Ministry of Education and Science of Ukraine
Black Sea Universities Network

# ODESA NATIONAL UNIVERSITY OF TECHNOLOGY

## International Competition of Student Scientific Works

# BLACK SEA SCIENCE 2022

## PROCEEDINGS


ODESA, ONUT 2022

Ministry of Education and Science of Ukraine

Black Sea Universities Network

Odesa National University of Technology



International Competition of Student Scientific Works

# BLACK SEA SCIENCE 2022

## Proceedings

Odesa, ONUT 2022

**UDC 001.8(063)**



**Black Sea Science 2022**: Proceedings of the International Competition of Student Scientific Works / Odesa National University of Technology; B. Iegorov, M. Mardar (editors-in-chief) [*et al.*]. – Odesa: ONUT, 2022. – 749 p.

Proceedings of International Competition of Student Scientific Works «Black Sea Science 2022» contain the works of winners of the competition.

The author of the work is responsible for the accuracy of the information.

## Organizing committee:

**Prof. Bogdan Iegorov,** D.Sc., Rector of Odesa National University of Technology, Head of the Committee

**Prof. Maryna Mardar,** D.Sc., Vice-Rector for Scientific and Pedagogical Work and International Relations of Odesa National University of Technology, Deputy Head of the Committee

**Prof. Baurzhan Nurakhmetov,** D.Sc., First Vice-Rector of Almaty Technological University (Kazakhstan)

**Prof. Michael Zinigrad,** D.Sc., Rector of Ariel University (Israel)

**Prof. Plamen Kangalov,** Ph.D., Vice-Rector for Academic Affairs of "Angel Kanchev" University of Ruse (Bulgaria)

**Prof. Heinz Leuenberger,** Ph.D., Professor of the Institute of Ecopreneurship of University of Applied Sciences and Arts (Switzerland)

**Prof. Edward Pospiech**, Dr. habil., Professor of the Institute of Meat Technology of Poznan University of Life Sciences (Poland)

**Prof. Lali Elanidze,** Ph.D., Professor of the Faculty of Agrarian Sciences of Iakob Gogebashvili Telavi State University (Georgia)

**Dr. Dan-Marius Voicilas,** Ph.D., Associate Professor of the Institute of Agrarian Economics of Romanian Academy (Romania)

**Prof. Stefan Dragoev,** D.Sc., Vice-Rector for Scientific Work and Business Partnerships of University of Food Technologies (Bulgaria)

**Prof. Jacek Wrobel,** Dr. habil., Rector of West Pomeranian University of Technology (Poland)

**Dr. Mei Lehe,** Ph.D., Vice-President of Ningbo Institute of Technology, Zhejiang University (China)

**Dr. V. Kozhevnikova,** Ph.D., Associate Professor of the Department of Hotel and Catering Business of Odesa National University of Technology, Secretary of the Committee

# INTRODUCTION

International Competition of Student Scientific Works “Black Sea Science” has been held annually since 2018 at the initiative of Odesa National University of Technology (formerly Odesa National Academy of Food Technologies) with the support of the Ministry of Education and Science of Ukraine. It has been supported by Black Sea Universities Network (the Association of 110 higher education institutions from 12 countries of the Black Sea Region) since 2019, and by Iseki-FOOD Association (European Integrating Food Science and Engineering Knowledge into the Food Chain Association) since 2020.

The goal of the competition is to expand international relations and attract students to research activities. It is held in the following fields:

- Food science and technologies
- Economics and administration
- Information technologies, automation and robotics
- Power engineering and energy efficiency
- Ecology and environmental protection

The jury includes both Ukrainian and foreign scientists. In the 4 years that the competition has been held, the jury included scientists from universities of 24 countries: Angola, Azerbaijan, Benin, Bulgaria, China, Czech Republic, France, Georgia, Germany, Greece, Israel, Italy, Kazakhstan, Latvia, Lithuania, Moldova, Pakistan, Poland, Romania, Serbia, Slovakia, Switzerland, Turkey, USA.

At the same time, every year the geography has expanded and the number of foreign jury members has increased: from 46 jury members representing 25 universities from 12 countries in 2018, to 73 jury members of the 46 universities from 19 countries in 2022.

More than a thousand student research papers have been submitted to the competition from both Ukrainian and foreign institutions from 25 countries: China, Poland, Mexico, USA, France, Greece, Germany, Canada, Costa Rica, Brazil, India, Pakistan, Israel, Macedonia, Lithuania, Latvia, Slovakia, Romania, Kyrgyzstan, Kazakhstan, Bulgaria, Moldova, Georgia, Turkey, Serbia.

The interest of foreign students in the competition grew every year. In 2018, the students representing 15 institutions from 7 countries have submitted 33 works. In 2021 the number of submitted works increased to 73, authored by the students of 40 institutions from 18 countries.

The competition is held in two stages. In the first stage, student research papers are reviewed by members of the jury who are experts in the relevant fields. In the second stage of the competition, the winners of the first stage have the opportunity to present their work to a wide audience in person or online.

All participants of the competition and their scientific supervisors are awarded appropriate certificates, and the scientific works of the winners are included in the electronic proceedings of the competition. Every year the competition receives a large number of positive responses from Ukrainian and foreign colleagues with the desire to participate in the coming years.

# 3. INFORMATION TECHNOLOGIES, AUTOMATION AND ROBOTICS

# DECISION SUPPORT SYSTEM FOR FORECASTING THE NUMBERS OF THE TROOP IN THE MIDDLE AGES

**Author:** Andrei Kapeleshchuk
**Advisor:** Oleksandr Melnykov
Donbas State Engineering Academy (Ukraine)

***Abstract.*** *This work is devoted to solving the problem of predicting the number of troops in the Middle Ages. Three general tasks are formulated: forecasting the number of troops based on available factors; verification of the reality of the existence of troops of such a certain number; calculation of the size of the army after a certain time of the campaign. The main mathematical formulas necessary for carrying out calculations for each problem are given. The task of developing specialized software is formulated - a decision support system that allows you to test the hypothesis of the number of troops, dynamically simulate the number of troops at each moment of the campaign and calculate the number of troops using indirect data. An information model of the system is presented in the form of a set of UML diagrams (use cases, classes, sequence and components). Examples of using the developed system are described.*

***Keywords:*** *medieval military history, forecasting, unified modeling language, Python, Eel.*

## I. INTRODUCTION

Nowadays, the theme of medieval history is quite popular in popular culture. However, most of the historical media projects are quite far from the modern idea of medieval history. The reason for this phenomenon is a large number of historical myths roaming the Internet and the use of outdated historical literature. One of the most interesting moments of medieval history are wars and military campaigns.

One of the problems in studying military operations of a fairly distant past is determining the number of opponents on both sides. Medieval chronicles and some authors of fiction are tend to exaggerate the military events of the distant past, so it is very difficult to find more or less real facts among fantasies.

A more realistic understanding of the events of a very distant past will help us, the descendants, understand better the historical processes that took place more than half a millennium ago.

With the advent of the computer technology in historical science, various modeling systems are increasingly being used, as they allow visualizing and making visual and more understandable to the general public the information recorded in dry scientific articles, understandable only to specialists.

The purpose of the work is to find out non-combat losses in the medieval armies during marches.

The object of the study is the number of dead soldiers due to non-combat losses. The subject of the research is models, methods and information technologies for solving the task.

## II. LITERATURE ANALYSIS

There are no open access applications for solving this problem, which is not surprising in view of a particularly narrow range of tasks to be solved. You can calculate the number of medieval troops using standard mathematical packages (SMatchStudio, MatchCad, etc.) or an Excel spreadsheet. But for each individual task, the Excel workbook will have to be redone and the database for each task will have to be created independently. In addition, it is impossible to create cycles in Excel, and this imposes additional restrictions on the accuracy of the calculations.

## III. OBJECT, SUBJECT AND METHODS OF RESEARCH

Three general tasks can be identified. The main task: you need to predict the number of troops based on the available factors:

$$y = \{a_1, a_2, \ldots, a_n\}, y = \{a_1, a_2, \ldots, a_n\}, \quad (1)$$

where y is the total number of troops to be calculated;

$a_i$ , i=1..n are factors affecting the number of troops (season, terrain, presence of epidemics, etc.);

n is the number of factors affecting the number of troops.

The total predicted number of troops can be divided into components:

$$y = y_1 + y_2 + \ldots, + y_m, y = y_1 + y_2 + \ldots + y_m, \quad (2)$$

where y is the total number of troops to be calculated;

$y_i$ , i=1..m are the numbers of a separate category of troops (cavalry, infantry, etc.);

m is the number of categories of troops.

The second task is to check the reality of the existence of troops of such a (given) number:

$$F(x) = \begin{cases} f_1(x, a_1) = y_1 \\ f_2(x, a_2) = y_2 \\ \ldots \\ f_n(x, a_n) = y_n \end{cases}, F(x) = \begin{cases} f_1(x, a_1) = y_1 \\ f_2(x, a_2) = y_2 \\ \ldots \\ f_n(x, a_n) = y_n \end{cases}, \quad (3)$$

$$Y = y_1 + y_2 + \ldots + y_n, Y = y_1 + y_2 + \ldots + y_n, \quad (4)$$

where x is the number of troops entered by the user;

$a_i$, i=1..n are factors affecting the number of troops (season, terrain, presence of epidemics, etc.);

n is the number of factors affecting the number of troops.

$f_n(x,a_i)$ is a function that calculates penalty points by checking x against the criteria {a};

Y is the total number of penalty points, indicating the correctness of the entered data.

Thus, by generating the number of a certain army and counting the number of penalty points, one can find the most probable value.

The third task is to calculate the size of the army after a certain time of the campaign. This can be done with the following function:

$$x_k = pood(x, d, \{a\}), x_k = pohod(x, d, \{a\}), \quad (5)$$

where x is the number of troops entered by the user;

d is the number of days of staying in the campaign;

{a} is a combination of other factors (season, location, presence of epidemics, etc.

xk is the number of warriors who reached the goal of the campaign.

The number of troops can still be determined by knowing the number of enemy troops in the battle and its result, but such a calculation can be implemented only using artificial intelligence methods, and in some cases only.

## IV. RESULTS

The application has three usage scenarios: hypothesis testing (troop size), dynamic simulation of the troop size at each moment of the campaign, calculation of the troop size using indirect data. All of these use cases are shown in the usage diagram (Diagram 1). The information model of the new designed system was created in the unified modeling language UML - Unified Modeling Language [5].

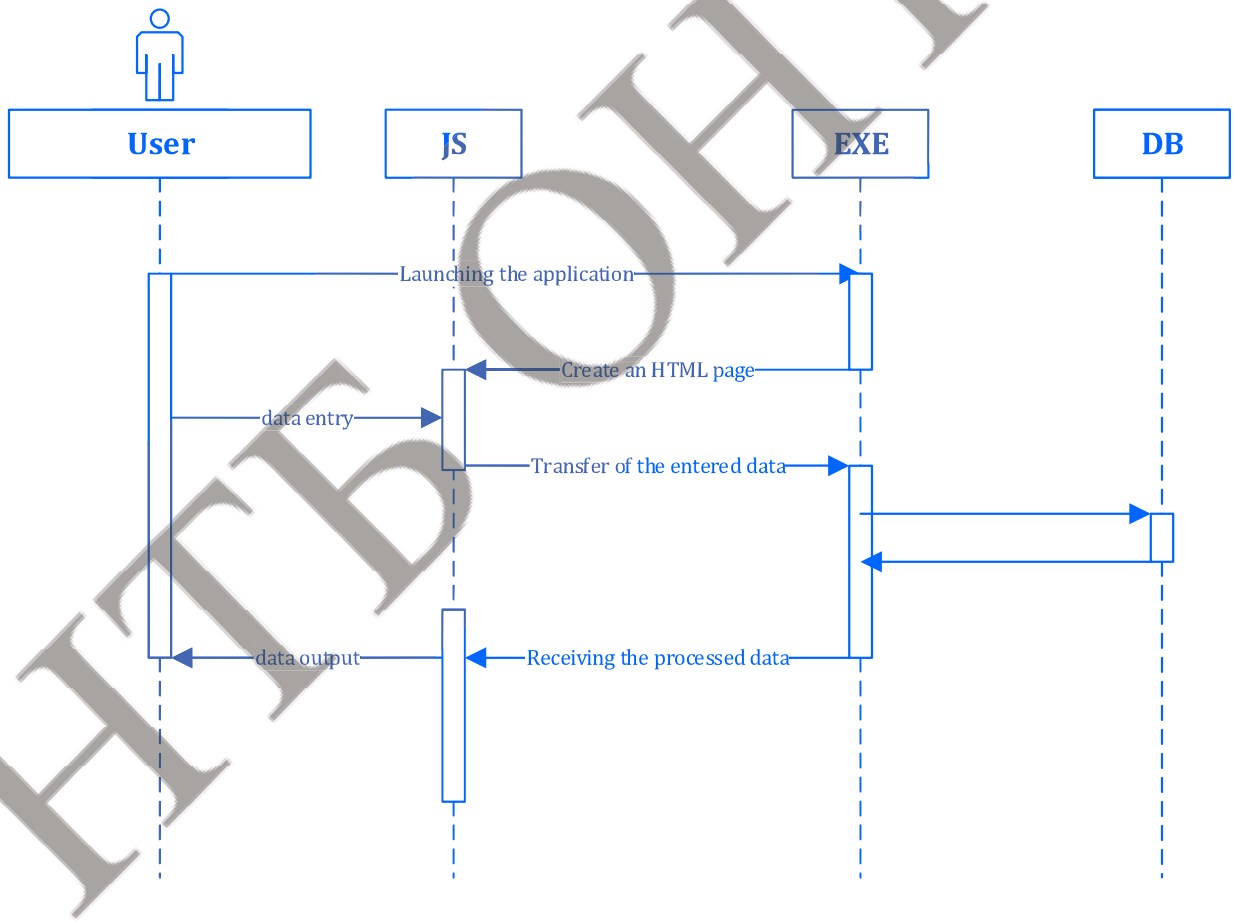


Fig. 1. Use Case diagram

The sequence diagram (Figure 2) shows the interaction between Python and JS while the application is running.

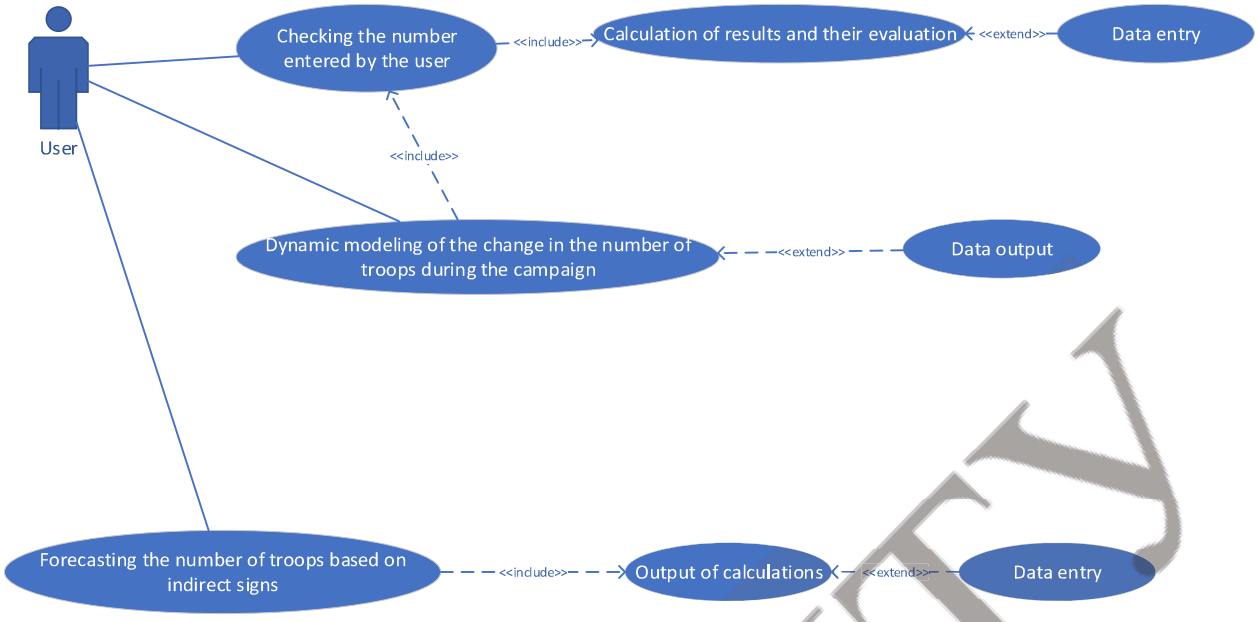


Fig. 2. Sequence diagram

The class diagram (Figure 3) shows JavaScript classes that display information to the user and receive it from him for transmission to Python, as well as two Python calculation classes for performing calculations according to the first and second scenarios.

To develop an information system, it is planned to use the Eel library for the Python programming language. Using this library allows you to develop an interface using standard web development techniques. This will allow you quickly to adapt the application to a large number of platforms, as well as transfer some of the functions for computing on the user's computer, reducing the load on the server (if the system is used as an online application). The detailed structure of the program files is shown in the component diagram (Fig. 4).

Having available UML diagrams, you can start the software implementation of the information system.

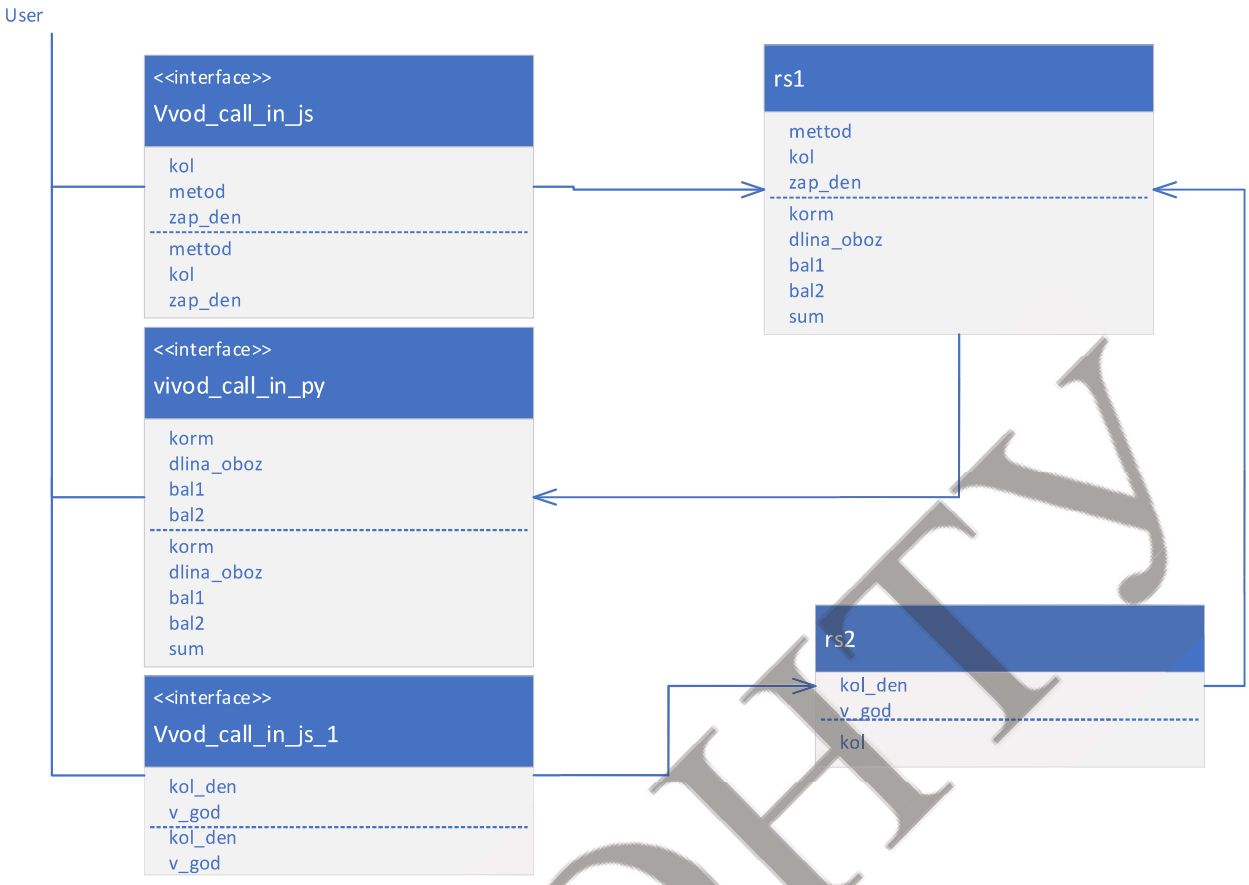


Fig. 3. Class diagram

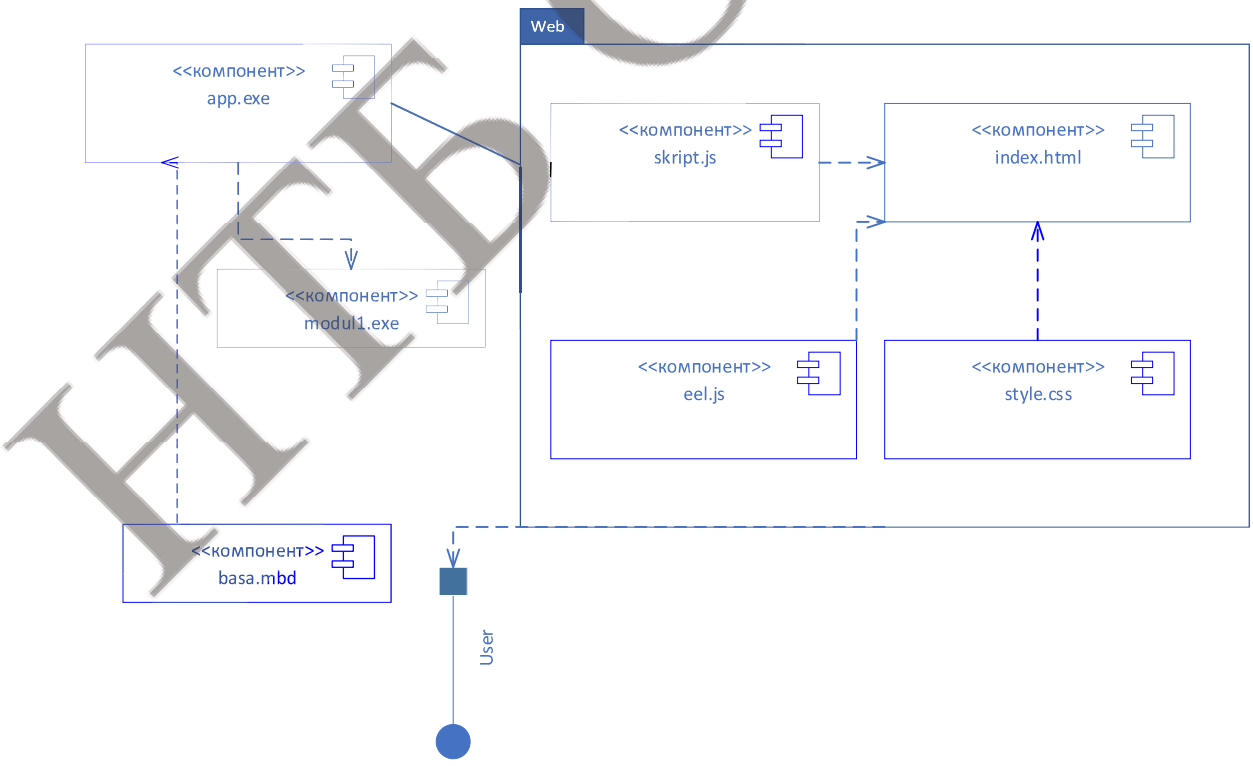


Fig. 4. Component diagram

Now some historians believe that the number of the Mongol army that came to Russia was no more than 40,000 [2]. Let's enter this value into the application (Figure 5).

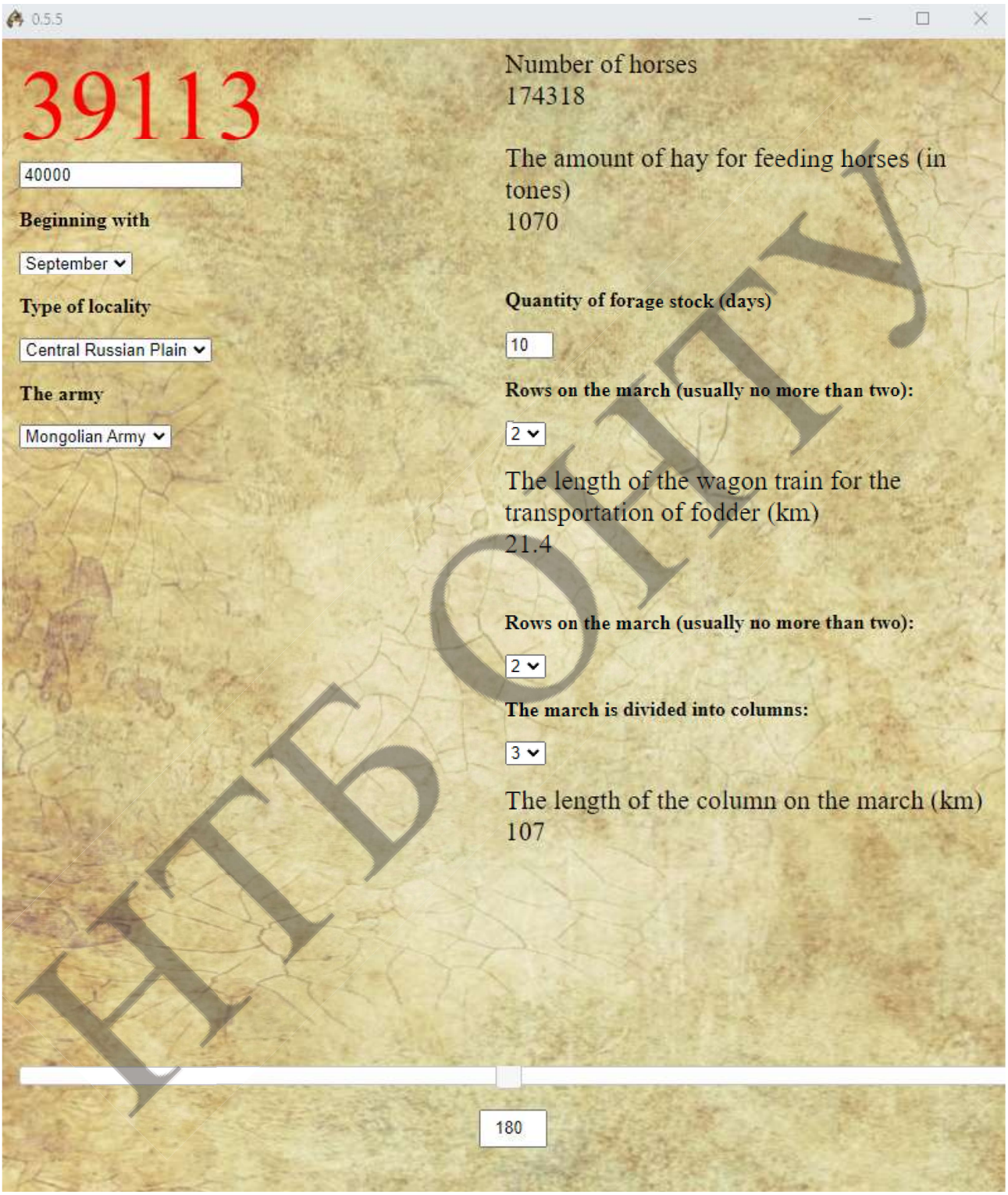


Fig. 5. Application's work

The calculations show that during the six months of the campaign, non-combat losses will reach thousands of units. But even an army divided into three columns could

stretch for more than 100 km on the march, and a convoy with fodder for 10 days would stretch for more than 20 km.

Let's enter the data calculated by the historians from direct reading of the historical sources, for example 139,000 (Figure 6).


Fig. 6. Application's work

With the introduction of the initial value of the army at 139,000 for six months, non-combat losses will amount to almost 4,000 thousand units, but with this

calculation, the length of the convoy began to equal 69 km, so you need to reduce the number of days of army autonomy to 4 in order to at least slightly reach the value of up to 30 km, because a larger convoy cannot be controlled. The application warns that the autonomy parameter of the troops is greatly underestimated, because in real life the Mongol army would starve to death with an autonomy of less than four days.

The length of the column of soldiers on the march would stretch for 340 km, which would significantly reduce the efficiency of the army's advance compared to the first case.

## V. CONCLUSIONS

A system was developed for modeling the number of the medieval troops during a campaign, which allows you to calculate the number of troops at every moment of their combat path.

All application components have been tested for correct operation and for incorrect user input, and those which did not work correctly have been disabled. Also, the study of literary sources made it possible to organize a hint system that would help the user while working with the application.

For software implementation, I have chosen the connection between Python and JS using the Eel library, because it makes it possible to make a nice graphical interface using the simple Python programming language.

## VI. REFERENCES

1. *Educational program: the number of medieval armies.* https://warhead.su/2019/07/14/likbez-chislennost-srednevekovyh-armiy.

2. Zhukov, K. A., *Puchkov, D. Yu.* (2019). *Ancient Russia. From Rurik to Batu. - S-Pb.: Peter.*

3. *Warfare in Western Europe in the Central Middle Ages.* https://www.swansea.ac.uk/history/history-study-guides/warfare-in-western-europe-in-the-central-middle-ages.

4. *Medieval: Warfare.* https://www.english-heritage.org.uk/learn/story-of-england/medieval/war.

5. Melnykov, O. Yu. (2020). *Object-oriented analysis and design of information systems: manual for students majoring in "Systems Analysis" and "Information Systems and Technologies". View. 3rd, reworked. and additional*. Kramatorsk: DSEA

6. *Python & EEL. We do it simply in Python and beautifully in JS.* https://habr.com/ru/post/550426/

7. Kapeleshchuk, A. O., Melnykov, O. Yu. (2021). Forecasting the number of troops in the Middle Ages using mathematical modeling. *Proceedings of the IV All-Ukrainian scientific-practical online conference of students, graduate students and young scientists on "Modern computer systems and networks in management": a collection of scientific papers / Edited G.O. Raiko.* Kherson: Publishing House FOP Vyshemirsky VS, 228-230.

8. Kapeleshchuk, A. O. (2021). Statement of the problem of determining the number of troops in the Middle Ages using mathematical modeling and information technology. *Youth Science in the context of socio-economic development of the country: a collection of abstracts of participants of the V Jubilee Student Conference, Cherkasy, December 2, 2021.* Cherkasy: Rauf Ablyazov East European University, 214-216.