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Musculoskeletal Physiotherapy using Artificial Intelligence and Machine Learning

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Abstract:- Physiotherapy is the trending medication for curing bones related injuries and pain. In many cases, due to sudden jerks or accidents, the patient might suffer from severe pain. Therefore, it is the miracle medication for curing patients. Our aim here is to build a framework using Artificial Intelligence and Machine Learning for providing users with a digitalized system for physiotherapy. Even though varied computer-aided assessment of physiotherapy rehabilitation exist still recent approaches for computer aided monitoring and performance lack versatility and robustness. In our approach we have come up with proposition of an application which will record user's physiotherapy exercises and also it will provide personalized advice based on user performance for refinement of therapy. By using Open Pose Library our system will detect angle between the joints and depending upon the range of motion it will guide patient in accomplishing physiotherapy at home. It will also suggest patients about different physio-exercises. With the help of Open Pose it is possible to render the patient's images or real-time video.

Keyword:- *Physiotherapy, Artificial Intelligence, Machine Learning, Open Pose, Rendering.*

I. INTRODUCTION

➢ *Motivation*

Physiotherapists often work with other health professionals to meet individual's health care needs. These days demands of physiotherapist are increasing but there is a lack of supply. Also, there are many benefits of physiotherapy which includes avoiding surgery, improved mobility and development, management of age related problem and improved balance. With increase in demand of physiotherapy its demand at home is also rising. But we cannot deny the fact there are some advantages of physiotherapy at home. At home better health outcomes are observed when a person is surrounded by people with whom they feel connected and at home they feel positive. Also, it is observed that at home healing is done faster.

It is observed that technology in the field of medical has been proven very beneficial. Varied amount of applications are being developed which are making life of doctors as well as patients easier. Technologies such as virtual reality, artificial intelligence and machine learning are among the most popular one in Medical applications. Exoskeletons is one of them which is use for arms, legs and hands videogames that motivate patients to move and motivates them to improve.

With the help of applications like these medical technology therapists are getting tools they need to give the kind of care and support which is required by the patients in need. It is also decreasing workloads from the therapists and providing them means to treat more patients than before. Therefore, advancement of technology in medical with the help of cutting edge technology inspired us to develop a system which will be changing the lives of therapists as well as patients everywhere.

➢ *Problem Statement*

People might have 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 Automated system which will track human Range of motion while physiotherapy of patient.

➢ *Background*

In recent years with increase in treatment of injury, physical strength, functioning of body and overall movement of body with involvement of science of movement of body rather than involvement of drugs and surgery has evolved need of physiotherapy. With increase in physical activity the demand of physiotherapy has increased. As well as it has increased the requirement of rehabilitation centers and demand of physiotherapists. Technology in the field of medical is now acting as supporting system of workload on physiotherapists.

Artificial Intelligence is technically defined as the development of technology which is used to perform technology operations which require involvement of human intelligence. Recently Artificial intelligence is playing major role in advancement of technology. Machine learning is one of the key component of artificial intelligence and it provides us with the ability of both supervised and unsupervised learning for training our model. Also, there are copious amount of model provided by machine learning which can be used for better training and prediction of our system. AI technology today can be in different forms such as software programs as well as hardware interface 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.

Open Pose is an open source library developed in C++ for the posture detection. It is used by importing open pose and later image is passed as NumPy matrices which is then converted to human key points. It is combination of Caffee, OpenCV and OpenCL which is used for rendering of passed image. It is used in different fields such as hand gesture detection, Basketball games for prediction of basket throw and various other sports activities. It is also easier to use because of its capability to replace methods which involve high cost along with more equipment and time for processing.

➢ *Existing System*

Our system don't demand the need for any personal physio- therapists to look after the patient and teach exercises. It's all online, and no hardware is required and inexpensive as only pictures or videos are required for successful execution.

- Physera: Online application that provides patients with excellent physiotherapists. The patient can have face- to-face video chat with their PT and escape their pain. Personalized plans are available to buy.
- Sword Health: Digitalized physiotherapy solution. Digital physio therapists are available to check patient's motion and provide them exercises. Patients can chat with their therapists to adopt the changes physically and emotionally. That is, real- time bio-feedback is provided. Patients can just stay at home and learn these physio-exercises and improve their health.
- Physitrack: Application that provides home solutions to patients in areas such as Orthopedics, Neurology, etc. Patients can view and learn from thousands of uploaded videos and can also upload their own PDFs and exercise videos. It also allows to book appointment in nearby clinics.
- Vera Health- Family Doctor Clinic: Growing community of doctors. It provides services in Vera Care, Vera Wellness, Vera Physio and Vera Community. It is an offline rehabilitation that monitors the patient.

➢ *Proposed System*

Our proposed system consists of series of processing starting from recording of video at one end to evaluation of pose detected at the other end. Our proposed architecture consists of different stages such as video recording, pose detection, estimation of human key points and lastly evaluation of physiotherapy for betterment of therapy. Given below is the architecture of our system which includes pipeline of our proposed idea.

- *Uploading Recorded Video*

Initial step for the patient who will be using our system will be to record video of the exercise patient will be performing. In recording of video we are providing complete flexibility to user. Patient will be given complete liberty to let them crop and to choose which video they want to upload. Once patient will be done recording and uploading video, next step will involve our posture detection library. Posture detection library will be used for rendering and generating human key points using Open pose which is built on C++ and includes Cafee, OpenCV, OpenCL and Cuda.

- *Posture Detection*

Our proposed system consists of series of processing starting from recording of video at one end to evaluation of pose detected at the other end. Our proposed architecture consists of different stages such as video recording, pose detection, estimation of human key points and lastly evaluation of physiotherapy for betterment of therapy. Given below is the architecture of our system which includes pipeline of our proposed idea.

- *Scoring Function*

In our system after we are done with the detection of key points then we execute our parser which uses key points as input. These set of key points is recorded in the form of x and y coordinates where x will represent frame of recorded video and y represents angle which is recorded. These set of inputs which we will get after posture detection will be then compared with already fed input key points of particular exercise performed by healthy person.

Later depending upon the values of current therapy key points and already fed key points error will be calculated. For calculation of scoring function we will take average of error which will be normalized to range between 0 and 1. After the calculation of score of therapy, current score will be then compared with previous score for evaluation of progress.

II. WORKFLOW

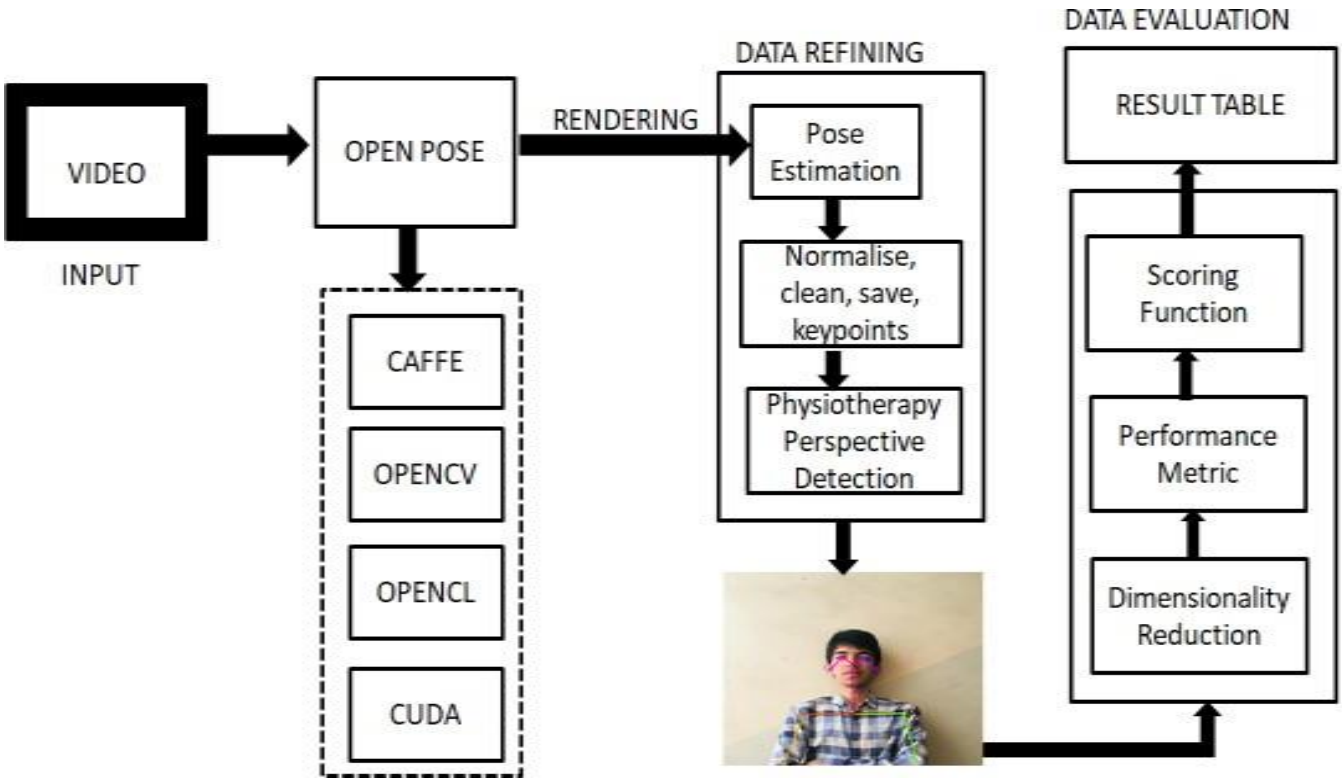

Fig 1:- Workflow of the Model

In brief complete workflow of our project consists of steps of processing which will include uploading video of exercise, pose estimation, scoring function, result and sending of feedback to doctors for further suggestion. At the initial stage users will be expected to register and depending on the instructions of musculoskeletal exercises they will be required to record video of the exercise. At the later stage of processing pose estimation will be executed and it will be analysed under the machine learning algorithms.

In our proposed system along with video, few extra inputs such as weight, height etc. will also be asked for accuracy of analysis. As we are going to consider range of motion for the analysis of physiotherapy therefore, there are different perspectives which are needed to consider in our model. Person with different weight have different joint angles and if not taken into account can result in inaccuracy of desired results.

Last stage of our model will present result in different format such as tabular or graphical representation of results. These reports will be then forwarded to doctors whom you need to consult, which will incorporate involvement of doctors in the process of your recovery. Inclusion of diet charts will also add as extras in our system because it is an important step in recovery of any patient with little bit of motivation and positivity.

III. SYSTEM FUNCTIONALITY

- *Register:*

Interface that allows the "Doctor" or "User" actor to provide credentials/information required for registering with the application.

- *Login:*

Interface for "Doctor" or "User" actor to sign into the application. Credentials are necessary to log in.

- *Input Video:*

The raw media, such as image or video footage. Raw video is pass to the rendered engine for further post-processing.

- *Image Processing:*

The raw video is shredded into frames. These frames are analyzed, then resized to a specific form factor and converted to certain format with minimum quality loss. Frame processing is necessary since it reduces the load on processors during rendering as well as it eliminates bad frames during sanity check.

- *Pose Estimation:*

Frames are rendered to estimate human posture. During rendering task keypoints are generated for the estimated posture. Keypoints are numeric values for 18 body parts ->

"nose", "neck", "rshoulder", "relbow", "rwrist", "lshoulder", "lelbow", "lwrist", "rhip", "rknee", "rankle", "lhip", "lknee", "lankle", "reye", "leye", "rear", "lear".

➢ *Performance Metrics:*

Rendered key points are parsed to estimate range or motion, angle, measurement between two key points.

➢ *Scoring Function:*

For error calculation and analysis of exercises performed by patients Scoring Function will be used. It will compare processed key points with already fed key points of healthy human. For comparison extra inputs that includes height, weight, etc will be considered which will decide the dataset from which we need to compare. For every key points, error will ne calculated which will be normalized first and then mean square error will be calculated. Current error record will be then compared with previous error records to conclude about the performance of physiotherapy.

➢ *Result:*

Based on previous calculations, a detailed report consisting of rendered images and performance metrics is generated for recipient, that is interactive as well as easier to understand.

➢ *Feedback:*

Remedy to improve posture. An exercise is suggested to the recipient.

➢ *Logout:*

Interface for "Doctor" or "User" actor to log out of the application.

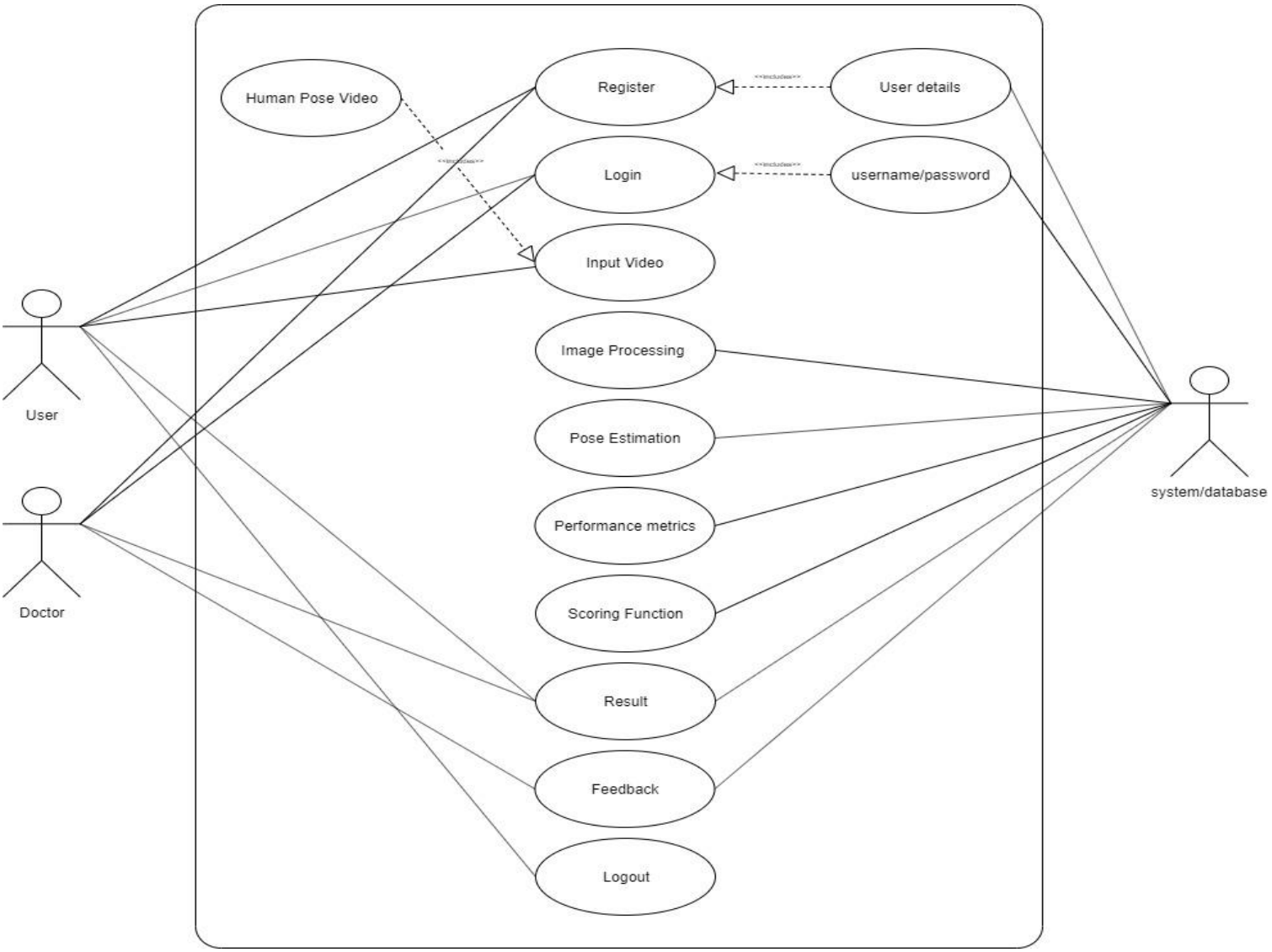

Fig 2:- Use Case Diagram

IV. LITERATURE SURVEY

	Classification question	Classification label	Data source	Classification Accuracy[%]	Algorithm used
Ashinsky et al. (2017)	Is pathology present or not?	Fracture (vs no fracture)	X-ray	83	16 layer CNN
Olczak et al. (2017)		Pfirmann grade Disc narrowing Spondylolisthesis Central canal Stenosis	MRI	70.4 75.4 95.4 94.7	CNN
Jamaludin et al. (2017)		Cartilage mapping	MRI	75	WND-CHRM
Bagarinao et al. (2014)	Is pain neuromapping phenotype identifiable with clinical diagnosis?	Structural MRI	CPP	73	SVM
Ung et al. (2012)			CLBP	76	SVM
Robinson et al. (2015)		fMRI	FM	76	LR, MP, Bayes, SVM, j48 DT
Callan et al. (2014)			CLBP	92	SLR
López-Solà et al. (2017)			FM	93	SVM, LR
Burns et al. (2018)	Can successful exercise performance be identified?	Accurate exercise performance	Inertial Sensor	99.4 97.8 94.1	CNN k-NN SVM
Kianifar et al. (2017)	Can risk of injury be classified based upon movement quality?	Risk of injury with movement: "high" vs "low" "high" vs "moderate" "low" Accuracy of performance: "poor" vs "good" "poor" vs "moderate" vs "good"	Inertial sensor	95 72 920 60	10F-CV 10F-CV LOSO-CV LOSO-CV
Nijewemed'Hollosy et al. (2018)	Can CLBP subgroups be stratified accurately?	"Physiotherapy" vs "GP" vs "self-management"	HER	71.05 71.05	DT BT
Sen Qiao Yilin Wang Jian Li	Can different gestures be described precisely?		Camera	83.3	2-Branch Multi-stage CNN Bezier Curve

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Steven Chen Richard Yang	Can user's exercise pose be detected accurately?	DTW	Camera	73	OpenPose Multi-Stage CNN CUDA CuDNN
Yalin Liao Aleksandar Vakanski	Can patient's performance in prescribed	DTW Human Movement	Motion Sensors	87	NN
Min Xian	rehabilitation exercises improved?	Modelling	Rehabilitation exercise		
Masato Nakai Yoshihiko Tsunoda Hisashi Hayashi Hideki Murakoshi	Is ball entering the basket or not as a binary target variable?	Real time diagnosis	Camera Motion capture analysis Video motion analysis	41	Logistic regression
Gin´es Hidalgo Mart´ınez	Can whole body pose be estimated?	PAF Confidence map	COCO dataset OpenPose foot dataset OpenPose hand dataset	70	CNN Multi-task Learning

Table 1

V. CONCLUSION

Our approach will be an end to end computer vision application which will be using pose estimation technique and visual geometry to provide personalize feedback on fitness exercise. We are using Machine learning because it has potential to involve physiotherapy practice through human level diagnostic, decision making and measurement. We are also using a function to score which will map the performance metric into movement quality scores and to generate metrics score for repetitions of exercises. We use output of pose estimation with the help of open pose to evaluate physiotherapy videos to evaluate exercise through human pose key points. We will be using this to for assessing and improvement of rehabilitation exercise.

In future scope we can also add a chat bot system which will be solve the issue of reluctant nature of patients toward physiotherapy. Mostly patient's don't see improvement in therapy because there are some set of exercises which are needed to be performed with strict discipline. Most of the patients don't follow regularity in their therapy. Therefore, this chat bot system will be using cognitive therapy for understanding of psychology of patients for faster healing of them and to maintain regularity. It will also be able to keep track of their routines and it will chat with them on regular basis for collecting more data for processing of psychology. Thus we will be able to make a system which will not only be providing support for physiotherapy but it will also help in maintaining emotional stability of the human for healing.

REFERENCES

[1]. Niall McGrane, Tara Cusack, Grainne O'Donoghue, Emma Stokes1, Motivational strategies for physiotherapists, Physical Therapy Reviews VOL. 19 NO. 2,2014

[2]. Masato Nakai, Yoshihiko Tsunoda, Hisashi Hayashi, Hideki Murakoshi, Prediction of Basketball Free Throw Shooting by Open- Pose, School of Industrial Technology, Advanced Institute of Indus- trial Technology 1-10-40, Higashiooi, Shinagawa-Ku, Tokyo, 140-0011, Japan, October, 2018

[3]. Shabnam Sadeghi Esfahlani, Tommy Thompson, Intelligent Physiotherapy Through Procedural Content Generation, Department of Computing Technology Anglia Ruskin University Cambridge, UK, 2016

[4]. Zhe Cao, Student Member, IEEE, Gines Hidalgo, Student Member, IEEE, Tomas Simon, Shih-En Wei, and Yaser Sheikh, OpenPose: Realtime Multi- Person 2D Pose Estimation using Part Affinity Fields, 30 May 2019.

[5]. Christopher Tack, Artificial intelligence and machine learning — applications in musculoskeletal physiotherapy, Guy's and St Thomas' NHS Foundation Trust, Guy's Hospital, Great Maze Pond, SE1 9RT, London, UK, 2019.

[6]. Daniil Osokin, Real-time 2D Multi-Person Pose Estimation on CPU: Lightweight OpenPose,29 Nov 2018
[7]. Yalin Liao, Aleksandar Vakanski, Member, IEEE, and Min Xian1, A Deep Learning Framework for Assessing Physical Rehabilitation Exercises, 30 Jan 2019
[8]. Sumaira Ghazal, Umar S. Khan, Human Posture Classification Using Skeleton Information, National University of Sciences and Technology, H-12, Islamabad, Pakistan,2018
[9]. Gin´es Hidalgo Mart´ınez, OpenPose: Whole-Body Pose Estimation, April 2019
[10]. Steven Chen, Richard Yang, Pose Trainer: Correcting Exercise Posture using Pose Estimation,Department of Computer Science, Stanford University
[11]. Sen Qiao,Yilin Wang,Jian Li,Real-Time Human Gesture Grading Based on OpenPose,2017
[12]. Junchen Shen, Yanlin Luo, Zhongke Wu, Yun Tian, Qingqiong Deng, CUDA-based real-time hand gesture interaction and visualization for CT volume dataset using leap motion,Springer-Verlag Berlin Heidelberg 2016.