VISUAL ASSESSMENT TOOLS IN TENNIS

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The ability to analyse high-speed strokes in tennis is at least in-part dependant on a coach's ability to 'see' the critical features of the stroke being analysed. While the 'eye' provides visual feedback of the highest order, there are times when technology can play an important role in assisting a coach to observe specific body movements or alternatively to present 'pictures of performance' to a player. Visual feedback is an integral part of performance feedback. This paper will discuss the different visual approaches that may be used by coaches. A relatively recent development the high-speed opto-reflective motion analysis system, has offered an alternate research design investigating tennis stroke production. Using such a system, results from a service analysis of high performance players will be presented in an endeavour to better understand the inter-relationship between the legs and the trunk in the tennis serve.

KEY WORDS: vision, service, motion analysis, photography.

INTRODUCTION: The eyes do not capture still images but continuously record information of light moving across the retina. To observe high-speed motions, that are common to tennis stroke production, the eyes do not continuously track movement (e.g. the ball following a serve) but track several brief sections of the motion using saccades (eyes jump from one fixation to another). Our eyes therefore observe critical cues from the ball and the opponent's racket and body at and before impact in order to predict where to track the ball in flight. Similarly in observing fast body segment rotations in strokes, the eyes obtain information that assists in the prediction of ball flight. Visual technology may then be used to assist these processes by allowing us to see more or to quantify aspects of selected movements. This paper will briefly review a number of ways that visual imaging may be used by the coach to improve performance (stroke production and court movement) and possible reduce the likelihood of injury.

STILL PHOTOGRAPHY: This produces a single image at a discrete point in tennis stroke production or court movement. Motor drives attached to a 35 mm camera (generally with a telescopic lens) will allow a series of images to be recorded, but limits on frame rates (generally up to about 12 pictures per second) inevitably mean that discrete, often important positions in a swing, or positioning of the body with reference to the court are often missed.

VIDEO PHOTOGRAPHY: The greatest advantage of video replay in qualitative analysis is the ability to stop and replay movement for comparative purposes. Standard video allows body positions to be frozen in time (25/50 frames/fields per second – PAL format or 30/60 frames/fields per second NTSC format). Currently, a television video frame is interlaced meaning it is composed of two half-spatial resolution fields. One large advantage of linking video to appropriate computer software is that you are able to view the 50 or 60 fields per second. The more recent development of progressive scan cameras means that the above technology will slowly be replaced.

The capture of key discrete positions integral to an analysis (e.g. such as impact) requires the use of high-speed video cameras (e.g. Phantom, Redlake, NAC), with recording rates in hundreds and thousands of frames per second. While these may be used in isolation to view stroke production or court movement, they are a far better coaching tool when linked with appropriate software discussed below.

VIDEO LINKED TO 2D COMPUTER SOFTWARE: Digital video signals can now be directly imported to computers so that the video may be replayed using a variety of software packages designed for qualitative analysis and to a lesser extent quantitative analysis of the movement. Some examples of these programs include Dartfish, NEAT, SiliconCOACH, MOStill, Swinger and Quintic, with features that enable coaches to:

- Present multiple videos (event synchronized) showing athlete versus model comparisons (Figure 1). Multiple videos may be viewed. This approach may also be used to track a player's performance over time, as is currently performed by many Tennis Associations.

Figure 1:SiliconCOACH program replay of split-screen images. Image courtesy of Silicon COACH, Dunedin, New Zealand.

- Bring the player's attention to specific aspects of performance by drawing on a frame or by tracing a movement over a number of frames.
- The overlay of one performer on top of another for comparative purposes.
- Display visual reference objects, points and lines. This may be used to emphasize the movement of the head during for example, a forehand drive.
- Calculate two-dimensional planar data. It is imperative that only measures are taken that are within one plane and that the camera is suitably positioned to record movement in this plane.

Other programs such as 'TimeWARP' (SiliconCOACH), Snapper (Webbsoft Technologies) and SportsCode (Sportstec) permit additional features to be accessed using 2D software packages. TimeWARP permits a video camera to continue recording a practice session, while a coach talks with and reviews performance by a particular player. Whereas SportsCode and Snapper, which are performance analysis packages, permit video to be marked such that selected shots can be identified and then recalled for inspection. Forehands hit down-the-line from an across court return may be identified and reviewed if a coach believes that there is a weakness in this area of play.

VIDEO LINKED TO 3D COMPUTER SOFTWARE: Anytime that a coach or player requires accurate measurement of long axis rotations of the limb segments (eg, forearm, upper arm), or movement in a number of planes (as is generally the case in tennis) it is necessary to utilise 3D motion analysis systems (e.g. ViconPeak, SIMI, Ariel) (Figure 2). In practice, the availability and cost of 3D motion analysis systems precludes such an approach for coaches. However, it is essential that coaches understand how analyses must be structured and appreciate the data reported in the coaching literature. For instance Elliott et al. (2003) used Peak Motus to analyze data collected with 200 Hz video cameras at the 2000 Sydney Olympics. They were able to show the value of "leg-drive' in reducing the loading at the shoulder and elbow joints during the service action.

A B

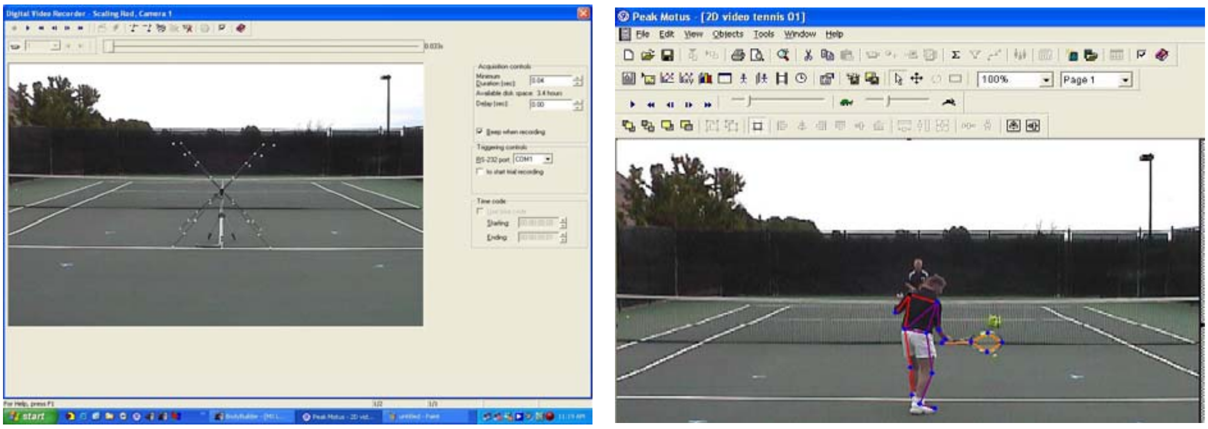


Figure 2: 3D system calibration frame (A) and image analysis (B). (Published with permission of ViconPeak)

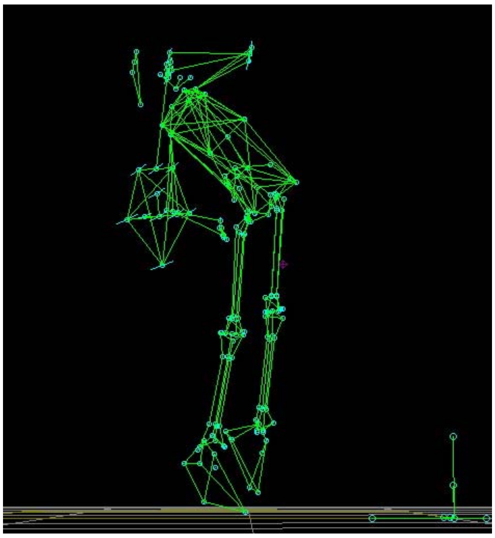
OPTO-REFLECTIVE PHOTOGRAPHY: These systems (eg, Vicon, Motion Analysis, Elite) have been the standard approach for gait laboratories for a number of decades. However, improved computer speed and camera resolution have recently seen this approach adopted by sport biomechanists. Laboratories that use opto-reflective systems will typically position the 6-12 cameras around the laboratory in a manner that best tracks the markers used in the analysis. These infra-red cameras are generally capable of recording images up to 1000 Hz, although 250 Hz was found sufficient for the tennis service action. Figure 3A shows a wheelchair subject ready for testing using an opto-reflective approach (upper body only), while Figure 3B shows a full body anatomical reconstruction of a discrete point in the service action.

In the service action the inter-relationship between the lower limbs and the trunk is critical to the successful high-performance action. Anatomical reconstructed images collected using a 612 Vicon motion analysis system at 250 Hz and presented from all planes of motion, will be used to show:

- Importance of leg-drive in creating an upward movement of the hitting-shoulder and a downward movement of the racket.
- The importance of shoulder rotation in the backswing phase of the service action.
- The creation of a 'separation angle' between the shoulders and the hips in the backswing.
- The importance of 'back-leg' drive in the shoulder-over-shoulder movement of the trunk.
- The importance of shoulder-over-shoulder trunk rotations in displacement of the racket away from the body.
- The importance of shoulder-over-shoulder trunk rotations in positioning the trunk for an optimal shoulder abduction angle for impact.

- The importance of shoulder external/internal rotation in the generation of racket speed.

A



B

Figure 3: Upper body opto-reflective markers for a wheelchair service analysis (A) and full body reconstructed image (B) of a service action.

REFERENCES:

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