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Advanced Video Compression – A Breakthrough to Speed up Internet Downloads

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Abstract: **There's a huge transition going on now. Whatever was over the air is increasingly moving onto fibre, and what was on the wires is now being delivered over the air. We are talking about data. A technology commentator Peter Cochrane, former CTO and head of research at British Telecom says "Data downloads for the year 2013-2014 is about 17GB/ Month per user, and by 2017 that will go up to 70GB / Month per user. The sole reason behind this is exponential increase in video content over internet, as more people are working either at home or on the move".**

In broadband hotspots like Hong Kong, where they have 100Mbps services even in HOTEL ROOMS, people are no longer interested in watching TV or listening to their favorite radio over the air as everything is being put down fibre, that fascinates them more. Likewise, in UK there is a dedicated, reliable, fast broadband network.

This all hails the need of more powerful techniques for video streaming, which give rise to a powerful video compression technology HEVC. As believed by researchers that in near future using HVEC we will soon are able to make even 4K videos stream able. "HEVC will enable service providers to extend their reach and expand the footprint of TV everywhere outside the home.

Keywords: HEVC, Streaming, Broadband, Optical Fibre, Compression, Blur, noise.

I. INTRODUCTION

High Efficiency Video Coding (HEVC) is the most recent standardized video compression technology. This technology is developed by a Joint Collaborative Team on Video Coding (JCT-VC) of the ITU-T Visual Coding Experts Group (VCEG) and the ISO/IEC Moving Pictures Experts Group (MPEG). The first version of this new technology as a standard has recently been consented as Recommendation ITU-T H.265 and will shortly been approved by ISO/IEC as ISO/IEC 23008-2 (MPEG-H Part 2). As its most important feature, HEVC will provide around 50% reduction in bit-rate while maintaining the same subjective video quality relative to its predecessor H.264/AVC. This is considered as one of the remarkable discovery in the field of Internet technologies.

The Image & Video Coding Group has recently contributed a couple of important coding tools to the new HEVC standard. Also, in cooperation with the Multimedia Communication Group at HHI, the Image & Video Coding Group have been developed and contributed some useful high-level features for ultra low-delay coding and parallelization.

The High Efficiency Video Coding (HEVC) is the current joint video coding standardization project of the ITU-T Video Coding Experts Group (ITU-T Q.6/SG 16) and ISO/IEC Moving Picture Experts Group (ISO/IEC JTC 1/SC 29/WG 11). The Joint Collaborative Team on Video Coding (JCT-VC) has been established to work on this project.

II. COMPRESSION (THE GOOD, THE BAD, AND THE LOSSY)

The amount of raw data that is coming out from a professional HD video camera is a massive and there's no way to conveniently transport it to your home. Instead, we generally compress the video to reduce the amount of data into a more manageable form.

This compression can be done in numerous ways, and one of the easiest way is to reduce the size i.e. being reducing the quality, which is mostly done with a damp heart as we have to compromise with the quality of the video. In some cases this is OK, as we think of our average YouTube video. But that’s not great, Right?

That simply because the video is highly compressed (either before or during the upload). Heavy compression might keep the

resolution technically the same, but the video that appears is softer, noisier, or have **weird distracting artifacts** as seen in the figure below:

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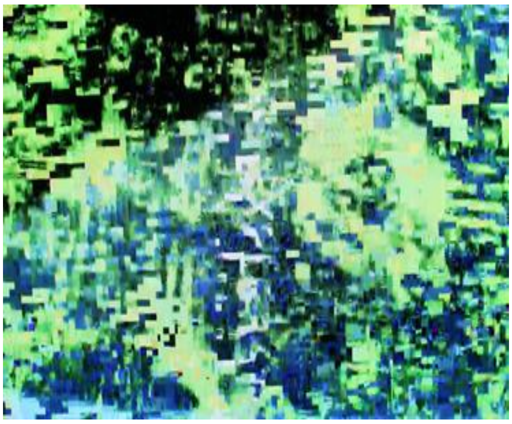
Figure 1: Macro blocking artifacts



But that’s never being a great idea if the point is to preserve a director's intent, or show off your new 77-inch OLED Television. So the other option is to use *better* compression technique. In this case, we can basically think of SMARTER compression as a BETTER compression. This is to think over a technique that by taking the same original video, and finding out better ways to make the amount of data loss, without sacrificing video quality. As with every passing year the processing power computer system has been improved enough to let more processor intensive compression algorithms to be used for compression, and further compress the data without making much effect on the quality of video/image.

This distinction between "more" compression and "better" compression is very important, as in reality, the terms can never be interchangeable, as one can decrease the amount of data required for a signal either by cranking up the compression and making the image worse (i.e. "more" compression), or by using a more efficient compression technique (i.e. "better" compression).

III. COMPRESSION TYPES

1. Lossy compression: A lossy compression works by simply eliminate "unnecessary" bits of information, tailoring the file so that it is smaller. This type of compression is used a lot for reducing the file size of bitmap pictures, which tend to be fairly bulky. To see how this works, let's consider how your computer migh0t compress a scanned photograph.

2. Lossless Compression: A lossless compression does much with this type of file. While large parts of the picture may look the same -- the whole sky is blue, for example -- most of the individual pixels are a little bit different. To make this picture smaller without compromising the resolution, you have to change the color value for certain pixels. If the picture had a lot of blue sky, the program would pick one color of blue that could be used for every pixel. Then, the program rewrites the file so that the value for every sky pixel refers back to this information. If the compression scheme works well, you won't notice the change, but the file size will be significantly reduced.

The major disadvantage is Of course, with lossy compression, we will not get our original file back after it has been compressed and we are stuck with the compression program's reinterpretation of the original. For this reason, we generally don’t use this sort of compression for anything that needs to be reproduced exactly, including software applications, databases and presidential inauguration speeches.

IV. CORE CONCEPT OF COMPRESSION

Video compression techniques are all about reducing the size of video by removing redundant video data of original video file so that it can be effectively sent over a network and stored onto computer disks. With an efficient compression technique, the file size can be reduced significantly with a very little or no adverse effect on the visual quality. However, the video quality, can be affected if the file size is further lowered by increasing the compression level for a given compression technique.

A large number of different compression standards exploit different methods for reducing data, and hence, their results differ in bit rate, quality and latency.

Figure 2: Compression OF Lossy and Lossless compression

Compression algorithms can be categorized into two types: Image Compression & Video Compression.

The image compression techniques employs intraframe coding technology in which data is reduced within an image frame simply by removing unnecessary information that may not be noticeable to human eye. The Motion JPEG is an example of such a compression standard. Images in a Motion JPEG sequence is coded or compressed as individual JPEG images.

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Figure 3: With the Motion JPEG format, the three images in the above sequence are coded and sent as separate unique images (I-frames) with no dependencies on each other.

Video compression algorithms such as MPEG-4 and H.264 use interframe prediction to reduce video data between a series of frames. This involves techniques such as difference coding, where one frame is compared with a reference frame and only pixels that have changed with respect to the reference frame are coded. In this way, the number of pixel values that is coded and sent is reduced. When such an encoded sequence is displayed, the images appear as in the original video sequence.

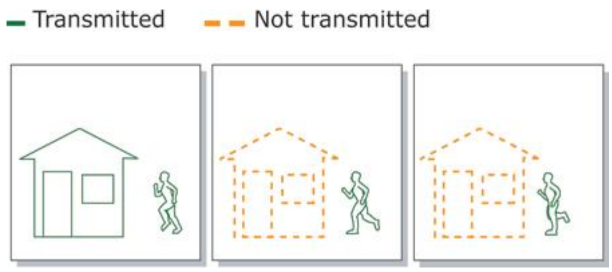

Figure 4: With difference coding, only the first image (I-frame) is coded in its entirety. In the two following images (P-frames), references are made to the first picture for the static elements, i.e. the house. Only the moving parts, i.e. the running man, are coded using motion vectors, thus reducing the amount of information that is sent and stored.

V. THE H.256 COMPRESSION TECHNIQUES

As data-intensive as HD is, 4K is even worse. While most of us were just getting used to the idea of H.264's advantages over MPEG-2 on Blu-ray, the Motion Picture Experts Group (MPEG) and the International Telecommunication Union's Telecommunication Standardization Sector (ITU-T) were already starting work on the next generation of video compression, with an eye on the future.Not wanting to mess around with small, incremental improvements, whenever a new compression standard is introduced, it has to be a sizable change. With each jump, the general rule is half the bit rate for the same quality (or greater quality at the same bit rate).

First, it looks at multiple frames to see what doesn't change. In most scenes in a TV show or movie, the vast majority of the frame doesn't change much. Think of a scene with someone talking. The shot is mostly their head. The background isn't going to change much for many frames. For that matter, most of the pixels representing their face probably won't change much (other than their lips, of course). So instead of encoding every pixel from every frame, an initial frame is encoded, and then after that only what changes is encoded (basically).HEVC then expands the size of the area that's looked at for these changes. Larger and smaller "blocks" essentially, which offers additional efficiency. Ever seen blocks in your image, when the picture goes foul? Those can be bigger, smaller, and differently shaped with ***Figure 5: Difference between H.264 and H.265***

HEVC than with previous compression methods. Larger blocks, for example, were found to be more efficient.

On the left is macroblocking as done by AVC/H.264. As you can see on the right, there's a lot more flexibility, not to mention larger sizes, for the HEVC/H.265 encoder to work with.

Then other things were improved, like motion compensation, spatial prediction, and so on. All of these things would have been done with AVC or even earlier, but it required more processing power than was economically feasible at the time.

During the development phase, the compression algorithm is tested objectively, for its raw number efficiency, but also subjectively, by video professionals comparing different compression methods and amounts in a "blind" test, where they don't know which method is which. The human element is crucial.

Figure H.264 is perhaps best known as being one of the video encoding standards for Blue-ray Discs; all Blu-ray Disc players must be able to decode H.264. It is also widely used by streaming internet sources, such as videos from Vimeo, YouTube, and the iTunes Store, web software such as the Adobe Flash Player and Microsoft Silverlight, and also various HDTV broadcasts over terrestrial (ATSC, ISDB-T, DVB-T or DVB-T2), cable (DVB-C), and satellite (DVB-S and DVB-S2).

H.264 is typically used for lossy compression in the strict mathematical sense, although the amount of loss may sometimes be imperceptible. It is also possible to Fig;5

Figure:5: create truly lossless encodings using it — e.g., to have localized lossless-coded regions within lossy-coded pictures or to support rare use cases for which the entire encoding is lossless.

VI. IMAGE PROCESSING THROUGH HVEC

IMAGE PROCESSING-Generic Formats for 3D Video

3D Video is the next step in the evolution of motion picture formats. This new format allows the representation of 3D visual information through a display that provides the illusion of depth perception. 2D video signals offer a number of monocular cues for depth perception including linear perspective and

occlusion. The extension to 3D video offers the sensation of depth from two slightly

MPEG-2, HEVC & H.264 Tools comparison

Tool	MPEG-2	H.264	HEVC
Partition size	16x16 (Macroblock)	16x16 (Macroblock)	8x8 to 64x64 (Coding Unit)
Partitioning	Inter 16x16, Intra 8x8	Sub block down to 4x4	Intra: Down to 4x4 (symmetric). Inter 4x8 or 8x4 uni directional, larger symmetric/asymmetric (bi-di)
Transform	Floating DCT	Integer DCT 8x8 4x4	Square IDCT from 32x32 to 4x4 + DST Luma Intra 4x4
Intra prediction	DC predictor	Up to 9 predictors	35 predictors
Motion prediction	Vector from one neighbor	Spatial Median (3 blocks)	Advanced Motion Vector Prediction spatial + temporal
Motion-copy mode	/	Direct Mode	Merge Mode
Motion precision	½ Pixel bilinear	½ Pixel 6-tap ¼ Pixel bi-linear	¼ Pixel 7 or 8 tap Luma / 1/8 Pixel 4-tap chroma
Entropy coding	VLC	CABAC or CAVLC	CABAC (with parallel operations)
Filters	/	Deblocking Filter	Deblocking Filter & Sample Adaptive Offset
Multi core tools	Slices	Slices	Wavefront Parallel processing, tiles, slices
Scalability tools	Through extensions	Through extensions	Temporal scalability included (others under discussion)

Figure:6

different projections of the scene onto the two eyes of the viewer. For this, different types of 3D displays are now available, including stereoscopic 2-view displays and auto-stereoscopic multi-view displays. For multiple users, stereoscopic displays require special glasses, while auto-stereoscopic displays do not require extra glasses.

For 3D Home Entertainment, we develop generic 3D video formats and associated coding technology for support of stereoscopic displays with different baselines (distance between both views) and various types of multi-view displays

IMAGE PROCESSING-HEVC Extension

The Image and Video Coding Group and the 3D Coding Group developed an extension of HEVC for coding of 3D video data in the MVD format. Similar as for MVC, all video pictures and depth maps that represent the video scene at the same time instant build an access unit and the access units of the input MVD signal are coded consecutively.

Inside an access unit, the video picture of the so-called independent view is transmitted first directly followed by the associated depth map. Thereafter, the video pictures and depth maps of other views are transmitted. A video picture is always directly followed by the associated depth map. In principle each component signal is coded using an HEVC-based coder.

The corresponding bit stream packets are multiplexed to form the 3D video bit stream. The independent view is coded using a non-modified HEVC coder. The corresponding sub-bit stream can be extracted from the 3D bit stream, decoded with an HEVC decoder, and displayed on a conventional 2D display. The other components are coded using modified HEVC coders, which are extended by including additional coding tools and inter-component prediction techniques that employ already coded data inside the same access unit as indicated by the red arrows in Figure 1. For enabling an optional discarding of depth data from the bit stream, e.g., for decoding a two-view video suitable for conventional stereo displays, the inter-component prediction can be configured in a way that video pictures can be decoded independently of the depth data.

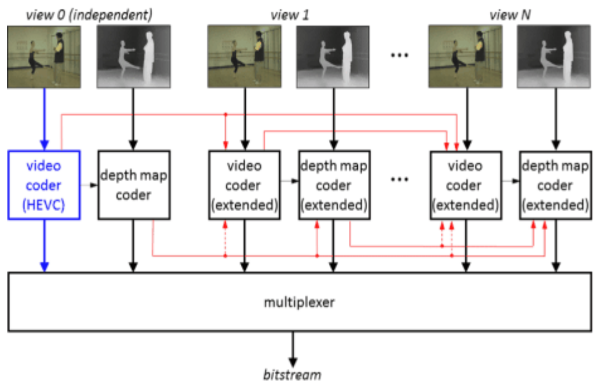

Figure 7: Simplified block diagram of the HEVC extension for 3d video coding

For dependent video view, the following tools have been added:

- Disparity-compensated prediction (as known from MVC)
- Inter-view prediction of motion parameters
- Inter-view prediction of residual data

For coding of depth data, the following tools have been added:

- Disparity-compensated prediction for depth data of dependent views
- Decreased motion parameter accuracy
- New modes for intra prediction and inter-component prediction
- A new mode for inheriting the motion parameters from the associated video view
- A new encoder control concept for depth data that estimates the distortion in synthesized views instead of using the distortion in the depth domain

Furthermore, for increasing the end-to-end quality of a 3D video coding system, we investigated:

- Improvements for a decoder-side view synthesis based on depth data

- A depth-aware encoder control that encodes areas in dependent view that can be synthesized using the base view with a smaller fidelity

The 3D HEVC extension has been proposed to MPEG and VCEG and was chosen as the starting point for the development of an HEVC-based 3D video coding standard.

VII. ADVANTAGES OF HEVC OVER OTHER TECHNOLOGY:

1. With the advent of HEVC ,the new codec will support 50 percent better compression efficiency than H.264 and support for resolutions up to 8192 x 4320.

2. HEVC's key benefit is bandwidth efficiency, targeting a 50% reduction in bitrates versus today's MPEG-4 AVC benchmark at comparable video quality.

3. In applications where minimizing bandwidth is not the highest priority, HEVC can be used to improve video quality at the same bitrates as AVC and the enabling technology for the delivery of 4K Ultra HD content.

4. HEVC meaningfully reduces the cost of delivering videos versus all other methods ,achieving quick ROI.

5. Content owners could store more video and movies for the same cost ,broadcasters could stream video more efficiently across networks ,and consumers could enjoy a much better entertainment experience as video is more easily streamed directly to all other devices.

6. HEVC offers variable blocks that can handle up to 64x64 pixels, changing the size according to the texture ,while the previous generation H.264 standard relied on a fixed macro block size that has a maximum of 16x16 pixels.

7. HEVC can reduce those worries eho enjoy watching videos on smartphones but are wary of big bill at the end of the month will benefit most as the expense of digital video delivery over mobile network is reduced.

8. What's more, as devices start supporting HEVC playback at the chip level, the processing power required to play these videos will decrease, saving battery life and in general, improving the overall experience with mobile video.

VIII. CONCLUSION

While most of HEVC's potential benefits are focused on 4K,its better compression provides benefits for HD, too. Lower bandwidth with HD means more people can get HD. People out in the sticks with connections too slow for current HD might be able to get HEVC –encoded HD. If one pay per megabyte (mobile or at home),lower bit rates mean cheaper HD viewing as well.

There were a lot of grumblings during the transition to H.264/AVC at the advent of Blue Ray, now it's a given. The same will be true of HEVC, eventually.Lower data rates ,while maintaining quality ,are a good thing for everyone.

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