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TECHNOLOGIES FOR EMOTION RECOGNITION USING ARTIFICIAL INTELLIGENCE

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Annotatsiya. Ushbu ilmiy maqolada sun'iy intellekt (SI) tizimlarining inson hissiyotlarini aniqlash va tahlil qilish imkoniyatlari, ya'ni "Affektiv hisoblash" sohasidagi zamonaviy texnologik yutuqlar tahlil qilinadi. Maqolada yuz ifodalari, nutq intonatsiyasi, matn mazmuni va fiziologik ko‘rsatkichlar orqali hissiyotlarni tasniflash algoritmlari, chuqur o‘qitish va konvolyutsion neyron tarmoqlar (CNN) ning roli ko‘rib chiqiladi. Tadqiqotda hissiyotlarni aniqlash texnologiyalarining iqtisodiyot, tibbiyot, ta'lim va xavfsizlikdagi amaliy ahamiyati, shuningdek etik va ma'lumotlar maxfiyligi muammolari o‘rganiladi.

Kalit so‘zlar: sun'iy intellekt, affektiv hisoblash, hissiyotlarni aniqlash, neyron tarmoqlar, chuqur o‘qitish, yuz ifodalari tahlili, nutqni qayta ishlash, multimodal tizimlar, mashinali o‘qitish, biometriya.

Abstract. This scientific article examines the capabilities of Artificial Intelligence (AI) systems in detecting and analyzing human emotions, namely modern technological advancements in the field of "Affective Computing." The article analyzes algorithms for classifying emotions through facial expressions, speech intonation, text content, and physiological indicators, with particular attention to the role of Deep Learning and Convolutional Neural Networks (CNN). The research explores the practical significance of emotion recognition technologies in economics, medicine, education, and security, as well as the ethical and data-privacy issues that arise in this process.

Keywords: Artificial Intelligence, Affective Computing, emotion recognition, neural networks, deep learning, facial expression analysis, speech processing, multimodal systems, machine learning, biometrics.

Аннотация. В данной научной статье анализируются возможности систем искусственного интеллекта (ИИ) в распознавании и анализе человеческих эмоций, то есть современные технологические достижения в области «аффективных вычислений». В статье рассматриваются алгоритмы классификации эмоций по выражению лица, интонации речи, содержанию текста и физиологическим показателям, а также роль глубокого обучения и свёрточных нейронных сетей (CNN). Исследуется практическое значение

технологий распознавания эмоций в экономике, медицине, образовании и сфере безопасности, а также этические проблемы и вопросы конфиденциальности данных.

Ключевые слова: искусственный интеллект, аффективные вычисления, распознавание эмоций, нейронные сети, глубокое обучение, анализ выражения лица, обработка речи, мультимодальные системы, машинное обучение, биометрия.

INTRODUCTION.

Today, artificial intelligence technologies are rapidly penetrating every sphere of human life. As a result of advances in machine learning and neural networks, computers are achieving significant results not only in logical tasks but also in understanding the complex psychological states of human beings. This field, known as Affective Computing, is one of the most promising directions of artificial intelligence, enabling machines to sense, interpret, and respond appropriately to human emotions [1]. The relevance of this technology lies in the fact that when people communicate with each other, they transmit a large part of information through non-verbal channels, including facial expressions, body language, voice tone, and eye contact. Therefore, in order to make Human-Computer Interaction (HCI) more natural and effective, AI systems must be able to read these signals.

Emotion AI technologies are not only a technological novelty but also an important tool for solving socio-economic problems. For example, in medicine they help with the early detection of signs of depression or autism; in education they help to assess students' level of mastery of lessons through their emotions of interest and boredom; and in marketing they provide unparalleled help in analyzing consumers' true attitudes toward products [14]. However, human emotions are extremely complex and subjective in nature. The same facial expression may mean different things in different cultures or contexts. Therefore, increasing the accuracy of AI in emotion recognition remains one of the most pressing scientific problems today.

The purpose of this article is to systematize the current state of emotion recognition technologies, to explain their working mechanisms, and to show the role of this direction in the development of information systems in the context of Uzbekistan [11]. The research also scientifically justifies the advantages of biometric and multimodal approaches used in emotion recognition. This article is devoted to a wide-ranging analysis of the technical foundations of emotion recognition, the algorithms used, and the existing obstacles in this field.

LITERATURE REVIEW.

Scientific discussions on emotion recognition technologies are mainly conducted in two directions: psychological modeling and technical

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algorithmization. From the psychological point of view, researchers mainly rely on the "six basic emotions" model (joy, anger, fear, disgust, sadness, surprise) proposed by Paul Ekman [2]. However, modern AI systems consider this model insufficient, because human emotions do not always fit into these six categories. Russell's "valence-arousal" model is being discussed as more suitable for technical systems, since it allows emotions to be viewed as a continuous spectrum, which is convenient for regression analysis in neural networks [10].

From a technical point of view, Convolutional Neural Networks (CNN) play a leading role in Facial Expression Recognition (FER) [4, 16]. However, the main problem being discussed is the quality and diversity of datasets. Many popular datasets are obtained in laboratory conditions and do not take into account factors such as real-life lighting levels, the angle of the face, and obstructions such as glasses or masks. This causes a model that has shown high accuracy in the laboratory to drop significantly in real practice [13]. Similarly, in Speech Emotion Recognition (SER), in addition to tone and tempo, there is a need to also consider the linguistic content of the speech [7].

The methodological basis of this research is the analysis and systematization of scientific literature, a comparative approach to existing emotion-recognition methods, and the generalization of practical application cases. The study relies on foundational works in affective computing [1, 15], surveys of facial-affect analysis [6], and research on multimodal approaches [9]. Research shows that recognizing emotion through only one channel increases the probability of error; therefore the multimodal approach — combining facial expression, speech, text, and physiological signals — is examined as the most reliable method [9, 17].

RESULTS.

Technological stages of emotion recognition. The process of recognizing emotions using artificial intelligence usually consists of four main stages: data acquisition (raw data obtained through cameras, microphones, or sensors); pre-processing (noise removal, image normalization, face detection, and centering); feature extraction (extracting key facial points, voice frequencies, and key words from text); and classification (using machine learning algorithms such as SVM, Random Forest, or Deep Learning to assign the extracted features to a specific emotion category) [3].

Analyzing emotions through facial expressions (FER). The human face is the richest source of emotions. Modern FER systems analyze small muscle movements called "Action Units." CNN models automatically detect these action units by studying the relationships between pixels in an image. Deep architectures such as VGG-16, ResNet, and Inception can detect even the most subtle changes in the face [16]. However, there is a problem of "cultural characteristics" in face

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recognition: in some cultures, people tend to hide their emotions with a more serious facial expression, which can lead the AI to draw incorrect conclusions.

Speech and voice analysis (SER). In recognizing emotions through speech, the acoustic features of the voice play an important role, including the fundamental frequency (pitch), intensity, speech rate, and spectral features. Typically, in anger the volume and frequency of the voice rise sharply, while in sadness the speech slows down and becomes monotonous. In modern systems, Recurrent Neural Networks (RNN) and Long Short-Term Memory (LSTM) networks are used, since they are specialized for analyzing audio signals that change over time. In recent years, the Transformers architecture has shown revolutionary results in this field [5, 7].

Natural Language Processing and text-based sentiment analysis. Text analysis is very important in social media comments, e-mails, and customer communications. Here, the AI must understand not only the words in the dictionary but also the context of the sentence. Models such as BERT solve such complexities by learning the bidirectional context of the sentence [8]. Multilingual word-vector models extend these capabilities to many languages [18].

Multimodal and physiological approaches. The highest peak of emotion recognition is multimodal systems. A person may control their facial expression, but it is difficult to deceive their physiological indicators such as heart rate, blood pressure, and electrical conductivity of the skin. Data obtained through wearable devices helps AI to determine the true level of a person's stress or excitement. For example, in determining the level of fatigue of drivers, both facial expression and the strength of gripping the steering wheel are analyzed together [9].

DISCUSSION.

Areas of practical application. In economics and marketing, companies analyze the facial expressions of customers watching advertising clips to determine which frame generated more interest, a practice called "Neuromarketing" [14]. In healthcare, AI monitors changes in the patient's voice and face over time and warns the doctor of the risk of depression. In education, smart distance-learning systems detect when a student is not understanding a lesson and recommend simplifying the material [17]. In security, the technology helps identify suspicious or overly agitated individuals at airports or mass events [12].

Problems and limitations. No matter how advanced the technology, there is a big difference between "understanding emotions" and "recognizing emotions." AI can recognize the biological expression of emotion, but it does not understand its underlying cause and meaning. Likewise, the problem of "bias" in datasets remains relevant: if a neural network has been trained only on images of one population group, it may make significant errors in recognizing the emotions of

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other groups [13, 16]. Another issue at the center of discussion is ethics — analyzing a person's emotional state without their permission can be considered a violation of human rights. Therefore, alongside the development of the technology, the need to develop its legal and moral norms is being actively discussed [11].

CONCLUSION.

Emotion recognition technologies based on artificial intelligence are taking human-machine communication to a new level. Today, these systems have come a long way from simple facial expression recognition to complex multimodal analyses. Advances in affective computing are creating unprecedented opportunities for increasing economic efficiency, improving the quality of social services, and protecting human health. However, the wide-scale implementation of this technology depends not only on technical perfection but also on how correctly the ethical and legal norms are formed [11, 15].

Research shows that in the future AI systems will not only recognize a person's current emotion but also have the ability to predict their emotional state. This in turn requires a deeper integration of cognitive psychology and information technology. In Uzbekistan, too, when implementing digital economy and AI strategies, it is relevant to use emotion recognition technologies and create models adapted to local conditions, taking into account the phonetic and cultural features of the Uzbek language.

In conclusion, artificial intelligence that can recognize emotions is not just an interesting technology, but a powerful tool that helps humanity better understand itself and create a safer, more convenient, and more effective digital environment. In the future, by ensuring algorithm transparency and data integrity, this technology can be usefully applied to all spheres of society.

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