AUGMENT IT FOR SHOT PUT

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Abstract—**The technologies currently on the market for evaluating the quality of shot puts are expensive, hard to use and not intuitive. Therefore, the object of this study has been measuring the performance of shot put athletes, especially the acceleration and the gyroscope, in order to improve their training and make it more efficient and professional. Our solution is developing a Matlab application that uses an inertial measurement unit (IMU) as a method of detecting acceleration and rotation. The athletes will ideally record themselves with their own smartphones and the video will afterwards be visualized, processed and synchronized in Matlab together with the graphs obtained from the sensor data. In addition, the signals and the videos used were captured from a professional shot put athlete.**

Keywords: *Shot put, IMU, Acceleration, Gyroscope, Software, Athlete, Matlab application*

I. INTRODUCTION

The shot put is a track and field event involving pushing a heavy spherical ball, known as the shot, as far as possible.

Nowadays, shot put is one of the most popular events of track and field and requires a perfect set of strength, speed, and technical abilities. Shot put performance is based on technical patterns that create a sum of forces generated by various parts of the body [1]. According to the professional athlete interviewed, the technologies that the shot put athletes use nowadays are motion capture labs and video analysis. They tend to have an online coach that analyzes the video recorded by themselves and gives feedback on what needs improvement [2]. In addition, high-speed cameras are also used to record the action during shot put competitions and analyze the throw.

A perfect technical sequence of body movements is crucial for the specific performance. Therefore, developing an application with accurate data and intuitive video during the shot put performance can help athletes improve and correct their flaws.

II. OBJECTIVES

A. General objectives

This work aims to study the limitations and current state of the technologies used during shot put performance in order to develop an application where athletes can record themselves and analyze the data recorded by a sensor placed on their dorsal hand.

B. Specific objectives

- Record acceleration and gyroscope data with the IMU sensor.
- Process, filter and analyze data with Matlab.
- Define the parameters of interest calculation.
- Develop an application in Matlab that is able to incorporate a video recorded on the phone and synchronize it with the data.

C. Needs

The developed application will ideally fulfill shot put athletes needs because it will help them identify their flaws during the performance and their coaches will be able to detect and improve the sports technique. In order to create a useful app, a professional athlete was interviewed and innovative parameters such as the peak velocity and force were achieved.

III. HARDWARE

Inertial measurement unit (IMU) is a device that measures acceleration, angular velocity and magnetic field using accelerometers, gyroscopes and magnetometers, respectively. IMU measures the change in each of the three principal axes – Roll, Pitch and Yaw (X, Y, Z). Initial sensors such as accelerometers (ACCs) and gyroscopes (Gyros) are the core of IMU utilized in the shot put record.

IV. DATA

Matlab is a programming platform designed to analyze and process data and tt is the software that was used during this project to build the App and analyze the shot put athlete data.

A. Data recorded

The acceleration and gyroscope data was recorded from a 25 year old male shot put athlete with a height of 185 cm and a weight of 120 kg and then transferred to Matlab.
The data was recorded using the SmartGym app [3].

The sampling frequency used in this case was 416 Hz and the shot put ball used during data acquisition was a standardized one used during men competitions with a weight of 7.26 kg. The shot put throw recorded is 2.7 seconds. A total of 12 throws have been recorded in order to present consistent results.

B. Data interpretation

Firstly, the average of the total acceleration and gyroscope values was done, using respectively the equation 1 and 2 presented below.

$$Accelerationtotal\ (m/s^2) = \sqrt{accX^2 + accY^2 + accZ^2} - g \ (1)$$

$$Gyroscoptotal\ (deg/s) = \sqrt{gccX^2 + gccY^2 + gccZ^2} \ (2)$$

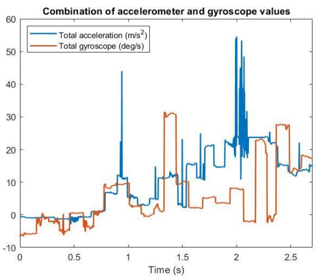

Figure 1. *Plot of the combination values of the gyroscope and accelerometer.*

Additionally, in order to calculate the force, the second law of Newton (3) was used.

$$Force\ (N) = Accelerationtotal * mass\ ball\ (3)$$

Once the force was achieved, a simple program was developed in order to delete the negative values of the graph. Then, the impulse was obtained by calculating the area underneath the curve of the force vs time graph with the trapeze integration method. A short program was implemented to find the maximum force value to obtain the peak force. In addition, the velocity was obtained by integrating the total acceleration vector and the maximum of the result velocity vector is shown as the peak velocity.

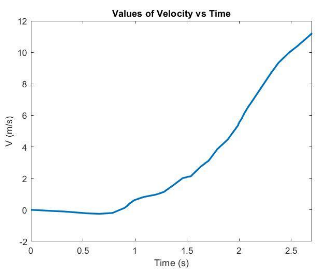

Figure 2. *Plot of the values of the velocity vector vs time.*

Finally, the peak rotation speed was obtained as the maximum value of the total gyroscope graph and the distance was measured with a tape measure.

Magnitude	***Results***	***Units***
Impulse (I)	375.8 ± 48.75	kN*s
Peak force (PF)	63.49 ± 30.67	N
Peak velocity (OV)	3168 ± 875.8	m/s
Peak rotation speed (RS)	8.75 ± 4.22	deg/s
Distance (D)	16.9 ± 0.34	m

Table 1. *Table with the mean results of the 10 throws and errors (standard deviation) obtained during the data processing.*

C. Data filtered

Whenever a sensor is used to measure a signal, an unwanted signal in the form of a noise is always present in the measurement. Therefore, our next step was applying an Exponentially-Weighted Moving Average (EWMA) filter in order to process the shot put athlete data and graph it[4].

The EWMA filter is used for smoothing data series readings. In this project an EWMA filter with alpha=0.75 was designed and implemented using Matlab [4].

D. Data validation

Firstly, the quality test assessment of the sensor used has been determined by throwing the sensor on a table and uploading the data on Matlab. A peak has been observed in all plots on the exact time when the sensor hits the table, proving that the sensor works correctly.

In addition, to validate the usability and reliability of the results, the data from the professional athlete has been recorded twelve times in order to calculate the average and the miscalculation with the standard deviation of all the parameters illustrated in *Table 1.* Nevertheless, it has only been taken into account 7 out of 12 recordings due to some unexpected errors. In some parameters shown in *Table 1*, a high standard deviation is observed due to some assumptions and roundings that have been made.

V. APPLICATION

An application using Matlab AppDesigner has been implemented in order to give a useful tool for shot put athletes improvement.
Firstly, the athletes will place the IMU sensor in the back of their hand and record a video of their throw with their own smartphone. Both the data and the video recorded will be afterwards uploaded in the Matlab App and then the results will be displayed in the proper window once the user has introduced the ball weight and pushed the buttons.

The App has been divided into five windows as it can be shown in *Figure 3*. The first one shows an introduction to the developed App and explains the main objective and how to use it. The second window is where the users will upload their IMU data in order to get the first four parameters mentioned above in *Table 1*. Window three shows the graphs of the combination of the total acceleration with the gyroscope, the values of the velocity vs time and the values of the accelerometer vs time with filtered, raw or both data. In the fourth window the user uploads the video and it simultaneously represents the video recorded with the acceleration graph. As the video is displayed, the user will observe a red dot moving through the acceleration graph. The objective is to. In the last window (*Figure 4)* the user can choose through a slider the exact frame of the video they want to observe in the acceleration graph. This enables them to display each moment of the shot and makes it easier to visualize and interpret the data .

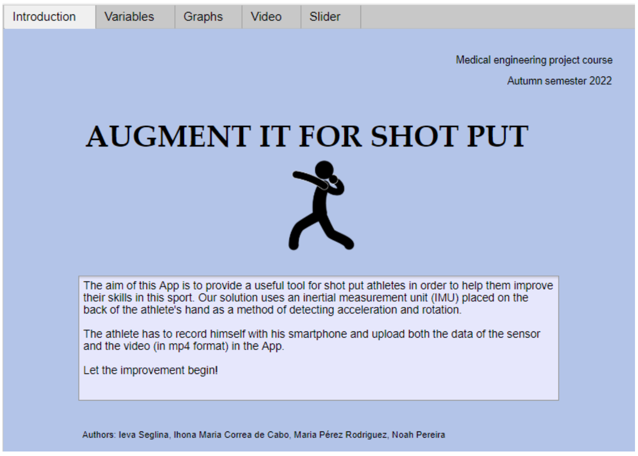

Figure 3*. First window of the app.*

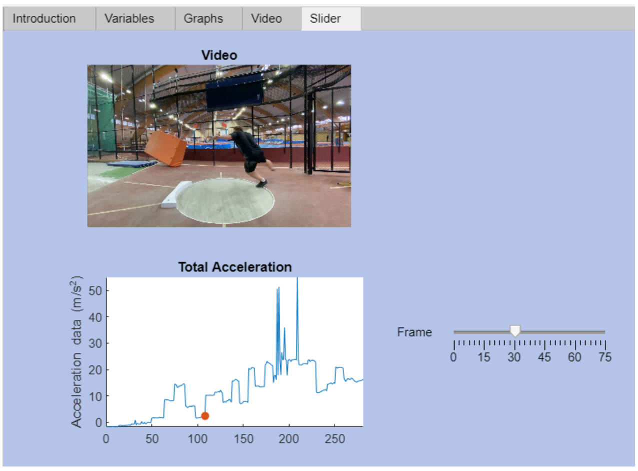

Figure 4*. Fifth window of the app.*

Further explanation with a detailed video exemplifying how the app works, as well as the commented matlab code can be found on our GitHub [5].

VI. CONCLUSION

In the light of the above, this final short paper has covered our sprints and has given an approach to the solution proposed. An automated application has been successfully developed with Matlab following the athlete's needs. The application is able to display simultaneously on screen both video and graphs so that the user can visualize at the same time the video and the graphs of the data recorded by the sensor correlated in every second of the video. Moreover, some graphs are obtained and important parameters are calculated with little human intervention.

Nevertheless, further work needs to be done in this code so that the application designed for shot put athletes is also useful for other sports like sledge hammer, discus and javelin throw.

Another improvement could be to implement the Kalman filter, collect more data from professionals to accurately validate the results and modify the code so that it automatically selects the start and end from the throw.

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