A Computerized Measurement of CROM (Cervical Range of Motion) by Using Smartphone Based HMD (Head Mounted Display)

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Abstract. This paper proposes a computerized measurement of cervical range of motion (CROM) without the help of experts. We aim to develop a reliable and easy-to-use application for CROM by using smartphone based head mounted display (HMD). This healthcare application provides a measuring instrument for 6 cervical motion and tangible visualization for the active cervical ROM data. This computerized approach will increase the accuracy of measurement of CROM by providing real-time feedback for the correct posture during examination.

Keywords: Cervical range of motion · Head mounted display · Computerized measurement · Healthcare application

1 Introduction

According to the Korean National Health Insurance Corporation, the number of patients with cervical disc herniation has increased from 573,912 in 2007 to 784,121 in 2011. The growth rate of patients with the neck disease was 29.7 % compared with 2009, much higher than 18.4 % of increase in spinal herniated disc patients during the same period. In terms of age, patients in their 20 s have seen the largest increase, with those in their teens and 30 s following. Cervical herniated discs, which used to be known as a degenerative disease that occurs in people in their 40 s to 60 s, has become more common in younger generations. In particular, high usage of smartphones and tablets causes a surge of cervical herniated disc patients. When using smartphones, people have their head bowed, which strains the neck and causes herniated discs. Whilst a human head weighs approximately 10 lb, staring at a phone with your head tilted forward will feel more akin to a 20 to 30-pound load.

2 Computerized Measurement of Cervical Spin Motion

2.1 Function

Measuring the active CROM is essential in objective assessment of neck symptomology and the effects of any intervention [1, 2]. The limitations of CROM may

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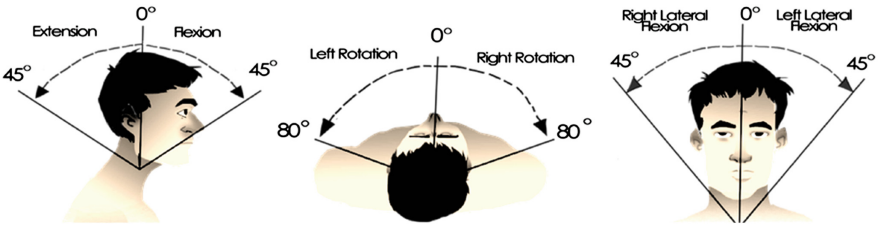

Fig. 1. General cervical range of motion

indicate musculoskeletal disorders, neck pain resulting from trauma or idiopathic [3, 4], headaches [3, 5–7] or some dysfunctions in the temporo-mandibular joints and masticatory muscles [7–9].

In spite of cervical ROM being such a frequently studied impairment, the accuracy of this measure as a diagnostic tool has been controversial due to conflicting evidence concerning its specificity and sensitivity [10, 11]. This paper aims to propose a computerized measurement of cervical range of motion (CROM) by using smartphone based head mounted display (HMD) (Fig. 1).

2.2 System Overview

To develop a reliable and easy-to-use method, we introduce Gear VR, smartphone based HMD. HMD is a display device, worn on the head, that has a small display optic in front of each eye. In order to provide a realistic 360° immersive experience, the HMD must be tracked with fast update rates, low latency with no jitter. Head tracking is used to generate the appropriate computer-generated imagery (CGI) for the angle-of-look at the particular time (Fig. 2).

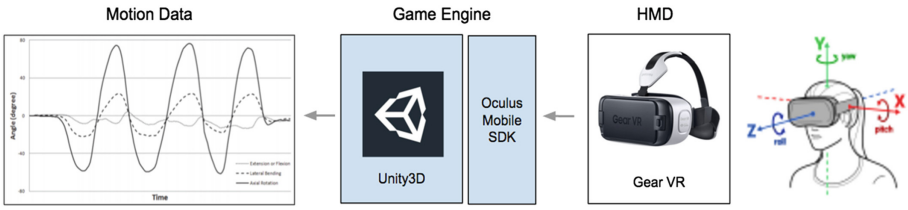

Fig. 2. HMD to data stream

This allows the user to "look around" a virtual reality environment simply by moving the head without the need for a separate controller to change the angle of the imagery. In this paper, we use Gear VR to track the 3-axis orientation of head for the measurement of CROM. Gear VR includes a special IMU for head tracking which updates at a 1000 Hz, where most phone sensors only do 100 Hz or 200 Hz. This IMU is more accurate and well calibrated with lower latency than internal smartphone IMUs.

3 Implementation

We developed a mobile healthcare application by using Unity3D, a commercial game engine. By using head tracking technology of HMD, this application provides measuring instruments for 6 cervical motion the flexion, extension, right lateral inclination, left lateral inclination, right rotation and left rotation. In the application, user interaction is designed for participants to spin his or her head for the measurement of CROM without the help of experts. For the accuracy of measurement, real-time feedback will be presented to maintain the correct posture during examination (Fig. 3).

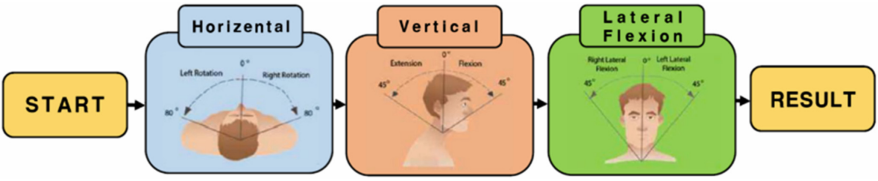

Fig. 3. Diagnosis flow

The mobile healthcare application aims to provide the active cervical ROM data of the six motion of the cervical spine in a more clear and effective way. To archive this, we design and implement tangible visualization like the figure considering immersive display of HMD. This approach will help the user understand the measurement results of CROM easily comparing with reference values for normal CROM (Fig. 4).

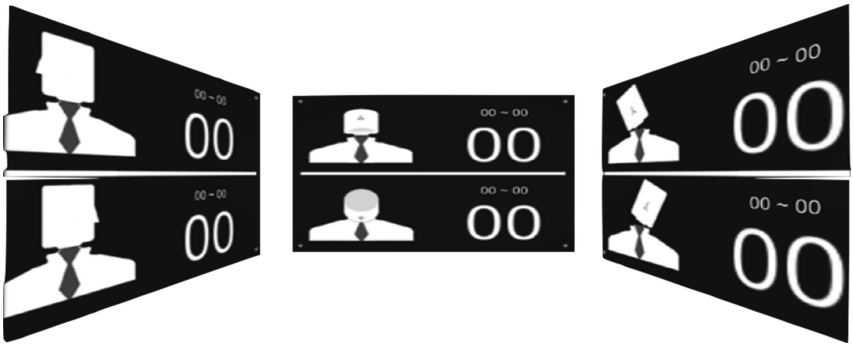

Fig. 4. Representation of diagnosis results using HMD

4 Conclusion and Future Work

In this paper, we proposed a reliable and easy-to-use healthcare application for accessing CROM using smartphone based head mounted display (HMD). This application provides a measuring instrument for 6 cervical motion and tangible visualization

for the active cervical ROM data. This computerized approach will increase the accuracy of measurement of CROM without the help of experts. In addition to measuring the limitation in cervical ROM, velocity and smoothness of motion will be also examined. And, we will develop a game like application for exercise as well as measurement of CROM (Fig. 5).

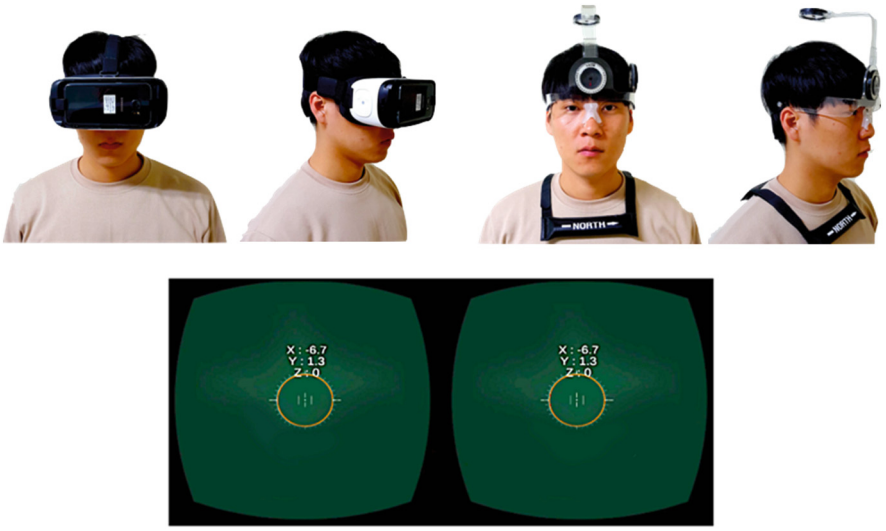

Fig. 5. Computerized measurement using gear VR and CROM3. Screenshots of computerized measurement

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