www.ijecs.in
International Journal Of Engineering And Computer Science ISSN:2319-7242
Volume 7 Issue 7 July 2018, Page No. 24168-24173
Index Copernicus Value (2015): 58.10, 76.25 (2016) DOI: 10.18535/ijecs/v7i7.08

A method for measuring the movement of Gravity center of body of golf swing based on Kinect Sensor

Xiangmin Wang[1], Jie Chen[1]

[1] Nanjing University of Science and Technology, School of Automation,
XiaoLingWei Ttreet 200, Nanjing, Jiangsu, China

Abstract:
In this paper, we propose a method to measure the movement of skeletons of body of golf swing by the use of a Kinect sensor, and an algorithm to calculate the track of motion of the Gravity center of body. Because swing speed is usually fast, tracking a golf swing with one Kinect sensor causes less skeleton data to be sampled. Taking into account the continuity and trajectory characteristics of the skeleton data of the golfer, a reasonable interpolation method can effectively compensate for the lack of data. By comparing with the test data of the balance pedal, the measurement method is valid and accurate.

Keywords: golf swing; Kinect sensor; gravity center of body; balance board

1. Introduction

Golf is a popular gentleman sport in the world. In recent years, it has gradually attracted individua's attention in some developing countries. The critical action of golf is swing and putt. Among them, golf swing is the most basic and most important action in golf [1]. Golf has very high requirements for the accuracy of swing and the accuracy of swing. It is directly related to the final result of hitting the ball. The final effect of the professional golfer's hitting depends on the technical indicators of the player's swing speed, angle, etc., so the practice and improvement of the swing action is the key of player golf level [2-5]. Both the swing and putt need regular practice to get better. However, due to the constraints of place and cost, the expensive course training is not affordable for a lot of people. Therefore, the method of assisted training with cost advantages has attracted the attention of many golfers and coaches [6].

The current golf training is mainly aimed at swing and swing strength training. When the golfer is doing swing training, the instantaneous club head angle and head speed of the golf swing determine the direction and Distance of the golf ball, which are two key indicators to evaluate the athlete's swing stroke and swing strength [7]. The traditional golf teaching is usually through the face-to-face teaching and communication between the coach and the trainee. The coach observes the swing technical movement of the trainee, and then judges whether the movement of the trainee is based on his own teaching experience. Such training method only relies on the visual observation of the coach and the player's own feeling of swinging to analyze the technical movement. The player cannot see his complete swing process and cannot know the detail of his own action defect.

With the rapid development of sensor and computer technology, the data acquisition and analysis of human motion are increasingly gained attention by using various sensors in sports training. In the past, the quality of the athlete's movements was limited to qualitative analysis without enough sport data, but now more and more athletic measurement data can be obtained, and the athlete's skill, strength, and coordination of movement could be quantitatively assessed. At present, the research on the measurement part of the motion data mainly uses the sensor sampling method combined with the computer processing The sensor transmits the sampled data to the computer, and the computer uses the corresponding algorithm for data analysis and processing.

For golf, the study of the movement posture capture is very important. After accurately obtaining the golf and club head movement parameters, the following step is to analyze the reasons for such a shot, and the human posture changes. It is one of the most important factors in determining the impact of a ball

[8]. Therefore, the analysis of the golfer posture is an important part of the golf training system.

In this paper, we propose a novel approach for measuring the motion trajectory of the body's center of gravity. The novelty is that we use the movement data of human skeleton indirectly to estimate the moving track of the center of gravity when the golfer does the action of swing or butt. We propose a method for obtaining the body rotation and calculating the center of gravity, which is based on skeletal data. We consider four types of swing and butt of the golf: full-swing, half-swing, short-butt and long-butt. We show that on our measuring system the proposed method is accurate and facilitate for data analysis of the golf swing. The rest of this paper is organized as follows. In Section II, we introduce related works. Section III introduces the proposed measuring system of the body's center of gravity (MSBCG). In Section IV, we describe the experimental results. Finally, Section V presents our conclusions.

2. Relation Work

Using the balance pedal can conveniently obtain the accurate changes in the human body center of gravity for the golf swing. However, the balance pedal which has the High measurement accuracy is very expensive. In addition, the balance pedal needs to set up carefully in order to keep the accuracy. Using the Imaging equipment can easily record the movement of the human body, but the contour of the human body can't reflect the sports state well during the movement. The main factors are external interference, clothing and other factors[9]. The human skeleton is a good way to reflect the topological structure and shape information of the human body. The graphic recognition of the skeleton is an important research content in the computer field. With the Kinect2.0 depth camera, three-dimensional coordinate data of 25 skeletal points of the human body can be obtained, and according to the obtained three-dimensional data, we can more easily calculate the related kinematic indexes of the golf swing. The relevant kinematic indicators of this article were selected based on previous research [10]. The main calculations were human body weight center shift, shoulder rotation angle change, hip rotation angle change and the change of the adductor angle of the upper arm.

Kinect is a somatosensory peripheral equipment released by Microsoft.

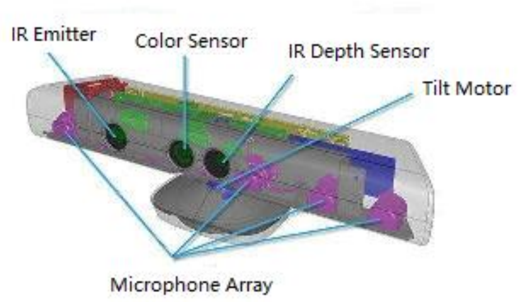
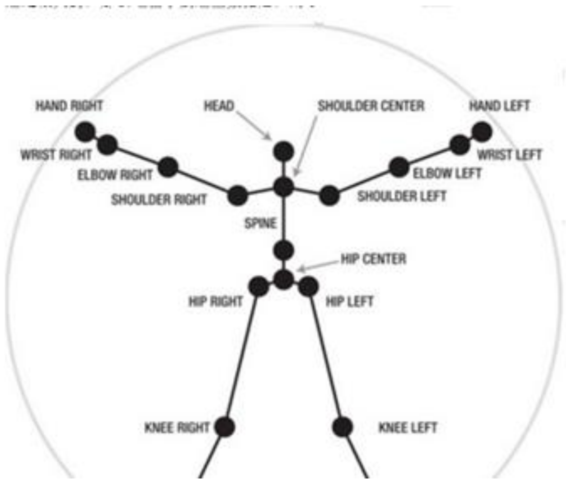


Figure1. The structure of the Kinect sensor

It projects a group of infrared laser lattices onto the player's body through an infrared laser projection lens, and two other CMOS cameras perform three-bit scanning to obtain the human body's depth of field data. Kinect provides libraries for interacting which makes it easy to implement bone tracking. Once we have initialized and opened the skeletal track, we can get skeleton data from the Skeleton-Stream. Each frame data skeleton-Frame generated by Skeleton-Stream is a collection of bone objects. Contains an array of skeleton data structures, where each element represents a skeleton information that is recognized by the skeleton tracking system. Each skeleton contains data that describes the location of the skeleton and the skeleton's joints. Each joint has a unique identifier such as head, shoulder, elbow, and corresponding three-dimensional coordinate data. Through the time mode, we can get the bone data we want at a certain time.



• **Figure2.** The segments of human body

3. Algorithm for the Center of Body’s Gravity

In the course of a golf swing, in order to obtain a high speed and a small degree of hitting, it is necessary for the player's arms to move in the same plane as the club's trajectory, if the two are not in the same plane. A plane will have a loss of hitting energy or a deviation in the angle of hitting. At the same time, when the player's arms and the club's movement trajectory are not on the same plane, the player's body will have different amplitudes in the Y-axis direction, and the player's body movement in the Y-axis direction can use the person's center of gravity. The movement in the direction of the Y axis is measured, and the large movement of the center of gravity in the direction of the Z axis results in a decrease in the power of the hitting ball. Therefore, we use the human body center of gravity as the research goal, record and analyze the movement of the center of gravity in the direction of each axis in the process of hitting the ball, thereby measuring the athlete's effort and energy loss during the completion of the action.

Our calculation of the center-of-gravity shift is based on the human body segment method that is commonly used in the current method of measuring the body's center of gravity. The method firstly divides the human body into different body segments according to a certain proportion, and then calculates the respective centroid coordinates of all human body segments[11]. Finally, these centroid coordinates are calculated by a certain weighted average to obtain the barycentric coordinates of the human body. According to the human body link parameters study, the human body is divided into 15 segments including: head and neck, upper trunk, lower trunk, left and right upper arms, left and right lower arms, left and right hands, left and right thighs, left and right lower legs, and left and right feet. The barycentric coordinates of each link can be calculated according to the following Equation 1

$$\mathrm{X}_{COMi} = X_F \times \%COM + X_C \times (1 - \%COM) \quad (1)$$

Among them, the X_{COMi} coordinates of the centroid of the human segment i in the X direction are the coordinates of the calibration point of the proximal limb in the X direction, and the X_F coordinates of the calibration point of the distal body of the limb in the X direction, the $\%COM$ is constant parameter of each node. Symmetrical body parts have the same segment, and male and female have different parameters due to their different body types. For the specific parameter table, see the relative positions of the mass centers of the human body in Chinese adult human body inertia parameters as Table 1.

Table1. The relative position of the centroids of body segments

Segment name	gender	L_{cs}	L_{cx}
Head and neck	M	46.9%	53.1%
	F	47.3%	52.7%
Upper trunk	M	53.6%	46.4%
	F	49.3%	50.7%
Lower trunk	M	40.3%	59.7%
	F	44.6%	55.4%
thigh	M	45.3%	54.7%
	F	44.2%	55.8%
shank	M	39.3%	60.7%
	F	42.5%	57.5%
Upper arm	M	47.8%	52.2%
	F	46.7%	53.3%
forearm	M	42.4%	57.6%
	F	45.3%	54.7%
hand	M	36.6%	63.4%
	F	34.9%	65.1%
foot	M	43.8%	51.4%
	F	44.5%	54.9%

After obtaining the centroid of each body segment, the overall center of gravity can be calculated and the overall center of gravity can be calculated:

$$COM = \sum (COM_i \times m_i) / N \quad (2)$$

m_i is the percentage of the body's total body weight by the weight of a certain segment of the body. The specific data values can be found in the following Table 2: China's adult human body inertia parameter standard, COM_i is the center position of the corresponding segment, and N is the segment number of the human segment, and we set N=15.

Table2. Weight distribution of body segments

Segment name	gender	L_{cs}
Head and neck	M	8.62%
	F	8.20%
Upper trunk	M	16.82%
	F	16.53%
Lower trunk	M	27.23%
	F	27.48%
thigh	M	14.19%
	F	14.10%
shank	M	3.67%

	F	4.43%
Upper arm	M	2.43%
	F	2.66%
forearm	M	1.25%
	F	1.14%
hand	M	0.64%
	F	0.42%
foot	M	1.48%
	F	1.24%

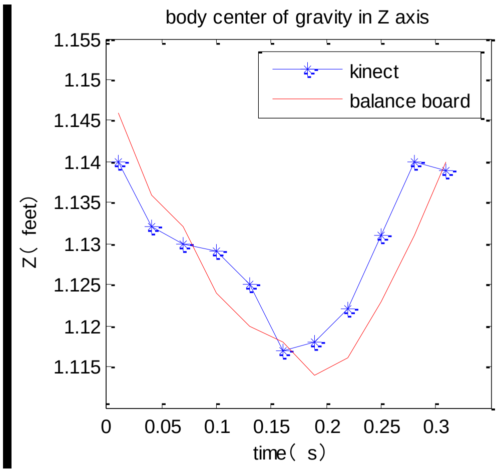
In comparison of the same set of swing data obtained by using Kinect and the balance pedal, it is found that there is a notable decrease in the center of gravity when the lower club is lowered. Combining the calculation method and the swing posture analysis, it can be known that the shift of the center of gravity occurs at the lower club moment. The reason is that in the method of calculating the center of gravity of human body segment method used in this article, when the head and the neck of the human body are intercepted according to the joint points obtained by Kinect, the head joint point of the head obtained by Kinect is the center point of the head, and thus calculated The head and neck body segment lacks the upper half of the head, resulting in a reduction in the weight of the head and neck, and at the moment of the athlete performing a full swing downswing, the athlete's head has a significant decline process, and the head and neck The reduction in weight will result in a reduction in the weight of the head and neck body segment in the calculation of the center of gravity, resulting in a decrease in the magnitude of the center of gravity reduction in the lower shaft.

4. Experimental Results

Figure3 is the experimental system. In the system, a Kinect sensor and a balance board are used. a golfer stand on the balance board while the Kinect sensor capture the skeleton data during golf swing once, and the data measured by the balance board are also recorded. Then, we compare the results of Kinect and balance board in the same golf swings.

Figure3. The experimental system

The movement of the player's center of gravity during a swing can be compared in three directions respectively. The vertical (Z-axis) center-of-gravity transition can be used to analyze the player's sense of rhythm and force when hitting the next shot. The more the center of gravity declines at the same time, the more force is applied at that time. The transfer of the standard can be used to determine the energy use of the player when swinging. The smaller the horizontal (X-axis) shift of the center of gravity, and the smaller the energy loss of the player's swing, Most of the potential energy is converted into the kinetic energy of players hitting the ball. The change of the center-of-gravity in Y-axis represents the stability of the body.



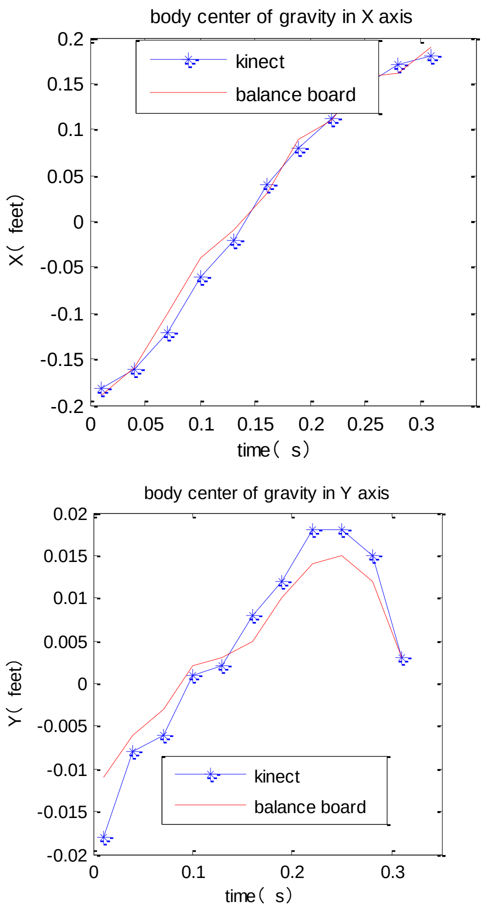


Figure4. The movement of gravity center of body

From the above comparison of the center-of-gravity transition diagrams, it can be seen that the measurement of the center-of-gravity shift of the system equipment is consistent with the data obtained from the balance pedal in the general trajectory, and there are only a few gaps in the individual values, indicating that the accuracy of the system's measurement center of gravity can meet the requirements. Only the sampling frequency of Kinect is only 30 frames/s, and only one second of a swing is required to complete the swing from the down to the swing. Therefore, only about 10 pictures can be collected, this leads to a non-smooth curve.

5. Conclusion

This paper proposed a Kinect-based measurement system to estimate golfer's the track of gravity center of body. We compared the experimental results between Kinect sensor and balance board, it shows that the proposed system could effective detect the movement. However, it is still needed to be further investigated to provide helpful guidance to improve swing motion with the data of gravity center of body.

References

[1]. Yeung, L.F., Cheng, K.C., Fong, C.H., Lee, W.C., Tong, K.Y, 2014. "Evaluation of the Microsoft Kinect as a clinical assessment tool of body sway". Gait Posture **40**(4), 532–538

[2]. Whyte, E.F., Moran, K., Shortt, C.P., Marshall, B, 2010. "The influence of reduced hamstring length on patellofemoral joint stress during squatting in healthy male adults", Gait Posture **31**(1), 47–51

[3]. Van Csamp, C.M., Hayes, L.B, 2012. "Assessing and increasing physical activity". Journal of Applied Behavioral Anal. **45**(4), 871–875

[4]. Chu, Y., Sell, T.C., Lephart, S.M,2010. "The relationship between biomechanical variables and driving performance during the golf swing", Journal of Sports Science. **28**(11), 1251–1259

[5]. H. Negoro, M. Ueda, K. Watanabe, K. Kobayashi, Y. Kurihara, "Measurement and analysis of golf swing using 3D acceleration and gyroscopic sensors", 2011.SICE Annual Conference (SICE) 2011 Proceedings .1111-1114.

[6]. Y. Koyama, K. Watanabe, 2014. "Auditory golf coaching system using perceptive sportswear based on hetero-core optics", *Consumer Electronics (GCCE) 2014 IEEE 3rd Global Conference on*. 643-646.

[7]. C.N. K. Nam, H.J. Kang, Y.S. Suh, 2014. "Golf swing motion tracking using inertial sensors and a stereo camera", IEEE Trans. Instrumentation and Measurement, 63(4), 943-952.

[8]. M. Ueda, H. Negoro, Y. Kurihara, K. Watanabe, 2013. "Measurement of angular motion in golf swing by a local sensor at the grip end of a golf club", IEEE Trans. Human-Machine Systems, 43(4), 398-404.

[9]. Shum HP, Ho ES, Jiang Y, Takagi S,2013. "Real-time posture reconstruction for Microsoft kinect". IEEE Trans Cybern ,43(5),1357–1369

[10]. MacKenzie SJ, 2012. "Club position relative to the golfer's swing plane meaningfully affects swing dynamics", Sports Biomech 11(2):149–164

[11]. Zhou H, Hu H,2008. "Human motion tracking for rehabilitation—a survey",Biomed Signal Process Control 3(1),1–18.

Author Profile

<Author Photo>

Taro Denshi received the B.S. and M.S. degrees in Electrical Engineering from Shibaura Institute of Technology in 1997 and 1999, respectively. During 1997-1999, he stayed in Communications Research

Laboratory (CRL), Ministry of Posts and Telecommunications of Japan to study digital beam forming antennas, mobile satellite communication systems, and wireless access network using stratospheric platforms. He now with DDI Tokyo Pocket Telephone, Inc.