

## **REPORT**

### **INSTITUTE OF MATHEMATICS AND MECHANICS OF ANAS**

**on the annual scientific and scientific - organizational activities for 2022  
of the Department “Computer Technologies and Mathematical Statistics”**

#### **About scientific activity**

During the reporting period, the Department of Computer Technologies and Mathematical Statistics carried out research work on the topic “Algorithms for visual control of dynamic production processes and the study of some issues of probability theory” and 5 works were completed.

The department has 11 employees. Among them, 1 is a doctor of science, 4 is a doctor of philosophy, 4 is a software engineer, and 2 are laboratory assistants. The department has two doctoral students.

The staff of the department published 9 scientific papers, 5 of which are scientific articles, 4 are abstracts of conferences.

#### **About individual works**

**Work 1:** Development of an optimal control strategy in a limited time interval for a motor fuel hydrotreater operating on feedstock with a variable sulfur content.

**Executer: Ph.D. in Engineering, Associate Professor H. A. Nagiev, Head of Department**

The equations of chemical kinetics of a motor fuel hydrotreater operating on variable sour raw materials consist of differential equations of mass balance and heat balance. The mass balance is based on the rate of change in the amount of matter, and the heat balance is based on the rate of change in the amount of heat. The following issue has been resolved on the development of an optimal strategy for managing a hydrotreating unit in a limited time interval:

- The software for the "man-machine" control interface has been developed and a simulation model has been developed for visual control of the process.

The results obtained are published in the proceedings of the International Conference on Human-Computer Interaction held at Nakhichevan State University (September 9-10, 2022 IECHCI2022) "Probabilistic Approach to the Problem of Studying Residence Time Distribution for a Flow with Ideal Mixing".

The number of scientific publications carried out also includes the article "On one algorithm for the numerical simulation of mechanical systems with variators, taking into account the rigidity of differential connections between state coordinates" included in No. 6, 2022, of the Oil and Gas Business journal (included in RSCI.) published in the Russian Federation. One article (H. A. Nagiev. Scaling the representativeness of sample statistics to the solution of a stochastic problem of production planning) was accepted by the editors for publication in the journal Statistics & Probability Letters with an impact factor.

**Work 2:** Limit theorems for the continuous branching stochastic processes with migration.

**Executer: d.ph.-m.s.,prof.,sen.r.a. Aliyev Soltan A.**

A system consisting of some similar particles is considered. Along with reproduction, transformation to other particles or disappearance of these particles, some other particles enter the system from outside (immigration) or some particles leave the system (migration).

During the reporting period, the indicated continuous time branching processes where researched probability characteristics of processes were studied and under certain conditions limit theorems were obtained.

2 articles, 3 abstracts were printed and 1 article, 1 abstract were sent for printing.

1. Limit theorems for the moment of the first reaching a high level by branching processes// Azərb.Respublikası Təhsil Nazirliyi Naxçıvan Dövlət Universitrti, İSSN 2222-940X, Elmi əsərlər Fizika-Riyaziyyat və Texniki elmlər

seriyası 2021, №4 (113), UOT: 512, pp.9-13, <https://ndu.edu.az/wp-content/uploads/Elmi%20Eserler/d%C9%99qiq%202021.pdf>.

2. On the family of the Markov random walks described by the generalization of autoregressive process of order one (AR(1))// proceedings of the 8th International Conference on Control and Optimization with Industrial Applications - COIA 2022 , 24-26 August 2022, Baku, Azerbaijan.pp.90-92 [www.coia-conf.org](http://www.coia-conf.org).

3. Convergence of branching processes with migration and continuous time// Online International Symposium on Applied Mathematics and Engineering (ISAME22) Abstracts Book January 21-23, pp.129, 2022, Biruni Univ. İstanbul-Turkey.

4. Limit theorems for the random walks describes by the generalization of autoregressive process of order one (AR(1))// Modern Problems of Matematics and Mechanics proceedings of the International scientific conference devoted to the 110-th anniversary of academicial Ibrahim Ibrahimov. Baku June 29-July1, 2022, pp.41

5.Сходимости ветвящихся процессов с непрерывным фазовым пространством// Министерство Науки И Высшего Образования Дагестанский Государственный Университет Актуальные Проблемы Математики И Информационных Технологий Материалы III Всероссийской конференции с международным участием (г. Махачкала, 7-9 февраля 2022 г.) Махачкала Издательство ДГУ 2022, ст,25-26

6. On limit behavior of the Markov random walks describes by the generalization of autoregressive process of order one (AR(1))// International Scientific Conference "Limit Theorems Of Probability Theory And Mathematical Statistics" September 26-28, 2022 Tashkent Uzbekistan

**Work 3:** Reduction of boundary value problems for second-order parabolic equations with discontinuous coefficients to integral equations and their solution by numerical analysis methods

**Executer: c.ph.math.sci., senior researcher N. J. Jafarov**

The boundary value problem for a parabolic equation with discontinuous coefficients in areas of the paraboloid type is reduced to the Fredholm integral equation with respect to the variable "x" and Voltaire with respect to the variable

"t" using the double layer potential and solved by methods of numerical analysis by approximating the kernel.

The work is currently being prepared for publication.

**Work 4:** Limit theorems for Markov random walks described by generalized first-order autoregressive processes

**Executer: c.ph.m.s.,lead.r.a. Ibadova Irade A.**

The paper proves the central limit theorem for the value at the moment of level crossing by a random walk described by a generalized first-order autoregressive process.

Printed 2 articles, 5 theses and sent to print 1 article.

1. On one family of first passage times of a Markov random walk described by an autoregressive process  $AR(1)$  for nonlinear boundaries// Informatics and Control Problems 41 Issue 2 (2021) journal homepage: [www.icp.az](http://www.icp.az) , pp.40-46 DOI: <https://www.doi.org/10.54381/icp.2021.2.07>

2. Limit theorems for the moment of the first reaching a high level by branching processes// Azərb.Respublikası Təhsil Nazirliyi Naxçıvan Dövlət Universitrti, İSSN 2222-940X, Elmi əsərlər Fizika-Riyaziyyat və Texniki elmlər seriyası 2021, №4 (113), UOT: 512, pp.9-13, <https://ndu.edu.az/wp-content/uploads/Elmi%20Eserler/d%C9%99qiq%202021.pdf>.

3. On the family of the Markov random walks described by the generalization of autoregressive process of order one ( $AR(1)$ )// proceedings of the 8th International Conference on Control and Optimization with Industrial Applications - COIA 2022 , 24-26 August 2022, Baku, Azerbaijan.pp.90-92 [www.coia-conf.org](http://www.coia-conf.org).

4. Convergence of branching processes with migration and continuous time// Online International Symposium on Applied Mathematics and Engineering (ISAME22) Abstracts Book January 21-23, pp.129, 2022, Biruni Univ. İstanbul-Turkey.

5. Limit theorems for the random walks describes by the generalization of autoregressive process of order one ( $AR(1)$ )// Modern Problems of Matematics and Mechanics proceedings of the International scientific conference devoted to the 110-th anniversary of academical Ibrahim Ibrahimov. Baku June 29-July1, 2022, pp.41

6. Сходимости ветвящихся процессов с непрерывным фазовым пространством// Министерство Науки И Высшего Образования Дагестанский Государственный Университет Актуальные Проблемы Математики И Информационных Технологий Материалы III Всероссийской конференции с международным участием (г. Махачкала, 7-9 февраля 2022 г.) Махачкала Издательство ДГУ 2022, ст,25-26

7. Limit theorems for the Markov random walk describes by an autoregressive process ( $AR(1)$ ) for non linear boundaries// Modern Problems of Matematics and Mechanics proceedings of the International scientific conference devoted to the 110-th anniversary of academicial Ibrahim Ibrahimov. Baku June 29-July1, 2022, pp.177

**Work 5:** Boundary value problems for random walks associated with autoregressive processes are studied.

**Executer: phd in math., lead.r.a. Khalilov Vuqar S.**

Limit theorems are proved for the moment when branching processes reach a high level. Published 1 article, 3 theses.

1. Limit theorems for the moment of the first reaching a high level by branching processes// Azərb.Respublikası Təhsil Nazirliyi Naxçıvan Dövlət Universitrti, İSSN 2222-940X, Elmi əsərlər Fizika-Riyaziyyat və Texniki elmlər seriyası 2021, №4 (113), UOT: 512, pp.9-13, <https://ndu.edu.az/wp-content/uploads/Elmi%20Eserler/d%C9%99qiq%202021.pdf>.

2. Convergence of branching processes with migration and continuous time// Online International Symposium on Applied Mathematics and Engineering (ISAME22) Abstracts Book January 21-23, pp.129, 2022, Biruni Univ. İstanbul-Turkey.

3. Сходимости ветвящихся процессов с непрерывным фазовым пространством// Министерство Науки И Высшего Образования Дагестанский Государственный Университет Актуальные Проблемы Математики И Информационных Технологий Материалы III Всероссийской конференции с международным участием (г. Махачкала, 7-9 февраля 2022 г.) Махачкала Издательство ДГУ 2022, ст,25-26

4. Limit theorems for the Markov random walk describes by an autoregressive process ( $AR(1)$ ) for nonlinear boundaries// Modern Problems of

Mathematics and Mechanics proceedings of the International scientific conference devoted to the 110-th anniversary of academical Ibrahim Ibrahimov. Baku June 29-July1, 2022, pp.177

### **About scientific and organizational activity**

Among several areas of cooperation between the National Aerospace Agency of the Ministry of Defense Industry (NAKA) and the Institute of Mathematics and Mechanics of ANAS, work was carried out in the following areas:

- Preparation of guidelines for expanding and modernizing the functionality of the UAV.

Based on the information received from the UAV in this direction, the issues of providing navigation were investigated. A mathematical method is proposed for the optimal choice of the height of photographing when controlling uneven sections of the relief. Based on the method, terrain irregularities are determined from photographic images and the flight altitude is output to the UAV control system.

One article was published:

Н.Г.Джавадов, М.Дж.Марданов, Г.А.Нагиев. Оптимизация высоты полета в системе аэрофотозондирования, с учетом рельефности контролируемой территории / Известия АНАА, Баку 2022, N:3 (25), стр.4-14

Also, as part of this cooperation, on March 2, 2022, the staff of the Institute, Professor Elkhan Abbasov and Associate Professor Gasan Nagiyev, took part in the conference "Training qualified personnel for the defense industry: an innovative approach to integrating scientific research and education."

During the reporting period, d.ph.m.s., prof. Soltan Aliev was a member of the Dissertation Council operating at the Institute of Control Systems, and the head of the Scientific Seminar of the Council (specialty in Probability Theory).

The staff of the department, d.ph.m.s., prof. Soltan Aliyev, phd in math. İrada İbadova, phd in math. V. S. Khalilov. Vugar Khalilov completed works on

the topic “Investigation of random walks described by innovative autoregressive Semi-Markov processes” (№EIF-ETL-2020-2(36-16/05/1-M-05), recognized as the winner grant competition worth 50,000 AZN (12 months, 01 April 2021-2022), established by the Science Development Foundation under the President of the Republic of Azerbaijan, led by Rövşən Telman oğlu Əliyev.

Associate Professor H.A. Nagiev made a report at the Institute Seminar (January 12, 2022) on the topic "Visual control of second and third order dynamic systems in the Matlab environment"

Employee Aynur Tairova is busy with editorial and design work related to the official "youtube" and "facebook" pages, which also includes the duties of their technical support. It also performs the function of technical support for employees using Wikipedia.

On every day of the week, 15 students of the Faculty of Information Technology and Management of ASOIU took place in the department of online work practice under the bachelor's program, under the guidance of the department's employees. Intern students were divided into 3 groups in each of which the internship was conducted on the following topic:

- Creation of software for managing queuing enterprises in the Python/Django environment;
- Methods for solving mathematical and physical equations in the Matlab system.
- Preparation of scientific articles for publication using the LaTeX text editor.

**Doctor of Philosophy in Engineering,**

**Associate Professor**

**Hasan Nagiyev**