

OPEN-SOURCE VIDEO PLAYERS FOR COACHES AND SPORT SCIENTISTS

Boris Bačić¹

School of Computer and Mathematical Sciences, Auckland University of
Technology, Auckland, New Zealand¹

The aim of this study was to introduce free open-source software (OSS) and identify the tasks associated with video-supported coaching, rehabilitation and scholarly activities. The usability and functional requirements of the candidate OSS have been established by user participation in field studies and by the consensus of literature, on- and off-line discussion groups, and collaboration with coaches and the scientific community over the past decade. The critical analysis focused on functionality, 'use cases', 'user goals', environmental constraints, and covered relative performance testing using various collected media formats. Instructional guidelines and insights for the target audience were aligned with the use of OSS SMPlayer and VLC media player. Future developments are aimed at external playlist customisation, tablet and distributed video delivery.

KEY WORDS: augmented coaching technology, usability, HCI, external playlists.

INTRODUCTION: The use of video tools for analysis and augmented coaching is common amongst sport professionals, coaches, rehabilitation specialists, sport scientists and sport enthusiasts. Access to newer, affordable and increasingly powerful video technology and the growing multi-disciplinary audience are contributing to the broadening application contexts of video replay use. The early commercial developments of video capture, analysis and replay tools for sports contexts (Alderson & Elliott, 2006; Knudson & Morrison, 2002) were aligned with Knudson & Morrison's (2002) model of qualitative analysis (preparation, observation, analysis and feedback/intervention). To support the globally growing interest in sport contexts, the open source software (OSS) community also developed specialised video analysis tools (Bačić & Hume, 2012). In addition, there is also a growing number of free generic video player tools that could be also used for ad-hoc analysis and to communicate feedback/interventions. The focus of this paper is video replay in augmented coaching contexts, utilising two OSS video players candidates: SMPlayer and VLC media player.

METHODS: The investigated usability aspects covering people interacting with technology in the context of coaching, rehabilitation and sport science are common to human computer interaction (HCI) and software engineering. The target audience comprises of: coaches, rehabilitation practitioners, sport scientists, athletes and sport enthusiasts. The functional requirements, *use case* and *user goals* examples were gathered over the past decade from field studies in coaching practice, observations, cross-disciplinary interviews, discussion groups (on- and off-line) and two case studies in tennis rehabilitation and golf-coaching (ethics approvals: AUTEK No. 06/105 and 12/18). The collected data set, reported in the test results, included various formats of video samples collected using the various camera equipment and mobile devices. The instructional videos (e.g. VOB, WMV, MKV, and FLV file types) have also been included in the usability tests for video coaching and presentation purposes. For sport and rehabilitation contexts, both VLC and SMPlayer were able to produce replays from the video cameras used in the case studies and coaching practice (including FireWire-based Sony DCR-TRV110E-PAL and DCR-TRV8E-PAL; and High-speed GoPro Hero 3, Sony HDR-AZ1, and Casio Exilim EX-FH25 and EX-ZR100). The test data included video files in a number of formats (DV-AVI, MPEG-2, MPEG-4/H.264 AVC, MOV, MKV and MTS), resolutions (DV-AVI 720x516, DVD 720x480, HD 1280x720, Full-HD 1920x1080), PAL/NTSC 25/30 (or 50/60) fps and high-speed frame rates (i.e. 1000 fps at 224x64; 480 fps at 224x160; 240 fps at 432x320; and 120 fps at 640x480 and 1280x720).

RESULTS: The critical analysis included video coaching functionality groups (Table 1) tested on the supplied video data set. Both 32-bit VLC and SMPlayer (www.videolan.org/vlc/ and <http://smplayer.sourceforge.net/>, retrieved on 30 Jan. 2015) were tested on the 64-bit Windows 7 and 32-bit Windows XP operating systems (OS).

Table 1
Video Players' Functionality for Coaching, Rehabilitation and Sport Science Contexts

Functionality group	Use case/user goal examples and remarks	Testing remarks: [1] VLC (ver. 2.15) and [2] SMPlayer (14.9.0.6690)
<p>Minimalistic start-up steps and flexible replay initialisation</p> <p>Interactive replay controls, customisation and instant feedback</p> <p>Use of the keyboard shortcuts:</p> <ul style="list-style-type: none"> • availability • configurability <p>Flexible GUI design including the toolbar options.^{N,I}</p> <ul style="list-style-type: none"> • configurability and control functions • customisation of common tasks <p>Real-time filters for low resolution and customised replay contexts.^{I,E}</p> <ul style="list-style-type: none"> • zoom control • de-interlacing (de-combing, de-blurring) • rotate • light and contrast • swap <p>Simultaneous replays</p> <p>Internet access and privacy control</p> <p>Use of the playlists</p>	<p>Video presentation of learning objectives, visual feedback, drawing athlete focus on critical features for the movement of interest. Start-up via file association (e.g. media file double click) or 'drag and drop' of a video file.</p> <p>For replays and ad-hoc analysis, interactive controls should include:</p> <ul style="list-style-type: none"> • Play/Pause • Single frame-step control • Repeat video or A-B loop section • Variable replay speed control • Video feedback of last control action • Volume control for individual replay. <p>Replay on restricted space for mouse use e.g. outdoor laptop stands. User interaction relying on a touchpad, remote controller or keyboard shortcuts. The use of the shortcuts may be more efficient^{I,E} than mouse/touchpad.</p> <p>Hiding toolbars during the replay allows maximised viewing experience and utilisation of the available display area for multiple simultaneous replays. Toggling toolbar visibility may also help in directing the presentation focus between video content and timeline information.</p> <p>De-interlaced video filters can produce sharper frame view and double the frame rate (e.g. Yadif filter x2)^{I,E}.</p> <p>For low resolution video replays, users may prefer: zoom in region of interest (e.g. grip form); de-interlace and rotate views (e.g. for optimal viewing), and to eliminate post-production transcoding. Some high-speed video replays may require interactive adjustments of light, colour and contrast settings.</p> <p>Swap filter allows comparisons of left-handed with right-handed technique.</p> <p>Multiple videos can play simultaneously for comparative or other presentation purposes.</p> <p>Privacy/security control and eliminating redundant processing tasks.</p> <p>Playlist may represent a mental model equivalent to e.g. a PowerPoint slides presentation. Playlist file content may be updated in the background with on-line streaming for instantaneous or delayed video coaching^{I,E}.</p>	<p>Supported in [1][2].</p> <p>[1] Graphical User Interface (GUI) start-up using default mode^N.</p> <p>[2] GUI start-up using the last-file replayed mode^{I,E} or according to the video file's last replay settings.</p> <p>Replay navigation and instant feedback of selected controls is displayed as fading text or a symbol over video replay supported in [1].</p> <p>Configurable default mouse scroll: [1] volume control. [2] variable speed of video navigation.</p> <p>Keyboard shortcuts supported in [1][2] [1] Tools>Preferences>Hotkeys [1] Less available shortcuts than in [2] (e.g. not supported: A-B loop, media zoom and rotate keyboard shortcuts). [2] Options>Preferences>Keyboard and mouse Toolbar on/off toggle default shortcuts (would not auto-adjust optimal window size): [1] Ctrl+h [2] Ctrl+c Toolbar configurations: [1] Tools>Customize Interface... [2] Options>Toolbars>Edit main toolbar [1][2] Zoom in/out within active window, de-interlace, rotate, light and contrast, swap.</p> <p>[1] Ctrl+e, for Adjustments and Effect interactive GUI dialog box.</p> <p>Zoom in/out: [1] Ctrl+e>Video Effects>Crop [2] using default shortcuts: e and w. Note: [1] and [2] vary in diversity of real-time filters and features.</p> <p>[1] Enabled by default [2] Options>Preferences>Instances:</p> <p>[1][2] User configurable for computers that may be connected to the network.</p> <p>Playlist's file save and file open functions are supported in [1][2]. [2] NB: External playlist as a directory structure might be more convenient than the playlist if the last replay settings of individual videos are needed.</p>

External playlist and external control concepts.	Organising presentation directory structure; automating sequence of presentation videos ^{I,E} ; using spreadsheet organisation containing notes and presentation sequence control for single or multiple/concurrent replays ^{I,E} .	Start up options/command line parameters for external playlists ^{I,E} . [2] Managing last replays' settings ^E . Closing all video player's windows using OS shortcuts or batch files ^{I,E} e.g. <code>taskkill /f /t /im vlc.exe</code>
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Note – expected user profile/skill level for video coaching software adaptation:

^N **Novice – advanced novice:** Relies on pointing device and established presentation routine. Can use and configure toolbars and shortcuts. Gaining confidence with common and frequent tasks.

^I **Intermediate – proficient:** Utilises keyboard shortcuts for frequent tasks. Would have low-cognitive load associated with video coaching allowing focus on coaching objectives, robust focus/improvisation, fast recovery from interference (human or technological nature) and ability to transfer knowledge to new circumstances, contexts and technologies.

^E **Expert:** Can perform sustained deep focus and instantaneous task execution (e.g. in coaching or video analysis) with little attention to user interaction.

For professional practice using video replays, it is recommended to gain at least an intermediate skill level for at least one video player.

The observations regarding the utility of frame rates for video coaching and analysis include:

- **25 – 60 fps:** Regular frame-rate replays including game strategy; player's courtside manners/court presence; court coverage; posture (and other static critical features); kinematic sequence (focusing mostly on the large muscles) and coaching rules adherence covering common errors. For coaching tennis serve and golf swing relying on reduced video size (e.g. DV streaming and DVD quality), it is recommended to rotate the camera by 90° as both VLC and SMPlayer are able to rotate video replays in real-time.
- **120 (or 240) fps:** Extending regular frame-rate replays e.g. for the artefacts in augmented coaching and analysis beyond human cognitive abilities. Such high frame rates combined with relatively large HD (720p) resolution settings are recommended for general coaching (e.g. tennis techniques) and may provide video evidence (e.g. recorded technique/critical features) associated with injury prevention or performance. Some video encoding formats (e.g. HD at 120 fps for GoPro cameras) allow default replays at normal speed rate, while at reduced speed or frame-by-frame replays the adjacent frames would not be omitted. For replays of high-frame rates in slow-motion speed, most tennis coaches and athletes preferred 120 fps over 240 fps due to 'too slow' slow-motion effect.
- **480 fps:** Suitable for human body and equipment around action zone replays.
- **1000 fps:** Suitable for replay analysis of equipment interacting with, for example, a ball around the impact zone; or providing evidence of lost distance if maximum velocity of a club face is before the impact with the ball. Due to limited resolution and increased lightness requirement, it was difficult to observe the impact shock wave through human tissue with the available technology in the case studies.

DISCUSSION: In the context of sport and rehabilitation, multi-user video interaction and user goal examples include: communicating coaching objectives; focusing on selected critical features; showing elite athletes' performance; reducing the need for a number of daily warm-up/demonstrate/cool-down cycles; providing immediate augmented proprioceptive feedback and (ad-hoc) analysis as delayed replay feedback on captured motion; reviewing suggested lists of interventions; comparing performances; providing evidence beyond athlete's proprioceptive or cognitive abilities; clarifying safe vs. unsafe practice (for injury prevention, fear of reinjuries, rehabilitation and return to sport); reviewing strategic game dynamics, evidence of fatigue and pathomechanics; and replaying 'best moments', umpiring and dispute resolutions. Single and peer user-computer interactions may include examples of athletic trainers, rehabilitation specialists or sport psychologists using video replay for analysis or progressive achievement reviewing, rather than visual coaching of basic motor skills. The reported tests for the candidate OSS players were limited to Windows-based computers. Both the VLC media player and SMPlayer were also running on Linux. However, the VLC player is also available for Mac OS-X (with minor limitations e.g. lack of toolbar customisation). Both VLC and SMPlayer can use the external third party codecs or their own

set of media codecs that could be updated to follow advancements in media encoding technology. For augmented video coaching, qualitative analysis and post-production, users may consider OSS alternatives such as VirtualDub, FFmpeg, HandBrake and Kinovea (Bačić & Hume, 2012). Regarding backward frame-step navigation, many media encoding schemes do not perform well. In such cases, users may consider updating their codecs, transcoding files into another video format, or using other video players (e.g. Kinovea). The importance of 'user locus control' related to shortcuts, toolbar and replay customisation is evident when learning how to use a new video player. The time invested in configuring the shortcuts to the accustomed layout may also help in learning additional features listed in the shortcuts configuration table. An external playlists concept may be supported via: (1) a directory structure and trimmed videos equivalent to A-B replay, (2) by the advanced use of *batch files*, or (3) more complex integration of batch files reading a spread sheet file (e.g. media file, start up instruction parameters and coach's comments). Before attempting advanced implementations of external playlists, users are expected to progress through skill levels and gain an understanding of video players' command line (CL), whose basic concepts are transferrable from Windows to Mac OS and Linux. For example, the basic start-up CL parameter allows a media file to be opened/played with a specified video player application. Additional CL parameters allow advanced users to consider organising a playlist as a series of instructions stored in a text file to combine presentations of videos in parallel (e.g. multiple instances of player's windows) and in a specified sequence (e.g. opening the next video after the previous video(s) has/have been closed). Furthermore, a CL parameter allowing to start a video at a particular position can reduce efforts and resources associated with copying and trimming videos. Whether aiming to improve performance, safety, helping with fear of re-injury, or to accelerate recovery, augmented video evidence represents 'seeing is believing' for all skill level athletes.

CONCLUSION: The results of the usability study demonstrate that VLC and SMPlayer as generic OSS for various video format replays were suitable to support sport and rehabilitation contexts. The presented use cases are repeatable and applicable to many related domains. Extending a player's command line parameters would enable advanced use of the external playlists; advance video-based presentations; meta-data collection/retrieval; analysis and organisation. Furthermore, for the OSS community, implementing macro functionality (keyboard, mouse and multi-touch gestures) and inter-process communication for data and commands exchange would encourage future development of new functionality, interaction paradigms and user interfaces within the contexts of sport and rehabilitation.

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Acknowledgement

I wish to express my appreciation for shared insights, positive encouragement and feedback regarding use of video technology and coaching practice requirements to: Prof. Patria Hume, Prof. Duane Knudson, Assoc. Prof. Monique Mokha, Assoc. Prof. Sayumi Iwamoto, Kevin Woolcott and Petar Bačić.