Robust Virtual Instructor Aided Rehabilitation for Patients with Arthritis

Pranav Badhe[1] Sachin Gawate[2]
[1]M.E. Student [2]Assistant Professor
[1]Department of Embedded System and Computing [2]Department of Computer Science and Engineering
[1,2]G.H Raisoni College of Engineering Nagpur, Maharashtra, India

Abstract— Arthritis is a disease that is mainly because of the swelling that arises all over the joint of the person ,ruin the joints of the human body, scrap of joint, muscle strains caused by forceful movements against stiff painful joints and fatigue. Arthritis can cause vital organ vandalization and is an independent peril factor for heart disease. The pain which causes from Physiotherapy and physical activity are effective for treating the disease. They are ambiguous or improper instructions though, patients often do not fully benefit from prescription practice. Many times patients are unable to follow the recommended exercise routine accurately and frequently. For this the patients visiting the Medical Centre where they might not get a dedicated trainer to monitor their exercises and this will not help them to cure their disease. This paper presents a technique that will provide virtual instructor to the patients with arthritis the exercises, to teach them their exercise routine and also will monitor them while performing the exercises.

Key words: Skelton tracking, Depth image, motion tracking, Arthritis, Microsoft Kinect

I. INTRODUCTION

Arthritis is a disease that particularly affects the joints of human body and also the range of motion. This leads to making the joints painful and swallow. Acute level of arthritis can result in persistent pain, impotence to do daily activities and make it tough to walk or climb stairs. Arthritis can be the origin for immutable joint changes. These changes can be seen, such as knurled finger joints, but generally the damage can only be seen on X-ray. Some types of arthritis also affect the eyes, lungs, kidneys and skin as well as the joints. Arthritis can also be the genesis for radical organ mutilation. It may also induce inflammation in the lungs and it is also an independent peril factor for cardiovascular diseases. Figure 1 shows the multiple joints of human body with Arthritis.

The prime intent of Physical therapy is to conserve the functional range of motion and amplifying the cardiovascular health in person who is dealing with the arthritis and it is essential the quality of life. Physical Therapy consist of suitable exercises that can help to boost the joint range of motion and muscular force production. Physical therapy play a crucial role in improving the daily life of the person who are dealing with the arthritis. It is essential to promote regular physical activities and reducing the harmful effects cause from physical indolence. Therefore, physical therapists consists of both exercise and physical activity. The aim of physiotherapy is to improve muscle strength and joint mobility, often requiring sizeable dedication by patients over long periods of time [6]. Persons with Arthritis who exercise regularly show development in range of motion, physical function, pain, muscle strength, blood sugar, aerobic capacity and blood pressure.

Fig. 1: Multiple joints of human body with Arthritis

The 3D motion tracking system are very useful in tracking the motion in real time .The accuracy and efficiency of 3D motion tracking is better than 2D .However these systems are not integrated in daily life because of the high cost and the complexness of some systems for users and it is also not user friendly. The user have to convey the electromagnetic sensors or attach special markers on their body for tracking the motion in real time. This limits their handling and user friendliness. Hence majority of clinics are using the manual and reckless methods. There are not affordable systems which provide accurate tracking of the motion. Patient have to attend physiotherapy clinics but they don't provide a personal dedicated trainer. Ignorance to recommend exercises by doctors will increase the disease. Patients may not copy the recommended exercises. These systems are not integrated routinely into daily clinical interactions because they pull out high costs. The above challenges are the fundamental origin for developing an affordable system for monitoring the exercises of patients.

In the paper, we presented a robust approach to track and monitor the exercises of patients with arthritis to enhance the rehabilitation. The system uses Kinect sensor for motion tracking in real time. The system uses a skeleton tracking method for tracking the human motion in real time. The system will help in engaging the patients in the exercises without the presence of the physical therapy experts. This system provides a virtual trainer to teach, monitor and evaluate the exercises that are useful and recommended to the patients.

II. LITERATURE SURVEY

In 2013 Baoliang Wang, Zeyu Chen, Jing Chen [1], proposed a technique that can perform the gesture recognition using Kinect Skeleton tracking system. In this

paper the authors used feature of two-hand gestures and build Coupled Hidden Markov Models gesture recognition. This method can recognize and detect the two hand gesture of a person who is in front of the Kinect camera. The experimental results demonstrate that it is an effective method for gesture recognition accurately.

In 2014 Niranjan Deokule, Geetanjali Kale [2], proposed a method for human action recognition using the Kinect. The system performs preprocessing on the depth information for reducing the noisy pixels and getting the information in appropriate format. The system extracts contours of person. The Hu moments are extracted from contours of person for training action classifier. The Support Vector Machine (SVM) is used for classifying human activities. The Support Vector Machine (SVM) is used for classifying human movements into action classes.

In 2014 Ondrej Kainz, František Jakab [3],proposed an approach for gesture recognition and hand tracking build on surface electromyography (SEMG) and Leap Motion device. This system uses the depth image data and the electric agitation generated by the skeletal muscle of the forearm of a person and these techniques are used to amplify the gesture recognition pace. This technique helps in neglects the risk of unsuccessful tracking of hand when any obstacle which may cover the hand of person.

In 2012 Licong Zhang, Jurgen Sturm, Daniel Cremers, Dongheui Lee [4] proposed a human motion tracking method using the multiple Kinect cameras. The method is capable of tracking the high dimensional human pose accurately.They also used the partition sampling along with annealed particle filtering to track the real time 22 – DOF human pose using GPGPU support.

In 2015 Aeri Rachmad, Muhammad Fuad [5], proposed a technique that bring the information of the gesture using the specific tools like flags or rods. For presenting the examples as well as to make correction that may cause when an error may occur, instructors are required to teach this Semaphore. This research proposes the operation of geometry algorithm to develop a gesture recognition build on data of skeleton image acquire from the Kinect sensor.

In 2000, R Campbell, M Evans, M Tucker, B Quilty, P Dieppe, J L Donovan [6], delivers the results which have some potential implications for physiotherapy. Patients were most compliant when they were still seeing the physiotherapist. Even the most compliant patients says that they would have appreciated some further input from the physiotherapist. While the provision of continuing physiotherapy care would require changes in patterns of service delivery, there is increasing recognition of the need to upgrade rehabilitation services to target the changing patient needs, some encouragement for such developments.

III. FRAMEWORK

The main purpose of this project is to develop a system that will show the prescribed exercise and also monitor and accurately track the exercises in real time by the performed motion activities. This system will guide the patients to perform the recommended exercises in proper manner. The system will track the motion of patient performing the recommended exercise and matched with the ideal exercise pattern.

This project is using Kinect sensor for motion tracking. The Kinect sensor allow to perform the depth image and skeleton tracking techniques. These techniques can track the motion in efficiently and accurately in real time. Skeleton tracking is one of the most accurately and efficient technique for motion tracking.

Kinect is a motion sensing input device developed by Microsoft for the Xbox 360, Windows PC's and Xbox One video game consoles [3]. The main features of the Kinect are the RGB camera along with the Depth Sensor and multi array microphone[3][14].Based on the resolution the output video frame rate of Kinect sensor is from 9Hz to 30HZ.The RGB video stream uses the default 8-bit VGA resolution (640 x 480 pixels) .The video stream of monochrome depth sensing is in VGA resolution (640x480 pixels) with 11-bit.The depth sensor which includes an infrared laser projector combined with monochrome CMOS sensor is capable of capturing the 3D video data under any type of ambient light conditions. The 3D input given by Kinect regarding the subject's body posture is more illuminating contrast to the information of the 2D that we could get from the RGB video. The value in a depth video stream frame of each pixel is in millimeters of the corresponding surface part of the object from the sensor. The range of Kinect sensor is 1.2-3.5 ft. The angular field of view of Kinect sensor is 57° horizontally and 43° vertically and the motorized pivot of Kinect is capable of tilting the sensor up to 27° either up or down. The Microsoft SDK is required for using the Kinect sensor fore motion tracking. Fig shows Microsoft Kinect.

Fig. 2: Microsoft Kinect

IV. WORKING

The basic functionality of the system is stated in the block diagram. Firstly, the system will extract the image of a person through the Kinect sensor. With this acquired images the system will make the database of ideal exercises .Later the system will acquire the line skeleton position and pattern of the person using skeleton tracking technique and this will give the joint co-ordinates of the ideal exercise pattern. After getting the ideal pattern the system will project the ideal position when the system is run. Then tracking of the line skeleton will be carry out in real time and After that the integration of the software and the hardware, the result will be analyze with the help of the collected data. The system programming is done in MATLAB. Fig 2 shows the Block diagram of the system.

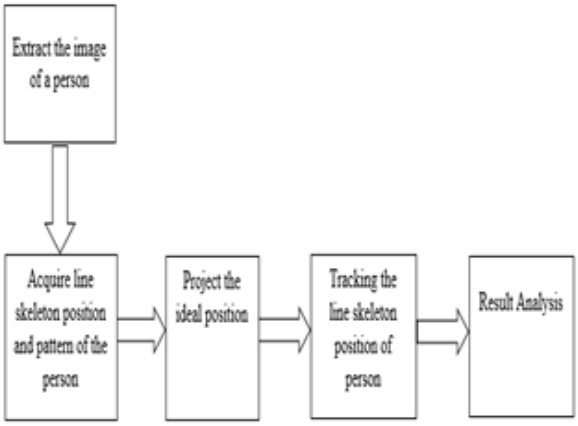

Fig. 2: Block Diagram

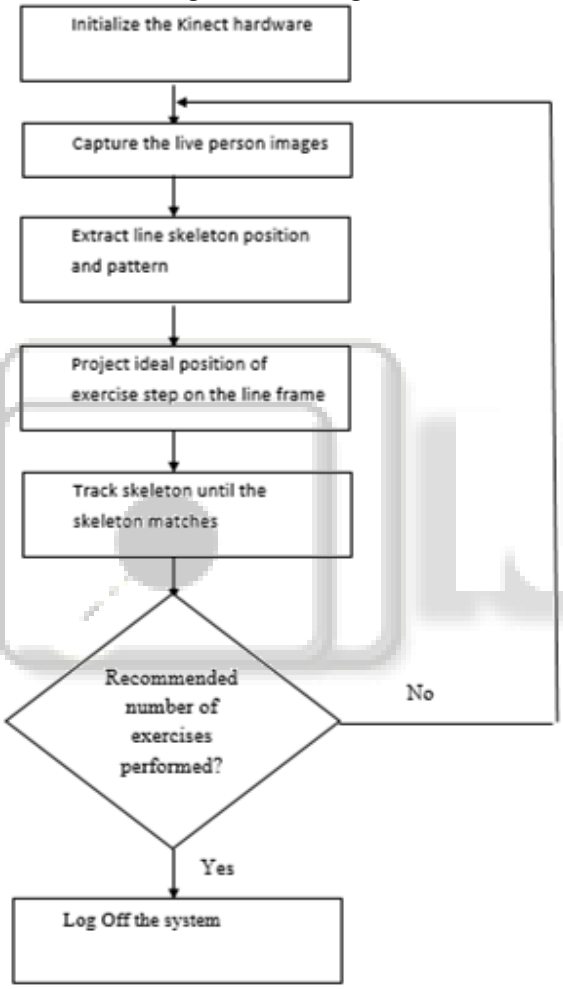

Fig. 3: Flow chart

Fig 3 shows the flow chart of the working of the system. There is switch which is provide to activate the Kinect camera. The Kinect will start the functioning as soon as the switch is pressed. This switch help in activating the system from the distance the person will not have to go near the system to turn on the Kinect then come to the recommended position from which the entire body of the person can be track according to the angular field of view of the Kinect.

After that the system will create a database of the exercises recommended to the patient by capturing the live image of the person performing the ideal recommended exercise. The line skeleton position and pattern tracking is done by the Kinect and this will store the joint co-coordinates by extracting the ideal line skeleton pattern and position. This will be done by skeleton tracking technique. The infrared emitter of a Kinect sensor projects a pattern of infrared sensors[10]. With this infrared pattern the Kinect gets the depth image co-ordinates of the person facing the Kinect in 3D space. This depth image co-ordinates will later be converted into the skeleton co-ordinates. The skeleton tracking is technique which is related with the Kinect sensor and this technique can only be used by using the Microsoft Kinect SDK.The skeleton tacking will provide the skeletal information by detecting the location of the main joints of the body of the human being in 3D space. The skeleton tracking technique can track the 20 joints of the human body in 3D space. The Kinect can track the skeleton in standing as well as in sitting position. In siting position it can track the 10 joints of the human body. The Kinect is capable of tracking the skeleton of six person simultaneously and it can also track tall the 20 joints of two person at the same time.Fig 4 shows the skeleton tracking of a person in real time.

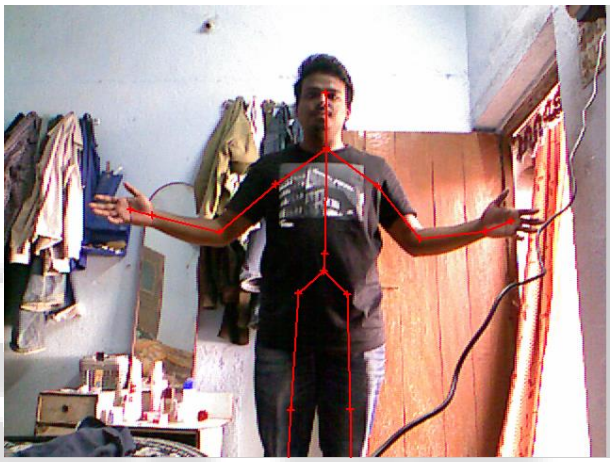

Fig. 4: the skeleton tracking of a person in real time

When the system gets the ideal skeleton pattern and position of the recommended exercise, it will create a required threshold by projecting the ideal pattern and real time skeleton tracking of person performing the same exercise in real time. The threshold is created by considering the difference in the joint co-ordinates of all the 20 joint of a human body between the ideal skeleton pattern and the real time skeleton tracking performing the same exercise. Fig 5 shows the matching of the skeleton pattern of real time and the ideal skeleton pattern.

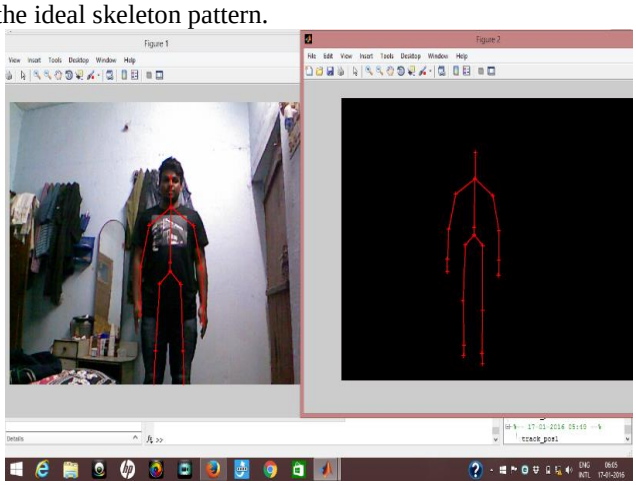

Fig. 5: the matching of the skeleton pattern of real wime and the ideal skeleton pattern

After deciding the appropriate threshold, the system create the program of recommended exercises according to the database created by the system. After running the particular program recommended to a person for a particular part of arthritis like elbow arthritis. The patient have to go to the recommended distance from the Kinect so that the entire body can be track and monitored based on the Kinect field of view. Then after pressing the switch at that recommended position the Kinect will start functioning. The Kinect will track the skeleton of the person standing in front of the Kinect in real time and this skeleton tracking is in the red colour and simultaneously a green skeleton pattern of ideal exercise is also projected .This green skeleton pattern is the virtual instructor of the system that will guide the patient to perform the recommended exercise properly. The person whose real time skeleton is tracking can match the pattern projected by the virtual instructor and try to perform the exercise. As soon as the virtual instructor matches the ideal position the virtual instructor will project the next exercise recommended to that particular patient otherwise it will not project the next exercise. The virtual instructor is not only matching the recommended exercise in real time but also monitoring the patient performing the recommended exercise in real time. The virtual instructor will also guide and monitor the patient to perform the particular exercise perfectly and also monitor to do it for the recommended number of time. This way the virtual instructor will monitor the patients entire recommended exercise routine. As the patient can see their progress and live tracking of themselves performing the exercise, this will act as an entertainment factor for patients while doing the exercises and this will help in engaging the patient to perform their recommended exercise routine and this will lead to enhance rehabilitation system. Fig 3 & 4 shows the evaluated result of the system.

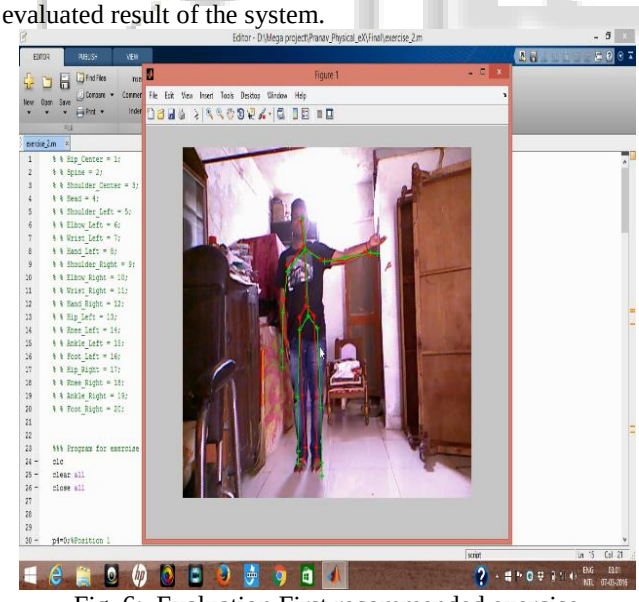

Fig. 6: Evaluation First recommended exercise

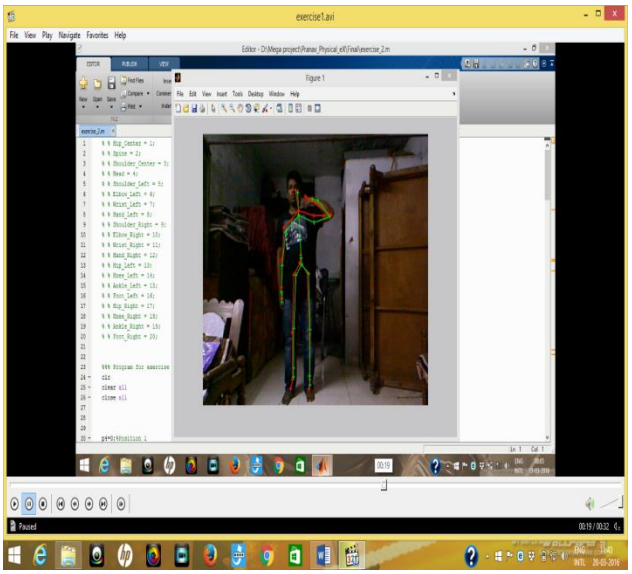

Fig. 7: Evaluation of Second recommended exercise

V. CONCLUSION

In this paper, a system is presented that will provide a virtual instructor that will guide, track and monitor the physical therapy of patients with arthritis. This system will enhance the rehabilitation of patients with arthritis and also help in making the physical therapy routines more fascinating and make the patients engage in their physical therapy routine. This system will track the physical therapy routine in real time and guide the patient to do the recommended exercise. Once patient perform the first exercise successfully it will generate the next recommended exercise otherwise it will not progress from first exercise till the patient is able to perform the first exercise. This way the virtual instructor will monitor the entire physical therapy routine of patient with arthritis.

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