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Expressing Human Sentiments through the Art Of Dance

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Abstract: *Emotions play a crucial role in human experience, influencing social interactions, behavior, and decision-making. This study explores the intersection of performing arts and artificial intelligence by analyzing emotional expressions in Bharatanatyam, a classical Indian dance form known for its expressive storytelling. Specifically, we focus on recognizing and classifying the Navarasas—the nine fundamental emotional states—through advanced pose analysis and machine learning techniques. By employing a biologically inspired neural framework, we aim to distinguish emotions based on full-body movements, bridging the gap between artistic expression and computational emotion recognition.*

Our approach integrates deep learning techniques, including Log-Gabor filtering, Max Pooling, Principal Component Analysis (PCA), and Support Vector Machines (SVM), to enhance posture recognition and classification accuracy. Additionally, Natural Language Processing (NLP) and sentiment analysis contribute to understanding the textual and symbolic representations of emotions in Bharatanatyam. Empirical analysis validates the effectiveness of our proposed model in accurately identifying emotional expressions, offering insights into AI-driven cultural preservation and digital dance analysis. This research has broad applications in automated dance evaluation, interactive learning, and human-computer interaction, providing a foundation for future interdisciplinary studies at the intersection of performing arts, artificial intelligence, and sentiment analysis.

Keywords: Emotion Recognition, Bharatanatyam, Navarasas, Pose Analysis, Machine Learning, NLP, Sentiment Analysis, AI in Performing Arts.

I. INTRODUCTION

Emotions are fundamental to human experience, influencing behavior, decision-making, and social interactions. They shape the way individuals perceive and respond to the world around them, adding richness and complexity to every aspect of life. In the domain of human-computer interaction (HCI), accurately understanding emotions is essential for designing intuitive and responsive systems. While significant advancements have been made in emotion recognition through facial expressions and vocal intonations, there is an emerging interest in analyzing emotions conveyed through bodily movements and postures. This shift presents novel challenges and opportunities for computational emotion analysis.

This study explores the recognition of emotions in Bharatanatyam, a revered classical Indian dance form known for its profound storytelling and expressive gestures. Specifically, our research focuses on identifying and classifying the Navarasas—the nine primary emotional states embodied in Bharatanatyam—through advanced pose analysis techniques. By leveraging a biologically inspired neural framework, we aim to distinguish these emotions based on full-body movements, highlighting the intricate connection between physical expression and emotional depth.

Furthermore, our study evaluates the efficacy and user perception of Navarasa-based emotion recognition technologies. Through empirical analysis, we seek to validate the capability of computational models to interpret emotional expressions in dance. This research lays a foundation for future exploration at the intersection of performing arts, artificial intelligence, and emotion recognition, offering insights for both scholars and practitioners interested in the convergence of technology and artistic expression.

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II. RESEARCH OVERVIEW

Emotion Recognition in Indian Classical Dance (Sriparna et al.)

Sriparna et al. (2023) explored the recognition of emotions in Indian classical dance using a Kinect sensor, which captures body movements in three-dimensional space. Their study employed a Support Vector Machine (SVM) classifier to analyze five primary emotions—anger, fear, happiness, sadness, and relaxation—by focusing on movements of the head, hands, and torso while excluding footwork.

The proposed method demonstrated robustness across varying lighting conditions, achieving an accuracy of 86.8%. By calculating distances between key skeletal points—such as the head, shoulders, hands, elbows, and spine—they effectively distinguished different emotional states. Their approach offers potential applications beyond Indian classical dance, extending to other global dance traditions.

Gesture Recognition in Kazakh Traditional Dance (Nussiphelcov et al.)

Nussiphelcov et al. (2022) utilized Kinect-based skeletal tracking in combination with a Hidden Markov Model (HMM) to classify gestures in Kazakh traditional dance. HMM, a probabilistic model, was instrumental in analyzing movement sequences to identify specific gestures with precision.

To enhance classification accuracy, the researchers incorporated headwear tracking as an additional joint and applied advanced techniques such as Bayesian networks and clustering. Their method achieved a high accuracy rate of 90.82%, demonstrating the effectiveness of their approach in distinguishing dance gestures with significant reliability.

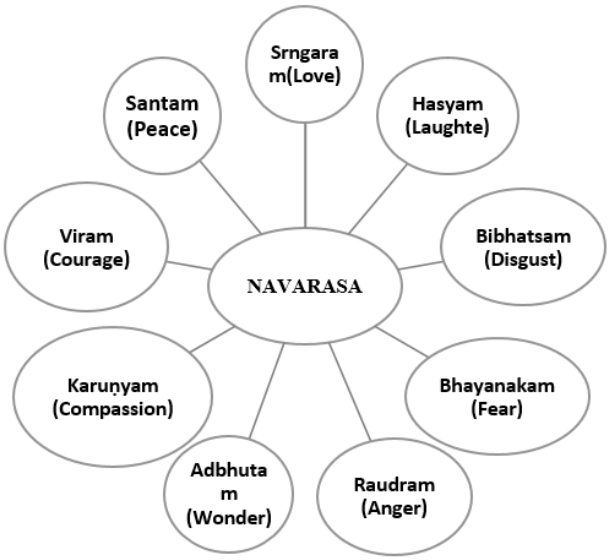
Emotion Recognition in Bharatanatyam Using Graph-Based Analysis (Sugathan et al.)

Sugathan et al. (2024) proposed a graph-based framework for recognizing emotions in Bharatanatyam, focusing on static 2D dance poses captured from images. Instead of analyzing full-body motion sequences, their method emphasized key postures and symbolic hand gestures (mudras).

By utilizing skeletonization and graph-based modeling, they refined pose analysis with algorithms that simplified skeletal structures to enhance classification accuracy. Their approach represented body movements as graphs, where joints functioned as nodes and limb connections as edges, assigning weights based on angular relations, distances, and movement intensities. This method proved effective in distinguishing emotions in Bharatanatyam, highlighting the potential of graph-based analysis in dance pose recognition.

III. RESEARCH OUTLOOK

Building on these advancements, our research aims to develop an advanced recognition system specifically designed to identify the Navarasas—the nine fundamental emotions expressed in Bharatanatyam. These emotions include:



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By leveraging cutting-edge computational techniques, we seek to bridge the gap between artistic expression and technological interpretation, contributing to the broader fields of artificial intelligence, human-computer interaction, and performing arts.

Emotion Recognition Framework

Our proposed approach will employ a biologically inspired hierarchical model of neural detectors to systematically recognize the nine Navarasas in Bharatanatyam dance postures. This model is designed to capture the intricate relationship between movement and emotional expression by mimicking the layered processing mechanisms of the human visual and cognitive systems.

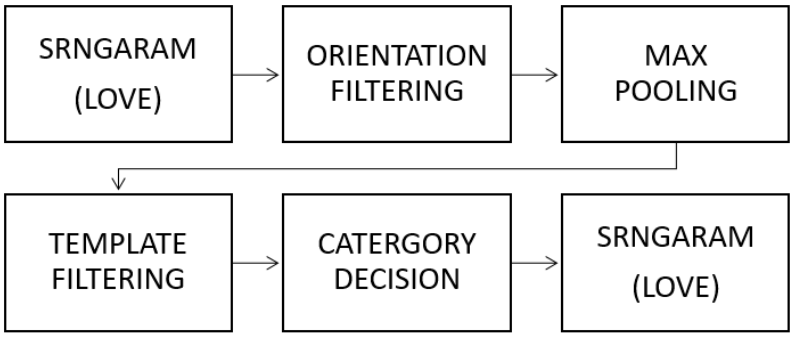
Role of Sentiment Analysis and NLP

Natural Language Processing (NLP) plays a crucial role in understanding and analyzing emotions from text and speech. Khandar (2023) emphasized that NLP techniques, particularly sentiment analysis, can be effectively used to interpret digital expressions of emotions. By integrating sentiment analysis techniques with dance pose recognition, our research aims to enhance emotion classification by leveraging textual descriptions and symbolic gestures. NLP methodologies such as Named Entity Recognition (NER) and semantic analysis help bridge the gap between human sentiments and their physical expressions in Bharatanatyam.

IV. COMPUTATIONAL TECHNIQUES

The emotion recognition process in Bharatanatyam follows a structured sequence of steps:

- **Pose Analysis:** The system first analyzes the dancer's posture, extracting key skeletal features that define movement and body orientation.
- **Orientation Filtering:** To determine the direction of movement, orientation filtering is applied. This helps in distinguishing subtle variations in gestures and expressions.
- **Noise Reduction:** Max pooling is utilized to eliminate unnecessary data and retain the most critical posture details, ensuring accuracy in recognition.
- **Gesture Identification:** The extracted pose is then compared against a predefined database of dance postures, enabling the system to associate specific gestures with corresponding emotional expressions.
- **Emotion Classification:** The final step involves classifying the expression into one of the nine Navarasas—Śṛṅgāram (Love), Adbhutam (Wonder), Raudram (Anger), Bhayānakam (Fear), Bībhatsam (Disgust), Hāsyam (Laughter), Kāruṇyam (Compassion), Śāntam (Peace), and Vīram (Courage). For instance, when the system identifies Śṛṅgāram, it visually highlights it in green to indicate its detection.



Orientation Filtering

To enhance image processing and capture both frequency and orientation details, our model employs the **Log-Gabor filter.** This filter is particularly effective in analyzing intricate dance movements and gestures, as it offers superior feature localization, minimizes redundancy, and improves sensitivity to posture variations compared to traditional

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Gabor filters. In our approach, orientation is determined using a **Gaussian distance function in polarcoordinates**, enabling precise analysis of angles and curvatures in Bharatanatyam postures.

Max Pooling for Feature Extraction

Max Pooling, a widely used deep learning technique, enhances recognition efficiency by selecting the most significant feature values within a defined region rather than averaging them. This process not only reduces computational complexity but also preserves essential posture characteristics while minimizing noise. By employing Max Pooling, our model effectively focuses on critical dance movements, ensuring robust feature extraction.

Template Matching for Gesture Identification

Template matching is a pattern recognition technique that identifies objects by comparing them to predefined templates. It is commonly applied in fields such as quality control, navigation, and edge detection. In our study, this method plays a crucial role in recognizing subtle variations in Bharatanatyam postures, particularly in **hand gestures (mudras) and body alignments**. By mapping predefined movements to real-time data, template matching enhances the accuracy of **Navarasa recognition**. Additionally, for structured postures, a hybrid approach integrating **feature-based methods** may further improve classification precision.

Principal Component Analysis (PCA) for Dimensionality Reduction

To optimize computational efficiency**, Principal Component Analysis (PCA)**is utilized for dimensionality reduction. PCA is extensively applied in**facial recognition andfeature extraction**, as it eliminates redundant information while preserving essential features. In our model, PCA improves retrieval speed and indexing by refining pose classification, resulting in a more lightweight and effective recognition system for analyzing Bharatanatyam dance postures.

Emotion Classification Using Support Vector Machine (SVM)

The final step in our framework involves classifying emotions using a Support Vector Machine (SVM), a robust machine learning algorithm known for its high accuracy and reliability in pattern recognition tasks. SVM maps input features into a high-dimensional space, constructing decision boundaries that enhance class separation. Utilizing kernel functions, it efficiently handles nonlinear classification. In our system, SVM analyzes dance movements and posture variations to accurately classify Navarasas, ensuring robust performanceacross different performers and varying conditions.

V. CONCLUSION

This study presents a comprehensive model for emotion recognition in Bharatanatyam through the integration of image processing, machine learning, and NLP techniques. The system follows a structured approach to analyze dance postures and classify emotions with precision.

- **Log-Gabor filtering** extracts key orientation features, improving posture recognition.
- **Max Pooling** refines these features, selecting the most significant ones while reducing noise.
- **PCA** optimizes the recognition process by reducing data dimensions without compromising essential details, making the system computationally efficient.
- **SVM** provides highly accurate emotion classification, ensuring robustness and reliability.
- **NLP and sentiment analysis** contribute to better understanding the connection between physical expressions and digital emotions.

By incorporating these advanced techniques, our model contributes to the fields of AI-driven cultural preservation, digital dance analysis, and interactive learning. It holds potential applications in automated dance evaluation, dancer training programs, and immersive learning environments, bridging the gap between traditional performing arts and artificial intelligence.

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