Sitting Posture Recognition System-Supervise Dentist to Maintain a Neutral Body Posture

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Abstract: As the professional Nature of the dentist, uncomfortable sitting posture will increase the risk of suffering from shoulder-neck disease. For a healthy and productive career, the dentist suggested to maintain a neutral, balanced seated posture. Therefore, an intelligent system to supervision dentist to keep suitable sitting posture is urgent needed. This article presents a real time dynamic sitting posture recognition system researched and developed for dentist to maintain a neutral body posture (NBP). The system uses RGB-D camera to capture and calculate the 3D coordinates of markers paste on the coat. With the 3D coordinates, the back, neck and arm posture can be characterization with the angles between back, neck and arm with long axis of the body. So, the system can recognize sitting posture accurately without any wearable sensor. The system has been successfully tested with many people under varying light conditions. The experiment results show that the angle error of the system introduced in this paper is less than 5 degrees.

1. Introduction

Although the theme of the dentist's posture is treated with great care and often presented in the undergraduate courses and the continuing education courses on ergonomics in dentistry. However many dentists cannot use them in practical applicability. Unfortunately, many dentists are in the situation of feeling the negative effects of unbalanced postures in the first years of practice. In case musculoskeletal disorders arise, they should take correcting actions and compensatory measures in order to compensate the negative effects of the unbalanced posture. Each dentist who feels responsible for his health should reassess his working posture. A good posture is not a luxury and it does not require major investments but a rethinking of the way of working. The dentists should not live their professional life in terms of discomfort and musculoskeletal disorders perspective.

The neutral body posture is the posture the human body naturally assumes in microgravity [1]. Adopting any other posture while floating requires muscular effort. The risk and perspective of the musculoskeletal disorders related to unbalanced postures should determine the dentist take postural corrective actions and compensation measures in order to limit the negative effects of working in a bad posture. For a healthy and productive career, the dentist suggested to maintain a neutral, balanced seated posture. Therefore, an intelligent system to supervision dentist to maintain a suitable sitting posture is urgent needed.

Several articles were proposed for sitting posture detection or recognition. There are two main kinds for sitting posture measurement: image processing technology [2] [3] and sensor-based [4]-[8]. In [2], a surveillance system for human sitting posture is presented. The goal of the proposed stem is to prevent myopia and backbone/neck diseases caused by using computers. First, the profile of sitting posture is extracted. By comparison of the real-time profile features and the standard profile features, the surveillance system will remind the user to correct sitting posture. In [3], on the basis of detecting human skin area, 8 typical sitting postures were recognized using PCA. In [4], this article demonstrated the usage of a bed-based optical pressure sensor array to recognize sitting and lying postures. Data was collected using a pressure sensor array and video cameras.

In this article we propose a system for information capture and analysis of dentist`s sitting posture

with image processing technology. The system includes a suit of clothes with special markers paste on head, back and arm and two RGB-D cameras to capture the 3D coordinates of the markers. We analyze the captured information for recognizing and evaluation the sitting postures based on neutral body posture. With this system, when practice of dentistry, dentist could develop a good sitting posture habit to avoid suffering from shoulder-neck disease.

2. Sitting posture recognition system

As diseases of shoulder-neck usually occur because of unsuitable sitting posture, so suitable sitting posture is very important to dentist. However, how to detect and correct the sitting posture is an essential technology recently. In the following subsections, we introduce the definition of neutral body posture, and present the characterization of these posture for detection and recognition in this system. Then, we present how to capture these characterizations and evaluate postures. Because of monocular viewpoint is quite limited and prone to occlusion. Therefore, at last we present a multiple viewpoints method to avoid posture occlusion.

2.1 The definition of neutral body posture [9]

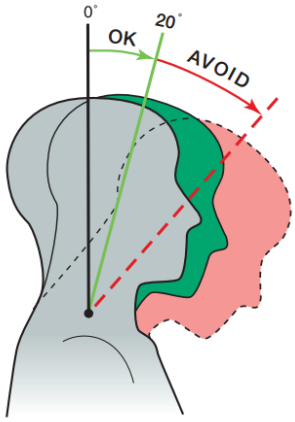


Figure 1. Neutral Neck Position

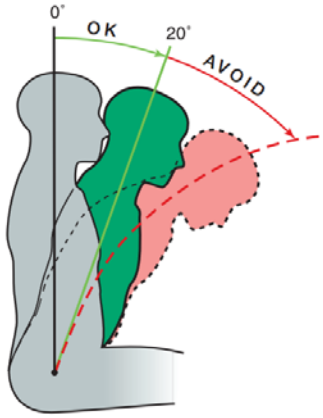


Figure 2. Neutral Back Position

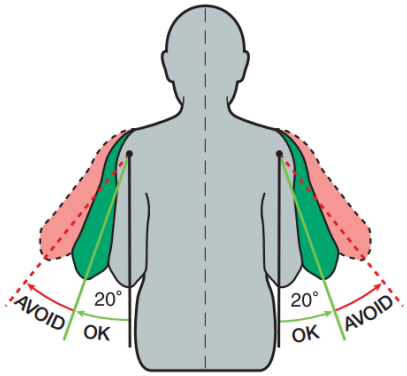


Figure 3. Neutral Upper Arm Position

In the system we observe only parts of neutral body posture, neutral neck position, neutral back position and neutral upper arm position. The definition of these position are as shown in the figures. As Fig. 1, neutral neck position require head tilt of 0 degree to 20 degree, and the line from eyes to the treatment area should be as near to vertical as possible. What's more, head tipped too far forward or tilted to one side should be avoid. As Fig. 2, the goal of neutral back position is leaning forward slightly from the hips (hinge at hips) and trunk flexion of 0 degree to 20 degree. And avoid over flexion of the spine (curved back). As Fig. 3, neutral upper arm position asks upper arms hang parallel to the long axis of torso and elbows at waist level held slightly away from body. Greater than 20 degree of elbow abduction away from the body or elbows held above waist level is forbidden.

According to the definitions, we use head tilt, trunk flexion and elbow abduction angles to characterize head, back and upper arm postures in this system.

2.2 Posture recognition and evaluation

To mark the position of the joints, 12 markers with different patterns is designed and paste to specific locations on the coat (As shown in Fig. 4). Get the RGB and depth image of the scene with a RGB-D camera. Then use template matching algorithm to get the image coordinates I (u, v) from RGB image and the depth D to camera from the depth image of the markers. Therefore, the 3D coordinates M (X, Y, Z) can be calculated with the image coordinates and the depth information with equation DI= AM, and A is the internal parameters of the camera .

We use the 3D coordinates of the three markers on the back (0, 9 and 10) to fit the trunk, 3, 4, 5 to fit the left arm and 6, 7, 8 to fit the right arm, 0 and 11 to fit the neck. The characteristic vector n is equal to [(x1, y1, z1)-(x0, y0, z0)] + [(x2, y2, z2)-(x0, y0, z0)] with 3 markers and (x1, y1, z1)-(x0, y0, z0) with 2 markers ((x0, y0, z0), (x1, y1, z1), (x2, y2, z2) is the coordinates of markers). In order to finger out movement direction of arm and neck, we fit the back plane with markers 0, 1, 2, 9 and 10. Decompose the vectors of arm into the extended back plane direction and the vertical back plane direction. Then use angles between vectors adjoining back plane direction and vector of trunk to show the movement in left-right, and vertical back plane direction to show the movement in front-rear. As the upper arm move in front and rear is required in the operation, so this posture is evaluated only with angle of movement in left-right.

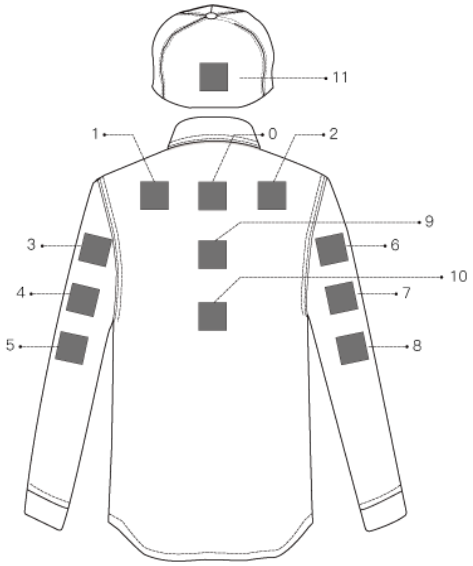


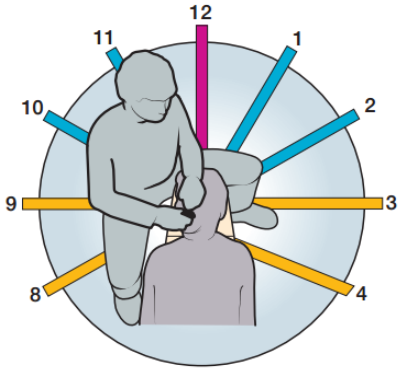
Figure 4. Markers positions

2.3 Multiple viewpoints to avoid posture occlusion

The seated dentist can assume a range of positions around the patient during periodontal operation. The positions that the clinician assumes in relation to the patient's head are known as clock positions [9] (As Fig. 5). Traditional clock positions for the right-handed clinician range from 8 to 1 o'clock, and 11 to 4 o'clock for the left-handed clinician. However, the viewing angle of a single camera is quite limited for the changing positions of dentist. In this condition, serious posture occlusion and joint point lost could happen. Thus, we use multiple viewpoints to avoid it.

In the system we use two camera at different point to cover the entire operating area. The scene distribution set as Fig. 6. One placed on the 12 o'clock, and another placed on 9 o'clock for right-handed clinician and 3 o'clock for left-handed clinician. With space coordinate transformation algorithm, we transform coordinates of markers in one camera coordinate space to the other one. So we can merge coordinates got by two different camera into the same space.

Therefore, the merging viewpoint can cover the whole operating area. The dentist can be supervised when moving in it.



Figuue 5. Clock positions of dentist

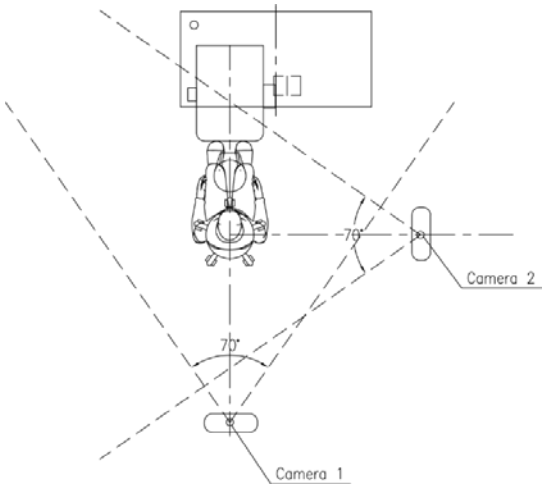


Figure 6. Scene distribution of the system

3. Experimental results

The sitting posture system required to use on window 10 os, the RGB-D camera is used Kinect 2.0. Fig. 7 denotes the posture angle captured with system presents in this article from different sitting posture that we predefine. Polyline A1 and A4 are the supervise results of posture angle with trunk leaning forward of 5 degree and 35 degree. A3 and A2 are the supervise results with elbow abduction away from the body of 18 degree and 45 degree. And A5 and A6 are supervise results with head tilt of 5 degree and 30 degree. The results show that the error of supervise is less than 5 degree. With this accuracy, we can classified the posture to the correct grade (excellent, good and wrong). Therefore, the accuracy is enough for sitting posture recognize and evaluate.

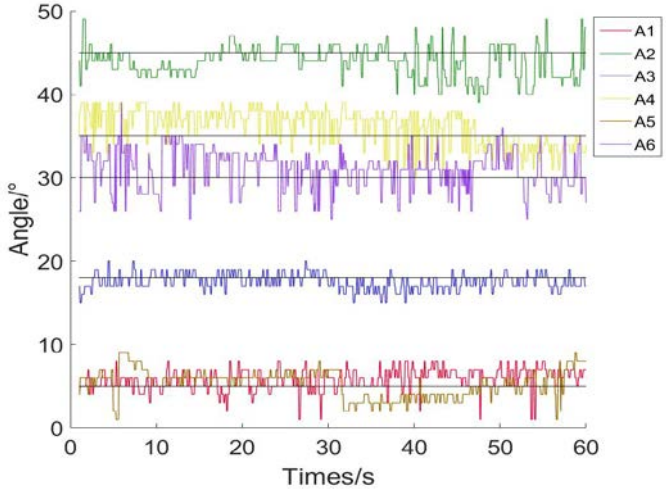


Figure 7. Posture recognize results

4. Conclusion

This paper presents a system to capture and evaluate the sitting posture of dentist based on RGB-D camera. The system get coordinates of feature markers with template matching algorithm, and then calculate the characteristic vectors and angles of each postures. We evaluate dentist's posture basis of neutral body posture. And we give feedback on the user interface as well as voice prompt to help the dentist find posture mistakes. The system has high recognition accuracy, better real-time performance, robustness and strong and good scalability. What's more, it well solves the posture occlusion problem, and has been successfully tested with many people under varying light conditions.

Acknowledgments

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