Ergonomic-Monitoring of Office Workplaces using Kinect

L.G. Wiedemann[1], R. Planinc[2], M. Kampel[2]

[1] University Of Applied Sciences Technikum Wien, Vienna, Austria
[2] Vienna University of Technology, Vienna, Austria

Abstract. Prolonged sitting is an aggravating factor in low back and neck pain. Increased use of computers at workplaces could therefore cause health risks. This paper evaluates the application of the Microsoft Kinect in order to investigate the ergonomics at the place of employment. The Kinect is a cheap device and commercially available which enables the user to record 3D data of the human body. Within this paper, guidelines for the 'ideal' placement of the Kinect are provided in order to enhance the robustness of the skeleton recognition algorithm. An evaluation of 35 sequences (7 different positions in combination with 5 different sitting postures) showed that placing the Kinect sensor slantingly forward at an angle of 20° (in front of the subject) the joint recognition rate achieved 89.62%. According to these results, the device should be positioned between 20° to 45° in order to robustly track a sitting person.

Keywords: Ergonomics, Kinect, sitting, workplace

1 Introduction

About 75% of employees in industrializes countries perform their work seated [1]. Most of the working time is spent in front of a computer which results in sedentary activity of 597 ± 122min/day [2]. In this process sitting is considered to be an aggravating factor in lumbal back and neck pain [3, 4]. Moreover, it is not quite clear which sitting posture is 'ideal' [5]. However, a number of international standards are developed to provide ergonomic guidelines for workplaces (EN ISO 9241). The goal of this article is to evaluate the suitability of the Microsoft Kinect to investigate ergonomic parameters of workplaces. The Kinect is a markerless and low-cost motion capture system which enables the user to investigate the joints of the human body without the need for additional sensors or markers. A free Software Development Kit (SDK) provided by Microsoft is used to access sensor data which makes it intelligibly to apply own code within the scope of proposed research questions [6]. In this paper different Kinect positions are compared to each other in order to provide guidelines for the 'optimal' positioning of the device.

2 Methodology

The Kinect sensor contains a depth sensor, allowing to record 3D data of human joints with 30 frames per second (fps). Thus ergonomic parameters like the viewing distance to the screen, tilting of the head, spine curvature, hip and knee angle can be analyzed. Within the framework of this paper seven positions of the Kinect sensor are compared to each other (tab. 1). Additionally, five sitting postures are defined for each measurement: an "upright" (upright upper body, knee angle is 90°), "supporting" (head supported by the hands, right leg stretched), "slumped" (leaning backwards, both legs stretched), "lordosis" (strong lumbar lordosis, right leg bent) and "tired" (head resting on the arms, both legs bent) sitting position. These postures were chosen to analyze different angles in the upper and lower extremity.

Table 1. Definition of the Kinect placements with the corresponding angles and distance to the hip centre

Kinect placement	Angle [°]	Distance [m]
1. "lateral"	90	2
2. "inclined 45°"	45	2.5
3. "inclined 20°"	20	2.5
4. "inclined 20° with armrest"	20	2.5
5. "frontal"	0	2.3
6. "upper body only"	45	1.7
7. "inclined 110°"	110	1.8

The angle is formed by the points of the middle of the computer screen, the hip center and the middle of the depth sensor of the Microsoft Kinect. The distance from the device to the subject is as low as possible while the whole body can be viewed. Each trial is recorded for 60s and therefore 1800 frames are captured. A total of 35 measurements are recorded (7 Kinect placements with 5 sitting postures each). 3D-coordinate data and the "Tracking States" of each joint are analysed using Matlab. The relative tracking rates are examined through the number of frames where each joint is stated "tracked" divided by the total number of frames. Joints, which are identified "tracked" but seem to be tracked incorrectly because they contain jitter, are defined as "not-tracked" by defining a velocity threshold. While a joint's velocity exceeds this limit, it is recognized as jitter and thus not tracked. This threshold is calculated using the joint with the minimum mean velocity plus three times of its standard deviation.

3 Results

3.1 Tracking rates depending on the Kinect placement

On average the tracking rate of the whole-body joints (WB) using all sitting postures is 86.03%. The rates of each position range from 80.95% (position 1) to 89.62% (position 3). Further, the mean tracking rate of the lower body equals 78.37% and the joints of the upper body are tracked 76.23% of the whole time (tab. 2). The head-joint has the lowest mean velocity of 0.05m/s ± 0.36m/s (0.17km/h ± 1.30km/h). The velocity limit for jitter is set to 1.13m/s (4.06km/h).

Table 2. Relative joint-rates (Mean ± Standard Deviation in %) for each Kinect placement (joints of the whole-body - WB; lower body - LB; upper body - UB).

Kinect placement	WB [%]	LB [%]	UB [%]
1. "lateral"	80.95 ± 6.92	69.84 ± 10.16	74.53 ± 4.07
2. "inclined 45°"	88.22 ± 7.69	73.69 ± 17.33	80.69 ± 8.45
3. "inclined 20°"	89.62 ± 12.85	84.70 ± 18.90	78.63 ± 9.67
4. "inclined 20° armrest"	87.28 ± 8.61	79.36 ± 18.36	79.69 ± 9.95
5. "frontal"	85.78 ± 4.57	82.16 ± 3.78	71.19 ± 8.75
6. "upper body only"	-	-	80.68 ± 11.88
7. "inclined 110°"	84.32 ± 11.49	80.45 ± 18.10	67.11 ± 18.90

3.2 Tracking rates depending on the Sitting Posture

The tracking rates depending on the posture range between 82.23% (1. sitting posture) and 90.17% (2. sitting posture) of the WB joints (tab. 3).

Table 3. Relative joint-rates (Mean ± Standard Deviation in %) for each sitting posture (joints of the whole-body - WB; lower body - LB; upper body - UB).

Sitting posture	WB [%]	LB [%]	UB [%]
1. "upright"	82.23 ± 6.94	71.02 ± 9.52	78.60 ± 8.28
2. "supporting"	90.17 ± 8.37	77.48 ± 18.08	81.41 ± 7.17
3. "slumped"	87.82 ± 12.31	85.69 ± 17.09	74.67 ± 17.01
4. "lordosis"	84.22 ± 10.73	74.57 ± 20.17	75.93 ± 12.27

5. "tired"	85.69 ± 4.10	83.08 ± 4.02	70.55 ± 8.02

4 Discussion

The third Kinect position and the sitting posture "supporting" show the highest tracking rates with 89.62% and 90.17% respectively. The joints in Kinect position 3 contain 3.24% jitter of the whole measurement time. Hence, an inclined Kinect placement of 20° results in robust tracking of body joints. The rather small difference of 2.34% between Kinect-placement "inclined 20°" and "inclined 20° with armrest" indicate the possibility to gain 3D-coordinate information via Kinect even if the worker sits in a chair with armrests. When only analyzing the upper body joints, the Kinect is placed 45° relative to the line of sight of the subject and the results of this paper indicate a joint tracking rate of 80.68% while using this Kinect placement. Based on the results of this work, it is recommended to locate the Kinect sensor between 20° and 45° relative to the line of sight and about 5cm above the table height. Its distance to the subject should be as low as possible - to minimize measuring errors due to the distance - ensuring that the whole body is within the field of view.

5 References

1. McCrady, S., & Levine, J. (2010). Sedentariness at work; how much do we really sit? *Obesity, 17*(11), 2103–2105.

2. Zemp, R., Taylor, W. R., & Lorenzetti, S. (2013). In vivo spinal posture during upright and reclined sitting in an office chair. BioMed Research International.

3. O'Sullivan, K., O'Sullivan, P., O'Sullivan, L., & Dankaerts, W. (2012). What do physiotherapists consider to be the best sitting spinal posture? *Manual Therapy, 17*(5), 432–7.

4. Caneiro, J. P., O'Sullivan, P., Burnett, A., Barach, A., O'Neil, D., Tveit, O., & Olafsdottir, K. (2010). The influence of different sitting postures on head/neck posture and muscle activity. *Manual Therapy, 15*(1), 54–60.

5. O'Sullivan, K., O'Dea, P., Dankaerts, W., O'Sullivan, P., Clifford, A., & O'Sullivan, L. (2010). Neutral lumbar spine sitting posture in pain-free subjects. *Manual Therapy, 15*(6), 557–61.

6. Diego-Mas, J. A., & Alcaide-Marzal, J. (2014). Using Kinect sensor in observational methods for assessing postures at work. *Applied Ergonomics, 45*(4), 976–85.