) = \begin{pmatrix} 0 & 0 & C \\ 0 & C & -\bar{A}C \\ 1 & -\bar{A} & \bar{A}^2 \end{pmatrix}$$ is equal to 3.

We calculate the fundamental matrix (2). The characteristic matrix $\lambda E_3 - A$ will be equal to:

$$\lambda E_3 - A = \begin{pmatrix} \lambda & -1 & 0 \\ 0 & \lambda + K & -C \\ 0 & 0 & \lambda + \bar{A} \end{pmatrix}$$ and characteristic determinant: $\Delta(\lambda) = \det\left(\lambda E_3 - A\right) = \lambda\left(\lambda + K\right)\left(\lambda + \bar{A}\right)$.

The matrix attached to the matrix $\lambda E_3 - A$ has the form:

$$ad_j\left(\lambda E_3 - A\right) = \begin{pmatrix} \left(\lambda + K\right)\left(\lambda + \bar{A}\right) & \lambda + \bar{A} & C \\ 0 & \lambda\left(\lambda + \bar{A}\right) & C\lambda \\ 0 & 0 & \lambda\left(\lambda + K\right) \end{pmatrix}$$

Common greatest divisor of the elements of the adjoint matrix: $D_2(\lambda) = 1$. The minimum polynomial of matrix A will be as follows:

$$\psi(\lambda) = \frac{\Delta(\lambda)}{D_2(\lambda)} = \lambda\left(\lambda + K\right)\left(\lambda + \bar{A}\right).$$

The values of the function $e^{\lambda t}$ on the spectrum of the matrix A will be

$$\left(e^{\lambda t}\right)_{\lambda=0} = 1, \left(e^{\lambda t}\right)_{\lambda=-K} = e^{-Kt}, \left(e^{\lambda t}\right)_{\lambda=-\bar{A}} = e^{-\bar{A}t}.$$

The interpolation conditions are as follows: $r(\lambda_1) = 1$, $r(\lambda_2) = e^{-Kt}$, $r(\lambda_3) = e^{-\bar{A}t}$. Where $\lambda_1 = 0$, $\lambda_2 = -K$, $\lambda_3 = -\bar{A}$ – the roots of the characteristic equation $\det\left(\lambda E_3 - A\right) = 0.$

Since for the considered matrix A:

$$\psi_1(\lambda) = \frac{\psi(\lambda)}{\lambda - \lambda_1} = \left(\lambda + K\right)\left(\lambda + \bar{A}\right),$$

$$\psi_2(\lambda) = \frac{\psi(\lambda)}{\lambda - \lambda_2} = \lambda\left(\lambda + \bar{A}\right),$$

$$\psi_3(\lambda) = \frac{\psi(\lambda)}{\lambda - \lambda_3} = \lambda\left(\lambda + K\right)$$

Then the Lagrange-Sylvester interpolation polynomial [4] has the form

$$r(\lambda)=\left(\frac{e^{\lambda t}}{(\lambda+K)(\lambda+\bar{A})}\right)_{\lambda=0}(\lambda+K)(\lambda+\bar{A})+\left(\frac{e^{\lambda t}}{\lambda(\lambda+\bar{A})}\right)_{\lambda=-K}\lambda(\lambda+\bar{A})+$$
$$+\left(\frac{e^{\lambda t}}{\lambda(\lambda+K)}\right)_{\lambda=-\bar{A}}\lambda(\lambda+K)=1+\beta_1(t)\lambda+\beta_2(t)\lambda^2$$

where $\beta_1(t)=\frac{K+\bar{A}}{K\bar{A}}-\frac{\bar{A}e^{-Kt}}{K(\bar{A}-K)}-\frac{Ke^{-\bar{A}t}}{\bar{A}(K-\bar{A})}$, $\beta_2(t)=\frac{1}{K\bar{A}}-\frac{e^{-Kt}}{K(\bar{A}-K)}-\frac{e^{-\bar{A}t}}{\bar{A}(K-\bar{A})}$.

Therefore,

$$e^{At}=E_3+\beta_1(t)A+\beta_2(t)A^2=\begin{pmatrix}1 & \beta_1-K\beta_2 & \beta_2 C\\ 0 & 1-K\beta_1+K^2\beta_2 & \beta_2 C-\bar{A}C\beta_2\\ 0 & 0 & 1-\bar{A}\beta_1+\bar{A}^2\beta_2\end{pmatrix}.$$

why,

$$\beta_1-K\beta_2=\frac{\bar{A}}{K\bar{A}}-\frac{\bar{A}e^{-Kt}}{K(\bar{A}-K)}+\frac{e^{-Kt}}{\bar{A}-K}=\frac{1}{K}\left(1-e^{-Kt}\right)$$

$$(\beta_1-\bar{A}\beta_2)C=\frac{C}{\bar{A}}\left(1-e^{-\bar{A}t}\right),\quad 1-K\beta_1+K^2\beta_2=e^{-Kt},\quad 1-\bar{A}\beta_1+\bar{A}^2\beta_2=e^{-\bar{A}t}.$$

Then we finally have:

$$\theta(t)=e^{At}\begin{pmatrix}1 & \frac{1}{K}\left(1-e^{-Kt}\right) & r_0-r_1e^{-Kt}+r_2e^{-\bar{A}t}\\ 0 & e^{-Kt} & \frac{C}{\bar{A}}\left(1-e^{-\bar{A}t}\right)\\ 0 & 0 & e^{-\bar{A}t}\end{pmatrix}.$$

where, $r_0=\frac{C}{K\bar{A}}$, $r_1=\frac{C}{K(\bar{A}-K)}$, $r_2=\frac{C}{\bar{A}(\bar{A}-K)}$. If $t_0=0$, then:

$\Phi(t,t_0)=\theta(t)$, $\Phi(t_0,t)=\theta^{-1}(t)$, $\theta(t_0)=E_3$, $\theta^{-1}(t_0)=E_3$ and $W(0,t)=\int_0^t e^{A(t-r)}BB^*e^{A^*(t-r)}dr$,

$W(0,t_1)=\int_0^{t_1} e^{A(t_1-r)}BB^*e^{A^*(t_1-r)}dr$.

In our case, the equations are written as follows:

$$\tilde{\delta}_i=\delta_{i-1}+hf(\delta_{i-1}),$$
$$\delta_i=\delta_{i-1}+h\frac{f(\delta_{i-1})+f(\tilde{\delta}_i)}{2},$$
$$\tilde{S}_i=S_{i-1}+hf(\delta_{i-1},S_{i-1},P_{i-1}),$$

$$S_i = S_{i-1} + h\frac{f\left(\delta_{i-1}, S_{i-1}, P_{i-1}\right) + f\left(\tilde{\delta}_i, \tilde{S}_i, \tilde{P}_i\right)}{2},$$

$$\tilde{P}_i = P_{i-1} + hf\left(P_{i-1}\right),$$

$$P_i = P_{i-1} + h\frac{f\left(P_{i-1}\right) + f\left(\tilde{P}_{i-1}\right)}{2}.$$

It is also easy to calculate the inverse matrix $\theta^{-1}(t)$:

$$\theta^{-1}(t) = e^{At} = \begin{pmatrix} 1 & \frac{1}{K}\left(1-e^{Kt}\right) & l_1\left(e^{\bar{\lambda}_1 t} - e^{Kt}\right) - l_2 e^{\bar{A}t} + r_1 e^{\lambda_2 t} + l_3 \\ 0 & e^{Kt} & l_4\left(e^{Kt} - e^{\bar{\lambda}_1 t}\right) \\ 0 & 0 & e^{-\bar{A}t} \end{pmatrix}$$

Numerical calculation.

Predictor: $\tilde{y}_i = y_{i-1} + hf\left(x_{i-1}, y_{i-1}\right)$. Corrector: $y_i = y_{i-1} + h\frac{f\left(x_{i-1}, y_{i-1}\right) + f\left(x_i, \tilde{y}_i\right)}{2}$.
The results are shown below:

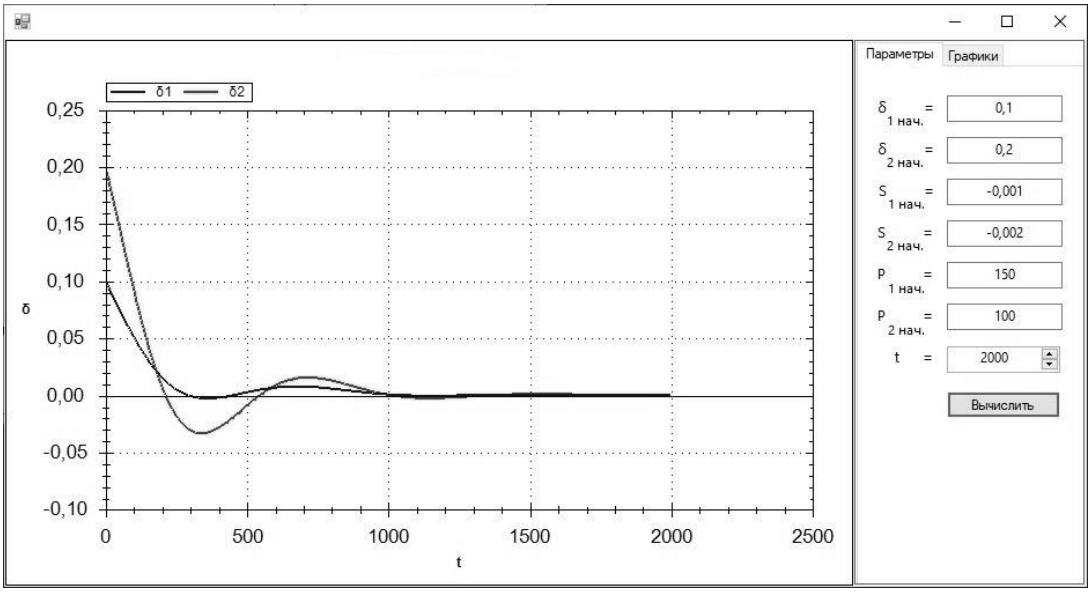

Figure 1 - δ1, δ2

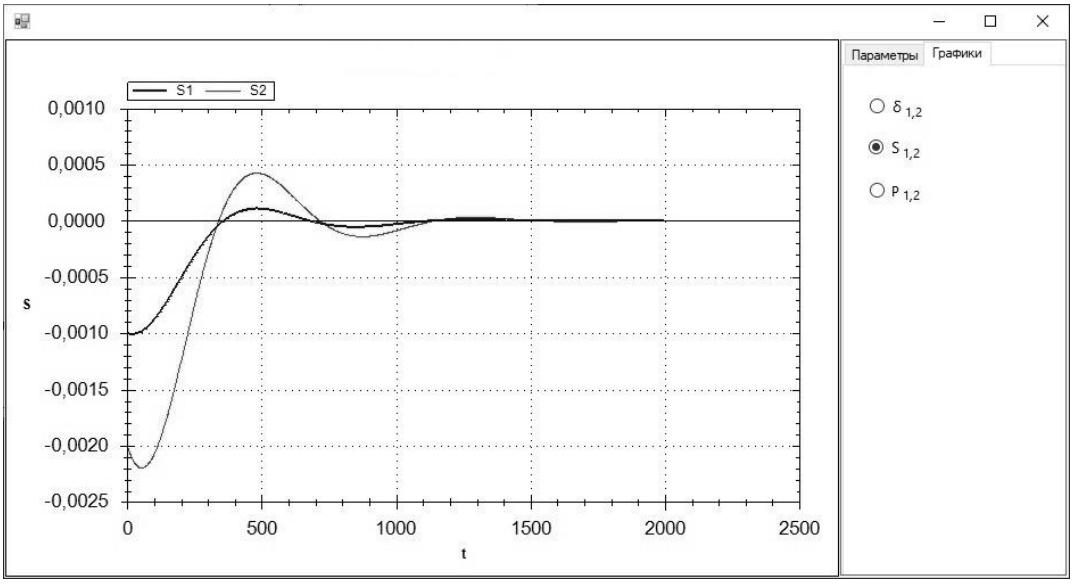

Figure 2 - S1, S2

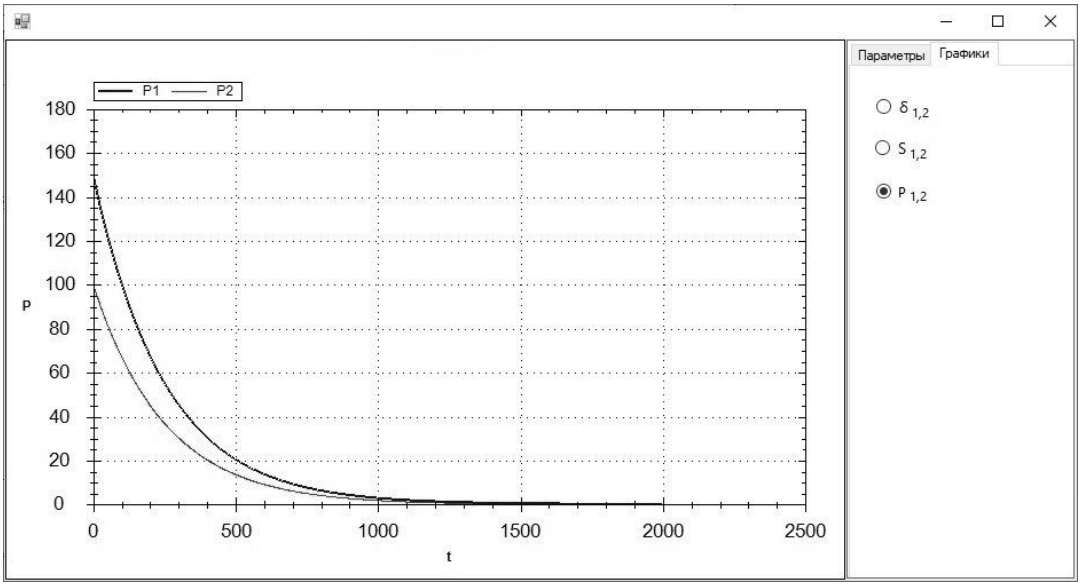

Figure 3 - P1, P2

Consider the problem of optimal motion control of two-machine system. The stability of the synthesized system is tested by the Lyapunov function method. The correctness of the solutions found is verified by the numerical solution of the considered and the example.

One of the mathematical models that describes transient processes in a two-machine electrical system is the following system of differential equations:

$$\begin{aligned} \frac{d\delta_1}{dt} &= S_1 \\ \frac{d\delta_2}{dt} &= S_2 \\ H_1 \frac{dS_1}{dt} &= -E_1^2 Y_{11} \sin\alpha_{11} - P_1 \sin\left(\delta_1 - \alpha_1\right) - P_{12} \sin\left(\delta_{12} - \alpha_{12}\right) + u_1 \end{aligned} \tag{3}$$

$$H_2 \frac{dS_2}{dt} = -E_2^2 Y_{22} \sin\alpha_{22} - P_2 \sin\left(\delta_2 - \alpha_2\right) - P_{21} \sin\left(\delta_{21} - \alpha_{21}\right) + u_2$$

$$\delta_{12} = \delta_1 - \delta_2,\ \delta_{21} = \delta_2 - \delta_1,\ P_1 = E_1 U Y_{1,n+1},\ P_{12} = E_1 E_2 Y_{12}$$

where δ_i – the angle of rotation of the rotor of the i-th generator relative to some synchronous axis of rotation, S_i – slip of the i-th generator, H_i – constant of inertia of the i-th machine; $u_i = P_{Ti}$ – mechanical power supplied to the generator; E_i – EMF of the i-th synchronous machine, $U = const$ – DC bus voltage; $Y_{1,n+1}$ – characterizes the connection of the i-th generator with constant voltage buses; Y_{ij} – mutual conductivity of the i-th and j-th branches of the system; $\alpha_{ii}, \alpha_i, \alpha_{ij}$ – constant values that take into account the effect of active resistances in the stator circuits of generators; $\alpha_{ij} = \alpha_{ji}$.

Let the state variables and control in the steady-state post-emergency mode have the following meanings:

Si = 0, $\delta_i = \delta_i^F$, $u_i = u_i^F$, i = 1, 2.

Perturbed motion equations:

$$\begin{aligned}
\frac{d\delta_1}{dt} &= S_1 \\
\frac{dS_1}{dt} &= \frac{1}{H_1}\left[-f_1\left(\delta_1\right) - N_1\left(\delta\right) - M_1\left(\delta\right) + u_1\right] \\
\frac{d\delta_2}{dt} &= S_2 \\
\frac{dS_2}{dt} &= \frac{1}{H_2}\left[-f_2\left(\delta_2\right) - N_1\left(\delta\right) - M_1\left(\delta\right) + u_2\right]
\end{aligned} \tag{4}$$

where

$$f_1\left(\delta_1\right) = P_1\left[\sin\left(\delta_1 + \delta_1^F - \alpha_1\right) - \sin\left(\delta_1^F - \alpha_1\right)\right],$$

$$f_2\left(\delta_2\right) = P_2\left[\sin\left(\delta_2 + \delta_2^F - \alpha_2\right) - \sin\left(\delta_2^F - \alpha_2\right)\right],$$

$$N_1\left(\delta\right) = \Gamma_1\left[\sin\left(\delta_{12} + \delta_{12}^F\right)\right]$$

$$M_1\left(\delta\right) = \Gamma_2\left[\sin\left(\delta_{12} + \delta_{12}^F\right)\right]$$

where $\delta_{12}^F = \delta_1^F - \delta_2^F$, $\Gamma_1 = P_{12}\cos\alpha_{12}$, $\Gamma_2 = P_{12}\sin\alpha_{12}$.

Numerical data of the system:

$\delta_1 = -0.052$, $\delta_2 = -0.104$, H_1=2135, H_2=1256, P_1=0.85, P_2=0.69, δ_1^F=0.827, δ_2^F =0.828, $\alpha_{12} = -0.078$ and initial conditions:

$\delta_1\left(0\right) = 0.18$, $\delta_2\left(0\right) = 0.1$, $S_1\left(0\right) = 0.001$, $S_2\left(0\right) = 0.002$.

Consider the following optimal control problem: minimize functionality

$$J\left(\nu\right) = J\left(\nu_1, ..., \nu_l\right) = \frac{1}{2}\int_0^T \sum_{i=1}^{l}\left(w_{si} S_i^2 + w_{\nu i}\nu_i^2\right)dt + \Lambda\left(\delta\left(T\right)S\left(T\right)\right) \tag{5}$$

under conditions:

$$\begin{aligned}&\frac{d\delta_i}{dt}=S_i\\&\frac{dS_i}{dt}=\frac{1}{H_i}\left[-f_i(\delta_i)-N_i(\delta)-M_i(\delta)+\nu_i\right]\end{aligned},\qquad(6)$$

$i=\overline{1,l}$, $t\in[0,T]$, $\delta=(\delta_1,...,\delta_l)$, $S=(S_1,...,S_l)$

where w_{si}, w_{vi} – positive constant weight coefficients; $f_i(\delta_i)$ – 2π – periodic continuously differentiable function; $N_i(\delta)$ – 2π – periodic continuously differentiable function with respect to δ_{ij}; with respect to the term $N_i(\delta)$ the integrability condition is satisfied

$$\frac{\partial N_i(\delta)}{\partial\delta_k}=\frac{\partial N_k(\delta)}{\partial\delta_i}\qquad(\forall i\neq k)\qquad(7)$$

T – the duration of the transient is considered unknown.
Given initial conditions are:

$$\delta_i(0)=\delta_{i0},\ S_i(0)=S_{i0},\ \ i=\overline{1,l}\qquad(8)$$

and $\delta(T), S(T)$ unknown in advance.

Theorem 1. For the control $v_i^0(S_i)=-\frac{1}{w_{vi}}S_i$, $i=\overline{1,l}$ and the corresponding solution of system (6) - (8) to be optimal, it is necessary and sufficient that $\Lambda(\delta(T),S(T))=K(\delta(T),S(T))$ and $w_{Si}=2D_i+\frac{1}{w_{vi}}>0,\ \ i=\overline{1,l}$ where

$K(\delta,S)=\frac{1}{2}\sum_{i=1}^{l}H_iS_i^2+\sum_{i=1}^{l}\int_0^{\delta_i}f_i(\delta_i)d\delta_i+\sum_{i=1,\delta_j=0,\,j>i}^{l}\int_0^{\delta_i}N_i(\delta_1,...,\delta_{i-1},\xi_i,\delta_{i+1},...,\delta_l)\,d\xi_i$ – Bellman function, at that

$$J(v^0)=\min_v J(v)=K(\delta_0,S_0).\qquad(9)$$

Evidence

For a continuous function $K(\delta(t),S(t))$ of the variable t-functional (5) can be represented as:

$$J(v)=J(\delta(t),S(t),v(t))=\int_0^T R(\delta(t),S(t),v(t))dt+m_0(\delta(0),S(0))+m_i(\delta(T)S(T))$$

where

$$R(\delta,S,\nu)=\sum_{i=1}^{l}\left[K_{\delta i}S_i+\frac{1}{H_i}K_{Si}\left(D_iS_i-f_i(\delta_i)-N_i(\delta)+f_i(\delta_i)+\nu_i\right)+\frac{1}{2}\left(w_{Si}S_i^2+w_{\nu i}\nu_i^2\right)\right] \quad (10)$$

where

$$K_{\delta i}=-\frac{\partial K}{\partial \delta_i},\ K_{Si}=-\frac{\partial K}{\partial S_i}. \quad (11)$$

To determine the Bellman function $K(\delta,S)$, consider the following Cauchy-Bellman problem:

$$\inf_{\nu} R(\delta,s,\nu)=0,\ 0\le t\le T,\ K\left(\delta(T),S(T)\right)=\Lambda\left(\delta(T),S(T)\right). \quad (12)$$

From the necessary condition for the extremum of the function $R(\delta,S,\nu)$ with respect to $\nu_i\in R_i^1$ we obtain

$$R_{\nu i}\equiv\frac{1}{H_i}K_{Si}+w_{\nu i}\nu_i=0,\quad i=\overline{1,l},$$

Therefore the optimal controls

$$\nu_i^0\equiv-\frac{1}{H_iw_{\nu i}}K_{Si},\ i=\overline{1,l}. \quad (13)$$

The function $K(\delta,S)$ and the weight coefficients $w_{si},w_{\nu i}$ are found from condition (12) i.e:

$$\bar{R}=\min_{\nu}R(\delta,S,\nu)=\sum_{i=1}^{l}\left[K_{\delta i}S_i-\frac{1}{H_i}K_{Si}\left(D_iS_i+f_i(\delta_i)+N_i(\delta)\right)-\frac{1}{2H_i^2}K_{Si}^2+\frac{1}{2}w_{Si}S_i^2\right]=0 \quad (14)$$

For this we put $K_{\delta i}S_i=\frac{K_{Si}}{H_i}\left(f_i(\delta_i)+N_i(\delta)\right),\ i=\overline{1,l}$ i.e.

$$K_{Si}=H_iS_i,\ K_{\delta i}=f_i(\delta_i)+N_i(\delta),\ i=\overline{1,l}.$$

Then, taking into account (15), from relation (14) we obtain that

$$\sum_{i=1}^{l}\left[-D_iS_i^2-\frac{1}{w_{\nu i}}S_i^2+\frac{1}{2}w_{Si}S_i^2\right]=0$$

or

$$w_{Si}=2D_i+\frac{1}{2w_{\nu i}}>0,\ w_{\nu i}>0,\ i=\overline{1,l}. \quad (15)$$

Moreover, from (13) we obtain that the optimal controls $\nu_i^0,\ i=\overline{1,l}$ have the form:

$$v_i^0(S_i) = -\frac{1}{w_{vi}} S_i, \; i = \overline{1,l}. \tag{16}$$

Let us now consider the question of how the Bellman function – K_{Si}, $K_{\delta i}$ can be determined, knowing the quotients $K(\delta, S)$. The integrability conditions(15) for the function $K(\delta, S)$ are equivalent to the condition (7). Really

$$\frac{\partial N_i(\delta)}{\partial \delta_k} = -\Gamma_{ik}^1 \cos\left(\delta_{ik} + \delta_{ik}^F\right),$$
$$\frac{\partial N_k(\delta)}{\partial \delta_i} = -\Gamma_{ki}^1 \cos\left(\delta_{ki} + \delta_{ki}^F\right) = -\Gamma_{ik}^1 \cos\left(\delta_{ik} + \delta_{ik}^F\right).$$

Consequently, the function $K(\delta, S)$ can be represented in the form:

$$K(\delta, S) = \frac{1}{2}\sum_{i=1}^{l} H_i S_i^2 + \sum_{i=1}^{l}\int_0^{\delta_i} f_i(\delta_i)\,d\delta_i + \sum_{\substack{i=1,\\ \delta_j=0,\, j>i}}^{l}\int_0^{\delta_i} N_i(\delta_1,...,\delta_{i-1},\xi_i,\delta_{i+1},...,\delta_i)\,d\xi_i =$$
$$= \frac{1}{2}\sum_{i=1}^{l} H_i S_i^2 + \sum_{i=1}^{l}\int_0^{\delta_i} f_i(\delta_i)\,d\delta_i + \int_0^{\delta_1}\sum_{j=1,\, j\neq i}^{l} \bar{N}_{1j}(\xi_1,0,...0)\,d\xi_1 +$$
$$= \int_0^{\delta_2}\sum_{j=1,\, j\neq i}^{l} \bar{N}_{2j}(\delta_1,\xi_2,0,...0)\,d\xi_2 + ... + \int_0^{\delta_l}\sum_{j=1,\, j\neq i}^{l} \bar{N}_{lj}(\delta_1,...,\delta_{l-1},\xi_l)\,d\xi_2. \tag{17}$$

Note that for the case l=2:

$$\int_0^{\delta_1} N_{12}(\xi_1,0)\,d\xi_1 + \int_0^{\delta_2} \bar{N}_{21}(\delta_1,\xi_2)\,d\xi_2 = \Gamma_{12}^1\left[-\cos\left(\delta_1+\delta_{12}^F\right) - \delta_1\sin\delta_{12}^F + \cos\delta_{12}^F\right] +$$
$$+\Gamma_{21}^1\left[-\cos\left(\delta_{12}+\delta_{12}^F\right) + \delta_2\sin\delta_{12}^F + \cos\left(\delta_1+\delta_{12}^F\right)\right] = \Gamma_{12}^1\left[-\cos\left(\delta_{12}+\delta_{12}^F\right) - \delta_{12}\sin\delta_{12}^F + \cos\delta_{12}^F\right].$$

On the other hand

$$\int_0^{\delta_{12}} N_{12}(\delta)\,d\delta = \int_0^{\delta_{12}} \Gamma_{12}^1\left[\sin\left(x+\delta_{12}^F\right) - \sin\delta_{12}^F\right]dx = \Gamma_{21}^1\left[-\cos\left(\delta_{12}+\delta_{12}^F\right) + \delta_{12}\sin\delta_{12}^F + \cos\delta_{12}^F\right].$$

therefore, for l = 2, as well as for any l> 2, the function $K(\delta, S)$ from (17) can be represented in the form:

$$K(\delta, S) = \frac{1}{2}\sum_{i=1}^{l} H_i S_i^2 + \sum_{i=1}^{l}\int_0^{\delta_i} f_i(\delta_i)\,d\delta_i + \sum_{j=2}^{l}\sum_{i=1}^{j-1}\int_0^{\delta_{ij}} N_{ij}(x)dx.$$

Observe, that in the region $\{\delta, S\}$, where $K(\delta, S)$ – is a definitely positive function, the Bellman function $K(\delta, S)$ becomes the Lyapunov function for the synthesized system (6), (16) i.e. the synthesized system is Lyapunov stable. According to the boundary condition, for the Bellman equation (12), we can take the function $\Lambda(\delta, S)$ in the form

$$\Lambda\left(\delta(T), S(T)\right) = K\left(\delta(T), S(T)\right)$$

and the value of the functional $J(\nu)$, will be equal to the value (9). The theorem is proved. According to the considered theorem, the optimal control has the form:

$$u_1 = -\frac{1}{w_1} S_1 - M_1(\delta),$$

$$u_2 = -\frac{1}{w_2} S_2 - M_2(\delta),$$

where $w_1 = 0.1$, $w_2 = 0.1$.

The results of the numerical solution of the equation are given below:

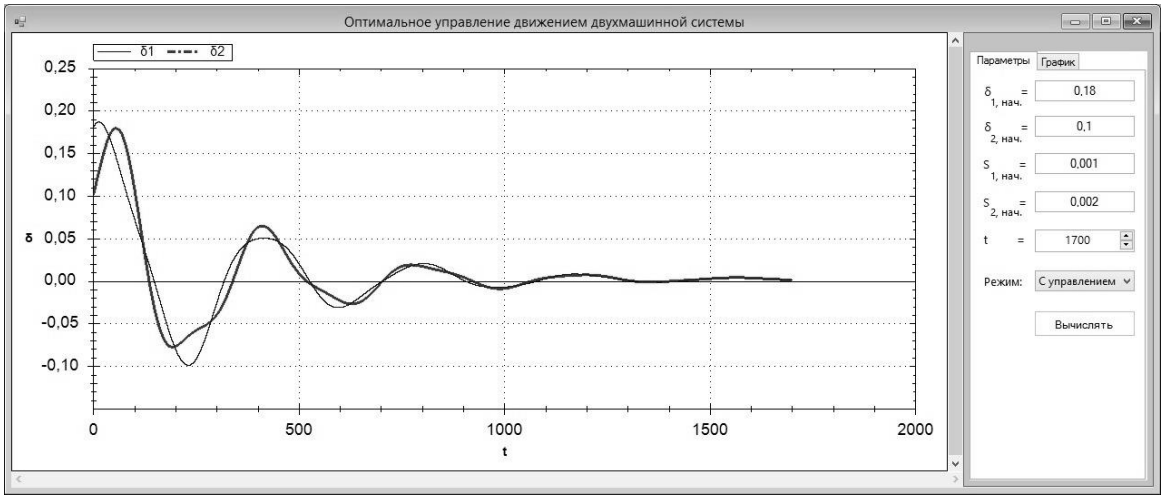

Figure 4 - δ1, δ2

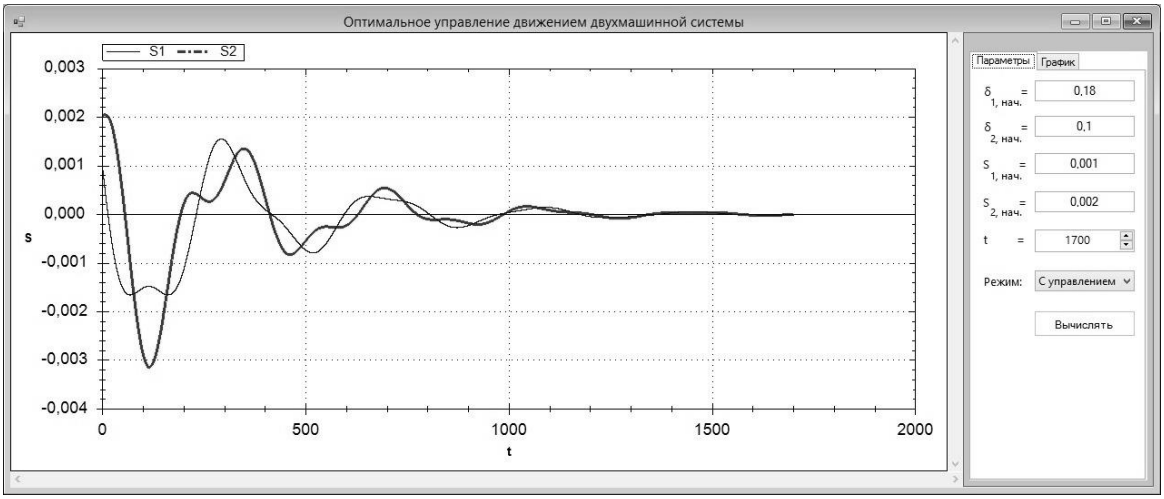

Figure 5 - S1, S2

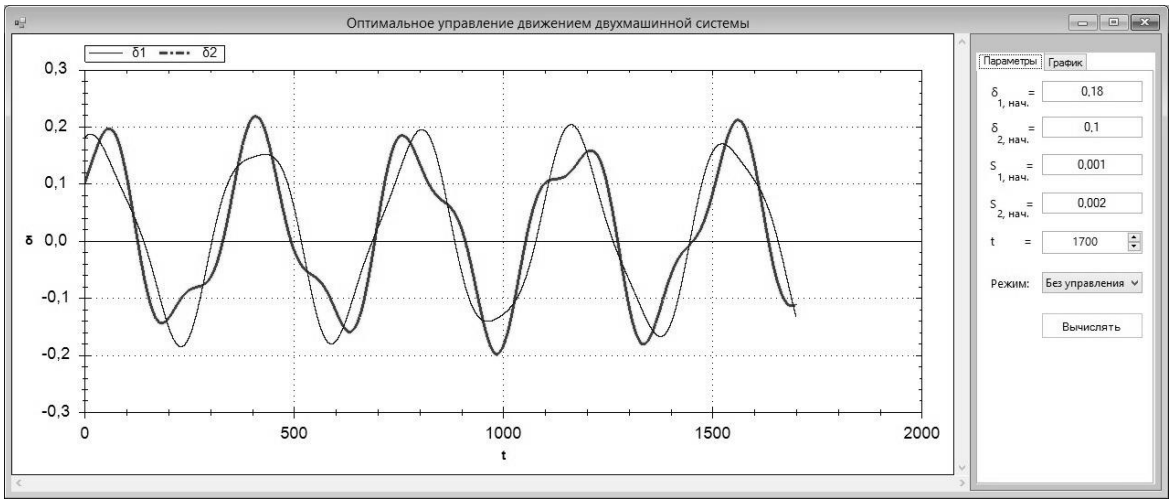

Figure 6 - δ1, δ2 – without control.

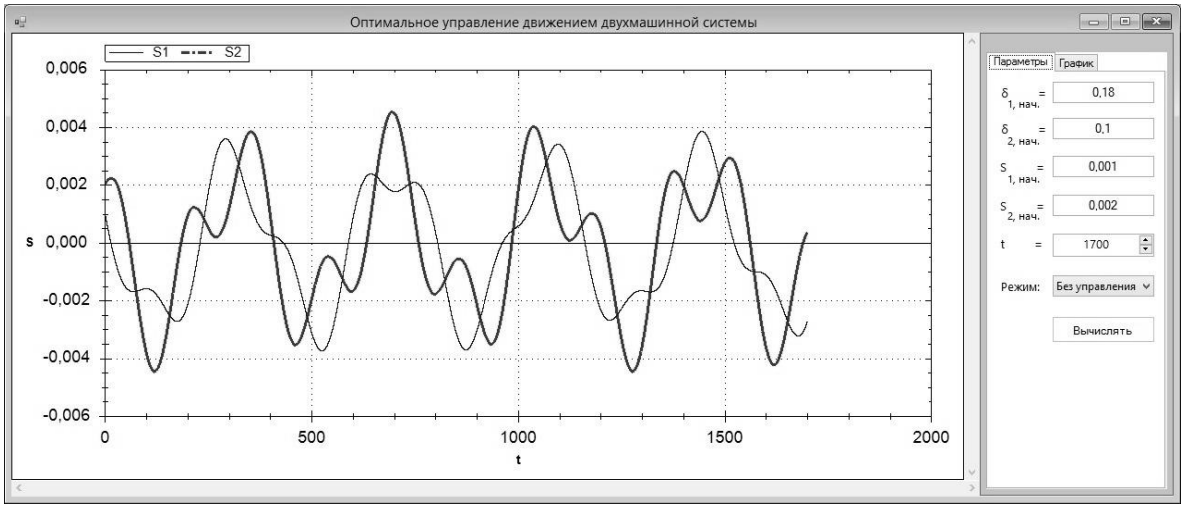

Figure 7 - S1, S2 – without control.

Conclusion

To check the accuracy of the obtained results created programs. Programs written in the C# programming language. For the numerical solution of the task is used modified Euler method. As

can be seen from the received graphs, the received controls ensure the stable operation of the system by minimizing the deviation of the system parameters from the primary values. And in case of lack of control the parameters of the system are deviated from the initial value and the system does not work stably.

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THREE- DIMENSIONAL SIMULATION IN THE SCALAR FUNCTION USING THE SIMPLEX ELEMENT

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Abstract. The finite element method is a numerical method for solving differential equations encountered in physics and technology. The emergence of this method is associated with the solution of space research problems. It was first published in the work of Turner, Cluj, Martin and Topp. This work contributed to the emergence of other works; a number of articles were published with examples of the finite element method to the problems of structural mechanics of continuous media.

The main idea of the finite element method is that any continuous quantity, such as temperature, pressure and displacement, can be approximated by a discrete model, which is built on a set of piece-continuous functions defined on a finite number of subdomains.

The finite element method has evolved from a numerical procedure for solving problems in structural mechanics into a general method for numerically solving a differential equation or a system of differential equations. This progress has been made over a fifteen-year period through the development of high-speed, digital computing machines needed for more accurate calculations of aircraft structures, as well as through "the assistance of the National Committee for Space Research. The computing machine has accelerated many complex numerical calculations. space required the allocation of funds for fundamental research and stimulated the improvement of universal computing programs.The finite element method is used in the design of aircraft, rockets, various spatial shells.

Key words: Finite element, pipe, motion, compression, lubrication, system, vibration, equilibrium, continuous value, discrete model, cross section, node.

Introduction

In the general case, the continuous quantity is unknown in advance, and it is necessary to determine the value of this quantity at some interior points of the region. A discrete model, however, is very easy to construct if we first assume that the numerical values of this quantity at each interior point of the region are known. After that, you can move on to the general case. For each element, its own polynomial is determined, but the polynomials are selected in such a way that the continuity of the value along the boundaries of the element is preserved.

The finite element method is based on the idea of approximating a continuous function by a discrete model, which is built on the set of piecewise continuous functions defined on a finite number of subdomains, called elements. A polynomial is most often used as an element function. The order of the polynomial depends on the number of continuous function data items used at each node.

Main part

A one-dimensional simplex element is a straight line segment of length L with two nodes, one at each end of the segment.

$$T = \varphi_1 T_1 + \varphi_2 T_2$$

$$\varphi_1 = \frac{x_2 - x}{L} \qquad \varphi_2 = \frac{x - x_1}{L}$$

A two-dimensional simplex element is a triangle with rectilinear sides and three nodes, one for each vertex requires logical numbering of element nodes.

$$T = \varphi_1 T_1 + \varphi_2 T_2 + \varphi_3 T_3$$

$$\varphi_1 = \frac{1}{2A}(a_1 + b_1 x + c_1 y)$$

$$\begin{cases} a_1 = x_2 y_3 - x_3 y_2 \\ b_1 = y_2 - y_3 \\ c_1 = x_3 - x_2 \end{cases}$$

$$\varphi_2 = \frac{1}{2A}(a_2 + b_2 x + c_2 y)$$

$$\begin{cases} a_2 = x_3 y_1 - y_3 y_1 \\ b_2 = y_3 - y_1 \\ c_2 = x_1 - x_3 \end{cases}$$

$$\varphi_3 = \frac{1}{2A}(a_3 + b_3 x + c_3 y)$$

$$\begin{cases} a_3 = x_1 y_2 - x_2 y_1 \\ b_3 = y_1 - y_2 \\ c_3 = x_2 - x_1 \end{cases}$$

$$2A = \begin{vmatrix} 1 & x_1 & y_1 \\ 1 & x_2 & y_2 \\ 1 & x_3 & y_3 \end{vmatrix}$$

We will consider a three-dimensional simplex element.

$$T = \varphi_1 T_1 + \varphi_2 T_2 + \varphi_3 T_3 + \varphi_4 T_4$$

Consider a three-dimensional function T (x, y, z), the value of which is given at the corner points of the parallelepiped. (1,2, ... 8) (1-T, 2-T, ... 8-T) (Fig. 1)

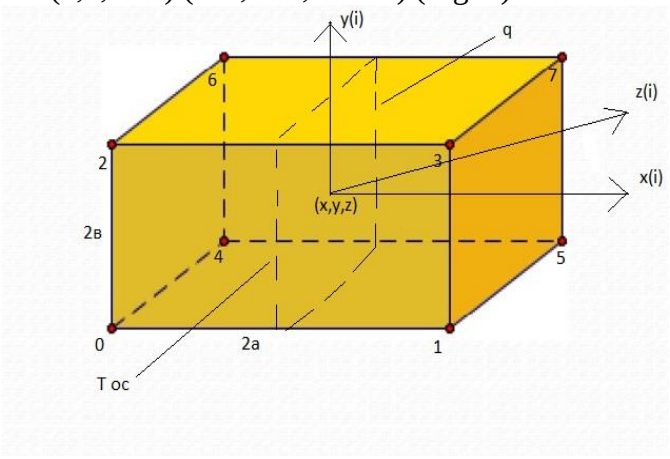

Figure 1- parallelepiped

If the length of the parallelepiped along the x→ 2a, along the y→ 2b, and along the z→ 2c, then the coordinates of the corner points relative to the center of the parallelepiped will be.

1- (-a; в; -c)= (x_1, y_1, z_1)
2- (a; в; -c)= (x_2, y_2, z_2)
3- (a; -в; -c)= (x_3, y_3, z_3)
4- (-a; -в; -c)= (x_4, y_4, z_4)
5- (-a; в; c)= (x_5, y_5, z_5)
6- (a; в; c)= (x_6, y_6, z_6)
7- (a; -в; c)= (x_7, y_7, z_7)
8-(-a; -в; c) = (x_8, y_8, z_8)

The value of the function T (x, y, z) to an arbitrary point (x, y, z) inside the parallelepiped is approximated as follows.

$$T(x,y,z) = \lambda_1 + \lambda_2 x_1 + \lambda_3 y_1 + \lambda_4 z_1 + \lambda_5 x_1 y_1 + \lambda_6 x_1 z_1 + \lambda_7 y_1 z_1 + \lambda_8 x_1 y_1 z_1 \quad (1)$$

To determine the constants Λ_i (i = 1; 8), we compose the following control system:

$$T_1 = T(x_1, y_1, z_1);\ T_2 = (x_2, y_2, z_2);\ T_3 = (x_3, y_3, z_3);$$
$$T_4 = T(x_4, y_4, z_4);\ T_5 = T(x_5, y_5, z_5);\ T_6 = T(x_6, y_6, z_6); \quad (2)$$
$$T_7 = T(x_7, y_7, z_7);\ T_8 = T(x_8, y_8, z_8);$$

Substituting the values of the arguments, we get the system of equations:

$$\begin{cases} \lambda_1 + \lambda_2 x_1 + \lambda_3 y_1 + \lambda_4 z_1 + \lambda_5 x_1 y_1 + \lambda_6 x_1 z_1 + \lambda_7 y_1 z_1 + \lambda_8 x_1 y_1 z_1 = T_1 \\ \lambda_1 + \lambda_2 x_2 + \lambda_3 y_2 + \lambda_4 z_2 + \lambda_5 x_2 y_2 + \lambda_6 x_2 z_2 + \lambda_7 y_2 z_2 + \lambda_8 x_2 y_2 z_2 = T_2 \\ \lambda_1 + \lambda_2 x_3 + \lambda_3 y_3 + \lambda_4 z_3 + \lambda_5 x_3 y_3 + \lambda_6 x_3 z_3 + \lambda_7 y_3 z_3 + \lambda_8 x_3 y_3 z_3 = T_3 \\ \lambda_1 + \lambda_2 x_4 + \lambda_3 y_4 + \lambda_4 z_4 + \lambda_5 x_4 y_4 + \lambda_6 x_4 z_4 + \lambda_7 y_4 z_4 + \lambda_8 x_4 y_4 z_4 = T_4 \\ \lambda_1 + \lambda_2 x_5 + \lambda_3 y_5 + \lambda_4 z_5 + \lambda_5 x_5 y_5 + \lambda_6 x_5 z_5 + \lambda_7 y_5 z_5 + \lambda_8 x_5 y_5 z_5 = T_5 \\ \lambda_1 + \lambda_2 x_6 + \lambda_3 y_6 + \lambda_4 z_6 + \lambda_5 x_6 y_6 + \lambda_6 x_6 z_6 + \lambda_7 y_6 z_6 + \lambda_8 x_6 y_6 z_6 = T_6 \\ \lambda_1 + \lambda_2 x_7 + \lambda_3 y_7 + \lambda_4 z_7 + \lambda_5 x_7 y_7 + \lambda_6 x_7 z_7 + \lambda_7 y_7 z_7 + \lambda_8 x_7 y_7 z_7 = T_7 \\ \lambda_1 + \lambda_2 x_8 + \lambda_3 y_8 + \lambda_4 z_8 + \lambda_5 x_8 y_8 + \lambda_6 x_8 z_8 + \lambda_7 y_8 z_8 + \lambda_8 x_8 y_8 z_8 = T_8 \end{cases} \quad (3)$$

Solving this system of linear equations, we obtain the values of the coefficients $\lambda_1, \lambda_2 \ldots \lambda_8$

$$\begin{cases} \Lambda_1 = \frac{T_8+T_7+T_6+T_5+T_4+T_3+T_2+T_1}{8} \\ \Lambda_2 = \frac{-T_8+T_7+T_6-T_5-T_4+T_3+T_2-T_1}{8a} \\ \Lambda_3 = \frac{-T_8-T_7+T_6+T_5-T_4-T_3+T_2+T_1}{8b} \\ \Lambda_4 = \frac{T_8+T_7+T_6+T_5-T_4-T_3-T_2-T_1}{8c} \\ \Lambda_5 = \frac{T_8+T_7+T_6+T_5+T_4+T_3+T_2+T_1}{8ab} \\ \Lambda_6 = \frac{T_8-T_7+T_6-T_5+T_4-T_3+T_2-T_1}{8ac} \\ \Lambda_7 = \frac{-T_8-T_7+T_6+T_5+T_4+T_3-T_2-T_1}{8bc} \\ \Lambda_8 = \frac{T_8-T_7+T_6-T_5-T_4+T_3-T_2+T_1}{8abc} \end{cases}$$

(7) substituting these values into equation (2) we obtain:

$$T(x,y,z) = \varphi_1(x,y,z) * T_1 + \varphi_2(x,y,z) * T_2 + \varphi_3(x,y,z) * T_3 + \varphi_4 T_4 + \varphi_5(x,y,z) * T_5 + \varphi_6(x,y,z) * T_6 + \varphi_7(x,y,z) * T_7 + \varphi_8(x,y,z) * T_8; \quad (4)$$

-a ≤ x ≤a; -b ≤x ≤b; -c ≤ x≤ c;

Here φ_i(i= 1, 8) are defined as follows:

$$\varphi_1(x,y,z) = \left(\frac{1}{8} - \frac{x}{8a} + \frac{y}{8b} - \frac{z}{8c} - \frac{xy}{8ab} + \frac{xz}{8ac} - \frac{yz}{8bc} + \frac{xyz}{8abc}\right);$$
$$\varphi_2(x,y,z) = \left(\frac{1}{8} + \frac{x}{8a} + \frac{y}{8b} - \frac{z}{8c} + \frac{xy}{8ab} - \frac{xz}{8ac} - \frac{yz}{8bc} - \frac{xyz}{8abc}\right);$$
$$\varphi_3(x,y,z) = \left(\frac{1}{8} + \frac{x}{8a} - \frac{y}{8b} - \frac{z}{8c} - \frac{xy}{8ab} - \frac{xz}{8ac} + \frac{yz}{8bc} + \frac{xyz}{8abc}\right);$$
$$\varphi_4(x,y,z) = \left(\frac{1}{8} - \frac{x}{8a} - \frac{y}{8b} - \frac{z}{8c} + \frac{xy}{8ab} + \frac{xz}{8ac} + \frac{yz}{8bc} - \frac{xyz}{8abc}\right); \quad (5)$$
$$\varphi_5(x,y,z) = \left(\frac{1}{8} - \frac{x}{8a} + \frac{y}{8b} + \frac{z}{8c} - \frac{xy}{8ab} - \frac{xz}{8ac} + \frac{yz}{8bc} - \frac{xyz}{8abc}\right);$$
$$\varphi_6(x,y,z) = \left(\frac{1}{8} + \frac{x}{8a} + \frac{y}{8b} + \frac{z}{8c} + \frac{xy}{8ab} + \frac{xz}{8ac} + \frac{yz}{8bc} + \frac{xyz}{8abc}\right);$$
$$\varphi_7(x,y,z) = \left(\frac{1}{8} + \frac{x}{8a} - \frac{y}{8b} + \frac{z}{8c} - \frac{xy}{8ab} + \frac{xz}{8ac} - \frac{yz}{8bc} - \frac{xyz}{8abc}\right);$$
$$\varphi_8(x,y,z) = \left(\frac{1}{8} - \frac{x}{8a} - \frac{y}{8b} + \frac{z}{8c} + \frac{xy}{8ab} - \frac{xz}{8ac} - \frac{yz}{8bc} + \frac{xyz}{8abc}\right);$$

why -a ≤ x ≤a; -b ≤y ≤b; -c ≤ z≤ c

The value of the functions φ_i(x, y, z) (i=1,8) at the corner points of the parallelepiped is determined as follows:

$\varphi_1(x_1,y_1,z_1)=1;\varphi_1(x_1,y_1,z_1)=\varphi_1(x_2,y_2,z_2)=\varphi_1(x_3,y_3,z_3)=\varphi_1(x_4,y_4,z_4)=\varphi_1(x_5,y_5,z_5)=\varphi_1(x_6,y_6,z_6)=\varphi_1(x_7,y_7,z_7)=\varphi_1(x_8,y_8,z_8)=0$

$\varphi_2(x_2,y_2,z_2)=1;\varphi_2(x_1,y_1,z_1)=\varphi_2(x_2,y_2,z_2)=\varphi_2(x_3,y_3,z_3)=\varphi_2(x_4,y_4,z_4)=\varphi_2(x_5,y_5,z_5)=\varphi_2(x_6,y_6,z_6)=\varphi_2(x_7,y_7,z_7)=\varphi_2(x_8,y_8,z_8)=0$

$\varphi_3(x_3,y_3,z_3)=1;\varphi_3(x_1,y_1,z_1)=\varphi_3(x_2,y_2,z_2)=\varphi_3(x_3,y_3,z_3)=\varphi_3(x_4,y_4,z_4)=\varphi_3(x_5,y_5,z_5)=\varphi_3(x_6,y_6,z_6)=\varphi_3(x_7,y_7,z_7)=\varphi_3(x_8,y_8,z_8)=0$

$\varphi_4(x_4,y_4,z_4)=1;\varphi_4(x_1,y_1,z_1)=\varphi_4(x_2,y_2,z_2)=\varphi_4(x_3,y_3,z_3)=\varphi_4(x_4,y_4,z_4)=\varphi_4(x_5,y_5,z_5)=\varphi_4(x_6,y_6,z_6)=\varphi_4(x_7,y_7,z_7)=\varphi_4(x_8,y_8,z_8)=0$ (6)

$\varphi_5(x_5,y_5,z_5)=1;\varphi_5(x_1,y_1,z_1)=\varphi_5(x_2,y_2,z_2)=\varphi_5(x_3,y_3,z_3)=\varphi_5(x_4,y_4,z_4)=\varphi_5(x_5,y_5,z_5)=\varphi_5(x_6,y_6,z_6)=\varphi_5(x_7,y_7,z_7)=\varphi_5(x_8,y_8,z_8)=0$

$\varphi_6(x_6,y_6,z_6)=1;\varphi_6(x_1,y_1,z_1)=\varphi_6(x_2,y_2,z_2)=\varphi_6(x_3,y_3,z_3)=\varphi_6(x_4,y_4,z_4)=\varphi_6(x_5,y_5,z_5)=\varphi_6(x_6,y_6,z_6)=\varphi_6(x_7,y_7,z_7)=\varphi_6(x_8,y_8,z_8)=0$

$\varphi_7(x_7,y_7,z_7)=1;\varphi_7(x_1,y_1,z_1)=\varphi_7(x_2,y_2,z_2)=\varphi_7(x_3,y_3,z_3)=\varphi_7(x_4,y_4,z_4)=\varphi_7(x_5,y_5,z_5)=\varphi_7(x_6,y_6,z_6)=\varphi_7(x_7,y_7,z_7)=\varphi_7(x_8,y_8,z_8)=0$

$\varphi_8(x_8,y_8,z_8)=1;\varphi_8(x_1,y_1,z_1)=\varphi_8(x_2,y_2,z_2)=\varphi_8(x_3,y_3,z_3)=\varphi_8(x_4,y_4,z_4)=\varphi_8(x_5,y_5,z_5)=\varphi_8(x_6,y_6,z_6)=\varphi_8(x_7,y_7,z_7)=\varphi_8(x_8,y_8,z_8)=0$

Now let's calculate the temperature gradient within the volume of one parallelepiped:

$$\frac{\partial T}{\partial x}=\sum_{i=1}^{8}\frac{\partial\varphi_i}{\partial x}T_i,\ \mathrm{i}=1,8;\ \frac{\partial T}{\partial y}=\sum_{i=1}^{8}\frac{\partial\varphi_i}{\partial y}T_i;\ \frac{\partial T}{\partial z}=\sum_{i=1}^{8}\frac{\partial\varphi_i}{\partial z}T_i \quad (7)$$

We calculate separately $\frac{\partial\varphi_i}{\partial x}$:

$$\frac{\partial\varphi_1}{\partial x}=\left(-\frac{1}{8a}-\frac{y}{8ab}+\frac{z}{8ac}+\frac{yz}{8abc}\right);$$
$$\frac{\partial\varphi_1}{\partial y}=\left(\frac{1}{8b}-\frac{x}{8ab}-\frac{z}{8bc}+\frac{xz}{8abc}\right);$$
$$\frac{\partial\varphi_1}{\partial z}=\left(-\frac{1}{8c}+\frac{x}{8ac}-\frac{y}{8bc}+\frac{xy}{8abc}\right);$$
$$\frac{\partial\varphi_2}{\partial x}=\left(\frac{1}{8a}+\frac{y}{8ab}-\frac{z}{8ac}-\frac{yz}{8abc}\right);$$
$$\frac{\partial\varphi_2}{\partial y}=\left(\frac{1}{8b}+\frac{x}{8ab}-\frac{z}{8bc}-\frac{xz}{8abc}\right);$$
$$\frac{\partial\varphi_2}{\partial z}=\left(-\frac{1}{8c}-\frac{x}{8ac}-\frac{y}{8bc}-\frac{xy}{8abc}\right);$$
$$\frac{\partial\varphi_3}{\partial x}=\left(\frac{1}{8a}-\frac{y}{8ab}-\frac{z}{8ac}+\frac{yz}{8abc}\right);$$
$$\frac{\partial\varphi_3}{\partial y}=\left(-\frac{1}{8b}-\frac{x}{8ab}+\frac{z}{8bc}+\frac{xz}{8abc}\right);$$
$$\frac{\partial\varphi_3}{\partial z}=\left(-\frac{1}{8c}-\frac{x}{8ac}+\frac{y}{8bc}+\frac{xy}{8abc}\right);$$
$$\frac{\partial\varphi_4}{\partial x}=\left(-\frac{1}{8a}+\frac{y}{8ab}+\frac{z}{8ac}-\frac{yz}{8abc}\right);$$
$$\frac{\partial\varphi_4}{\partial y}=\left(-\frac{1}{8b}+\frac{x}{8ab}+\frac{z}{8bc}-\frac{xz}{8abc}\right);$$ (8)
$$\frac{\partial\varphi_4}{\partial z}=\left(-\frac{1}{8c}+\frac{x}{8ac}+\frac{y}{8bc}-\frac{xy}{8abc}\right);$$
$$\frac{\partial\varphi_5}{\partial x}=\left(-\frac{1}{8a}-\frac{y}{8ab}-\frac{z}{8ac}-\frac{yz}{8abc}\right);$$
$$\frac{\partial\varphi_5}{\partial y}=\left(\frac{1}{8b}-\frac{x}{8ab}+\frac{z}{8bc}-\frac{xz}{8abc}\right);$$
$$\frac{\partial\varphi_5}{\partial z}=\left(\frac{1}{8c}-\frac{x}{8ac}+\frac{y}{8bc}-\frac{xy}{8abc}\right);$$
$$\frac{\partial\varphi_6}{\partial x}=\left(\frac{1}{8a}+\frac{y}{8ab}+\frac{z}{8ac}+\frac{yz}{8abc}\right);$$
$$\frac{\partial\varphi_6}{\partial y}=\left(\frac{1}{8b}+\frac{x}{8ab}+\frac{z}{8bc}+\frac{xz}{8abc}\right);$$
$$\frac{\partial\varphi_6}{\partial z}=\left(\frac{1}{8c}+\frac{x}{8ac}+\frac{y}{8bc}+\frac{xy}{8abc}\right);$$
$$\frac{\partial\varphi_7}{\partial x}=\left(\frac{1}{8a}-\frac{y}{8ab}+\frac{z}{8ac}-\frac{yz}{8abc}\right);$$

$\frac{\partial \varphi_7}{\partial y}= (-\frac{1}{8b}-\frac{x}{8ab}-\frac{z}{8bc}-\frac{xz}{8abc})$;
$\frac{\partial \varphi_7}{\partial z}= (\frac{1}{8c}+\frac{x}{8ac}-\frac{y}{8bc}-\frac{xy}{8abc})$;
$\frac{\partial \varphi_8}{\partial x}= (-\frac{1}{8a}+\frac{y}{8ab}-\frac{z}{8ac}+\frac{yz}{8abc})$;
$\frac{\partial \varphi_8}{\partial y}= (-\frac{1}{8b}+\frac{x}{8ab}-\frac{z}{8bc}+\frac{xz}{8abc})$;
$\frac{\partial \varphi_8}{\partial z}= (\frac{1}{8c}-\frac{x}{8ac}-\frac{y}{8bc}+\frac{xy}{8abc})$;

$$T(x,y,z)=\varphi_1T_1+\varphi_2T_2+\varphi_3T_3+\varphi_4T_4+\varphi_5T_5+\varphi_6T_6+\varphi_7T_7\varphi_8T_8; \quad (9)$$

$$\frac{\partial T}{\partial x}=\frac{\partial \varphi_1}{\partial x}T_1+\frac{\partial \varphi_2}{\partial x}T_2+\frac{\partial \varphi_3}{\partial x}T_3+\frac{\partial \varphi_4}{\partial x}T_4+\frac{\partial \varphi_5}{\partial x}T_5\frac{\partial \varphi_6}{\partial x}T_6\frac{\partial \varphi_7}{\partial x}T_7)+\frac{\partial \varphi_8}{\partial x}T_8;$$
$$\frac{\partial T}{\partial y}=\frac{\partial \varphi_1}{\partial y}T_1+\frac{\partial \varphi_2}{\partial y}T_2+\frac{\partial \varphi_3}{\partial y}T_3+\frac{\partial \varphi_4}{\partial y}T_4+\frac{\partial \varphi_5}{\partial y}T_5\frac{\partial \varphi_6}{\partial y}T_6\frac{\partial \varphi_7}{\partial y}T_7)+\frac{\partial \varphi_8}{\partial y}T_8; \quad (10)$$
$$\frac{\partial T}{\partial z}=\frac{\partial \varphi_1}{\partial z}T_1+\frac{\partial \varphi_2}{\partial z}T_2+\frac{\partial \varphi_3}{\partial z}T_3+\frac{\partial \varphi_4}{\partial z}T_4+\frac{\partial \varphi_5}{\partial z}T_5\frac{\partial \varphi_6}{\partial z}T_6\frac{\partial \varphi_7}{\partial z}T_7)+\frac{\partial \varphi_8}{\partial z}T_8;$$

$$F(0)=\left(\frac{1}{8}-\frac{x}{8a}-\frac{y}{8b}--\frac{z}{8c}+\frac{xy}{8ab}+\frac{xz}{8ac}+\frac{yz}{8bc}-\frac{xyz}{8abc}\right);$$
$$F(1)=\left(\frac{1}{8}+\frac{x}{8a}-\frac{y}{8b}-\frac{z}{8c}-\frac{xy}{8ab}-\frac{xz}{8ac}+\frac{yz}{8bc}+\frac{xyz}{8abc}\right);$$
$$F(2)=\left(\frac{1}{8}-\frac{x}{8a}-\frac{y}{8b}-\frac{z}{8c}-\frac{xy}{8ab}-\frac{xz}{8ac}+\frac{yz}{8bc}+\frac{xyz}{8abc}\right);$$
$$F(3)=\left(\frac{1}{8}+\frac{x}{8a}-\frac{y}{8b}-\frac{z}{8c}+\frac{xy}{8ab}+\frac{xz}{8ac}+\frac{yz}{8bc}-\frac{xyz}{8abc}\right);$$
$$F(4)=\left(\frac{1}{8}+\frac{x}{8a}+\frac{y}{8b}+\frac{z}{8c}-\frac{xy}{8ab}-\frac{xz}{8ac}+\frac{yz}{8bc}-\frac{xyz}{8abc}\right); \quad (11)$$
$$F(5)=\left(\frac{1}{8}-\frac{x}{8a}+\frac{y}{8b}+\frac{z}{8c}+\frac{xy}{8ab}+\frac{xz}{8ac}+\frac{yz}{8bc}+\frac{xyz}{8abc}\right);$$
$$F(6)=\left(\frac{1}{8}+\frac{x}{8a}-\frac{y}{8b}+\frac{z}{8c}-\frac{xy}{8ab}+\frac{xz}{8ac}-\frac{yz}{8bc}-\frac{xyz}{8abc}\right);$$
$$F(7)=\left(\frac{1}{8}-\frac{x}{8a}-\frac{y}{8b}+\frac{z}{8c}+\frac{xy}{8ab}-\frac{xz}{8ac}-\frac{yz}{8bc}+\frac{xyz}{8abc}\right);$$

$F(x,y,z)=F(0)T_0+F(1)T_1+F(2)T_2+F(3)T_3+F(4)T_4+F(5)T_5+F(6)T_6+F(7)T_7$;

The general functional is

$J=J_1+J_2+J_3$;
$J_1=\int_V \frac{1}{2}[k_{xx}(\frac{\partial T}{\partial x})^2+k_{yy}(\frac{\partial T}{\partial y})^2+k_{zz}(\frac{\partial T}{\partial z})^2]dv$;
$J_2=\int_{S_n} qT'ds$;
$J_3=\int_{S_n}\frac{h}{2}(T^2-T_{oc})^2ds$;
$T^1=F(4)T_4+F(5)T_5+F(6)T_6+F(7)T_7$;
$T^2=F(0)T_0+F(1)T_1+F(2)T_2+F(3)T_3$;
$J_1=\int_{-a}^{a}\int_{-b}^{b}\int_{-c}^{c}k_{xx}[(\frac{\partial T(x,y,z)}{\partial x})^2+(\frac{\partial T(x,y,z)}{\partial y})^2+(\frac{\partial T(x,y,z)}{\partial z})^2]dxdydz$;
$J_2=\int_{-a}^{a}\int_{-b}^{b}qT'(x,y)dxdy$;
$J_3=\int_{-a}^{a}\int_{-b}^{b}\frac{h}{2}(T^2-T_{oc})^2dxdy$;
$J=J_1+J_2+J_3=J(T_0,T_1,T_2,T_3,T_4,T_5,T_6,T_7)$;

$$\begin{cases}\frac{\partial J()}{\partial T_0}=0,\\ \frac{\partial J()}{\partial T_1}=0,\\ \dots\\ \frac{\partial J()}{\partial T_7}=0,\end{cases}\begin{cases}a_{00}T_0+a_{01}T_1+a_{02}T_2+a_{03}T_3+a_{04}T_4+a_{05}T_5+a_{06}T_6+a_{07}T_7=b_0\\ a_{10}T_0+a_{11}T_1+a_{12}T_2+a_{13}T_3+a_{14}T_4+a_{15}T_5+a_{16}T_6+a_{17}T_7=b_1\\ \dots\\ a_{70}T_0+a_{71}T_1+a_{72}T_2+a_{73}T_3+a_{74}T_4+a_{75}T_5+a_{76}T_6+a_{77}T_7=b_7\end{cases};$$

Result: $T'_0, T'_1, T'_2, T'_3, T'_4, T'_5, T'_6, T'_7$;

$T(x,y,z)=F(0)T'_0+F(1)T'_1+F(2)T'_2+F(3)T'_3+F(4)T'_4+F(5)T'_5+F(6)T'_6+F(7)T'_7$;

$x = 0$;

$T(y,z) = F(0)T'_0 + F(1)T'_1 + F(2)T'_2 + F(3)T'_3 + F(4)T'_4 + F(5)T'_5 + F(6)T'_6 + F(7)T'_7$;

$y = 0$'

Conclusion

The results of this work can be used to determine the temperature distribution law in three-dimensional rods in the form of a parallelepiped. When solving problems by the finite element method, a variety of elements are used. Some of the more important ones were introduced in this chapter in connection with the consideration of solid body discretization. These elements are emphasized for several reasons. They are simple in theory, which makes it easy to illustrate their application. Triangular and tetrahedral elements can be used to approximate complex boundaries because they can be oriented as desired. Another important reason is that many of the available computing programs use these elements.

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TECHNOLOGY OF BUILDING ADAPTIVE GRAPHICAL WEB INTERFACES FOR DATA EDITING

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Abstract. The article discusses the technology of creating and modifying data in a heterogeneous information system using adaptive graphical web interfaces. The purpose of the work is to create a set of technical developments and techniques that implement a systematic and integrated approach to the construction of adaptive user interfaces. The research method is based on a systematic analysis of modern technologies for creating adaptive graphical interfaces, developing their own technology and testing it experimentally. A server-side Web application has been developed that provides on-screen forms for creating and editing XML documents in accordance with the selected XSD schema. On-screen forms are generated on the server side and are provided to the user as HTML pages. The field of application of the above-mentioned technology is the integration of the created adaptive graphical web interface in a distributed information system in order to increase the efficiency of user access to heterogeneous information and the ability to manipulate it.

Keywords: adaptive web interfaces, integration of heterogeneous information, xml document navigation, xslt technologies.

Introduction

The technological basis for building distributed information systems (DIS) is based on three technological "whales": WWW technologies, the LDAP directory model, and the Z39.50 protocol model.

By far the most convenient is the Z39.50 standard. No other international standard contains a complete set of necessary rules for searching for information, extracting this information from storage and providing it to the user in the necessary formats. At the same time, the standard regulates network access to databases and abstracts from specific schemas and data structures [1].

Technologies based on the LDAP protocol model are most suitable for implementing the functions of managing access to DIS and distributed information management. This is due to the fact that LDAP is the easiest way to organize the technology of a "single point of access" to information resources, including identification, authentication and authorization of users in distributed information systems. An essential circumstance in this case is the fact that LDAP is based on the ideology of distributed storage of information - directory trees [5]. Against the background of global identification of all directory elements, it contains definitions of mechanisms and procedures for data replication between different servers and is very well supported by application and system software developers. All this makes it quite easy to move from local to distributed management of information systems and control access to their resources.

To work with databases, remote document repositories, and repositories, select the Z39.50 protocol and its extensions: SRW/SRU protocols. If they are not available in the open access archive, you can choose the OAI-PMH protocol [1, 5]. This is extremely rare when the remote

archive supports the OAI-PMH protocol. Here you have to use NTTP, without any metadata. To extract metadata, algorithms for parsing the title page, extracting keywords in their absence, and an algorithm for constructing an abstract based on a graph connected to the text are used [6].

Heterogeneous distributed information systems should include user and administrative interfaces (graphical WEB interfaces) that provide the ability to manage data from heterogeneous information sources. Interfaces that adapt to the structure and functionality of information resources are adaptive. Each specific information resource usually corresponds to only a fairly narrow range of parameters from their potentially possible values. Therefore, when selecting control parameters for various information resources, it is necessary to attract additional information about a specific information resource [11].

Over the past two decades, XML has become not only the standard format for data exchange between different web applications, but also the model for a family of some new databases or NoSQL databases, called XML databases. In addition to the efficiency of managing regular data, XML is also an excellent support for storing, processing, and querying temporary data due to its hierarchical structure. [2]

The technology of creating and modifying data in a heterogeneous information system using adaptive graphical WEB interfaces will be discussed below. It is assumed that the data can be extracted from the relevant information sources in XML format, since it is the most suitable for building WEB-based data editing interfaces.

Technology for building WEB interfaces

To simplify the perception of information by users, there are various methods of presenting it. One of the most common ways of visual representation that allows you to display the structure of information is to write it in the form of an HTML page in the browser. XML and HTML are subsets of SGML, and therefore inherit its basic principles [7]. The structure of an XML document is similar to a regular HTML page. By simple manipulations, information from an XML document can be presented as an HTML page. HTML forms and XML elements are logically equivalent in terms of the content of the information. This makes it possible to automatically convert them via a web browser using a single software tool for any XML data. The generated HTML form that acts as a data entry form is essentially a simple low-level web-based XML editor, and is an adaptive graphical interface [8,9].

The process of converting XML documents from one XML schema to another can be divided into three main parts [10]:

- Create XML code-Create code using regular text or specialized XML code editors. Many DBMSs are equipped with the function of direct generation of XML code.

- Create XSL style sheets for processing and displaying an XML document. XSL tables are created by the administrator-programmer.

- Overlay of XSL style sheets. The XML document is overlaid with XSL style tables according to certain formatting rules, and the result is a document that corresponds to the client's request in the following output formats: HTML, PDF, WML, and XML.

On the client-side

The conversion of XML documents by overlaying XSL style sheets is usually performed on the client side. The style sheet is loaded only once, reducing the load on the server. Based on the principle of overlaying a CSS file with an HTML file, browsers can attach styles to XML documents and form the final document.

Server-side

If browsers do not understand full-fledged HTML, and cannot perform xml\xsl transformations themselves, then the style application to an XML document can be performed on the server in two ways [7-10]:

- Manually - compiles xml files/style sheets and places the resulting files on the server;

-Automatically – content management framework (CMF) performs the required transformation of the xml document and transmits to the user: at the request of the Acrobat Reader

program-the published page will come in PDF format, at the request of the WAP device - the client will receive a WML page, Web browsers will receive an HTML/XHTML page.

To represent structured information in XML format, the main thing is to have a description of the rules for constructing the structure of an XML record, i.e., a description of the data schema. Typically for XML, these rules are formulated in terms of XSD and represent an XML structure that can be processed by standard means, such as XSLT [11].

Thus, graphical web interfaces built on the basis of XML technologies allow you to display any structure of a file presented in XML format.

When using the XML format to represent structured information, it is essential to have a description of the rules for constructing the structure of an XML record, i.e., a description of the data schema. Usually for XML, these rules are formulated in terms of XSD [2, 3] and represent an XML structure that can be processed by standard means, for example, XSLT [10].

When extracting a record from a specific information source in a heterogeneous information system and presenting this record in XML format for editing, you need to get a complete description of the possible structure of the extracted record (XSD).

To get the XSD, follow these steps [11]:

- Get a reference to the original XSD data schema as a URL as the attribute schemaLocation when defining the namespace to use. It is usually contained in the root element of an XML record.
- Make a request to the information system to provide XSD by the ID database, if the XML record extracted for editing contains the Uniform Resource Identifier (URI), but does not contain a link to the XSD data schema used in the form of a URL. Such a request can be processed by the Explain service.
- Make a request to the information system for the provision of XSD by the name of the information resource (database) or the use of XSD, which corresponds to the scheme requested when forming the request for data extraction, in the case when the XML record extracted for editing does not contain namespace definitions.

In any of these cases, data modifications are required to initialize graphical interfaces [11]:

- Description of the data schema in the form of an XML structure in accordance with the XSD rules.
- XML structure containing extracted data for editing (not required to create a new record).
- Description of styles for forming GUI elements (optional).
- Description of the rules for forming the elements of the graphical interface in accordance with the rules of the XSD used and the value of the elements of the XML record being edited. However, these rules can be XSLT transformation rules applied to XSD.

The principle of operation of the XML record editor in the client-server architecture is as follows:

- For the client part, a ready-made HTML form is provided for entering and / or editing data. At the same time, the form already contains all the necessary tools (java scripts) for correct data entry;

-The editing form is generated on the server side by XSLT transformation of the modified XSD structure. First, an empty edit form is generated (without data), which, after the XSLT processor finishes working, is filled with the record data in XML format.

For the client part, a ready-made HTML form for entering and / or editing data is provided, which contains all the necessary tools for correct data entry, including:

- Script for duplicating duplicate elements according to XSD.
- A script for deleting items that can be deleted according to XSD.
- A script for checking the correctness of data input, provided that the corresponding template is present in the form of a regular expression in XSD.
- The scenario of closing then opening any data element in the edit form.

Figure 1 shows a fragment of an HTML form generated by the XML record editor. Next to the field names are the information input fields.

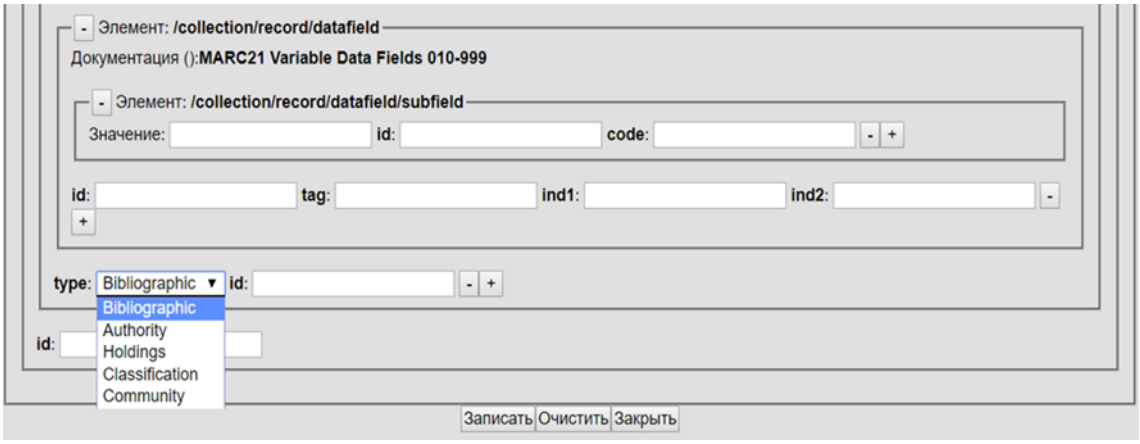

Figure 1 - Graphical editor for XML records: data entry fields

When processing XSD with XSLT, various features of the XSD definitions are taken into account, including references and recursion. The entered data is automatically saved in the same database from which the record was extracted.

Conclusion

The developed technology for building adaptive graphical WEB interfaces allows you to effectively solve the problem of integrating heterogeneous information resources based on the database schemes of the XSD application using XSLT transformations. The described methodology has quite general ways of using it and can be used to build adaptive graphical WEB interfaces that allow you to generate sent HTML forms for entering and editing data.

The developed adaptive graphical editor of XML records allows you to import any XML data and transform its structure efficiently and simply, while the same processing process allows you to transform the source data of any structure without any modification of the program code.

Currently, the adaptive graphical editor of XML records is implemented in the ZooSPACE-W subsystem of the ZooSPACE platform of the ICT SB RAS (Institute of Computational Technologies, Novosibirsk). Work is underway to improve the functionality of the editor in terms of expanding the list of supported XSD and JSON elements.

This software product can be used as an independent module for creating and editing data presented in XML format, as well as an embedded module in various server software for heterogeneous information systems.

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DEVELOPMENT OF A SYSTEM OF QUESTIONS AND ANSWERS FOR THE KAZAKH LANGUAGE BASED ON RULE-BASED AND HMM

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Abstract. This study describes and evaluates the methods developed for the module analysis of problems of the closed subject system of answers to questions for the Kazakh language (QA). Analyzing questions in order to obtain the necessary information to determine what is asked and how to respond to them, analyzing questions is one of the most important components of a quality control system. Therefore, we propose new methods for analyzing questions based on two main problems, in particular, on the basis of rules (Rule-based) and on the Hidden Markov model (HMM), based on the integration of the system classification approach, focus extraction and question classifiers, both of which use the relationship of dependence between the words in the question. A comparison of these solutions with basic models is also given. This study also provides a manual summary and annotated data of the gold standard for further research in this area.

Key words: Rule-base, Hidden Markov Model (HMM), Class extraction.

1 Introduction

The question answer system (QA) aims to obtain automatically generated answers to questions generated in natural languages. Over the past decade, radical improvements in natural language processing (NLP) and information retrieval (IR) methods have led to the development of well-known quality control systems, some of which are available for public use, such as AnswerMachine and WolframAlpha. It was even possible to develop a quality control system in which a person could compete with his rivals in a TV show [8]. However, it makes sense to create a fully operational system of quality control, mainly problem analysis (including preliminary processing and classification of questions), information retrieval, cross-linguistics and response generation (including obtaining and formulating answers), as well as rewriting. This is complicated by the many complex transmissions that need to be addressed, such as some lower-level transmissions, such as implications or link resolution. In addition, the architecture of the quality control system, as well as the methods used, usually depend on factors such as subject area and language. Many researchers have considered individual issues related to such systems. Although some of them are considered solved, most of the problems are still open for further research [9,1]. In this study, an attempt was made to analyze the first problem of the quality control system - the problem. In the general system you can ask questions in the Kazakh language. For the system to be truly useful, in addition to accuracy, each module must be carefully designed with a common architecture that is thoroughly analyzed and evaluated individually. In this study, we propose the development and evaluation of the first module, in particular, the analysis of issues for use in the prototype of the geography subject area on the assembly line of our system. The main task of the analysis of questions is to obtain useful information from the given question, which is used in the following modules to form the final correct answer. In particular, information that reflects a particular type or central property of a given object, in addition to classifying the problem into predefined classes in the subject area, can significantly reduce the amount of work space in

subsequent stages of the system, such as information retrieval or candidate generation. In the following example, we are asked for information that shows the name of the plane called the focus and the form of classification. ENTITY.CITY helps us to orient ourselves around these concepts on the basis of knowledge, looking for answers.

"What is the name of the largest city in Kazakhstan?"

To get the focus, we developed a rule-based model, as well as a statistical model based on the hidden stamp model (HMM). We study the accuracy of these two factors when getting the focus. In addition, to classify the problems, we show that the rule-based model is more successful in finding rough classes than the tf-idf-based bag of words base model, which uses the frequency of words in a question. It is especially difficult for the Kazakh language to develop such a module of problem analysis, not to mention the QA system, as it is an agglutinative language with a rich morphology and derivation structure. Therefore, we process preliminary questions by performing morphological analysis and unambiguous elimination, as well as dependency analysis using the NLP conveyor [16,6,15]. Morphological analysis and elimination of ambiguity leads to the acquisition of root forms of words and signs of their speech (POS). Dependency analysis creates a dependency relationship between the words in this sentence. The tags used by the dependency analyzer are defined in the Kazakh bank of the dependency tree, which is the subject, object, proposition, modifier, classifier, owner, etc. b. tags such as [6,7]. We propose a new approach to classifying issues and defining the focus based on the integration of a rule-based method with a HMM-based chain classification method for a closed quality control system. In addition, we offer a first-hand collection and annotation of gold standard analysis data for the Kazakh language. Data on the Kazakh issue of input codes and the gold standard will be made publicly available for reproduction and further study.

2 Related works

The fundamental task of a quality control system is to determine the type of response, its properties and possible limitations. Given the demand in natural language, the quality control system often receives certain direct information, such as the class of the question (for example, who, when, etc.) on the basis of predefined types of answers [4]. The latest modern methods of classifying questions often include statistical methods [12,13]. In addition, some quality control systems are focused on general semantics and form a direct knowledge base from unprocessed texts of questions [10]. However, these systems only determine the type of problem. They no longer specify, for example, what type of object is requested, which significantly narrows the search space. One way to model the analysis of questions is to use general-purpose search engines. One of the earliest studies using such a strategy is the OpenBus quality control system. AnswerBus search engines use a word bag strategy that is evaluated based on the number of requests returned for each word. The total search engine score for a particular question is the amount of hits returned for each word of the question. Based on their total score, the best search engine is determined as the most suitable source of knowledge to answer the question. However, AnswerBus does not use any semantic information and does not receive any information to create a more Competent Response Strategy. The first successful Turkic-language facto quality control system used a hybrid approach (rule-based as well as statistical), but not for the analysis of questions, but for direct answers by comparing samples of questions and answers at the surface level [5]. It does not use explicit question analysis, except for pre-defined samples of questions and answers. Inspired by its significant achievements, our system adapts its strategies to analyze the problems used in one of the most powerful quality control systems IBM Watson [11]. To analyze this question, Watson first takes a piece of the key that is the answer link (focus); second, it takes terms that describe the type of value being asked (lexical answer type, LAT); third, the key class (QClass); and finally, some additional key elements (QSection) if it needs special processing. Lalli et al. Evaluate the importance of distilling such information to get the right answer. To obtain this information, Watson typically uses rules based on regular expressions in combination with statistical classifiers to assess the acquired reliability of the rules. On the other hand, to analyze a complete problem in

a closed quality control system, it is sufficient to extract only LAT and QClass, because in a complete question sentence Watson calls the focus, often the question word (for example, "what" in Section 1). Thus, the real focus of the problem, something we call focus, is actually called LAT according to Watson. In this regard, our focus definition:

"question terms that specify what type of object is being requested".

A more relevant study was conducted to analyze our problems [3], which are used together to obtain the focus of the question in an open quality control system based on rules and statistical methods. In this study, binary classification using reference vector (SVM) machines is performed for words in English problems analyzed by a constituency analyzer. In addition, experts with selected rules are used to define different functions, which are then applied in SVM. In contrast, our analysis is based on rules and uses statistical models individually to get the focus. It also performs a classification of questions for Kazakh questions to be analyzed with the help of a dependency analyzer. In addition, the classification of chains is performed using an algorithm based on the latent markov model (HMM), the results of which are combined with the results of experts based on the rules to obtain the final focus. Unfortunately, our study is inconsistent with this study. First, the definition of focus [3] is related to the analysis of voters and the decision-making of key decisions that are not currently available for the Kazakh language. Therefore, it is not possible to define alternative rules to the English data set, and the methods proposed in [3] cannot be applied to the Kazakh data set.

3 System structure

Although the main technical part of this study is the methodology (ie the combination of rules and statistical models), one of the principles of this work is to implement a quality control system based on this analysis module and create a starting point for the development of subsequent modules. Therefore, this section presents the general architecture of the system, as well as how to add a problem analysis module to it. The overall architecture of the system is based on the DeepQA technology presented in the work [8]. The basic principle in DeepQA is to have parallel blocks with several submodules, which produce different results for the candidates for each application, and then the trained models of machine learning are evaluated according to the evidence collected. The most likely candidate is then returned as the final answer. The focus obtained after the analysis of the question is used in the information retrieval module to obtain the appropriate 4 units of knowledge that can be cut and refined in QClass. These relevant units are then passed to a candidate response module with several different information retrieval algorithms to obtain all possible relevant response units. For each unit of candidate's answer, units of syntactic and semantic evidence are collected, which are then used to evaluate the candidate's answers, and those with low scores are cut. Finally, the strong candidates are synthesized into a final set of answers, in which the most likely answer is passed to the response generation module along with the other k top answers to provide optionality.

3.1 Question analysis module

The question analysis module consists of three parallel sub-modules shown in Figure 1, Distiller, HMM-glasses and ClassRules. The first two modules are for solving the focus of the question, and the third module is for determining whether the question is classified into a predefined class of classes (QClass).

Focus shows exactly what the question asks and what type it is. In the example in Section 1, the focus is on the sum of these parts: “city name” (name of a specific city) because the question asks for a name. In particular, it asks for the name of the city. Therefore, the phrase "city name" can be syntactically derived from the word "city name", because we have morphological roots in the question parts. Because "city" is a root, and "nyn" is a suffix meaning "city name". The QClass for this question is ENTITY (table 2). Note the following example - "Who is a sailor" and Qclass - this is HUMAN.INDIVIDUAL. The question is the basis of the trick that asks the person's name and it is known that the person is a sailor. We capture the distinctive properties of meaning in

question (for example, the first sailor), because at this point we are interested in the relationship "there" and "part", which indicates a particular type of object. The remaining properties are used by subsequent modules of the system to semantically cut both the relevant units of knowledge and the candidate's answers.

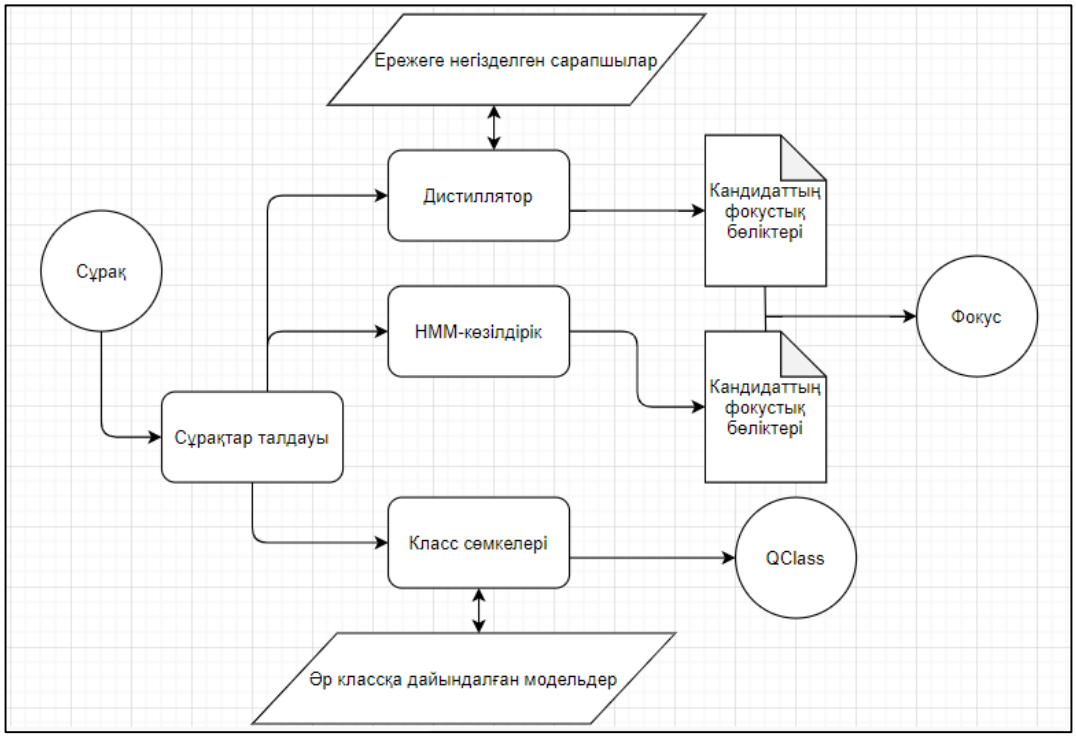

Figure 1 - Question Analysis Module

4 Methodology

To get the focus, we have special rules for dependency trees for all types of specific questions in the geographic domain, a fast-controlled focus extractor, and an HMM classifier that uses a distiller and variation, HMM-glasses. The Wetterby algorithm [17] to some extent makes it much more liberal than distillers. In addition to one general feature that affects the relationship between the words under consideration, their views on the main problem (ie, to get the focus) are based on completely different principles at different levels of solution. This feature is very important for our methodology, as it provides the necessary insight into the effective management of languages with a rich derivative structure, such as Kazakh. At the same time, a delicate balance is needed for the combination of these models. To this end, we take into account the individual reliability of both the distiller and the HMM-glasses in the set of exercises with personal data. In addition, to classify a question from a specific domain (geography in our case) into predefined classes, we have a rule-based classifier that produces a rough class based on hand-constructed sentence-based rules.

4.1 Focus extraction

Distiller. We have noticed that in the geography domain we have chosen, there are certain rules for asking common (predicate-based) questions to many questions. We identified each such model (type of question) and manually determined the rules (experts) for focusing on the dependency analysis of each question. This set of rules is called a Distiller. We currently have an expert on seven rules, as well as a general expert who handles rare cases using one general rule. The main reason for adding an expert is the lack of data. However, we would like to make this optional, as the presence of a specific general expert and a number of experts may result in the accuracy of the fine instead of a small or increased recall depending on the size of the data set, which is not always the case. option required in practice. The data set of all experts and their aggregates are given in Table 1. The rules contain navigation instructions in the dependency

section of the question. For example, the rule for the "what" expert is, and the rule for the "given" expert, as well as the general rule is as follows (Figure 2).

not: (what is…)

Get a sentence on the question (SENTENCE)

- Get traceback from the subject and collect only the owner (POSSESSOR) and the classifier (CLASSIFIER)

given: (… is given…)

- Remove the subject from the sentence in question (SENTENCE)
- Save and control the first degree DATIVE.ADJUNCT of the sentence (SENTENCE) and assemble only the first degree modifier (MODIFIER)

general:

- Remove the subject from the sentence in question (SENTENCE)
- Observe from the subject and get the first rank of the owner (POSSESSOR) and / or classifier (CLASSIFIER) together with their owner (POSSESSOR) and / or classifier (CLASSIFIER)

Each rule-based expert has a level of confidence based on the results of his or her work to distinguish the correct focus from the questions related to the examination. This score is later used to indicate the reliability of the expert's opinion when combined with HMM-glasses. In addition to the focal parts of the question, both the distiller and HMM-glasses report the reliability in the form of a trio:

$$\langle fpt, fpd, fpc \rangle_n$$

here n {{1 ..| Q/}, FPT (focus Part text) represents the text of the focus part, fpd (focus part dependency tag) represents the focus part, and fpc (focus part confidence score) represents the confidence of the focus part. | Q / Q represents the number of words in the question.

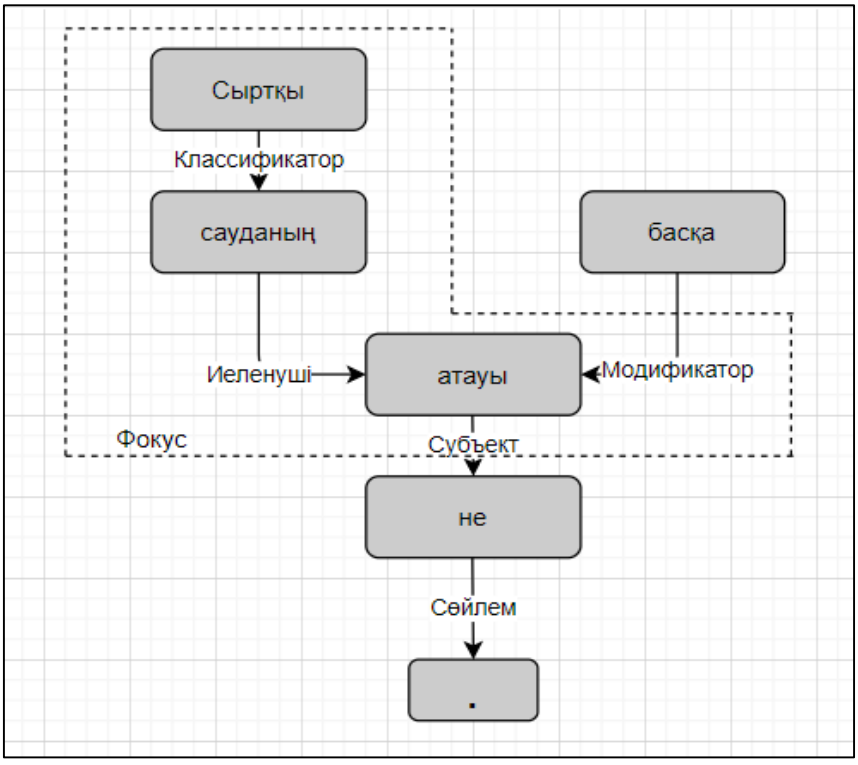

Figure 2 - The expert" What "indicates that the focus of the question is" the name of foreign trade

Table 1. Experts and the frequency of questions in their training data

Expert Type	Frequency (%)
general	25.6
which	19.5

what is	15.0
is called	9.6
how many	9.6
is given	7.2
which	7.2
how many	6.3

Both models produce similar triplets for each part of the focus. However, there is a significant difference between the rules and statistical models in the way in which confidential data is presented for each part of the focus. As explained in detail in Section 4.1, the HMM-glasses work on individual parts of the question, while the distiller sub-trees the dependence of the question on the tree.

Therefore, the distiller's solution is not sufficient to take into account the individual probabilities for each part in focus. Thus, the distiller collects the particles as a focus, and a total confidence score (total confidence score) reported by the responsible expert, which compares the f pc scores of all the particles, making all the particles equal in terms of the distiller in focus.

HMM-glasses. HMM-glasses model the focus capture as HMM (Hidden Markov Model) and perform a sequential classification of words in the question using the Witherby algorithm. There are only two latent states, namely FOC (i.e. the controlled part is part of the focus) and NON (i.e. the controlled part is not part of the focus), which treats each part of the problem as a follow-up and is the controlled part part of the question focus? First, we serialize the dependency tree of the question and send the serialized tree. Serialization (or coding) of a tree is its systematic expression, which is mainly used in the fields of applied mathematics, databases and networks [18,14]. Of course, the method of wood serialization has a significant impact on the characteristics of the algorithm results. We have studied and empirically tested this effect using two common approaches to serialization (see Section 5). Commonly accepted methods of tree serialization try to effectively serialize the tree within the information-theoretical resource boundaries (in terms of time and space). On the other hand, we are only interested in the coherence of the tree-like structure. In other words, the dependency relationship must be agreed between all methods of serialization. Therefore, we considered the simplest methods, direct mode and reverse mode.

Direct and reverse modes. When creating a chain from the dependency tree in the direct mode, the left children (according to the reverse visualization of the dependency tree) prevail over the children who are taken in turn. So first the left branch on the left is taken, then the branch on the right right is taken, and so on. Finally, the parent joins. The reverse is true - positive children outnumber those children. Any difference in serialization changes the whole learning process, thereby reflecting the specifics of a particular series. In this way, the serialization depending on the method of teaching provides a significant diversity of characteristics. Figure 2 below shows the serialization of the question. Recall that we consider only the morphemes of words (ie, excluded from all corrections).

direct serialization (- >)

what is another name for foreign trade

FOC FOC NON FOC NON

reverse serialization (< -)

or the name of another foreign trade

NON FOC NON FOC FOC

In essence, the direct mode of serialization corresponds to the reading of the question from left to right (or from beginning to end), and the reverse mode corresponds to its reading to the end. Different approaches to serialization allow the creation of ensembles of different types of models that process different parts of the question, as they explore different features of the data during the study. Thus, a complex model can be obtained by combining several HMM-glasses with different approaches to serialization. We model the focus task as HMM, first by calculating the previous

probability of our latent state (i.e., FOC and NON), and second, by studying the probability from this set of serialized questions as follows $a_{jk} = P(t^j|t^k)$ $b_{ij} = P(w_i|t^j)$ then a_{jk} previous condition t^k given that, but b_{ij} current control w_i the word indicates the probability that, current status is t^j . Decoding is performed using the Whiterby algorithm, in which the state corresponds to the nodes in the Whiterby strings that represent the most probable judgments for each part that is the focal part of the question. In addition, the control probability b_{ij} is used as a three-fold reliable estimate (ie fpc). Recall that all results are presented in the form of triplets (see Section 4.1).

Dependency tags compared to Word text. In all parts of problem analysis, when possible, it is easier to determine the possible relationship of large distances in problem-solving, for example, by using dependent relationships between words, compared to simple syntactic approaches for languages with a rich derivation structure. Therefore, the very first design of HMM-glasses is designed to study and evaluate the sequence of dependence tags of the problem, which corresponds to the study of the shape of the tree, rather than the sequence of words. However, this approach leads to model confusion, as some tags are more common than others, for example, the problem has only one suggestion tag, and it has many tag-converters. More importantly, focus is often a small part of the question. For example, the idea that a modifier is part of the focus is greatly distorted by the fact that the number of cases without a modifier is higher than the opposite. In addition, working with normalized frequencies requires a large amount of training data to be a statistically significant learning experience. Thus, HMM-glasses are currently studying the probability of a part of the text (ie words) in question. This leaves the template with no information about the manual dependency relationship. However, this is offset by the distiller, as experts only determine the rules of dependence for extraction.

Combination of distiller and HMM-glasses. Recall that the distiller produces focal parts with a single total expert confidence score. In addition, we have HMM-glasses products:

$$\begin{matrix} \text{HMM} & \text{Distiller} \\ \left\{\begin{matrix} \langle fpn_1, fpt_1, fpc_1\rangle & \langle fpn_1, fpt_1, fpc\rangle \\ \langle fpn_2, fpt_2, fpc_2\rangle & \langle fpn_2, fpt_2, fpc\rangle \\ \vdots & \vdots \\ \langle fpn_p, fpt_p, fpc_p\rangle & \langle fpn_q, fpt_q, fpc\rangle \end{matrix}\right. \end{matrix}$$

The combination of possible focal parts with different models is done by parts. In other words, the models try to convince each other that each part is within the last parts of the focus. To do this, we use fpc points, measure them by individual f points of the model according to the training data and get the maximum. Note that only if one detail is defined as a potential focus particle is one of the M1 models (ie, another M2 model assumes that this part is not part of the focus), then we calculate the confidence score M1 and compare it with the M2 f score as described above. If the confidence score M1 is greater than M2, the word is classified as part of the focus, otherwise it is removed from the focus.

4.2 Class extraction

To classify the questions, we identified two types of manual classes, namely [12,13] adapted, coarse and fine classes with different semantic permissions. The thin class of the question establishes a strong connection with a particular subject area, and its coarse class is essentially incorporated into a generalization model, which creates a classification used in areas other than geography. We currently have seven rough classes (Table 2) and a total of 57 fine classes. In this study, we focused only on rough grades. We plan to group thin classes using statistical methods, which requires a full number of questions in each thin class.

Table 2. Rough classes for the domain of geography

Question class	Frequency (%)
Description	25,2

Digital	24,2
The essence	19,6
Temporary	12,4
Location	11,9
Abbreviation	3,8
Man	2,4

To classify this question into one of the rough classes, we created a set of general phrases for each class that is unique to this class. For example, for the NUMERIC class, we have two sentences: "how many" and "how many". The classifier searches for the given patterns in the given question and classifies them accordingly. We additionally implement a statistical classifier that uses a tf-idf-based “word bag” strategy as a basic model for comparison in a rule-based manner. In the basic model, the weight of the word w for class c is calculated as follows:

$$tf\_idf_{w,c} = tf_{w,c} \times idf_w$$

where $f_{w,c}$ indicates the number when the word is in class c, and idf_w is calculated as shown below:

$$idf_w = \log \frac{class\ number}{w\ number\ of\ classes\ available}$$

Then, for the given Q question, we assign it to a class that multiplies the sum of tf-idf points: $argmax_c \sum_{w \in Q} tf\_idf_{w,c}$.

5 Evaluation and results

One of the main problems we faced was the lack of a suitable baseline (from previous studies, etc.) to demonstrate the real severity of the problem and the actual effectiveness of our solutions. Therefore, we implemented a basic model to obtain a focus that matches the words adjacent to the key word of the question for a certain proximity as part of the focus. The proximity model is slightly worse, but the results are similar to the tf.idf model. We selected only the original data with the best results (ie tf.idf) for the actual comparison. It's worth noting that the initial models should be made in a simple way, as no preliminary research has been conducted in the analysis of statistical issues in the Kazakh language. Therefore, the rationale for setting the lower limits of the problem is simple. In addition, a basic statistical model based on tf-idf is introduced to classify the questions, which uses a strategy of word set. All results are presented in the form of comparisons with the basic models given in tables 3 and 4.

Table 3. Results of evaluation of all models of focus

Model	Accuracy	Withdrawal (recall)	F-Assessment
Basic (tf.idf model)	0,769	0,197	0,290
Distiller (Generic Enabled)	0,714	0,751	0,732
Distiller (Generic Disabled)	0,816	0,623	0,706
HMM-Glasses (Backward Mode)	0,839	0,443	0,580
HMM-Glasses (Forward Mode)	0,847	0,495	0,625
HMM-Glasses (Forward and Backward Mode)	0,821	0,515	0,633
Combined	0,734	0,841	0,784

(Generic Enabled, Backward)			
Combined (Generic Enabled, Forward)	0,732	0,846	0,785
Combined (Generic Enabled, Forward & Backward)	0,721	0,851	0,781
Combined (Generic Disabled, Backward)	0,821	0,759	0,789
Combined (Generic Disabled, Forward)	0,818	0,765	0,791
Combined (Generic Disabled, Forward & Backward)	0,802	0,776	0,788

Table 4. Results of QClass classification. The upper part is a model based on tf-idf, the lower part is a rule-based model

Class	Accuracy	Recall	F-Assessment
Description	0,662	0,908	0,764
Temporary	0,767	0,618	0,670
Digital	0,801	0,758	0,776
The essence	0,100	0,025	0,040
Cut back	0,933	0,766	0,823
Location	0,759	0,212	0,312
Man	0,600	0,600	0,600
Tf.Idf total	0,660	0,555	0,569
Description	0,874	0,732	0,797
Temporary	1,000	1,000	1,000
Digital	0,995	0,911	0,951
The essence	0,603	0,817	0,694
Cut back	0,871	0,894	0,883
Location	0,944	0,880	0,911
Man	0,869	0,833	0,851
Rule-based total	0,879	0,867	0,869

Since the data to be evaluated on the basis of our models were prepared in this study course, we are building our evaluation strategy around the concept of hygiene, in which we provide two fundamental principles. First, at any point and for each model, the scores are derived from the result obtained for questions that the model has not previously crossed. Secondly, for a reasonable comparison of models, single points are calculated using the same questions in each price iteration for different models with different parameters. To evaluate the distillery, experts based on the rules are developed using only the first 107 issues that we had at the beginning. Thus, the remaining questions are safely considered as test data, since after receiving a large number of questions, no changes have been made. For all models, ratings are performed using 10-fold cross-validation, which is stratified for all questions. To get focus, the final results (i.e. accuracy, feedback, and f-Score) are obtained by macrosaving individual results. The distiller has the ability to turn the

Universal expert on and off, and HMM-Glasses has forward, backward, and forward-backward modes that calibrate the serialization of the dependency tree. All different combinations of these parameters are evaluated individually for each model, as well as individually in the combination, in each iteration of the accumulation process. To get the focus and classify the questions, the results are presented in Tables 3 and 4, respectively.

5.1 Results of getting the focus

As a result of individual evaluation of the distiller, comparison accuracy and lower return scores (compared to mixed models) were obtained. An important result of the evaluation of the distiller is the actions of a general expert. The results show that the general expert reduces the accuracy of the results obtained when enlarging the sample (i.e. the return) (i.e. the accuracy). However, both results do not compensate, because the results obtained show that the f-Score of the distiller with the general expert turned on is higher than that of the general expert turned off. Individual evaluation of the effect of serialization methods shows that it is slightly better than in the reverse mode, taking into account the f-scores in the forward and reverse modes. The reverse mode probably increases the negative impact of any model it is connected to, but the f-scores indicate that it is not useful to increase the recall, as it reduces the performance of the mixed models when it is connected. In general, although the individual accuracy of the models is quite reasonable, increasing the coverage (recall) for all combined models with both a distiller and HMM-glasses shows that the combination is more useful than individual scores, as it does not destroy the actual scores we observe in individual assessments. , f-scores. Therefore, it can be concluded that the models complement each other well.

5.2 Results of class rules

The results show that the use of knowledge in the subject area has led to significant success, which could not be approached by the basic statistical model. However, a set of manual rules is a big problem when changing a domain. Therefore, it is planned to further develop statistical reading, which automatically learns phrases related to these domains, as each instance requires many instances.

This shortage is the reason for leaving a definition of good classes for future study. Table 4, along with the results of the tf-idf-based classification, shows the macro-accuracy, recall, and f-scores of the rule-based classifier's rough class identification.

6 Conclusion

In this study, we Kazakh language, such as agglyutïnatïvti closed domain system used to answer the questions for the proposed combination of new rules and statistical methods to analyze the question. Question analysis consists of focusing and classifying questions. To get the focus, we have several experts based on the rules for frequently asked questions in the Kazakh language. In addition, we described the method of sequential classification of the novel based on HMM, as well as combined the results of the rules and statistical models on the individual reliability of each model. To classify the questions, we used a rule-based classifier that uses phrases that are not appropriate for each class. We used basic models for both issues and reported on the comparison here. In addition to the proposed methodology, we offer a set of handwritten questions for reproduction and subsequent research. The work herein has been executed in the frame of the project AP09259556 «Development of methods and systems for integrated learning and natural language processing, based on artificial intelligence technologies».

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