ABSTRACT
of the doctoral thesis for the degree of Doctor of Philosophy (PhD) in the specialty: 6D070300 - «Information systems (by industry)

KARMENOVA MARKHABA AKHMETOLLINOVNA

DEVELOPMENT OF METHODS FOR SEISMIC RESISTANCE ASSESSMENT OF URBAN OBJECTS BASED ON DATA ANALYSIS TECHNOLOGY

General characteristics of the research: Dissertation work is devoted to the development of a method for assessing the seismic resistance of urban objects, taking into account the seismic data which is based on the use of intellectual data analysis. The proposed method makes it possible to carry out a «quick» assessment of data on the seismic resistance of typical urban objects, which significantly reduces the time and costs for assessing the seismic vulnerability of buildings. Based on the developed method for seismic resistance assessment of urban objects the architecture of an intelligent analytical system and its software implementation are designed.

Key words: technology of intellectual data analysis, cluster analysis, classification methods, identification of important variables, spatial clustering based on density with the presence of noise, architecture of an intelligent information and analytical system.

The relevance of the research. Currently, the prosperity and dynamic development of the Republic of Kazakhstan is associated with high-quality development, systemic implementation and effective implementation of government programs and strategic plans, which is covering almost all spheres of human life. Global trends, scientific achievements and technological innovative solutions contribute to the growth and prosperity of the fundamental industries of our country, and also allow us to be a competitive country in the world.

In the long term (Strategy «Kazakhstan-2050») of the development of our country, special attention is paid to industrialization, the introduction of modern technologies in the construction and communal sector, the development of the concept of a smart city. The construction industry is one of the actively developing sectors of the economy of the Republic of Kazakhstan, which has a significant impact on the social-economic development of the country and regions. As well as, applied scientific researches are under special attention which is aimed at ensuring the seismic safety of the country as a whole. First of all, the catalyst for the implementation of innovative solutions and practically significant results of scientific research are the developing information technologies, platforms, and their architectures, as well as intelligent information and analytical systems to support for making decision.

Currently, digital and information technologies are changing the construction. Information modeling technologies (BIM technologies) are being actively introduced in the construction of buildings and structures, new standards are being adapted and developed, thus, the digital transformation of the construction industry is taking place. Such global changes also raise actual issues such as modern construction in conditions

of seismic risk, forecasting seismic risks, updating and digitalization of seismic maps of localities, as well as the development of information technologies, models and methods that allow a «quick» assessment of the seismic vulnerability of objects, taking into account seismic data. Solving such problems requires from the researcher to use new approaches and technologies for the analysis of accumulated data sets and their processing. In this regard, the using of technology data analysis and machine learning methods together opened up new perspectives in scientific research for analyzing the daily growing volumes of seismic data and data on urban objects. Thus, the relevance of the dissertation work is associated with solving the problem of developing a method for assessing of the seismic resistance of urban objects with the seismic data on the bases of using intellectual data analysis, which allows for a «quick» assessment of the seismic resistance of typical urban objects.

The using of this approach brings its scientific contribution to the development of one («Creation of an innovative ecosystem») of the five key areas of the state program «Digital Kazakhstan». In addition, the dissertation research was carried out within the framework of state assignment № 748715F.99.1.BB97AA00002 of the Federal State Budgetary Educational Institution of Higher Education of Altai State University on the topic «The Turkic world of «the Great Altai»: unity and diversity in history and modernity» for 2020-2021 with funding from the Ministry of Science and Higher Education Russian Federation.

The main idea of the research is to develop a method for assessing the seismic resistance of urban objects based on the use of data mining, which significantly reduces the time and costs for assessing the seismic vulnerability of buildings. The developed method provides for an integrated approach to assessing the seismic resistance of urban objects, taking into account the analysis of seismic data. Cluster analysis is used in assessing the seismic resistance of urban objects, which distinguishes typical urban objects according to their seismic vulnerability.

Classification methods are applied to the obtained cluster results to study the data structure and refine the decision boundaries in each cluster, as well as to identify important characteristics that affect the seismic resistance of an urban object. Analysis of seismic data is based on the use of a spatial clustering algorithm for identifying dense areas of earthquakes. The values of the input parameters of the DBSCAN algorithm were determined in the process of using the spatial clustering. Taking into account seismic data, the architecture of an intelligent information and analytical system and its software implementation have been designed on the basis of the developed method for assessing the seismic resistance of urban objects.

The object of research of the dissertation work is the process of assessing the seismic resistance of urban objects and the seismic data analysis.

The subject of research is methods and algorithms of machine learning for assessing the seismic resistance of urban objects and analyzing seismic data.

The research goal: The goal of the dissertation research is to develop a method for assessing the seismic resistance of urban objects with the seismic data on the bases of using intellectual data analysis, which allows for a «quick» assessment of the seismic resistance of typical urban objects.

Research objectives. In accordance with the set goal, there are set and solved

the following research objectives:

- to analyze and research the existing approaches and methods of machine learning which used in solving the task of assessing the seismic resistance of urban objects and analyzing seismic data;
- to study existing information technologies and systems for assessing the seismic vulnerability of objects and processing of the seismic data;
- to develop a method for assessing the seismic resistance of urban objects taking into account seismic data on the bases of using data analysis technology and machine learning methods;
- to design the architecture of an intelligent information and analytical system for assessing the seismic resistance of urban objects, taking into account seismic data.
- to develop an intelligent information and analytical system for assessing the seismic resistance of urban objects, taking into account seismic data.

The main research methods. In this work, the machine of the theory of systems control, methods of statistical analysis, artificial intelligence, technologies for designing information systems are used to solve the set tasks.

Scientific provisions and results presented for defense of dissertation:

- developed method for assessing the the seismic resistance of urban objects on the bases of using the intellectual data analysis, which allows a «quick» assessment of the seismic resistance of urban typical objects. It is significantly reduces the time and costs for assessing the seismic vulnerability of buildings.
- spatial clustering algorithm that provides efficient analysis and processing of spatial seismic datasets to identify dense areas of earthquakes;
- architecture of an intelligent information and analytical system for assessing the seismic resistance of urban objects, taking into account seismic data.

The scientific novelty of the dissertation research concluded in the fact that for the first time a method is proposed for assessing the seismic resistance of urban objects, including algorithms of intellectual data analysis, which make it possible to distinguish groups of urban objects according to their seismic vulnerability.

Scientific and practical significance of the research.

The algorithmic and software unit developed in the dissertation work represents the possibility of processing and analyzing data sets (urban objects, seismic events) that are found in the structure of seismic risk assessment systems.

The research results are used in the educational process of the Department of Theoretical Cybernetics and Applied Mathematics of the Federal State Budgetary Educational Institution of Higher Education of Altai State University (Barnaul, Russia). The implementation of the results of the dissertation research is confirmed by the act of implementation of the Altai State University (Barnaul, Russia). The application of the results of the dissertation research served as the basis for the development and implementation of a joint educational program (JEP), including approved curricula in the direction - 09.04.03 «Applied Informatics» (Master's degree), profile «Digital data analysis technologies for sustainable development of regions of North and Central Asia». The development and implementation of the master's program was carried out jointly by the NJSC «Sarsen Amanzholov East Kazakhstan University» and the Federal State Budgetary Educational Institution of

Higher Education «Altai State University» within the framework of the state assignment of the Altai State University on the topic «The Turkic world of «the Great Altai»: unity and diversity in history and modernity» (№ 748715F.99.1.BB97AA00002). A set of students for the 2021-2022 academic year was completed and the educational process was launched according to the developed joint educational program. The developed software will be used within the framework of the training course «Methods and models of intellectual analysis».

Approbation of the research. The main provisions and results of the work were reported and approved at the following international and scientific conferences:

1) «World science: Problems and Innovations», Russia, Penza, 2018;

2) V International scientific and technical conference of bachelor and master students and young scientists «Creativity of young people - innovative development of Kazakhstan», Kazakhstan, Ust-Kamenogorsk, 2019;

3) 6th International Conference on Computer and Technology Applications - ICCTA 2020, Turkey, Antalya, 2020;

4) VI International scientific- technical conference of bachelor and master students and young scientists «Creativity of young people - innovative development of Kazakhstan» (Kazakhstan, Ust-Kamenogorsk, 2020);

5) «Computational and Information Technologies in Science, Engineering and Education (CITech-2020)», Kazakhstan, Almaty, 2020.

Publications. The obtained results in the dissertation were published in 9 works, including 1 article in the journal peer-reviewed in the Scopus database (the percentile indicator for CiteScore is 34%), 4 articles in publications recommended by the Committee for Control in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, 4 works in collections of international conferences (1 of which is reviewed in the Scopus database). There are also 2 copyright certificates №14910 from 05.02.2021 and №15298 from 18.02.2021.

The structure and scope of the dissertation work. The dissertation consists of an introduction, 4 chapters, a conclusion, a list of used sources of 170 titles, set out on 123 pages of computer text, includes 55 figures, 21 tables and 3 annexes.

The introduction substantiates the relevance of the research topic, purpose, object, subject, tasks and methods of research, scientific novelty, scientific provisions, practical value and implementation of the results of the work, provides information about publications and approbation of the work.

In the first section, provides an overview and analysis of existing approaches, methods and information technologies for assessing the seismic vulnerability of objects and seismic events with the possibility of using data analysis technology and machine learning methods are presented. There were studied and described the features of the application of these methods where conclusions were drawn in the first section.

In the second section, researches are devoted to the development of a method for assessing the seismic resistance of urban objects on the bases of data analysis technology and machine learning methods, which make it possible to distinguish groups of urban objects by their seismic vulnerability.

The third section research the seismic data and presents the results of statistical analysis of earthquake data and the results of using the spatial clustering algorithm on

the bases of density with the presence of DBSCAN noise, which provides efficient analysis and processing of spatial seismic data to identify dense areas of earthquakes.

The fourth section presents the architecture and software implementation of an intelligent information and analytical system for assessing the seismic resistance of urban objects, taking into account seismic data.

In the conclusion, the results of the executed work are summed up within the framework of the dissertation work.

The content of the dissertation concluded with a list of used sources and annexes.