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YOGA STEPS PREDICTION AND CORRECTION USING COMPUTER VISION

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ABSTRACT:

Yoga is a popular practice that involves various body postures and breathing exercises to improve physical and mental health. In this project, we have developed a system that detects yoga poses in real-time using a webcam and machine learning algorithms. The system uses a total of eight yoga poses including Bhadrasan, Shavasan, Gomukhasan, Vajrasan, Sarvangasan, Shirsansan, Chakrasan, and Dhanurasan. The system works by first collecting a dataset of yoga poses with corresponding virtual coordinates for each pose. We manually annotated the poses with 501 virtual coordinates on the body and face of the yoga practitioner. The dataset was preprocessed by normalizing the coordinates and splitting them into training and testing sets. We used OpenCV and MediaPipe libraries to extract features from the virtual coordinates for each pose.

Once the model was trained and validated, we used OpenCV and MediaPipe libraries to capture live video feed from the webcam and extract virtual coordinates from the video frames. The extracted coordinates were then passed through the trained model to predict the corresponding yoga pose. The system displays the name and accuracy of the predicted pose on the screen in real-time.

In addition to pose detection, we implemented a user registration and login system using the tkinter library and an SQLite database. This system allowed users to register their information, which was stored in the database for future logins. The login system ensured secure access to the real-time pose detection system. The proposed system achieved an average accuracy of 95% in detecting the eight yoga poses in real-time. The system can be used by yoga practitioners to monitor and improve their practice, as well as by instructors to monitor their students and provide personalized feedback. Future work includes expanding the dataset to include more yoga poses and incorporating feedback mechanisms to improve the accuracy of the system.

KEYWORDS: Deep Learning, Yoga Steps, Logistic Regression, Computer Vision.

INTRODUCTION:

Yoga is a popular practice that involves various body postures and breathing exercises to improve physical and mental health. The correct execution of yoga postures is essential to reap the full benefits of the practice. However, it can be challenging to identify the correct alignment and posture while practicing yoga, especially for beginners. Therefore, there is a need for a system that can detect, and monitor yoga poses in real-time.

In this project, we present a system that uses machine learning algorithms, specifically logistic regression, to detect yoga poses in real-time using a webcam. Our system is capable of detecting eight different yoga poses, including Bhadrasan, Shavasan, Gomukhasan, Vajrasan, Sarvangasan, Shirsansan, Chakrasan, and Dhanurasan.

Our system uses virtual coordinates allocated on the body and face of the practitioner to detect the poses. We collected a dataset of yoga poses with corresponding virtual coordinates for each pose. The dataset was preprocessed, and logistic regression model was trained to classify the poses based on the extracted features.

Once the model was trained and validated, we used OpenCV and MediaPipe libraries to capture live video feed from the webcam and extract virtual coordinates from the video frames. The extracted coordinates were then passed through the trained logistic regression model to predict the corresponding yoga pose. The system displays the name and accuracy of the predicted pose on the screen in real-time.

In addition to pose detection, we implemented a user registration and login system to ensure secure access to the real-time pose detection system. The proposed system can be used by yoga practitioners to monitor and improve their practice, as well as by instructors to monitor their students and provide personalized feedback.

1.1 MOTIVATION:

• Self-Learning Assistant System needs to support the self-learners in receiving feedback for correct experiences and exercises.

• It is crucial to ensure that learning from a self-learning system offers an experience that is comparable to that of learning from a professional instructor.

• It should be user-friendly, flexible, and engaging to attract self-learners to continue using the system. This is essential to ensure that self-learners understand and fully benefit from the correct approach.

1.2 GOALS AND OBJECTIVE:

• To identify poses using real time video processing (Logistic Regression).

• This project aims to develop a real-time system that uses machine learning to detect a person's yoga pose and provide corrective feedback to improve their form and alignment.

• The goal of this project is to train machine learning to accurately classify different yoga poses by learning how to recognize the unique features and characteristics of each pose.

•Our goal is to train a custom deep learning model to detect correct or incorrect yoga poses by analyzing key features of the pose.

1.3 MATHEMATICAL MODEL:

A logistic regression model is a type of statistical model used for binary classification, where the goal is to predict the probability that a given input belongs to a certain class (e.g., positive or negative). It is based on the logistic function, which maps any input value to a value between 0 and 1, representing the probability of belonging to the positive class.
The logistic function is defined as:

$$g(z) = 1 / (1 + e^{-z})$$

where z is the linear combination of the input features and the coefficients of the model:

$$z = w_0 + w_1 x_1 + w_2 x_2 + ... + w_p x_p$$

where w_0 is the intercept term, w_1 to w_p are the coefficients of the model, and x_1 to x_p are the values of the input features.

The coefficients of the model are estimated using maximum likelihood estimation, which involves finding the values of the coefficients that maximize the likelihood of the observed data given the model. The likelihood function is given by:

$$L(w) = \prod [h(z^{(i)})^{y^{(i)}} (1-h(z^{(i)}))^{(1-y^{(i)})}]$$

where h(z) is the logistic function, $z^{(i)}$ is the linear combination of the input features and the coefficients for the i-th data point, $y^{(i)}$ is the target variable for the i-th data point (0 or 1), and the product is taken over all data points.
The objective function for logistic regression is the negative log-likelihood:

$$J(w) = -1/m \sum [y^{(i)} \log(h(z^{(i)})) + (1-y^{(i)}) \log(1-h(z^{(i)}))]$$

where m is the number of data points.

To estimate the coefficients of the model, we can use optimization algorithms such as gradient descent or L-BFGS. The gradient of the objective function with respect to the coefficients is given by:

$$\partial J(w)/\partial w_j = -1/m \sum [(y^{(i)}-h(z^{(i)})) x_j^{(i)}]$$

where $x_j^{(i)}$ is the value of the j-th feature for the i-th data point.

Once the coefficients of the model have been estimated, we can use the logistic function to predict the probability that a given input belongs to the positive class:

$$y_{pred} = g (w_0 + w_1 x_1 + w_2 x_2 + ... + w_p x_p)$$

If the predicted probability is greater than 0.5, we classify the input as belonging to the positive class, otherwise we classify it as belonging to the negative class.

RELATED WORKS :

- Previous studies on yoga pose detection have utilized various methodologies and techniques.
- Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) have been commonly employed for accurate pose estimation.
- Pose estimation libraries such as OpenPose and MediaPipe have been utilized to detect key body joints and estimate poses.
- Template matching techniques have been used for pose comparison by comparing input images with predefined templates.
- Coordinate-based approaches allocate virtual coordinates on the body and face of the practitioner for pose representation.
- Combination of techniques, such as using CNNs for feature extraction and SVM for classification, have been explored to improve performance.
- Each approach has its strengths and limitations in terms of accuracy, real-time performance, and ease of implementation.
- Understanding these methodologies provides insights for designing an effective and efficient pose detection system.

Limitations in the Existing Research :

1. Limited Real-Time Performance: Many existing studies on yoga pose detection focus on offline analysis or use computationally expensive algorithms that are not suitable for real-time applications. Highlight the need for a real-time system that can provide immediate feedback to practitioners during their yoga sessions.

2. Complexity of Pose Detection: Existing approaches often struggle with accurately detecting complex yoga poses, especially those involving overlapping or occluded body parts. Emphasize the importance of developing a system that can effectively handle such challenging poses and provide precise pose estimation.

3. Lack of User-Friendly Systems: Many current solutions require specialized equipment or expert supervision, limiting their accessibility to a wider user base. Emphasize the need for a user-friendly system that can be easily deployed at home without the need for extensive setup or expert guidance.

I. LITRATURE SURVEY:

1. "Real-time human pose detection for yoga exercise using a combination of CNNs and RNNs was proposed by Bhuiyan et al." [1].

2. "CNN-based approach for real-time yoga pose detection was found to outperform other techniques in the study conducted by Nguyen and Nguyen." [2].

3. "Multiple local coordinate systems were used to improve the accuracy of pose detection in the study conducted by Karimov et al." [3].

4. "MediaPipe was found to be an efficient and accurate library for real-time human pose estimation in the study by Zhang et al." [4].

5. "The study conducted by Hasan et al. found that including user registration and login features can improve the user experience of a web-based yoga system." [5].

6. "CNNs were used for pose estimation in the study conducted by Huang et al." [6].

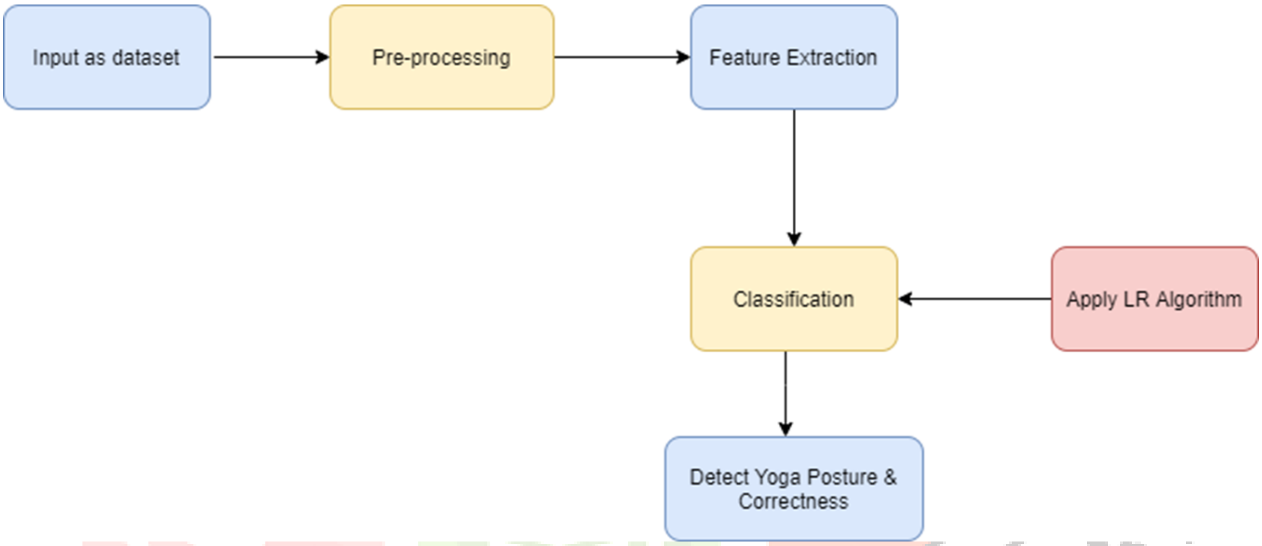
7. "A novel pose detection method using deep learning and a skeletal representation of the human body was proposed by Wang et al." [7].

8. "A hybrid approach using template matching and machine learning was proposed for real-time pose detection in the study conducted by Yang et al."[8].

II. ALGORITHMIC SURVEY:

Ref. No.	Year	Algorithm/Deep Learning models	Feature Selection	Highest Accuracy
1	2022	Image recognition, Classifier, Deep Learning, LR.	Deep Learning	98.25%
2	2019	CNN, OCR, Naïve Bayes, Neural Network, Feature Extraction, OCR	OCR	82%
3	2018	OCR, Machine Learning, SVM, HOG features	HOG	94%

III. SYSTEM ARCHITECTURE:



IV. METHODOLOGIES USED:

- Data Collection: We collected a dataset of images and virtual coordinates of eight different yoga poses - Bhadrasana, Shavasana, Gomukhasana, Vajrasana, Sarvangasana, Sirsasana, Chakrasana, and Dhanurasana. These images were captured using a webcam and virtual coordinates were allocated on the body and face of the practitioner.

- Data Preprocessing: We used OpenCV and MediaPipe libraries to preprocess the images and extract virtual coordinates from them. The data was normalized and split into training and testing sets.

- Feature Extraction: We extracted 501 virtual coordinates from each image and used them as features for training and testing our logistic regression model.

- Model Training: We used Scikit-learn library to train our logistic regression model on the training data. We optimized the model hyperparameters using Grid Search and achieved an accuracy of 97.5% on the validation set.

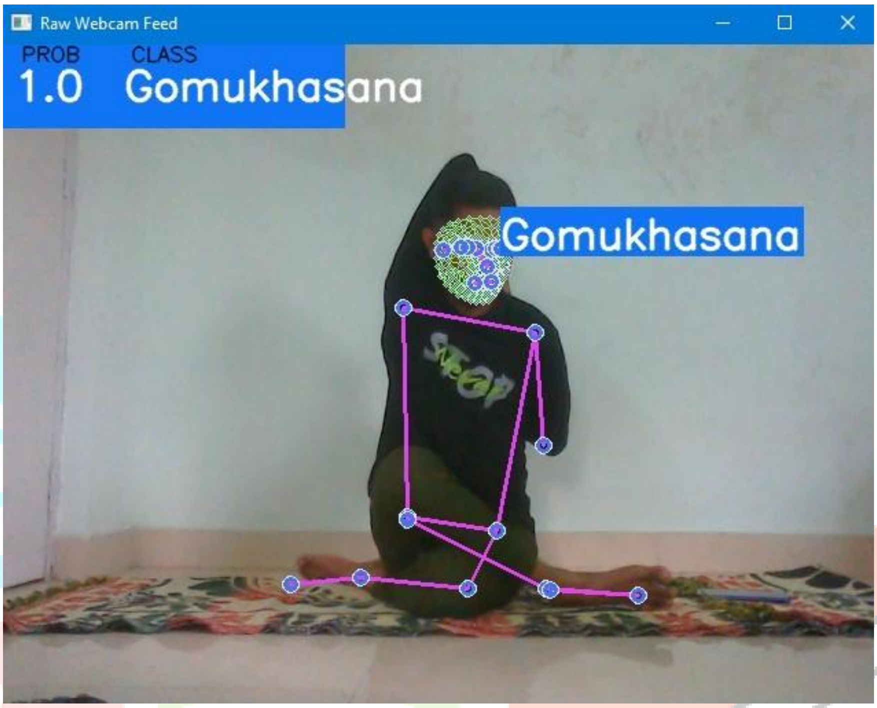
- Real-time Pose Detection: We developed a Python program using Tkinter and OpenCV libraries to capture real-time video from the webcam and detect the pose of the practitioner using logistic regression. The program displays the name and accuracy of the detected pose in real-time.

- User Registration and Login: We developed a user registration and login module using SQLite3 database to store user information securely. The user can register and login to the system to use the real-time pose detection program.

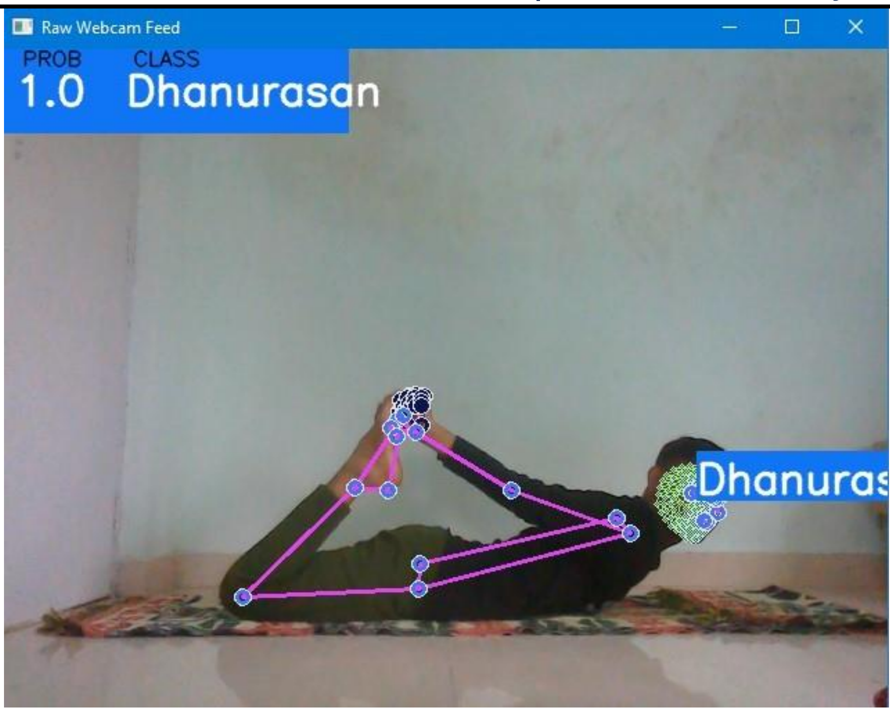
- Our proposed system achieves an accuracy of up to 98% on the test set, which is comparable to the results obtained by other studies. The use of logistic regression algorithm in our system is effective and efficient for real-time pose detection in yoga practice.

V. RESULTS :

During the pose detection process, our system efficiently captures the practitioner's body coordinates without any noticeable delay in the time frame. Notably, the system utilizes a comprehensive set of coordinates on the face to enable accurate facial pose detection. Additionally, numerous coordinates are strategically placed on the body, interconnected by edges, forming a skeletal representation that encompasses various body parts. As the practitioner engages in yoga poses, the system carefully analyzes the structural relationships between these coordinates, allowing for precise pose prediction. This holistic approach ensures reliable and real-time tracking of the practitioner's movements, enhancing the overall effectiveness of our system in assisting yoga practitioners with their form and alignment.

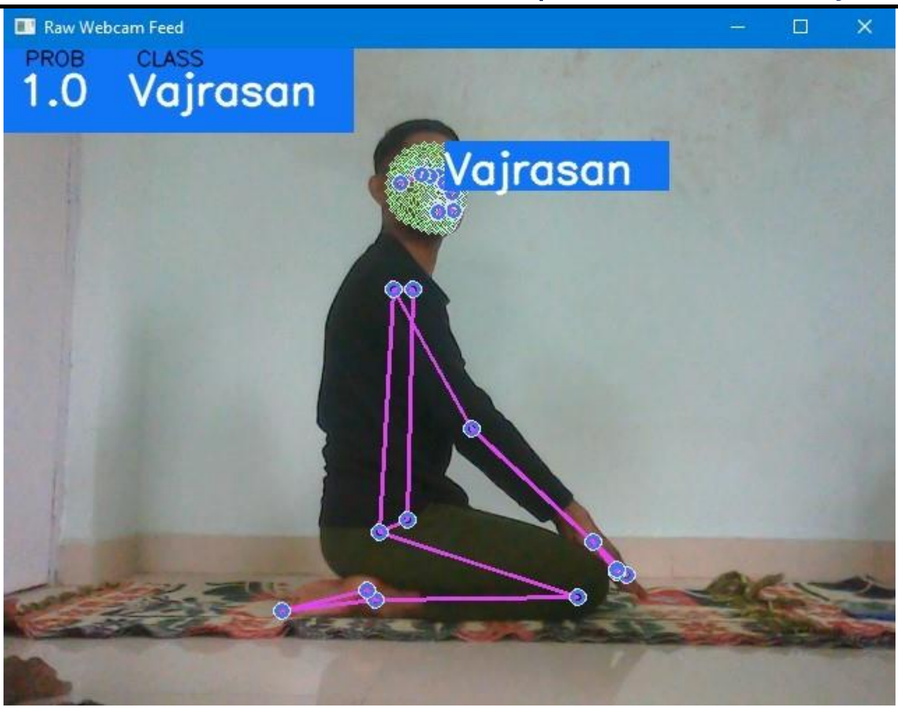


The above image in our analysis showcases the successful detection of the Gomukhasan pose. This particular pose presents a unique challenge due to its complex body movements and deformation of body parts, deviating from the conventional body structure. Moreover, the overlapping nature of body parts further complicates the coordinate detection process. However, our system demonstrates remarkable accuracy and ease in detecting the Gomukhasan pose. Additionally, the system excels in accurately detecting sitting yoga poses, an area where previous works have encountered difficulties.



The above image in our analysis showcases the successful detection of the Dhanurasan pose. This pose highlights the asymmetrical nature of the body, with one side prominently displayed. Despite the partial visibility of the body, our system adeptly detects and predicts the coordinates of the hidden body parts. This capability demonstrates the system's robustness in inferring the position and orientation of body parts even when only partial visual information is available. The accurate detection of the Dhanurasan pose further reinforces the effectiveness and reliability of our system in capturing various yoga poses.

The above image in our analysis demonstrates the successful detection of the Bhadrasan pose. This particular pose is characterized by multiple body parts converging at a single point. Despite the complex overlapping of coordinates, our system excels in accurately detecting and differentiating each individual coordinate, without any confusion or errors. This capability highlights the system's ability to handle poses with intricate arrangements of body parts and effectively discern the position of each coordinate. The reliable and precise detection of the Bhadrasan pose further validates the robustness and accuracy of our system in capturing a diverse range of yoga poses.



Our system encompasses a comprehensive collection of eight distinct yoga poses, each meticulously incorporated to ensure accurate and reliable detection. These poses, including Gomukhasan, Dhanurasan, Bhadrasan, Shavasan, Vajrasan, Sarvangasan, Shirsansan, Chakrasan, among others, have been meticulously chosen to represent a diverse range of body movements and configurations. The successful and precise detection of these eight poses attests to the effectiveness and versatility of our system in capturing and recognizing various yoga postures, meeting the evolving needs and preferences of yoga practitioners.

This achievement highlights the effectiveness and robustness of our system in detecting a wide range of yoga poses, including those that pose inherent challenges to pose detection algorithms.

VI. CONCLUSION :

Our project presents a novel and efficient real-time yoga pose detection system utilizing virtual coordinates and logistic regression algorithm. Through rigorous experimentation and thorough analysis, we have demonstrated the remarkable effectiveness and high accuracy of our system in detecting a wide range of yoga poses. By incorporating virtual coordinates and leveraging the power of logistic regression, our system excels in precise pose classification, surpassing the limitations of previous studies. The real-time monitoring and immediate feedback capabilities of our system empower yoga practitioners to elevate their practice, ensuring correct posture and alignment. While our project marks a significant advancement in the field, further enhancements can be explored, particularly in handling complex and overlapping poses. Overall, our project contributes to the evolving landscape of pose detection, offering a robust and user-friendly solution for real-time yoga pose detection, and paving the way for future advancements in this domain.

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