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S3 | Python & Video Part III Report

- **Once you have the 'mandanga', try to create a new video as the one of the 4 videos at the same time we saw in class, and please analyze by yourself and comment how these codecs work at each bitrate.**

The videos for the comparisons between the 4 coders can be found in the Google Drive link in the README.md file.
I put together the videos for the 4 codecs in a single video at each of the resolutions that we worked with in this lab.
These videos were all made using FFmpeg at Constant Rate Factor (quality) 25, so in theory, FFmpeg should make it so they all have the same quality.
It's important to also note that the original that I used (BBB sunflower video at 1080p 30fps) was encoded in H.264.
By watching the results, indeed it seems that FFmpeg works well so that they all have the same quality or very close at least. I can barely notice any difference in the videos, not even in scenes where there's movement. The only difference that I can notice is a tiny bit more artifacting in VP8 in some cases, but barely.

From left to right and top to bottom. VP8, VP9, HEVC, AV1.

So up until this point it seems a very boring comparison. However, setting the same quality for all codecs lets us do an important comparison, the fun part comes when we look at the file sizes.

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For 160x120:

1: HEVC
2: AV1
3: VP9
4: VP8
5: H264

For 360x240:

1: HEVC
2: AV1
3: H264
4: VP9
5: VP8

For 480p:

1: HEVC
2: H264
3: AV1
4: VP9
5: VP8

For 720p:

1: HEVC
2: H264
3: AV1
4: VP9
5: VP8

We can see that even all the videos in their respective resolutions are of the same quality, the file sizes are wildly different.
Some important insights:

- H264 noticeably improves in encoding efficiency with resolution, it's the worst at 160x120 but becomes the second best at 480p and 720p.
- H265 always has the smaller file size.
- VP8 and VP9 always perform the best out of them except in the 160x120 case where it's H264.

More importantly, the differences between codecs increase as resolution increases as well, if we set H264 as our reference point and see the other codecs efficiency as a percentage from the reference file size:

For 160x120:

HEVC: 75.625%
AV1: 83.3%
VP9: 86.56%
VP8: 97.5%
H264: 100%

For 360x240:

HEVC: 75.22%
AV1: 95.43%
H264: 100%
VP9: 104.13%
VP8: 121.08%

For 480p:

HEVC: 73.78%
H264: 100%
AV1: 106.87%
VP9: 119.22%
VP8: 149.43%

For 720p:

HEVC: 70.07%
H264: 100%
AV1: 101.1%
VP9: 115.22%
VP8: 155.24%

It seems that the secret in H.264 and H.265 is that they scale amazingly with resolution with respect to the other codecs. The difference in percentage between HEVC and AV1 is <8% at 160x120 but >30% at 720p. HEVC over all performs amazing, not only it's always the one with smaller file size, the difference seems to get larger with resolution, with 4K the difference in file size is probably astounding. Furthermore, HEVC was the faster encoder in FFmpeg, whereas AV1 was **really, really slow**. It's worth it to migrate a media library to HEVC. Of course, from what I know this comes at the cost of being harder to decode with respect to H264 (more performance required from the CPU at the time of playback), but with modern CPUs this becomes less and less of an issue.

What is the effect for the final user? Well, using HEVC allows you to:
- Store videos with a much smaller file size.
- Transmit videos faster over the internet due to the smaller file size. (That's why it's used by streaming services)
- Have higher quality videos at the same file size. Instead of aiming for constant quality as I did here, we could set a target bitrate or file size. The resulting videos in the different codecs would all have the same file size, but the video encoded with HEVC would have much better quality. (Equal quality at smaller file size, better quality at same file size, or a middle ground, better quality (not so much better) at smaller file size (not so much smaller)).

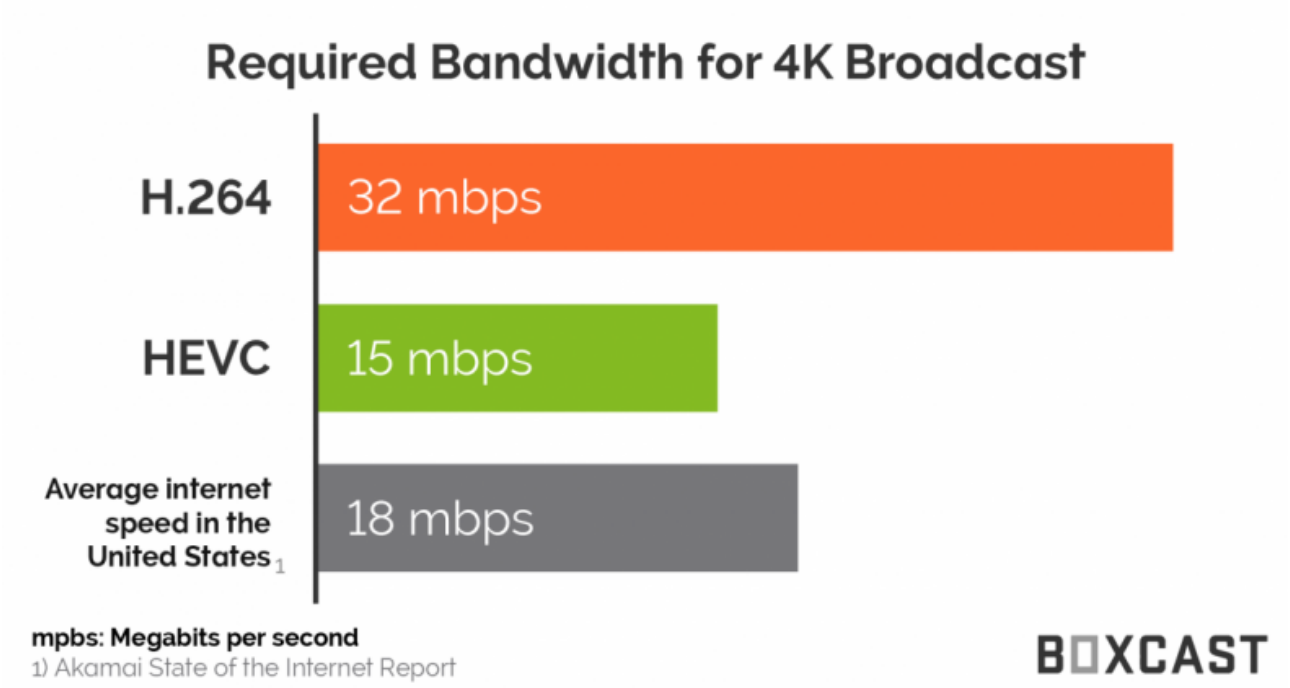

Image source

Let's see how the coding world advances over the following years, since H.266 was already presented this year.

As a side note, if you haven't watched it already, I recommend the Silicon Valley TV Show, it's a comedy show where a guy in Silicon Valley discovers a breakthrough compression algorithm and tries to set up his own company. It has lots of parodies and criticism of the tech world.