Extended Essay

Subject: Computer Science

Which video data compression standard provides the best combination of video quality, encoding time, compression ratio: MPEG-4 vs H.264?

Word Count: 3661 words

Abstract

Video Compression is required for transmission and storage of videos as it reduces and removes redundant video data, resulting in a smaller file size with little effect on the visual quality (“Video Compression”). Standards are responsible for compressing and decompressing video files. MPEG-4 and H.264 are the most widely used video compression standards. This essay investigates the question: “Which of the following video data compression standards provide the best combination of video quality, encoding time, compression ratio: MPEG-4 vs H.264? “

To approach this question, I researched a wide range of compression standards. Several Computer Science textbooks, research essays by universities, journals, online videos and an online course which explained video compression, criteria for comparing videos and the different standards. After this I selected two extensively used standards for investigating. To investigate the question, the essay begins by explaining video compression and the types of redundancies. The two standards are introduced and their workings are explained. This is followed by a theoretical comparison of the standards. Two experiments are then conducted. In experiment 1, 5 videos having different resolutions were compressed by implementing the standards-MPEG4 and H.264- using handbrake software. Encoding time, original file size, compressed file size and compression ratio were measured.

In Experiment 2 the 858 x 480 pixel resolution compressed videos were compared using the MSU video quality measurement tool. The 13 graphs of the different criteria were analyzed and the data was plotted into a table.

The data was analyzed while considering previously conducted experiments and research. I found that the H.264 compressed video had a lower file size and lower errors. MPEG 4 did reduce file size but not to the extent that H.264 did, but the MPEG 4 had a faster encoding time and a higher VQM measurement.

Word Count: 291

Table of Contents

1. Introduction 1
2. Video Compression 3
2.1 Definition 3
2.2 Important Concepts in Video Compression 4
2.3 Stages Of Video Compression 6
2.4 Redundancy 7
3. The Standards 10
3.1 MPEG-4 10
3.2 H.264 15
3.3 Theoretical Analysis 18
4. Investigation 20
4.1 Experiment 1 20
4.2 Experiment 2 25
4.3 Analysis 35
4.4 Limitations of Investigation 36
5. Conclusion 37
6. Work Cited 38

1. Introduction

In the year 1980 video files were large and downloads were slow. The tiny hard drives could not store the large video files (Bylund). Due to this video data compression was introduced. The International Telecommunication Union (ITU) created the first video coding standard in 1984, the H.120. (“Realtimes”). This was followed by the creation of MPEG-1 designed by the Motion Picture Experts Group in 1991.

Videos are becoming of increasing significance in our worlds today. Today businesses believe a video advertisement is the most effective since it provides an authentic feel. Consumers want the highest video resolutions and fastest loading times. Globally, IP video traffic will be 82 percent of all consumer Internet traffic by 2020(“By 2020 Global”). This rampant growth of internet data will affect data transmission worldwide. Due to the large file sizes of uncompressed videos (In an HDTV the bit rate of an uncompressed video is very high: 1920 x 1080 x 30 frames per second x 8 bits per second = 1.5Gbps) networks will either drastically reduce in speed of data transfer or will not be able to transfer data due to their limited bandwidth (Mitrovic). Furthermore, the computational demands for uncompressed videos are very high which may lead to longer processing times.

In this essay I am going to explain, “Which video data compression standard provides the best combination of video quality, encoding time, compression ratio: MPEG-4 vs H.264?”. MPEG-4 is currently used for web streaming, video conferencing and television broadcasts whereas H.264 is used for streaming internet sources such as YouTube and in software such as Adobe

Flash Player(Robertson). These standards are the most widely used for video compression, each having their own special features. This essay examines whether one standard is better than the other and should be used industry-wide and replace the other. Because video compression depends on several factors, both MPEG-4 and H.264 have their own strengths for different users.

Note: All photographs, diagrams, charts, graphs etc are my own work except where I have shown otherwise.

2. Video Compression

In order to compare the two standards a basic understanding of video compression is required.

2.1 Definition

Compression is the encoding of information using fewer bits than the original representation (Mahdi, Omar, Mazin, and Ahmed). Information exhibits patterns and is not random. Compression extracts that pattern and represents information using less data than the original. Once received the original data can be very closely reconstructed. The logic behind compression is that it involves transforming data in some representation to a new collection of bits which contains the same data but whose length is as small as possible.

Video compression uses coding techniques to reduce redundancy in video data. It can either be: lossy or lossless. After lossy compression the original video can never be decompressed with all the original information (Mitrovic). Lossy compression techniques remove redundancies from videos and hence are more effective in reducing file size while not compensating on quality. Both standards examined in this essay use primarily lossy compression.

Videos are essential a sequence of images shown in quick succession. The minimal delay tricks our brain into thinking it is seeing a continuous video. Videos are simply a collection of individual frames.(“Final Cut Pro”)

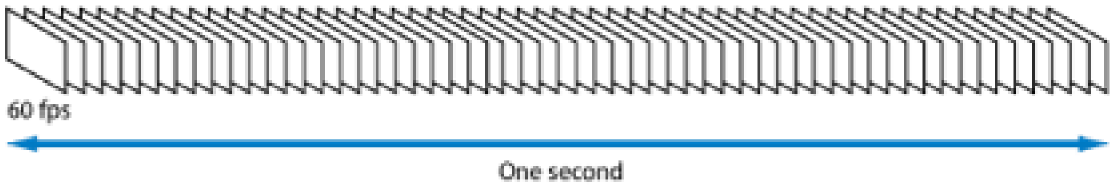


Figure 1 A Collection of Several frames that make a continuous video("Final Cut Pro")

2.2 Important Concepts in Video Compression:

Pixels : Tiny rectangles containing the colours - Red, Green, Blue represented as hexa-decimal values. They can produce several variations of colours using different intensities of each component.

Bit Rate: The number of bits per second that can be transmitted along a digital network.(Christensson)

Latency : The delay (usually measured in milliseconds) between when a video signal enters and when it emerges from a system.("RS 160, 170")

Frames per second(fps): is the number of images displayed per second

Codec : A device or program that compresses data to enable faster transmission and decompresses received data.("Codec")

Compression Ratio : It is a quantified measure of the reduction in data representation size. A higher compression ratio results in less bandwidth consumption.

$$Compression\ Ratio = \frac{Uncompressed\ Size}{Compressed\ Size}$$

Formula 1 Compression Ratio

Motion Vector: A two-dimensional vector used to represent a macro-block in a frame based on the position of the macro-block.

Compression Artifact(Artefact): A noticeable loss in quality or distortion of media when it is compressed.

Resolution: The number of colours displayed on a screen, usually dealt in an RGB format. One of the most common video formats is YUV

The YUV model defines a color space in terms of one luma (Y)(the brightness) and two chrominance (UV)(colour) components.

2.3 Stages of Video Compression:

1) The video is initially in a particular format known as the data container.
2) The Codec receives the data and implements a compression standard.
3) The standard removes redundancy in the video.
4) The Codec describes how the video and audio data is to be compressed.
5) The Compressed data can either be stored or transmitted.
6) If it is transmitted, it is decompressed at the source using the Codec and the original video is reconstructed. (Mitrovic)

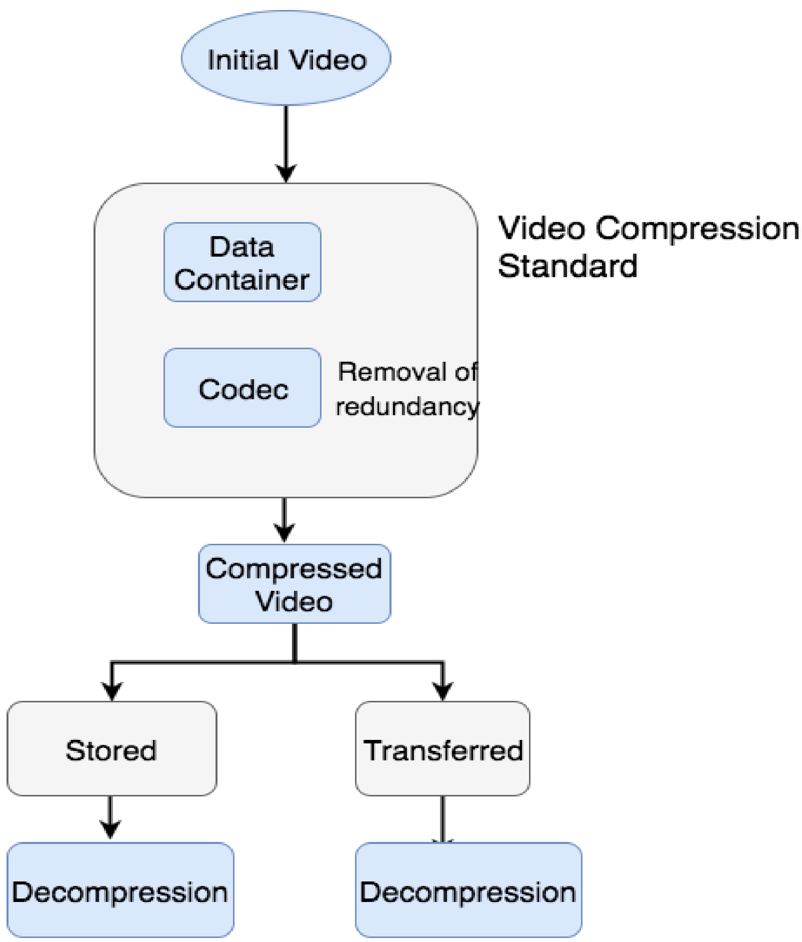


Figure 2 Steps In Video Compression(“Vcodex”)

2.4 Redundancy

The two aims of compression are: to remove redundancy and to remove irrelevance. Any data that is exceeding what is necessary or normal is regarded as redundant data and can be compressed.(Xie Lexing)

2.4.1 Removal of Redundancy

Redundancy can be removed by either an inter frame method or intra frame method.

Intra-frame - Encodes every frame as an individual image. Redundancy removed in individual frames.("Intra-frame vs")

Figure 3 Intra Frame Compression("Morris")

Inter-frame - For a particular group of frames only the difference between each frame is encoded. Redundancy removed between similar frames.(Morris; "Intra-frame vs")

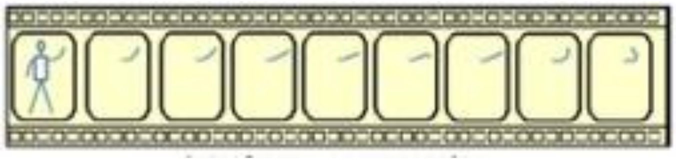


Figure 4 Inter Frame Compression (Morris)

*2.4.2 Types of Redundancies(*Ponlatha,S. and R.S.Sabeenian*) :*

There are several types of redundancies. The effectiveness of compression standards can be compared on the basis of the types of redundancies removed by them.

I. Temporal Redundancy:

Working: This relies on the similarity between frames of a video. Pixels having the similar values in the next frame are regarded as the redundancies.(Prof. Bebis)

Inter-frame/Intra-frame: Inter frame

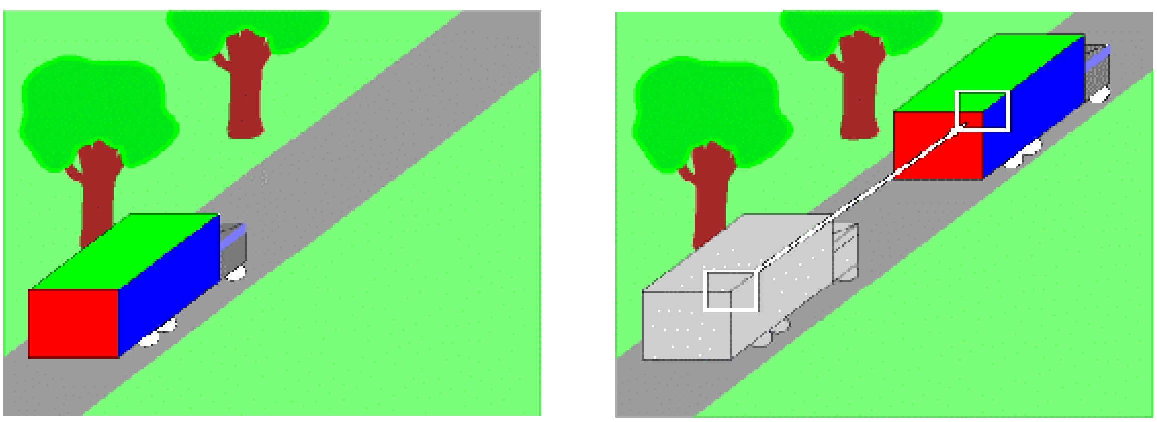


Figure 5 Representation of Temporal Redundancy ("Ein")

II. Spatial Redundancy

Working: Similarity between neighbouring pixels in the same frame.

Inter-frame or Intra-frame: Intra frame

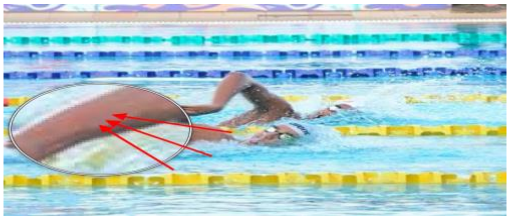


Figure 6 Representation of similarities between pixels in the same frame

III. Spectral Redundancy:

Working: Correlation between colour or luminescence components. Redundancy among different colour panes.

Inter-frame or Intra-frame: Both

Figure 7 Spatial Redundancy ("Digital Image")

IV. Psycho-Visual/Perceptual Redundancy:

Working: Since the human eye is not equally sensitive to all visual information, this discards the details of a video frame that the human eye cannot perceive. These redundancies can be discarded without affecting the quality of a video according to a human.(Prof. Bebis)

Inter-frame or Intra-frame: Can be both

Figure 8 Images with psycho-visual redundancy(Prof. Bebis)

3. The Standards

In order to effectively investigate and compare the standards it is important to understand their differences in methodology when trying to compress videos. This will make it possible to see why one standard is better than the other in certain scenarios.

3.1 MPEG 4

The MPEG-4 standard was introduced in 1998 by the ISO Moving Picture Experts Group(MPEG). It extended the features provided by MPEG-1 and MPEG-2 by providing special features such as (Koenen):

- Support for 2D and 3D content
- Added support for coding at low bit rates(2 Kbit/s for speech, 5 Kbit/s for video) and very high bit rates(5 Mbit for transparent quality Video, 64 Kbit/s per channel for CD quality Audio).
- High security for protection of intellectual property

- Added support for external content in the form of objects. These objects could be recorded entities such as a person, a table or synthesized entities such as(a voice, a face, a 3D model)(Koenen)

MPEG 4 removes the following redundancies: Temporal, Spatial.

3.1.1 Working

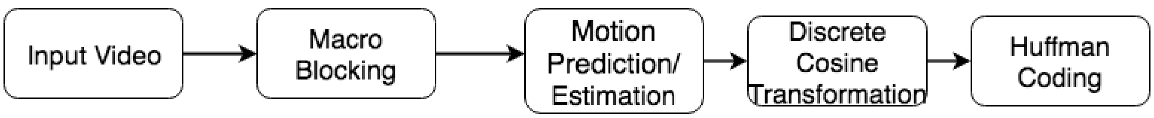


Figure 9 Working Of Compression using MPEG-4 (Ponlatha.S. and R.S.Sabeenian)

1)MACRO BLOCKING

Each frame is split up into blocks of pixels. These are then further subdivided into smaller blocks. The Discrete Cosine Transformation is done on 8 x 8 blocks and the motion estimation is done on 16x16 blocks(S. Ponlatha and R. S. Sabeenian)

2)MOTION ESTIMATION

Type: Inter-frame using motion vectors

Aim: Reducing temporal redundancy

After the frame is split into blocks, motion estimation examines the movement of objects in the block to obtain a vector representing the motion of the object. Since most videos have a frame rate between 15 to 30 frames per second there is minimum motion of an object between two frames. Therefore the algorithm searches for the matching block in the neighbourhood of the position of the object in the successive frame. After this the algorithm finds the best match of the object in the frame. It calculates the difference in pixels between the previous block and the new block. The block with the lowest difference is used as the motion vector. The displacement of the block is calculated.

3) Discrete Cosine Transformation

Type: In principle it is lossless. (Note: There is very little loss of information due to rounding)

Aim: Reducing Spatial Redundancy

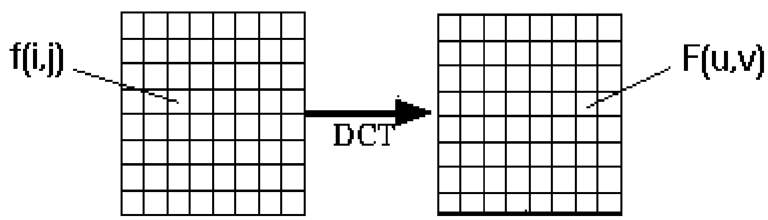


Figure 10 ("Marshall")

The DCT transforms the intensity of the pixel(i,j) in row i and column j into a DCT coefficient F(u,v). This process continues for all pixels in the 8x8 block frame. The DCT coefficient represents the frequency of the signal (input video) energy. This is then represented as a cosine function. In most frames the signal energy lies at low frequencies(Marshall). Compression is achieved since the high frequency values are rare enough to be neglected and therefore, are represented as 0.

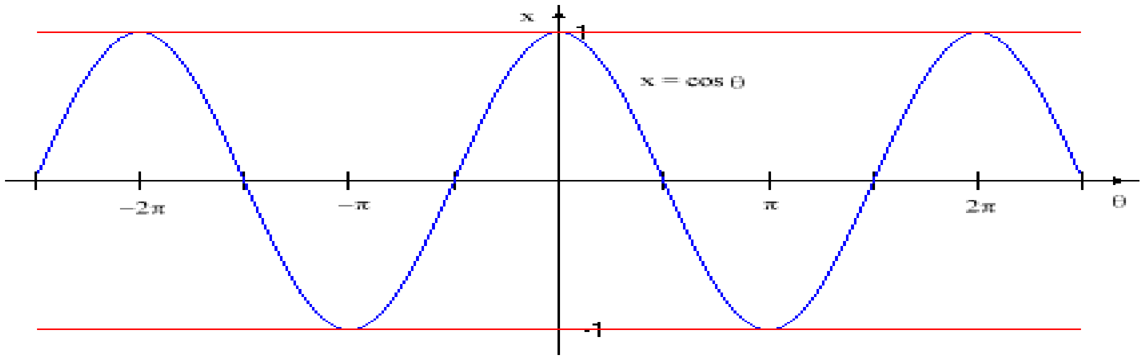


Figure 11 A General Cosine Function(“The Cosine”)

4) HUFFMAN CODING

Features : Lossless

Intra frame

Huffman code takes the data of the previous algorithms which include DCT coefficients and the motion vectors. This data is represented using binary trees. Compression is achieved by merging the sub trees until a tree with a single root is achieved.(Lecture 15)

For example if the following data is entered (a=20,b=15,c=5,d=15,e=45)

It begins by generating independent nodes for each value. It then merges nodes c and d to create sub-tree n1 = 20

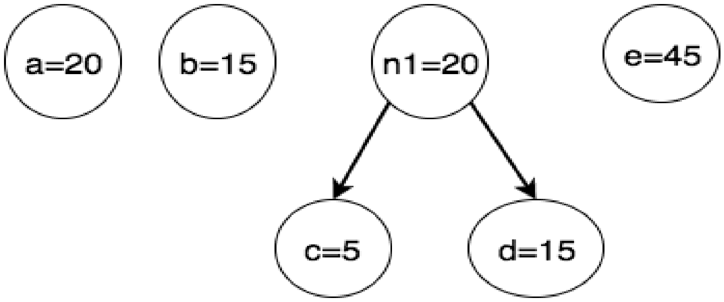


Figure 12

Nodes a and b are merged to create sub-tree n2=35

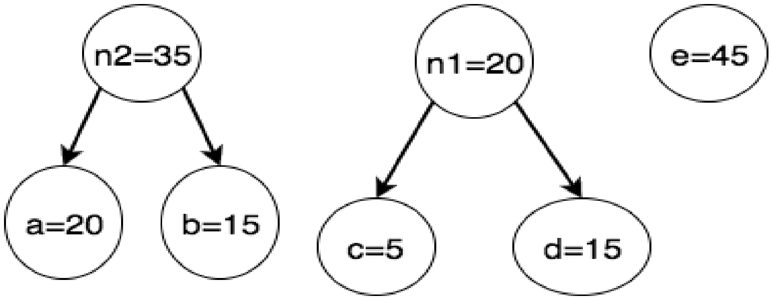


Figure 13

Sub-trees n2 and n1 are merged to give n3 = 55

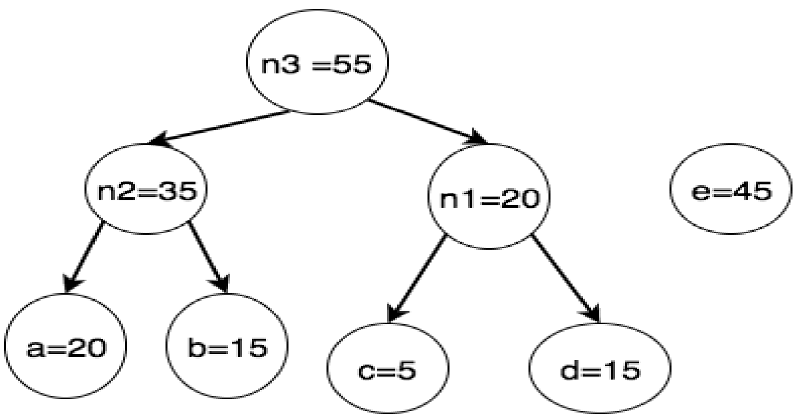


Figure 14

Sub-tree n3 and node e are merged to give root n4=100

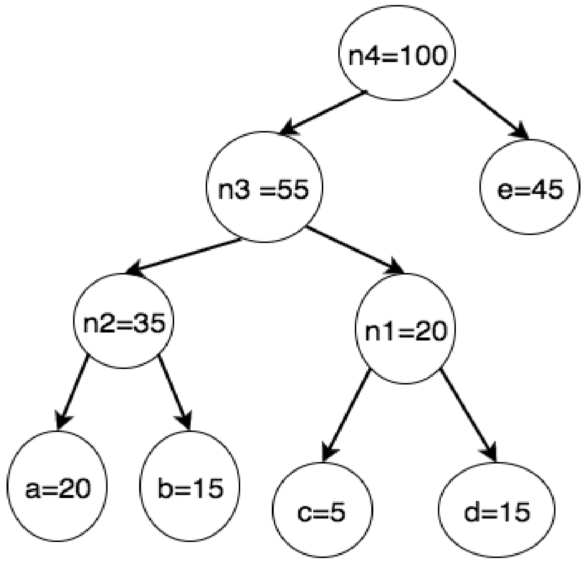


Figure 15

3.2 H.264

High Efficiency video coding was developed by the ITU-T Video Coding Experts Group together with the ISO Moving Picture Experts Group (MPEG). It aimed to create a standard that can provide lower bit rates without increasing complexity of design. It uses Block oriented motion compensation(Ozer)

Working

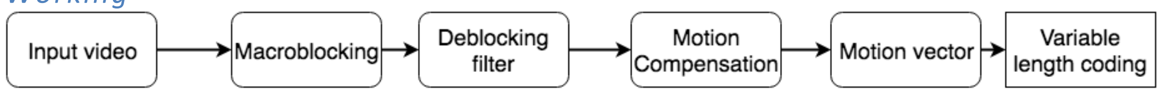


Figure 16 (Carle)

It removes the following types of redundancies: Temporal, Spectral, Psycho-Visual

1) Macro Blocking

The same Macro blocking steps take place. However H.264 splits the frames into 32 x 32 blocks, making it more precise.

2) De-blocking Filter

This filter removes blocking artifacts created due to very high compression. It smoothens the edges between macroblocks and improves video quality.
(Carle)

3) Motion Compensation

It begins by splitting up the video into several frames.

The frames can be of three types :

1) I-frame : This is usually the first frame of a video. It can be encoded independently without referencing any frames. They are starting points for for synchronization. An encoder will insert I-frames at regular intervals.
2) P-frame: This is the predictive inter frame. It predicts the frame based on previous P- frames or I-frames. They require fewer bits than I-frames.
3) B-frame: This is the bi – predictive inter frame. This frame references previous and future frames to make a predictive frame ("H.264 Video")

By This process the H.264 standard achieves low latency.

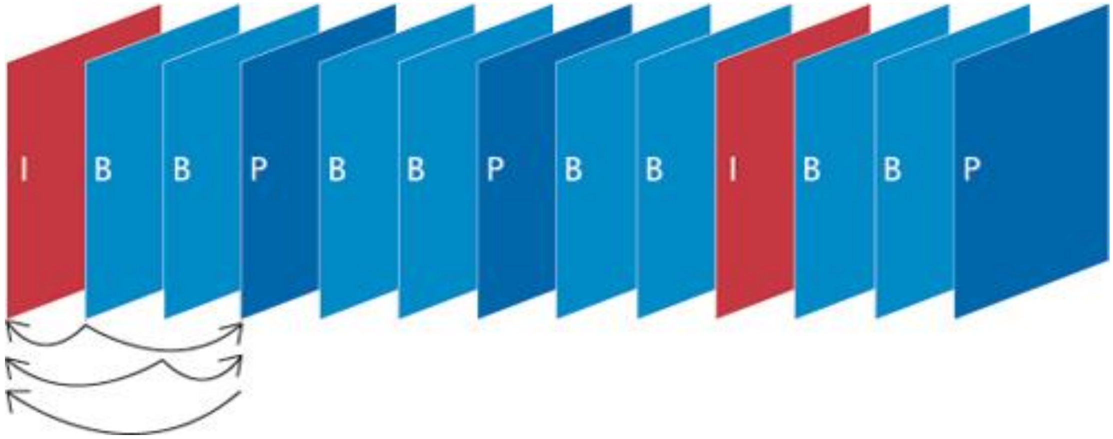


Figure 17 (“H.264 Video”)

4) Motion Vectors

This uses the three types of frames(I , P ,B) in a video. The frames are compared with the I–frame. The pixels that have changed with respect to the I – frame are encoded and given motion vectors.

5) Variable Length Coding

This uses data from motion compensation and motion vectors. Symbols are used for coding. Each input data is assigned a code based on the frequency. Unlikely Symbols are given longer code words whereas likely Symbols are assigned shorter code words.

Example : If (E, F, G, H) each having probabilities of occurrence(based on the frequency) (0.8,0.5,0.20,0.20) needed to be represented, the algorithm would generate a code word for each symbol based on the probability.

Symbol	Code word
E	0
F	10
G	110
H	111

A 1 digit code word (0) is used to represent ‘E’ and a 2 digit code word (10) is used to represent ‘F’.

The expected number of bits required would be:

$$(1 \times 0.80) + (2 \times 0.50) + (3 \times 0.20) + (3 \times 0.20) = 3$$

The source is compressed as much as possible in order to get zero error.

3.3 Theoretical Analysis

H.264

ADVANTAGES

H.264 is the newest standard for video compression. It has more advanced compression methods such as variable length coding and motion compensation. Due to this H.264 will have a higher compression ratio. This high ratio makes H.264 suitable for high definition videos having large file sizes. The motion compensation feature provides high latency which enables real time communication. Since the H.264 removes the maximum amount of temporal redundancy and includes a de-blocking filter(which removes blocking artifacts) it can provide high quality videos at a low bit rate.("The Difference between")

DISADVANTAGES

H.264 has a higher amount of computational complexity which leads to higher encoding runtimes. It has less encoding options.("H.264 VS MPEG-4")
H.264 removes a high amount of psycho-visual redundancy during motion compensation, this leads to a slight observable loss in quality.

MPEG-4

ADVANTAGES

Due to compression techniques such as motion estimation and DCT it is efficient and can provide high quality video using smaller file sizes. The Huffman coding makes it scalable i.e it can deliver video at any data rate (slow or fast). It removes maximum amount of temporal and spatial redundancy. Due to these factors it is widely accepted and used by major media players.("The Difference between")

DISADVANTAGES :

Degree of compression is not as great as H.264. Due to lower precision during compression there are higher chances of errors.

4. Investigation

In order to investigate the research question, two experiments will be conducted.

The experiments were conducted on a system with the following specifications:

CPU : Intel Core i3 (4th Gen) 4330T / 3 GHz

Dual Core processor

RAM: 1600MHz

Memory: 16 GB

Hard Drive Capacity:500GB

Operating System: Windows 7, 64 bit architecture

Manufacturer : HP

Softwares Used: Handbrake 0.10.5 and MSU VQMT 8.0 BETA Free 64-bit

4.1 Experiment 1

Methodolgy:

Five different videos were used:

Trial 1- A 858 x 480 pixel resolution sample video (“Example video-480p”)

Trial 2 – A 1280 x 720 pixel resolution advertisement (“Introducing Pixel”)

Trial 3 – A 1920 x 1080 pixel resolution music video (“Alesso - Take”)

Trial 4 – A 480 x 360 pixel resolution TED talk video (“TED X Talks”)

Trial 5 - A 1280 x 720 pixel resolution short review film (“DRONE BATTLE”)

The original videos will be compressed using the HandBrake software (“HandBrake”). Both the standards-MPEG 4 and H.264 will be implemented and two compressed video files will be formed. During this time original file size, compressed files size, compression ratio and encoding time will be measured.

Hypothesis:

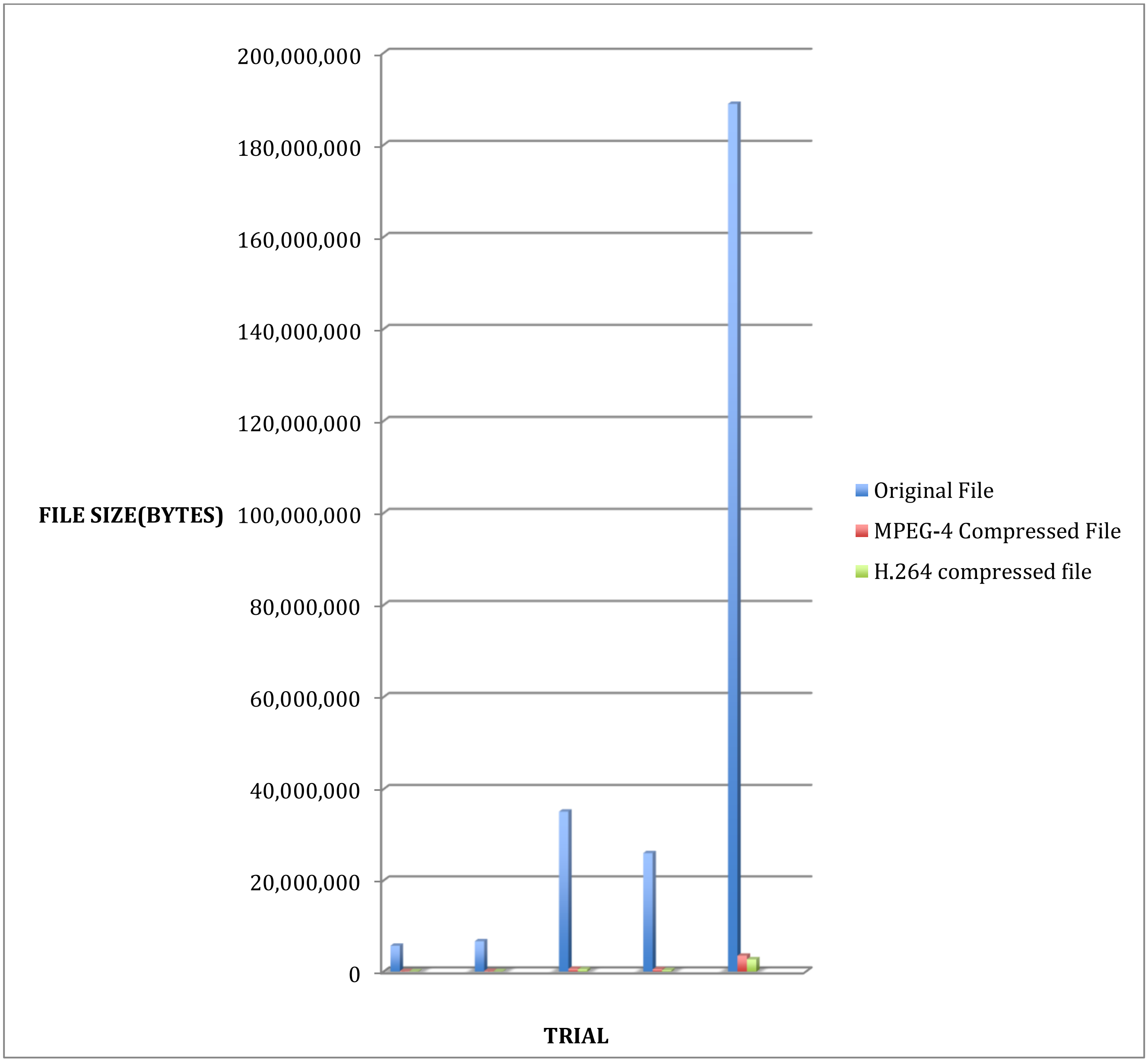
My hypothesis is that H.264 will be able to compress the video files to a smaller size. However, due to its computational complexity the runtime of encoding will be greater.

Readings:

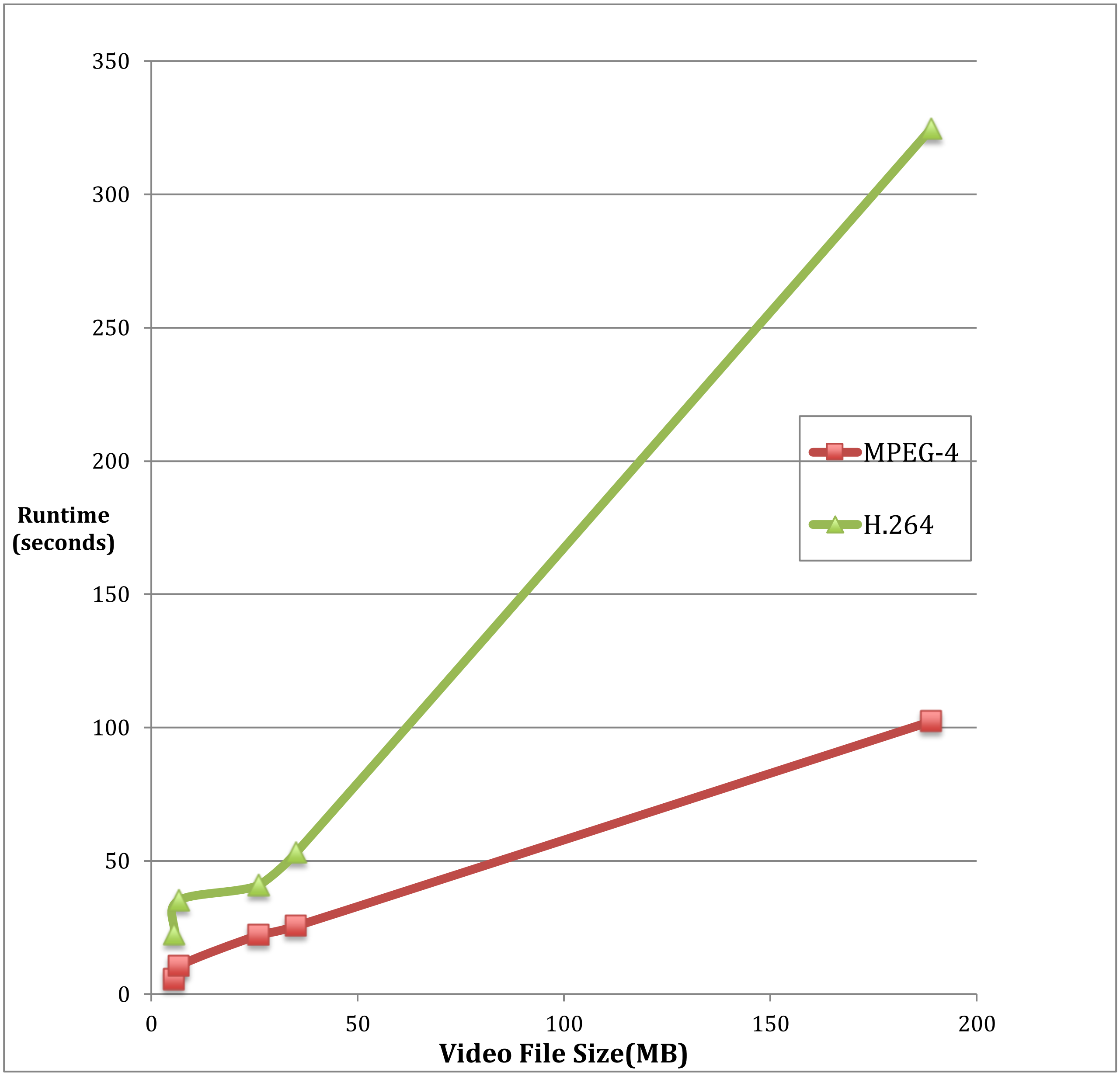
	Original Size(bytes)	Compressed Size (bytes)	Compression Ratio*	Encoding Time(seconds)**
TRIAL 1				
MPEG-4	56,78,571	1,16,254	1:48	5.38 ± .01
H.264	56,78,571	74,522	1:76	22.47 ± .01
TRIAL 2				
MPEG-4	66,69,337	1,51,576	1:44	10.57 ± .01
H.264	66,69,337	86,615	1:77	35.16 ± .01
TRIAL 3				
MPEG-4	3,51,21,298	6,16,163	1:57	25.48 ± .01
H.264	3,51,21,298	4,87,796	1:72	53.03 ± .01
TRIAL 4				
MPEG-4	2,60,29,997	5,20,600	1:50	22.12 ± .01
H.264	2,60,29,997	3,17,439	1:82	40.78 ± .01
TRIAL 5				
MPEG-4	18,89,50,741	34,99,088	1:54	102.28 ± .01
H.264	18,89,50,741	26,99,296	1:70	324.71 ± .01

Note: 1* For calculating compression ratio decimals were rounded to the nearest significant figure. eg if compression ratio = 1:49.3455, compression ratio = 1:49
Note: 2 Stopwatch used to measure consists of an uncertainty of .01 seconds**

Graphs:



Graph 1 File Sizes in Trials 1, 2, 3, 4 and 5



Graph 2 Runtime vs Video File Size

4.2 Experiment 2

Methodolgy:

The same videos will be used in Experiment 2(Original,MPEG-4 compressed and H.264 compressed).

The MSU Video Quality Measurement tool(“MSU Quality”) will be used for the compressed videos to measure the following variables: **Peak Signal Noise Ratio(PSNR), Aligned Peak Signal Noise Ratio(APSNR), Blocking Metric, SSIM(fast), Video Quality Measurement(VQM), Mean Square Error(MSE), Noise Estimation Metric, Brightness independent PSNR(BI-PSNR)**

Hypothesis:

According to me the video quality of both compressed videos will be similar, with H.264 having lesser errors.

Readings :

Legend	
Original File:	480p.avi
File Compressed using MPEG-4:	480p-1.mkv.mpeg 4
File Compressed using H.264:	480p-1.mkv

1.MEAN SQUARE ERROR (MSE) : squared error between the compressed and the original frame. (“ Everything about Compression”)

$$MSE = \frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}\left[I(x,y) - I'(x,y)\right]^2$$

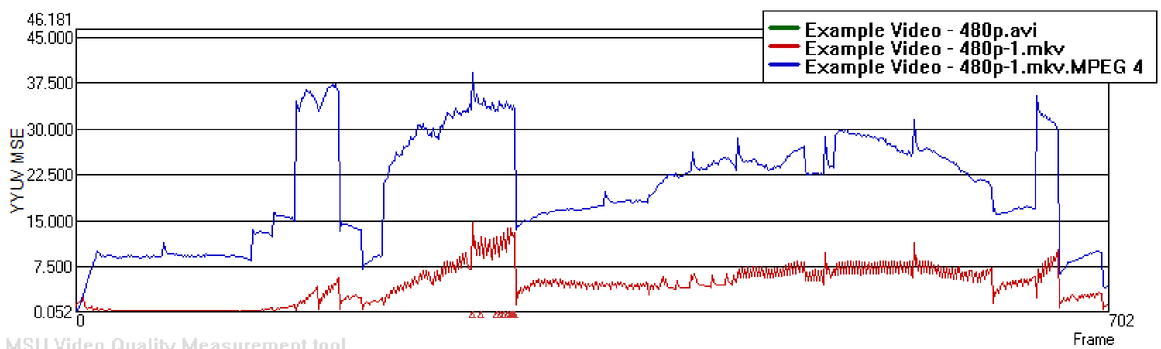
Formula 2 MSE ("Everything about Compression”)

I(x,y) = original frame

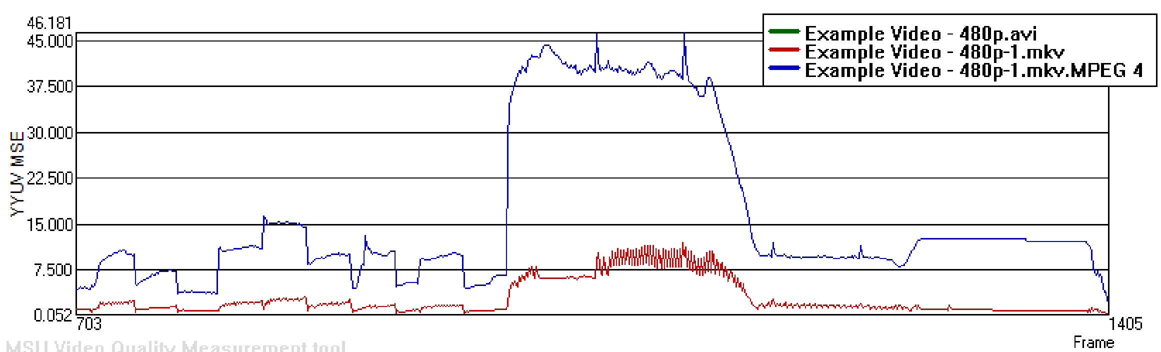
I'(x,y) = approximated version (decompressed frame)

M,N are the dimensions of the frame

Hence a lower value for MSE means lesser error(“MSU Quality”)



Graph 2 MSE Frames 0 to 702

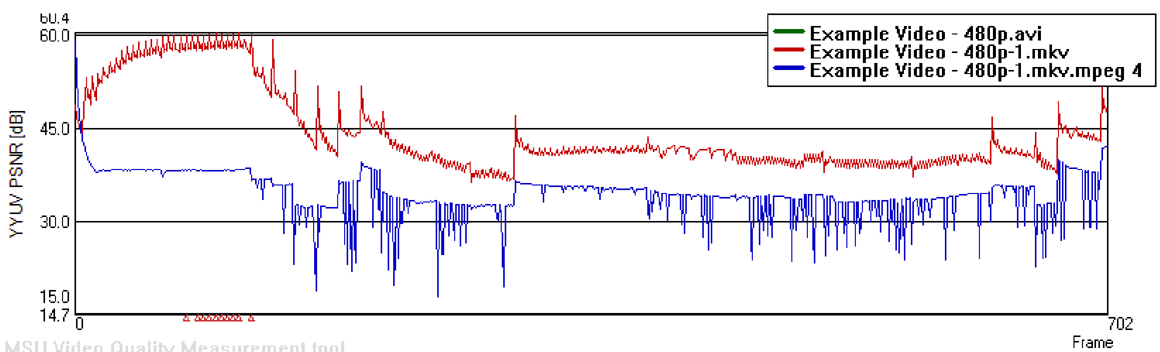


Graph 3 MSE Frames 703 to 1405

2. PSNR : An engineering term for the ratio between maximum possible power of a signal and the power of corrupting noise affecting the representation. The 'signal' is the original image, and the 'noise' is the error in reconstruction. It is expressed in terms of the logarithmic decibel scale(“MSU Quality”). A higher value of PSNR indicates better quality because it means that the ratio of Signal to Noise is higher.

$$PSNR = 20 \times \log 10(\frac{255}{\sqrt{MSE}})$$

Formula 3 PSNR("Everything about Compression")



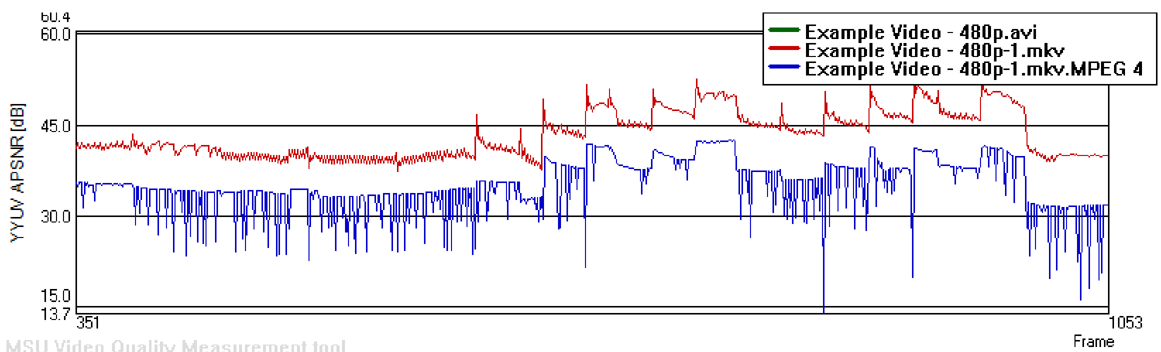
Graph 4 PSNR Frames 0 - 702

2.1 Uncertainties in PSNR

The value of PSNR depends on several factors. Some of these factors do not affect video quality and may lead to inaccurate readings. To prevent uncertainties and ensure the correct reading the following readings were taken.

2.1.1 APSNR

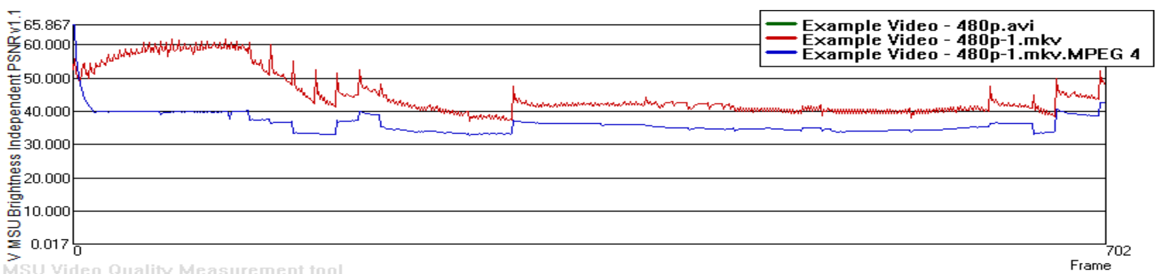
PSNR consists of inaccuracies in measurement when applied to video stream over wireless or mobile networks due to packet loss. Aligned PSNR is dynamic and is accurate in the case of loss of frames.(Syahbana, Yoanda, Herman, and Azizah)



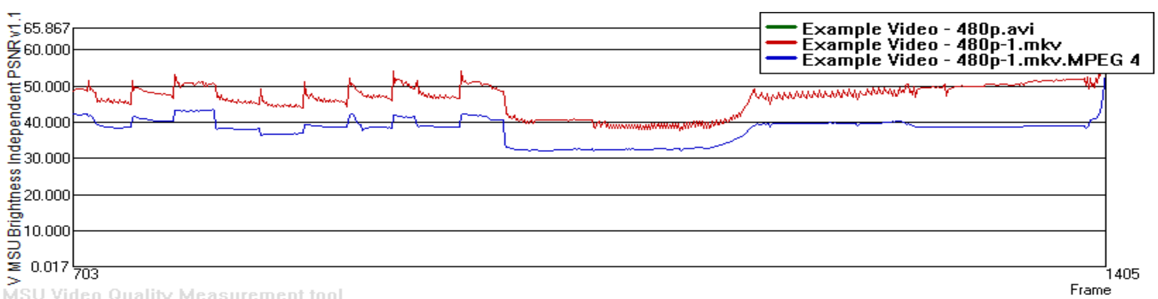
Graph 5 APSNR Frames 351 to 1053

2.1.2 BRIGHTNESS INDEPENDENT(BI) PSNR

Frames having Brightness Transformations (The uniform increase or decrease of brightness of frames) affect the values of PSNR. BI-PSNR calculates the value of PSNR taking into account these transformations.



Graph 12 Brightness Independent PSNR Frames 0 to 702



Graph 13 Brightness Independent PSNR Frames 703 to 1405

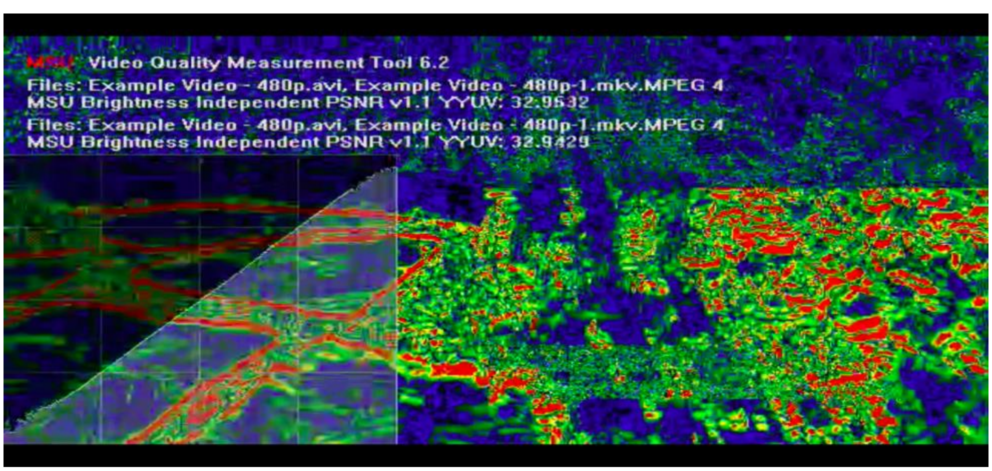
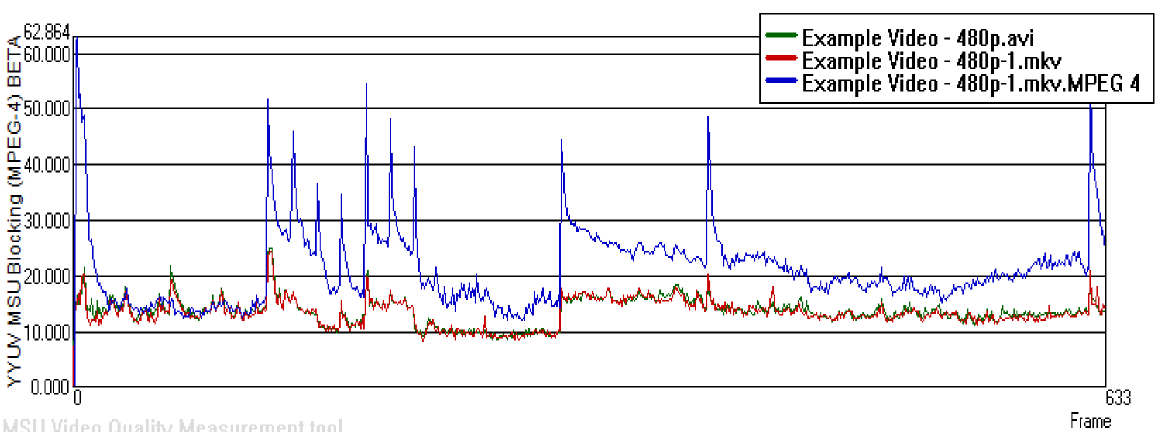


Figure 18 Frame of Video during analysis of Brightness Independent PSNR

3.BLOCKING METRIC :

This is the Blocking effect in a video. In contrast areas of the frame blocking is not appreciable, but in smooth areas these edges are visible.(“Blocking Artifacts”) The blocking features are calculated independently for the original and compressed video. This value represents the degree of blocking artifacts

Figure 19 Image showing blocking artifacts present("Blocking Artifacts")



Graph 6 Blocking Metric Frames 0 to 633

4. SSIM(FAST)

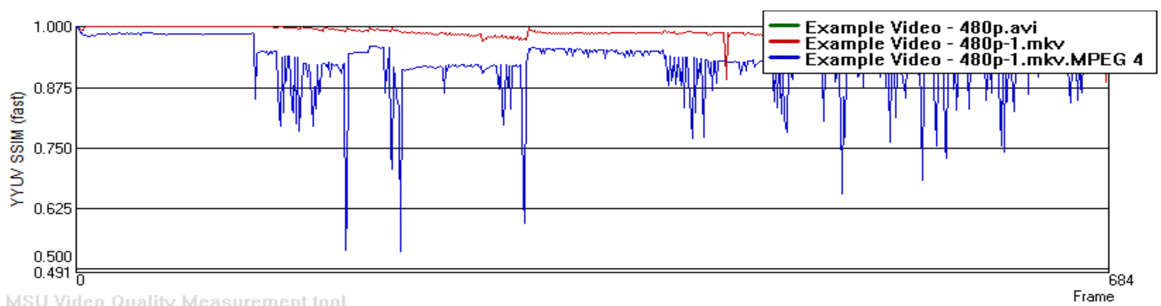
SSIM measures the similarity between two frames(“MSU Quality”)

SSIM metric has two coefficients. They depend on the maximum value of the frame color component. They are calculated using the following equations:

- *C1 = 0.01 * 0.01 * frame1Max * frame2Max*
- *C2 = 0.03 * 0.03 * frame1Max * frame2Max*

frame1Max = maximum value of a given color component for the first frame

frame2Max = maximum value of the same color component for the second frame



Graph 7 SSIM(Fast) Frames 0 to 684

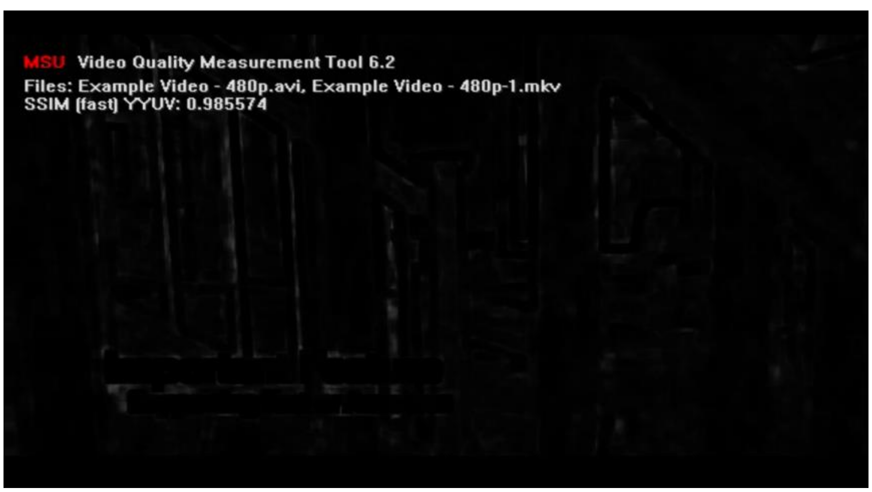
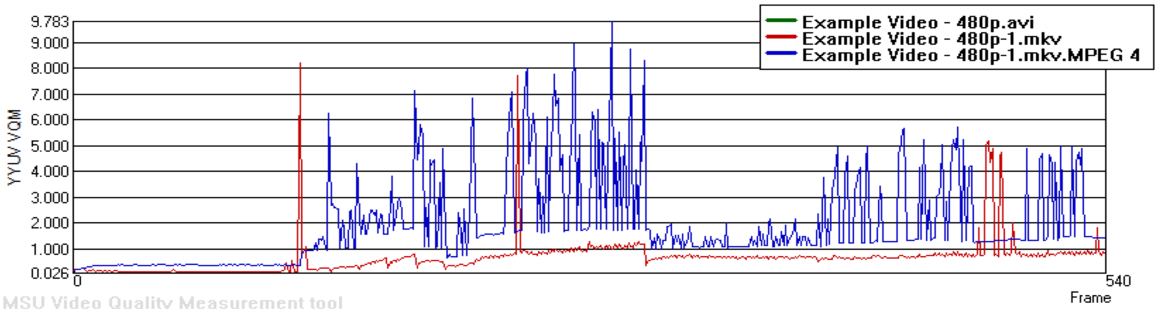


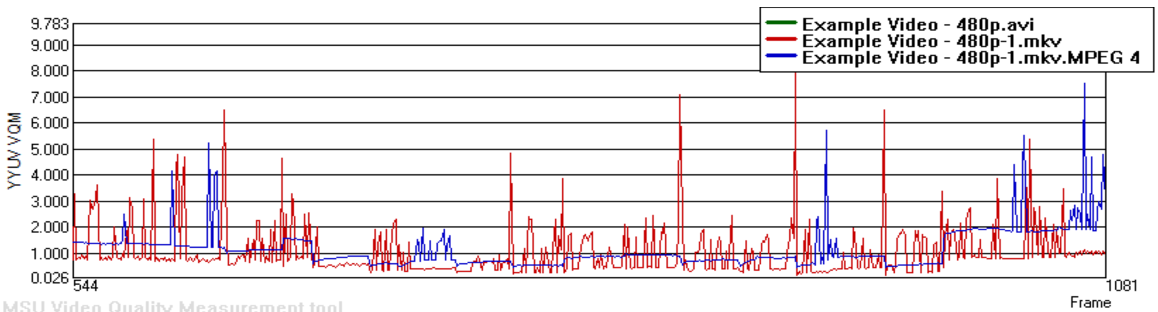
Figure 20 Frame of the video during analysis of SSIM(fast)

5.VIDEO QUALITY MEASUREMENT(VQM)

Since PSNR does not consider the human visual perception another metric is required. VQM is a measurement of the Spatial-temporal property of human's visual perception. It is a measurement of the quality of the compressed video considering factors from the perception of a human eye.



Graph 8 VQM Frames 0 to 540



Graph 9 VQM Frames 544 to 1081

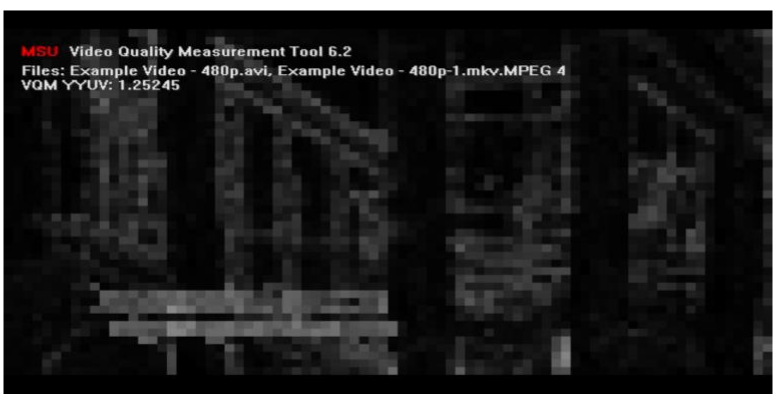


Figure 21 Frame of video during analysis of VQM

6. NOISE ESTIMATION METRIC

IT MEASURES THE MOSQUITO NOISE, the ringing or busyness seen in successive still frames.("Definition: Mosquito Noise")

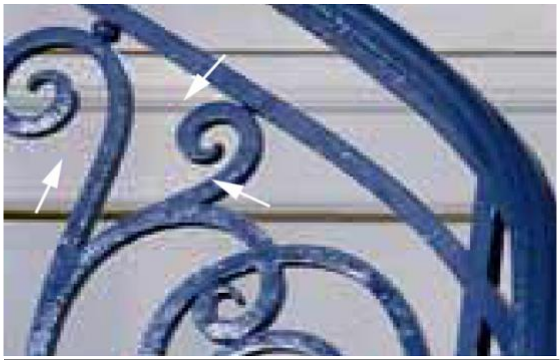
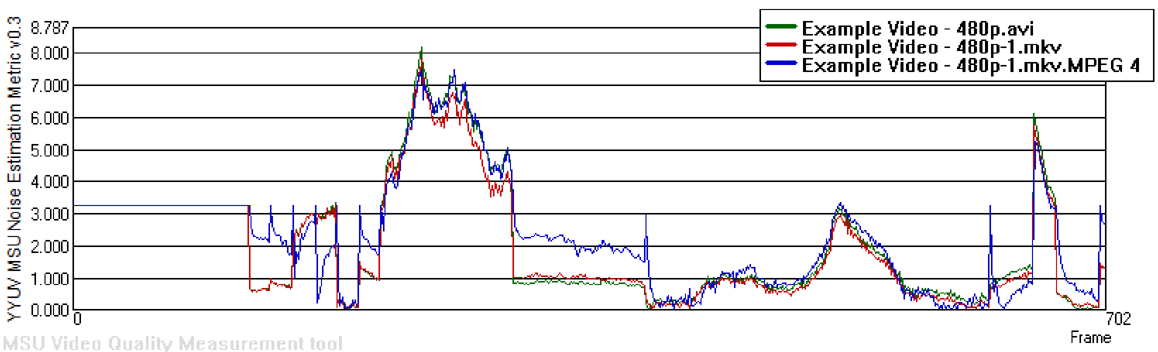
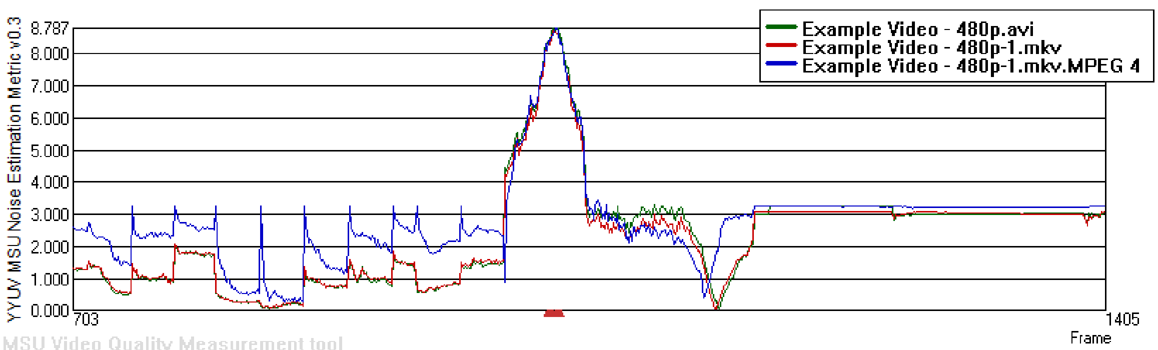


Figure 22 Mosquito Noise around the edges ("Definition: Mosquito Noise")



Graph 10 Noise Estimation Metric Frames 0 to 702



Graph 11 Noise Estimation Metric Frames 703 to 1405

Readings:

Variable	**Maximum value of H.264 compressed video**	**Maximum value of MPEG-4 compressed video**	**Analysis of Graph**
MSE (Lower value corresponds to better quality)	15	46.181	Variations occur during the same frames. However, MPEG-4 amplifies the errors.
PSNR (Higher value corresponds to better quality)	60.40	41.25	H.264 has a higher peak value but MPEG 4 has a greater range
APSNR (Higher value corresponds to better quality)	52.5 decibel	41.25	MPEG-4 causes it to have a greater range.
BI-PSNR (Higher value corresponds to better quality)	60.500	44.000	Almost the same value through most of the frames. Slight differences present.
BLOCKING METRIC (Lower value corresponds to better quality)	24.991	62.864	The H.264 video has almost the same values as the original. The MPEG-4 has a very high blocking metric.
SSIM (Higher value corresponds to similarity between frames.)	1	0.912	H.264 has a almost constant value around 1. MPEG 4 has several variations but a lower value
VQM (Higher value corresponds to better quality)	8.522	9.783	MPEG -4 has a higher peak of 9.783 And is consistently higher till frame 504.After this it is almost equal.
NOISE ESTIMATION METRIC (Lower value corresponds to better quality)	8.787	8.787	The values are almost the same as the original through all frames. In some frames the MPEG-4 video has a higher value.

4.3 Analysis

MPEG 4 offers an efficient compression ratio and low encoding times due to the lower computational complexity. H.264 has a consistently better compression ratio (for all types of videos) but increasing encoding times as file size increases.

MPEG-4 had more significant errors(the MSE value was greater) since H.264 measures differences between successive frames. This led to larger differences between the compressed and original videos, which in turn led to lower PSNR, APSNR, BI-PSNR values.

Since H.264 uses a blocking filter as part of the compression it achieved a lower block metric value, indicating it had lower blocking artifacts.

The SSIM value of H.264 is higher and almost constant this means that after compressing the video, the similarity between frames of the H.264 compressed video is higher in comparison to the MPEG-4 compressed video. This is because the H.264 uses Motion compensation which considers inter-frame similarities.

The MPEG 4 compressed video had a higher (VQM) value. Since the H.264 removes a larger amount of psycho-visual redundancy.

Both compressed videos did not increase noise present in the original video. However MPEG-4 contained higher variations.

4.4 Limitations Of Investigation

Uncertainties in Experiments- Experiment 1 consisted of two uncertainties, Measurement of encoding time and Compression Ratio. Encoding time was measured in seconds using a stopwatch, due to this there was a possibility of a ± .01 second error. The compression ratios were rounded to the nearest significant figures. Since the difference in encoding times and compression ratios was significant (difference > 1) this limitation did not affect the conclusions drawn.

5. Conclusion

The investigation clearly highlights that H.264 is feasible for high definition videos, large size videos because it has lesser errors and a high amount of compression. However the large encoding times indicates that MPEG.4 is better suited for online streaming of high quality videos, because it provided a similar degree of compression with some errors but much faster encoding runtimes. Futhermore, the MPEG-4 compressed video had a higher VQM measurement as it does not remove psycho-visual redundancy.

Concluding the question “Which video data compression standard provides the best combination of video quality, encoding time, compression ratio: MPEG-4 vs H.264?” depends on several factors. Theoretically a standard that removes all redundancies would be optimal. However, this is practically not possible as there would be sacrifices on crucial aspects such as encoding time and video quality. There is always a trade off between amount of compression and video quality.

The experiments proved the hypothesis but subjective criteria of video quality could not be measured since these vary for different users. H.264’s higher amount of compression, lower amount of errors and better video quality make it the more optimal standard. There is constant improvement in video compression standards. H.265 and VP8 are currently in the stage of development and implement the best qualities of both MPEG-4 and H.264.

6. Work Cited - MLA

Alesso - Take My Breath Away (Lyric Video). Prod. Alesso. YouTube. N.p., 2 Nov. 2016. Web. 6 Nov. 2016.

Ars Technica. N.p., 22 Dec. 2009. Web. 06 Nov. 2016.

Bebis, Prof. "Image Compression." *Image Compression*. SlideShare, 16 June 2013. Web. 01 Nov. 2016.

Blocking Artifacts at Start of Each Cut/re-encoded Part. Fame-Ring, n.d. Web. 01 Nov. 2016.

By 2020, Global IP traffic will Reach 2.3 ZB per Year, or 194 EB per Month. "White Paper: Cisco VNI Forecast and Methodology, 2015-2020." *Cisco*. N.p., 1 June 2016. Web. 30 Oct. 2016.

Carle, Brian. "How Does H.264 Work?" SALIENT SYSTEMS WHITE PAPER (2012): 2-6. Salient Systems. Web. 5 Sept. 2016.

Christensson, Per. "Bitrate Definition." *TechTerms*. Sharpened Productions, 2006. Web. 30 October 2016. <http://techterms.com/definition/bitrate>.

“Codec." - Memidex Dictionary/thesaurus. N.p., n.d. Web. 06 Nov. 2016.

Digital image. N.p., n.d. Web. 1 Nov. 2016. <http://www.ual.es/~vruiz/Docencia/Apuntes/Coding/Image/00-Fundamentals/correlacion_lena.png>.

"Definition: Mosquito Noise." *Definition: Mosquito Noise*. PCMag, n.d. Web. 01 Nov. 2016.

DRONE BATTLE GoPro Karma vs. Phantom 4. Dir. Casey Neistat. Perf. Casey Neistat. YouTube. YouTube, 04 Nov. 2016. Web. 06 Nov. 2016.

Ein Steilkurs. *In Diesem Kapitel Wird Auf Die Entwicklung Und Normierung Von MPEG Eingegangen.* N.p., n.d. Web. 01 Nov. 2016.

Example Video - 480p. Prod. Zephyr McIntyre. *YouTube*. YouTube, 02 July 2015. Web. 04 Nov. 2016.

"Final Cut Pro 7 User Manual." *Final Cut Pro 7 User Manual*. Apple, n.d. Web. 01 Nov. 2016.

HandBrake. Computer software. HandBrake The Open Source Video Transcoder. Vers. 0.10.5. Ethercycle, n.d. Web. 23 Aug. 2016.

"H.264 VS MPEG4: Detailed Comparison between H.264 and MPEG4." H.264 VS MPEG4: Video Encoding Formats Comparison. Digiarity, n.d. Web. 11 Oct. 2016.

"H.264 Video Compression Standard." (n.d.): 4-5. Http://www.axis.com/files/whitepaper/wp_h264_31669_en_0803_lo.pdf. Axis Communication. Web. 6 Nov. 2016.

Introducing Pixel, Phone by Google. Prod. Google. YouTube. Google, 24 Oct. 2016. Web. 6 Nov. 2016.

"Intra-frame vs Inter-frame Compression." Wolfcrow. N.p., n.d. Web. 21 Sept. 2016.

Koenen, Rob. "MPEG-4: A Powerful Standard for Use in Web and Television Environments." *MPEG-4: A Powerful Standard for Use in Web and Television Environments*. N.p., n.d. Web. 02 Nov. 2016.

"Lecture 15: Huffman Coding." (n.d.): 12. Print. 21 Oct. 2016

Mahdi, Omar Adil, Mazin Abed Mohammed, and Ahmed Jasim Mohamed. "Audio Compression and Coding Techniques." *Implementing a Novel Approach an Convert Audio Compression to Text Coding via Hybrid Technique* 3rd ser. 9.6 (2012): 53. Nov. 2012. Web. 2 Nov. 2016.

Marshall, Dave. "The Discrete Cosine Transform (DCT)." The Discrete Cosine

Transform (DCT). N.p., 4 Oct. 2001. Web. 06 Nov. 2016.

Mitrovic, Djordje. "Video Compression." (n.d.): 1. University Of Edinburgh. Web. 1 Oct. 2016.

Morris, James. "The Codec Primer: Part One." *TrustedReviews*. TrustedReviews, 22 Dec. 2007. Web. 01 Nov. 2016. <http://www.trustedreviews.com/opinions/the-codec-primer-part-one>.

"MSU Quality Measurement Tool: Metrics Information." MSU Quality Measurement

MSU Quality Measurement Tool. Computer software. MSU Quality Measurement Tool: Download Page. Vers. MSU VQMT 8.0 BETA Free 64-bit. MSU Graphics & Media Lab, n.d. Web. 7 Sept. 2016.

Ozer, Jan. "Encoding for Multiple Screen Delivery." *Udemy*. N.p., n.d. Web. 08 Jan. 2017.

Ponlatha, S., and R.S. Sabeenian. "Comparison of Video Compression Standards." International Journal of Computer and Electrical Engineering 5.6 (2011): 359-421. Dec. 2013. Web. 12 Sept. 2016.

Realtimes. "The History of Video File Formats Infographic - RealPlayer." RealTimes. N.p., 19 May 2015. Web. 06 Nov. 2016.

Robertson, Mark. "H.264 versus MPEG-4 - Video Encoding Formats Compared." Tubular Insights. N.p., 23 Oct. 2007. Web. 5 Oct. 2016.

"RS 160, 170 And 180 Latency Issues." - Sennheiser UK Support. N.p., n.d. Web. 06 Nov. 2016.

Syahbana, Yoanda Alim, Herman, and Azizah Abdul Rahman. "Aligned-PSNR (APSNR) for Objective Video Quality Measurement (VQM) in Video Stream over Wireless and Mobile Network." IEEE, 30 Jan. 2012. Web. 03 Nov. 2016.

TED X Talks. "This Is What Happens When You Reply to Spam Email | James Veitch." YouTube. YouTube, 01 Feb. 2016. Web. 06 Nov. 2016.

The Difference between MPEG-4 and H.264. Whakatāne: Bay of Plenty Regional

Council, 2013. Velleman. Web. 2 Aug. 2016.

Tool: Metrics Information. MSU Graphics & Media Lab, n.d. Web. 21 Sept. 2016.

Vcodex: Introduction to Video Coding. Dir. Vcodexer. YouTube, 26 June 2013. Web. 02 Nov. 2016.

Video Compression as Fast As Possible. Prod. Techquickie. YouTube, 10 Aug. 2014. Web. 02 Nov. 2016.

"Video Compression." Axis Communications. N.p., n.d. Web. 06 Nov. 2016.
Bylund, Anders. "From Cinepak to H.265: A Brief History of Video Compression."

“Xie, Lexing. "Image and Video Compression Fundamentals." Video Codec Design (n.d.): 6-71. Columbia University In The City Of New York, 27 Apr. 2009. Web. 2 Oct. 2016.

I Declare “That this work is my own work and is the final version. I have acknowledged each use of the words or ideas of another person, whether written, oral or visual.”