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Team 1: Smart Tennis Racquet

# Smart Tennis Sensors for Improved Tennis Game Play

## Introduction

Tennis is a widely played sport that continues to grow in popularity. In 2020, tennis participation in the U.S. alone increased by 22% with 21.64 million people playing nationwide [1]. While some of these players may be playing purely for fun or for the health benefits, there is still many players who play competitively and professionally. With tennis scholarships, company endorsements, and international fame being possible from playing professional tennis, there are no shortage of people who are looking to improve their game play and skills. However, with private tennis lessons averaging $75 an hour and professional coaching ranging from $1000-2500 a week plus a percentage of one's earnings and a bonus, becoming a top ranked, skilled player has an expensive upfront cost [2,3]. The creation of a cheap and accurate tennis sensor designed to improve a player's game play could allow less financially well-off players to have the opportunity to compete professionally as well. This technical review briefly summaries some of the current commercially available tennis sensors, the benefits of using sensor-based game analysis in tennis, the implementation of tennis sensors for game play analysis, and the current shortcomings of tennis sensors.

## Current Commercially Available Tennis Sensors

There are a few tennis sensors currently on the market with ZEPP and Coollang being two of the largest players. Because tennis is a sport that requires immense precision and accuracy, tennis sensors must be light-weight and unnoticeable enough as to not affect a player's hits and game play. ZEPP has created the ZEPP 2 which is an in-racquet sensor goes into the butt of the racquet and analyzes sweet spot detection, ball speed, spin speed and stroke type. The ZEPP 2 sensor weighs 6.25g and contains dual accelerometers and dual 3-axis gyroscopes for match analysis. The sensor contains a lithium-ion battery and uses Bluetooth to connect to one's phone to upload the game play data to their mobile application for viewing [4]. The ZEPP 2 Tennis sensor is priced at $99, however, it only seems to be available on Amazon for $220 [5].

Another competing sensor on the market is the Coollang Smart Tennis Sensor. Similarly, to the ZEPP 2 sensor, the Coollang sensor is an in-racquet sensor that attaches to the butt of the racquet and identifies shot type, spin type, and ball speed. However, unlike the ZEPP 2, the Collang sensor does not seem to have sweet spot detection. The Coollang sensor is slightly lighter than the ZEPP 2, only weighing 6g, and also uses Bluetooth to upload game play data to their mobile app on one's phone. This sensor retails for $54.99 [6,7].

**Benefits of Using Sensor-based Game Analysis in Tennis**

Tennis, being a highly strategic game, requires a lot of players to analyze and review their game play and mechanics to accurately improve as play. The availability of smart tennis sensors has now allowed players and coaches to review game play data from previous practices and games to plan and produce future workouts, practices, and possible match strategies more efficiently. This becomes especially useful for junior tennis players in preparing workload and practice schedules in preparation for upcoming tournaments.

In an article published by the International Journal of Sports Science & Coaching, 14 high school players used the Sony Smart Tennis Sensor (SSTS) for six weeks. These sensors were placed in the butt of the racquet and was used during all tennis events. The study found that the SSTS was 94% accurate in tracking total hitting volume over an extended amount of time, and since hitting volume is used as a measure of external workload, this data would be useful in the creation and monitoring of training workloads. Injuries tend to occur when a workload is increased by more than 10% from week-to-week, so the SSTS and many other smart tennis devices could help decrease injury and overworked rates among players [8].

**Implementation of Tennis Sensors**

Despite various companies all having smart tennis sensors, the general design and implementation of each sensor is the same. The inertial sensor is connected to the racquet and contains an accelerometer and angular rate (gyro) array with three degrees of freedom in acceleration and rotation respectively. A processor is connected to the inertial sensor to determine stroke type based off the accelerometer and gyro arrays. The stroke type is then stored in the connected memory device. Due to the size and weight limitations, IMUs are consistently used in combination with either a microcontroller or microprocessor, a lightweight power battery, transmitter, and memory system. The stroke type analysis can differ greatly

from sensor to sensor between using Kalman filtering for state vector estimation, physics-based analysis, statistical analysis, or a combination of the aforementioned [9].

**Current Shortcomings of Tennis Sensors**

Despite the various number of tennis sensors on the market, it seems that smart tennis sensors have been particularly popular or used in the tennis community. One article examined the validity of the BABOLAT and HEAD tennis sensors and found that in match environments, there was a high error percentage (>10%) for the number of forehand and volley strokes [10]. This article's findings are consistent with the review from many customers complaining about the inaccurate swing analysis, specifically with serves and volleys, terrible user interface, short battery life, and even poor mounting [5]. While tennis sensors seem to have a lot of potential to improve game play and skills, it seems that the current available sensors are not reliable enough for significant game play and skills development and improvement.

## References


[1] "U.S. tennis participation surges in 2020, Physical Activity Council (PAC) report finds," *USTA*, 11-Feb-2021. [Online]. Available: https://www.usta.com/en/home/stay-current/national/u-s--tennis-participation-surges-in-2020--pac-report-finds.html. [Accessed: 08-Oct-2021].

[2] "Find tennis lessons: Find tennis coaches: Find tennis instructors," *FindTennisLessons.com*, 07-May-2021. [Online]. Available: https://www.findtennislessons.com/. [Accessed: 08-Oct-2021].

[3] M. Zeegers, "How much do professional tennis coaches make? - sportscasting: Pure sports," *Sportscasting*, 16-Sep-2020. [Online]. Available: https://www.sportscasting.com/how-much-do-professional-tennis-coaches-make/. [Accessed: 08-Oct-2021].

[4] *ZEPP TENNIS 2 USER GUIDE***,** ZEPP, Cupertino, CA, USA, Oct. 2017, pp. xxx-xxx (pages if relevant). Accessed on: Oct. 8, 2021. [Online]. Available: https://www.manualslib.com/manual/1407290/Zepp-Tennis-2.html#manual

[5] "Amazon.com: Zepp Tennis Swing Analyzer: Sports & Outdoors." [Online]. Available: https://www.amazon.com/-/es/ZA1T2NA-Zepp-Tennis-Swing-Analyzer/dp/B00IIF6POE. [Accessed: 08-Oct-2021].

[6] "Coollang Smart Tennis Sensor," *Coollang*. [Online]. Available: http://www.coollang-global.com/welcome/tennis. [Accessed: 08-Oct-2021].

[7] "Amazon.com : Coollang Tennis Racket Sensor Tracker motion ..." [Online]. Available: https://www.amazon.com/Coollang-Detector-Analyzer-Bluetooth-Compatible/dp/B08XV94FZ6. [Accessed: 08-Oct-2021].

[8] N. L. Myers, W. B. Kibler, A. H. Axtell, and T. L. Uhl, "The Sony Smart Tennis Sensor accurately measures external workload in junior tennis players," *International Journal of Sports Science & Coaching*, vol. 14, no. 1, pp. 24–31, 2018.

[9] B. Mettler, "Racket Sport Inertial Sensor Motion Tracking Analysis," 03-Feb-2015.

[10] A. Edelmann-Nusser, A. Raschke, A. Bentz, S. Montenbruck, J. Edelmann-Nusser, and M. Lames, "Validation of sensor-based game analysis tools in tennis," *International Journal of Computer Science in Sport*, vol. 18, no. 2, pp. 49–59, 2019.