

Study on Determining Scoliosis Using Depth Image

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Abstract. Scoliosis is a 3 dimensional spinal deformity when flank deviation or rotation occurs to one or two spines by leaning to the side from the anatomical center of axis. If the treatment starts in an early age, the chance of correction is higher and as the age increases, the correction effects decrease. Therefore, early detection and treatments are important. To diagnose scoliosis, there are many methods including Adams forward-bending test, radiologic examination, neurological examination, thoracic spine, lumbar, pelvic topographies, balance ability measurement and body shape measurement using Moiré Topography. Moiré Topography is a method to obtain the 3 dimensional image of trunk shape. It is a safe, accurate and simple measurement method that is used in mass screening of scoliosis. In this paper, to detect scoliosis early the method to determine scoliosis was proposed using depth image of human back.

Keywords: Moiré Topography, Back measurement, Scoliosis, Kinect sensor, Depth sensor

1 Introduction

Scoliosis is a 3 dimensional spinal deformity when flank deviation or rotation occurs to one or two spines by leaning to the side from the anatomical center of axis. Scoliosis causes disorders in daily life including chronic fatigue, poor concentration, digestive disorders, pain, illness and etc. In addition, severe thoracic spine curvature causes the thoracic malformation, resulting in the respiratory dysfunction and may lead to the secondary damage to the cardiac function [1]. For structural scoliosis cases which leave severe disorder, about 70~80% are occupied by idiopathic scoliosis and in most cases the specific cause is not identified. The idiopathic scoliosis shows mainly the adolescent spinal deformity. It usually appears between the periods of completing the growth at age of 10 and is developing rapidly between ages of 12 and 16 [2]. To diagnose scoliosis, there are many methods including Adams forward-bending test, radiologic examination, neurological examination, thoracic spine,

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lumbar, pelvic topographies, balance ability measurement and body shape measurement using Moiré. If the treatment starts in an early age, the chance of correction is higher, and as the age increases, the correction effects decrease. In addition, if it is detected early and the initial scoliosis angle is low, the correction effect will be high. Scoliosis can't be just a cosmetic problem, but it becomes factors to cause the dysfunction due to the abnormal organ position, especially lowering of cardiopulmonary function and all kinds of pains so the early detection and appropriate treatments are necessary. Despite the importance of early detection and early treatment, the detection of scoliosis is late not only because most of scoliosis does not have pain and parental awareness about the scoliosis is lacked, but also as the children enters puberty, they don't want to show their bodies to their parents [3].

In this paper, in order to determine scoliosis by oneself just obtaining the simple image, the study has been conducted for the method determining scoliosis by obtaining the rear image using Kinect sensor. As a result of experiment, it is confirmed that the depth image of Kinect sensor can be applied to scoliosis determination.

2 Moiré Topography

Moiré Topography is a three dimensional method to obtain the 3-dimensional image of trunk shape which is used in mass examination of scoliosis in Japan, Canada and Singapore [4][5]. Moiré screening method has high sensitivity because it checks the trunk imbalance by obtaining the three-dimensional image of trunk. Figure 1 is a Moiré topographic image taken the human back [6]. This method has been reported that it is exactly matched with simple radiographic examination findings than Adams forward-bending test, and the false-positive findings have no statistically significant differences with Adams forward-bending test [7].

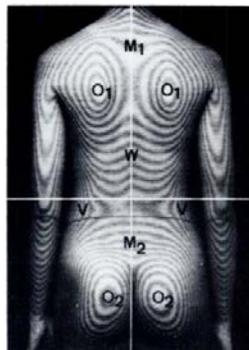


Fig. 1. Moiré fringe topograph of a normal subject

Moiré topographic image determines the scoliosis by checking the number of contour, height of left and right shoulder, angle of left and right shoulder, the distance between right and left based on pelvic reference line, interval between pelvic reference line and neck reference line, the ratio between thoracic and lumbar spines

and misalignment between thoracic and lumbar spines. Table 1 shows criteria to determine the abnormal findings when analyzing the Moiré Topographic image.

Table 1. Scoliosis determination criteria in Moiré image analysis

Analysis items	Decision criteria
Difference in the number of contours (shoulder, chest, lumbar)	1: Normal, 2: Re-examination, 3 or more: Consult a specialist
Difference in shoulder height	When the difference between right and left shoulder height is more than 0.5 cm
Difference in shoulder angle	When the difference between right and left shoulder angle is more than 4 degree
Distance difference in right and left based on pelvic reference line.	When the distance difference between right and left is more than 1 cm
Interval difference in pelvic reference line and neck reference line	When the interval difference between two reference lines is more than 1 cm
Ratio of thoracic spine and lumbar spine	All ratios except 6:4 and 5:5
Misalignment between thoracic spine and lumbar spine	When there is a misalignment between thoracic spine and lumbar spine

3 Scoliosis Determination using the Kinect Sensor

3.1 Kinect Sensor

In this paper, the human back depth image is obtained to determine scoliosis using Kinect sensor in Figure 2. Kinect is composed of RGB Camera, two Depth Sensors, four Multi-array Microphone and Motorized Tilt.



Fig. 2. Microsoft Kinect Sensor

Since Kinect recognizes the user information using RGB Camera, Depth Sensor and Multi-array Microphone, it can control the interface and interact through the user's gestures and speech without a separate controller. From the simple computer software operation such as mouse control through the user's motion to the medical procedure simulation and assistive devices for disabilities, the ideas using Kinect human body recognition technology is very diverse [8]. Especially, it is used as technology for new application in the fields of motion recognition or image processing [9].

3.2 The Proposed Method

Figure 3 is the experiment for obtaining the rear image using Kinect sensor. The subject places the feet on the established reference line and stares straight ahead in releasing the tension of the body and standing upright. Raise the Kinect sensor to the height of 100cm from the ground and take the rear image after exposing parts above the gluteal region of subject.

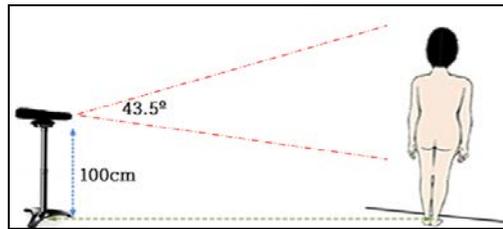


Fig. 3. The rear image acquisition method using the Kinect sensor

Figure 4 is the flow chart to output the rear contour image of human body using Kinect sensor. Using Player ID information of Depth data, if the Player ID is 0, it is determined as a background. If Player ID is not 0, meaning that it recognized a person, it obtains 13bit depth data of that pixel. To express the acquired 13bit depth data into the image, it is converted to 8bit data using Formula 1. The equalization is performed as a pre-processing procedure to sharpen the contour of Depth image acquired by conversion. Finally, the natural contour image can be obtained with Median Filter.

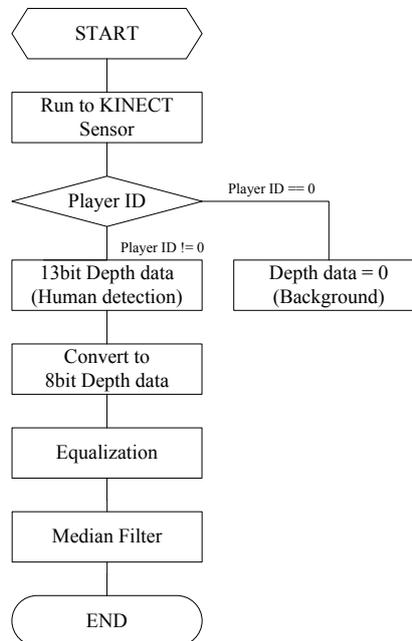


Fig. 4. The rear image acquisition flow chart using the Kinect sensor

$$C(i, j) = 255 - (255 \times \frac{D(i, j)}{0x0fff}) \quad (1)$$

$C(i, j)$: Converted 8bit depth pixel
 $D(i, j)$: 13bit depth pixel

3.3 Experimental Result

Figure 5 is contour images acquired when the Kinect sensor is located at 100cm height from the ground and 150cm distance from the reference line. If the acquired 13bit depth data is converted to 8bit data, the image shown in Figure 5 (a) is obtained. When the equalization is applied to the image in Figure 5 (a), the image which is able to check the height of rear is obtained as shown in Figure 5 (b). Finally, by processing Median filter, the unwanted noise is disappeared and the smooth contour like in Figure 5 (c) can be obtained.

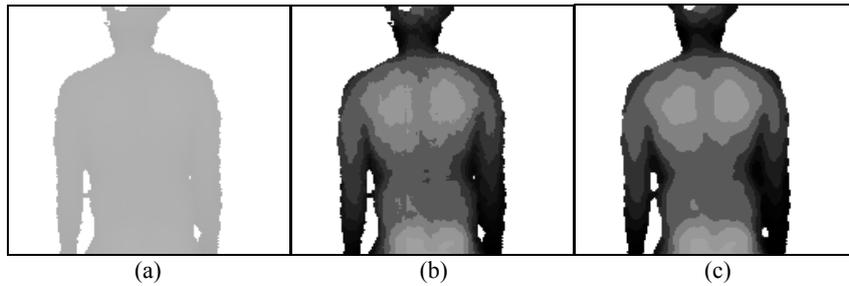


Fig. 5. Image pre-processing: (a) Grayscale image, (b) Equalization, (c) Median filtering

Figure 6 is an image of analyzing the contour image acquired after pre-processing in Figure 5. Through the line (a) in the figure, the height difference of left and right shoulder is checked and by calculating the height and slope of (b₁) and (b₂), the differences of width and height of the scapular region is checked.

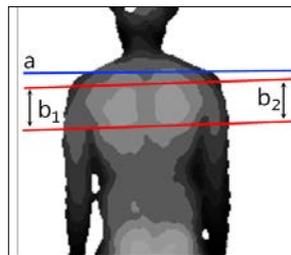


Fig. 6. Analysis Result Image

According to experimental results, it is confirmed that the shoulder height and position of the scapular region can be determined from this experiment through the analysis of depth image obtained with Kinect sensor as shown in Figure 6.

4 Conclusions

In this paper, the method to determine scoliosis was proposed using depth image of human back and Moiré Topography. To analyze acquired contour images, the height difference of right and left shoulder was checked by connecting the both ends of left and right shoulder points as a straight line like line (a) in Figure 6. In addition, the difference and slope of right and left scapular area was checked by connecting the most top point and the bottom point of area that has the highest pixel among depth areas in the scapular region as a line. As a result of analyzing the contour image obtained by distance, it was confirmed that all had the same results regardless of distance. From experimental results, depth image using Kinect sensor has the similar contour shape with Moiré Topography. Therefore, the information acquired from Kinect sensor can be applied to the topography, and it is expected to be able to utilize in self-determination of scoliosis.

Acknowledgment

This work was supported by the Ministry of Knowledge Economy (MKE), Rep. of Korea, under the IT R&D program supervised by the KOREA Evaluation Institute of Industrial Technology (KEIT) (10041059).

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