IOP Conf. Series: Journal of Physics: Conf. Series **1489** (2020) 012026 doi:10.1088/1742-6596/1489/1/012026

Development of BasketBall Coaching APP

Wan Azizun Adnan[1,a], Siti Mariam Shafie[1,b], Sharifah Mumtazah Syed Ahmad[1,c], Samsiah Radiman[2],Aiman Haziq Bin Rashdan[2,d], Muhammad Khazin Bin Noor Hisham[2], Emeirul Ezzudean Bin Jefri[2] and Salasiah Hitam[3]

[1] Faculti of Engineering, Univeristi Putra Malaysia, Selangor

[2] Sekolah Alam Shah, Putrajaya, Malaysia

[3]Princess Nourah Bint Abdulrahman University, Riyadh, Saudia Arabia

Emails: [a]wawa@upm.edu.my, [b]mariam@upm.edu.my, [c]s_mumtazah@upm.edu.my, [d]aimanhaziqrashdan@gmail.com

Abstract. In a basketball game, to shoot a ball accurately is the main aim of basketball players. This paper describes a smartphone application with Gyroscope and Accelerometer Sensors which was developed to help basketball players to practise their free throw shootings. Free throw is an important part of a basketball game which may determine the success of the team. The developed application is based on the theory of projectiles motion. The main advantage of this application is that it assist player to be consistent~~t~~ in every free throw sessions without the help of a coach.

1. Introduction

Plethora of studies [1, 2, 3] have been conducted to address the problem of getting optimal trajectory of a basketball shot were derived from the classical problem of projectiles motion. The studies have determined that the probability of shooting success depends on the velocity of the ball and the shooting angle of the player. As reported in [4], the number of free throws effectiveness was one of the most significant of scoring points in NCAA Division 1 Basketball. It is a single most important shot to score points given to player that was fouled. It is performed unopposed on the free throw line with no adjustment for the distance. Hence, for beginners, these skills can be improved with training since it requires the same shooting techniques. Figure 1 shows the conditions of 9 different successful free throws shots. The ball can hit the backboard or the rim before it successfully enters the hop depending on the choice of throwing angle.

Tran and Silverberg [5] state that the shooter's main success depends on understanding of the desired shots and the player consistency. The common adage of "Practice make perfect" is applied here by proposing an application to help players to enhance their skills and capability by practicing the best angle for their successful shots. In this paper we focus on developing an application to assist a player on free throw shooting ball through the rim (i.e. type b of Figure 1).

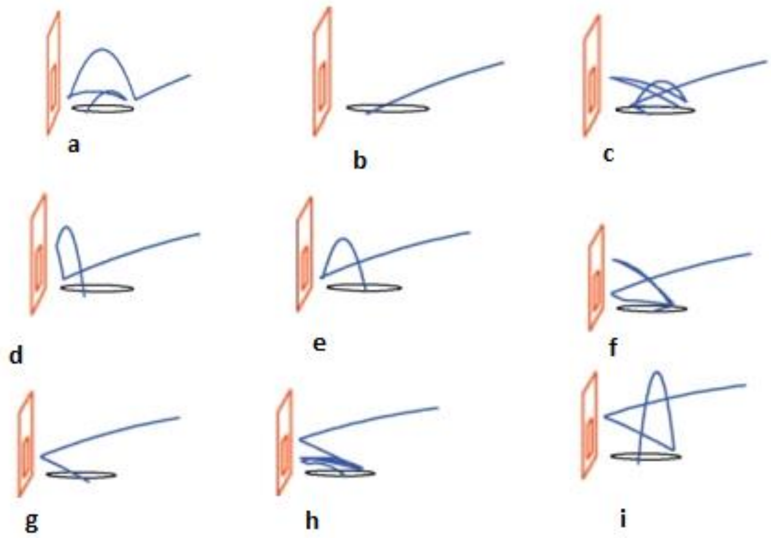

Figure 1. Nine Different types of successful shots [5]

The rest of the paper is organized as follows. Section 2 introduces the basic principles of projectiles. Section 3 presents the system design while section 4 discusses the results obtained. Finally Section 5 concludes the paper which include listing of possible future work.

2. Basic Principles

For analyzing the projectile motion of the ball, motion in the vertical and horizontal directions are considered.

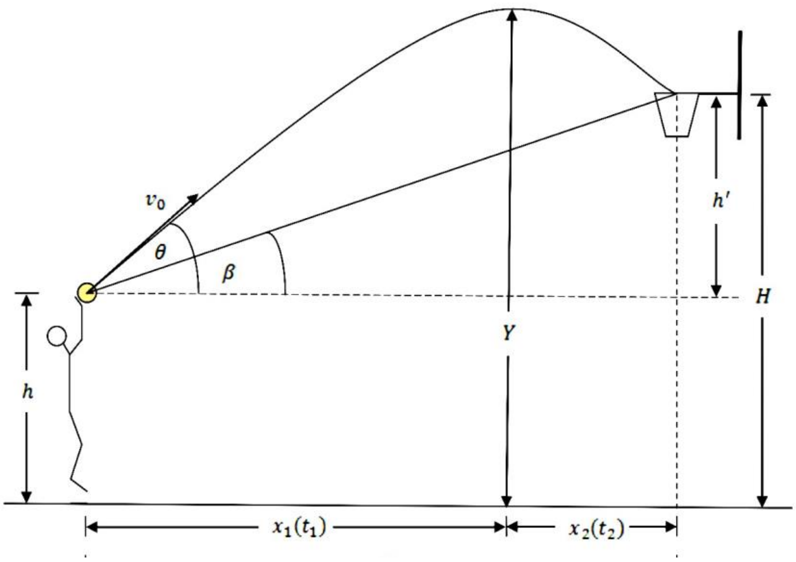

Figure 2. Trajectory of the ball from the player to the hoop [6]

By referring Figure 2, the following parameters are used:

h is the height from the ground to the position where the ball is released,

Y is the maximum height of the ball trajectory,

H is the height of the pole,

X is the horizontal distance of the player from the pole ($X = x_1(t_1) + x_2(t_2)$),

v_0 is the initial velocity of the ball when it is released, and

θ is the angle to the horizontal axis where the ball is released.

Horizontal motion is represented by x while y represents the vertical motion where air resistance is assumed to be negligible.

Case 1: The ball from the released position to its maximum height

For vertical motion: the initial velocity $u_y = v_0 \sin\theta$, acceleration $a_y = -g$ where g is the gravity, displacement $s_y = Y - h$ = maximum height, which occurs when the final vertical velocity component $v_y = 0$ since it is at the highest height.

The maximum height can be found using equation $v^2 = u^2 + 2as$. Hence, the maximum height the ball reached is defined as

$$(Y - h) = (v_0 \sin\theta)^2 / 2g \quad (1)$$

Using $u = v + at$, the time taken to reach the highest height can be calculated which is equal to $t_1 = v_0 \sin\theta / g$.

In order for the ball to enter the hoop, the maximum height above the ground, Y must be greater than the height of the pole, which is H. From equation 1,

$$Y = \frac{(v_0 \sin\theta)^2}{2g} - h > \mathrm{H} \quad (2)$$

Knowing the value of H and h, the relationship between the angle of projection θ and the initial velocity v_0 can be calculated. The fixed value from the equation above is g, which is the gravity and H, which is the height of the basketball pole. h varies according to the height of the player and also the position of the body when the ball is thrown.

Case 2: The ball from the released position until it goes into the loop

Now, let's consider the motion of the ball until it goes into the hoop. Assuming the time taken for the ball to enter the hoop without touching the rim is t_2:

For horizontal motion: the initial velocity $u_x = v_0 \cos\theta$, accelearation $a_x = 0$, displacement $s_x = x_1(t_1)$ using $u = v + at$ where u is the initial veleocity, v the final velocity and t is the time.

Therefore, the initial velocity is always equal to the final velocity since the acceleration is zero horizontally.

By considering horizontal motion: displacement $s_x = X$, $u_x = v_0 \cos\theta$ and acceleration is zero using equation $s = ut + \frac{1}{2}at^2$, the time t_2 can be calculated and is equal to $X/(v_0 \cos\theta)$. From the figure, X is the distance of the pole to the player for free throw. This time taken t_2 should be more than the time taken to reach the highest height which is $t_1 = v_0 \sin\theta / g$.

Hence $v_0 \sin\theta / g < X/(v_0 \cos\theta)$ which becomes

$$X > {v_0}^2 \sin 2\theta / 2g \quad (3)$$

As can be seen from this equation, the angle θ is inversely proportional to the initial release velocity of the ball. This shows that a greater angle of projections requires less velocity of release for a greater chance of scoring. Hence less force is needed to throw since force is proportional to change in velocity. Solving these two inequalities, equation 2 and equation 3, the range of both values can be calculated.

3. System Design

We propose the use of a light arm wearable system to be used by basketball players during training session in order to monitor the angle the ball is thrown and also the force that is being given to the ball for a successful shot. The proposed system design is as shown in Figure 3. It consists of two units namely angle analysis and wireless communication. Inertia Measurement Unit (IMU) based on Accelerometer and Gyroscope sensors is the angle analysis unit. As shown in Figure 4, combining the readings from accelerometer and gyroscope, rotation angle and angular velocity can be obtained. The acceleration obtained from the accelerator is used to calculate the initial force given to the ball during shooting using newton's 2nd law of motion. The transmission of data to the smartphone is performed by the wireless communication unit which has the Bluetooth module. The vibrator motor relates with improper angle of release of the ball. Graphical user interface and real-time data processing unit developed as smartphone application helps the player to have visual feedback of the initial release angles and the force given to the ball.

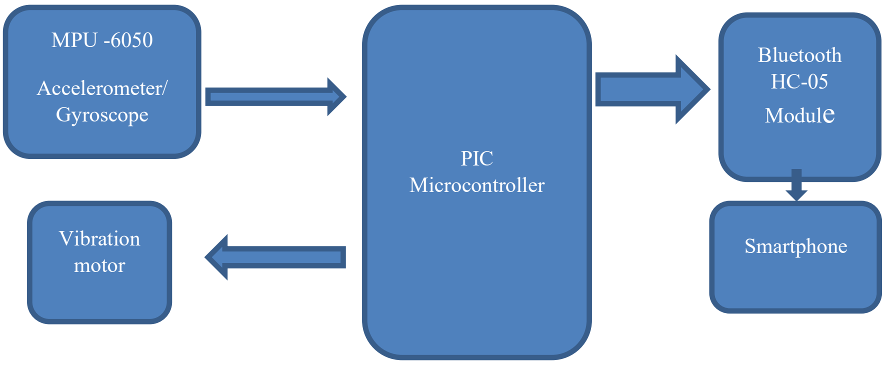

Figure 3. System Design

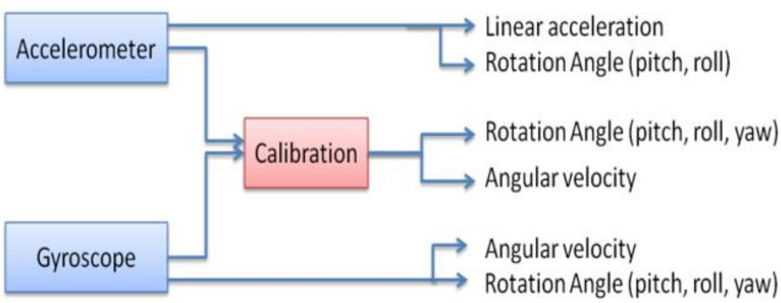

Figure 4. IMU based on two types of sensors [7]

IOP Conf. Series: Journal of Physics: Conf. Series **1489** (2020) 012026 doi:10.1088/1742-6596/1489/1/012026

4. Results and Discussion

The developed system is tested by 2 players, which represent a beginner and experienced basketball players respectively during training sessions. The player needs to wear the device at his arm as shown in Figure 5.

Figure 5. Wearable System

The process flow is shown in Figure 6. When the player holds the ball and aims at the target, the device will start to buzz and will vibrate until it achieves the correct angle of the arm based on the calculation used in equation 2 and 3 as presented in section 2. The player throws the ball and this angle and also the force needed to throw the ball are kept in the phone memory. Hence, the player can practice using this angle of thrown in order to make a successful shot.

Figure 6. Process Flow

Observations on their successful free throws shot are made with 10 attempts per sessions. Figure 7 represents the results of the experiment, which shows an improvement in their attempts when the developed application is used. An increase of successful shot for the beginner and experienced players are 50% and 40% respectively. This shows that the developed application helps players to improve in their free throws shooting performance.

IOP Conf. Series: Journal of Physics: Conf. Series **1489** (2020) 012026 doi:10.1088/1742-6596/1489/1/012026

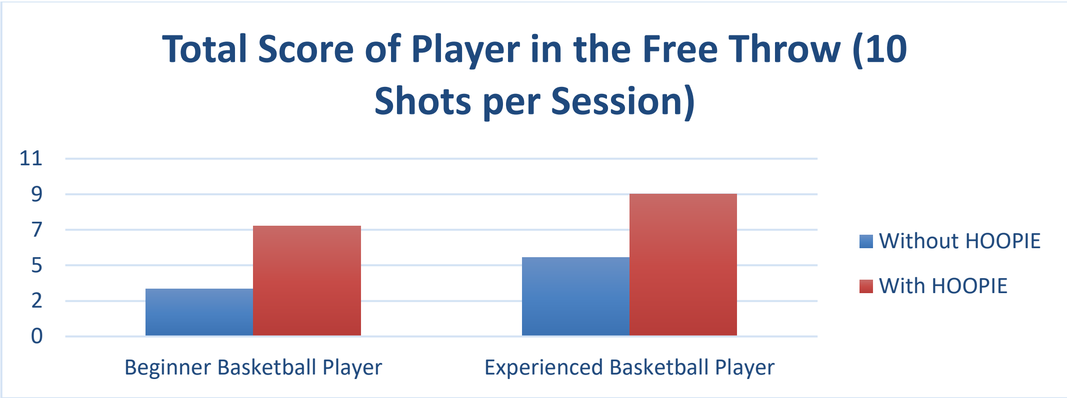

Figure 7. Experimental Result

5. Conclusion

In this paper, we present development of a basketball free throw training application based on theory of projectiles motion. The application consists of a lightweight arm wearable connected with smartphone application. IMU based on Accelerometer and Gyroscope sensors and the Bluetooth module are hardware components used to develop the arm wearable. The initial experiment result show that there is an improvement in their successful shot for the beginners and also experienced players. However, the application is only tested on free throw shooting through the ring without the ball touching the rim. The application will be enhanced to cater for another 8 different types of successful free throw shot as shown in Figure 1. On top of that, improvement of application for shooting from different places, with varying body position and diverse angles of ball release will be made.

References

[1] H Okubo and M Hubbard 2011 Basketball free-throw rebound motions *Procedia Engineering* **13** pp 194-199
[2] J J Fontanella 2006 *The Physics Of Basketball* The Johns Hopkins University Press
[3] J M Gablonsky and A S I D Lang 2005 Modeling Basketball Free Throws *SIAM Review* **47**(4) pp 775-798
[4] K Mikołajec, A Maszczyk and T Zając 2013 Game indicators determining sports performance in the NBA *Journal of human kinetics* **37** pp 145-151
[5] C M Tran and L M Silverberg 2008 Optimal release conditions for the free throw in men's basketball *Journal of sports sciences* **26** pp 1147-1155
[6] A Changjan and W Mueanploy 2015 Projectile motion in real-life situation: Kinematics of basketball shooting *Journal of Physics: Conference Series* **622** 012008
[7] N Ahmadet, R A R Ghazilla and N M Khairi 2013 Reviews on various inertial measurement unit (IMU) sensor applications *International Journal of Signal Processing Systems* **1**(2) pp 256-262