Guide to Video Quality

– achieving the best possible video images from your mobile surveillance system

Mobile video surveillance offers a valuable return on investment if it provides good quality, usable video. The quality of your system is important, but it is not the only factor involved. If your settings are not optimal, video quality can suffer. The quality of a DVR's recorded video depends largely on three factors – frame rate, resolution and compression. This paper explains the different aspects of video quality, and how to achieve it.

A TTI white paper

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Organizations invest in mobile video surveillance systems for many reasons. They deter crime, protect property, prevent litigation and assist with driver management and customer concerns or complaints. Video provides critical evidence, enables effective prosecution, and promotes a safe environment for both the public and employees. With so many benefits, organizations that invest in quality mobile video surveillance quickly realize a calculable return on investment.

Mobile video surveillance is only useful, however, if the video it produces is of sufficient quality to identify people and events. The quality of your system is important, but it is only part of the equation. An organization can invest in the best cameras, digital video recorders (DVRs) and monitors on the market, but if the settings on any one of these components are not optimal, video quality can suffer. There is also little point in investing in a high quality component, such as a DVR, if your camera or monitor is poor. The ultimate quality of your video will reflect the quality of the weakest component in your system. The purpose of this paper is to explain the different aspects of video quality and how to achieve the best possible performance from your system.

The quality of the recorded video from a DVR depends on three factors – frame rate, resolution and compression. Resolution is the level of detail recorded, frame rate is the number of individual images that a device records per second, and compression relates to how video data is recorded for storage on a hard drive.

1 RESOLUTION

Resolution describes the level of detail a device can record in pixels. A pixel (or picture element) is the smallest item of information in an image. They are sometimes represented as tiny dots. Each pixel is a part of the original image. The more parts, the more accurate the representation of the original image will be. The greater the number of pixels, the sharper and more detailed the image appears. Resolution is a measurement of the number of pixels that are displayed horizontally and vertically.

DVRs utilize two common resolutions, D1 and CIF (Common Intermediate Format). They standardize the horizontal and vertical resolution of a video signal in pixels. D1 is defined as 720 x 480 pixels (345,600 pixels total), while CIF is defined 352 x 240 pixels (84,480 pixels total). This means that at D1 resolution, 480 lines will be filled with 720 pixels across each line (Fig. 1). In CIF, 240 lines will be filled with 352 pixels (Fig. 2). D1 has four times the number of pixels as CIF.

D1 represents the highest resolution available on the market when using analog cameras. CIF is lower. If a CIF image is expanded to 720 x 480 for larger viewing, the result will be a poor quality image, since your computer must invent pixels in order to expand the image (Fig. 3). The invented pixels are based on the existing sampling. Your computer cannot create detail that was never recorded in the first place.

The final resolution of your video, however, is determined by the weakest link in your mobile surveillance system, including your camera, recorder and monitor. If your camera's resolution is 720 x 486 pixels, your recorder 720 x 480 pixels, and your monitor 480 x 320 pixels, your final resolution will be that of the weakest component.

Higher resolution means a greater file size, which means there is a greater amount of detail to be stored. In general, the higher the resolution of your video recording, the shorter the recording time on your hard drive. Video quality is often a matter of balancing resolution, frame rate and file size (video compression) to obtain the best quality video possible while maximizing hard drive space.

It is important to note that there is a difference between the resolution that a DVR records and the video's final display resolution on-screen. Recorded resolution occurs inside the DVR, and it can be changed through the DVR's settings; however, you cannot change the recorded resolution after you have made the recording. The display resolution affects how the video appears on playback. At this point, the camera and the DVR have done their work. The display resolution, or quality of the video on-screen, is now determined by the amount of compression and the resolution of the monitor.

Fig. 1: D1 resolution – 720 x 480 pixels

Fig. 2: CIF resolution – 352 x 240 pixels

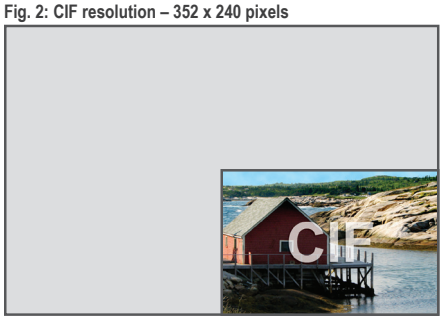


Fig. 3: CIF image expanded to 720 x 480 for larger viewing. Image quality declines.

❷ FRAME RATE

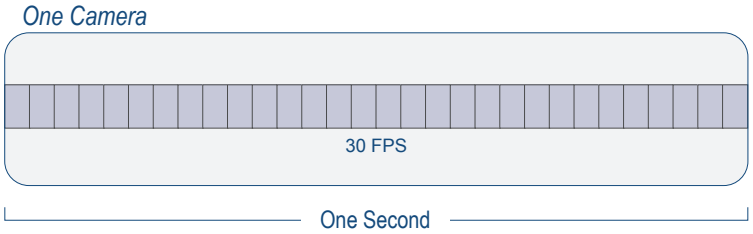
Frame rate is the number of individual images (frames) per second which combine to make a moving picture. Think of early Walt Disney cartoons which were drawn manually. Characters were drawn over and over, page after page, one slight movement at a time. Animation was achieved by transferring the images to film. Today, frame rate is a term most often associated with video cameras and computer graphics. A commercial movie is typically projected at 24 frames per second (FPS). Commercial television is displayed at 30 FPS in North America and 25 FPS in Europe, Asia, and other areas. Virtual real-time is 24 FPS (NTSC standards).

All DVRs have a maximum frame rate that can be recorded. Most systems' recording speed will be split depending on the number of cameras that are plugged in. For example, a DVR with a maximum frame rate of 30 FPS for one camera will record 15 FPS for two cameras and 7.5 FPS for four cameras (Fig. 4). At 15 FPS, the images still appear as smooth video, but half the images that actually occurred during that one second are missing. However, to the human eye, the difference between 15 FPS and 30 FPS is almost unnoticeable. Below this number, movement becomes less fluid. At 7.5 FPS, for example, movement appears less natural because 75% of the images are missing.

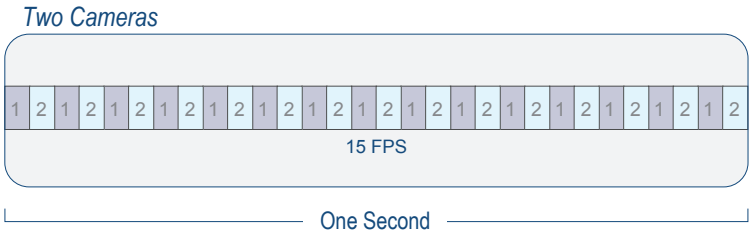
If you exceed a DVR's total maximum FPS, the less fluid your video's movement will be. If your DVR has a 120 FPS maximum, adding two, three or four cameras will not decrease the FPS on camera 1, since all four can record 30 FPS. If you have four cameras plugged into a 30 FPS DVR, only 7.5 FPS will be recorded per camera. In this case, when the video is played back, the video footage may appear jerky because of the reduced FPS. However, if you freeze the frame, the image will appear clear. The resolution of the image will reflect the resolution settings of the weakest link in your system (camera, recorder, monitor).

Fig. 4: Frame Rate Speed

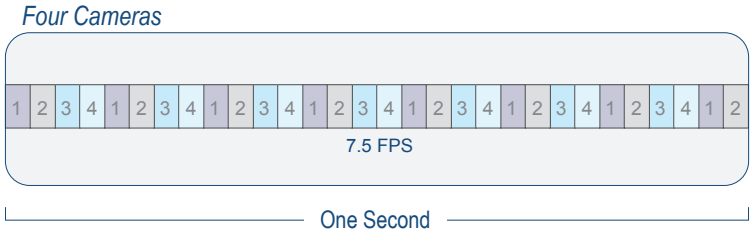
One camera set to the highest possible recording speed, 30 FPS. The video appears in virtual real-time.



Frame rate split between two cameras, each recording 15 FPS. Although each camera is set to record half the frames, the difference between 15 FPS and 30 FPS video is almost unnoticeable to the human eye.



Frame rate split between four cameras, each recording 7.5 frames per second. Movement appears less fluid because each camera is only recording 25% of the images.



❸ COMPRESSION

The third factor that affects video quality is file size, or the level of compression. If you look at video on camera, the footage will reflect the resolution of your camera setting. If you view that same footage after it has been recorded, you may notice that it appears lower in resolution, depending on the file size option or level of compression that you have selected on your DVR. The reason this occurs is directly related to the process of compression.

When video data enters a DVR, the file is compressed for storage. Compression occurs inside the DVR, and the level of compression depends on the DVR's settings. During compression, data is usually lost or thrown away, so your image quality after decoding will be less than the original picture. The bigger the file size (the less compression) the better your image quality. The smaller the file size, the more your image quality will be affected. Sometimes it is best not to choose the highest available quality setting or file size on your DVR, simply due to the availability of storage space on your hard drive.

The technology for compressing and decompressing video data is known as a codec, which is short for compressor/decompressor. In order to understand the relationship between video compression and hard drive storage, it is important to understand how your DVR's codec can affect the size of your files and the amount of storage space you need. There are three codecs common to the mobile surveillance industry, MJPEG, MPEG-4 and H.264 (Fig 5).

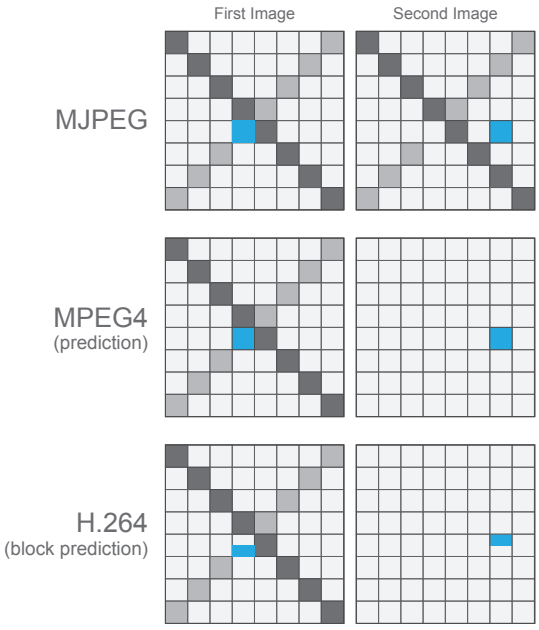
MJPEG works similarly to the way old film or video used to work. The entire image or field of view is recorded, and then reproduced in every frame, including all the elements of the image that have not changed.

MPEG-4 works on the more efficient concept of *prediction*. While MJPEG looked at the whole image and keeps recording the entire field of view, MPEG-4 actually looks only at what areas of the field of view changed, and it only records those changes, keeping the rest of the image intact.

H.264 introduces yet another concept, *block prediction*, which further increases efficiency. Within each area of the image that has changed, some part of it would remain the same (i.e. part of the changed block actually did not change). This format allows for yet fewer pixels to be re-recorded.

MPEG-4 and H.264 are more efficient because they do not re-record unchanged information, which means your video file will be smaller and require less hard drive space. This feature is only more efficient, however, if your DVR is set to record at a higher frame rate, since the likelihood of something changing between frames is less than with a lower frame rate.

Fig. 5: Common Codecs



The left squares represent the first image recorded with MJPEG at top, MPEG-4 in the middle, and H.264 at bottom. The video recorded is the same in all three formats. The blocks on the right represent the next image. As you can see, with MJPEG (top 2) only one blue square has moved; however, MJPEG has recorded the entire image, including the moved block.

The middle blocks represent MPEG-4, which has only recorded the square that has moved. During video playback, MPEG-4 simply over-imposes the older video data that did not move. This feature saves recording space, since the entire image does not need to be re-recorded since only one block has changed.

The bottom two blocks represent H.264. Here, only the top section of the blue block has actually moved. The bottom half has not changed, so H.264 has only recorded the portion of the block that has moved. During playback, H.264 over-imposes the unchanged elements,

RESOLUTION, FRAME RATE & QUALITY

Video quality is determined by your DVR's resolution, frame rate and compression settings. In the end, if video is going to be used for evidentiary or training purposes, it is essential that the images are clear.

High frame rate, low resolution video is useless if the image is unclear once you freeze the frame. However, if you record high resolution video at a lower frame rate, even if the movement isn't fluid, an image extracted from that frame will still appear clear.

High resolution video should also be recorded with a low compression setting. There is little point in recording high resolution video with high compression, as high compression will cost you video quality. Remember, the higher the level of compression, the more video data is lost. The more video data that is lost, the lower your displayed video quality appears.

System operators need to determine a balance between a frame rate that is high enough to capture an event, resolution and file size. 30 FPS may be a waste if 15 FPS is adequate. Similarly, if you record video with low resolution but a high frame rate, you will simply have more frames of low quality (possibly useless) video. It is better to make sure you have sufficient image quality first by choosing a high enough resolution and quality setting, and then setting the frame rate according to the desired recording time on your hard drive.

Your resolution, frame rate and compression settings all affect your DVR's recording time. The relationship between these factors is generally described in reference charts in your product manual. DVRs usually come with a rating system that indicates how much a file is compressed versus the amount of room it will require on a hard drive.

Video quality depends on the quality of your camera, DVR and monitor, and their settings. Resolution, frame rate and compression must be carefully chosen in order to achieve usable video while optimizing hard drive storage space. The higher the resolution and frame rate, and the lower the level of compression, the better your video quality will be; however, your file size will also be larger. The larger your files, the more hard drive space you will require, which will shorten your DVR's recording time. For this reason, system operators need to determine a balance between resolution, frame rate and level of compression. Your ideal settings will depend on your priorities and needs. For more information on achieving video quality, contact your system provider.

About TTI Tracking Technology Inc.

Located in North America, TTI. is a global leading supplier of Trucking, Commercial & School Bus mobile video surveillance technology.[1] Our highly experienced representatives help customers specify the right solution to meet their unique requirements and achieve the maximum return on investment. Customer satisfaction is paramount, making TTI the most trusted partner in the industry. The Buddy BX4, a DVR which offers high resolution and frame rate combination in the market. Using H.264 compression, all four channels can record simultaneously at 25 FPS with D1 (720 x 480) resolution. Designed for customers who require a powerful mini DVR, the Buddy BX4 represents the new generation DVR. For more information please visit www.tt-i.info