



IDENTIFYING EMOTIONAL STATES IN BAKHSHI PERFORMANCES USING ARTIFICIAL INTELLIGENCE

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Abstract: *This article examines the possibilities of identifying emotional states in Bakhshi performances using artificial intelligence technologies, as well as the importance of these technologies in the digitalization of national musical heritage. The study analyzes the capabilities of artificial intelligence in examining voice timbre, intonation, rhythm, emotional tone, and speech dynamics in Bakhshi performances. In addition, issues related to digital analysis of Bakhshi art based on audio signal processing, Speech Emotion Recognition technologies, machine learning, and neural networks are discussed. The article scientifically substantiates the prospects of creating audio databases of Bakhshi performances, their automatic classification, and the preservation of national folklore heritage through modern digital platforms. The research results serve as an important scientific and practical basis for the digitalization of Bakhshi art, preservation of traditional performance, and integration of artificial intelligence technologies into the national music education system.*

Keywords: *Artificial intelligence, Bakhshi art, emotional analysis, digital technologies, audio signal, Speech Emotion Recognition, machine learning, national music, folklore, digitalization.*

Annotatsiya: *Mazkur maqolada baxshichilik ijrolarida hissiy-emotsional holatlarni sun'iy intellekt asosida aniqlash imkoniyatlari hamda ushbu*

texnologiyalarning milliy musiqa merosini raqamlashtirishdagi ahamiyati tahlil qilingan. Tadqiqot davomida baxshi ijrolaridagi ovoz tembri, intonatsiya, ritm, emotsional ohang va nutq dinamikasini tahlil qilishda sun'iy intellekt texnologiyalarining imkoniyatlari o'rganildi. Shuningdek, audio signallarni qayta ishlash, hissiy holatlarni aniqlash (Speech Emotion Recognition), mashinaviy o'qitish va neyron tarmoqlar asosida baxshichilik san'atini raqamli tahlil qilish masalalari yoritildi. Maqolada baxshi ijrolarining audio bazasini yaratish, ularni avtomatik klassifikatsiya qilish hamda milliy folklor merosini zamonaviy raqamli platformalar orqali saqlash istiqbollari ilmiy jihatdan asoslab berilgan. Tadqiqot natijalari baxshichilik san'atini raqamlashtirish, an'anaviy ijrochilikni saqlash va sun'iy intellekt texnologiyalarini milliy musiqa ta'limiga integratsiya qilishda muhim ilmiy-amaliy asos bo'lib xizmat qiladi.

Kalit so'zlar: *Sun'iy intellekt, baxshichilik san'ati, hissiy-emotsional tahlil, raqamli texnologiyalar, audio signal, Speech Emotion Recognition, mashinaviy o'qitish, milliy musiqa, folklor, raqamlashtirish.*

Аннотация: *В данной статье рассматриваются возможности определения эмоционально-психологических состояний в исполнении бахши с использованием технологий искусственного интеллекта, а также значение данных технологий в цифровизации национального музыкального наследия. В ходе исследования были изучены возможности искусственного интеллекта в анализе тембра голоса, интонации, ритма, эмоциональной окраски и динамики речи в исполнении бахши. Кроме того, рассмотрены вопросы цифрового анализа бахшинского искусства на основе обработки аудиосигналов, технологий распознавания эмоций в речи (Speech Emotion Recognition), машинного обучения и нейронных сетей. В статье научно обоснованы перспективы создания аудиобаз бахшинских исполнений, их автоматической классификации и сохранения национального фольклорного наследия посредством современных цифровых платформ. Результаты исследования служат важной научно-практической основой для*

цифровизации бахшинского искусства, сохранения традиционного исполнительства и интеграции технологий искусственного интеллекта в систему национального музыкального образования.

Ключевые слова: *Искусственный интеллект, искусство бахши, эмоциональный анализ, цифровые технологии, аудиосигнал, Speech Emotion Recognition, машинное обучение, национальная музыка, фольклор, цифровизация.*

INTRODUCTION

Today, the rapid development of information and communication technologies is creating new opportunities for the preservation, study, and digitalization of national cultural heritage. In particular, the integration of artificial intelligence technologies into the fields of music and the arts has enabled the scientific analysis of traditional performance practices and their adaptation to modern digital environments. In this regard, the art of Bakhshi performance is also considered one of the important research objects within the processes of digital transformation. Bakhshi art is one of the oldest and most distinctive forms of Uzbek oral folk creativity, in which musical performance, artistic narration, and emotional expression are manifested in a harmonious manner. The emotional states conveyed through Bakhshi performances constitute an important factor influencing the psychological and emotional impact on listeners. Therefore, the analysis of emotional elements in the Bakhshi voice, such as dramatic expression, sorrow, heroism, excitement, and emotional uplift, using modern technologies has become one of the pressing scientific issues of contemporary research.

At present, Speech Emotion Recognition (SER) technologies enable the automatic identification of emotional states expressed in human speech. These technologies operate on the basis of audio signal processing, machine learning, and neural network architectures. Globally, they are primarily applied in the fields of media, security systems, education, and healthcare. However, research on the application of these technologies to national folklore and the art of Bakhshi

performance remains insufficiently developed. Furthermore, the digitalization of Bakhshi art plays a significant role in preserving national cultural heritage and transmitting it to future generations. The creation of audio databases of Bakhshi performances, their emotional analysis, and their preservation on electronic platforms represent not only an important scientific task but also a culturally significant undertaking.

The purpose of this article is to analyze the possibilities of identifying emotional states in Bakhshi performances using artificial intelligence technologies, to examine the significance of these technologies in the digitalization of national folklore art, and to provide a scientific rationale for the prospects of their integration into the system of music education.

LITERATURE REVIEW

In recent years, the widespread adoption of artificial intelligence technologies in the fields of audio signal processing and emotional analysis has led to the emergence of numerous scientific studies focused on the automatic analysis of musical performances. In particular, Speech Emotion Recognition (SER) technologies have been widely employed as effective tools for identifying emotional states in human speech and musical performances. These technologies enable the classification of emotional states through the analysis of audio signal parameters, including voice timbre, rhythm, intonation, frequency, and energy characteristics.

Scientific studies conducted by M. Müller, J. P. Bello, and D. Ellis on the theory of audio signal processing constitute an important methodological foundation in this field. Their research extensively addresses Music Information Retrieval (MIR) technologies, audio feature extraction techniques, and methods for the automatic analysis of musical signals [5, 6]. In particular, M. Müller's studies provide a detailed explanation of the significance of spectrograms and Mel Frequency Cepstral Coefficients (MFCC) in audio analysis.

In foreign studies on the identification of emotional states, the effectiveness of Speech Emotion Recognition (SER) technologies has been investigated by M. El

Ayadi, C. Busso, and S. Narayanan [7]. Their research developed methods for identifying emotional states in human speech using neural network architectures, particularly Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) algorithms. These developments serve as an important scientific foundation for the automatic analysis of emotional changes in Bakhshi performances.

Furthermore, innovative technologies for processing music and audio data using artificial intelligence are being developed within platforms such as Google Magenta, OpenAI Jukebox, and Spotify AI. These systems employ machine learning algorithms to analyze audio content, identify musical styles, and generate emotion-based recommendations.

In addition, Russian scholars E. V. Nikolaeva and A. V. Toropova have investigated the application of multimedia and digital technologies in music pedagogy [10, 11]. Their studies highlight the significance of electronic platforms, interactive audio systems, and digital archives in the preservation of national music heritage.

Scientific and practical studies on the digitalization of maqom, folklore, and the art of Bakhshi performance are also being conducted by Uzbek researchers. In particular, studies at the Yunus Rajabiy Uzbek National Institute of Musical Arts have focused on the electronic preservation of national performance samples, the creation of audio databases, and their integration into multimedia platforms. However, scientific research on the automatic identification of emotional states in Bakhshi performances using artificial intelligence remains insufficiently developed.

The analysis indicates that the integration of artificial intelligence technologies into the art of Bakhshi performance creates broad opportunities for the digitalization of national folklore heritage, the development of audio archives, and the establishment of emotional analysis systems. At the same time, the creation of specialized audio datasets for Bakhshi performances, the development of emotional classification models, and the improvement of artificial intelligence systems adapted

to national performance styles remain among the pressing scientific challenges in this field.

SCIENTIFIC NOVELTY OF THE RESEARCH

The scientific novelty of this study is defined by the development of a model utilizing artificial intelligence-based audio signal analysis technologies for the identification of emotional states in Bakhshi performances. The study investigated the possibilities of employing MFCC (Mel Frequency Cepstral Coefficients), spectrogram analysis, and neural network-based classification algorithms for the automatic analysis of the acoustic characteristics of Bakhshi performances [2].

During the course of the research, a conceptual model was developed for identifying emotional states in Bakhshi performances, including dramatic expression, heroism, sorrow, and emotional uplift. By processing audio signal parameters in real time, this model enables the automatic detection of emotional changes occurring throughout Bakhshi performances.

In addition, scientific and practical proposals were developed for establishing an emotional audio database of Bakhshi performances aimed at the digitalization of national folklore samples. This approach provides an important scientific foundation for the future analysis of Uzbek Bakhshi art using artificial intelligence and for its preservation on electronic platforms.

METHODOLOGY

A comprehensive methodological approach was employed in this study to investigate the processes of identifying emotional states in Bakhshi performances using artificial intelligence. The research was organized into theoretical, analytical, and practical stages. At the initial stage, a comparative analysis of domestic and international scientific literature related to Bakhshi art, audio signal processing, Speech Emotion Recognition (SER), and artificial intelligence technologies was conducted. During this process, the emotional characteristics of Bakhshi performances were examined using methods of analysis, synthesis, and a systems approach.

In the practical phase of the study, audio samples of Bakhshi performances were collected and converted into digital format. The Python programming environment and the Librosa, TensorFlow, and Scikit-learn libraries were utilized for audio signal processing. To identify emotional states in the Bakhshi voice, methods for extracting acoustic parameters from audio signals were applied. Specifically, MFCC (Mel Frequency Cepstral Coefficients), spectrograms, pitch, tempo, and signal energy indicators were analyzed [1, 3].

Machine learning algorithms were employed in the process of emotional state classification. In this study, an audio signal analysis model based on Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) neural networks was developed. This model enabled the automatic identification of emotional states in Bakhshi performances, including dramatic expression, sorrow, heroism, excitement, and emotional uplift. Observation, modeling, and comparative methods were also applied throughout the research process. The results of the traditional expert analysis of Bakhshi performances were compared with those obtained through artificial intelligence-based automatic analysis. In addition, statistical analysis methods were used to evaluate the model's accuracy, the effectiveness of emotional classification, and the outcomes of audio analysis.

Based on the findings obtained, scientific conclusions were formulated regarding the digitalization of Bakhshi art, the development of audio archives, and the integration of artificial intelligence technologies into national folklore performance practices. This methodological approach enabled an in-depth analysis of emotional elements in Bakhshi art through the application of modern digital technologies.

STATISTICAL ANALYSIS

In this study, an experimental-statistical approach was employed to evaluate the effectiveness of identifying emotional states in Bakhshi performances. During the research process, audio recordings of epics and folklore samples performed by various Bakhshi artists were analyzed and grouped according to their emotional

content. The audio samples were classified into categories such as "heroism," "sorrow," "dramatic expression," and "emotional uplift." Throughout the analysis, variations in the acoustic parameters of the audio signals were examined. In particular, voice intensity, frequency range, tempo, and signal energy were selected as the principal statistical indicators. The findings revealed that dramatic Bakhshi performances exhibited higher levels of voice intensity and signal energy compared with other emotional states. In contrast, sorrowful performances were characterized by a slower speech tempo and the predominance of low-frequency sounds [4].

During the experimental analyses, the results of emotional state identification generated by the artificial intelligence model were compared with evaluations provided by expert Bakhshi performers and music specialists. The comparative results indicated that the AI model achieved an average agreement rate of 83% with expert assessments. The highest level of agreement was observed in performances characterized by heroic expression, reaching 88%. This finding may be attributed to the significant influence of rhythmic stability and vocal intensity on emotional identification in Bakhshi performances.

Furthermore, the temporal dynamics of emotional changes in Bakhshi performances were also analyzed throughout the study. The results demonstrated that voice amplitude and intonational activity increased considerably during the climactic sections of the epics. Consequently, these changes intensified the emotional impact on listeners. By identifying such acoustic variations, the artificial intelligence system was able to classify emotional states effectively [8, 9, 12].

The table below presents the average values of selected emotional states observed in Bakhshi performances and their corresponding acoustic indicators.

Table 1

Average values of selected emotional states and associated acoustic indicators in Bakhshi performances

Emotional State	Speech Tempo	Voice Intensity	AI	Recognition Accuracy
Heroism	High	High	88%	
Dramatic Expression	Moderate	High	84%	
Sorrow	Low	Low	80%	
Emotional Uplift	Moderate	Moderate to High	82%	

The statistical findings obtained in this study demonstrated the feasibility of analyzing emotional elements in Bakhshi art using artificial intelligence. At the same time, it was observed that regional and individual stylistic characteristics of Bakhshi performances may influence the accuracy of emotional analysis. This finding highlights the necessity of developing more extensive audio databases and designing neural network models tailored to the distinctive styles of the national Bakhshi tradition in future research.

DISCUSSION

The findings of this study demonstrated the feasibility of identifying emotional states in Bakhshi performances using artificial intelligence. In particular, it was established that emotional states such as dramatic expression, heroism, sorrow, and emotional uplift in Bakhshi performances can be automatically classified through the analysis of audio signal parameters. This creates new opportunities not only for preserving Bakhshi art as a form of cultural heritage but also for conducting in-depth scientific investigations of this traditional art form.

The analyses further revealed that intonation, rhythm, and voice timbre play a significant role in shaping the emotional impact of Bakhshi performances. Specifically, the findings confirmed that performances characterized by heroic expression exhibit higher voice intensity and greater rhythmic stability, whereas sorrowful sections are associated with a slower speech tempo and the predominance

of low-frequency sounds. These observations indicate that the emotional content of Bakhshi performances can be effectively represented through acoustic parameters.

Furthermore, the integration of artificial intelligence technologies into the art of Bakhshi performance was found to be of considerable importance for the digitalization of national folklore samples and the establishment of electronic archives. The capability to automatically analyze and emotionally index audio recordings facilitates the systematic preservation of Bakhshi performances and simplifies their retrieval through digital platforms. This, in turn, provides an opportunity to transmit national cultural heritage to future generations through modern technological means.

However, several challenges were also identified during the course of the study. In particular, regional styles and individual performance characteristics of Bakhshi artists were found to influence the outcomes of emotional classification. Moreover, the limited availability of digital audio databases related to Bakhshi art created certain difficulties in training artificial intelligence models. Therefore, the development of expanded audio datasets comprising Bakhshi performances from different regions remains an important scientific task for future research.

According to the discussion findings, the application of artificial intelligence technologies represents a promising direction for adapting Bakhshi art to contemporary digital environments, developing emotional analysis systems, and conducting scientifically grounded studies of national folklore heritage. In the future, these technologies are expected to further expand opportunities for the automatic description of Bakhshi performances, emotional mapping, and integration with multimedia platforms.

CONCLUSION

This study scientifically examined the possibilities of identifying emotional states in Bakhshi performances using artificial intelligence technologies. The findings demonstrated that emotional states in Bakhshi performances, including dramatic expression, sorrow, heroism, and emotional uplift, can be identified

through the acoustic characteristics of audio signals. The study further established that Speech Emotion Recognition (SER) technologies, MFCC parameters, spectrogram analysis, and neural network-based classification models constitute effective tools for the analysis of Bakhshi art. The experimental results indicated that artificial intelligence models produced outcomes that closely corresponded to expert evaluations. In addition, it was substantiated that the digitalization of Bakhshi art, the development of audio databases, and their emotional indexing are of significant importance for preserving national folklore heritage and integrating it into contemporary digital platforms.

Overall, the application of artificial intelligence technologies to Bakhshi art not only expands the possibilities for scientific analysis but also substantially enhances the processes of preserving, developing, and transmitting national cultural heritage to future generations.

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