

**Ukrainian Scientific
and Practical
Conference**

The logo for the Scientific Research Methodology (SRM) conference. The letters 'SRM' are rendered in a large, bold, black sans-serif font. Surrounding the letters is a network diagram consisting of several colored nodes (red, blue, yellow, orange) connected by thin lines, suggesting a complex or interconnected system.

SRM

**«Scientific Research
Methodology – 2024»**



November, 2024

Proceedings

Ukrainian Scientific and Practical Conference

Scientific Research Methodology – 2024



Editor-in-Chief: Doctor of Technical Sciences, Professor, **Constantine BAZILO**
In charge for the issue: Ph.D., Assistant, **Anna TOPTUN**

Organizing Committee

Oleg GRYGOR, Doctor of Political Sciences, Professor, Cherkasy State Technological University (ChSTU), Cherkasy
Emil FAURE, Doctor of Technical Sciences, Professor, Cherkasy State Technological University (ChSTU), Cherkasy
Maksym BONDARENKO, Doctor of Technical Sciences, Professor, Cherkasy State Technological University (ChSTU), Cherkasy
Constantine BAZILO, Doctor of Technical Sciences, Professor, Cherkasy State Technological University (ChSTU), Cherkasy
Vyacheslav TUZ, Candidate of Technical Sciences, Associate Professor, Cherkasy State Technological University (ChSTU), Cherkasy
Liudmyla USYK, Candidate of Philological Sciences, Associate Professor, Cherkasy State Technological University (ChSTU), Cherkasy
Anna TOPTUN, Ph.D., Assistant, Cherkasy State Technological University (ChSTU), Cherkasy

Conference research topics

- Theoretical and Methodological Foundations of Scientific Research
- Interdisciplinary Research Methodology
- Methodological Aspects of Innovative Technologies
- Empirical Methods in Scientific Research
- Ethical and Legal Aspects of Scientific Research

The Ukrainian Scientific and Practical Conference "Scientific Research Methodology – 2024"

The Ukrainian Scientific and Practical Conference "Scientific Research Methodology – 2024" provides a platform for multi-dimensional discussions on theoretical concepts and methods in modern scientific research, approaches and integrated methods deployed in various scientific disciplines to solve complex problems, state-of-art methods and tools for investigating latest technologies and their impact on scientific activity, quantitative and qualitative methods of data collection and analysis in various scientific disciplines, and legal aspects related to intellectual property and research publications.

Address (Organizing Committee)

Ukraine, 18006, Cherkasy,
Shevchenko Blvd., 460,
Cherkasy State Technological University (ChSTU),
IMCT Department
SRM-2024 Organizing Committee

Approved by the Academic Council of
Cherkasy State Technological University,
Protocol 4 of November 25, 2024

Articles are published in the author's original version.

The editorial board's vision does not always coincide with the authors' position.

The authors of the published materials bear full responsibility for the selection and accuracy of the facts and quotes provided, economic, statistical, and technical data, proper names, and other information presented.

The editorial board is not responsible for the accuracy of the submitted material but reserves the right to abridge and edit the submitted materials to be optimally presented to the readers.

CONTENTS

<u>R. Titorenko, V. Tychkov, R. Trembovetska, V. Halchenko</u>	
<i>QUALITY CONTROL SYSTEM FOR ANTICORROSIVE COATINGS OF STEEL PRODUCTS</i>	5
<u>O. Zrazhevskiy</u>	
<i>MITIGATING EXPLOITATION OF SOFTWARE VULNERABILITIES IN PROGRAMMING LANGUAGE INTERPRETERS</i>	7
<u>A. Yaroslavskiy</u>	
<i>APPLICATION AND MATHEMATICAL MODELING OF PIEZOCERAMIC ELEMENTS FOR INDUSTRY</i>	10
<u>O. Yalynskiy</u>	
<i>MODERNIZATION OF THE ENERGY SYSTEM OF UKRAINE</i>	16
<u>R. Lutsenko</u>	
<i>INTELLIGENT DATA ANALYSIS SYSTEMS FOR RESEARCH IN BEHAVIORAL ECONOMICS OF VIRTUAL ASSETS</i>	19
<u>O. Protsenko</u>	
<i>METHODOLOGY FOR ENSURING CYBER RESILIENCE IN THE CLOUD ENVIRONMENT AT THE ENTERPRISE</i>	22
<u>V. Shymko, V. Dudka, A. Toptun</u>	
<i>ANALYSIS OF THE EFFECT OF AIR POLLUTION ON THE CONDITION OF HUMAN HAIR BY SCANNING PROBE MICROSCOPY</i>	25
<u>O. Filimonova, S. Filimonov</u>	
<i>MUSCLE FOR A FLYING MINIROBOT</i>	28
<u>O. Myhal</u>	
<i>IMPROVING THE ENERGY EFFICIENCY OF THE SUPPLY SYSTEM OF COMPRESSED AIR</i>	31
<u>Y. Korolkov</u>	
<i>REACTIVE POWER COMPENSATION FOR RESIDENTIAL CONSUMERS</i>	35
<u>B. Yakovlev</u>	
<i>LEVERAGING ZABBIX FOR CYBERSECURITY</i>	37
<u>V. Samsonenko, V. Palahin, O. Palahina</u>	
<i>INTEGRATION OF COMPUTER VISION INTO ROBOTIC TECHNICAL SYSTEMS USING THE YOLO PLATFORM</i>	40
<u>A. Grushnitskiy, V. Palahin</u>	
<i>DEVELOPMENT OF AN END-TO-END ENCRYPTED MESSAGING CHATBOT</i>	43
<u>B. Bielkov, V. Palahin, O. Palahina</u>	
<i>DEVELOPMENT OF AN ANTI-SPOOFING METHOD FOR IMAGES IN BIOMETRIC SECURITY SYSTEMS USING ML</i>	46
<u>D. Hrebenuk</u>	
<i>UTILIZING RUBY FOR MACHINE LEARNING WORKFLOWS</i>	48
<u>R. Ptashkin</u>	51



FORENSIC EXAMINATION OF OBFUSCATED CODE

<u>V. Simonov</u>	
METHODOLOGY FOR INFORMATION LEAK RESEARCH	54
<u>V. Chornodobravska</u>	
PSYCHOLOGICAL MANIPULATIONS IN CYBERSPACE: MECHANISMS OF SOCIAL ENGINEERING IMPACT ON POTENTIAL VICTIMS	56
<u>C. Bazilo, M. Bondarenko, L. Usyk, E. Faure</u>	
ULTRASONIC TECHNOLOGY FOR PRODUCING FUNCTIONAL BEVERAGES TO REHABILITATE AND PREVENT POST-TRAUMATIC STRESS DISORDERS	59
<u>O. Shymko, V. Tuz</u>	
IMPROVING THE CONTROL SYSTEM OF AN UNMANNED VEHICLE	61
<u>V. Tupota, I. Zhaivoronok, M. Bondarenko</u>	
SYSTEM FOR DETERMINING THE MECHANICAL STRENGTH OF SAFETY GLASS	63
<u>V. Kodola, S. Saienko, M. Bondarenko</u>	
ANALYSIS AND MODELING OF HEAT TRANSFER PROCESSES DURING NANOMETRIC MEASUREMENTS	65
<u>A. Bobrov, V. Andreiko, M. Bondarenko</u>	
MULTIFUNCTIONAL LASER CORRECTION COMPLEX FOR OPTICAL SYSTEMS	67
<u>N. Bondarenko</u>	
DATA ANALYSIS IMPACT ON SCIENTIFIC RESEARCH	69
<u>O. Berezhnyi, V. Tuz, R. Trembovetska</u>	
DEVELOPMENT AND RESEARCH OF AN AUTOMATED SYSTEM FOR PREVENTING CRITICAL SHOCK AND WAVE LOADS	71
<u>V. Syvachenko, V. Tuz</u>	
CONTROL SYSTEM FOR A BIOREACTOR	73
<u>D. Holoborodko, S. Filimonov</u>	
DEVELOPMENT OF RADIO-CONTROLLED PIEZOELECTRIC ROBOT	75
<u>O. Stankevych, V. Tuz</u>	
AUTOMATION CONTROL OF COUNTRY HOUSE BY VOICE AI ASSISTANT	77
<u>I. Chornovil, V. Tuz, R. Trembovetska</u>	
DEVELOPMENT AND RESEARCH OF AN AUTOMATIC REAGENT DOSING SYSTEM	80
<u>A. Sotnyk, V. Tuz</u>	
MODELING OF HIGH-PERFORMANCE SONAR FOR THREE-DIMENSIONAL MAPPING OF THE RESERVOIR BOTTOM	82
<u>V. Starikov, V. Tuz, V. Tychkov</u>	
IMPROVEMENT OF THE WIND TURBINE CONTROL SYSTEM	84
<u>S. Matviienko, V. Tuz</u>	
DEVELOPMENT AND RESEARCH OF A CONTROL SYSTEM FOR A ROD SUBMERSIBLE PUMP	86

<u>V. Bondar</u>		
	<i>THE MAIN TYPES OF MODELS IN MACHINE LEARNING</i>	88
<u>I. Zdoryk, V. Tuz, R. Trembovetska</u>		
	<i>IMPROVEMENT OF THE CHARGING SYSTEM OF A LITHIUM-ION BATTERY</i>	91
<u>V. Kulba, V. Tuz, V. Tychkov</u>		
	<i>CONTROL SYSTEM FOR URBAN TRAFFIC LIGHT NETWORK</i>	93
<u>A. Romanov</u>		
	<i>ARTIFICIAL INTELLIGENCE APPLICATIONS IN THE ENERGY SECTOR FOR IMPROVING POWER SYSTEM MANAGEMENT</i>	95
<u>O. Brunov</u>		
	<i>TECHNOLOGIES OF SUPERCONDUCTIVITY AND THEIR POTENTIAL IMPACT ON THE FUTURE OF ELECTRICAL ENGINEERING</i>	97
<u>A. Toptun</u>		
	<i>ANALYSIS OF MATERIALS FOR THE PRODUCTION OF WIND TURBINE BLADES</i>	99
<u>M. Manko, V. Tuz</u>		
	<i>ANALYSIS OF TYPES AND METHODS FOR GENERATING QUANTUM SECRET KEYS</i>	101
<u>D. Polukhin</u>		
	<i>ANALYSIS OF AUTOMATION OF TECHNOLOGICAL PROCESSES BY ROBOTIC MANIPULATORS</i>	103
<u>O. Snisarenko, V. Tuz</u>		
	<i>IMPROVEMENT OF AN AUTOMATED QUALITY CONTROL SYSTEM FOR OPTICAL PARTS</i>	105
<u>B. Savosta, V. Tuz, V. Halchenko</u>		
	<i>MODELING AND DEVELOPMENT OF A SYSTEM FOR NON-CONTACT MEASUREMENT OF MECHANICAL CHARACTERISTICS OF THE ELECTRIC DRIVE</i>	108
<u>D. Dvoriatkin, V. Tuz</u>		
	<i>IMPROVEMENT OF THE THERMAL REGIME CONTROL SYSTEM IN INDUSTRIAL PREMISES</i>	111
<u>D. Moiseiev, V. Tuz, V. Halchenko</u>		
	<i>DEVELOPMENT AND RESEARCH OF A SYSTEM FOR CONTROLLING THE CONCENTRATION OF EXPLOSIVE DUST AND GAS COMPONENT OF THE ATMOSPHERE</i>	114
<u>N. Bugaichuk, V. Tuz, O. Kamsha, R. Trembovetska</u>		
	<i>DEVELOPMENT AND RESEARCH OF A MICROPROCESSOR CONTROL SYSTEM FOR AN ELECTRICAL MEASURING ROBOT</i>	117
<u>I. Tsarenko, S. Filimonov</u>		
	<i>IMPROVEMENT OF THE AUTOMATING SYSTEM OF THE THERMAL ENERGY PRODUCTION FACILITY</i>	120

Dmytro Moiseiev, post-graduate student at the Department of Instrumentation, Mechatronics and Computerized Technologies, Cherkasy State Technological University, e-mail: d.o.moiseiev.fetam23@chdtu.edu.ua

Vyacheslav Tuz, Cand.Tech.Sc., Associate Professor, Associate Professor at the Department of Instrumentation, Mechatronics and Computerized Technologies, Cherkasy State Technological University, e-mail: v.tuz@chdtu.edu.ua

Volodymyr Halchenko, Dr.Sc., Professor, Professor at the Department of Instrumentation, Mechatronics, and Computerized Technologies, Cherkasy State Technological University, e-mail: v.halchenko@chdtu.edu.ua

DEVELOPMENT AND RESEARCH OF A SYSTEM FOR CONTROLLING THE CONCENTRATION OF EXPLOSIVE DUST AND GAS COMPONENT OF THE ATMOSPHERE

Abstract. This paper focuses on the development and experimental study of an optical-electronic system (OES) for monitoring explosive dust-gas atmospheres. The system employs dual-spectrum measurements for early detection of fire events while maintaining resilience against optical interference and dust. The proposed solution significantly reduces false alarms, ensuring accurate fire detection in hazardous environments.

Key words: optical-electronic system, fire detection, explosive atmosphere, spectral analysis, dust concentration, optical interference.

Introduction. Explosive dust-gas atmospheres pose a critical safety risk in industries like mining, chemical plants, and power stations. Conventional fire detection systems often struggle in such environments due to high levels of dust and optical interference, leading to false alarms or missed detections. The development of an OES using dual-spectrum measurements addresses these challenges, providing reliable early-stage fire detection.

The goal of this research is to design and validate an OES capable of maintaining high detection accuracy in challenging industrial conditions.

Methods and Materials. The system integrates spectral pyrometry and paraxial optics to measure emissions across different wavelengths. MATLAB and ANSYS Maxwell were used for modeling system performance under varying conditions, including high dust concentrations and interference from industrial light sources.

Key Formulas Used:

1. Spectral Transmission and Absorption:

The transmission $\tau(\lambda)$ of light through a medium is defined as (1):

$$\tau(\lambda) = \frac{I(\lambda)}{I_0(\lambda)} = \exp(-k_\lambda \cdot l) \quad (1)$$

where $I(\lambda)$ is transmitted light intensity, $I_0(\lambda)$ is incident light intensity, k_λ is spectral absorption coefficient, l is path length through the medium.

2. Spectral Ratio for Fire Detection:

The system calculates the spectral ratio RRR as follows (2):

$$R = \frac{I_1}{I_2} \quad (2)$$

where I_1 and I_2 are the intensities in two spectral bands. This ratio helps distinguish between fire signals and external noise.

3. Signal-to-Noise Ratio (SNR) (3):

$$\text{SNR} = \frac{\mu_s}{\sigma_n} \quad (3)$$



where μ_n is mean signal value, σ_n is standard deviation of noise.

The proposed OES is based on a dual-spectral-ratio method. It features a three-channel optical system for improved accuracy and noise rejection. The system (Fig. 1) demonstrated the following characteristics:

- Detection time: less than 5 ms, crucial for early fire detection.
- Detection probability: exceeding 95%, even under conditions with significant dust and optical interference.

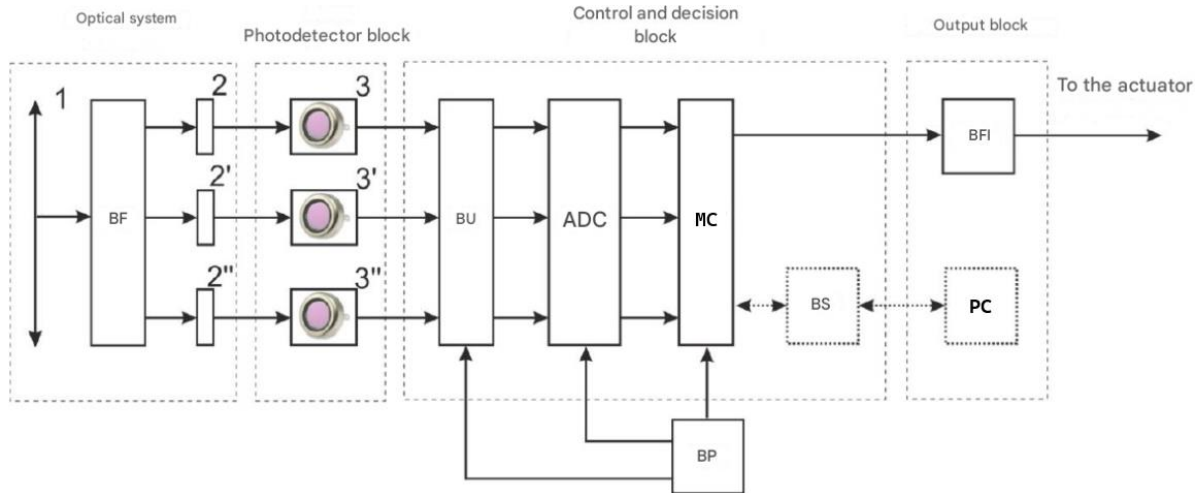


Fig. 1. Structural Diagram of the OES

One of the core functionalities of the OES is its ability to accurately determine dust concentration using spectral-ratio methods (Fig. 2). By measuring the absorption and scattering effects at two distinct spectral bands, the system can isolate the impact of dust on the signal.

In laboratory tests, the OES accurately measured dust concentrations ranging from 0.01 g/m³ to 0.5 g/m³.

Spectral filtering ensured minimal signal distortion, even in environments with varying dust particle sizes and densities.

The measured intensity after passing through a dust-laden medium was modeled using (4):

$$I_d = I_0 \cdot e^{-k_d \cdot l} \tag{4}$$

where k_d is dust-specific absorption coefficient.

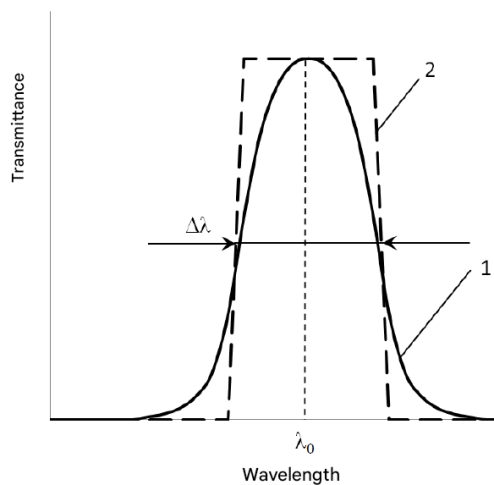


Fig. 2. Spectral Response Under Varying Dust Concentrations
1 – typical characteristic; 2 – presentation of characteristics in a simplified form

The system's (Fig. 3) performance was further validated in environments with artificial light sources. Industrial lighting, such as LED and incandescent lamps, introduced significant optical noise, yet the OES successfully distinguished between true fire signals and interference.

Probability of false detection due to optical noise was reduced to less than 5%.
The intensity ratio approach used is given by (5):

$$R_{opt} = \frac{I_{fire}}{I_{ambient}} \tag{5}$$

where I_{fire} and $I_{ambient}$ represent fire and ambient light intensities, respectively.

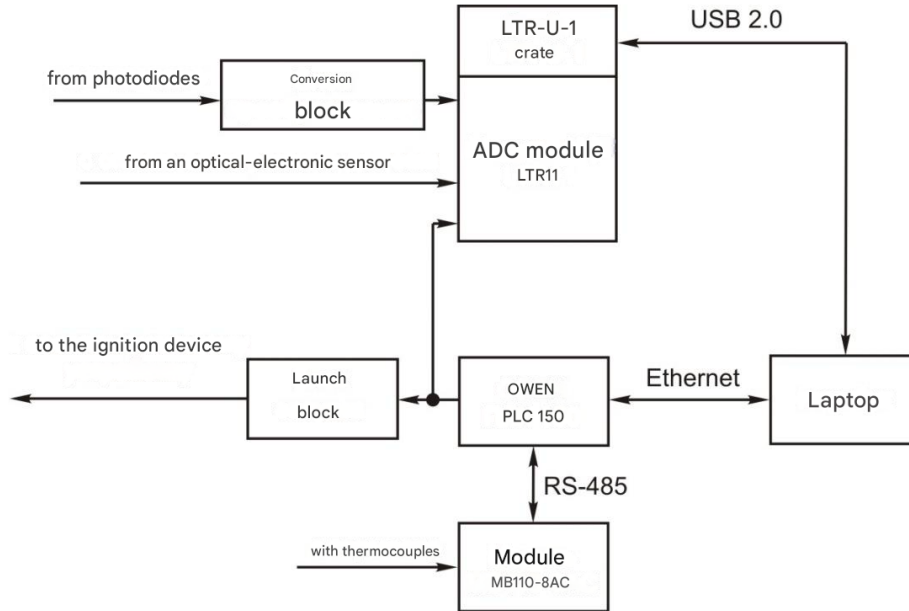


Fig. 3. Block diagram of an automated control system

The system’s practical application was tested in a controlled industrial chamber simulating environments found in mining and power stations. Key outcomes include:

- Detection range: Up to 35 meters for small ignition sources.
- Consistency: Reliable operation in dusty and poorly lit environments, with negligible delay or accuracy loss.

Conclusions. This research successfully developed and validated an optical-electronic system for detecting fires in explosive dust-gas atmospheres. Key outcomes include:

- Fast response time (<5 ms).
- High fire detection probability (>95%).
- Robust performance in dusty and optically noisy environments.
- Detection range: Effective up to 35 meters.

The system's resilience and accuracy make it an ideal solution for enhancing industrial safety, with potential applications in mining, chemical plants, and power stations. Future research will focus on further optimizing the system and expanding its applicability.

References

1. Radu M. A., Avram L., Matei D. I. Development of methods for assessing the safety of dust removal facilities in environments with a danger of explosive atmosphere. MATEC Web of Conferences 373, 00024 (2022).
2. Popa C. M., Păun F. A., Gabor D. S. Aspects regarding the explosion risk assessment of installations in atmospheres with combustible dust. MATEC Web of Conferences 354, 00010 (2022).