Tennis Racquet Stringing Patterns

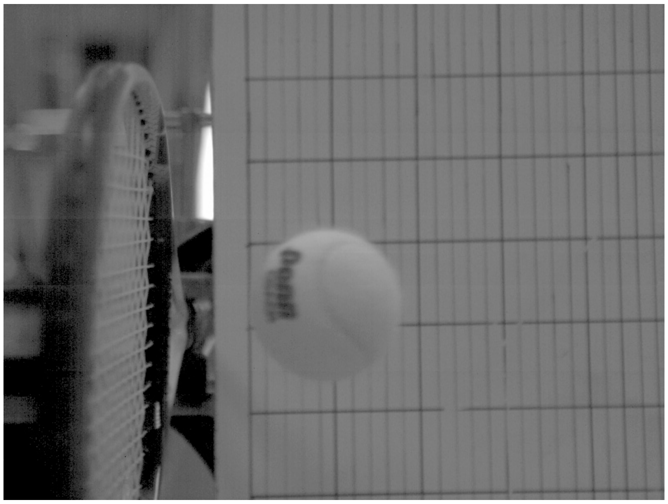
Phantom camera is used to characterize performance of diagonally-strung tennis racquets

Tennis is a game of speed, agility and precision. The sport requires a significant amount of concentration and hand-eye coordination, especially when your opponent serves a felt tennis ball in your direction at speeds upwards of 120 miles-per-hour! It's also a sport known for its subsequent injuries, especially lateral epicondylitis (tennis elbow), which affects 40 percent to 50 percent of tennis players. That being said, those who take to the court are always in search of ways to reduce stress and potential injury, as long as the solution doesn't sacrifice performance.

Reassessment and modifications to tennis equipment, namely the racquet, have been the focus of many manufacturers and professionals over the years, with a significant amount of attention falling on the stringing pattern, where the impact with the tennis ball actually takes place. Besides the obvious advantages yielded by high-performance, lightweight composite materials such as graphite - used in the construction of the racquet frame - and the benefits of natural gut and synthetic gut (nylon) for stringing, many tennis players feel that employing a diagonal stringing pattern can effectively reduce vibration, a leading cause of tennis elbow. Diagonal stringing, a method consisting of opposite pairs of equal strings, has been developed to reduce harmful vibrations without compromising the performance offered by a conventional (perpendicular) pattern.

To clearly identify the benefits of each stringing pattern, Vision Research worked alongside Micah Joselow, a junior at Ossining High School, in Ossining, N.Y., who spearheaded a scientific research project focused on highlighting the characteristics of a diagonally strung racquet versus a conventionally strung racquet. Vision Research provided Joselow with a high-speed, Phantom® V7.1 digital camera, which was utilized to record the interaction of a projected tennis ball with each racquet. Joselow's findings were impressive and in recognition of his work, the project took first place honors in the Physics category at the Westchester Science and Engineering Fair (WESEF) and won the prestigious Yale Science and Engineering Award.

"In a controlled environment, the racquets were each subjected to a projected tennis ball, launched at the same speed from a tennis ball projectile device," said Joselow. "Levels of oscillation (vibration) were determined through the use of a piezoelectric disk setup. A piezoelectric disk was placed upon the handle of each individual racquet, and attached to an oscilloscope. Each racquet was hung upon an identical apparatus as a freely moving pendulum, and tennis balls were projected upon their strings at various locations from the handle. During each test, the piezoelectric disk on each racquet handle gave off a specific level of voltage to the attached oscilloscope, which then recorded the oscillations given off by each racquet."



In order to test for the overall "performance" of each stringing pattern, hundreds of high speed videos of tennis balls being projected upon each racquet were recorded by the Phantom V7.1, and analyzed for the elasticity (power) of the strings and ball control.

"This process was repeated over and over again, amassing hundreds of videos of the events. The speed of the camera, coupled with the resolution and detail, took this experiment to a whole new level."

Thanks to the speed and sensitivity of the V7.1, Joselow was able to capture videos of the tennis ball making contact with the racquets at the camera's maximum resolution of 800 x 600 pixels, at speeds up to 4,800 pictures-per-second. For even faster frame rates, Joselow was able to lower the V7.1's resolution to achieve speeds maxing out at 160,000 pictures-per-second. At such high speeds, even the most miniscule details of motion become visible, allowing for precise measurements and the application of analytical tools and software.

"Without the help of Vision Research, this physics project would not have been possible," said Joselow. "Furthermore, the ease-of-use of such a high-performance piece of equipment truly took me by surprise. With very little training, I was able to employ the V7.1 and take full advantage of its full array of features."

The Phantom V7.1's CMOS image sensor also played a significant role throughout the research experiment. All of Vision Research's digital cameras utilize the company's own proprietary CMOS sensors, which have been exclusively designed for high-speed use to balance sensitivity, speed and resolution. Additionally, unlike a CCD sensor, CMOS will not "bloom" (creating fringes of light around very bright objects in an image), and the Vision Research sensors used in its Phantom cameras are totally immune from multi-panel imaging artifacts associated with many older generation high speed sensors.

When operating the camera at high frame rates, a substantial amount of light is required to adequately expose the images. In the setup used for this research project, Joselow had access only to the already existing fluorescent lighting in the facility as well as residual daylight from outside the windows. Nevertheless, thanks to the high ISO rating of 4800 (monochrome), Joselow was able to overcome the challenging lighting scenario and effortlessly capture crisp, clear images.

Added Joselow, "Through this analysis, I found that diagonal stringing can be used in the game of tennis without compensation in quality of play, as the two different stringing techniques brought about identical power and control data findings. Thus, my project was able to exemplify the concept that diagonal stringing can be used to reduce vibrations by 40 percent without hampering a given tennis player's ability to serve or return the tennis ball during play."

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