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Development of Image Based Model for Basic Standing Yoga Poses that Control Type-2 Diabetes

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Abstract— Yoga is one of the ancient practices originated in India that helps in balancing mind and body of human. For the past few decades it has got wide spread throughout the world. Many are practicing it in the presence of yoga tutor or following some online modes. But improper practice may cause major harm to muscles and ligaments of the human body. There are different asanas proposed in the Patanjali Yoga Sutra that can cure different diseases. This paper, proposes a mathematical model for a set of yoga asanas that can help cure Type -2 Diabetes. A noninvasive analysis has been implemented using Kinect Sensor and LabVIEW software to analyze the performance of the practitioner. The joints are subjected to the flexibility of the practitioner without any overstress.

Keywords- Asanas, Diabetes, Kinect Sensor, LabVIEW, Practitioner

I. INTRODUCTION

Yoga is a posture based physical fitness, relieves stress and relaxes both mind and body. There are a wide variety of schools of yoga and many people practicing yoga for maintaining proper physical and mental health. Eight limbs of Yoga sutras have been described in the history. They are Yama, Niyama, Asana, Pranayama, Pratyahara, Dharana, Dhyana, Samadhi. Each of these eight limbs defines a different sense of practicing yoga. Of these eight limbs, asana is the one of the technique widely practiced by throughout the world. Asana defines performing a physical posture following a set of steps for development of health and steadiness of mind.

But performance without proper guidance under the yoga tutor may lead to several problems. At the same time, it may not always be possible for everyone to visit a yoga center or take the guidance under physical presence of yoga tutor. Hence, development of technological support to assist the yoga practitioner is one of the emerging research areas. Retrieval of the yoga asana being performed from the database that consists of set of asanas performed by the yoga master helps the practitioner to follow the instructions carefully and perform the asana.

Now a day’s type 2 diabetes has been a common disorder in most of the human beings throughout the world. This is caused by insulin resistance. As per the statistics from WHO this was the ninth leading cause of death and is also major cause for many other disorders like blindness, heart diseases, kidney failure etc. [1]. As per the information provided by International Diabetes Federation, in 2022 approximately 537 million people are affected with diabetes in the age group of 20-79 years and 240 million adults are undiagnosed [2]. Many researches have concluded that improper intake of diet and lack of physical exercise (physical inactiveness) are one of main reasons for the cause of diabetes.

In this paper, mathematical analysis for a set of yoga asanas that can cure Type-2 diabetes has been proposed. The set of 4 standing asanas namely Tadasan (Palm Tree Pose), TiryakTadasan (Bent Palm Tree Pose), Veerabhadrasan (Warrior Pose) and Trikonasan (Triangle Pose) [3] have been considered and analyzed. These asanascan be perfo rmed in a limited space without the use of any wearable devices, in a specific amount of time.

The rest of the paper is organized as Section II discusses the work that has been carried out in these lines. Section III gives the mathematical model developed for analyzing the asanas. In Section IV results have been produced and Section V is the conclusion.

II. LITERATURE SURVEY

Yoga has been one of the prevention techniques for many of the diseases. People affected with diabetes generally feel

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depression and anxiety at a higher rate compared to that of a normal person. They may opt for alternative medical treatment apart from conventional medical treatment for managing diabetes. Yoga is one such alternative therapy which is originated in India and is being practiced by many people throughout the world for their physical and mental fitness. There has been a good amount of research carried out by researchers in these directions. Valeria Calcaterra et.al.had conducted an online training program for exploration of physical activity and variation in glycaemia in type 1 diabetic effected children during lockdown [4]. Rashmi Shiju et.al.studied the effect of Surya KriyaYoga (SKY) on people with type 2 diabetes and have observed that practicing SKY has impact on reducing anxiety and depression in these people[5]. Authors in [6] have conducted a study to identify the effect of yoga on cardiac autonomic dysfunction and resistance due to insulin on non-diabetic offspring of diabetic patients. Their study had concluded that practicing yoga can reduce the risk of diabetes development in such patients. Nisha Shantakumari[7] and her team made a study to determine the effect of yoga on dyslipidemia management in diabetic patients. They divided the participants into two groups with one group following the oral drugs and the other practicing yoga along with these oral drugs. It has been concluded from their study that on practicing yoga along with the oral drugs for duration of three months, the practitioners have achieved improvement in their health. Authors in [8] have made experimentation on 48 participants by randomly selecting them to practice Iyengar yoga for two days a week or standard exercises for the same duration. They observed an improvement in self-care and quality of life in the participants who practiced yoga than that of the standard exercise with their experiment. Xiaohui, Tan et al presented an automatic human body feature extraction and size measurement by random forest regression analysis of geodesics distance. [9]. Nobutaka Shimada et.al, proposed hand posture estimation by combining 2D appearance matching and 3D model based fitting. They used PCA compression for shape modeling [10]. Marcin Eichner et.al, proposed a human pose co-estimation for joint pose estimation over multiple persons. System has been trained directly from web images without any additional stickmen annotations [11]. Simon Ouellet et. al, implemented automated body feature extraction method using 2D images with real time recognition [12].

S.N. Omkar and his team developed a mathematical model for the analysis of the Sun Salutations- a sequence of yoga postures. They calculated the forces and moments at various joints during the performance of the sun salutation postures. They implemented the model using rigid mechanics and free body diagram [13]. Arun Kumar, et.al, [14] have implemented a musculoskeletal modeling for the analysis of Trikonasanna. The authors have followed noninvasive methods using optical motion capture system.

M T Islam et.al proposed a novel method of predicting a person with diabetic with the help of their retinal photographs using CNN based models [15]. Authors in [16] have evaluated complications that can be caused on skin due to diabetes mellitus using photonics based technology along with machine learning algorithms. Xiaokang Liang et.al worked on fundus images through radiomics features for diabetic foot prediction [17]. Gudigar, A and his team developed a computer aided diagnostic tool using images of fetal ultrasound, pregestational diabetes mellitus and gestational diabetes mellitus of mothers [18]. Zarkogianni, K et. al had carried out an investigative study on the use of machine learning techniques for the development of models that can predict risk of cardiovascular diseases in Type 2 Diabetes Mellitus patients. Authors in [20] have made a study on thermal change index classification and using deep CNN methods implemented different data augmentation methods for detecting patients with diabetes mellitus from foot thermography. S El-Sappagh et.al implemented a semantically interpretable fuzzy rule based system framework using knowledge fuzzy inference, ontology reasoning and fuzzy analytical hierarchy process for diagnosis of diabetes [21]. Y Zhou et.al had developed a dataset with 1842 large fine grained annotated diabetic retinopathy images [22]. Authors in [23-25] proposed algorithms to overcome the considerations of missing and imbalanced data about diabetes. Authors in [26] developed a Multiview Convolutional Neural Network that can be used as feature classification for amnestic mild cognitive impairment with type2 diabetes. Ghosal.S et. al proposed a smart diabetic sensing model which segments blood vessels and gives the tortuosity measure [27].

Though there has been a good amount of research carried out in analyzing the benefits of yoga for treating type 2 diabetes, but the analysis is mostly qualitative. If the analysis could be made quantitative by conducting mathematical analysis of the posture and instruct the practitioner to follow the sequence of steps it would be more effective. As it may not be possible for all the people to visit a yoga tutor or an institute for practicing yoga, a system with proper instructions and feedback could be developed.

III. PROPOSED MODEL

The Yoga has been practiced to a larger extent by many people throughout the globe. But as it may not be possible for everyone to go with a trainer technology intervention has become a common platform where the practitioner can practice with the support of online videos. But improper practice leads to strain or hurt the muscles and ligaments. Hence a proper analysis along with feedback is very much essential. In these

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lines a mathematical model for a set of four standing asanas has been proposed here with.

Every asana has a sequence of steps to be followed. The four asanas selected here comes under the category of the standing yoga asanas. The first asana is Tadasana (Tree Pose) followed by TiryaTadasana (bending tree pose). Then Trikonasana (Triangular pose) and the fourth one to be practiced is Veerabhadra asana (The Warrior pose).

While performing the asana, it is very important for the practitioner to maintain the angular moments and the alignment of body parts in a perfect position. Improper alignment leads to strain of the body parts and hence an analysis of asana is required to be known before performing it. In this paper, the angles the heights and distances between different body parts for performing a specific asana without an error to the extent possible are said to analyzed and a feedback will be provided to the practitioner if their position of any part of the body for that specific asana is not perfectly aligned. This helps the practitioner to improve his performance over a period of time and get perfection in asana. The analysis of the asana is carried out by considering the relations between different parts of the body with respect to total height of the practitioner [28].

To exemplify the analysis of the postures considered a sample calculation for Trikonasana as shown is explained here.

While performing the Trikonansana, the following are the steps to be followed:

Step1: Stand straight and keep the feet apart such that a distance of 4 feet is maintained.

Step2: The angle at the waist must be 600

Step 3: Stretch the hands parallel to ground

Step 4: Inhale, Bend towards right and touch your right feet with right hand. i.e. the X-coordinate of hands should be same.

Step 5: Stay in this position for 10-15 Seconds

Step 6: Come back to the standing position and relax. Repeat the same to the left direction.

Initially the height (H) of the practitioner is said to be estimated.

The practitioner is instructed to stand straight and the coordinates at the center of foot (fx, fy) and head (hx, hy) are calculated. The distance between these two points gives the height of the practitioner as defined in (1).

$$H = \sqrt{(hx - fx)^2 + (hy - fy)^2} \quad (1)$$

In the first step, the practitioner is instructed to maintain 4 feet distance between his two feet. The distance here is said to be calculated using Euclidean distance where the coordinates are considered from centers of right and left foot as defined in (2).

$$D_f = \sqrt{(rx - lx)^2 + (ry - ly)^2} \quad (2)$$

where Df defines the distance between the feet, (rx, ry) – coordinates of center of right foot and (lx, ly) – coordinates of center of left foot.

The practitioner is instructed to maintain this distance. The foot length (FL) of the practitioner is estimated with the help of his height according to the relation given in (3)

$$F_L = 0.152H. \quad (3)$$

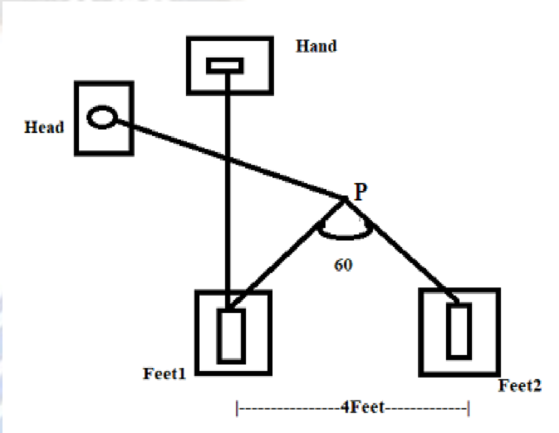

Fig.1. Trikonasana

Now the practitioner forms a triangle with his two legs as shown in the Fig. 1. The angular calculations are now said to be considered. The angle at the position P, as shown in the fig1 should be 60^0. If the angle is above or below 60^0, the practitioner would have bent his knee. Accordingly, he will be instructed to maintain his knee in a straight position such that the angle at the joint will be satisfied. This forms an equilateral triangle with the ground.

```
Algorithm 1:
if
{
    y1-y2 = +ve value
    Instruction: down your right hand
    else if
            {
            y1-y2 = -ve value
            Instruction: down your left
                    hand
            else if
                    {
                    y1 = y2 = 0
                    posture is correct
                    }
            }
}
```

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Then in step 3, the practitioner has to stretch both his hands straight, parallel to the ground. So that the Y- coordinates of two edges measured should be zero as it is parallel to X- axis. If there is any deviation, the practitioner will be instructed to lift up or down the respective hand. Algorithm 1 briefs this process.

Let Hr = (x1, y1), Hl = (x2, y2) be the left and right hand coordinates respectively.

Step 4, instructs the practitioner to bend towards his right, touching his right foot with right hand and left hand has to be stretched upwards. Now the axis will be inverted and hence the x-coordinates of the hands should be zero. Along with the direction and positions of hands in step 4, the alignment of waist is also to be taken in to consideration. For this the waist and head are to be aligned in a single direction.

Accordingly, the y coordinates at these points will be zero as the position is parallel to x-axis. This process is illustrated in Algorithm -2.

He = (hx, hy), w = (wx, wy) are the coordinates of head and waist respectively,

The algorithm is as follows:

```
Algorithm2:
if
{
    hy-wy = +ve value
    Instruction: Bend downwards
            else if
                {
                hx=wx=0
                posture is correct
                }
}
```

As it may not be possible for every practitioner to follow the exact calculation, a threshold of +/- 20 units is allowed. The analysis is carried out with reference to the images of the practitioners and hence the units are considered in terms of number of pixels. Fig. 2 explains the complete flow of the process is described in the flow chart. Fig. 3 shows the block diagram of the mathematical model developed for the Trikonasana.

IV. EXPERIMENTAL RESULTS

The proposed yoga asanas have been implemented using LabVIEW 2016 software and run on Intel(R) Core(TM) i5-8250U CPU @ 1.60GHz and 12GB RAM. A yoga studio has been created with sufficient amount of lighting and a green background is used in order to have perfect luminance of the captured images. For capturing the practitioner's performance, a Kinect sensor is used which is placed at approximately 10 feet from the practitioner's position. The depth camera of the Kinect sensor gives the image in black and white mode which is convenient for the analysis and accordingly the feedback will be provided for correction of the posture.

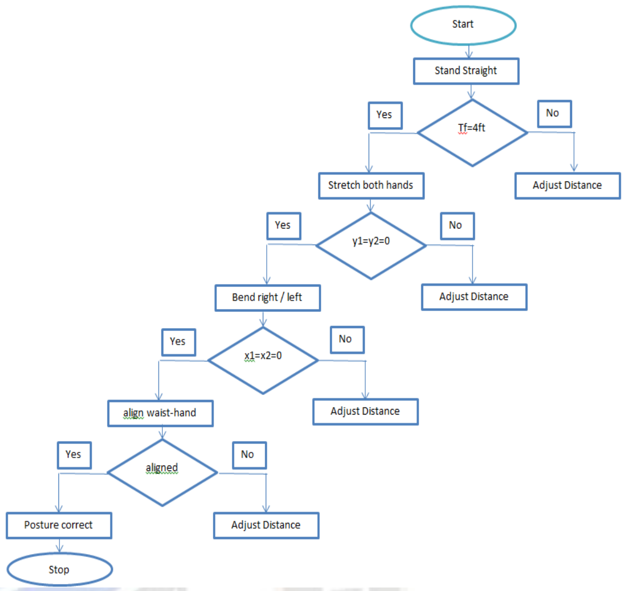

Fig.2. Flow chart for performing Trikonasana

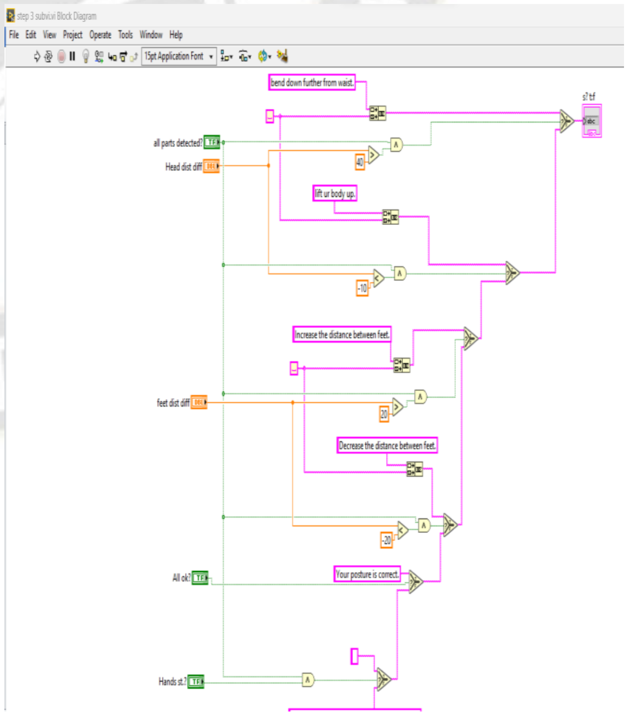

Fig.3. LabVIEW Block diagram for modelling the Trikonasana

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Initially these asanas are said to be performed to collect the training data and the same is saved as dataset.

For this, 10 persons who are practicing the yoga postures regularly are requested to perform these set of four asanas and their images were captured using the Kinect sensor. These captured images are segmented as hands, legs, waist and head using bounding box algorithm. These segmented images are saved separately to create the dataset in different folders as waist images, head images, hand images and leg images.

The practitioner will be instructed to perform the asanas in a sequence, step by step which will be shown on the display screen of the system.

Initially the practitioner is instructed to stand straight in order to calculate the total height. By detecting the position of head and feet, the distance between these two will be calculated for total height of the practitioner. As shown in Fig. 4, head and feet of the practitioner is detected using bounding box algorithm and are indicated in red color.

The LEDs indicate the proper detection of the same, if any of the two are not in perfect alignment, an instruction will be given to the practitioner to stand straight.

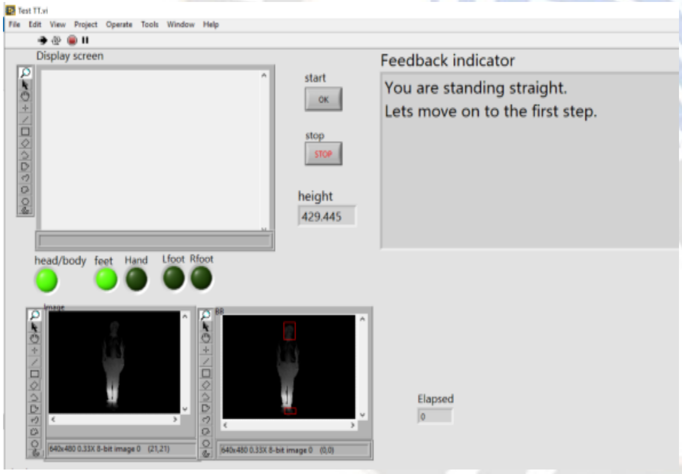

Fig.4. Detection of head and feet to calculate the height of the practitioner.

Now the practitioner will be instructed to perform the asana as indicated in the display screen of LabVIEW front panel as shown in Fig 5.

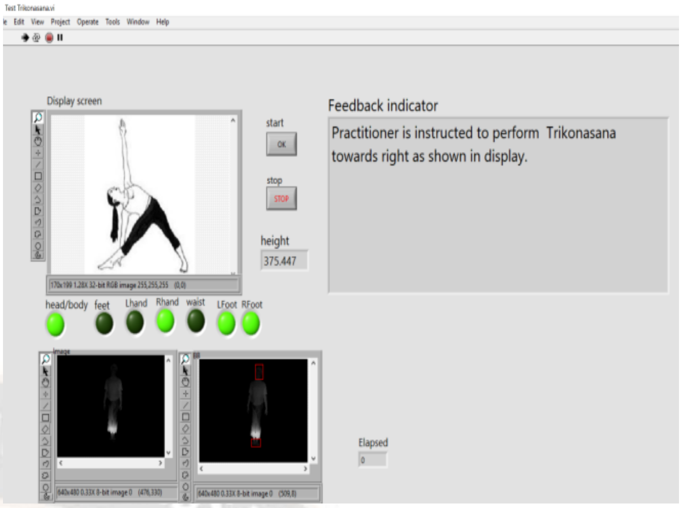

Fig.5. Instruction to perform Trikonasana

As per the mathematical model developed, the system calculates the distance between the feet, alignment of head, hands and waist. Accordingly, if the practitioner did not satisfy the conditions for performing the asana, he will be instructed to adjust the posture as shown in Fig 6 and Fig 7.

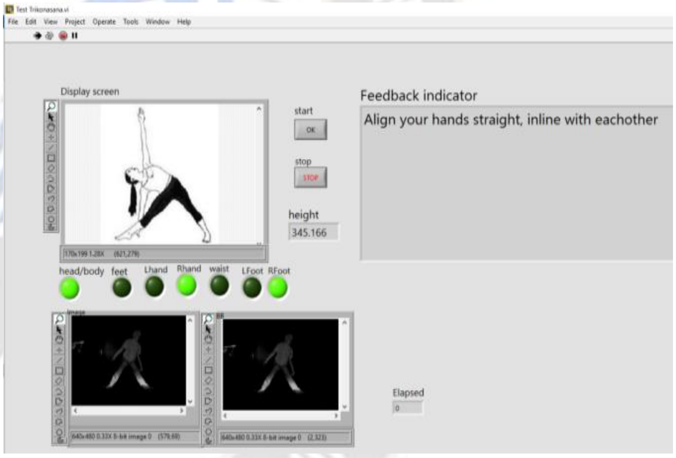

Fig.6. Improper alignment of hands and the corresponding instruction.

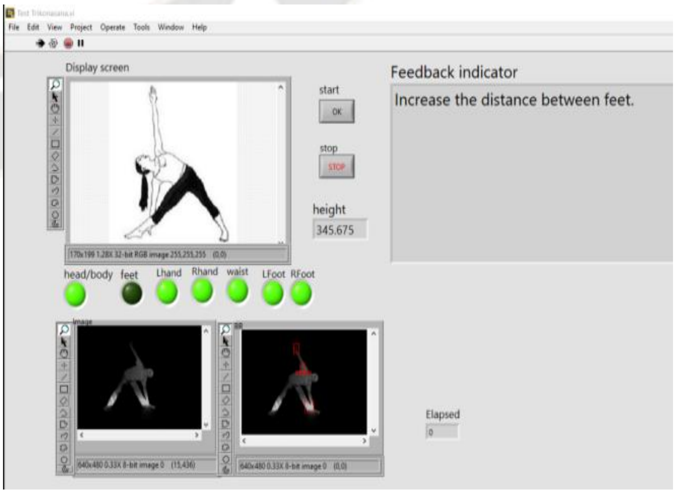

Fig.7. Practitioner is instructed to increase the distance between the feet.

When all the conditions are satisfied the posture is correct and the practitioner has to repeat the same asana in the other direction. Performing asana towards left and then towards right completes one cycle.

The feature points to be obtained in order to estimate the location of bounding boxes and direct the practitioner varies from asana to asana. Table 1 provides the location of feature points to be estimated for the four asanas under consideration.

TABLE I. DETECTION OF FEATURE POINTS FOR DIFFERENT ASANAS

Feature points/ Asana	He	Ft	Wa	Rh	Lh	Rf	Lf	Ha
Tadasana	√	√				√	√	√
Tiryak Tadasana	√	√				√	√	√
Trikonasana	√	√	√	√	√	√	√	
Veerabhadra asana	√	√	√	√	√	√	√	

He: Head, Ft: Feet, Wa: Waist, Rh: Right Hand, Lh: Left Hand, Rf: Right Foot, Rf: Right Foot, Ha: Both Hands

V. CONCLUSION

Yoga has been one of the therapies for many of the health issues and today most of the population is practicing it. Practicing under proper guidance helps improve the health. For this, analysis of asana is much required and the same is proposed in this paper. Mathematical analysis and preparing the training data for the basic standing asanas that help cure Diabetes is discussed here. Different feature points have been identified for different asanas using bounding box algorithm. In the next stage of the process using this training data, experiments will be conducted on diabetic patients and compared with their clinical results.

REFERENCES

[1] Available from: World Health Organization News room, fact sheets. https://www.who.int/newsroom/factsheets/detail/diabetes#:~:text=The%20number%20of%20people%20with,than%20in%20high% 2Dincome%20countries.

[2] Available from: International Diabetes Federation: Diabetes facts and figures: Diabetes Atlas Tenth Edition 2021. https://idf.org/aboutdiabetes/what-is-diabetes/facts-figures.html

[3] Raveendran, A.V., Deshpandae, A. and Joshi, S.R., Therapeutic role of yoga in type 2 diabetes. Endocrinology and Metabolism, 33(3), pp.307-317 (2018).

[4] Calcaterra, V., Iafusco, D., Pellino, V.C., Mameli, C., Tornese, G., Chianese, A., Cascella, C., Macedoni, M., Redaelli, F., Zuccotti, G. and Vandoni, M., “CoVidentary”: An online exercise training program to reduce sedentary behaviours in children with type 1 diabetes during the COVID-19 pandemic. Journal of Clinical & Translational Endocrinology, 25, p.100261 (2021).

[5] Shiju, R., Thomas, D., Al Arouj, M., Sharma, P., Tuomilehto, J. and Bennakhi, A., Effect of Sudarshan Kriya Yoga on anxiety, depression, and quality of life in people with type 2 diabetes: A pilot study in Kuwait. Diabetes & Metabolic Syndrome: clinical research & reviews, 13(3), pp.1995-1999 (2019).

[6] Patil, S.G., Aithala, M.R., Naregal, G.V., Shanmukhe, A.G. and Chopade, S.S., Effect of yoga on cardiac autonomic dysfunction and insulin resistance in non-diabetic offspring of type-2-diabetes parents: A randomized controlled study. Complementary therapies in clinical practice, 34, pp.288-293 (2019).

[7] Shantakumari, N. and Sequeira, S., Effects of a yoga intervention on lipid profiles of diabetes patients with dyslipidemia. Indian heart journal, 65(2), pp.127-131 (2013).

[8] Bock, B.C., Thind, H., Fava, J.L., Dunsiger, S., Guthrie, K.M., Stroud, L., Gopalakrishnan, G., Sillice, M. and Wu, W., Feasibility of yoga as a complementary therapy for patients with type 2 diabetes: The Healthy Active and in Control (HA1C) study. Complementary therapies in medicine, 42, pp.125-131 (2019).

[9] Xiaohui, T., Xiaoyu, P., Liwen, L. and Qing, X., Automatic human body feature extraction and personal size measurement. Journal of Visual Languages & Computing, 47, pp.9-18 (2018).

[10] Shimada, N., Kimura, K. and Shirai, Y., July. Real-time 3D hand posture estimation based on 2D appearance retrieval using monocular camera. In Proceedings IEEE ICCV Workshop on Recognition, Analysis, and Tracking of Faces and Gestures in Real-Time Systems (pp. 23-30). IEEE (2001).

[11] Werghi, N., Xiao, Y. and Siebert, J.P., A functional-based segmentation of human body scans in arbitrary postures. IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics), 36(1), pp.153-165 (2006).

[12] Rama Prabha Krishnamoorthy, Abdul Rahman bin Senathirajah, Robinson Savarimuthu, Abdul Rahim Sadiq Batcha. (2023). An Ultracompact All Optical Two-Dimensional Photonic Crystal Based and Gate. International Journal of Intelligent Systems and Applications in Engineering, 11(4s), 328–333. Retrieved from https://ijisae.org/index.php/IJISAE/article/view/2672

[13] Ouellet, S. and Michaud, F., Enhanced automated body feature extraction from a 2D image using anthropomorphic measures for silhouette analysis. Expert Systems with Applications, 91, pp.270-276 (2018).

[14] Omkar, S.N., Mour, M. and Das D., A mathematical model of effects on specific joints during practice of the sun salutation–a sequence of yoga postures. Journal of Bodywork and Movement Therapies, 15(2), pp.201-208 (2011.).

[15] Kumar, A., Kapse, R.C., Paul, N., Vanjare, A.M. and Omkar, S.N., Musculoskeletal modeling and analysis of trikonasana. International journal of yoga, 11(3), p.201 (2018).

[16] Islam, M.T., Al-Absi, H.R., Ruagh, E.A. and Alam, T., DiaNet: A deep learning based architecture to diagnose diabetes using retinal images only. IEEE Access, 9, pp.15686-15695 (2021).

[17] Dremin, V., Marcinkevics, Z., Zherebtsov, E., Popov, A., Grabovskis, A., Kronberga, H., Geldnere, K., Doronin, A., Meglinski, I. and Bykov, A., Skin complications of diabetes mellitus revealed by polarized hyperspectral imaging and

machine learning. IEEE Transactions on Medical Imaging, 40(4), pp.1207-1216 (2021).

[18] Liang, X., Alshemmary, E.N., Ma, M., Liao, S., Zhou, W. and Lu, Z., Automatic Diabetic Foot Prediction Through Fundus Images by Radiomics Features. IEEE Access, 9, pp.92776-92787 (2021).

[19] Gudigar, A., Samanth, J., Raghavendra, U., Dharmik, C., Vasudeva, A., Padmakumar, R., Tan, R.S., Ciaccio, E.J., Molinari, F. and Acharya, U.R., Local preserving class separation framework to identify gestational diabetes mellitus mother using ultrasound fetal cardiac image. IEEE Access, 8, pp.229043-229051 (2020).

[20] Paul Garcia, Ian Martin, Laura López, Sigurðsson Ólafur, Matti Virtanen. Enhancing Student Engagement through Machine Learning: A Review. Kuwait Journal of Machine Learning, 2(1). Retrieved from http://kuwaitjournals.com/index.php/kjml/article/view/163

[21] Zarkogianni, K., Athanasiou, M., Thanopoulou, A.C. and Nikita, K.S., Comparison of machine learning approaches toward assessing the risk of developing cardiovascular disease as a long-term diabetes complication. IEEE journal of biomedical and health informatics, 22(5), pp.1637-1647 (2017).

[22] Anaya-Isaza, A. and Zequera-Diaz, M., Detection of diabetes mellitus with deep learning and data augmentation techniques on foot thermography. IEEE Access (2022).

[23] El-Sappagh, S., Alonso, J.M., Ali, F., Ali, A., Jang, J.H. and Kwak, K.S., An ontology-based interpretable fuzzy decision support system for diabetes diagnosis. IEEE Access, 6, pp.37371-37394 (2018).

[24] Zhou, Y., Wang, B., Huang, L., Cui, S. and Shao, L., A benchmark for studying diabetic retinopathy: segmentation, grading, and transferability. IEEE Transactions on Medical Imaging, 40(3), pp.818-828 (2020).

[25] Jia, L., Wang, Z., Lv, S. and Xu, Z., PE_DIM: An Efficient Probabilistic Ensemble Classification Algorithm for Diabetes Handling Class Imbalance Missing Values. IEEE Access (2022).

[26] Wang, Q., Cao, W., Guo, J., Ren, J., Cheng, Y. and Davis, D.N., DMP_MI: an effective diabetes mellitus classification algorithm on imbalanced data with missing values. IEEE Access, 7, pp.102232-102238 (2019).

[27] Wen, D., Li, P., Zhou, Y., Sun, Y., Xu, J., Liu, Y., Li, X., Li, J., Bian, Z. and Wang, L., Feature classification method of resting-state EEG signals from amnestic mild cognitive impairment with type 2 diabetes mellitus based on multi-view convolutional neural network. IEEE Transactions on Neural Systems and Rehabilitation Engineering, 28(8), pp.1702-1709 (2020).

[28] Wang, Y., Li, P.F., Tian, Y., Ren, J.J. and Li, J.S., A shared decision-making system for diabetes medication choice utilizing electronic health record data. IEEE journal of biomedical and health informatics, 21(5), pp.1280-1287 (2016).

[29] Ghosal, S., Kumar, A., Udutalapally, V. and Das, D., glucam: Smartphone based blood glucose monitoring and diabetic sensing. IEEE Sensors Journal, 21(21), pp.24869-24878 (2021).

[30] Winter, D.A., Biomechanics and motor control of human movement. John Wiley & Sons (2009).