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SIGN AND MUDRA RECOGNITION SYSTEM

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Abstract : Effective communication is a cornerstone of human interaction, yet hearing or speech disabilities in individuals require alternative communication beyond verbal expression. The absence of accessible communication channels poses significant barriers to their engagement in education, healthcare, employment, and everyday activities. The expressive hand gestures integral to this classical Indian dance form. With a dual focus on communication and cultural preservation alongside of technological innovation, employing machine learning to recognise Bharatanatyam sign language as a solution to bridge the communication divide, enabling better interaction between deaf individuals and the wider community this initiative aims to bridge the traditional and modern realms. By developing a learning, recognition and translation tool for Bharatanatyam sign language, these article proposed a model to enhance communication accessibility and potentially contribute to the development of autonomous systems for assisting Bharatanatyam individuals with hearing or speech disabilities.

***IndexTerms* - mudra, CNN, LSTM, sign, gesture, feature extraction.**

I.INTRODUCTION

Communication is a fundamental aspect of social survival, yet conventional speech-based approaches may not suffice for hearing or speech disabilities individuals. According to World Federation of the Deaf (WFD), approximately 360 million people globally, constituting over 5% of the world's population, experience some form of hearing impairment includes 300+ million adults and 30+ million children [10,11,20]. Sign language is primary mode of communication for the mute and deaf community, but its comprehension remains a challenge for those who are unfamiliar with sign language [4,16]. Real-time gesture recognition has emerged as a vital area of research, offering numerous human-computer interface applications, including sign language translation and virtual reality. Sign language, historically the predominant mode of communication, can now be enhanced through technologies like image processing and machine learning that converts sign language to text or speech, thus providing invaluable assistance to individuals with speech disabilities [17]. This report proposes employing machine learning to recognise bharatanatyam sign language as a solution to bridge the communication divide, enabling better interaction between deaf individuals and the wider community [6].

Bharatanatyam mudras, intricate hand gestures integral to the classical Indian dance form. Each mudra has a specific name and conveys a distinct meaning or symbolism. The hand movements, fig-1.1 finger positions, and the overall posture contribute to the rich storytelling aspect of Bharatanatyam Mudras like katakamukha indicates plucking flowers, arrangement and holding garland or necklaces of pearl, etc,. The successful creation of a machine learning techniques based on sign language recognition system holds the promise of substantially enhancing the quality of life for Deaf and mute individuals. This technology empowers them to communicate more proficiently across educational, healthcare, and social contexts, thereby dismantling language barriers and fostering inclusivity. Moreover, this system's versatility extends its utility to public services, customer support, and diverse domains, guaranteeing accessibility and equitable opportunities for Deaf individuals.

Kartarimukha Mudra to denote lightening, separation of couple, falling, weeping, plundering and corner of an eye. suchi Mudra as hand gestures/seals and has healing properties. Katakamukha is preferred to mean plucking flowers, arrangement and holding garland or necklaces of pearl, etc. Pataka mudra is used to show clouds, wind, door closing and finally the musti mudra is stretched straight to form the shikhara mudra to denote sounding bell, a peak, a bow, a pillar and certainty and so on. There are numerous mudras to narrate the story. Machine learning algorithms and techniques involves collecting a diverse dataset encompassing variations. for recognising mudra gesture [14]. Leveraging techniques such as LSTM (Long Short-Term Memory), RNNs (Recurrent Neural Networks), CNNs (Convolutional Neural Networks), or, the model undergoes rigorous training and evaluation [11,12,13]. Enthusiast who are in these recognition system recommend there is need for a real-time gesture recognition system capable of applications in cultural preservation, dance education, and interactive experiences.

Fig 1.1: Mudras

II. SIGN RECOGNITION SYSTEM

1. Sign Language Recognition with the Kinect Sensor Based on Conditional Random Fields [19] - introduces a pioneering technique for recognising hand gestures in sign language. Leveraging depth data acquired from Microsoft's Kinect, the 3D positions of hands and faces are accurately determined. Additionally, a hierarchical threshold Conditional Random Field (CRF) model is employed to interpret continuous hand movements and identify meaningful sign language gestures

2. Real-time Vernacular Sign Language Recognition using MediaPipe and Machine Learning [20] - Provided prediction algorithms and framework to interpret and translate various sign languages seamlessly in real-time. By leveraging this innovative fusion, the system facilitates swift and accurate interpretation of sign language nuances, thereby fostering inclusive communication across diverse linguistic landscapes.

3. Sign Language Recognition System using TensorFlow Object Detection API [8] - developed a real-time sign language detector by utilising the TensorFlow object detection API. Through transfer learning, the model would be trained using a dataset specifically curated for this purpose. This approach leverages pre-trained models and adapts them to the unique characteristics of sign language gestures, thus enabling efficient and accurate detection in real-time scenarios.

III. PROPOSED SYSTEM

In our progressive society, social interaction serves as a fundamental aspect of connecting with others for various purposes. Individuals with hearing impairments often face challenges in general communication, as their gestures may not be widely recognised by others, leading to difficulties in interaction [18]. To confront this gap and foster inclusivity, the creation of a precise and sign language recognition system in real-time using machine learning is imperative, a system would empower hearing or speech disabilities in individuals to communicate effectively, ensuring their full participation and integration into society [7]. Hence, the proposal is to develop a Sign and Mudra recognition system utilising LSTM.

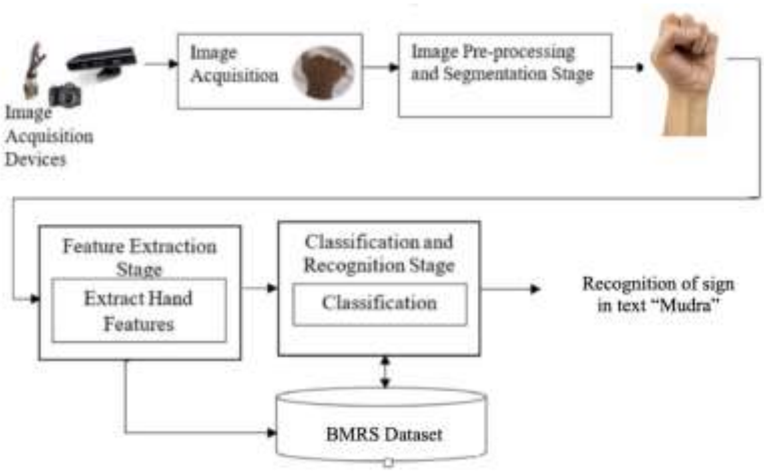

Fig 3.1 : LSTM model

The Sign and Mudra Recognition system stands out as the most intricate and pivotal element, offering a range of implementation options, including convolutional neural networks (CNNs), recurrent neural networks (RNNs), or cutting-edge models like Transformer-based architectures[5]. Training the model necessitates an extensive dataset comprising sign language gestures and corresponding labels to guarantee precise recognition.

IV. PROPOSED MODEL

4.1 Proposed Steps in SMR system

1. Data Gathering: Collection of diverse dataset of Bharatanatyam mudras Ensure variations in lighting, hand angles, and backgrounds[1,9,15]. Annotation, captured through images or videos. Label each image or video frame with the corresponding mudra gesture to create a labeled dataset.
2. Preprocessing: Normalise images for consistent lighting, remove noise, and standardise hand positions [3].
3. Feature Extraction: Extract relevant features like hand shape, finger positions, and contours that represent the mudras [1, 9].
4. Model Development: Choice of Model: Use of LSTM in recognition performance can also be improved by increasing the number of training data for better model learning. Split the dataset into training and validation sets. Train the model used labeled data to learn the mapping between input (mudra images) and output (mudra labels). Optimise model architecture, learning rate, and other parameters to improve accuracy [12, 13].
5. Evaluation: Measure performance using metrics like recall, accuracy, precision, and F1 score. Further validate the model on a separate test dataset to assess its generalisation and performance on unseen data. Refine the model based on validation results, tweaking parameters.
6. Deployment: Interface Development: Create an interface to capture live video or images and feed them into the trained model for real-time gesture recognition.
7. Testing: Test the model with dancers and experts to ensure accuracy and usability.

A Sign and Mudra Recognition System using LSTM networks is a fascinating application of machine learning in the realm of classical Indian dance forms. Bharatanatyam involves intricate hand gestures, known as mudras, which convey specific meanings, emotions, and stories. LSTM model shown in fig 3.1 is well-suited for sequence modelling tasks, making it a potentially effective tool for recognising and classifying these sequential patterns of mudras in Bharatanatyam. Proposed model aims at developing a model capable of accurately identifying and classifying different mudras performed by a bharatanatyam dancer.

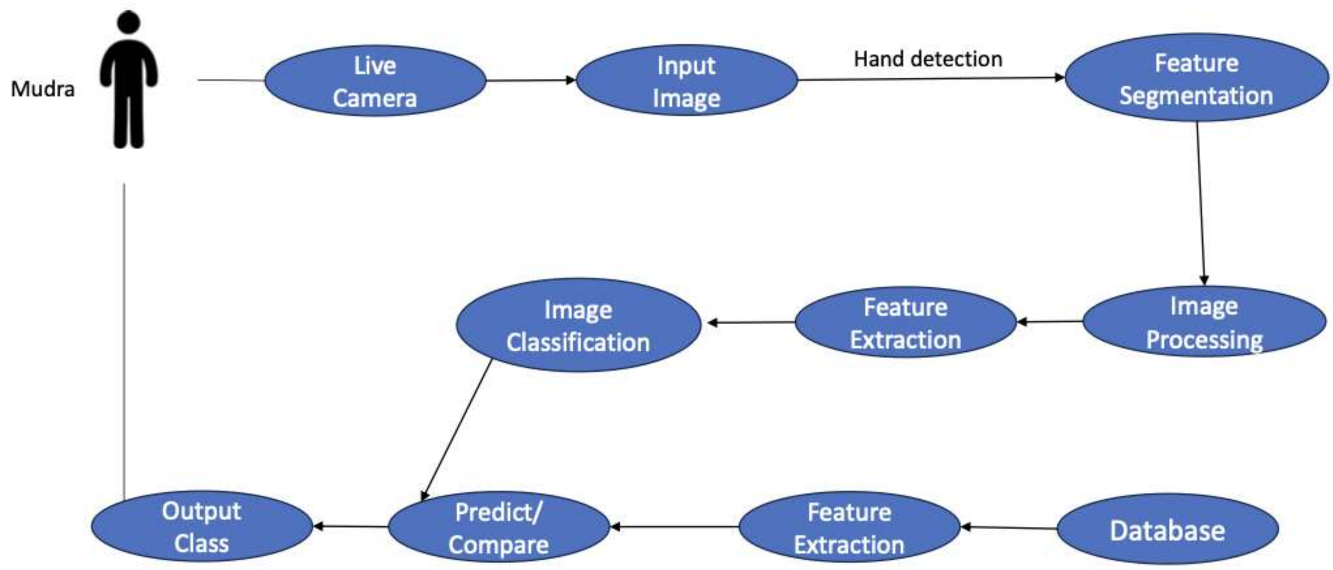

Fig 4.1 : Proposed model to detect Bharatanatyam Mudra using LSTM

The LSTM is used to compare and find the best architecture with appropriate hyper-parameters. Recognising Bharatanatyam mudras (hand gestures) through machine learning involves a combination of computer vision and pattern recognition techniques.

4.2 Abbreviations and Acronyms

SMR - Sign and Mudra Recognition System is a machine learning solution designed to identify Bharatanatyam sign language, with the goal of fostering improved communication between deaf individuals and the broader community. This initiative seeks to merge traditional and modern domains by creating a tool for learning, recognising, and translating Bharatanatyam sign language. By doing so, it aims to improve communication accessibility and potentially support the development of autonomous systems to aid individuals within the Bharatanatyam community who have hearing or speech impairments.

4.3 Working steps of proposed system:

- Step 1: Gather a diverse dataset of Bharatanatyam mudras captured through images, covering various angles, lighting conditions, and hand positions [1].
- Step 2: Assign labels to each image, annotating them with the corresponding mudra gesture to create a labeled dataset.
- Step 3: Normalise images, remove noise, and extract relevant features such as hand shapes, finger positions, or contours. Organise sequences of frames for LSTM input.
- Step 4: Divide and classify the dataset into training, validation, and test sets for model training and evaluation[2].

- Step 5: Convert preprocessed image sequences into numerical representations suitable for LSTM input, ensuring compatibility with the network.
- Step 6: Construct an LSTM-based model with appropriate architecture parameters, including the number of layers, hidden units, and sequence length. Initialise the LSTM network's weights and biases. Iterate through the training set, feeding sequences into the LSTM network. Use back propagation through time (BPTT) to optimise the network's parameters.
- Step 7: Adjust learning rates, batch sizes, dropout rates, and other parameters to optimise the model's performance. Monitor validation accuracy to prevent overfitting [3].
- Step 8: Assess the trained LSTM model's performance on the separate test set, calculating precision, recall, accuracy and other relevant metrics.
- Step 9: Develop an interface for live gesture input, testing the model's accuracy with dancers and experts. Gather feedback for refinement and potential model enhancements, iterating based on user input and performance analysis.

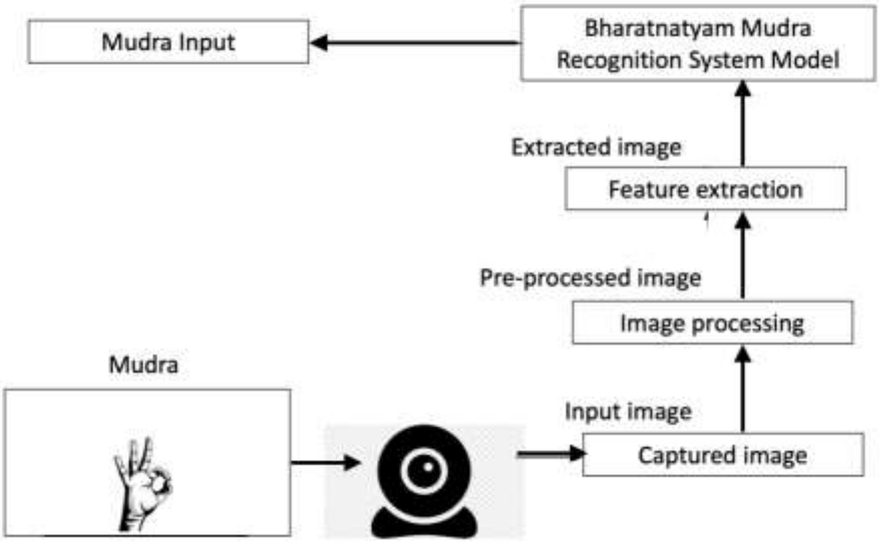

Fig 4.2 : SMR system flow diagram

V. DATASET

Creating a dataset for Sign and Mudra Recognition System using LSTM involves gathering images that represent different mudras in Bharatanatyam dance. Mudras are hand gestures that convey specific meanings or emotions in classical Indian dance forms like Bharatanatyam.

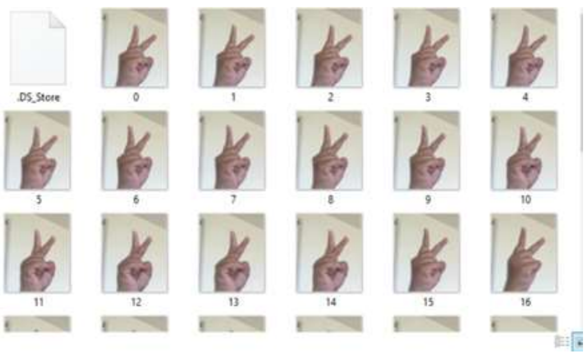

Fig 5.1: Kartarimukha Mudra

Fig 5.2: Soochi Mudra

Fig 5.3: Katakamukha Mudra

Fig 5.4: Mushti Mudra

Fig 5.5: Pataka Mudra

VI. RESULTS AND INTERPRETATION

The system's ability to achieve such high accuracy rates, especially above the 95% threshold, signifies its reliability and effectiveness in recognising these specific Bharatanatyam mudras. This outcome holds a significant promise and result for applications within dance education, real-time gesture recognition systems, or cultural preservation efforts, as it suggests a reliable automated means of comprehensively identifying and interpreting these crucial elements of Bharatanatyam dance. The precise recognition and classification of these gestures above the 95% accuracy mark affirm the system's potential to contribute meaningfully to both technological advancements and cultural preservation within the realm of classical dance forms.

The output from the Bharatanatyam Mudras Recognition System, utilising LSTM, highlighted exceptional accuracy rates exceeding 95% for five specific mudras: Mushti Mudra, Kartarimukha Mudra, Katakamukha Mudra, Pataka Mudra, and Sochi Mudra. This robust performance indicates the system's proficiency in accurately identifying and classifying these gestures within the Bharatanatyam dance vocabulary. The LSTM model showcased remarkable precision, successfully capturing the intricate hand movements and nuances associated with these mudras, demonstrating its capacity to discern and differentiate subtle variations in gesture execution.

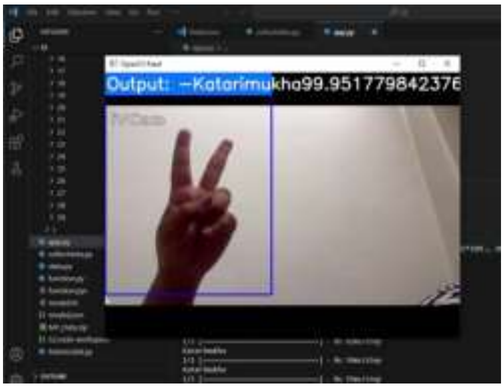

Fig 6.1: Katarimukha Mudra with Accuracy

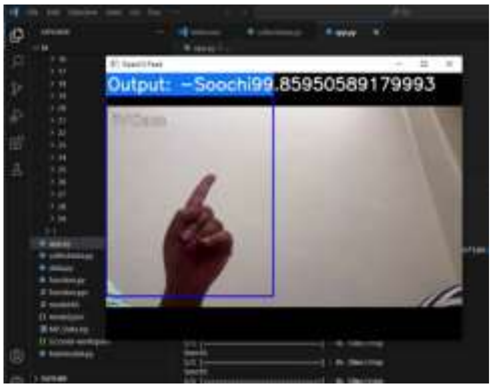

Fig 6.2: Soochi Mudra with Accuracy

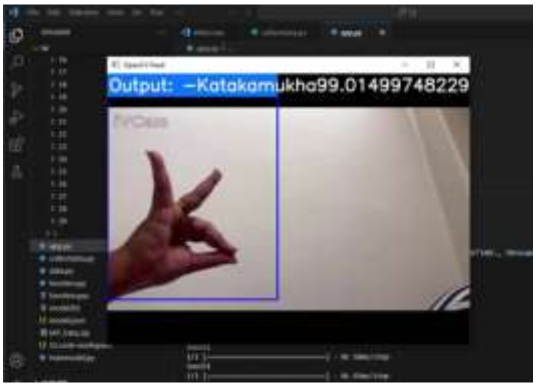

Fig 6.3: Katakamukha Mudra with Accuracy

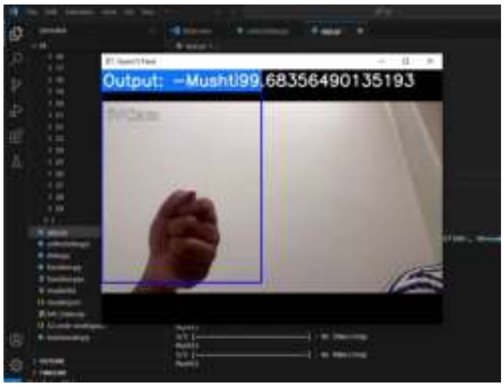

Fig 6.4: Mushti Mudra with Accuracy

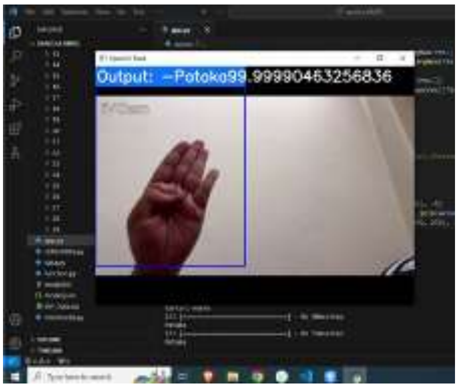

Fig 6.5:Pataka Mudra with Accuracy

6.1 TESTING

The proposed model and its working we have considered the placement of the camera from the distance, model were trained using various sign gesture as shown above testing within a distance range of 20-50cm named as scenario 1. Twenty individuals hand gestures (mudras), samples were capturing. The evaluation revealed varying performances among individuals, with some consistently executing multiple mudras with extended durations, while others displayed intermittent success or challenges in executing certain gestures. Interestingly, age did not align with performance, indicating a diverse skill set across different age groups.

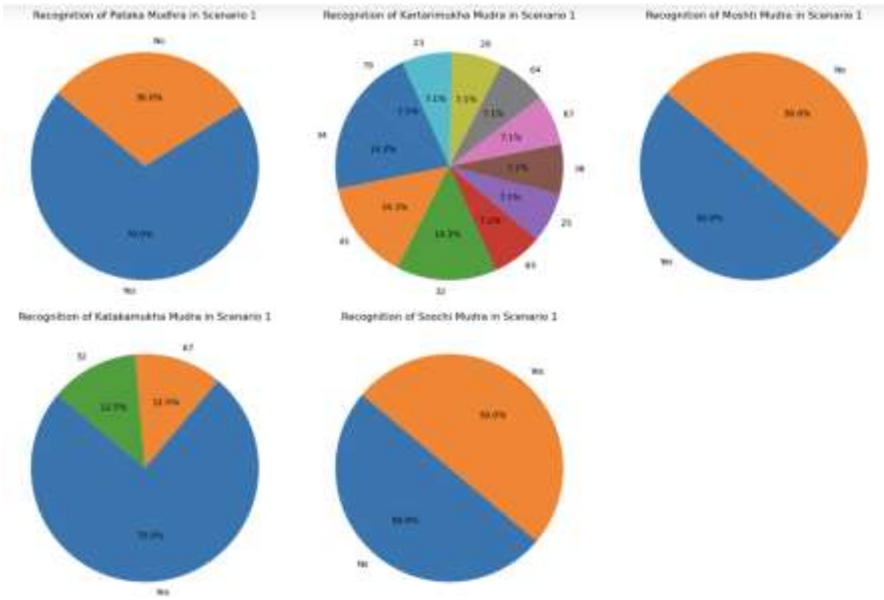

Fig 6.6 Pie chart distribution on recognition

VII. CONCLUSION

Sign language recognition encompasses various fields such as natural language processing, computer vision, and machine learning. This review delves into diverse methodologies and tools essential for sign language recognition, with their suitability contingent on specific application requirements. Convolutional Neural Networks (CNNs), Long Short-Term Memory (LSTM) networks, and Hidden Markov Models (HMMs) are among the techniques explored, each with distinct strengths and limitations tailored to different aspects of sign language recognition. The utilisation of LSTM-based machine learning for B Sign and Mudra Recognition System presents both significant advancements and inherent challenges. This initiative marks a significant stride in technological innovation and cultural preservation, encouraging further exploration at the nexus of machine learning and traditional arts. The report elaborates on two specific scenarios focusing on the recognition of five mudras – Soochi, Katamukha, Katarimukha, Mushti, and Pataka – at distances 20-50cm.

The recognition process the accuracy rates owing to closer proximity, resulting in shorter recognition times. Clearer and more distinguishable input features at this range likely contributed to the model's efficacy. Accuracy rates for mudras in this scenario were as follows: Soochi (88%-99%), Katamukha (91%-99%), Katarimukha (89%-100%), Mushti (85%-99%), and Pataka (95%-100%). However, these outcomes point to potential system refinements to accommodate factors like variable distances and individual proficiency, aiming to improve the system's accuracy and consistency in recognizing and timing Bharatanatyam mudras under diverse conditions.

Future enhancements in this Sign and Mudra Recognition System could entail gathering more diverse and comprehensive data and fine-tuning the model. By integrating these advancements and refining the dataset, there's considerable potential to create and develop a more resilient Sign and Mudra Recognition System using LSTM, offering heightened accuracy and usability in real-world applications. This endeavor marks a significant milestone in both technological innovation and cultural preservation, prompting further exploration at the convergence of machine learning and traditional arts.

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