November 6, 2024

Dear Editor and reviewers,

RE: Manuscript No.: SENSORS-3287358

Title: Research Progress of the Intelligent Sensors Applying on Sports Science.

Thank you very much for reviewing our manuscript. We appreciate the Editor's and reviewer's comments and suggestions to improve our manuscript. Below is the list of the detailed responses to the comments from the Editor and reviewers. We have clearly shown all textual changes using track changes, shown in "Marked-up original manuscript" document.

Yours Sincerely and Respectfully,

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RE: Reviewer #1

This manuscript provides an overview of the research progress in the application of smart sensor in the field of sports science, highlights the current advances, challenges, and future directions in the development of smart sensor technologies, and anticipates their transformative impact on sports science and athlete development. However, there are some points needing to be clarified. The detailed points are as follows:

1. There needs to be attention paid to the author's name format to ensure consistency.

(Response) Thank you very much for your comments. We apologize for the author name formatting error and have now standardized the formatting of all author names.

2. Please explain the meaning of points 1-7 in Figure 4. Besides, please explain the process of data extraction in detail, including how to deal with data inconsistencies and how to ensure the accuracy of data extraction.

(Response) Thank you very much for your comments and suggestions. We apologize profusely for not explaining in detail the information conveyed by points 1-7 in Figure 4 and the process of data extraction. The sentences "Hakim et al. [27] used an MPU6050 sensor, which includes an accelerometer and a gyroscope, in an IMU single chip. The gyroscope was set to measure up to 1000 degrees per second. Since the gyroscope measures the angular velocity of the motion, the proposed device has a significant data change in the gyroscope y-axis. If the foot moves forward, the sensor rotates on the y-axis. The sampling rate data is $33H$, so the prototype needs to store 33 data in 1 second. An Xbee transmitter mounted on the prototype sends the data to an Xbee receiver connected to a computer. Creating an on purpose application to be used by this prototype for data retrieval, the obtained data transmitted wirelessly. The acquired data was saved into a file in Excel format.

As shown in the data presented in Figure 4a, a distinct pattern emerges during the step sequence. The intervals from point 1 to point 3, point 3 to point 5, and point 5 to point 7 exhibit two-step waveforms. The movement from point 1 to point 3 corresponds to the motion of the foot, as illustrated in Figure 4b. Specifically, the change in the waveform from point 1 to point 2 in Figure 4a reflects the movement of the foot during action 1 to action 2, as the device is attached to the right foot pedal. During this phase, the angular velocity is significantly measured by the device. In contrast, the change in angular velocity between point 2 and point 3 is less pronounced, as shown in Figure 4b, when motion 3 and motion 4 occur. This is attributed to the inward movement of the left foot. This pattern can be utilized to determine the frequency value of a two-step cycle based on the time domain. As shown in Fig. 4, the wave from point a to point b represents a 2-foot stride. Point a to point b consists of 65 data points. With a sampling rate of 33 H, the period to produce 65 data points is 1.95 s, corresponding to 2 steps. The analysis of fluctuation points during the step yielded a footstep frequency of 0.513 H. Furthermore, from the obtained time period, the linear

velocity was calculated to be 0.39 m/s or 1.404 km/h, thus completing the study of human gait monitoring, particularly footfall frequency and linear velocity. The relative error was utilized to compare the linear velocity of the treadmill with the measured values, and the Fast Fourier Transform (FFT) was used to validate the results of the time-domain data and accurately measure the exercise step frequency." have been added. (line number 228-254 on page 6)

The above also provides a brief description of the data processing inconsistencies and the methodological measures to ensure the accuracy of data extraction, which is centered around Fast Fourier Transform (FFT). At the same time, in order to make readers have a better understanding of the picture, we have beautified and improved Figure 4. As shown in the following figure:

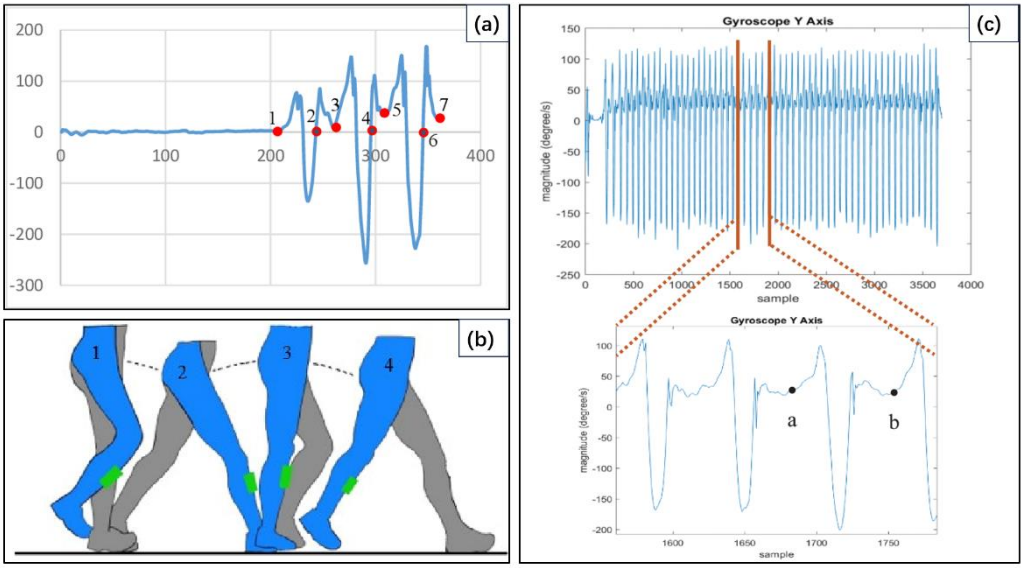

Figure 4. Graph of the gyroscope sensor data on the Y-axis for 6-foot steps and Representation graph of the y-axis of gyroscope where point a is 1683 samples and point b is 1748 samples[27].

3. It is recommended to check the resolution of figures to ensure they are clear.

(Response) Thank you very much for your comments and suggestions. We checked the clarity of all the images in the article and enhanced the clarity of Figures 4 & 7 as shown below.

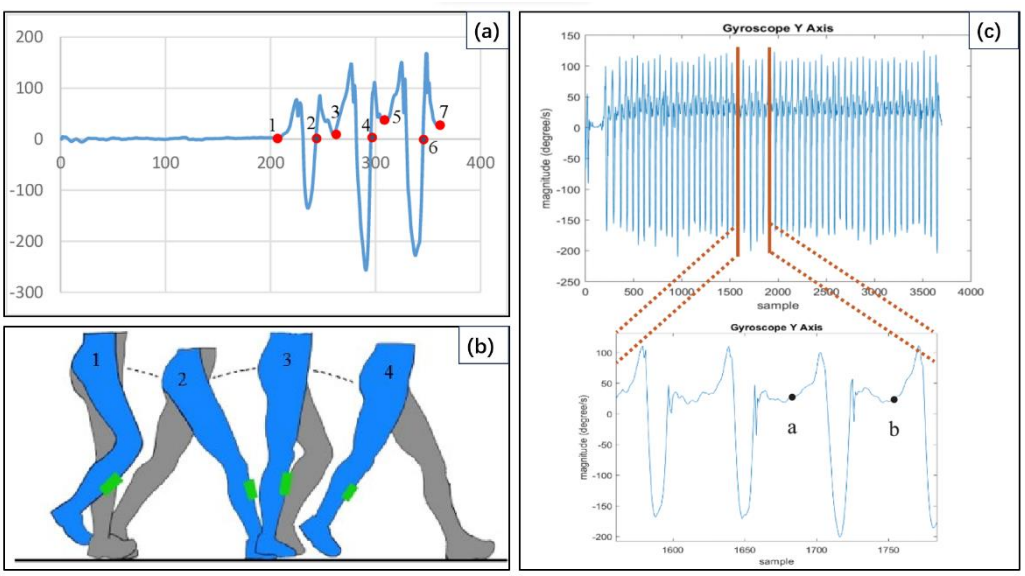

Figure 4. Graph of the gyroscope sensor data on the Y-axis for 6-foot steps and Representation

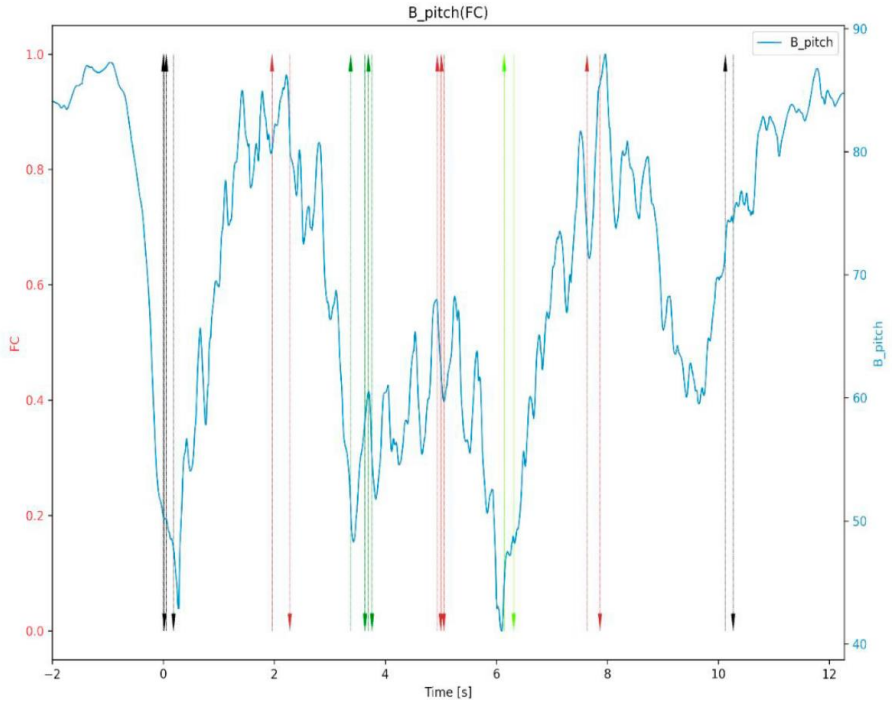

Figure 7. T-test graph containing optical gates data (vertical lines) and pitch signal from BNO055 (blue curve), at the beginning and at the end of the test the athlete is standing upright and the pitch is approximately 90° (the difference of a few

4. The format of references is not standardized, and it is suggested to be revised and improved.

(Response) Thank you very much for your comments. We apologize for the irregular formatting of the article references and have now standardized all of them. Examples of specific formats are as follows:

1. Umek, A.; Kos A.; Tomazic, S. SmartSKI: Application of Sensors Integrated into Sport Equipment. *In Proceedings of the 2016 International Conference on Identification, Information and Knowledge in The Internet Of Things (IIKI)*, Beijing, China, 20-21 October **2016**; pp. 122-127.
2. Rum, L.; Sten, O.; Vendrame, E.; Belluscio, V.; Camomilla, V.; Vannozzi, G.; Truppa, L.; Notarantonio, M.; Sciarra, T.; Lazich, A.; Mannini, A.; Bergamini, E. Wearable Sensors in Sports for Persons with Disability a Systematic Review. *Sensors-Basel* **2021**, 21: 1858.
3. Shi, Q.F.; Dong, B.W.; He, T.Y.Y.; Sun, Z.D.; Zhu, J.X.; Zhang, Z.X.; Lee, C. Progress in wearable electronics/photonics-Moving toward the era of artificial intelligence and internet of things. *Infomat* **2022**, 2: 1131-1162.

5. Please pay attention to the layout of the full text to make the layout of the article more beautiful.

(Response) Thank you very much for your comments and suggestion. We apologize for the inconsistencies in the formatting of the text and the layout of the images in the article, which have now been completed.

6. This article conducts an extensive literature review on the application of intelligent sensors in sports science, covering various aspects such as motion monitoring and physiological signal detection. However, it is suggested that the authors could further highlight the advantages, limitations, and applicable scenarios of different sensor technologies in the review, so that readers can have a more comprehensive understanding of the applicability of various technologies.

(Response) Thank you very much for your comments. To further highlight the advantages and disadvantages of different sensor technologies and their applications, we have enhanced the descriptions of the importance of inertial sensors, the characteristics of temperature sensors and their limitations, as well as the application scenarios of some of the sensors with respect to the content of Article 3.3.

The sentences “It is worth emphasizing that appropriate kinematics and forces can be measured using IMUs or strain gauges when power meters are either unavailable or impractical. The future prospects for mechanical power estimation using IMUs appear particularly promising, with potential for significant advancements through the integration of machine learning techniques. However, in specific cases, such as during wheelchair propulsion, force measurement via IMUs may be redundant. In such instances, me-chanical power can be estimated by combining rolling resistance losses with kinetic energy estimation.” (line number 353-370 on page 9), “Capable of sensing and recognizing the static and motion comfort of a shoe, it also shows the health of the shoe and the concentration of pressure on the toes.” (line number 373-375 on page 9), “providing guidance for foot monitoring and customized shoe design.” (line number 376-377 on page 9), “This study applied several sets of sensing devices such as force and bending sensors, inertial sensors, etc., in which IMUs were used to study the motion state of human body, which shows the importance of IMUs in motion science monitoring.” (line number 389-391 on page 10) and “The development of body temperature sensors has focused on achieving wearability, high sensitivity, accuracy, portability, large array coverage, and real-time monitoring capabilities. Typically, RTDs, thermocouples, and thermistors are employed to convert temperature changes into corresponding

electrical signals. These sensors can be ul-tra-thin, with low heat capacity and fast response times. In contrast, myoelectric sen-sors use flexible dry electrodes to capture electromyograms. When combined with highly conductive nanomaterials such as metals, carbon, and polymers, these sensors provide a good fit to the skin and are effective in reducing noise interference. However, it is important to note that the complex and dynamic environment of the sports field can lead to significant deviations in sensor measurements due to temperature fluctua-tions, while mechanical shocks and external wear during movement may degrade de-vice functionality. Therefore, integrating temperature sensors into various sensing systems should be considered to mitigate the adverse effects of these challenges through subsequent compensation algorithms." (line number 439-452 on page 12) have been added.