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**VIDEO ANALYSIS AND APPLICATION
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VIDEO Analysis and Applications in Sport

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Video is one of the most powerful and versatile tools in a coach's toolbox. Yet in considering the myriad ways video can be used it can become difficult to decide which analysis is best for you and the sport you coach. Factors like cost, practicality, equipment needs, and analysis time all impact a coach's decision about how to best utilize and analyze video. The purpose of this article is to provide an overview of the different ways video can be used to evaluate athletic performance, while providing some pros and cons for each. Consider how each analysis method can be applied to your sport. The bottom line is, no matter which analysis method you choose, you will likely be able to gain insight into your athletes' performances and see things you are not able to catch in real time.

THINGS TO CONSIDER

Before jumping into a full-on discussion of the types of video analysis that are available, let's take a moment to review some basic videography principles. Asking yourself a couple of basic questions, and taking some things into consideration, will help you focus your efforts and decide how you want to approach your video analysis.

- **Know what you want "to know" before you start to film.** What question do you want to be able to answer when reviewing the performance of your athlete or your team? If it's technique, what is the specific variable you want to know more about? If it's for scouting, what are the specific game strategies and tactics you want to be able to see?

- **Maintain consistency.** What camera angle will you need to be able to capture the necessary information? In most instances you will get the most "useable" information when you set up the camera so you are filming the athlete head on or directly from the side. However, in making the decision of where to place your camera, consider your ability to maintain consistency when you film in different venues or at different events - will you be able to use that same camera view every time? Maintaining consistency will allow you to compare video from one testing session or competition to another. While you may not think it a big deal, even a small change in camera angle will limit your ability to compare things like joint angles or other aspects of technique.
- **Think about the video format you will to use.** It used to be that you pretty much had only one choice when recording video - standard VHS tape. Now, however, the options are seemingly endless - high-definition video, high speed video, DV tape, DVD, as well as various electronic compression/ storage formats. Think about how the video will be used. If you're planning to use a computer based analysis system, does it only work with certain video formats? Does the video need to be of super-high quality, or can you save hard drive space by sacrificing a bit in this area? These are some questions to consider.
- **Consider your video settings and needs.** Do the settings on your camera, like the shutter speed, allow you to capture what you want? The higher the shutter speed, the better the clarity will be when filming high-speed activities. To capture events like a tennis serve or a bobsled run you should have a camera that goes to shutter speeds of 1/1000 of a second, and preferably



higher. Conversely, consider whether there will be enough ambient light? As you increase the shutter speed the lighting requirements go up. Also consider whether you will be able to run your video operation off of batteries (keeping in mind batteries don't last as long in the cold) or it you will need AC power to run your equipment. If so, where will you 'plug in' to get the necessary power?

- **Will you want to analyze the video qualitatively or quantitatively?** Qualitative analysis is related to the 'quality' of an athletic performance and does not give back any 'hard numbers' related to performance. An example is simply playing back and watching the video that was recorded. Quantitative analysis involves crunching some numbers to get actual data, and typically requires equipment and resources above what you would need for a qualitative analysis.
- **Don't have preconceived notions about what you will see.** Many times athletes and coaches will watch video with an expectation of what they are going to see. The risk is that in looking so hard to find that 'one thing' in the video that you may miss other equally important pieces of information.
- **Always conduct a 'test run' before shooting for real.** If possible always film a 'test run' and make sure your equipment is all functioning properly prior to the actual practice or competition. You'll kick yourself when you realize the glitch that caused you to miss a once in a lifetime performance could have been prevented if you'd only tested your equipment beforehand.

With these things in mind, let's take a look at some of the ways the video you collect can be used to analyze sport performance. In the following pages we present the most basic analysis options first and go on to describe systems that progressively increase in 'complexity'.

QUALITATIVE ANALYSIS – BASIC APPLICATIONS

Qualitative video analysis usually involves simply recording and replaying the recorded video. It requires very little equipment, but conversely, does not provide much in the way of quantifiable data. The most basic qualitative analysis scenario involves recording video straight from the TV – e.g. recording the NBC broadcast of the Olympics. In this situation, all you would need is the broadcast feed, a recording/ playback device (like a DVD recorder), and suitable media to record to. The USOC utilizes this method of analysis at the Olympic Games in their Performance Service Centers; raw video footage is recorded from the direct broadcast feeds from each of the competition venues. The USOC then provides these recordings to coaches and athletes to use for scouting opponents or making technical adjustments to their performances. While this type of analysis is typically 'cheap and easy' there are other factors to consider. For one, you will only have access to the camera angles provided by the broadcast

company and they may or may not focus on the athlete you want to see. If your athlete is not at the front of the pack, there is a good chance you will not get very much good video of her from a broadcast feed and not all competitions provide a video feed.

With a few more resources you can greatly enhance the quality of the video you collect. Using your own video camera you can choose to the camera angle you want, focus on a specific athlete (rather than just the leader or the full field), and even focus in on certain technical aspects of an athlete's performance (e.g. focusing in specifically on the lower body during a high jump approach).

The video can then be played back right on the spot, providing almost immediate feedback to the athlete. At the Olympic Training Centers, this type of qualitative analysis and feedback is used quite frequently. While this type of interaction works well in practice it is important to consider whether you will be able to replicate your filming in competition. Many events will restrict access to certain parts of the course and/or limit cameras to a specific area of the competition venue, introducing consistency and logistical concerns (like power). If in doubt as to what access you will have at an event, contact the event organizer and determine your options. Sometimes all it takes is asking and getting pre-approval for you to gain entry to filming locations you might otherwise not have access to.

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QUALITATIVE ANALYSIS - HIGH SPEED VIDEO

High speed video provides another option when performing qualitative filming. Most standard video cameras film at a rate of 30 frames per second – meaning you get 30 distinct images in every second of video you record. But what happens to everything that occurs during the time between those 30 frames? Well, this information is essentially lost. For most sports this is not an issue and the loss of information is acceptable. However, for some sports where things occur quickly (e.g. the release of an arrow in archery) or it is important to capture a specific event (e.g. racquet contact with the ball in a tennis serve) high speed video may be able to provide you with the necessary level of information. High speed cameras film at a faster rate (some in excess of 10,000 frames per second), allowing you to capture a wealth of information that would otherwise be lost using a traditional camera. Until recently, the cost of high speed cameras has limited their use in everyday sporting applications. However, several new high speed cameras have recently been introduced to the market and they should make high speed filming increasingly accessible to coaches. One model in particular, provides a great combination of function and application. The Casio EX-F1 camera (<http://www.dpreview.com/news/0801/08010601casiof1.asp>) looks like a typical SLR digital camera, but it allows you to film video at speeds (ranging from 30 to 1200 frames/ second) in addition to taking individual photos. Even more impressive, it retails for just under \$1000. This camera has proven extremely useful and versatile in our applications at



the USOC. A full review of this camera will be provided in the next *Coaches Quarterly*, but we mention it here to highlight how technological advancements are bringing products like this within reach of the everyday coach.

COMPUTER-BASED QUALITATIVE ANALYSIS

Just because you use a computer as part of your review process does not mean you need to engage in complicated or quantitative analyses. Every year more and more software packages become available to help you, as coaches, review and categorize video. At the USOC we use Dartfish – which recently released the newest version, Dartfish TeamPro 5.0. Dartfish offers a number of features that make video analysis and review easy and effective. Dartfish allows you to easily import video to your computer directly from the camera using the “In the Action” option, from a DVD, or from virtually any camera or recording device. Once the video is imported to the computer, you can analyze it in a number of unique ways. For example, you can:

- Play the video in slow-motion, even advancing and “re-winding” the video frame by frame, allowing you see the subtleties of technique.
- Pull up to four videos up in the screen side by side, and synchronize them to a common event (e.g. the takeoff for a triple jump) to compare the techniques used by different athletes or even see how technique has “evolved” over time in a given athlete. Recently the US bobsled athletes used this feature to pull up video of the top four sleds to see how the drivers most effectively negotiated the most difficult turns on the course.
- Highlight key frames of the video and add comments/ audio commentary for an athlete to access. It is even possible to “publish” the video along with the comments, so it can be sent by e-mail or incorporated into a website.
- Assign categories to specific video clips (e.g. date, event, athlete, etc). Once categories are assigned you can ‘search’ your video database for specific key works, providing a quick and easy way to categorize and sort a wide range of clips.

- Take advantage of “telestrator-type” functions that allow you to draw on screen and highlight certain features of the video.

QUANTITATIVE VIDEO ANALYSIS

Making the leap into quantitative analysis usually requires having a computer and some more complicated analysis software. While programs like Dartfish may allow you to obtain some quantitative data, traditional motion analysis packages that allow you to track points on the body and compute a wide range of kinematic variables will typically give you the best and most reliable information. For years the USOC has used the Peak Motion Analysis System to provide 2-D and 3-D information on athlete performance. However, this is not necessarily a quick process. Once the video is captured, it has to be digitized – i.e. specific points on the body have to be identified and tracked in each frame of the video. Depending on the software being used and how the video collection and testing is set up, the digitizing process can be performed automatically by the computer or manually, meaning the coach or scientist must click on each point of interest in each frame of video. This can be a time consuming process, especially when performing a 3-D analysis where multiple cameras are used. You will also have to calibrate the movement space (the area where the activity is being performed) by filming and digitizing an object with known dimensions; this helps with the conversion of pixels on the video screen to real world units of measure like meters or inches.

A 2-D analysis can be performed with one camera, and it is best when the camera is placed perpendicular to the athlete’s motion. This type of analysis is best suited for sports that occur primarily in one plane of motion, like cycling or rowing. Trying to quantify “out-of-plane” motions using a 2-D analysis will typically yield unreliable data. A three-dimensional quantitative analysis requires the use of multiple cameras, each filming the same activity from a different point of view. It is then necessary to digitize the footage taken from each camera to reconstruct the movement in three dimensions. Sports like figure skating have used 3-D analyses for years to evaluate skating and jumping performance.

While these types of analyses are powerful, and the information obtained can provide new insights into how a sport is performed, there are also some negatives that need to be considered. For one, the turn around time from data collection to feedback is typically longer than what one would consider ideal if you want to make an immediate impact on performance. Additionally, a 2-D or 3-D analysis is often performed in an “artificial” competitive environment – a laboratory – that may or may not accurately capture the factors faced by an athlete in a real practice or competition. The costs and time commitment to performing these analyses are also hurdles that must be overcome.

QUANTITATIVE VIDEO OVERLAY

In our experience, the most effective use of video occurs when it is coupled and presented with some other form of data; more and more, we find we are developing sport specific applications

that combine video with information from force plates, or accelerometers, or other types of sensors. In these applications, the data from the multiple sources are combined in real time to provide immediate feedback that is directly related to answering a specific performance-related question. As an example, we recently partnered with the US Nordic Combined team to develop a “dryland” jump training system. Faced with the challenge of only being able to get in a limited number of “on-hill” jumps a day, they were interested in being able to practice jumping off the hill while also obtaining quantifiable data that they could use to evaluate the quality of the jump. A system was developed that combined the output of a force plate with the video of their jump performance. In real time, the coach and athlete could see how the vertical force they exerted on the plate changed as they jumped while also tracking the location of the center of pressure under the foot. Immediately following the jump, the system provided information on the takeoff speed, takeoff angle, peak and average power, as well as the time it took them to execute the jump – all data they could use to refine technique. The video files, with the overlaid data, could also be saved for later review. Similar applications have been developed for boxing, weightlifting, and swimming to provide the athletes with meaningful information about their performance. While the costs associated with this type of application are considerably higher than what you would spend on just a video camera and playback device, the performance benefits one can receive and the quality of the information far outweigh what one gets from just video alone.

SCOUTING

Video has long been an integral part of scouting, yet some recent advances in how that video is processed have streamlined the scouting process considerably. We’ve mentioned Dartfish previously and one of the additional features provided by this software package is the ability to tag video. Tagging is the process of highlighting specific events or key moments as they occur. Say you are filming an entire soccer match but at halftime you want to be able to quickly locate and review all of the goals that were scored by the United States. As you are filming you would hit a computer key (defined by you) each time a goal is scored. This would “tag,” or mark, the event within the larger video clip, complete with a user-defined pre-roll and post-roll that allows you to see the events leading up to the goal. At halftime you can quickly search for all of the goals, pull them up, and review them with your team. A coach can set up as few or as many events as he/ she would like. Tagging has proven to be a very useful tool for storing and archiving data. Softball, for example, has hundreds of tagged games in their database; in an instant, a coach can pull up clips of a virtually any player in the world. The team is quickly able to get a feel for a pitcher’s delivery before they face her in a game, or identify the best way to pitch to a specific batter. But don’t walk away thinking tagging is only important

for team sports. Individual sports, like whitewater canoe/ kayak are developing tagging templates that allow coaches and athletes to track different moves and techniques to determine the most effective way to navigate a course.

VIDEO SHARING AND COMMUNICATION

The last topic we’ll address in this article is how to share video. More and more it seems that coaches are working with athletes across the country, or a coach is traveling to Europe and still needs to communicate with several developmental athletes back in the States - situations where day-to-day, face-to-face contact is limited. However, advances in video sharing are helping to bridge this gap. One new feature of Dartfish 5.0 is Dartfish TV. Dartfish TV is essentially a web-based video server that allows a coach or NGB to post and share video with whomever they choose across the country and around the world. An NGB must purchase a TV ‘channel’, and when they do, they will be able to upload video directly from Dartfish, complete with tags, comments, key frames, etc. The coach or NGB then defines who can have access to that video – it may be a certain training group or a set of coaches. This provides an easy way for a coach to communicate with an athlete or other coaches who may be separated geographically. There are examples of athletes who have filmed their workouts and posted the video to their Dartfish TV site for the coach to review and provide technique pointers. The coach can watch the video and either call the athlete with comments, or imbed an audio commentary right on the video itself. Check out Dartfish TV at www.Dartfish.tv where you can get access to a number of free channels and see the utility of this technology. We see this technology as having the potential to revolutionize how athletes, coaches, and other professionals interact to optimize an athlete’s training and preparation.

Video sharing can also be used to improve education. The US Tennis Association has done a nice job of making technique educational video clips available on their website (www.playerdevelopment.usta.com – Video Instruction). They provide some basic instruction to a broad audience by making video of the best players in the world available for all to access.

SUMMARY

In short, video can be used to enhance the understanding of tactics and techniques and improve performance in virtually any sport. Think about your sport, and the factors you feel limit performance. Can any of these be assessed with video? If so, what tools and resources would you need to be able to capture the necessary and relevant information? What methods would you use? If you have question about how you would identify the critical aspects of your sport and how you could assess them, don’t hesitate to contact the Performance Technology staff of the USOC.

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