ABSTRACT

of thesis for the degree of doctor of philosophy (PhD)
specialty "6D070400 - Computer engineering and Software"

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“Modeling and development of an automated system for monitoring and managing the social and epidemiological situation in the regions of Kazakhstan”

Relevance of the work. Since the beginning of the XX century, methods for predicting the epidemiological situation have been actively developed. Epidemiological forecasts are made for different periods and, depending on them, serve different purposes. Basically, three types of forecasting are performed, these are: long-term for a period from several months to several years, medium-term for a period from two months to half a year and short-term forecasts for several weeks in forwarding are used in operational management and in identifying epidemic outbreaks of disease. In recent years, the number of papers on this topic has been growing rapidly due to the deployment of information systems of monitoring and the appearance of large volumes of statistics available for analysis. The most useful method can be considered a medium-term forecast for a period from two months to six months, used in tactical control. Due to various factors, less accurate than short-term, it leaves enough time to prepare for possible emergencies and conduct preventive measures.

Mathematical modeling of the risk dynamics of an infectious disease is intensively used by specialists to solve a number of applied issues, such as planning various protective measures and treating infectious patients.

In scientific literature, the plague is called tularemia. The natural center of tularemia is common on all continents of the Northern Hemisphere in Europe, Asia and North America. Human diseases are recorded as isolated cases and epidemic outbreaks in Austria, France, Germany, Sweden, Japan, the USA and other countries. Often, flashes cover several hundred people. The increase in incidence is observed in the years of increasing the number of rodents. In the Russian Federation, tularemia was found on the territory of almost all territories, regions, and republics.

In Kazakhstan, the problems of monitoring and preventing epidemics of plague are dealt with by the M.Aykimbaev Kazakh Scientific Center for Quarantine and Zoonotic Infections and territorial anti-plague stations. The most dangerous are the following natural plague foci in Kazakhstan: Ural-Emba autonomous center, Aral sea-Karakum autonomous center, Balkhash sea autonomous center, Volgo-Ural autonomous center, Mangyshlak autonomous center, Trans -Ural autonomous center.

The purpose of the thesis is the development and study of mathematical models, which mean to obtain information in real time, algorithms and technologies for monitoring the epidemiological situation.

To achieve this goal in the thesis the following tasks are solved.

- analysis of known mathematical epidemiological models, data source,

- justification and study of a mathematical model for predicting the dynamics of abiotic factors of the epidemiological situation in real time,
- justification and study of a mathematical model for the management of biotic factors by an epidemiological model,
- development, justification and application of fuzzy mathematics for monitoring the epidemiological potential of the region depending on social-economic factors,
- development of an expert system for monitoring and forecasting epidemic potential,
- conducting experimental studies on model data to analyze the adequacy of the proposed mathematical models, methods and algorithms.

The scientific novelty of the thesis.

- proposed a mathematical model and sources of abiotic data in real time;
- the criterion of controllability of a mathematical model of the dynamics of biotic factors was obtained on the basis of interval mathematics;
- on the basis of fuzzy mathematics, a mathematical model was proposed which takes into account the social-economic potential of the region;
- developed mathematical models, methods and algorithms which implemented in the form of an expert system for monitoring the epidemiological situation in the regions.

Research methods. In solving the problems posed, the dissertation paper used methods of numerical analysis, mathematical modeling, database theory, the theory of digital signal processing and transmission, data processing methods on microprocessors, modern systems for designing and developing information systems.

Object of study. The object of the study is the epidemiological situation in the region.

The subject of the research is an automated system for monitoring and managing the social-epidemiological situation.

The practical significance of the work lies in the development of a mathematical model which takes into account the abiotic, biotic and social-economic factors of the region.

The applied value of the work results is in the ability of the state and health authorities to control the situation to make a decision on prevention.

Provisions for protection. According to the results of the study, the following tasks were solved:

- a program for predicting the dynamics of abiotic factors in real time has been developed;
- the controllability of a mathematical model of the dynamics of biotic factors was investigated — a controllability criterion based on interval and fuzzy mathematics was obtained for the first time;
- an algorithm for solving multi-criteria optimization to estimate the epidemiological status in the region;
- development of an expert system for forecasting and managing the epidemiology in the region.

Communication of the topics with the plans of research programs

The dissertation work was carried out in accordance with the schedule of research and research grant works according to priority: 4. Life and health sciences, according to priority: 4.2 Scientific and innovative biomedicine. Biotechnologies in medicine and nanomedicine on the subject of the project: 1.34 "Development of a hardware-medical complex to estimate the psycho-physiological parameters of a person" of the Institute of Information and Computing Technologies of the Committee of Science and MES RK.

The structure of the thesis includes an introduction, 4 sections, conclusion, list of references and applications.

The introduction provides a justification for the relevance of the selected topic of the dissertation. The purpose, object, subject and tasks of research work are formulated. The results of the conducted research are described, their scientific novelty and practical significance are shown. The data on the approbation of the main results of the thesis are given.

In the first section of the dissertation, the analysis of existing models for predicting abiotic factors is carried out. The general characteristics of the problem and the formulation of research objectives are given. Based on microprocessor technology and sensor sensors, an autonomous microcomputer climate data transmission system has been developed. A program for predicting abiotic factors in real time has been developed. The efficiency of the algorithm is shown on a model problem.

In the second section, the problem of controllability of the dynamic system which described by ordinary differential equations is solved. Based on the using of linguistic variables and interval mathematics, an effectively checkable criterion is obtained, which is formulated and proved as a theorem. The optimal control problem was solved under various constraints on the conditions of the problem: 1) with a fixed right end and a fixed time, 2) with a free right end, 3) optimal performance with fixed ends, and 4) with fixed ends and phase constraints. All tasks are investigated under control restrictions. The reliability of the obtained results follows from the stated and proved theorems. The effectiveness of the proposed algorithms is shown on a model problem.

The third section is devoted to the analysis of existing models of social-economic forecasting. The general characteristics of the problem and the formulation of research tasks are given. Analyzed the task and identified the main problems that may arise in the course of its solution. A method for monitoring epidemiological conditions based on fuzzy mathematics is proposed. Based on multi-criteria optimization, an algorithm for calculating convolution coefficients has been developed. The convergence of the proposed algorithm is proved.

The fourth section describes the developed expert system for forecasting and managing the epidemiological situation. The structures of database tables and their interrelationships are determined. An expert questionnaire system has been developed. A graphical user interface application. Describes the various workspaces of the interface. The interface part is implemented on the basis of VisualFoxPro9 DBMS.

In conclusion, the main results and conclusions of the thesis are presented.

The validity of the scientific provisions submitted for the defense, conclusions and recommendations are confirmed by the correctness of the using of the mathematical apparatus; correct formulation of experiments and their processing; qualitative and quantitative correspondence of the results of theoretical studies and experimental data; practical application of research results.

Approbation of work. The results of the thesis were reported at international scientific conferences, annual scientific conferences of the Institute of Computational and Information Technologies, International Conference of Students and Young Scientists of the Kazakh National University, as well as at scientific seminars of the Department "Computer Science" of Al-Farabi University.

Received 3 certificates of state registration of rights to the object of copyright.

Publications. On the topic of the thesis 17 works are published, of which 11 are publications in journals recommended by KKSON MES RK, 1 publication in the journal included in the Scopus database.

Scientific publications:

1. Жаугашева С.А., Нурбакова Г.С., Мукушев Б.А., Исимов Н.Т. Исследование колебаний нелинейного маятника посредством пакета прикладных программ MathCAD //Вестник КазНТУ. – 2016, № 4. – С.1-8.

2. Мукушев Б.А., Исимов Н.Т. Ограниченная задача о трех телах //Вестник КазНТУ им. К.И. Сатпаева. – 2016, b№ 2. – С.504-509.

3. Мукушев Б.А., Исимов Н.Т. Исследование закономерностей движения небесных тел с помощью пакета прикладных программ MathCAD //Вестник КазНТУ им. К.И. Сатпаева. – 2016, № 2. – С.496-504.

4. Нурбакова Г.С., Сарсембаев М.С., Мукушев Б.А., Исимов Н.Т. Гармонический анализ периодических несинусоидальных токов на основе численного метода //Материалы X Международной научно-практической конференции «Молодой ученый: Вызовы и перспективы», Интернаука. – 2016. – том 10, №8. – С.1-8.

5. Мукушев Б.А., Г.С., Исимов Н.Т. Электрлік тербелістерді зерттеуге арналған компьютерлік эксперименттер //«Хабаршы» КазНПУ им Абая. – 2016, № 3(55). - С. 96-102.

6. Мукушев Б.А., Нурбакова Г.С., Исимов Н.Т., Мусатаева И.С., Желдыбаева Б.С. Ван дер Поль теңдеуімен сипатталатын электрлік автотербелістерді MathCad пакеті көмегімен талдау //Вестник КазНИТУ им. К.И. Сатпаева. – 2017, № 1. – С.401-405.

7. Джомартова Ш.А., Мазакова А.Т., Майлыбаева А.Ж., Исимов Н.Т., Абдразак Ж. Математическое моделирование в управлении ВУЗом //Сборник материалов V международной научно-теоретической конференции «Роль физико-математических наук в современном образовательном пространстве». – Атырау, 6-7 апреля 2017. – С.130-136.

8. Джомартова Ш.А., Мазаков Т.Ж., Исимов Н.Т. Мазакова А.Т. Программа прогнозирования в реальном времени. //Вестник Национальной инженерной академии РК. – 2017, №4(66). – С.27-32.

9. Джомартова Ш.А., Исимов Н.Т., Байрбекова Г.С., Зиятбекова Г.З., Абдразак Ж. Идентификация личности на основе 2D и 3D изображений //Вестник Национальной инженерной академии РК. – 2018, № 2(68). - С.16-20.

10. Мазаков Т. Ж., Исимов Н.Т., Зиятбекова Г.З., Жолмагаметова Б.Р., Джомартова Д.Т., Ыдырышбаева М.Б. Обработка сигналов ЭКГ на микропроцессорах //Труды научной конференции Института информационных и вычислительных технологий МОН РК «Современные проблемы информатики и вычислительных технологий». – Алматы, 2018. – С.152-158.

11. Исимов Н.Т., Мазаков Т.Ж., Карымсакова Н.Т. Исследование модели прогнозирования и управления эпидобстановкой с применением нечеткого и интервального анализа //Научно-технический журнал «Вестник Алматинского университета энергетики и связи», спец.выпуск. – 2018. - С.147-155.

12. Исимов Н.Т., Мазаков Т.Ж, Карымсакова Н.Т., Жолмагамбетова Б.Р., Зиятбекова Г.З. Оптимальное управление эпидобстановкой //Труды 14-й международ. азиатской школы-семинара «Проблемы оптимизации сложных систем», Киргизская Республика. – Иссык-Куль, 20-31 июля, 2018. - С.250-258.

13. Issimov N., Mazakov T., Mamyrbayev O., Ziyatbekova G. Application of fuzzy and interval analysis to the study of the prediction and control model of the epidemiologic situation // Journal of Theoretical and Applied Information Technology. – 2018, vol. 96. – № 14. – P. 4358-4368.

14. Джомартова Ш.А., Карымсакова Н.Т., Исимов Н.Т., Зиятбекова Г.З., Мазакова А.Т. Программа перевода объемных изображений из формата в регулярную матрицу высот //Вестник Национальной инженерной академии РК. – 2018, №3(69) . с.34-37.

15. Мазаков Т.Ж., Исимов Н.Т., Жолмагаметова Б.Р., Карымсакова Н.Т., Ыдырышбаева М.Б. Об одном методе обработки экспертной информации // Материалы Ш межд. науч. конф. «Информатика и прикладная математика», часть 2, Алматы: 2018, с.221-224.

16. Алиаскар М.С., Джомартова Ш.А., Зиятбекова Г.С., Исимов Н.Т., Амирханов Б.С., Мазакова А.Т. Автономная микропроцессорная система передачи климатических данных //Вестник КазНИТУ им. К.И.Сатпаева, 2019, № 1 (131), с.371-377.

17. Әлиасқар М.С., Шорманов Т.С., Мамырбаев О.Ж., Исимов Н.Т. Применение биометрического сканера для идентификации человека по отпечаткам пальцев. Вестник КазУТБ – 2019, № 3. – С. 18-22.

Certificates of state registration of rights to the object of copyright:

1. The certificate of state registration of rights to the object of copyright No. 344 of February 27, 2017 "Finding the center of mass of the polygon" (computer program), authors: Nurbakova GS, Isimov NT, Kurma Zhanov A .T., Zheldybaeva B.S., Musatayeva I.S.

2. The certificate of state registration of rights to the object of copyright No. 345 of February 27, 2017 “Calculation of the center of mass of material points” (computer program), authors: Nurbakova GS, Isimov NT, Belisarova FB, Zheldybaeva B.S., Musatayeva I.S.

3. Certificate of state registration of rights to the object of copyright No. 2342 dated October 13, 2017 “Prognoz-RV” (computer program), authors: Mazakov T.Zh., Dzhomartova S.A., Isimov NT, Mazakova A.T.