

## JVC GY-HM100U HD video camera and FFmpeg libraries<sup>1</sup>

### From JVC

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**1. OVERVIEW.** This review discusses the JVC video camera GY-HM100U (henceforth JVC GY) as part of a linguistic *in situ* fieldwork workflow. It also includes a discussion of using open-source libraries, such as FFmpeg, for video encoding.

**2. CHOOSING A CAMERA.** It has been noted in previous issues of this journal that video is becoming a ubiquitous part of language documentation (Mihas & Loomis 2010, Ashmore 2008). The amount of extra information included in video recordings allows for more detailed and considered analysis, accessibility of data for tangential research fields (such as interaction or gesture research), and also allows for returns of valuable materials to communities. Furthermore, there is continued development of tools for video analysis that are continually being released to humanities researchers. This includes the well-known ELAN annotator, but there are other projects such as the important body of front-end/platform-independent recognizers developed by the cross-institutional AvaTech project (Auer et al. 2010). There is no doubt that high definition video will (and should) become the default medium for language documentation.



FIGURE 1. Members of the Ikawkaw community inspect their recordings on the JVC GY (wide angle lens and stereo XLR attached).

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<sup>1</sup> Thank you to Saskia van Putten for comments on the review, Paul Trilsbeek for his technical advice, the MPI TG for their support, and my colleagues in the Language and Cognition group for their user feedback.

However, before any research takes place, equipment must be ordered and tested for the field. This task is made more difficult by the plethora of video-recording devices on the market. A quick search of Amazon.com>Electronics>Camera and Photo>Camcorders lists over 2,500 entries. Furthermore, most smartphones, point-and-shoot cameras, and newer digital SLR (DSLR) cameras are capable of recording some amazing video footage. The choice of video recording devices can be overwhelming, and the process of selecting hardware is thus not an easy job. Margetts & Margetts (in press) have compiled a near-comprehensive list of considerations that field researchers should consult to gain an understanding of the equipment selection process.<sup>2</sup> Throughout this review (and during our camera selection process), we independently arrived at similar conclusions to theirs. We diverge from them in one key point; we can strongly recommend at least one high definition video camera (the JVC GY reviewed here) as a better alternative to MiniDV tape cameras. Margetts' dismissal of the high definition video format is unfounded, with the caveat that researchers should take care in understanding the video and audio codecs they are going to work with.

One serious problem is that linguists, anthropologists, and other field-based researchers work with media and archive standards that do not apply to standard consumers. We are in the process of creating high-quality documentation that has to be forward-compatible for as long as possible. We need to record human environments in their true state without excessive editing, meaning that the first recording should be as good as possible since it may be the only "take" we get. The recordings can be several hours long, depending on the task. DSLR and point-and-shoot cameras are not suited to this purpose because they are limited to 15 minutes recording time in 1020 High Definition (or 30 minutes in 720 High Definition) and are therefore immediately out of consideration in this context.

We are not making our recordings for profit and often have limited budgets that must last for many years. As a small user/consumer group, it is not reasonable to expect large camera companies to create our ideal setup. The monetary returns for these companies are in either consumer (high turnover) or professional (high profit per piece) lines, and field researchers must try to find a middle ground. This middle ground has few makes and models, and the model reviewed here comes in that range.<sup>3</sup> While it is not very cheap at around US\$ 2,750 (without an upgraded microphone or tripod), the JVC GY provides functions beyond other cameras that prove quite useful to a documentation project, without being prohibitively expensive or overly technical.

Recording media have changed dramatically over the past decade, from various kinds of tape to current solid-state storage. Interchangeable solid-state flash storage—such as the SDHC cards used by many camcorders—has no moving parts and is not susceptible to mold, dust, or sunlight. It continues to get cheaper and has therefore become the pre-

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<sup>2</sup> In fact, they also mention the JVC GY as one of the possible candidates to fulfill their requirements for a fieldwork-suitable video camera.

<sup>3</sup> As this review is being finalized Canon released the slightly cheaper XA10, which appears to be a direct competitor to the JVC GY reviewed here. It, too, has better audio connections packaged with solid-state high definition footage. It is worth considering as an option but has two immediately obvious drawbacks: it records in H.264, which is currently harder to use in-field, and records its audio stream using AC-3 compression.

ferred choice of recording media. It allows for quick transfer to a backup storage device or laptop, each card is lockable (i.e., you cannot accidentally write over media if the device is physically locked), and it also uses less power than tape-based or hard drive media. SD card storage also removes one possible failure point in a workflow. If a file is being copied from a camera's internal memory via a USB connection, there is a chance of corrupting files if the camera's battery power runs out. SD cards, however, can be directly mounted as an external drive on a laptop, using either a built-in or FireWire/USB/ExpressCard card reader. No other connection or power is required other than the laptop's own power supply. The JVC GY has two (hot-swappable) SD slots that can each accommodate 32GB cards, allowing for approximately four hours of uninterrupted, full quality recordings without any media change.

One issue with current video cameras is that image quality is being touted as the key selling point. To achieve this high quality video in manageable file sizes, newer compression algorithms, such as the H.264 codec, are widely used. These algorithms are not universal and do not have any industry standards for archiving purposes. Basically, each major camera producer and each of the computer operating systems creates their own special blend of codecs and file systems. (This is similar to the problems with Microsoft changing the standard document format, but with many more variables and more companies.) These special blends are developed each year, have hundreds of variables, and make no claim to being backward- or forward-compatible. This is hardly ideal for digital language archives which aim for medium- to long-term storage and playback.

It is also inadvisable to use audio streams that are compressed with codecs such as Dolby, MP3, or AAC (cf. Margetts & Margetts). Normal consumer-grade video cameras use audio compression because the average consumer does not use the sound stream for acoustic analysis, automated recognizers, or other high fidelity uses. While it is possible to record a secondary stream using a 16-bit audio recorder (and advisable, too, for backup purposes), this is not ideal, as different models and makes of audio recording equipment will differ slightly in their time alignment. This means that over a multiple-hour recording, there is a possibility that the primary audio and video will not be in sync. Ideally, the same machine should record the primary audio and video together, allowing for identical time alignment of the two (audio and video) streams.

Thus, keeping video footage in line with your institution's archiving policy is a good starting point for choosing a camera. It is better still if the camera can support the digital audio standards which the language documentation field has adopted over the past 15 years. The JVC GY does both of these, which was a primary factor in its choice for our current documentation projects. It records video with an MPEG2 codec (which is the same as a DVD codec). This means the data is still compressed and the bit rate is much higher than an MPEG4 H.264 equivalent. However, its advantage is that the bare video stream is one of the more stable and widely used codecs. It can also play back this "raw" video immediately on both PC and Mac OSX (using VLC media player). Once this video stream is quickly transcoded using FFmpeg, it can also be burned straight to DVD. The audio stream is recorded uncompressed in a 16-bit 48kHz WAV format and can be stripped from the recording for an immediate archive copy. In this respect the JVC is better than other consumer-grade cameras which have compressed audio.

Finally, other more practical issues should be considered when choosing a camera, and these are best discussed together. First, where and how are you going to make your

recordings?<sup>4</sup> This question will determine your tolerance for the size and weight of a video camera, as well as your placement of an external microphone. The JVC is not the smallest of cameras, weighing 1.5kg and measuring 138(W) x 178(H) x 365(D)mm. We will discuss the weight issue further in the second part of this review.

More important for the specification discussion here is that the JVC GY comes with an adapter for dual XLR inputs (which also doubles as a carry handle). This does make the camera larger, but it allows for nearly any mono- or stereo-condenser microphone to be attached without a mini-jack cable. This is advantageous over most consumer video cameras which only have a mini-jack input<sup>5</sup> because: XLR cables cannot accidentally come out (they require pressing a button); XLR cables are heavier duty than 3.5mm mini-jacks, meaning electrical interference and physical damage (e.g., from a stray boot or child) is minimized; and they allow for +48V phantom power (meaning the video camera itself provides the power for the microphone). The JVC GY's implementation of the XLR inputs is quite good, since it allows for separate adjustment of the two channels and is strongly connected to the camera on the hot shoe. This allows for a high quality microphone (with a robust connection) to be placed nearer to speakers. There is still a 3.5mm mini-jack, but it is disabled when the XLR mount is connected. The audio track on the JVC is therefore potentially as good (or better, as it is in sync with video) as any dedicated audio recorder if your field site allows for a stereo XLR microphone cable running from the camera to speakers. In effect, the JVC GY is a high quality audio recorder and high quality video recorder in one.



FIGURE 2. The JVC GY on a Velbon DV-6000 tripod with Velbon PH-358 panhead. Note the audio attachment/handle allows for the dual XLR inputs.

<sup>4</sup> We assume here that an external microphone is extremely important for linguistic work, since clear audio signals help greatly with analysis. Not only is an external microphone much closer to speakers (and thus better at picking up meaningful sound), but also the sound quality (dynamic range) of larger microphones is better.

<sup>5</sup> Even worse, some cheap consumer cameras have NO external audio input, which will severely limit your recording quality.

**3. IN PRACTICE: USING THE JVC GY-HM100U.** Thus far this review has discussed some of the arguments for the JVC GY as a candidate for a fieldwork camera. This section turns to the practicality of using the JVC GY in the field. This discussion is based on the experience of at least seven different *in situ* field workers who used this camera in 2010 in locations such as Siberia, Ecuador, Ghana, Vanuatu, and Italy. The locations were typical in the sense that they had a variety of environmental challenges, such as volcanic dust, humidity, remoteness, and solar-only power. We feel that any problems (other than the ones mentioned here) arising in the use of the camera would have surfaced during this period. We cannot comment on the long term prospects for durability since digital devices advance at a rapid rate.



FIGURE 3. A screenshot from the JVC GY.

The microphone was mounted on the camera for this recording and could pick up the speakers who were between 10 and 20 meters away.

Overall, the use of the JVC GY is similar to that of consumer-grade cameras. While it does provide many more settings for advanced users, it is possible to get acceptable video recordings from the fully automatic option. We found that mastering a few basics, in particular the Auto White Balance, Neutral Density Filter, and Light Gain modes, resulted in much better recordings. One small complaint is that it is not entirely transparent how to use these settings just by looking at the camera (but of course reading the manual provides some clues on how best to use them). One handy feature is that there are three user-customizable presets, meaning that you can program your most frequent environments (e.g., outside shade, outside sunlight, or inside candlelight) and quickly switch to the appropriate preset for the shoot. It is also possible to program the hot and cold thresholds to individual specifications so that you can see the exposure levels onscreen.

The weakest point of the JVC GY's video performance is in extremely low light. Because it is not a consumer model, it does not include a gimmicky "infra-red" (or green) view which will provide footage in low light, even if the resulting image is very bad quality. It seems the JVC GY is programmed not to compromise on high quality footage. While

we appreciate this for the audio stream, sometimes low quality footage is better than nothing. There is a light “gain” switch that is programmable to different levels of sensitivity (user-defined). The highest level (+18dB) does provide better low-light footage, but yields a somewhat grainy image. This setting does not provide much help in the dark. This means that post-twilight footage is limited unless an external light source is used.

The audio recording of the JVC GY is, in theory, far superior to other consumer-grade cameras. We assume that all researchers use an external microphone, even if it is still mounted on the camera. The setup of the XLR adapter is easy and requires no special tools. The audio level controls for the external microphone are on top of the camera (unlike the internal microphone or minijack connection, which must be found in the menu). These controls are easy to read and adjust as there is one dial for each channel. They also display a dB bar on the LCD display; however we found that the threshold displayed there was consistently lower than the recording. This means that recordings could constantly be in the red (i.e., above 0dB) and still not be clipped. This is a problem with the firmware that could be fixed by JVC, but it is easy for the day-to-day user to get used to.

Another benefit of the JVC GY is the use of XLR cables for the microphone. We found that a six-meter XLR cable allowed for a microphone to be placed close enough to speakers. With a wide-angle lens (HM100U169WC7X, which is .7x magnification; not included), this cable length could be shorter for shooting indoors or in restricted spaces, perhaps around 3.5m. In theory the XLR cable could be longer, and we have tested a 10m cable with success. This allows for the camera to record the whole “scene” with exceptional audio while also being set somewhat back from the interaction, allowing the researcher to be more discreet (assuming the cable and attached microphone are not a problem). It would not be advisable to have a 3.5mm mini-jack cable of 10m, and this is one big advantage the JVC GY has over other cameras for recording multiple-participant interaction.

The microphone selection was important, too, for audio quality. In general, we found that the supplied mono phantom-powered external microphone, while light and small, was of poor quality and had problems with echoes. We have used both the Beyerdynamic Stereo MCE-72 and the Sennheiser K6 (ME62/64/67) condenser microphones, and found them to be much better. Care was required, though, to make sure the phantom power did not cause interference with self-powered microphones. This was easily achieved by using the right settings on the external microphone-type switch.

While the bare camera is not too big, once the included XLR adapter (and perhaps a microphone) is added, it does become significantly heavier. Most researchers reported that it gets too heavy to hold for long periods if the microphone is mounted on top. If your recording situation includes lots of handheld recording longer than 15-20 minutes, the JVC GY with audio enhancement will be too big. Furthermore, the weight of the total setup affects the choice of tripod.<sup>6</sup> One researcher reported the head of the tripod breaking when tracking participants. A heavier duty tripod (one that can easily hold roughly 3kg) is required if the condenser microphone is mounted on top of the video camera. Preferable, too,

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<sup>6</sup> One researcher reported the Image Stabilizer (IS) misbehaving while the JVC GY was on a tripod. We recommend turning off IS for tripod use.



FIGURE 4. The audio controls for the XLR inputs.

is a video-style tripod mount that can rotate easily, thus taking strain off the holding mechanism. This weight issue is only a problem during the recording stage. When dismantled, the camera is not too heavy to carry in a backpack to a location and, when you consider the fact that you do not have to carry tapes, there is no overall weight disadvantage.

The menu system is accessed through the LCD display. This display is not touch-screen, but is articulated so it can face forward/downward/upward. This is a very useful feature that not all smaller camcorders have. The menu navigation is done through a joystick that is quite easy to use. The menu itself is straightforward and really needs to be explored in person to understand, but we will mention some highlights here. There are a variety of video quality settings. We all recorded our files at the highest possible quality: progressive PAL setting (1080p 25 fps with a data rate of 35Mbps). Storage space is cheap and, if you have an exceptional recording at low quality, it could be impossible to remake it at a higher quality later on.

More importantly, the camera keeps user settings, even when changing batteries or SD cards (which not all cameras do). This means that once you get your settings right, they do not need to be reapplied each time you use the camera. One important setting is the “Slot Auto Switching.” This allows for a recording to continue over to the next card without a frame being lost. Since the SD cards are hot-swappable (i.e., you can take one out while the other one is being written to), this effectively means that the JVC GY can record for an unlimited amount of time. The maximum file size is still roughly 4GB, but the camera will start a new file immediately without the loss of information, and this break can be re-joined in post-processing. An hour of recording uses roughly 16GB, so two 32GB cards will give just under four hours of recording. If you are two hours into a recording, the JVC allows you to take out the full card (locking it in the process of course!) and then put a new 32GB card in, thus expanding your current session to just under six hours.

Of course, one limiting factor is power, especially if you are relying on battery power. The display shows a battery indicator that is fairly reliable, and you get about one and a half to two hours recording time per fully charged battery. The JVC also allows for a battery and external power to be used at the same time. (In fact the battery compartment does not interfere with any external cables, which is a nice feature.) The JVC GY will also “save”

your data if you “accidentally” take out the battery without stopping the recording first. One user reported doing just this and, after inserting the new battery, the camera took a minute or two to rewrite the data and could then continue. While it may be annoying that this AutoSave function halts recording for a minute or two of action, this is a much better outcome than having a corrupted file or losing the last 15 minutes of data.

**4. SOFTWARE: USING FFMPEG LIBRARIES.** One problem that some researchers face is what to do with the files once they have recorded a session. The JVC GY’s feature list includes “native” integration into some commercial video editors.<sup>7</sup> However, Adobe CS4 or Apple Final Cut Pro are expensive software packages and not always easy to navigate and use. The versatility of their features also means that the possibility of getting a setting wrong is high. Further, they all require a time-consuming full encoding of the final output. This requires valuable power, which could be a problem when working in remote areas. One alternative is the provided freeware “JVC ProHD Clip manager,” which allows for easy viewing of recorded files on a PC or Mac and “stitches” together files longer than 15 minutes that have been cut into 4GB chunks<sup>8</sup> (only if they maintain their full metadata and original naming structure). However, this program cannot export the files to computer or archive-friendly versions and is not suitable as part of the camera-to-annotation workflow.

Making a quick, cross-platform version of video files is not a trivial task, as the complex arrangement of codecs and operating systems has not been standardized. As mentioned above, actual film editing is a time- and power-consuming task, and many researchers prefer to work with “raw” files. To solve these problems, we used an open-source library, FFmpeg, to transcode the video files from the JVC GY. This allows the clips to be immediately played in ELAN, and these files also work with any other player (or are easily edited with Adobe Premier). The goal of this process was to create the quickest copy of the video files that would be interoperable.

FFmpeg is a command line library collection used to convert multimedia files between formats. It is open source, so anyone can install it on their local machine. While the documentation is opaque, using it for basic transcode (i.e., not for editing) is not too difficult. For people not entirely comfortable with the command line interface, there are GUI implementations such as Handbrake and FFmpegX. However, we found that only the command-line version of FFmpeg allowed us to create the precise settings we needed for the quickest video conversions. Further, FFmpeg is truly cross-platform, and a basic knowledge of a scripting language or bash prompt will allow for an automation of the FFmpeg process. One advantage of using the JVC GY is that the raw audio stream in the file is already of archival standard. Thus, a simple command string for FFmpeg (as in 1) allowed for the extraction of the audio stream. This process is very quick. The WAV file (160MB) can be

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<sup>7</sup> This means that the JVC GY can record in .MP4 or .MOV containers for use in Adobe CS4 or Final Cut Pro, respectively. We found that the .MP4 was much easier to handle, and it became our default since no one in our group uses Final Cut Pro. The native files from the JVC GY can also be viewed using VLC media player.

<sup>8</sup> It does not physically put them back together but instead reads them in a linear order in the media player so that they seem to be a single file. The in-camera player, too, can “re-stitch” these files.

extracted from a 14-minute raw file (3.75GB) straight from the camera in under one minute in Mac OSX<sup>9</sup> or in Windows 7 32-Bit.<sup>10</sup>

**(1) WAV Extraction:** `ffmpeg.exe -i inputfilename.MP4 -acodec pcm_s16le -ar 48000 -ac 2 ouptutfilename.wav`

Creating the archive copy of the video stream (which is also useable with ELAN and other tools on Windows 7 and XP) is a similar process. This process uses a single command (as in 2), and since it is only changing the container and audio codec (i.e., the video stream is unaltered), this process is lossless on the image. The new MPEG2 file is roughly the same size (3.5GB). This copy is archive compliant and can also be easily burned to DVD. (We have successfully used Windows DVD maker for this task.)

**(2) Transcode video:** `ffmpeg.exe -i inputfilename.MP4 -vcodec copy -acodec mp2 -ab 224k -f vob ouptutfilename.mpeg`

One important aspect of this process is that it does not tie up your laptop while encoding. On the aforementioned windows laptop it took approximately 4 minutes for the 14-minute video file. You can line up all the videos you need to convert, let it run in the background, and still have a near-functional computer; FFmpeg uses only 25% of the processor for this task. Finally, these MPEG2 files can be concatenated to recreate full-length scenes. While the resulting joined file is rather large, it can be easily encoded using H.264 mp4 to reduce file size.

One final problem that has been plaguing researchers with video is cross-platform playback for analysis. Apple's OSX system is not very good at playing (or even reading) MPEG2 files, despite their prevalence in DVDs and other applications. FFmpeg can turn these MPEG2 files into easy-to-handle cross-platform mp4 files using the H.264 codec. Using the command line (as in 3), we can create a copy that is archive-compliant, high quality (i.e., little pixilation), and well-performing (playback in ELAN on both PC and Mac was acceptable) in less than twice real time; the test 14-minute clip takes around 20 minutes on the Mac OSX and 22 minutes on the PC Windows 7. This command line should work to turn any video file into an average quality H.264 version (including the joined-together MPEG2 from the JVC GY).

**(3) H.264 mp4 conversion:** `ffmpeg.exe -i inputfilename.MP4 -threads 4 -r 25 -vcodec libx264 -s 1280x720 -flags +loop -cmp +chroma -deblockalpha 0 -deblockbeta 0 -crf 24 -bt 256k -refs 1 -coder 0 -me_method umh -me_range 16 -subq 5 -partitions +parti4x4+parti8x8+partp8x8 -g 250 -keyint_min 25 -level 30 -qmin 10 -qmax 51 -trellis 2 -sc_threshold 40 -i_qfactor 0.71 -acodec libfaac -ab 128k -ar 48000 -ac 2 outputfilename_720.mp4`

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<sup>9</sup> iMac 3.06Ghz Core Duo with 4GB 1067MHz RAM

<sup>10</sup> Panasonic Toughbook 2.4GHz P9400 Core Due with 4GB 1067MHz RAM. We recorded similar times in XP as well.

The resulting file was approximately 230MB, meaning that you can get one hour of high definition footage to under 1GB. One problem with this process is that it is quite processor-intensive, so computer performance is rather slow. We would recommend that only researchers with access to 24-hour power use this and run it overnight. Since it is not necessary for PC users (i.e., the MPEG2 version is fine), this is not an issue for solar-based operations—so long as they are using a PC.

The FFmpeg process really brings to the fore the JVC GY's capability as an in-the-field camera. It allows for quick access to the recorded files in the field. Further, its use does not preclude serious editing in other software packages, but allows researchers to use their video/audio files nearly straight away for annotation purposes. The basic process takes roughly one-third to one-half real time to create a file that works with current linguistic annotation tools, is archivable, or can be copied on a DVD for distribution. In effect, it is creating a visual equivalent to what we have come to expect with audio streams.

In sum, the JVC GY is a slightly large camera that is capable of creating high-quality recordings. It requires some effort on the part of the user to get the most out of it, but the rewards are worth the time invested. Its greater audio control, settings, and uncompressed stream are a real bonus for the field linguist who does not want to compromise in this area. Implementation of the FFmpeg library into the workflow allows for the JVC GY's files to be easily used on a PC in a low-power situation. While there will always be a newer and shinier camera on the market, the JVC GY, size notwithstanding, is currently highly rated in the range of cameras that are best suited to documentary fieldwork and all its peculiar parameters.

## JVC GY

Primary function:	Recording video and audio streams
Pros:	Excellent video quality, uncompressed audio with dual XLR inputs, easy-to-manage files, effectively unlimited recording capacity
Cons:	Size/weight, low light performance
Platforms:	Cross-platform (but raw files perform better on Windows/Linux). 1080p HD video at 25/30fps. 1080i HD video at 50/60fps. 48kHz 16-bit linear WAV audio
Open Source:	No
Proprietary:	Yes
Available from:	JVC
Cost:	Professional camera stores, online. RRP US\$ 2,750 (Jan. 2011)
Reviewed version:	JVC GY-HM100U (released 2009) with JVC ProHD Clip; Manager version 1.01
Application size:	11.7MB
Documentation:	Manual provided with camera. Online fora

**FFmpeg**

Primary function:	Transcode, encode, or decode video and audio streams
Pros:	Quick and powerful video encoding/playing tool. Works with many formats. Command line interface
Cons:	Documentation is poor. Command line interface. Currently H.264 encoding does not have access to the AAC library
Platforms:	Truly cross-platform
Open Source:	Yes, source available from <a href="http://ffmpeg.org">http://ffmpeg.org</a> , various binaries also available
Proprietary:	No
Available from:	<a href="http://ffmpeg.org">http://ffmpeg.org</a>
Cost:	Free
Reviewed version:	Versions 0.5, 0.5.3 and 0.6.1
Application size:	10–15MB depending on version
Documentation:	Poor, but available at <a href="http://ffmpeg.org/ffmpeg-doc.html">http://ffmpeg.org/ffmpeg-doc.html</a>

**Additional Information**

The full specification list for the JVC GY can be found at [http://pro.jvc.com/prof/attributes/features.jsp?model\\_id=MDL101845](http://pro.jvc.com/prof/attributes/features.jsp?model_id=MDL101845) (accessed 1 February 2011)

ELAN, software for video annotation, can be found at <http://www.lat-mpi.eu/tools/elan/> (accessed 1 February 2011).

FFmpeg is “a complete, cross-platform solution to record, convert, and stream audio and video. It includes libavcodec—the leading audio/video codec library.” It can be found at <http://www.ffmpeg.org/> (accessed 1 February 2011).

We have also tested the following 2-pass encode for the JVC GY files. While it is slower (approximately seven times real time) and processor intensive, it provides an extremely high quality version that is cross-platform. Run pass 1 (as in 4) first, then pass 2 (as in 5). In theory, this 2-pass command should work with any current high definition video file.

**(4) High Quality H.264 mp4:** `ffmpeg.exe -i inputfilename.MP4 -y -pass 1 -vcodec libx264 -threads 4 -b 8024kbps -s 1280x720 -flags +loop -cmp +chroma -partitions +parti4x4+partp8x8+partb8x8 -me_method epzs -subq 1 -trellis 0 -refs 5 -bf 3 -b_strategy 1 -coder 1 -me_range 16 -g 25 -keyint_min 7 -sc_threshold 40 -i_qfactor 0.71 -rc_eq 'blurCplx^(1-qComp)' -qcomp 0.6 -qmin 10 -qmax 51 -qdiff 4 -an opututfilename _720.mp4`

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(5) ffmpeg.exe -i inputfilename.MP4 -y -pass 2 -vcodec libx264 -threads 4 -b 8024kbps
-s 1280x720 -flags +loop -cmp +chroma -partitions +parti4x4+partp8x8+partb8x8 -flags2
+mixed_refs -me_method umh -subq 7 -trellis 2 -refs 5 -bf 3 -b_strategy 1 -coder 1
-me_range 24 -g 25 -keyint_min 7 -sc_threshold 40 -i_qfactor 0.71 -rc_eq 'blurCplx^(1-
qComp)' -qcomp 0.6 -qmin 10 -qmax 51 -qdiff 4 -acodec libfaac -ab 128k ouptutfilename
_720.mp4
```

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