
Discussion

7.0 DISCUSSION

The present study included pose estimation and pose correction of five different yoga postures. It has utilized four different deep learning architectures i.e., Epipolar pose, Openpose, PoseNet and Mediapipe which are suitable for pose estimation and pose correction to evaluate Yoga postures and the results support the fact that the media pipe has better accuracy compared to the other methods in spite of using a single camera. As illustrated in an earlier work in which the authors have used a self-supervised Epipolar pose, pose estimation model which does not need 3D ground-truth data or camera parameters (Kocabas et al., 2019). During training, a 3D pose is obtained by using the geometry of a 2D pose estimated from multi-view images and used to train a 3D pose estimator. Also, the authors (He et al., 2020) have proposed a differentiable epipolar transformation model where 2D is detected to leverage 3D-aware features to improve 2D pose estimation (Haque et al., 2019). have used CNN to estimate the human pose present in a 2D image with an accuracy of 82.68 and (Mehta et al., 2019) have reported on techniques using CNN to estimate 2D and 3D pose features by using an architecture called Selec SLS Net and then predicted a skeletal model fit. The authors (Jose & Shailesh, 2021) have used 3D CNN architecture, a modified version of C3D architecture was used for pose estimation which gave an accuracy of 91.5%. (Yadav et al., 2019). In another work 99.04% efficiency was reported for using CNN for feature extraction and LSTM for temporal prediction.

It is very important to practice Yoga postures systematically and precisely with utmost accuracy to derive their defined benefits. Similar to exercises, Asanas when practiced wrongly can lead to injuries and produce adverse effects. Yoga practices involve body movements progressing from very simple stretches to more complex ones as well as breathing and meditation practices. These are generally safe when done under the guidance of a certified teacher yoga instructor regularly by healthy persons. In persons with any health problems, it is very important to do

Yoga under the guidance of certified therapists. About one in five yoga practitioners reported to have been injured or suffer from adverse events due to their yoga practice with unsupervised training and chronic medical conditions being the most important risk factors (Cramer et al., 2019); (Cramer et al., 2018). However, injuries were less frequent than with other forms of physical activity. When the recommended basic principles of Yoga practices are ignored even by healthy persons, it may result in some effects that are often termed as Yoga injuries. *Hatha Yoga Pradipika*, an important classical Yoga text, mentions clearly that the risk of Yoga injuries which can be strongly reduced or minimized (although not completely extinguished) when it adheres to the basic principles of Yoga (Mukthibodhananda, 2001). Due to such nonadherence to basic tenets of Yoga or while performing Yoga as rigorous physical exercise, injuries are being reported frequently (Choi & Lee, 2009); (Matsushita & Oka, 2015).

Hence, it is essential to have a monitoring system which can assist a practitioner and help in progressing from basic to advanced levels. As mentioned earlier, Yogasana being a form of physical exercise demands performing it accurately (Anilkumar et al., 2021). The authors have reported on a yoga monitoring system which is implemented to estimate and analyse the yoga posture where the user is notified of the error in the posture through a display screen or a wireless speaker. The inaccurate body pose of the user can be pointed out in real-time so that the user can rectify the mistakes. In this work the nose is assumed to be the origin so that all calculations are done with respect to the location of the nose in the image. An imaginary horizontal line passes through the nose's coordinates. This is the x-axis all the angles and are calculated with respect to this horizontal line. However, in our work we have divided the image into quadrants and compared the key points (Kumar & Sinha, 2020). We have uploaded a photo of the user performing the pose and compared with the pose of the expert and difference in angles of various body joints were calculated. Based on this difference of angles feedback is provided to the user to improve the pose. Chen and colleagues have developed a yoga posture recognition system using Microsoft kinetics to detect joints of the human body and to extract

the skeleton and then calculated various angles to estimate the poses confirming accuracy of 96% (C. H. Chen et al., 2019). Whereas, a recent study reported a technique for android application discussing the methodology used for yoga pose estimation (Chiddarwar et al., 2020). However, the present study demonstrated that media pipe has better accuracy compared to the other methods despite using a single camera.

The major advantages of the tools and technology used in the present study include the use of open source software and use of single camera for image acquisition. This process would help us to move from a computer-based technology to mobile based technology in future supported by a mobile application. This would minimize the use of technology and additional cost involved in procuring instruments for pose estimation and correction.

However, technology can't replace a teacher to teach and assess Yoga postures. While artificial intelligence can enhance the performance of a machine learning process, Yoga trains individuals to uplift their conscious intelligence. According to the renowned Yoga master BKS Iyengar, the basic principles of Yoga including Yamas and Niyamas should be practiced not only as independent methods but also while performing Asanas. Though, technology driven pose estimation and appropriate corrective measures can help the practitioner to understand the way he or she would progress correcting the possible mistakes. However, an individual based on the feel and experience while performing an *asāna* would facilitate him/her to judge how far they can stretch themselves in the final position.

Hence, the contributions of the present study can be considered as complimentary to existing methodology of learning Yoga, which primarily follows a guru shishya parampara. As Swami Vivekananda has proclaimed, "combine the best of the east with the best of the west", the present study is a sincere effort in bringing technology to understand and guide the practitioners of Yoga while performing Asanas to progress systematically.