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Yoga Pose Estimation along with Human Posture Detection using Deep Learning Approach

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Abstract. The yoga is the ancient art for keeping the human body healthy and fit and acquiring mental peace. This position in yoga almost matches with human posture for comfortable physical activity. The different sequence of body joint action leads to a specific yoga asana that has its own benefit for health. If asana are done in improper way, it would create a bad impact not only in health but also in mental peace. The advancement in computer vision technology help the yoga practitioner identify if they are doing right asana by applying various machine learning and deep learning algorithms for pose estimation. This article has done the concise literature survey on different machine and deep learning algorithm available in computer vision technology. The survey portraits the different classification for human posture estimation and yoga pose estimation along with their contributions and specific difference in between them. Especially the CNN, RNN and LSTM algorithm evolution is briefly narrated in this concise survey for yoga pose estimation.

Keywords: Yoga pose, Machine learning, Deep Learning, Computer vision technology, Neural Network.

1. Introduction

In the field of computer vision, predicting and estimating the human pose is a challenging problem. This particular type of prediction analysis focuses on where the joints of the human body are located as they are shown in videos or images. Automatic pose detection would be challenging because to variables including size, intensity, resolution, background noise, clothing, and a person's interaction with his environment. The human pose detection is useful in fitness centres for physical activity and body sculpting. Yoga is one of the well-liked activities that has gained popularity all over the world since it offers a variety of advantages, from mental tranquilly to physical fitness.

The one negative aspect of yoga exercise is that it may become just as detrimental when the incorrect posture is used. As a result, the yoga coach must pay closer attention to his yoga-practicing ward and correct any errors made by the practitioner. Because it is not always possible for all yoga practitioners to receive individualize attention from a yoga instructor, a computer vision technology can be used to determine the correct yoga posture and provide intelligent feedback to the practitioners in order to encourage appropriate yoga postureDeep learning is being utilised to recognise human posture as a result of advances in artificial intelligence technology. The deep learning method is a straightforward way to estimate the postural structure without relying on any other extra structures and with the help of a real

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person. With the aid of deep learning analysis, it is feasible to match human posture to a yoga position[1]. In this paper we have investigated the different methods for yoga pose classifications and pays attention on how deeplearning approaches are used to Identify Yoga Pose Estimation, Evaluation and Training in real time scenario.

2. The brief history of yoga art

Human being's muscles are vulnerable to musculoskeletal failure when they are becoming old due to aging or when they meet some accident [2]. In fact physical exercise helps human beings to keep them fit and nowadays physical exercise has become indispensable as nature of human work is automated because of computerized modern world. The yoga is kind of physical exercise that keeps human beings healthier in terms of mentally and physically. The number of medical expertise emphasized that yoga can cure many kind of illness without medication and it would pave a way for mental peacefulness [3]. The art of yoga includes many Asanas that depict different yoga posture. Many of the yoga posture are complex in physical structure when parts of body overlap each other yoga is practiced. This complicated yoga posture would pose challenges when posture prediction approach is applied. The posture estimation technique helps the yoga practitioner if they are doing yoga exercise in the way Asanas is suggested.

3. Human pose estimation

The posture of human being has been recognized in an advanced way in recent years. This human pose estimation has evolved from two dimensional to three dimensional pose estimation done on single person and also on group of persons. The machine learning approach has been utilized to identify the person who behaves illegal in shopping and high resolution RGB camera are used to snap the three dimensional human pose on group of people. Human pose estimation could be determined in two different ways, namely generative methods using geometric calculation and discriminative approach using image processing problems[4]. The other two more methods are called top down where algorithm involves generalization operation from top to bottom and bottom up approach where algorithm involves calculating pixels values from bottom to top[5].The human pose estimation is also mingled with yoga position which offers a valuable input for interactive analysis and movement recognition. Radiofrequency-based positioning combined computer vision-based human pose estimation provides a resolution that gives better optimized results. The researcher uses frequency position estimations errors to spot the perfect pose estimation. This approach uses RTLS promising continual checking of trailed subjects uniqueness and location. The RTLS is much better than RGBD devices. The authors used the sensor devises in recent advancement that enable the computing devices use opt methods to estimate human posture [6].

A hierarchical forecast framework is employed using part –based structural and geometric priors. The kinematic structure of human body is analyzed through keypoints of the yoga movements for particular posture through end-to-end training to predict the feature from geometric priors with the help of Coarsest Resolution for Kinematic posture record.Repose network stacking concept is used to exercise various convolutional block for each kinematic steps .This result analysis carried out between Kinematically ordered and Sequential Updates on LSP and MII data sets[7].Authors suggested a novel design to speedily and precisely forecast 3D positions of yoga posture from body joints is determined from one single depth image without need of temporal information. Randomized decision trees and forests algorithm is used and it proved that the accuracy is higher than nearest neighboring matching. Pixels information in a depth image specifies standardized depth in each frame division rather than calculating intensity and color [8]. The system employs the Kinect camera that offers a 640x480 image at 30 frames / second with considerable depth resolution. Depth cameras are more advantageous in solving image related noise which in turn removes the ambiguity in pose in intermediate image representation.

Usually this generative approach is easier because it works on limited constraints based on training pose data set[9]. The Bayesian generative method is used to trace the 3D human pose on videos. This is probabilistic distribution method include generative approach to identify the human pose with the help of probabilistic distribution function over posture and joint angles. It is not fully successful as it failed to track the image object in certain time.This discriminative method is better to extract the feature

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relationship between the human posture and evidence image based on trained data set. Though discriminative approach works on higher dimensional data, it is faster than generative method as it functions on the constrained space. The discriminative method would also perform well when high level of jitter happens. Further this method is split into two categories; they are exemplar method and learning method.

3.1. Leaning based method – deep learning

The learning-based method is based on deep learning approach that is devised with the help of Artificial Neural Networks (ANNs). Deep learning method offers the architecture that helps to identify the feature automatically based on trained information from image set. The Convolutional Neural Network (CNN) and stacked auto-encoder algorithms (SAE) are popular methods to identify the correct yoga posture from images.A Deep Learning approach called Relative Position Matrix and Convolutional Neural Network (RPMCNN) is most widely used for Time series classification (TSC) Time series classification (TSC) task which represents the 2D model which is also known as Relative Position Matrix RPM.

A distance yoga learning system has been built for people either to learn or to get self-evaluation with internet. For particular yoga posture evaluation, the yoga practitioner has to finish the suggested posture within a stipulated time period. The template matching of the experimental image to the standard template is evaluated with help of mutual correlation coefficient statistical analysis. The right yoga posture is valued based on the scored calculated using template matching.[10]. The expert group introduced a compositional models relate array of patterns with level of hierarchies with relationship among the parts represented by the patterns. Managing the higher-level parts is a complex task in terms of learning and deciding the inference in Human Pose Estimation (HPE). Deeply Learned Compositional Model (DLCM) addresses this problem to determine accurate posture estimation. Deep neural Network subsequently offers a compositional architecture with level of hierarchy in both top-down and bottom up interpretation of human posture. This approach introduces a bone-based part representation that deals with alignments, scales and silhouettes of parts. It also removes posture ambiguity in a multi-state space [11].

A novel Fast Pose Distillation (FPD) model learning approach supports lightweight pose neural network architecture that outperforms with computational cost. MPII Human Pose and Leeds Sports Pose datasets are used for experimental setup of this FPD.The FPD model follows two major stages: First teacher pose model is trained by the conventional MSE loss and target student model is trained by knowledge extraction from the teacher model during the entire training process. FDP focusses on simple human posture classification on teacher network at the testing phase of the process model. The dataset used in this model is widely supported by YouTube stream with a lot of human movement activities. FDP works on 250000 images and 40000 annotated persons including 290000 for training purpose and the rest for testing purpose. Each human posture is labeled with 16 body joints. The LSP benchmark comprises of real time human posture images from several sports events. FPD assess its performance using the Percentage of Correct Keypoints (PCK) as a metric to estimate the accurate human posture[12].

3.2. Exemplar methods

An exemplar based pose estimation is done with the help of unique set of posture related with equivalent depiction usingrandom forest and random tree. By analysing a large dataset consisting of minimum 5500 images of few different yoga poses using tf-pose estimation that outlines a skeleton of a human body when the practitioner is doing yoga exercise [13]. If a yoga practitioner does not follow the right direction, it would lead to harvest dangerous outcome of yoga practice. This research study proposed by [14] considers the lower muscle actions while the yoga exercise is being done. Two legs' lower limb muscles are analysed using electromyography signals. To achieve the required result, the algorithms SMO, J48, and Random Forest are used. To predict the appropriate posture, the four fundamental phases of muscle selection, EMG signal acquisition, data processing, and recognition are used. In the data preparation process, the Simple Average Moving (SMA) calculation is made. In comparison to other algorithms, the Random Forest Decision Tree method provided the highest precision in differentiating yoga postures with an accuracy rate of 87.43%.

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The research study done on yoga posture provides a way to add in motion analysis application into an exergame engine to deliver expertise upgrading criticism to apprentices in a college yoga practice.The hypothesis considered in this this research is that the iterative motor training would improve body orientation in yoga postures among yoga practitioners [15].The Kinect skeleton capture technique is used to measure the pre-measurement and post-measurement using the software SDK 2.0.This data analysis could be beneficial to confirm data collected from real time YT trainings. The application developed is to help if the practitioner has past experience in yoga practice or not.

A smart yoga mat is devised to give feedback about the posture done by the yoga practitioner. A new Embedded based Smart Yoga Mat (ESYM) design is implemented. This smart mat is embedded with sensor chips to measure the pressure level caused by different posture and its implementation. Based on the various level of pressure, the pattern of yoga posture is classified using the Force Sensitive Resistor (FSR) sensor.In the ESYM the Pattern generation algorithm is installed on FPGA with help of LabVIEW to identify the pattern and by analyzing the pattern using the parameters like asana type, posture sequence and pressure level.The results are validated with few yoga practitioners for asanas like Bhujangasana, Marjariasana and Matsyasana. This approach helps the tutor to identify the accurate posture estimation to train the yoga practitioners to keep them healthy by doing right posture[16].

Yoga therapy helps to overcome musculoskeletal disorder. Physical exercises could ease this disorder to some extent. Yoga has become a good remedy of physical exercise. It is not always possible to have a trainer with yoga practitioner to comment the right posture. In this Microsoft Kinect approach, the yoga practitioner is kept monitored and given feedback about the accurate posture while analyzing the movements of body joint parts. The joint point is measured with help of by calculating right angle for each yoga posture. Microsoft Kinect yoga pose estimation method is implemented in real time to help the yoga practitioner. Here the system is established in UNITY 3D by employing Microsoft Kinect that could record the various yoga posture and calculate the coordinates corresponding to joint keypoints. The difference in coordinate point helps in identifying the accurate yoga posture.

3.3. Deep learning

Deep learning is now emerging field for image classification analysis. The deep learning algorithm takes input a set of images and produces the prediction as output based on feature. Deep learning algorithms employ the principles of neural network to identify the relationship between the training data and trained data. In the pose estimation problem, the pose of an individual is taken as input and the exact classification of pose estimation is done based on feature extraction method. Most of the algorithm is determined to make trade-off between the accuracy and size of the input.

*3.3.1. Multilayer perceptron (MLP).*The MLP is a conventional neural network which involves a single input layer and a single out layer. There are many intermediate layers that exist are known as hidden layer. Every node available in one layer is connected to every other node in another layer. Hence the MLP is fully connected network that has become a base for deep learning. The MLP is a supervised learning strategy where the input data is consigned with a label or some class types. The images with low resolution taken using Kinect sensor can also be classified with accurate with the help of MLP [17].

The recent research suggested by [18] uses the yoga posture recognition to prevent the falls of elderly people. As yoga is preferably suitable learning method elders can do the different posture on their own. This system developed helps the one who is not interested to do yoga in public places. Any yoga poses constitute two fundamental sitting and standing postures. This approach is an assisted self-learning yoga system that uses joint angle measurements. When yoga posture is being done, there are no stable joint angle values in every movement on different participants. A self-assisting system of yoga is designed using the parameters such as hip joint and knee angles which are to be identified in the range and grouped for different asaanas.

The SURF algorithm designed is to identify the correct yoga posture performed by the practitioner while comparing the moving actions with the stored asana video. The practitioner's image is captured using webcam.Numerous pattern recognition and grouping methods, Scale Invariant Feature Transform

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(SIFT) is a remarkable method developed for object recognition. As many features are incorporated in SIFT, it is also used in image recognition, image stitching, 3D modeling, posture recognition, video tracing, and etc. SURF is more robust than SIFT algorithm. SURF acts as not only descriptor but also image detector which can be used in 3D reconstruction. The SURF algorithms help the practitioner to do right yoga posture without the intervention of expertise for yoga practice.

*3.3.2. Recurrent neural networks (RNN).*The RNN can be used to form a special kind of neural network that works on sequence problem prediction. The output is generated based on the previous learned information as the RNN supports different kinds of many to one and vice versa and many to many relationships between sequential data. This RNN can be applied to sequential images where there is some relationship exists between activities performed in the image. Hence the RNN is used to predict the pose estimation in yoga application.

An collaborating system developed that aided with Kinect sensor to give alive command on yoga posture that is to be practiced by the yoga practitioner in the subsequent steps [19]. This interactive system powered by Kinect is beneficial for both practitioners and tutors. Adaboost algorithm is used to construct this mechanism based on positive results and envisioned frame detection. AdaBoost is a cooperative technique that builds up a concrete classifier from a number of delicate ones. For obtaining integrated prearrangement results, it is frequently employed. This calculation first considers the initial data and the accompanying weight to be premature learning. When using the preceding order criteria, it is expected that the unclassified data has a high weightage after each recurrence. The first stage in setting up the Kinect sensor was to allow the three separate streams—color, depth, and body—and to assert the limitations that were going to be used by the software.

Most of yoga practitioner learns yoga posture on their own by watching yoga related videos without the intervention of proper guide. They practise incorrectly because they are unaware of the proper stances. To evaluate yoga postures and offer advice to practitioners, a full-body posture estimate modelling is used. Yoga postures are divided into distinct groups using the back propagation artificial neural network (BP-ANN) created by [20], and fuzzy C-means (FCM) is utilised as the secondary classifier to classify the yoga postures in a category-wise manner. A Bayesian network is formed upon each body joint the posture data by regarding a multidimensional Gaussian variable. This Gaussian variable is applied to the conditional probability with respect to each body joint.The angular deviation between non-standard posture and the accurate standard posture is identified and a perfect feedback is given to the practitioner based on the difference observed in the calculation. The probability ratio for non-standard body joint is taken for guidance to suggest the yoga practitioners.

*3.3.3. Long short- term memory (LSTM).*The trivial variant of the RNN is the LSTM which is capable of preserving long term sequential data to overcome the dependency problem in RNN. The LSTM is the special kind of RNN which would preserve the information for quite long time. The principle behind this long-term preservation is cell state. The regulatory structures called as gates used in LSTM to regulate the cell state. The gates are further split into current input state and update state and forget state. The LSTM switches between states selectively based on the required feature extraction, it switches from remember and forget by keep learning the sequential input data. The LSTM can withstand for longer time by holding the state so it can be useful for long term sequential data analysis. Further the LSTNM can be coupled with CNN for recognizing the various postures estimation with high accuracy.

Without the need of a full body model, proposed a novel method for accurately estimating 3D human posture using data from inertial measurement unit (IMU) and multi-viewpoint video (MVV) sensors [21]. In this approach, a multi-channel 3D convolutional neural network is used to obtain an approximate 2D pose from the MVV and a pose set from visual occupancy. A final totally linked layer is created by combining the temporal model (LSTM) and the well-trained pose video stream. The two opposing data sources enable ambiguity within each sensor modality, improving accuracy in comparison to the other earlier techniques. A comprehensive evaluation is completed on the widely used Human 3.6M TotalCapture dataset. The new hybrid MVV dataset known as TotalCapture was created by the author.

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Proposed a novel approach to precisely estimate 3D human posture as combined approach by multi-viewpoint video (MVV) and inertial measurement unit (IMU) sensor data without an intervention of a complete body model. In this mechanism a multi-channel 3D convolutional neural network is employed to acquire a pose set in from visual occupancy and semantic 2D pose approximations from the MVV. The well trained pose video stream and the temporal model (LSTM) are merged in a ultimate entirely connected layer. The two opposite data sources permit for vagueness to be solved within each sensor modal that upgraded accuracy comparing the other prior methods. Far-reaching assessment is accomplished on the prevalent Human 3.6M TotalCapture dataset The author developed the new hybrid MVV dataset denoted as TotalCapture encompassing of multi-viewpoint video.

*3.3.4. Convolutional neural network.*The CNN is a special kind of neural networks that is prevalently used in computer vision technique. The feature extraction from image data using CNN gives very good result and it was proved in most of the research. The CNN has at least one convolutional layer that accounts for feature extraction from image data. The figure shown in figure represents the architecture of CNN. The CNN has the convolutional filter that performs the data pre-processing operation on input data and its filtered data is analysed before they are sent to subsequent layer. This convolutional filter produces the feature map while pre-processing on input data is performed. The other important layer known as pooling layer that reduces the dimensionality on input data. As result of that, the training time is drastically reduced. The max pooling method is widely used in most of the cases where the maximum value is taken from pooling window. The pose classification can be easily done with the help of CNN as it offers promising results. In the yoga pose prediction joint point location is considered from the skeleton image so that training on data can be done directly. The open pose key points are used in [18] and it offered very good result with accuracy of 78 %. Hence open pose key point is more preferable to predict the yoga pose classification.As far as keyoints is considered, the feature extraction done by CNN from 2D coordinates after map reducing takes place. With respect to filter size, the amount input data slided by the filter varies for subsequent input data. To make up with linear operation of convolution filter, Rectified linear Unit (ReLU) is applied as real world data is non linear in nature.

*3.3.5. Deep convolutional neural networks.*Authors develoed a pose estimation technique is call as auto_fit is a utility software that gives feedback activities performed in yoga practice and it is used to track the posture with the help of 17 body posture key points using the DNN classifier. In this application, yoga practitioner collected the videos of yoga posture and uses them for training train Auto_fit. Auto_fit works on live video as well to count the repetitions of exercise done [22]. This technique helps to identify the seventeen key points posture in a video stream and then classify the pose estimation using a deep neural network which perform the comparison operation with respect the stored posture in the live stream. The DNN is helpful to identify the accurate posture in the exercise and yoga position.This technique is deep convolutional neural networks (CNNs) to calculate pose coordinates.Here the DNN classifier with 4 layers that predicts if the specified set of coordinates fit in to state 0 or 1 and produces 0 or 1 as output. Then the produced output is then changed to the corresponding state of the workout and exhibited onto the screen. The Binary-Cross Entropy is employed as a loss function and RMSprop is functined as an optimizer. Each layer of DNN classifier has own neuron strength.

A joint angular displacement map(JADM) method suggested by researchers that integrates joint movements along with the distance associated with joint in a spatio-temporal color determination approach [23]. In this method with reduced training time deep convolutional neural networks (CNNs is used to obtain invariance three dimensional human motion data. Authors used multimodal approach for posture controls and recognition A multi modal approach is described to help a person to accomplish a series of postures on their own without intervention of an yoga tutor. This could be achieved by applying a posture detection system.Data is gathered from the 3-D depth map of yoga practitioner by capturing the shape and position of the practitioner [24].

An IoT-based security-preserving yoga poses detection system using a deep convolutional neural network (DCNN) with wireless sensor network (WSN) aided by infrared sensor is very much helpful to

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address the privacy preserving issues. The WSN with 3 nodes of x, y, and z-axes are present where each node assimilates 8×8 pixels' thermal sensor module and a single Wi-Fi module for bridging the deep learning server. The experiment is done on 18 subjects with specified 26 yoga postures and session data are recorded in .csv files and converted into grayscale image. Approximately 93200 posture images are used for the performance validation of DCNN models. The cross validation results shows that F1-scores of DCNN the models accomplished with three axes and separate y-axis posture images are 0.9989 and 0.9854, accordingly [25].

The human posture estimation can be performed by ensemble convolutional neural networks (CNNs) at environments. Specially to save the elder from falls, falls detection or human posture estimation mechanism is required. Here posture estimation is done by identifying coordinates points with respect to key points of joints and depth data by analyzing the video stream [26]. The conventional method CNN is only useful for image recognition but the alternate method deep learning approach is used to recognize the posture from image itself. In this ensemble deep models, DenseNet, InceptionResNe, VGGNet, Xceptionand ResNet, types of preprocess task is done on CNN and average method is devised known as ensembele deep model.The experimental work is done with the help of dataset for human posture offered by the Electronics and Telecommunications Research Institute (ETRI),Korea. This database houses about 51,000 images for ten specific postures usually happened at home.

4. Conclusion

Pose detection is an active area of research in the field of computer vision. Performing exercses in an improper manner may lead to injuries, so a Self Instructing Model is required in the field of yoga to accurately inform the user if the exercise is performed in a correct manner. In this article, we tried study the various works carried out by the researchers for human pose detection especially in the filed of yoga.

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