ANNOTATION

of the dissertation for the degree of "Doctor of Philosophy" (PhD) in the specialty 8D06101 – "Information Systems (by industry)"

MURATULY DIDAR

DEVELOPMENT OF AN INFORMATION AND ANALYTICAL SYSTEM FOR CONSTRUCTING AND VERIFYING A SUBJECT'S BEHAVIOR MODEL BASED ON VIDEO MATERIAL ANALYSIS

The main idea of the research: The dissertation focuses on the development of an information and analytical system aimed at building and verifying a subject's behavior model based on video material analysis. The presented work is directed toward creating an intelligent system capable of detecting anomalous behavior of subjects with high accuracy and speed, considering image quality, external conditions, and equipment performance. The developed algorithms and methods for video material processing ensure the construction of subject behavior models, anomaly identification, and counteraction to the creation of "fake identities" in access control systems.

Keywords: online proctoring, academic integrity, biometric authentication, computer vision systems, video material analysis, subject behavior model, anomalous behavior, violation timing, motion tracking, educational technologies, information and analytical system, recognition algorithms, digital transformation, distance learning.

The relevance of the research.

The choice of this research direction is driven by the contemporary relevance of the dissertation topic for the modern education system, utilizing robust and scalable tools for online proctoring. Online proctoring ensures compliance with academic integrity by students and eliminates the need for universities to secure special rooms for examinations. The implementation of this project will help reduce costs associated with quality control, provide support and oversight for geographically remote exam processes, verify the identity of test-takers, and confirm the results of their assessments.

Modern researchers actively integrate innovative methods and technologies into proctoring systems and the development of information and analytical systems for constructing and verifying subject behavior models based on video analysis.

The dissertation, "Development of an information and analytical system for constructing and verifying a subject's behavior model based on video material analysis" is dedicated to research aimed at developing video material recognition algorithms to identify subject behavior. The central idea of the dissertation is to create an intelligent system capable of detecting anomalous subject behavior with high speed and accuracy by selecting a video information processing scenario based on conditions such as image quality, external factors, and equipment performance.

Additionally, this dissertation research is carried out as part of the grant-funded program for scientific and/or scientific-technical projects for 2023-2025 by the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP19677501: *"Development of Intelligent Services for a Smart Campus with Integration into the University's Information Ecosystem"*).

The Object of the Research. The object of the research is the subject's behavior model based on video material analysis.

The Subject of the Research. The subject of the research is a set of methods and algorithms for processing video materials in computer vision systems, enabling the formation of a subject's behavior model and the detection of anomalies.

The research goal: The aim of the research is to develop an information and analytical system with a set of image recognition algorithms to identify subject behavior using non-invasive methods while preserving the subject's identity and ensuring the possibility of correlating the obtained results.

Research Objectives:

1. Conduct research, analysis, and classification of typical scenarios for the development and application of computer vision systems.
2. Develop methods for analyzing normal and/or anomalous subject behavior based on computer vision technology.
3. Develop methods and create a personalized behavior model for a subject.
4. Develop measures to counteract the creation of "fake identities" in access control systems using biometric data.
5. Create a set of software frameworks for the development of computer vision systems.
6. Integrate the developed methods and software tools into existing computer vision systems.
7. Perform testing and analyze the efficiency of the developed methods and software tools under various operating conditions.

Main Research Methods: To address the outlined objectives, the study employs methods for processing streaming video based on behavioral scenarios, subject recognition techniques, and a scenario-based approach for automatically identifying key behavioral features, analyzing movement sequences, and detecting potential anomalies related to exam rule violations.

Scientific Propositions for Defense:

1. Biometric Authentication System A facial recognition-based biometric authentication system that ensures a high level of identification accuracy for students and minimizes the likelihood of academic violations during remote examinations.
2. Violation Timing Methodology. A methodology for timing violations during exams, enabling behavior control and monitoring of the examination process.
3. Student Motion Tracking Methods. Methods for tracking student movements during exams to monitor their behavior, aimed at enhancing control, transparency, and academic integrity within the educational environment.

4. Information and Analytical System for Skeletal Tracking. An information and analytical system for skeletal tracking to monitor and analyze student movements during exams.

Scientific Novelty of the Work

The scientific novelty of the research is justified by the project's relevance to the modern education system, which employs powerful and scalable online proctoring tools. The use of online proctoring facilitates the monitoring of students' adherence to academic integrity and eliminates the need for organizing dedicated physical rooms for conducting examinations.

Publications.

The results obtained in the dissertation have been published in five works, including one article in a journal indexed in the Scopus database (CiteScore percentile: 29%) and four articles in publications recommended by the Committee for Control in the Sphere of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan (MES RK).

Research Results Presented in the Published Articles:

1 Muratuly, D., Denissova, N.F. & Krak, I.V. Information Technology for a Proctor to Detect Violations during the Exam. Cybern Syst Anal 58, 983–990 (2022), https://doi.org/10.1007/s10559-023-00533-x Muratuly D., Denissova N., Krak Y (процентиль в Scopus 29%).

2 Muratuly, D. ., Denissova, N. ., Krak, Y. ., & Apayev K. Biometric authentication of students to control the learning process in online education//Scientific Journal of Astana IT University, Volume 10, 2022, pp. 193–206, ISSN (P): 2707-9031, ISSN (E): 2707-904X https://doi.org/DOI:10.37943/LYFW8581

3 Muratuly D., Denissova N, Krak Y., Subject behavior detection and analysis based on computer vision technology//Scientific Journal of Astana IT University, Volume 11, 2022, pp. 36–47, ISSN (P): 2707-9031, ISSN (E): 2707-904X, https://doi.org/DOI:10.37943/UIXY4934

4 Muratuly, D. peech Detection and Recognition for Use in Online Proctoring Systems: Review and Study of Technologies., Vestnik, Issue 4, Pages 179–188 (December 2022)., https://DOI: 10.51885/1561-4212_2022_4_179

5 Muratuly, D., Denissova , N. ., Dyomina, I. ., Tlebaldinova, A. ., Chettykbayev, R. ., & Zuev, V. . (2024). Using structural equation modeling methods to assess the university’s digital ecosystem. Scientific Journal of Astana IT University, 17(17), 95–105. https://doi.org/10.37943/17CCXJ5272

The main results of the dissertation work were presented and discussed at international conferences:

– "International Conference v.Int.Exchange", West Saxon University of Applied Sciences Zwickau, Germany, January 5, 2021.

– "2022 IEEE International Conference on SIST", Astana IT University, Nur-Sultan, Kazakhstan, April 29, 2022.

Structure and Volume of the Dissertation

The dissertation consists of 90 pages of typeset text and includes an introduction, three chapters, a conclusion, a reference list comprising 140 sources, and appendices. The text is illustrated with 13 tables, 56 figures, and 13 formulas.

The first section of the dissertation presents the results of a study on modern methods and technologies for video analysis and biometric identification in the context of proctoring systems and information-analytical systems based on computer vision. The main topics of this chapter include a literature review on video analysis for proctoring systems, an examination of technological solutions for biometric identification, an analysis and classification of standard scenarios for the development and use of computer vision systems, the application of computer vision for identifying and analyzing key behavioral characteristics of a subject, and an assessment of the applicability of information-analytical systems based on computer vision across various industries.

The second section of the dissertation presents the results of a study on the timing of violation detection during online exams within the context of educational information systems. The main aspects of this chapter include an investigation of the timeframes for violation detection by proctors in various scenarios and methods for optimizing these timings, a temporal analysis of violations to determine the optimal time intervals for identifying different types of violations during online exams, and an examination of automating the monitoring process for violation detection timing using machine learning algorithms and data analysis. This section represents a significant step in developing effective strategies for overseeing online exams and enhancing their reliability and credibility in educational institutions.

The third section of the dissertation presents the results of the experiments conducted as part of the research. It describes the experimental methodology and the criteria for data selection that formed the basis of the study. The experiments included biometric authentication and the analysis of student behavior in an educational environment. A key part of this section is the analysis of the obtained results and their interpretation in light of the stated objectives and hypotheses, aligning them with existing theoretical models. The discussion also addresses prospects for further research and development in this field, taking into account the identified findings and the potential for improving educational information systems.

The concluding section of the dissertation outlines the main results and conclusions of the research, which substantiate the statements submitted for defense. An assessment of the scientific novelty and practical significance of the study is also provided.

The dissertation concludes with a list of references and appendices.