A Proposal of Yoga Pose Assessment Method Using Pose Detection for Self-Learning

Maybel Chan Thar[1], Khine Zar Ne Winn[1], Nobuo Funabiki[2]
[1]University of Information Technology, Yangon, Myanmar
[2]Okayama University, Okayama, Japan
maybelchanthar@uit.edu.mm, khinezarnewinn@uit.edu.mm, funabiki@okayama-u.ac.jp

Abstract

Nowadays, Yoga is popular around the world. A lot of people are participating in it by themselves through watching TV/videos or teaching each other. However, it is not easy for novice people to find the incorrect parts of their Yoga poses by themselves. In this paper, we propose a Yoga pose assessment method using pose detection to help the self-learning of Yoga. The system first detects a Yoga pose using multi parts detection only with PC camera. Then, it calculates the difference of the specified body angles between the pose of an instructor and that of a user. Then, it calculates the difference of the specified body angles between the pose of an instructor and that of a user, and suggests the correction if larger than the given threshold. The total angle difference values are calculated averagely and defined as performance class level in Table 1. For evaluations, we applied the proposal to three persons with three Yoga poses of basic and easy Yoga poses for beginners and confirmed that it found the incorrect parts of each pose.

Key Words - Yoga, OpenPose, Pose Assessment, Body Angle, Self-learning, Evaluation

1. Introduction

Yoga is a safe and effective exercise to increase physical activity, especially, in strength, flexibility, and balance, to boost physical and mental well-being. Yoga is a kind of workout for the total mind-body that makes strengthening with deep breathing, meditation, or relaxation. Actually, Yoga is beneficial for people who are suffering from high blood pressures, heart problems, pains, or full of stresses. Regular yoga practices can reduce causes of their suffering. As a result, it has become growing massively and increasingly over the past few years around the world. However, in current situations, it is difficult to join Yoga ese guidelines include complete descriptions of the fonts, spacing, and related information for producing your proceedings manuscripts classes for a lot of people. For example, in Myanmar, a lot of people, particularly seniors, cannot go out by themselves to participate in Yoga classes due to inconvenient public transportation systems for the old people, although Myanmar is home to ancient spiritual practices including Yoga and have many Yoga schools. Seniors often cannot drive cars. To take a taxi at each class is not feasible, too. Therefore, it is important for them to practice Yoga at homes by themselves. However, it is not easy for novice Yoga people, particularly seniors, to find the incorrect parts of their Yoga poses by themselves.

The proposed method is for Yoga Pose Assessment using pose detection for self-learners. The method first detects a pose using OpenPose and a PC camera. Then, it calculates the difference of the specified body angles between the pose of an instructor and that of a user. If it is larger than the given threshold, the method suggests the correction of the part. With this proposal, it is expected that people can practice Yoga anywhere including home. Thus, everyone can practice Yoga, no matter age or health.

For evaluations, we applied the proposal to four different conditions such as different body sizes, different height, different ages, and different camera distance, with three Yoga poses, and found the incorrect parts each pose, which is expected to be corrected by referring to the output.

The paper is organized as followed for the rest of the sections: Section 2 shows some related works in literature. Section 3 reviews OpenPose. Section 4 presents the Yoga pose assessment method. Section 5 evaluates the proposal through applications. Finally, Section 6 concludes the chapter with some future works.

2. Related Works

In this section, we show some related works in literature. There are a lot of existing performance assessment systems that are using the simulator, sensors or other sensing equipment and devices to understand human body movements how much similar to the instructors' movement. It may cost and it cannot be said easy usage for the whole performance. It is not sure that all types of self-learners can be used in the system.

In [1], Chen et al. proposed Yoga training system using Y-system, to analyze the postures of a practitioner, which includes dominant axes, skeleton-based feature points, and contour based feature points. The system uses the postural feature extraction, and improves the methods of feature point detection and assistant axis generation. It generates body skeletons for yoga poses using Microsoft Kinect and OpenNI library for performance comparison, where a RGB camera and a depth sensor to access the depth information of a human body are used to estimate/track the articulate pose. Unfortunately, there are several errors in visualized instructions caused by incorrect segmentations of the body map.

In [2], Chen et al. reported the development and evaluation of yoga exercise as a programme for older adults, called the Silver Yoga Programme. First, they sent surveys to professional experts of the program on safety, clarity and feasibility of the protocol. Second, they inquired older adults on views on the program by using a descriptive design with quantitative and semi-structured evaluation. In data analysis, the statistical package for the social sciences was used. However, there were limitations related to design, sampling and generalizability of results.

In [3], Downs et al. mentioned the video modeling and feedback. They delivered instructions or self-monitored feedbacks to students to improve behavioral changes. The purpose of this study was to assess video self-evaluations. The correct percentage was calculated by dividing the number of correct steps by the total number of steps in the task analysis.

In [4], Eichner proposed articulated Human Pose Estimation (HPE) for recovering the spatial configuration of body parts of a person from images. The 2D body layout in a monocular is recovered without any prior knowledge of the person or the background appearance. It can improve the pose estimation accuracy over estimating each person independently. It can also learn prototype poses characterizing a pose class directly from an image search engine queried by the class name.

3. Review of OpenPose

In this section, we review OpenPose.

3.1. Overview

OpenPose is used for Human Pose estimation that will localize anatomical key points or parts largely focusing on finding body parts of the person [5]. It uses part affinity fields and multi convolutional neural network (CNN) architecture to extract human parts and their associations with high performance. It is built for the purpose of creating jointly learning parts detection and parts association. The part affinity score guides the connection.

3.2. Convolutional Neural Network

In neural networks, CNN is one of the main categories to do image recognition, image classifications, object detections, recognize faces, and part detections. It is the most common backbone network for image feature extraction [8]. It is also used for pose estimation. CNN image classifications take an input image; process it, depending on the output requirements and classify it under certain constraints. The network architecture iteratively predicts affinity fields that encode part-to-part association and detection confidence maps. The iterative prediction architecture refines the predictions over successive stages.

3.3. Pose Estimation

In computer vision, body pose detection and estimation is an understanding of moving joints and rigid parts using image based observation. It is very depended on the observation with poses and a variety of situations that can challenge the complexity of the models. In pose estimation, the feature is extracted from a measured data and these derived values (features) are processed to be informative and non-redundant; following subsequence learning and generalization steps [7].

It can lead to better human interpretations. It is also related to dimensionality reduction. It is optimized for effective model construction that is the combination of the variables to describe the data with sufficient accuracy.

3.4. Part Affinity Field

Part affinity field is one of artificial learning-based methods [6]. It is applied in neural network architecture in order to detect multi parts and associate for the complete body. It associates parts with confidence maps of the body parts and the vector field of part affinity. It is used in multi-stage architecture in order to refine and enforce consistency. It is a set of vector fields of limbs that encode the location, orientation of a particular limb of each position in the image domain [9]. It is defined by subtracting a body part's location from another body part's location (assuming both joints belong to a limb).

4. Proposal of Yoga Pose Assessment Method

In this section, we present the Yoga pose assessment method.

4.1. Motivation

Self-Learning Assistant System needs to support the self-learners in receiving feedbacks for correct experiences and exercises. It is very important that learning from the self-learning system should give the same feeling and experience to that of learning from the professional instructors. Moreover, it should make the self-learners more understandable and flexible. It should also attract self-learners in order to continue using the system.

The feedback function should give instructions to the self-learner, by recording the performance and estimating how much the learner can follow the instructions from the instructor and which parts are incorrect through similarity measurements.

This will help the learners to know their weak parts and be able to retry the wrong parts. That is the best way to let the self-learners understand and get the advantages of doing the correct one.

4.2. Idea

The similarity measurement is a significant task in comparing two different persons' performance and activities. It is very essential in the retrieval performance class of the pose assessment system. The proposal mainly depends on similarity measurement between the angles of specified body parts of the learner and of the instructor. Figure 1 illustrates the system flow of the proposal.

4.3. Feature Extraction and Pose Detection

While taking the self-learners performance via webcam, the system starts to extract the features. OpenPose mainly focused on accuracy and is able to detect real time pose detection and estimation. Therefore, OpenPose is applied for feature extractions and pose detection. It simultaneously predicts a set of confidence maps of the body part locations. The simultaneous detection and association of them are applied in multi CNN architecture. For any input image, it can take almost same time to detect whole body key point values.

The coordinated points are produced from the detected parts of the whole body. The whole body's joints are defined as 24 joints shown in Figure 2. There are pairs of coordinated points for each joint, saved as the values in the array. All these pairs of coordinated points for 24 joints are used to calculate the similarity.

The coordinate points produced can be used to apply in calculate similarity. From a practical point of view, different sizes of people must have different coordinated point values. Yoga pose assessment system does not mean that finding the similarity and difference of the sizes of self-learners and instructor but it actually means that finding and calculating the similarity of how much the self-learner can follow up the correct instruction, regardless of the body sizes such as fat or thin, short or tall, and child, adult or old senior.

Therefore, instead of using coordinated points, angles between two joints are essential requirements to calculate the correct joint movement of doing Yoga Pose.

4.4 Body Part Angle Calculation

The proposed system uses the angles on each joint of the whole body in order to calculate the position values of each Yoga pose. The angle of the two body parts at each joint is calculated by the following equation:

$$angle = |\, arc\tan m \,| \qquad (1)$$

where,

arc tan = trigonometry inverse tan function
| | = absolute function
m = slope

$$m = \frac{y2-y1}{x2-21} \qquad (2)$$

where,

x_1, y_1, x_2, y_2 = coordinate pairs of two points

The slope is defined by two coordinated pairs of a line. The proposed system uses the angle that is calculated on three mutual joints as shown in Figure 3.

$$angle = a1 - a2 \qquad (3)$$

where,

$$a1 = |arc\tan m1|\,,\ m1 = \frac{yf-y1}{xf-x1}$$
$$a2 = |arc\tan m2|\,,\ m2 = \frac{yf-y2}{xf-x2}$$

The angle value is calculated on each joint of the whole body and saved as an array of each self-learner.

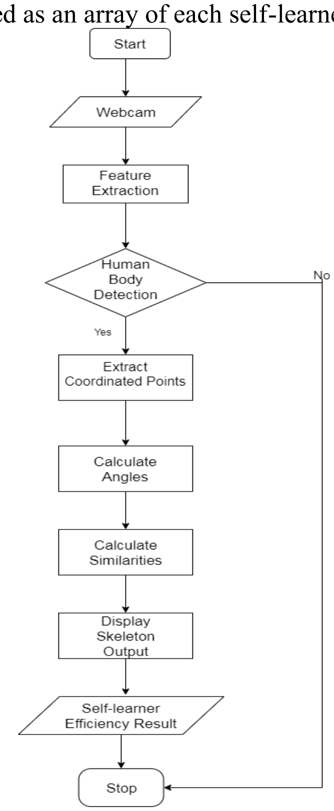

Figure 1. System flow Yoga poses assessment system

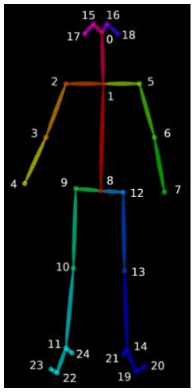

Figure 2. 24 Joints of human skeleton

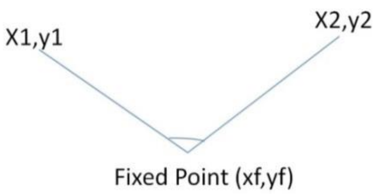

Figure 3. Calculating angle of mutual joints

4.5 Body Angle Difference

After the angle of each specified joint is calculated for both the images of the instructor and the learner, the difference of them is calculated by:

$$Difference = |instructor\ angle - learner\ angle| \quad (4)$$

These angle difference values are saved like an array according to the sequences of joints in order to show the self-learner how much it deviates from the correct one.

4.6 Assessment Result Output

To improve the understanding of a self-learner, a gradient colour display is a better way to show the result. The angle difference value is assigned to each joint with the corresponding colour value. The system maps the difference value to the colour value. Specifically, red is used to represent the large angle difference as the wrong result, and green is to represent the small difference as the correct result, as shown in Figure 4.

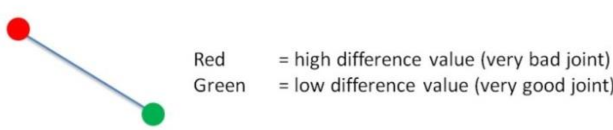

Figure 4. Example of drawing one segment linking two joints

Then, the gradient colour of this segment is determined by the following equation:

$$color\ value = \left[\frac{d1+d2}{2}\right] threshold \quad (5)$$

where,

d_1, d_2 = difference values of two consecutive joints

threshold = $\frac{255}{45}$

If the angle difference is zero, the colour is green. If the difference is over 45 degree, the colour turns red. Figure 5 shows the example for one segment, and Figure 6 shows the example for the whole body.

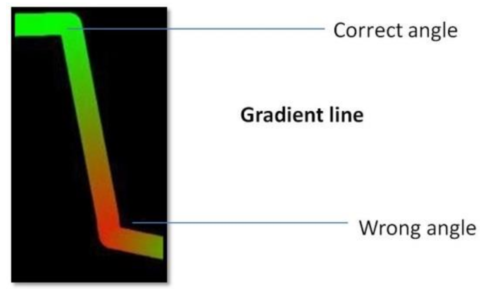

Figure 5. Example of drawing one segment with gradient color

This colour result is the most important section of the proposed system. The colour result will point out clearly which joint is how much incorrect and the self-learners could focus to be more correct.

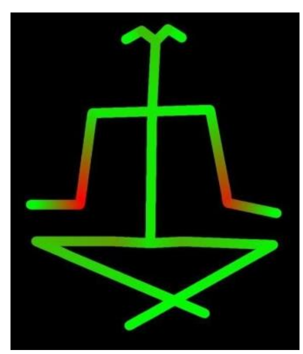

Figure 6. Example of drawing whole body skeleton with gradient color

4.7 Pose Classification

The proposed method classifies the Yoga pose into four levels so that the learner intuitively can understand the evaluation result. The four classes are “perfect”, “good”, “not good”, and “bad”. Each class is selected by comparing the average angle difference for all the joints.

$$result\ value = \frac{total\ angle\ difference}{total\ number\ of\ joints} \quad (6)$$

The result value is mapped with the range function of classifying the performance. The range is from 0 to 9 and there are at most 360 degrees. According to human's behaviour, they are interested in the overall performance result and they will try to improve the result's level. The pose classification is defined with the threshold given in Table I.

Table I. Performance results range

Class Level	Ranges
Perfect	0:9
Good	10:18
Fair	19:27
Not Good	28:36
Bad	37:360

5. Evaluations

In this section, we evaluate the proposal through applications to three learners using three Yoga poses. For learners in evaluations, different people in terms of the age, the gender, and the body shape should be considered. Thus, as the learners, we selected a 16-year old fat boy, an 8-year old slim girl, and a 23-year old normal lady for three evaluations. The proposed method can prove that it can point out exact different angle value on each joint by angle calculation, applying mathematical equations on extracted coordinated pairs produced by OpenPose.

5.1 First Evaluation

In the first evaluation, a 20-year old fat boy is selected as the learner of the system. First, he practiced the simple opening arms pose shown in Figure 7. Then, the proposed method classified the pose as "perfect". The angle is similar at any joint between him and the instructor.

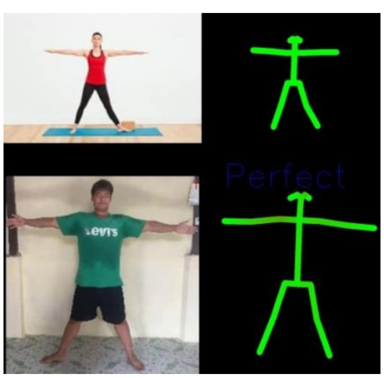

Figure 7. Opening arms pose of fat boy

Then, he practiced the more complex bending backward pose, shown in Figure 8. The method classified this pose as "bad", because the angles at several joints are much different between him and the instructor. He should practice the pose caring these incorrect parts.

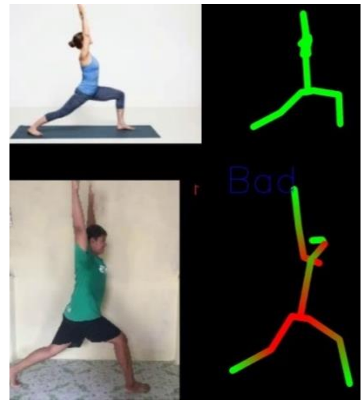

Figure 8. Bending backward pose of fat boy

5.2 Second Evaluation

In the second evaluation, an 8-year old slim girl is selected as the learner. She practiced the very complex one-leg standing pose shown in Figure 9. Then, the proposed method classified this pose as "perfect", where the angles at the both elbows and the left leg are slightly different from those of the instructor. She should practice the pose caring these incorrect parts.

Figure 9. One-leg standing pose of child

5.3 Third Evaluation

In the third evaluation, a 23-year old normal lady is selected as the learner. Again, she practiced the very complex one leg standing pose shown in Figure 10. The proposed method classified this pose as "not good", because the angles at the both elbows and the right knee are different from those of the instructor.

Then, she practiced the pose caring the incorrect parts. Figure 11 shows the pose after the practice, which was classified as “perfect”. Clearly, the new pose becomes similar to the pose of the instructor. Thus, the effectiveness of the proposed method is confirmed.

Figure 10. One-leg standing pose of adult girl

Figure 11. One-leg standing pose of adult girl after practice

6. Conclusion

This paper proposed Performance Evaluation System as Yoga Pose Training System to help the self-learning of Yoga. The system assesses a Yoga pose of a learner by: 1) detecting the pose or skeleton 2) calculating the difference of the body angles between the pose of an instructor and that of a user, 3) indicating the incorrect part between learner and instructor, and 4) classifying the pose into four levels with the average angle difference. The effectiveness of the system was confirmed through applications to three persons with different ages, genders, and body shapes using three Yoga poses. In future works, the system can approve that it will be applied in other physical exercises using other exercises poses evaluations.

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