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Research Article

PERFORMANCE MONITORING AND ANALYSIS OF SHOOTING FORM OF BASKETBALL PLAYER USING SMART WEARABLE DEVICE

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ABSTRACT

In modern sports training, collecting and analyzing basketball player's performance is of great significance for improving the scientific of the coach's training plan and improving the athlete's training effect. Rapid advancement in the development of Internet of Things (IoT) based smart wearable devices has motivated us to develop a device which can monitor the performance and analyze the shooting form of basketball players remotely. In this paper, we present the design of a system that can measure and analyze in real time, the free throw shooting action of a professional basketball player. A new heuristic tool has also been developed to analyse every phase of the shooting action to segment out an ideal shooting action of individual players. The developed tool is proven to be more efficient than the conventional k-map clustering approach.

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INTRODUCTION

In the process of basketball training and competition, coaches need to formulate corresponding training plans according to the individual conditions of different athletes to improve the basketball skills of athletes. Sports biomechanics is a quantitative based study and analysis of professional athletes and sports activities in general. It can simply be described as the physics of sports. The work in this paper will be able to provide athletes and coaches with objective information that help them better understand areas of performance requiring attention, the tactics they perform successfully and the strengths and weaknesses of forthcoming opponents. Weaknesses can be analyzed to help improve performance and show where a player is underachieving. In our work, we make use of inertial measurement units and a wi-fi module to develop a device that can record and recognize the movements while shooting a basketball. The whole action of shooting the ball is classified into three stages viz, the stationary phase, the holding phase and the loading action phase. The device is attached to the dorsal side of the hand and features like the flick velocity, loading angle and the overall shooting efficiency are extracted. Performance analysis tools and techniques have also been developed using parameters derived from feature extraction, classification algorithms and qualitative evaluation methods. We also train the system to identify and give an approximate range of parameters with which he/she has the maximum probability of making a shot.

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Data Collection

The player is made to stand at the free throw line which is approximately 15 feet from the backboard of the basket. The device is placed on the wrist of the player. It consists of a micro controller which communicates with the GY-80.Basically, we need to integrate the angular velocity (from the gyroscope) in order to compute the angle. Since every gyroscope measurement contains noise the integration process integrates the noise as well. The gyroscope data is sampled at 100Hz; thus the noise in included in the integration process 100 times every second. And this cause the angular position to drift in time using I2C protocol. We collect accelerometer and gyroscope data which is sent to an access point through UDP where it is collected and stored in 6 second windows. UDP is a uni directional connectionless protocol with low latency (there is no acknowledgement from receiver). A camera is placed at "side view" so as to observe the players' limb movement as well as the trajectory of the shot. We capture these camera frames serially which is then synchronized to the IMU data using the respective time. Data collection is repeated a number of times which is later used to perform analysis as described in Sections IV and V.

Shot Detection

For automated shot detection we place a sensor node on the net of the basket which tells us the outcome of the shot i.e. in or out. There are two sensor nodes: one on the wrist and one on the net. First the wrist node detects a shot (by measuring the flick velocity). A short time interval after this, there is a spike in measurements of the sensor mounted on the net. If the ball goes into the net there will be a large spike in the raw measurements of the net sensor. If the spike is not sufficiently large, then the ball has not gone inside. In this paper, our first objective is to classify basic shooting actions in basketball, including: stationary, holding and loading action.

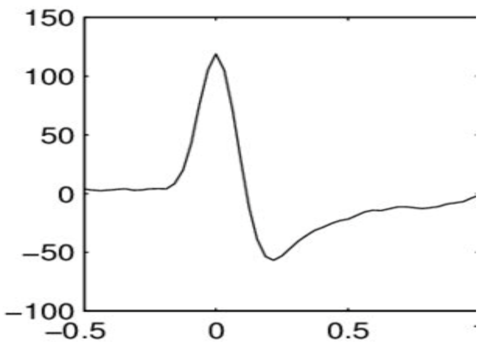
Classification of the Free Throw Action

Stationary **Holding** **Loading**

Table 1 Hitting the center of the rim with different heights and speeds

v(m)	h(m)	α1 (degree)	α2(degree)
8.0	1.8	62.4095	42.7936
	1.9	63.1177	42.9188
	2.0	637288	39.1283
	2.1	64.2671	37.4014
	1.8	64.6972	37.5061
	1.9	68.0289	34.5201
8.5	2.0	68.3367	33.0441
	2.1	68.6245	34.1333
	1.8	71.0697	32.7614
	1.9	71.2747	31.3874
	2.0	71.4707	30.0117
9.0	2.1	71.6567	30.0108

Plot of Holding and Loading



Heuristic based classification

Firstly, in order to recognize the stationary position we use the initial hundred samples for calibration. This is the duration at which the body is in its stationary position, and we calculate the mean value of the acceleration. A specific threshold is fixed about this mean value and whenever the acceleration is detected within the given limits, we recognize it to be in the stationary position. The loading position is detected by finding the maximum value of the angular velocity above a certain threshold in the six second window. The loading phase is the phase between this spike in the angular velocity and the zero crossing of the same just before the spike. The phase at the end of stationary until the loading phase, is recognized as the holding action.

Free Throw Analysis

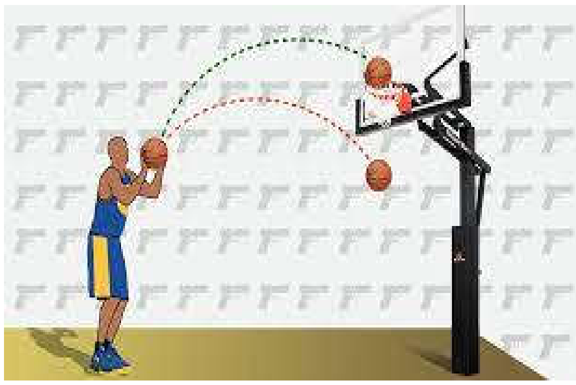
The primary variables determining the trajectory of a free throw are the release velocities and release angles. The release velocities are termed as flick velocities (due the flicking nature of the wrist action at the end of the free throw). Flick velocity represents the speed of flexion of the wrist at the time of release which causes a spike in the gyroscope measurement (i.e. angular velocity). This spike, if above a certain threshold, is defined as a flick (resulting in a free throw). The loading angle is the corresponding roll angle at which the extension of the wrist is maximum. This motion is detected in the gyroscope as the zero crossing of the angular velocity just before the release.

Analysis of the shooting angle and speed

The shooting angle in free throws is the angle formed by the ball and the horizontal direction at the moment when the ball leaves the hands. The shooting angle directly affects the radian of the ball whiling moving in the air and the angle it hits the rim. If the shooting speed is the same and the shooting angle is small, then the radian of the ball is low; if the shooting angle is big then the radian of the ball is high. So to ensure the ball hit the rim accurately, the shooting angle and speed have to be reasonable.

Analysis of the use of strength

The effort in free throw shootings is a process of integrated and coordinated effort of various parts of the body. Under normal circumstances, when the shooting distance is short, we can use less intensive integrated physical exertion. The small muscle groups in fingers and wrist are the main parts of exertion in shootings. When making free throws, it requires not only the muscles and joints in various parts of the body to make coordinated effort, but also to master the order and strength of the muscle, so that the efforts can be fully made and be the most labor-saving, it is also very favorable for mediating integrated exertion, so that the shooting action can be accurately completed.



Analysis the follow actions of the arms when and after the ball leaves the hands

In free throws, the movements from the shooting to the follow-up should be coherent and complete, both smooth and soft, for it is very important for improving hit rate. At the moment the ball leaves the hands, the arms, wrists, and fingers of the player shoud be fully stretched, the shaking of the wrists should be gentle and not too strong to avoid the spin of the ball. The shooting motion is correct when the wrists and fingers forms the gooseneck shape.

Trial	Shootig Accuracy (%)	Flick velocity	Loading angle (degrees)	Shot variance angles (degree)
Week1	54	270-310	-20to-16	13
Week2	67	293-307	-20to-16	4
Week3	71	284-318	-20to-16	4

We have conducted the experiment on a semi professional basketball player over a period of three weeks and evaluated his performance at the end of each week. The results of his performance is as tabulated above

We see that the player's shooting action becomes consistent within his preferred trajectory over the course of 3 weeks of training with the device.

CONCLUSION

In this paper a heuristic method of classification described, is designed for the sole purpose of measuring and estimating the performance/efficiency of free throw action to help improve shooting accuracy by providing feedback on parameters like flick velocity and release angle. As seen in the results, semi-professional players can get real-time feedback of shooting action (loading angle, flick velocity and trajectory and improve their shooting form to make it more consistent. The analysis shows that using the system has dramatically reduced the shot variance and enabled the player to be more accurate and consistent. The visual feedback provided through the efficiency plot helps a player to correct the shooting action to achieve an optimum shooting form. This device described in this paper can adapt to an individual's shooting action and provide accurate real-time improvements during training. Future work will focus on algorithms to better the person's shooting not only from the free throw line but various other positions on the court. This will take into the person's position on the court, speed of release, height of jump and other variable parameter.

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