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Physiotherapeutic Aid using ML and AI

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ABSTRACT

In the recent year 2020 due to corona many people were not able to have appointments with their doctors and they were locked in their house. The younger generation can possibly maintain their health even if they do not go outside for days, but the older generation have to do regular exercise to maintain their health and well-being; prescribed by the doctors. It is not just because of corona that we have experienced this but we have also come to a situation where older people cannot visit their doctors. So, as a solution for these problems/challenges, we came up with an idea so that they can do their exercise and maintain their health without visiting their doctors or physiotherapist. Artificial Intelligence is technically defined as the development of technology which is used to perform technology operations which require involvement of human intelligence. Machine learning is one of the key components of artificial intelligence and it provides us with the ability of both supervised and unsupervised learning for training our model. AI technology today can be in different forms such as software programs as well as hardware interfaces to develop a system which is capable of learning from their own datasets. In our project AI with machine learning can be used for posture detection and then assessment of patients. We provided physiotherapy using AI and ML. We used normal running feed and we got good frame rates. These older generations have to do live exercise in front of the camera, our software will detect their pose/position whether they are doing their exercises correctly or not. By comparing the poses obtained from the live feed to the images or the videos obtained from the dataset. If the pose is not matched to the dataset, it is terminated or denied and deemed as wrong exercise. Our software is going to tell them where they went wrong. Now we have to decide a perfect algorithm/method to detect/estimate the pose with much higher accuracy. We are going to compare all the algorithms present till date regarding pose estimation and select the algorithms which give

best accuracy.

Keywords : Physiotherapy, Artificial Intelligence, Machine Learning, Human pose estimation, Move Net, Tensor Flow, ReactJS, Deep Learning, CNN, Media Pipe

I. INTRODUCTION

A. Overview of Work

People might hurt their joints or for some other reason and cannot use their limbs to the full extent, such as after a fall, a stroke, or an accident. There is a need to develop an application to distinguish normal person and affected person using Artificial intelligence and Machine learning and to provide the need of physiotherapy to the affected people. We are proposing an idea of an Automated system which will track human range of motion while physiotherapy of patients.

B. Motivation of Work

The change in demographics manifesting in India and the resulting change in workforce demographics may pose an important problem to solve in the future. As populations grow older, the relative size of the workforce diminishes. This might ease the burden on human specialists when it comes to the treatment of conditions which require physical therapy. Exercises consist of performing specific movement sequences a certain number of times. These exercises should be performed correctly to advance the treatment. Patients can be instructed by therapists or by using brochures. Using brochures, instead of receiving in-person supervision, patients may be less likely to correctly perform their exercises. This way, the use of brochures may lead to a decreased rate of treatment effectiveness compared to being supervised by a physiotherapist. Additionally, patients receiving supervision in a clinical setting often show greater treatment effectiveness than those in a home setting, which provides for less supervision from therapists. Adherence to prescribed exercise plans is often lacking in a home environment. Due to the difference in treatment effectiveness between supervised and unsupervised exercise regimens, patients learning from brochures or performing exercises in a home environment may undergo longer overall treatment. These systems could improve recovery time for exercise sessions where no specialist is available to supervise. Also, due to the resulting higher efficacy of unattended sessions, more sessions could be performed at home overall.

II. LITERATURE SURVEY

A. Existing System

1- Development of a yoga posture coaching system using an interactive display based on Transfer Learning By Long et al. Data augmentation was applied to oversample and prevent overfitting of the training datasets. Six transfer learning models (TL-VGG16-DA, TL-VGG19-DA, TL-MobileNet-DA, TL-MobileNetV2-DA, TL-InceptionV3-DA, and TL-DenseNet201-DA) were exploited for classification tasks to select the optimal model for the yoga coaching system, based on evaluation metrics. As a result, the TL-MobileNet-DA model was selected as the optimal model, showing an overall accuracy of 98.43%, sensitivity of 98.30%, specificity of 99.88%, and Matthews correlation coefficient of 0.9831.

2- Musculoskeletal physiotherapy using artificial intelligence and machine learning By Shalini et.

al Their approach was an end to end computer vision application which was using pose estimation technique and visual geometry to provide personalized feedback on fitness exercise. They used a function to score which mapped the performance metric into movement quality scores and to generate metrics scores for repetitions of exercises. They used output of pose estimation with the help of open pose to evaluate physiotherapy videos to evaluate exercise through human pose key points. They used this to assess and improve rehabilitation exercise.

3- A Deep-Learning Based Posture Detection System for Preventing Telework-Related Musculoskeletal Disorders By Enrique el at. After evaluating several hardware platforms and testing the system with multiple users, the results obtained in this study show that a postural recommendation system is more than viable, using the resources presented. Results showed a posture detection accuracy over 80% for the 4-class original problem, and more than 90% for the 2-class classification system. On the other hand, the hardware platforms tested allows the system to run in a real-time environment with low power consumption requirements. With these two points in favor, we can conclude that the system can work completely autonomously and without the intervention of a computer, providing information in real time.

B. Research Gap

Several companies have developed various products associated with technology in the sports and exercise domain. Wearable X company proposed a wearable product called NADI X-Smart Yoga Pants, which could guide exercise form via a mobile application. Another company, SmartMat, established an intelligent yoga mat with an advanced sensor to detect the pressure node of posture on the mat and provide real-time feedback on how the user has performed the yoga posture, i.e., correctly or incorrectly, via a mobile application. YogaNotch came up with a yoga wearable device assistant, placed on the body, which provides audio feedback on alignments when the user practices yoga at home. One more popular exercise guidance product in this current era is MIRROR , which is a movable mirror for use in a home gym that enables exercises to be viewed together with the user's reflection.

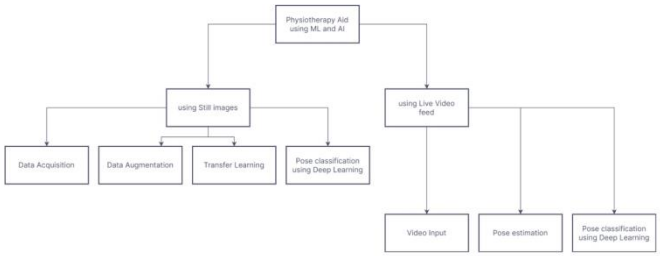
Palanimeera et al. presented yoga posture classification using ML for multiple people to detect real- time posture by using posture estimation with a 3D posture from an RGB camera. In, they considered 12 yoga postures, from the sun salutation asana, captured by a webcam camera. The method created a skeleton, applied featured extraction, and classified the sun salutation yoga postures through ML models as well as support vector machine (SVM), k-nearest neighbors (kNN), naïve Bayes, and logistic regression with a resulting of 96%. 15

Kumar et al. proposed yoga posture estimation by using keypoint detection method, called the OpenPose algorithm, on the public yoga asanas dataset . The method was collected in a video frame of six yoga asanas, including cobra posture, lotus posture or sitting posture, corpse posture, mountain posture, triangle posture, and tree posture.

Manisha et al. proposed a new dataset, called Yoga-82, for the fine-grained classification of human yoga postures. They modified the DenseNet201 model to classify yoga postures within their proposed Yoga-82 dataset and achieved the top-1 score of image classification performance at 79% of 82 multi-classes. The purpose of this study was to develop a yoga posture coaching system based on transfer learning. They collected yoga posture data for 14 yoga posture classifications and proposed a yoga posture coaching system, using an interactive display, based on transfer learning that pre-trained weights were from the CNN architecture model to recognize a yoga posture in real time. Furthermore, our yoga posture coaching system

provided posture instruction feedback when a user performed yoga in front of a yoga posture coaching system.

III. RESEARCH METHODOLOGY



The user interface allows users to access information on various yoga poses and their benefits. Users can practice each pose individually, with textual and verbal instructions provided to correct their posture. The system captures user movements using live video feeds from webcams, while PostNet, a machine learning model, is used to detect and correct yoga poses by providing constant human posture detection. Before capturing a user's yoga pose, the system prompts them to fix their position in front of the camera. The captured pose is then compared with a target yoga pose using key points identified and drawn on the video canvas. If the two poses have a high similarity status, the user's pose is considered perfect, and no correction is required. This approach allows for accurate detection and correction of yoga poses, helping users improve their posture and reap the benefits of yoga practice.

In case the user's yoga pose does not align with the target yoga pose coordinates, the system generates instructions for the user to modify their pose. To correct the mistake, the user can follow the instructions given by the instructor. Text instructions are converted into speech using the JavaScript speech synthesis API, providing verbal guidance to the user for pose correction. Once the user has completed their yoga practice, they can choose to continue the session or end the practice session. This feature allows users to customize their yoga practice according to their preferences and availability.

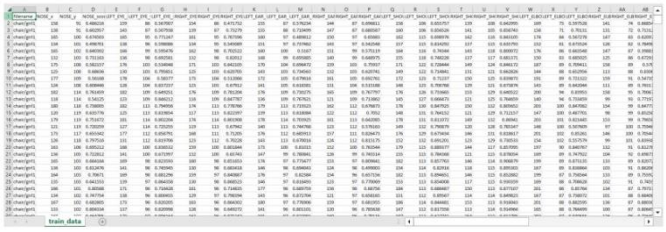
A. Dataset Collection

Poses	Test	Train
Chair	168	400
Cobra	232	400
Dog	180	400
No Pose	2	26
Shoulder Stand	9	50
Triangle	10	45
Tree	192	418
Warrior	218	400
Total	1011	2139

We have collected 1 dataset containing 5 models from Laurence Moroney.

(It can be found at this link - https://laurencemoroney.com/2021/08/23/yogapose-dataset.html).

https://laurencemoroney.com/2021/08/23/yogapose-dataset.html It contains photos in jpg format(RGB) of dimensions 300x300. We have added two more models to be dynamic and exclusive. The test and trained dataset are roughly of the ratio 3:7.



B. Evaluation Matrics

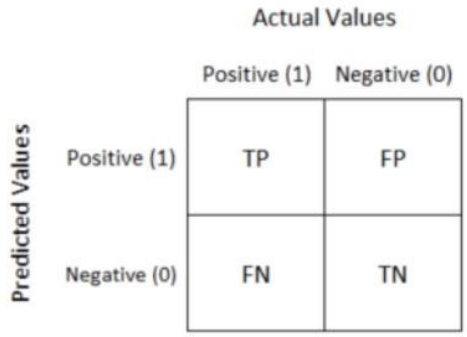
- Classification Score: Classification score refers to what we usually mean by accuracy of the model. It can be described as the proportion of the number of predictions that were correct to the total input samples. In case of multiclass classification, this metric gives good results when the number of samples in each class are almost the same.

$$Accuracy = \frac{Number\ of\ Correct\ predictions}{Total\ number\ of\ predictions\ made}$$

Confusion matrix represents a matrix which explains the accuracy of the model completely.

There are four important terms when it comes to measuring the performance of a model.

- True Positive: Predicted value and the actual output are both 1.
- True Negative: Predicted value and the actual output are both 0.
- False Positive: Predicted value is 1 but the actual output is 0.
- False Negative: Predicted value is 0 but the actual output is 1.



- Model accuracy and model loss curve: These curves are also referred to as learning curves and are mostly used for models that learn incrementally over time, for example, neural networks. They represent the evaluation on the training and validation data which gives us an idea of how well the model is learning and how well it is generalizing. The model loss curve represents a minimizing score (loss), which means that a lower score results in better model performance. The model accuracy curve represents a maximizing score (accuracy), which means that a higher score denotes better performance of the model. A good fitting model loss curve is one in which the training and validation loss decrease and reach a point of stability and have minimal gap between the final loss values. On the other hand, a good fitting model accuracy curve is one in which the training and validation accuracy increase and become stable and there is a minimum gap between the final accuracy values.

C. Software Requirement:

1. OS:-Windows 8,9,10, Linux, Unix, Ubuntu, MacOS
2. Libraries:- OpenCV, MediaPipe, Tensorflow, TensorflowJs, ReactJS, TailwindCSS, DiasyUI, React Router DOM, MoveNet Thunder

D. Hardware Requirements:

1. Processor:- intel i5,i7, Ryzen 3 and 5, Ryzen AMD
2. RAM:- 4GB and above.
3. HDD:- 256GB and above
4. Architecture:- 32 bit and above
5. Monitor:- 14 inch and above
6. Mouse:- in-built touchpad
7. Keyboard:- chiclet, gaming, mechanical, qwerty

IV. FEASIBILTIY STUDY

An essential aspect about the device is its feasibility. Feasibility relies upon at the sources and time the device is constrained to. There are three basic varieties of feasibility that are

1. Economic Feasibility
2. Technical Feasibility
3. Operational Feasibility

1. Economic Feasibility

The cost of developing a physiotherapy posture detection system using ML and AI would depend on several factors, including the complexity of the system, the expertise of the development team, and the availability of necessary hardware and software components. Additionally, ongoing maintenance and updates would add to the total cost of the system.

The potential return on investment would also impact the economic feasibility of the system. For example, the system could potentially reduce the need for in-person physiotherapy sessions, which could lead to cost savings for patients and healthcare providers. Additionally, the system could have the potential to be licensed or sold to other healthcare providers or

institutions, which could generate revenue for the developers.

Affordability for end-users is also an important consideration. The system should be priced in a way that is accessible and affordable for patients and healthcare providers, while also generating enough revenue to cover the costs of development and maintenance.

2. Technical Feasibility

According to Rogers. Pressman, Technical Feasibility is the evaluation of the specialized assets we used to build the layout.

Hardware requirements would include sensors or cameras capable of accurately capturing body posture data, which may require specialized equipment. Additionally, the system would need a computer or server with sufficient processing power and memory to run the machine learning algorithms efficiently.

Software requirements would include programming languages such as Python, JavaScript, and React JS, as well as libraries and frameworks for machine learning and web-based application development. The development team would need expertise in these areas, as well as experience with integrating and deploying machine learning algorithms in web-based applications.

The complexity of the machine learning algorithms used in the system would also impact technical feasibility. More complex algorithms may require more advanced hardware and software resources, as well as more expertise in machine learning and data analysis. However, simpler algorithms may be easier to implement and maintain, making them more feasible for development and deployment.

3. Operational Feasibility

Usability is a key factor in determining operational feasibility. The system would need to be user-friendly and intuitive, with clear instructions for use and feedback to the user. Additionally, the system should be accessible and usable for people with varying levels of technical skill and physical ability.

Cost and time requirements are also important considerations. The development and maintenance of the system would require financial resources, including hardware, software, and personnel costs. Additionally, the development process may be time-consuming, and the system may require ongoing updates and maintenance to remain effective.□ Technical Feasibility

V. LIMITATIONS

There are several limitations to a physiotherapy posture detection system using ML and AI.

- One limitation is the accuracy of the system. While ML and AI algorithms can be trained to detect specific postures with a high degree of accuracy, there is still the potential for false positives or false negatives. This could lead to incorrect diagnoses or treatment recommendations, which could potentially harm patients.
- Another limitation is the accessibility of the system. Not all patients may have access to the necessary hardware or software components required to use the system. Additionally, the system may not be accessible or usable for patients with disabilities or limitations that prevent them from using the system.
- The system may also have limitations in terms of the postures it can detect. While the system can be trained to detect a wide range of postures, there may be some postures or movements that are difficult to detect accurately.
- Privacy and security are also important considerations for a physiotherapy posture detection system using ML and AI. Patients may be concerned about the collection and use of their personal health data, and the system

must be designed to ensure the privacy and security of this data.

- Finally, cost may be a limitation for some patients or healthcare providers. The development and maintenance of the system may require significant financial resources, which could impact its accessibility and affordability.

Overall, a physiotherapy posture detection system using ML and AI has several limitations related to accuracy, accessibility, posture detection, privacy and security, and cost. Careful consideration of these limitations is necessary when designing and implementing such a system.

VI. FUTURE ENHANCEMENT

- As we aim to make this product for the older generation for the most part, we need a much simpler and minimalist UX.
- Older people have a low attention span compared to younger generations, so we also need to work on the optimization of the web App, Load Time and network Latency.
- The said project is very dynamic in nature. What that means is that we need to reshape our model constantly in order to fit the physiotherapy routine of the users. But in our case, we need a lot of development support to update the routine(we need to train the pose model from the start to adapt to the new routine).
- Since the model is hosted online, it would be better to use Server Side Rendering(NextJS) instead of Client Side Rendering(ReactJS).
- As of now, we can only monitor one person performing. This is very inconvenient since a lot of older people like to do these exercises in groups. We can possibly improve this feature on the tradeoff with performance(frame rate).
- The App is Web based, which means each time, we need to sit in front of a PC with a webcam, to monitor our movements, which is in itself very tedious.
- We can ship this model into Android Apps or Apple Apps. Moreover, we can ship this model into more simpler things like monitoring camera paired with an actuator (Buzzer or LED).
- We can add some smart Physiotherapy suggestion features based upon the given Symptoms and unease without ever visiting or paying a doctor.

VII. CONCLUSION

Yoga and exercise are very important for older and younger people to maintain their health. As doing regular exercise some may do in the wrong pose/position. Hence it is important to do it in the right way with proper guidance. Compared to video processing, image processing is easier. Still we opted for live video feed processing for better utility. We chose to go with a skeleton model since it selects the key points in the object or body. Now we had to select a better model which gives us live data on the real time exercise. For video processing we decided to compare between mediapipe and movenet. We used movenet over posenet as it is an upgraded version of posenet. Mediapipe captures multiple objects with greater accuracy. MediaPipe is a cross-platform pipeline framework to build custom machine learning solutions for live and streaming media. The framework was open-sourced by Google and is currently in the alpha stage. Movenet is an ultra fast and accurate model that detects 17 key points of a body. The model is offered on TF hub with two variants, known as Lightning and Thunder. Lightning is intended for latency-critical applications, while Thunder is intended for applications that require high accuracy. Movenet has 55fps whereas mediapipe has 30fps. Hence, we preferred movenet which had more frame rate, which provides us with greater accuracy

and for movenet device requirement is less than mediapipe.

VIII. ACKNOWLEDGMENT

We'd like to thank our council for furnishing us this platform to bring our idea into real time with further efforts and we look forward to put life into it. The idea of developing" Physiotherapeutic Aid using ML and AI " came to us while probing about inventions for society. Prostrating all the pebbles, we ought to give maximum support for society to avoid serious injury while practicing yoga.

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