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Measurement Straight Leg Raise for Low Back Pain Based Grayscale Depth

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Abstract

Spinal disorders are the most frequent cause of pain and lower part of the spine, which is often called Low Back Pain.Straight Leg Raise Test can provide important information to detect the cause of LBP and conducted by physican with a goniometer required accurately reading angle when your feet up. But this can be overcome with Kinect can detect motion and displays images and depth data. Methodological includes image acquisition method, algorithms of RGB and Grayscale depth, skeleton tracking and feature extraction detection Straight Leg Raise. The proposed algorithm describes a method for estimating the data triangulation angle Straight Leg Raise by Kinect. Results measurement if the positive Low Back Pain below 60 degrees there is a tendency to suffer from one of the causes of Low Back Pain. The results can be stored in the database as medical history and used to monitor the progress of therapy.

Keywords*: depth image, low back pain, kinect, extraction feature, straight leg raise*

1. Introduction

Human spinal plays a role and a very important function for the human activity. From the shape and structure of the human spinal can provide indications of diseases, among others such as lardosis, kyphosis, scoliosis, whereas disorders related to bones and joints such as osteoporosis, bone fractures or disorders related to the ligaments and muscles and related disorders disc and nerves such as a herniated nucleus pulposus (HNP) and nerve roots irritation. Spinal pain may spread to the thighs, calves and feet. One of the most common symptoms is called Low Back Pain (LBP) [1].

According to the U.S. Department of Health and Human Services in December 2014 publication stated aboutt 80 percent of adults experience low back pain at some point in their lifetimes. It is the most common cause of job-related disability and a leading contributor to missed work days. In a large survey, more than a quarter of adults reported experiencing low back pain during the past 3 months. Pain can begin abruptly as a result of an accident or by lifting something heavy, or it can develop over time due to age-related changes of the spine [2]**.** Straight Leg Raising Test is widely used as one of the primary diagnostic physical examination, patients with back pain, lower back and legs [3]. Straight Leg Raise (SLR) gives the meaning of the human body in a lying position and lift one leg upwards until pain where the limb movements start from the pelvic bone to the ankle, the knee is in a state of extension and form an angle less than 70 degrees which gives an indication of the severity irritation the nerve root [4]. Straight Leg Raising Test as below in Figure 1 [5].

This study about Straight Leg Raise exercise as a form of exercise to inform the correct quality of movement in patients with osteoarthritis of the knee with the accelometer sensor, and the subject is still done on healthy people [6]. This paper describes about clinical marker for patients with Low Back Pain, where doctors examine and observe the patient's posture and movements and assess range of motion including flexion, extension, and rotation. The SLR test should be performed in patients with evidence of sciatica or radicular pain and .this test specifically designed to detect lumbar nerve root irritation and positive identification when sciatica is produced between 30 and 60 degrees of elevation of the leg [7]. Paper [8], present research comparing how to assess test SLR with an instrument called a goniometer or tape measure.

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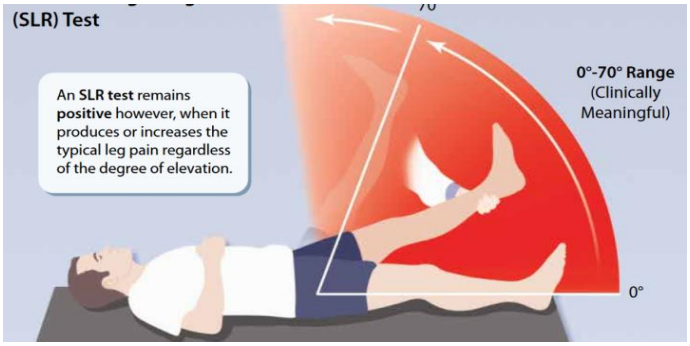

Figure 1. Straight Leg Raise (SLR)

Paper [9] did a comparative study of precision in computing joint angles using Kinect and optical motion capture method, by taking the movement of the three joints: shoulders, hips and knees, but the angle computation is not accurate and does not do a state of disease/disorder. This paper using Kinect in physical rehabilitation test to measure a person's ability to walk in the range of ten meters and a measurement range of joint motion neck, shoulders, elbows, thighs, knees. The disadvantage is tracking the joints are often unstable and not to the determination of a disorder [10]. Research using Kinect to detect falls in the elderly parent to test the movement of healthy people through the movement of sitting and standing [11]. Paper [12] analyzed that features of a person's gait can provide important information for the treatment of neurological disorders, including Parkinson disease and to observe the effects of treatment and rehabilitation. The methodology used allows detecting attributes gait by using the image sensor and the depth of Microsoft Kinect to track motion in three-dimensional space.

Based on the above description that the SLR tests conducted by one of the physical examination with measurement goniometer that can help you compare the painful joint with normal joint, but the measurements must be made quickly when the condition of leg raised in a state of pain, and other body parts should not be any movement, then the measurement would be difficult and reading the angle measurements must be precise. This test is done at the beginning of the examination for diagnosis. Where this is not done it will be worse the state would require examination are quite expensive and are only available at large hospitals, among others, using technology Magnetic Resonance Image (MRI) or CT- Scan. So also in the the recording and measurement angle joints of the human body structure is still common. It is not yet able to provide solutions quickly and precisely to the calculation of the angle problem SLR and also the absence of technology that can help early detection for monitoring the the process of rehabilitation of patients with low back pain is cheap and affordable for physicians in the clinic and in the future hospitals can also take advantage with the help of new technologies. This new technology is the Microsoft Kinect, it is the hardware in the form of a video camera using multiple sensors are used to detect motion. Kinect ability to detect motion and body shape can be applied to detect the skeleton SLR and getting the feature extraction from the angle of SLR in realtime. SLR feature extraction as basic features for analysis for the detection of the causes of low back pain. And also measure the effectiveness of rehabilitation training in the field of Medical Rehabilitation.

2. Microsoft Kinect.

Microsoft Kinect is an input device for detection gesture and Kinect is an RGB-Depth sensor from Microsoft that uses Light Coding technology from PrimeSense, the company Apple Inc. Light Coding is a technology that can reconstruct a 3 dimensional depth map of a state in realtime and detail. Depth resolution Kinect of 640 x 480 pixels. Kinect sensor includes the following major components, camera RGB (color), Infrared (IR) emitter and an IR sensor depth, Motor Tilt, Array Microphone, and Light Emitting Diode, shown in Figure 2 [13].

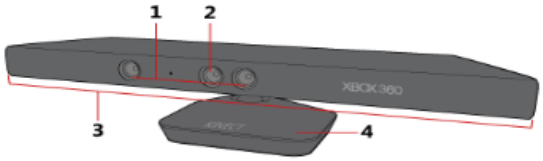

Figure 2. Kinect Sensor RGB-Depth: 1) Depth Sensor, 2) RGB Camera, 3) Microphone Array, 4) Motorized Base

Kinect is a camera peripheral by Microsoft for the - SDK video game console. It is a motion control system which captures the user's movements and translates them into control actions for - SDK, without the need of a controller, but through a Natural User Interface (NUI), using just gestures and spoken commands. OpenNI (Open Natural Interaction) is an open source framework that defines an API (Application Programming Interface) for writing applications using natural interfaces. OpenNI APIs are composed of a set of interfaces for writing NI applications to be implemented by the sensor devices and by the middleware components [14].

The Kinect sensor consists of an infrared laser emitter, an infrared camera and an RGB camera. The inventors describe the measurement of depth as a triangulation process [15]. The laser source emits a single beam which is split into multiple beams by a diffraction grating to create a constant pattern of speckles projected onto the scene. This pattern is captured by the infrared camera and is correlated against a reference pattern. The reference pattern is obtained by capturing a plane at a known distance from the sensor, and is stored in the memory of the sensor. When a speckle is projected on an object whose distance to the sensor is smaller or larger than that of the reference plane the position of the speckle in the infrared image will be shifted in the direction of the baseline between the laser projector and the perspective center of the infrared camera. These shifts are measured for all speckles by a simple image correlation procedure, which yields a disparity image [11]. In tracking the skeleton with a skeletal structure is an anatomy medically not correct, but the shape of joints and limbs like so tracked by Kinect is intended be helpful for building interactive applications, so kinect easily provide algorithms capable of detecting and also that Kinect easily work with the data anatomy skeleton, it's easy to consider it the perfect matching of the actual body of the user. Kinect then named and classify each joint. With a skeletal structure is an anatomy medically not corrects, but the shape of joints and limbs like so tracked by Kinect is intended be helpful for building interactive applications, so kinect easily provide algorithms capable of detecting and also that Kinect easily work with the data anatomy skeleton, it's easy to consider it the perfect matching of the actual body of the user. Kinect then named and classify each joint. The following diagram in Figure 3. represents a complete human skeleton facing the Kinect sensor [16].

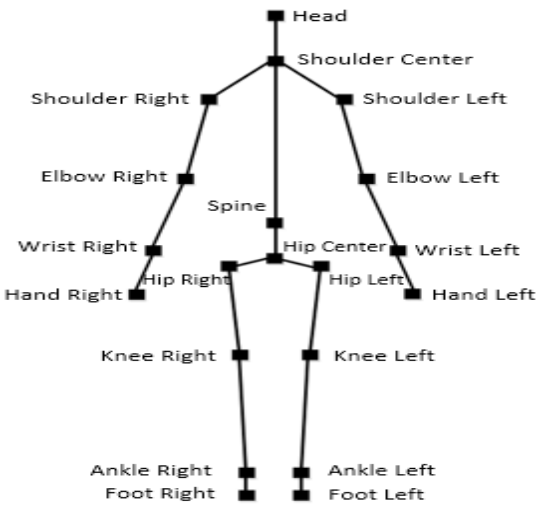

Figure 3. Skeletal Tracking

Figure 3 described human skeleton shaped with 20 joint points that can be tracked by the Kinect for Windows SDK. Each skeleton contains data for a series of joint point, wrapped in JointCollection object. Each joint has its own type of tracking mode and additional information to represent the position. Drawing skeleton from joints : Head - ShoulderCenter, ShoulderCenter - ShoulderLeft, ShoulderCenter - ShoulderRight, ShoulderLeft - ElbowLeft, ShoulderRight - ElbowRight, ElbowLeft - WristLeft, ElbowRight -WristRight, WristLeft - HandLeft, WristRight- HandRight, ShoulderCenter - Spine, Spine - HipCenter. HipCenter - HipLeft, HipCenter - HipRight, HipLeft - KneeLeft, HipRight - KneeRight, KneeLeft - AnkleLeft, KneeRight - AnkleRight, AnkleLeft – FootLeft, AnklerRight - FootRight.

3. Research Method

Stages of measurement the angle between the two legs when the SLR can be described in the following block-chart as shown Figure 4.

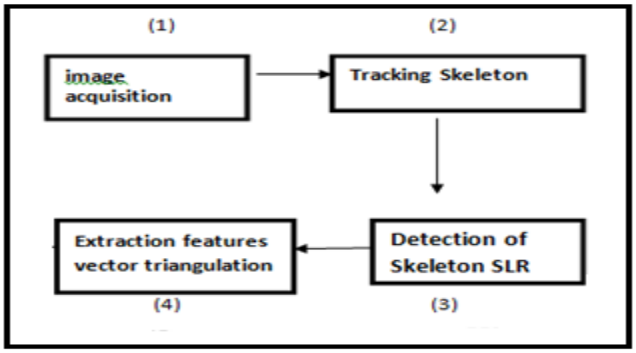

Figure 4. Stages of Measurement SLR

Figure 4 is a research method which comprises six blocks stages of the process. In diagram (1) is preparation include image acquisition of RGB camera image into grayscale-depth. Kinect image acquisition in real time video from cameras and camera RGB Depth was set up at the same time. These two real video displays may appear when enable. RGB and enable.Depth is successful. When unsuccessful, the necessary checks whether Kinect both RGB camera and an infrared sensor and component-komponenya well connected. The algorithm for this initial preparation will only access the Kinect and Kinect library is installed and connected to the computer, so that the processing start and run algorithms. Perform action into the area and facing the Kinect, it is one of the core actions. Kinect has a depth of color of the pixel in the image depthc representing how far away it is, the picture is brighter because it is closer and I'll be darker when more away from Kinect. In this research kinect distance to the object on the bed about 10 feet. Diagram (2) is process diagram after the set-up and image acquisition successfully established skeleton framework that is tracked throughout the body. The purpose of the track skeleton on the body is to allow the user to observe the movement of the lower body from hip to foot. Diagram (3) is process extraction feature by measuring the angle between the two feet in an SLR. feature extraction skeleton by forming vector is a vector that combines the two skeleton between the hip center to the knee right or knee left. And diagram (4) finally determine the angle SLR as the degree ROM for early detection of LBP and feature SLR is a angle in degree then analysis for early detection LBP and can store all data of people with disorders of LBP in a database.

To find the angle between the legs on the SLR, vector formed from the hip joint center to the right knee joint and hip vector from center to left knee, then by normalizing the vector in the coordinates of the angles between the two legs formed is θ as shown in Figure 5.

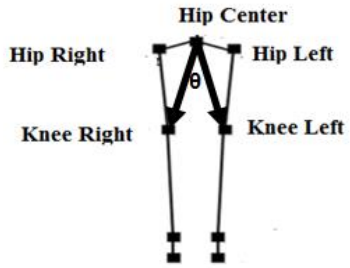

Figure 5. Angle between 2 Vectors

Based on the formula of trigonometry vectors in Figure 5 can calculate θ-angle described by the following algorithms :
//Convert Point To Vector :
Vector3D vectorA = KneeRight - HipCenter;
Vector3D vectorB = KneeLeft - HipCenter;

And the angle calculation is done by taking only two axes of 3D vector, that Y and Z with the following code:
//convert 3D to 2D
Angle = Math.Atan2 (vectorB.Y,vectorB.Z) - Math.Atan2 (vectorA.Y,vectorA.Z).

4. Results and Analysis

Results of the measurement SLR in blocks diagram is shown in Figure 5 subjects who entered the coverage area of Kinect, slowly lying in bed, then did a little hand until the entire skeleton body movements tracked. Then began a movement to lift one leg up (SLR) and the legs stop in a position that feels uncomfortable or painful. At the time of movement terminated when discomfort or pain, and movement as well as the of the degree appear on the screen as well as applications store data and stop recording. Then it can be further analyzed to determine the diagnosis and the development of pain by a physician.

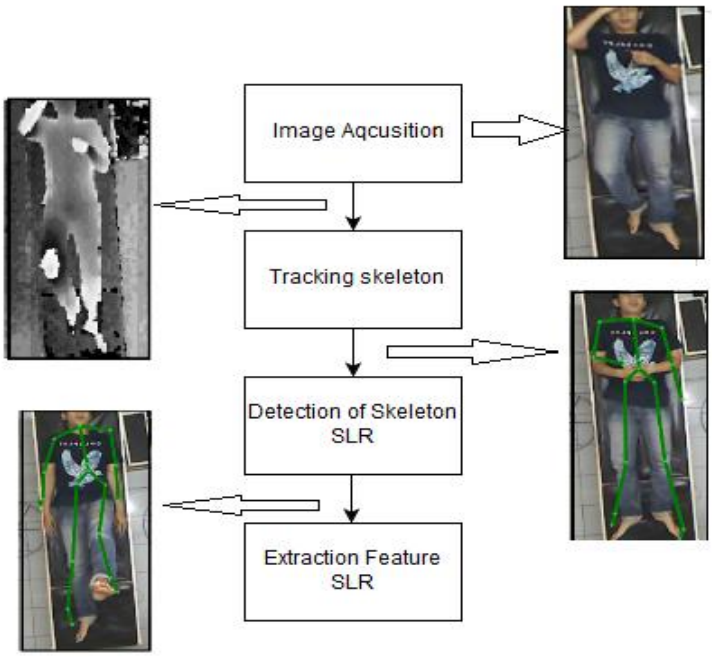

Figure 6. Result of Images SLR

Figure 6 was described results of Figure 4. After capture by Kinect was a real video in format RGB. If images were success displayed and Kinect detects that the user exists as a candidate for the detection process skeleton joints users and access information or draw something in depth image. Image depth as input data. If that process was successful then skeleton human body will appear or full tracked. After all of skeleton tracked, then skeleton detection can be performed SLR and specifies vectors of both legs in SLR. SLR angle appears onscreen display based formulas in Figure 5 and will be stored in a database at the time of the raised leg to stop the pain center.

Test is conducted on 12 healthy individuals of different sizes and different heights. To prove the accuracy of the measurements with kinect then performed manual measurements (goniometer) to be compared. Comparing these is presented in the following Table 1.

Table 1. Result of Measurement In Real Time (Kinect) and Manual (Goniometer)

#	Gender	Goniometer	Application SLR	Difference	Precentage of difference
1	Male	40	41,3	1,3	3,25%
2	Male	60	63,9	3,9	6,50%
4	Male	58	54,6	3,4	5,86%
6	Male	53	51,2	1,8	3,40%
7	Male	65	66,5	1,5	2,31%
8	Male	48	52,2	4,2	8,75%
9	Female	47	51,5	4,5	9,57%
10	Male	51	47,9	3,1	6,08%
11	Male	69	65,8	3,2	4,64%
12	Male	45	43,1	1,9	4,22%

Table 1 consits of data: gender, result of goniometer, result of SLR application, difference and precentage of difererence. Based on the results of the retrieval object data then obtained a percentage of the difference is used to determine the difference between the angle measurements using SLR and manual application (goniometer). After the value of the percentage difference is obtained, it can be calculated the percentage value of the application angle measurement error in the amount of data 10 data objects. From results of these calculations are 5.46%. The accuracy of the application this SLR is 100% - 5.46% = 94.54%.

5. Discussion

While visibility sensor was the same as the color camera that 58 degrees horizontal, vertical 45 degrees with 70 degrees diagonal, and the operating range is between 2.7 feet- 13 feet. The minimum distance required is used to capture the object on Kinect approximately 10’5”.[17]. Though it happens rarely, but detect the user and skeleton tracking can fail if the user has the shape of the body that are not usually for example, if they are extraordinarily high, with a height of 6'6 "and under 200 pounds. That means placing Kinect position should be higher towards ceiling high is also limited, it was one of an obstacle anymore. Because in this paper, there Kinect position at 7'2 " of the bed. This constraint occurs because the user's position in a state of lying, it will be easier and succeed when the user is standing position according to the specifications that belongs to the Kinect is a standing position. But this means my research proved that Kinect can be done in a lying position with anticipate Kinect position above the user's position. Then measurements with goniometer require speed and accuracy in reading and tool holding very is stable, especially the legs lifted by the user also has to be stable as well overcome the pain [18]. Therefore the use of Kinect device is promising enough to test SLR easily, quickly and accurately.

6. Conclusion

Based on the analysis and testing of human object data to test SLR that there is a promising potential of the Kinect device. Of all the joints are tracked by Kinect, the study found that the joint tracking relevant for use in detecting problems early recognition of the disease spinal pain, one of which is the early detection of disorders LBP. Data collected from the joint position of 12 people of different gender, height, and body type. In this study conducted in healthy individuals, are expected in the future can be performed on patients with lower back pain condition. From the angle and the pain, the paramedics can detect pain based on symptoms and other supporting factors for further confirm the disorder diagnosis LBP. The accuracy of the measurement results is support for physician diagnosis and data can be stored in a database that can later be reused in patients with a history of spinal disorders and also in monitoring patient's medical rehabilitation.

References

[1] Ehrlich GE. *Low Back Pain*. Bulletin of the World Health Organization. 2003; 81: 671-676.
[2] US Dept. of Health and Human Services, Public Health Service, Office of the Surgeon General. Bone health and osteoporosis: A report of the Surgeon General. Rockville, MD: US GPO; 2004: 436.
[3] Majlesi J,TogayH,Unalan H, Toprak S. The sensitivity and specificity of the Slump and the Straight Leg Raising tests in patients with lumbar disc herniation. *Journal of Clinical Rheumatology : Practical Reports on Rheumatic & Musculoskeletal Diseases*. 2008; 14(2): 87–91.
[4] Ho-Guen Chang, Young-Gun Lee. Natural History and Clinical Manifestations of Lumbar Disc Herniation. *J Korean Soc Spine Surg*. 2001; 8(3): 305-313.
[5] Hamilton H, McIntosh G. Passive Straight Leg Raise Test: Definition, Interpretation, Limitations and Utilization. *Spine Health: Journal of Current Clinical Care.* 2014; 4(6).
[6] Taylor PE, Almaida GJM, Kanade T, Hodgins JK. *Classifying Human Motion Quality for Knee Osteorthritis Using Accelerometers*. 32nd Annual International Conference of the IEEE EMBS, Buenos Aires, Argentina. 2010.
[7] Karnath B. Clinical Signs of Low Back Pain. 2003; 5: 39-44.
[8] Fabunmi AA, Awakan TA. Straight leg raising test - a comparison of two instruments, Journal of theRomanian Sports Medicine Society. *Medicina Sportiva.* 2015; XI(3): 2617-2620
[9] Fernandez-Baena A, Susin A. *Biomechanical Validation of Upper-Body and Lower-Body Joint Movements of Kinect Motion Capture Data for Rehabilitation Treatments*, IntelligentNetworking and CollaborativeSystems (INCoS), 4th International Conference on IEEE, Bucharest. 2012.
[10] Naofumi K, Eijiro A, Takashi M, Jun-ichi M. *KINECT Applications for the Physical Rehabilitation.* Medical Measurements and Applications Proceedings (MeMeA). IEEE International Symposium. 2013: 294 - 299
[11] Sinha S, Deb S. Depth Sensor Based Skeletal Tracking Evaluation for Fall Detection Systems. *International Journal of Computer Trends and Technology (IJCTT*). 2014; V9(7): 350-354
[12] Tupa O, Prochazka A, Vysata O, Schatz M, Mares J, Valis M, Marík V. *Motion tracking and gait feature estimation for recognising Parkinson's disease using MS Kinect*. Biomed Eng Online. 2015; 14: 97
[13] LaBelle, Kathryn. *Evaluation of Kinect Joint* Tracking *for Clinical and in Home Stroke Rehabilitation Tools.* Notre Dame. 2011,
[14] Nitescu D. *Evaluation of Pointing Startegies for Microsoft Kinect Sensor Device.* 2012.
[15] Khoshelham K, Elberink SO. *Accuracy and Resolution of Kinect Depth Data for Indoor Mapping Applications*. The Netherlands. 2012.
[16] Jana A. *Kinect for Windows SDK Programming Guide.* Mumbai: Packt Publishing. 2012.
[17] Webb J, Ashley J. *Kinect Programming with Microsoft Kinect SDK.* Apress Publishing Pte Ltd. 2012
[18] Richey R. *Goniometric Assement.* NASM Faculty Instructor. 2015: 9-10