ISSN XXXX XXXX © 2017 IJESC

Research Article Volume 7 Issue No.6

A Real Time Virtual Trainer for Rehabilitation

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Abstract:
Arthritis is a disease that is mainly because of the swelling that arises all over the joint of the person ,ruin the movements of joints, scrap of joint, muscle strains caused by forceful movements against stiff painful joints. Arthritis can cause vital organ disfunction and is an independent risk factor for heart disease. The stress which causes from Physiotherapy and physical activity are effective for treating the disease. There are ambivalent or improper instructions though, patients often do not fully benefit from prescription practice. Many times it is difficult for patients to follow the recommended exercise routine accurately and precisely. For this the patients visiting the Medical Centre where they might not get a personel trainer to monitor their exercises and this will not help them to recover from the disease. This paper presents a technique that will provide virtual personal instructor to the patients with arthritis, to teach them their exercise routine and also will monitor them while doing the exercises.

Keywords: Skelton tracking, Depth image, motion tracking, Arthritis, Microsoft Kinect.

1. 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 long term pain, difficult to do daily activities and make it tough to walk or climb stairs.

Arthritis can be the origin for permanent 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 lungs, kidneys, eyes and skin as well as the joints. It may also induce inflammation in the lungs and it is also an independent factor for cardiac related diseases.

Figure 1 shows the multiple joints of human body with Arthritis. The prime intention of Physical therapy is to improve the functional range of motion and boosting the cardiovascular health in person who is struggling with the arthritis and it is essential for healthy life.

Physical Therapy consist of certain suitable exercises that can help to improve the joint range of motion and muscular force production. Physical therapy play a vital role in improving the daily life of the person who are struggling with the arthritis. It is essential to promote regular physical activities and thus reducing the harmful effects cause from physical inactivity. Therefore, physical therapists consists of both exercise and physical activity. The aim of physiotherapy is to improve muscle strength and joint mobility, often requiring deep dedication by patients over long periods of time [6].

Persons with Arthritis who do physical exercise regularly show development in joint mobility, physical function, pain, muscle strength, aerobic capacity and blood pressure

Figure.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 adapted in daily life because of the high cost and the complexity of systems for users. The user have to convey the electromagnetic sensors or attach special nodes on their body for tracking the motion in real time. This limits their handling and covinience. Hence majority of clinics are using the manual and rash methods. There are not affordable systems which provide accurate tracking of the motion. Patient have to attend physiotherapy clinics regularly but they don't provide a personal dedicated trainer. Not giving attention to recommend exercises by doctors will increase the disease of patient. Patients may not copy the recommended exercises. These systems are not adapted routinely into daily clinical interactions because they pull out high costs. The above challenges forced the development of affordable system for monitoring the exercises of patients. In the paper, we presented a vigorous approach to track and monitor the exercises of patients with arthritis to boost the rehabilitation. The system uses Kinect sensor for tracking motion in real time.

kinect 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 therapist. 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 method that can perform the gesture recognition using Kinect Skeleton tracking system. In this paper the authors used feature of two-hand gestures. This method can detect the two hand gesture of a person who is in front of the Kinect camera. The experimental results shows that it is an efficient method for gesture recognition properly. In 2014 Niranjan Deokule, Geetanjali Kale [2], proposed a technique for human action detection using Kinect. The system performs processing on the depth information for reducing the erronious pixels and getting the information in proper format. The system extracts line skeleton of person. The Hu moments are extracted from line skeleton of person for training action classifier. The Support Vector Machine (SVM) is used for classifying human physical activities. The Support Vector Machine (SVM) is used for classifying human movements into action classes. In 2014 Ondrej Kainz, František Jakab [3],proposed an technique for gesture recognition and hand tracking build on surface electromyography (SEMG) and Leap Motion device. This system uses the depth image data generated by the skeletal muscle of the forearm of a person and these techniques are used to boost the gesture recognition pace.

This technique helps in reduce the probability of unsuccessful tracking of hand when any obstacle which may block the view of hand of person. In 2012 Licong Zhang, Jurgen Sturm, Daniel Cremers, Dongheui Lee [4] proposed a human motion tracking approach using the multiple Kinect cameras. The method is capable of tracking the high dimensional human posture efficiently and accurately. In 2015 Aeri Rachmad, Muhammad Fuad [5], proposed a method that collects the information of the gesture using the specific tool like flag. For presenting the examples as well as for making correction that may cause due to errors, 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 capture from the microsoft Kinect sensor.

In 2001, R Campbell, M Evans, M Tucker, B Quilty, P Dieppe, brings the results which have some strong inference for physiotherapy. Patients were most amenable when they were still seeing the physiotherapist. While the provision of continuing physiotherapy care would require changes in patterns of exercises, there is increasing recognition of the need to upgrade rehabilitation services to target the changing patient needs, some motivations for such developments.

III. FRAMEWORK

The moto of this project is to develop a system that will show the prescribed exercise and also monitor and track the exercises in real time by the performed motion activities. This system will guide the patients to perform the recommended exercises in proper format. 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 for motion tracking. Fig shows Microsoft Kinect

Figure.1. 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.

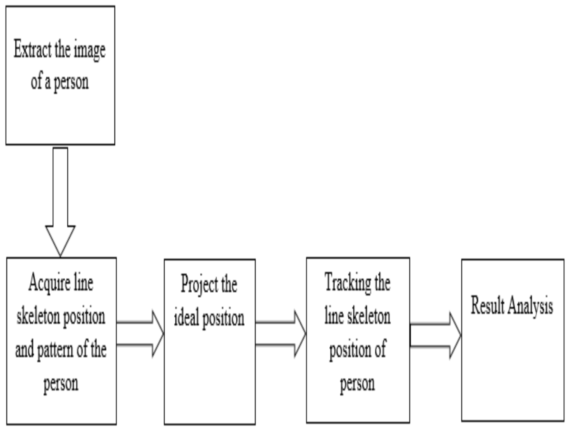

Figure.2. Block Diagram

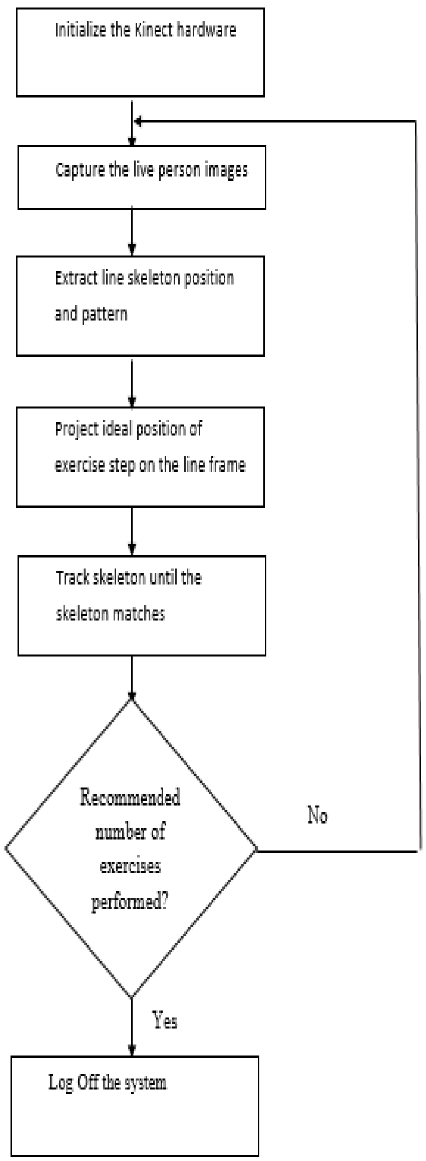

Figure.3. Flow chart

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.

Figure. 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

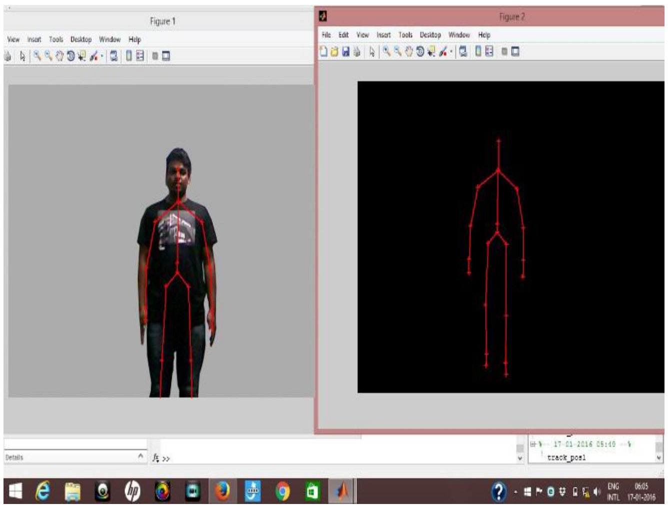

Figure.5.the matching of the skeleton pattern of real wime and the ideal skeleton pattern

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.

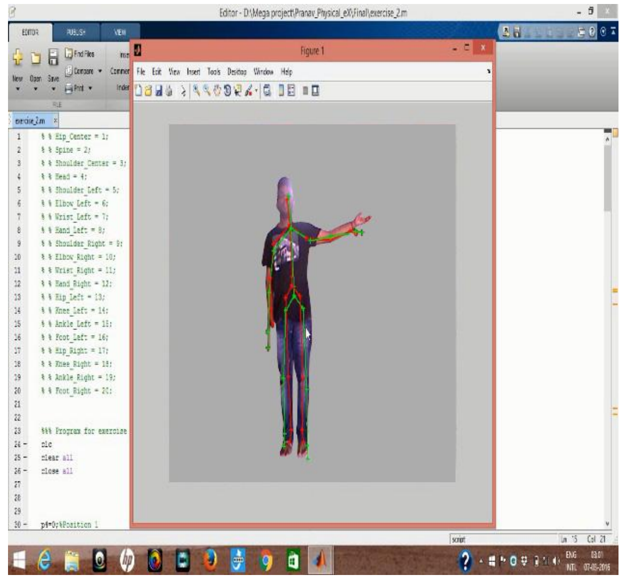

Figure. 6. Evaluation First recommended exercise

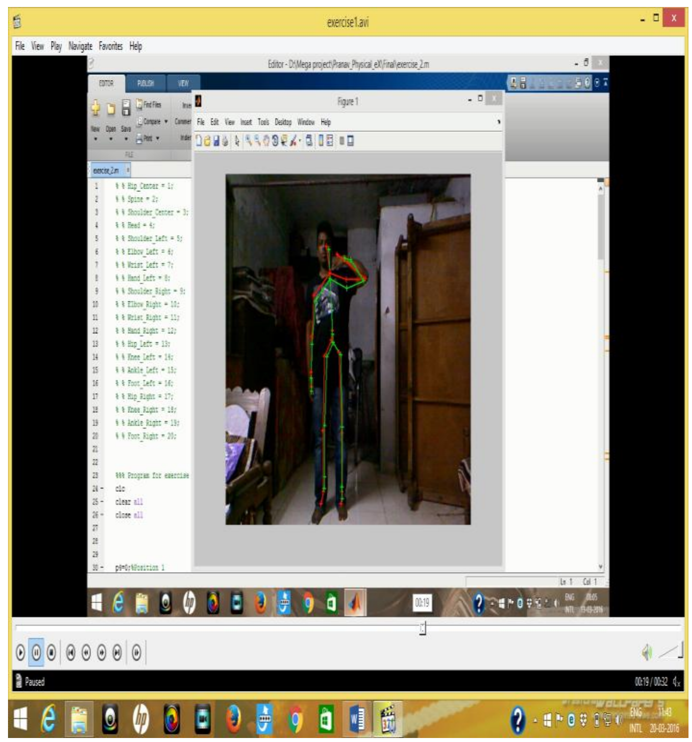

Figure.7. Evaluation of Second recommended exercise

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.

VI. ACKNOWLEDGMENT

I sincerely thank my project guide Prof. Mahua Bhowmik for her valuable support and motivation, I would also like to thank H.O.D of Electronics and Telecommunication department Dr. S. R. Jog for his kind support and encouragement.

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