Poster: Kinect-based Automatic Scoring System for Spasmodic Torticollis

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Abstract

Displacement and shaking of the human body are essential measures for the scoring of movement disorder. The aim of our research is to increase the accuracy and reproducibility of the scoring for spasmodic torticollis, a movement disorders that is characterized by poor head-posture. Although there are conventional scoring methods for torticollis severity, such as the Tsui Scale or TWSTRS, the results obtained are sometimes inaccurate or non-reproducible because these tests are performed manually. To capture the posture of patients' heads and bodies, we used Kinect, a three-dimensional depth sensor, and tracked their faces and bodies in real time. Using obtained data, the system automatically calculates TWSTRS without any special knowledge and training. An experiment comparing the accuracy of the system with medical specialist suggests that our system is sufficiently accurate.

Keywords: Kinect, Spasmodic Torticollis, Automatic Scoring.

Index Terms: H.5.2 [Information Interface and Presentation (e.g., HCI)]: User Interfaces— Evaluation/methodology

1 Introduction

Spasmodic torticollis is a movement disorders that is characterized by involuntary rotation and shift of the patient's head, caused by abnormal muscle activity in the neck (Figure 1) [1]. Treatment for spasmodic torticollis includes botulinum toxin injection into the dystonic muscle of the neck, which is not always economically and mentally affordable. To solve this problem, several studies have been conducted to develop a new low cost treatment [2].

To develop an effective treatment for torticollis quantitatively scoring (i.e., evaluating) the severity of the disorder is essential. There is a standard scoring method such as Toronto Western Spasmodic Torticollis Rating Scale (TWSTRS)[3]. TWSTRS consists of three scales: the Torticollis Severity Scale, assessing the posture of the neck and shoulder; the Disability Scale, assessing the effect on daily life; and the Pain Scale, assessing pain caused by torticollis.

These scoring are primarily done based on visual observation by medical specialists, which means that the accuracy of the scoring results depends on the skill of the rater. Therefore the scoring results cannot be compared with each other [4]. For the development of new treatments for torticollis, an accurate and reproducible scoring method is required.

Until now, three-dimensional measuring systems and wearable devices have been used to solve this problem [5]. However, these systems are expensive and require a skilled person to operate them, which has prevented their use from spreading.

Considering this background, we developed a low-cost and portable scoring system using Kinect for Windows, a gaming controller sold by Microsoft. The system automatically measures the posture of patients and assesses the severity of torticollis. With this system, we aim to supply an accurate, reproducible, and low-cost scoring method.

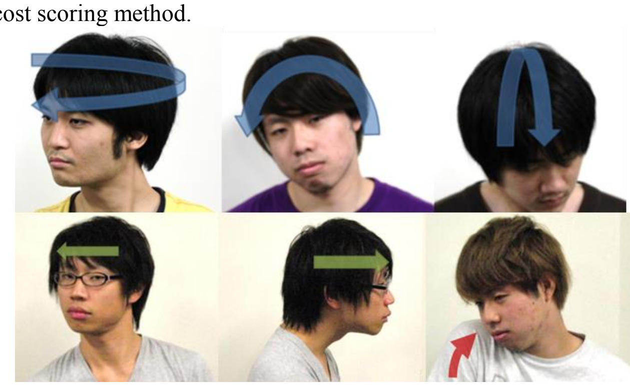

Figure 1: Spasmodic Torticollis is characterized by involuntary rotation and shift of head

2 System for Scoring the Posture

Kinect for Windows is a three-dimensional measuring device that can be used with a Windows PC and costs 250USD. This cost is low compared with that of conventional three-dimensional measuring devices. We developed software using the sample code "Face Tracking Basic" in the Kinect SDK, which detects and tracks human faces captured by Kinect.

Our system allows us to calculate TWSTRS-severity, a widely used scoring scale for torticollis severity. TWSTRS-severity is a subscale of TWSTRS and has ten items to assess [3]. Items in the TWSTRS-Severity are A: Maximal Excursion (including 5items; A1 through A3 are the three axes of the patient's head, and A4 and A5 are lateral and forward/backward displacement of the head), B: Duration Factor, C: Effect of Sensory Tricks, D: Shoulder Elevation / Anterior Displacement, E: Range of Motion, and F: Time.

The meaning and measurement method of each item are as follows. First, the system measures head, shoulder, and back posture. In this measurement, the system obtains 100 samples in 10 seconds (a 10 Hz sampling rate). The measuring targets for A1 through A3 are the displacement of the head angle along three axes (Figure 2(a)). The system measures the relative angles of the body and the neck, and the average angles obtained are applied to the TWSTRS-severity scale.

In A4: lateral shift, the simple method is to measure the lateral motion of the nose. However, this motion cannot be discriminated from rotation around the yaw-axis, or from rotation around the roll-axis. To cope with this problem, we connected the nose and chin with a line, and shifted the line to the vertex (top) of the head. We then measured the distance between the shifted line and the origin of the neck. The system judges if the patient has a lateral shift of the neck or not from the measured distance (Figure 2(b)).

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In A5: sagittal shift, the system measures the neck angles estimated from the vertex (top) of the head and the origin of the neck (Figure 2(c)). The system uses the estimated angles to judges whether the patient has a sagittal shift.

In B: duration factor, the system measures the time of the maximal deviation of symptoms in fixed time.

In C: sensory tricks, the system measures and assesses the improvement from the symptoms in A1 through A3when the patients' hands touch parts of the head such as the cheeks, known as sensory tricks (Figure 2(d)).

In D: shoulder elevation, the system asks patients to move their left and shoulders up and down alternatively, and measures the range of the shoulder motion Figure 2(e).

In E: range of motion, the system measures patients' range of head motion in the opposite direction from the symptoms.

In F: time, the system measures the duration for which patients could maintain their heads within 10°of the neutral position.

Combining all these measurements, our system established completely automatic scoring of A1 through A5, and B. For C through F, we established automatic scoring with instructions to patients.

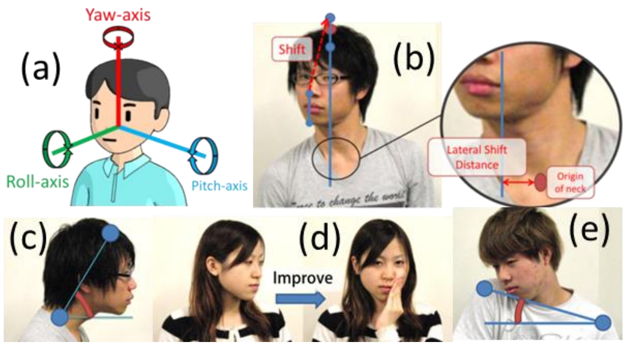

Figure 2: (a)Basic three axes measurement, (b)Distance of the lateral shift of the head, (c)Angle of neck estimated by the two points, (d)Improvement caused by the sensory trick, (e)Angle of shoulder elevation

3 ASSESSING VALIDITY OF THE SYSTEM

We conducted an experiment to show that the system is capable of scoring patients with torticollis, comparing the results with a medical specialist. In this experiment, participants' facial orientation was measured by the system, the visual observation of medical specialist, and a standard-sensor that gives "correct" values. The measuring targets were the yaw-axis, roll-axis, and pitch-axis of the head, which corresponds to A1 through A3 on the TWSTRS-Severity Scale (Figure 2(a)).

Visual observation was performed by a medical doctor who specialized in movement disorders including spasmodic torticollis. The measurement was taken over 10 seconds using the Kinect-based system located 1.0 m away from the participant. The angles were averaged and treated as the result of the measurement. The accelerometer and geomagnetic sensor of a smartphone (Xperia acro HD, SONY) were used as a standard sensor, by strapping the smartphone on the forehead using a headband. The accuracy of the smartphone was previously validated by mounting the smartphone to a wood block, and the errors along the roll and pitch-axes were around ±2°, and the error along the yaw-axis was around ±4°, which were well below those of visual observation and our Kinect system.

We recruited ten healthy laboratory members aged 21 through 25 (seven male, three female) for the Kinect measurement. We recruited five laboratory members aged 21 through 26 (five male) for the measurement using the visual observation of the medical specialist. In both measurements, participants were asked to rotate their heads to simulate a patient with torticollis. They initially took a neutral posture and the standard sensor measured the initial posture. Then, they started to act like a patient. The posture of the head was measured by standard sensor, the Kinect or the medical specialist. Each participant acted out 10 different head postures and was measured each time.

Table 1 shows the combined results of two measurements. TWSTRS, the conventional scoring scale for torticollis, add points for each 20°of head rotation in the yaw-axis, roll-axis, and pitch-axis [3]. Therefore, a ±10°deviation from the correct angle is regarded as a permissible range for TWSTRS. In the measurement performed with our system, more than 70% of the data from all three axes were within the ±10°range. In the measurement performed by the visual observation of the medical specialist, although more than 70% of the data from the roll-axis and pitch-axis were in the ±10°range, only 44% of the data from the yaw-axis were within the range.

Table 1. Data distribution with error ranges

	Yaw-axis		Roll-axis		Pitch-axis	
	Kinect	M.S.	Kinect	M.S.	Kinect	M.S.
±5.0°	39%	18%	48%	64%	53%	56%
±7.5°	55%	32%	61%	81%	73%	66%
±10.0°	71%	44%	76%	90%	84%	72%

4 CONCLUSION AND FUTURE WORK

In this paper, we developed a torticollis scoring system using Kinect to create a standardized scoring method with high accuracy and reproducibility. Assessing the accuracy of the system compared with visual observations by a medical specialist indicated that the system has comparable performance.

In future works we will apply this system to real patients and compare the TWSTRS score with that of a number of medical doctors who specialize in movement disorders. We will also assess other kinds of symptoms of spasmodic torticollis, such as head tremor, which are hard to quantify by visual observation. Moreover, we will extend our system to other diseases with similar symptoms, such as Parkinson's disease.

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