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Pattern Analysis of Golf Swing using Motion Sensors

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Abstract. This paper proposes pattern analysis of golf swing from data collection system. The system uses motion sensors of 9DOF Razor IMU to collect the data by attaching Razor IMUs to 3 positions of human body: upper back, lower back, and right wrist. The sensors can detect the patterns of body movement in golfing from the beginning to the end. Two types of data collected are acceleration and angle. The output of the data from the sensors can indicate the appropriate patterns of golf swing. The experimental result data from the sensors are illustrated in graphs showing each step of movement patterns in golf swing. These movement patterns can be beneficial for golf swing trainers in training. Moreover, they can help doctors to analyze the cause of golfers' injury.

Keywords: Motion Sensors, 9DOF Razor IMU, Pattern Analysis, Golf Swing

1. Introduction

Body movements in human's daily life such as walking, running, walking-up and down the stairs, carrying heavy items, or even sports have the certain patterns; therefore, making a wrong movement pattern can lead to injury. Recently, golfing is one of the most popular sports as anyone at any age or sex can play. Thus, the possibility of golfing in the wrong movement, which causes sudden or chronic injury of low waist muscle or spine in the waist area, is high [1]. Actually, there are some methods for safety, such as to keep the waist area firm, to make the body adjustable, to keep the back straight while golfing, and to warm-up the body before golfing. Apparently, these methods are not easily be judged by eye-observation without real movement data. Thus, many research topics have been proposed to investigate the proper measuring equipments of movement data or create suitable algorithm to classify and differentiate body movements in daily life.

This research focuses on the data collection of golf swing by using low-cost motion capture sensor. It is 9 Degrees of Freedom inertial measurement unit, called Razor IMU. In order to analyze the data, the sensors are attached on 3 positions of the body which are considered to be easily affected and injured after golfing. The structure of the following sections in this paper is: Section 2, the related works in golf swing and sensors are described, the design of the data collection from the sensors and the experimental results in graphs are shown in Section 3. Finally, conclusions are presented in Section 4.

2. Related Works

Since 1980s, the research topics related to human motion tracking for rehabilitation have gradually been concerned [2]. Many researchers proposed the methods to classify human motions. For instance, a novel memory-based motion simulation (MBMS) was presented as a general framework to simulate natural human motions by W. Park et al. [3]. In 2010, Y. Chen and Y. Hung [4] introduced the use of acceleration data for

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movement training in tennis and baseball with a decision tree. In this research, 3 Wiimotes were attached to the limb: grip, upper and lower arm, and then sent the acceleration information of each part of limb: X, Y, and Z axes back to the computer using wireless link. Later, the acquired information was classified by ID3 algorithm. This method is suitable for muscle training in some sports such as tennis and baseball. However, the weakness of Wiimote is its large size. D. James et al. [5] proposed the wearable sensor technology with a framework that allowed near real time data analysis of swimming monitoring system. In 2012, the method to recognize human activities and track full-body pose using wearable inertial sensors was proposed by L. Schwarz et al. [6].

Relating to golf swing, K. King et al. [7] proposed the theory, design, and evaluation of miniature, wireless six degree-of-freedom IMU to compute the dynamics of golf swing. In 2011, D. Lai et al. [8] introduced the use of micro-electromechanical systems (MEMs) inertial sensors to measure the differences between skilled golfers and non-golfers. Later, G. Fedorcik et al. [9] investigated the differences in the wrist kinematics between high and low handicap golfers by using 8 camera motion capture system.

In order to analyze the movement patterns in each part of the body while golfing, the key technical parameters in the golf swing that affected the analysis must be concerned. The golf swing is classified into 2 types for analysis [10]: 1) Body movements consist of an initial step, body twisting, and sequences of the body movements, 2) Hands and arms movement depends on the quality of golf clubs and the swings. In this paper, to collect proper details, 9 Degrees of Freedom - Razor IMU (9DOF Razor IMU) will be used to analyze the proper patterns of golf swing and capture the acceleration and angle data which will be described in Section 3.

3. Measurement Method and Results

In order to analyze the appropriate patterns of golf swing using motion sensors, the measurement method and experimental results are described in the sections below.

3.1 Motion Sensors

Recently, many wired or wireless physical motion sensors are used for physical therapy. Each type of sensor is different depending on data capture quality. In this research, 9DOF Razor IMUs are used to capture data on acceleration and angle.

In this experiment, 3 sensors were used to collect data of golf swing and then send to the system. Each sensor is stored in a fix size of closed box in order to prevent it from damage and to easily attach on the human body parts. Actually, the sensor needs Bluetooth and battery which will be assembled together as shown in Fig. 1.

Fig. 1: Motion sensor.

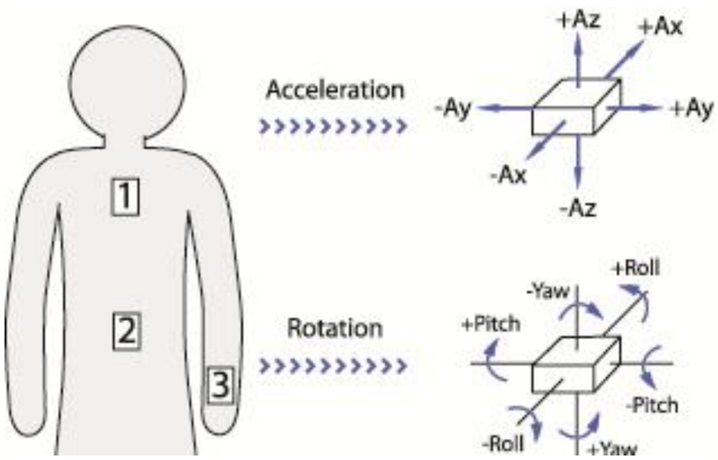


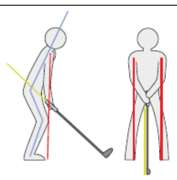
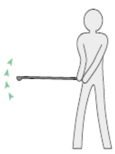
Fig. 2: The positions of attached motion sensors.

The sensors were attached on 3 positions of the golf coach's body to collect and send the data to the system. The data are classified into three types: Roll in X axis, Pitch in Y axis, and Yaw in Z axis, as shown in Fig. 2. The three axes are in the range of ±180 degree according to the movement direction of sensors. Acceleration data compared with Gravity (g) in X, Y, and Z, are Ax, Ay, and Az, respectively. The maximum of acceleration data is ±16g. And the data are sending via Bluetooth protocol at 50 records per second.

3.2 Model of Golf Swing

Golf swing is performed in 8 steps [11]: Set up, Back Swing-Takeaway, Back Swing-Half Swing, Top Swing, Down Swing, Impact, Follow through, and Finish, as shown in Table. 1. It shows pictures of each step and time of golf swing that sensors detected. The step times of results are illustrated in Fig. 3 to Fig. 5.

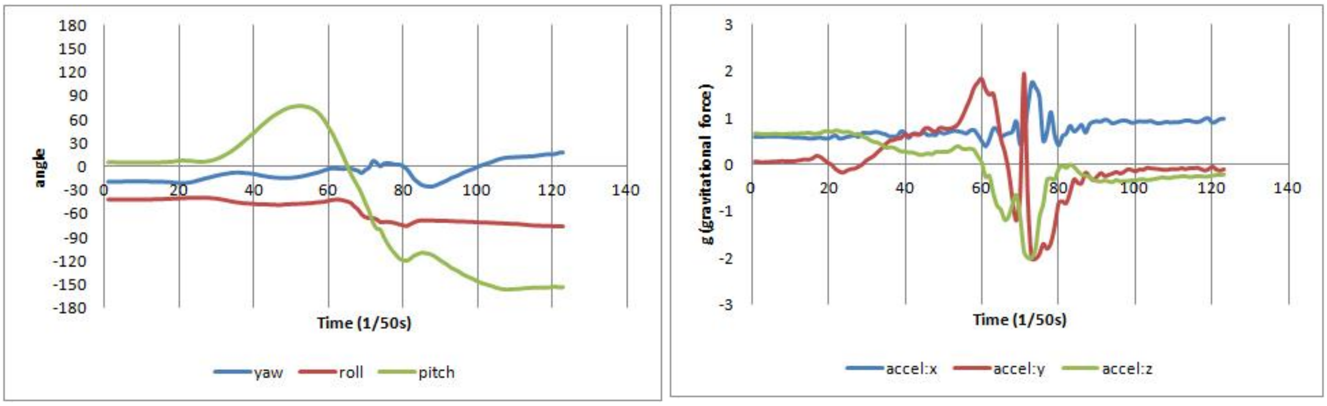
Table. 1: Eight steps of golf swing with step time.

Step	Picture	Time (1/50 sec.)	Step	Picture	Time (1/50 sec.)
1. Set up		0-22	**5. Down Swing**		60
2. Back Swing-Takeaway		28-42	**6. Impact**		65
3. Back Swing-Half Swing		43	**7. Follow through**		75-80
4. Top Swing		52	**8. Finish**		80-82

3.3 Experimental Results

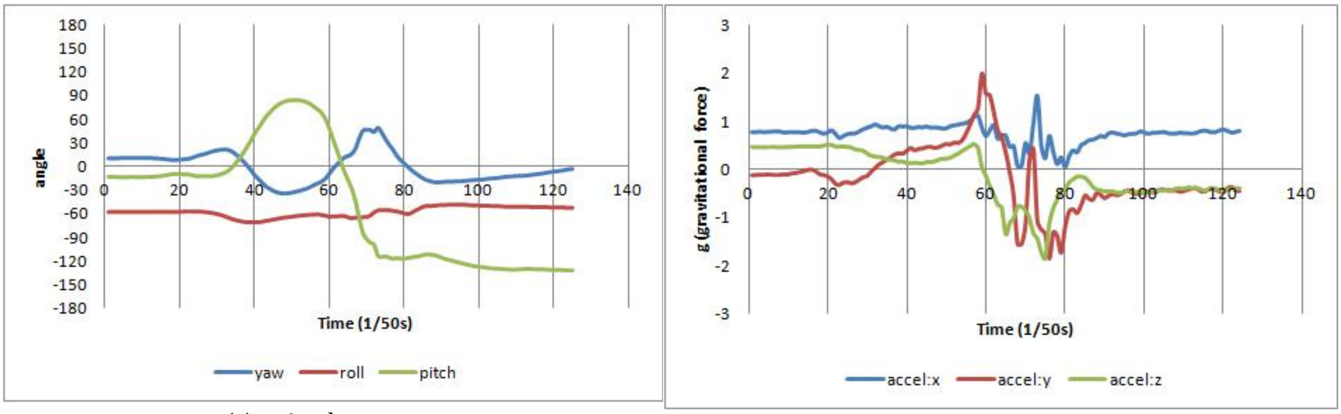
The data collection system was written in JAVA language. The experimental results in Fig. 3-5 show the data of golf swing of Angle of yaw, roll, and pitch and Gravitational force (g) of X, Y, and Z in each sensor.

X axis shows the swing time in 1/50 seconds. Fig. 3(a) and Fig. 3(b) indicate the results after Upper-back swing, Fig. 4(a) and Fig. 4(b) indicate the results after Lower-back swing. Fig. 5(a) and Fig. 5(b) indicate the results after Right-wrist swing.



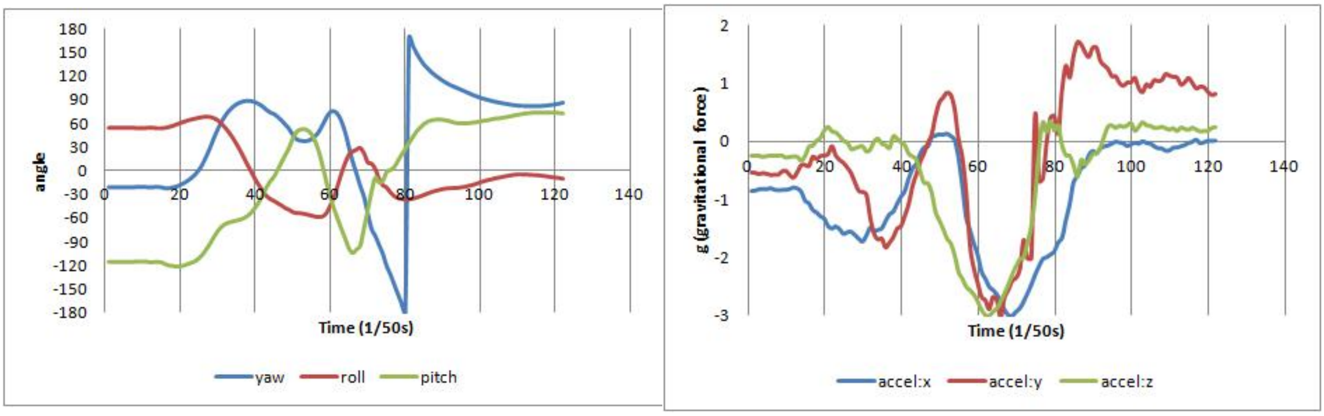
(a) Angle. (b) Gravitational force.

Fig. 3: Upper-back swing results.



(a) Angle. (b) Gravitational force.

Fig. 4: Lower-back swing results.



(a) Angle. (b) Gravitational force.

Fig. 5: Right-wrist swing results.

According to the experimental results, the graphs in Fig. 3(a), Fig. 4(a), and Fig. 5(a) indicate yaw, roll, and pitch. Y axes of 3 figures are the distances of the angle from the beginning value, which are in the range of ±180 degree. Meanwhile Fig. 3(b), Fig. 4(b), and Fig. 5(b) indicate the results of acceleration in 3D plane.

Y axis of each figure indicates the acceleration force to sensors in g unit. Each line refers to the acceleration of each axis; blue for X, red for Y, and green for Z.

4. Conclusions

The research proposes the low cost motion sensors, called 9 Degrees of Freedom - Razor IMU to detect the appropriate patterns of golf swing. The 3 sensors are used to attach on 3 positions of the golf coach's body: upper back, lower back, and right wrist. The experimental results showed that the sensors can detect the patterns in 8 steps of golf swing and each step time. The golf trainers can indicate the different patterns of players' swing comparing with the golf coach's patterns. For further study, the data from the sensors can be used to analyze the muscle pain in terms of muscle therapy.

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