DIGITAL IMAGE RECOMPRESSION ANALYSIS: FACEBOOK

by

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B.S., University of North Georgia, 2014

A thesis submitted to the

Faculty of the Graduate School of the

University of Colorado in partial fulfillment

of the requirement for the degree of

Master of Science

Recording Arts

2016

This thesis for the Master of Science degree by

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December 17th, 2016

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Digital Image Recompression Analysis: Facebook

Thesis directed by Assistant Professor Catalin Grigoras

ABSTRACT

Social media has become incorporated into our daily routine and has changed how we connect and communicate with other people. These sites offer slight differences in appearance and functionality, but they are primarily focused on sharing images to be viewed by friends. Whether these images are of people, places or things they tend to flood a social site and prior to uploading they can contain a large amount of embedded data. This thesis aims to identify both the effect of mobile and desktop uploading on images as well as the effect on image dimensions. These characteristics are changed by the host site, Facebook in this case, and will be analyzed into two different tests.

This thesis explores previous research into social media sites and JPEG compression while providing an overall look at Facebook. Next, the foundational steps of digital image compression will be presented. In Chapter 3, the process of data collection and preparation for this research is described. The results section follows and elaborates on the findings of both tests. Finally, future research topics are purposed for further examination.

The form and content of this abstract are approved. I recommend its publication.

Approved: Catalin Grigoras

DEDICATION

I would like to thank my parents for the constant push to strive for more out of life and to never accept defeat. Thank you for teaching me the value of a dollar earned and a dollar spent. You both showed me how to work for what you want out of life, ask questions and to learn from your mistakes. Thank you for continually being my biggest and loudest cheerleaders.

Justin, I want to thank you for your daily unwavering support. You gave me motivation and direction whenever it was needed. You took a great deal of my worries and stress throughout this endeavor and handled it with ease. And experiencing everyday with you by my side has been the greatest gift. I cannot wait to see where our life together takes us and you will forever be my favorite person on earth, I love you.

ACKNOWLEDGEMENTS

I want to thank Jeff & Catalin for their support, suggestions and immediate responses to my every email. I have learned more than I thought possible through their incredible teaching. This field of digital forensics is such an evolving area and I am thankful for the opportunity to see it grow. I am grateful for the National Center of Media Forensics for providing a wonderful environment to learn such an exciting discipline.

Leah, you rock! You always responded to my emails with clarity and promptness. You made class deadlines and important details well-known and you were always available for my thousands of questions. You made learning at a distance that much easier, thank you.

Mr. Lewis, thank you for agreeing to be a part of my committee. I enjoyed being in of your cell phone forensics class and valued your opinion on this research. You are incredibly knowledgeable and a wonderful teacher. I hope that I can continue to learn from you throughout my career.

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LIST OF ABBREVIATIONS

CFA – Color Filter Array

DCT – Discrete Cosine Transform

DSLR – Digital Single-Lens Reflex

ELA – Error Level Analysis

GPS – Global Positioning System

JPEG – Joint Photographic Experts Group

RLC – Run Length Coding

SWGDE – Scientific Working Group on Digital Evidence

SWGIT – Scientific Working Group on Imaging Technology

QMS – Quality Management System

CHAPTER I

INTRODUCTION

Facebook is one of the most well-known social media websites with an estimated "1.13 billion daily active users on average for June 2016" [4]. At its inception on February 4, 2004 Facebook began with the intent of joining Harvard college students [1]. Facebook now can connect billions of people in seconds to not only acquaintances and friends, but also to businesses, celebrities and political figures. Facebook has evolved in several ways and provides additional features to users but regardless of its growth it has continually allowed for the uploading and downloading of images. These images can be viewed on several devices such as desktops, laptops, cellphones and tablets. Facebook can be accessed through these devices via a downloadable application or directly through a web browser.

These photos are often uploaded, shared and then collected in the user's profile for later viewing. Images that have been uploaded and made viewable provide useful information to aid criminals in inferring the location of your home, family information and whether you may be home or on vacation, leaving your possessions unguarded. It is possible to protect certain elements of your page through privacy settings but these are often overlooked [7].

Facebook users can encounter phony profiles attempting to pose as friends or family members to gain your trust and swindle you out of your money or valuable information. Although Facebook states to have around one billion daily users, it is estimated that up to 8.7% of those could be fake accounts [6]. It is important to decipher profiles of legitimate

people and those of deceptive individuals, this can be accomplished by using digital forensics.

Forensic digital image analysis can aid in locating and interpreting the embedded data encoded inside of digital images, the Scientific Working Group on Digital Evidence (SWGDE) defines multimedia evidence as “Analog or digital media, including but not limited to, film, tape, magnetic and optical media, and/or the information contained therein” [13].

PREVIOUS RESEARCH

There has been previous research investigating the forensic analysis of digital image compression and the impact social media applications has on processed images. Wu et al. proposed a solution to “compress a set of JPEG coded correlated images without loss” by removing inter and intra repetition. This is done by decoding an image collection and a prediction structure is compiled that can determine any commonality across the images. Those similarities can be exploited for the collection rather than each individual picture. This type of analysis can be beneficial and reduce cost for storage of large social media sites [15].

In regards to different social networking sites, Castiglione et al. analyzed at three different social sites in 2011. They collected various sets of images that included different image resolutions and sizes as well as thumbnails and profile pictures. They determined that compression removed EXIF metadata from processed image and different quality images allow limited pixel resolution [3].

Marrion explored the discrete cosine transform (DCT) map and error level analysis (ELA) of images processed through Facebook to detect any indications of manipulation. The results concluded that once a tampered image was compressed by Facebook the previous manipulation was usually undetectable. The compression affected the surrounding neighboring pixels and masked the alterations [8].

CHAPTER II

OVERVIEW

The embedded data typically in an original image can be found in the following Table. This is a partial output generated by using Exiftool. The table shows the file size, file type, make and model of the camera, time stamp and the global positioning system (GPS) information.

Table 1.1: Exiftool Output from Original Image

```
ExifToolVersion = 10.25
FileName = 1920x1440!.jpg
Directory = C:/Users/megan_000/Desktop/Resized Images
FileSize = 688428
FileModifyDate = 1476455070.39326
FileAccessDate = 1476455070.38826
FileCreateDate = 1476455070.38826
FilePermissions = 33206
FileType = JPEG
FileTypeExtension = JPG
MIMEType = image/jpeg
JPEG APP0 (14 bytes):
+ [BinaryData directory, 9 bytes]
| JFIFVersion = 1 1
| ResolutionUnit = 1
| XResolution = 72
| YResolution = 72
JPEG APP1 (12284 bytes):
ExifByteOrder = MM
+ [IFD0 directory with 11 entries]
| 0)  Make = Apple
| 1)  Model = iPhone 6s
| 2)  Orientation = 6
| 3)  XResolution = 72 (72/1)
| 4)  YResolution = 72 (72/1)
| 5)  ResolutionUnit = 2
| 6)  Software = 9.3.4
```

Table 1.1: Exiftool Output from Original Image, Cont'd

| 7) ModifyDate = 2016:09:06 06:46:07
| 8) YCbCrPositioning = 1
| 9) ExifOffset (SubDirectory) -->
| + [ExifIFD directory with 32 entries]
| | 0) ExposureTime = 0.06666666667 (1/15)
| | 1) FNumber = 2.2 (11/5)
| | 2) ExposureProgram = 2
| | 3) ISO = 500
| | 4) ExifVersion = 0221
| | 5) DateTimeOriginal = 2016:09:06 06:46:07
| | 6) CreateDate = 2016:09:06 06:46:07
| | 7) ComponentsConfiguration = 1 2 3 0
| | 8) ShutterSpeedValue = 3.906969876 (13229/3386)
| | 9) ApertureValue = 2.275007125 (7983/3509)
| | 10) BrightnessValue = -1.80421074 (-17739/9832)
| | 11) ExposureCompensation = 0 (0/1)
| | 12) MeteringMode = 5
| | 13) Flash = 16
| | 14) FocalLength = 4.15 (83/20)
| | 15) SubjectArea = 2015 1511 2217 1330
| | 16) MakerNoteApple (SubDirectory) -->
| | + [MakerNotes directory with 11 entries]
| | | 0) Apple_0x0001 = 4
| | | 1) Apple_0x0002 = bplist00O....X]]]XRQRY^kqib..]_cbZTVU^fx{xq..^]cd]XW]^k...|.[snip]
| | | 2) RunTime (SubDirectory) -->
| | | + [Binary PLIST directory]
| | | | RunTimeFlags = 1
| | | | RunTimeValue = 490495960531250
| | | | RunTimeEpoch = 0
| | | | RunTimeScale = 1000000000
| | | 3) Apple_0x0004 = 1
| | | 4) Apple_0x0005 = 80
| | | 5) Apple_0x0006 = 92
| | | 6) Apple_0x0007 = 1
| | | 7) Apple_0x0008 = 0.03742304133 -0.7731738573 -0.603210609 (930/24851 -1810/23[snip]
| | | 8) Apple_0x0009 = 4371
| | | 9) Apple_0x000e = 0
| | | 10) Apple_0x0014 = 4
| | 17) SubSecTimeOriginal = 132
| | 18) SubSecTimeDigitized = 132

Table 1.1: Exiftool Output from Original Image, Cont'd

| | 19) FlashpixVersion = 0100
| | 20) ColorSpace = 1
| | 21) ExifImageWidth = 4032
| | 22) ExifImageHeight = 3024
| | 23) SensingMethod = 2
| | 24) SceneType = 1
| | 25) ExposureMode = 0
| | 26) WhiteBalance = 0
| | 27) FocalLengthIn35mmFormat = 29
| | 28) SceneCaptureType = 0
| | 29) LensInfo = 4.15 4.15 2.2 2.2 (83/20 83/20 11/5 11/5)
| | 30) LensMake = Apple
| | 31) LensModel = iPhone 6s back camera 4.15mm f/2.2
| 10) GPSInfo (SubDirectory) -->
| + [GPS directory with 15 entries]
| | 0) GPSLatitudeRef = N
| | 1) GPSLatitude = 39 39 54.25 (39/1 39/1 5425/100)
| | 2) GPSLongitudeRef = W
| | 3) GPSLongitude = 104 56 58.78 (104/1 56/1 5878/100)
| | 4) GPSAltitudeRef = 0
| | 5) GPSAltitude = 1630.50495 (164681/101)
| | 6) GPSTimeStamp = 12 46 6 (12/1 46/1 600/100)
| | 7) GPSSpeedRef = K
| | 8) GPSSpeed = 0 (0/1)
| | 9) GPSImgDirectionRef = T
| | 10) GPSImgDirection = 322.2258065 (9989/31)
| | 11) GPSDestBearingRef = T
| | 12) GPSDestBearing = 322.2258065 (9989/31)
| | 13) GPSDateStamp = 2016:09:06
| | 14) GPSHPositioningError = 10 (10/1)
+ [IFD1 directory with 6 entries]
| 0) Compression = 6
| 1) XResolution = 72 (72/1)
| 2) YResolution = 72 (72/1)
| 3) ResolutionUnit = 2
| 4) ThumbnailOffset = 2014
| 5) ThumbnailLength = 9017
JPEG DQT (65 bytes):
JPEG DQT (65 bytes):
JPEG SOF0 (15 bytes):
ImageWidth = 1920

ImageHeight = 1440
EncodingProcess = 0
BitsPerSample = 8
ColorComponents = 3
JPEG DHT (28 bytes):
JPEG DHT (72 bytes):
JPEG DHT (26 bytes):
JPEG DHT (47 bytes):
JPEG SOS

Table 1.1: Exiftool Output from Original Image, Cont'd

This information can be useful in an investigation and lend additional data that can be analyzed for authenticity purposes. This thesis presents research into how this material is changed when images are recompressed by Facebook.

EASE OF EDITING

Criminals currently do not run at a disadvantage when it comes to creating false images. Cellphones are cheaper than expensive DSLR (Digital Single-Lens Reflex) cameras and still produce a high-resolution image. Computers, laptops and rapid processing tablets are accessible in stores and online. Digital images are readily available on the internet for free download or for purchase through services such as Adobe Stock. The only difference is the motivation and intention of the person who produces the altered images. Unfortunately, manipulated images have affected well-known people such as presidents, politicians and celebrities. The main goal of these pictures is to skew the overall meaning or to achieve some type of political gain. The ability to change a digital image is not a new phenomenon but it does require editing software and the tenacity to learn this time-consuming skill. There are several programs for purchase such as Adobe Photoshop and Corel Paintshop that are very comprehensive and offer advanced features for manipulation

but programs can also be downloaded from the internet that can accomplish similar results. These software options paired with vast amounts of “how-to” videos on YouTube and informational forums and creating a manipulated image can be accomplished by someone with no formal training.

THE SCIENTIFIC WORKING GROUPS

As mentioned before what classifies as multimedia evidence and how its examination should be carried out are crucial to producing a clear analysis. One source for best practices in this discipline the Scientific Working Group on Digital Evidence (SWGDE) which is formed of committees which produce documents to guide examinations on various digital and multimedia devices, storage units, and files. The group “brings together organizations actively engaged in the field of digital and multimedia evidence to foster communication and cooperation as well as to ensure quality and consistency within the forensic community” [13]. Ultimately, creating a learning environment to produce the best techniques and adapting to new technology as it pertains to an investigation. Although SWGDE does not provide accreditation to labs it does offer documents to be incorporated into labs Quality Management Systems (QMS) [14].

There is another committee devoted to preparing documents to aid examiners in their investigations of digital media. The Scientific Working Group on Imaging Technology (SWGIT) has created a beneficial document regarding forensic image analysis. These documents focus on proper procedure for seizing, processing and analyzing forensic digital

imagery. Although now defunct, SWGIT working groups have been formed and are active within SWDGE.

JPEG OVERVIEW

In 1992, the Joint Photographic Experts Group, (JPEG) committee gathered to study color imagery and develop the well-known standard for image compression [10]. JPEG compression is lossy which SWGDE defines as "compression in which data is lost and cannot be retrieved in its original form" [13]. JPEG achieves the best results on areas of images that contain low frequency changes instead of stark color differences. For this research, the concern is with lossy compression and its effect on digital images processed through Facebook.

It is important to mention that there are many degrees of JPEG compression that can be applied to images that result in a range of overall quality degradation. The amount of quantization error is based on the selection of quantization tables which can roughly translate into a quality level that ranging from 1 (the lowest quality) to 99, (highest quality).

Typically, the amount of pixel information that is destroyed is not discernable to the human eye unless you move lower in quality factors. However, once a file is saved and the compression algorithm is applied continuously over several iterations the amount of visual degradation will become more visible. Following is a general overview of the JPEG compression process.

Color is received from the color filter array (CFA) commonly as RGB (red, blue, green) color values and then converted into YCbCr for compression. "Y" represents the

(luma) or luminance value which is simply the intensity of brightness in an image. “Cb” and “Cr” represent the two chrominance values of blue and red. This color space is more easily exploited for compression and can be stored with a higher image resolution and treated as separate entities for greater efficiency [11].

Figure 2.1 depicts the process that follows YCbCr conversion. The boxes show progression into an image being split into 8x8 blocks of pixels. Those areas are then subjected to a Discrete Cosine Transform (DCT) which “converts pixel values into transform coefficients corresponding to spatial frequencies” [5].

After DCT is applied, the values at each pixel are quantized; the resulting value can be correlated to the weight each pixel provides in producing details of the overall image. This step compresses the image by removing the less significant, less noticeable changes in values between pixels and the more pixels that can be made uniform, the smaller the resulting file. This results in removing high frequency details; a change which is less noticeable to the human eye. Information removed during the quantization phase cannot be retrieved during decompression and contribute most significantly to JPEG compression’s lossy [2].

The pixels now need to be rearranged from an 8x8 block into a one-dimensional array for subsequent Run Length Coding (RLE) and Huffman coding. This is achieved by collecting the values starting at the upper left corner of the block and creating a zig-zag pattern all through the block until the final piece is obtained from the bottom right corner.

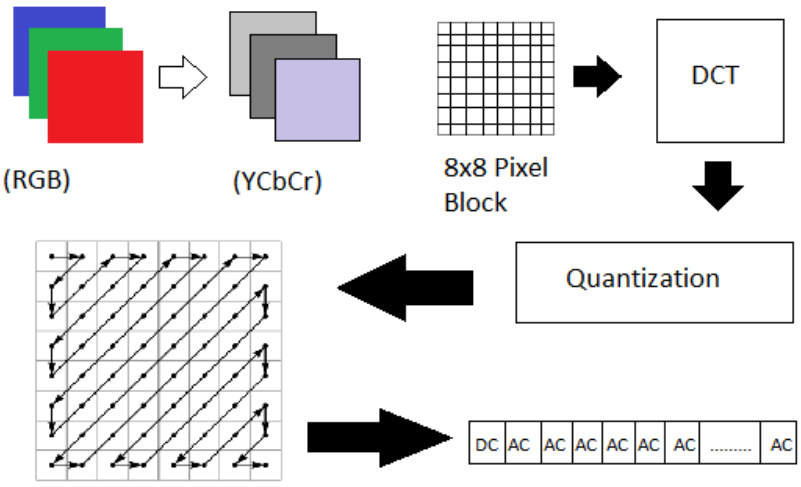

Figure 2.1: Steps in Digital Image Compression; RGB through Coding

CHAPTER III

PREPARATION STAGE

In this research, transcoding methods applied to images that are processed through Facebook were analyzed in two different tests utilizing both desktop and mobile devices. This transcoding step involves recompression of the image and the creation of new metadata in the resulting JPEG file. Both tests used the same desktop, ASUS laptop and a Samsung Galaxy Note 5 cellphone. A test Facebook profile and Google email, Gmail, account was created to separate images and emails from personal accounts. The data collected for analysis included the quantization tables, image size (height and width dimensions) and metadata structure; both before uploading to Facebook and after.

Both tests utilized programs that analyze embedded data and display it in a readable format. These programs include MediaInfo which was used to determine image size on processed images from Facebook, it also "is a convenient unified display of the most relevant technical and tag data for video and audio files" [9]. A script was created in MATLAB to extract the quantization tables and metadata structure for each image. Finally, Exiftool was used to view metadata structure and individual elements.

The following Table 3.1 shows the filename, image dimension, quantization tables and the Exiftool metadata dump of an original file prior to Facebook upload. This image was used in the first test for Facebook recompression analysis.

Table 3.1: Filename, Image Dimension, Quantization Tables and Exiftool Metadata Dump for Original Image 1 (FB Recompression Test)

Facebook Filename: 20160906_121154.jpg

Image Dimension: 2988 x 5312

```
ExifToolVersion = 10.25
  FileName = 20160906_121154.jpg
  Directory = C:/Users/megan_000/Desktop/Original Image 1
  FileSize = 5015528
  FileModifyDate = 1473178697.94831
  FileAccessDate = 1480562476.34245
  FileCreateDate = 1480562476.34245
  FilePermissions = 33206
  FileType = JPEG
  FileTypeExtension = JPG
  MIMEType = image/jpeg
JPEG APP1 (15990 bytes):
  ExifByteOrder = II
  + [IFD0 directory with 13 entries]
  | 0)  ImageWidth = 5312
  | 1)  ImageHeight = 2988
  | 2)  Make = Samsung
  | 3)  Model = SAMSUNG-SM-N920A
  | 4)  Orientation = 6
  | 5)  XResolution = 72 (72/1)
  | 6)  YResolution = 72 (72/1)
  | 7)  ResolutionUnit = 2
  | 8)  Software = N920AUCS3BPH4
  | 9)  ModifyDate = 2016:09:06 12:11:54
  | 10) YCbCrPositioning = 1
  | 11) ExifOffset (SubDirectory) -->
  | + [ExifIFD directory with 26 entries]
  | | 0)  ExposureTime = 0.1 (1/10)
  | | 1)  FNumber = 1.9 (19/10)
  | | 2)  ExposureProgram = 2
  | | 3)  ISO = 250
  | | 4)  ExifVersion = 0220
  | | 5)  DateTimeOriginal = 2016:09:06 12:11:54
  | | 6)  CreateDate = 2016:09:06 12:11:54
  | | 7)  ShutterSpeedValue = 3.32 (332/100)
```

Table 3.1: Filename, Image Dimension, Quantization Tables and Exiftool Metadata Dump for Original Image 1 (FB Recompression Test), Cont'd

| | 8) ApertureValue = 1.85 (185/100)
| | 9) BrightnessValue = -1.06 (-106/100)
| | 10) ExposureCompensation = 0 (0/10)
| | 11) MaxApertureValue = 1.85 (185/100)
| | 12) MeteringMode = 2
| | 13) Flash = 0
| | 14) FocalLength = 4.3 (430/100)
| | 15) MakerNoteUnknown (SubDirectory) -->
| | + [MakerNotes directory with 7 entries]
| | | 0) Unknown_0x0001 = 0100
| | | 1) Unknown_0x0002 = 73728
| | | 2) Unknown_0x000c = 0
| | | 3) Unknown_0x0010 = undef (0/0)
| | | 4) Unknown_0x0040 = 0
| | | 5) Unknown_0x0050 = 1
| | | 6) Unknown_0x0100 = 0
| | 16) UserComment =
| | 17) FlashpixVersion = 0100
| | 18) ColorSpace = 1
| | 19) ExifImageWidth = 5312
| | 20) ExifImageHeight = 2988
| | 21) ExposureMode = 0
| | 22) WhiteBalance = 0
| | 23) FocalLengthIn35mmFormat = 28
| | 24) SceneCaptureType = 0
| | 25) ImageUniqueID = B16LSIA00SM B16LSIL03SM.
| 12) GPSInfo (SubDirectory) -->
| + [GPS directory with 9 entries]
| | 0) GPSVersionID = 2 2 0 0
| | 1) GPSLatitudeRef = N
| | 2) GPSLatitude = 34 6 31 (34/1 6/1 31/1)
| | 3) GPSLongitudeRef = W
| | 4) GPSLongitude = 83 52 33 (83/1 52/1 33/1)
| | 5) GPSAltitudeRef = 1
| | 6) GPSAltitude = 0 (0/1)
| | 7) GPSTimeStamp = 16 11 38 (16/1 11/1 38/1)
| | 8) GPSDateStamp = 2016:09:06
+ [IFD1 directory with 9 entries]
| 0) ImageWidth = 512

Table 3.1: Filename, Image Dimension, Quantization Tables and Exiftool Metadata Dump for Original Image 1 (FB Recompression Test), Cont'd

| 1) ImageHeight = 288
| 2) Compression = 6
| 3) Orientation = 6
| 4) XResolution = 72 (72/1)
| 5) YResolution = 72 (72/1)
| 6) ResolutionUnit = 2
| 7) ThumbnailOffset = 1154
| 8) ThumbnailLength = 14830
JPEG APP4 (13142 bytes):
JPEG APP5 (24 bytes):
JPEG DHT (416 bytes):
JPEG DQT (130 bytes):
JPEG SOF0 (15 bytes):
ImageWidth = 5312
ImageHeight = 2988
EncodingProcess = 0
BitsPerSample = 8
ColorComponents = 3
JPEG SOS
Samsung trailer (67 bytes at offset 0x4c87a5):
Samsung_Trailer_0x0a01-name = Image_UTC_Data
TimeStamp = 1473178315139

3	4	4	4	4	3	3	4
4	4	4	4	3	3	3	4
4	4	4	4	3	3	4	5
4	3	3	3	3	4	5	6
3	3	3	3	5	6	7	8
3	3	3	4	6	8	9	12
3	3	4	5	7	9	12	15
4	4	5	6	8	12	15	21

3	3	3	3	3	3	3	4
3	3	3	3	3	3	3	4
3	3	3	3	3	3	4	5
3	3	3	3	3	4	5	6

3	3	3	3	5	6	7	8
3	3	3	4	6	8	9	12
3	3	4	5	7	9	12	15
4	4	5	6	8	12	15	21

Table 3.1: Filename, Image Dimension, Quantization Tables and Exiftool Metadata Dump for Original Image 1 (FB Recompression Test), Cont'd

FIRST TEST SETUP

Currently, there are two different ways to upload an image through Facebook, via a desktop with an internet browser and a mobile device either through a browser or with the Facebook application. With these options, an image can be uploaded as a single image or in a collection of images, called an album. Downloading capabilities are slightly more limited; images can be downloaded using both a mobile and desktop but at the time of the research the ability to download an album through a mobile device is not available. Since these options allow for twelve different scenarios a matrix was created to input all data and properly explore all options seen that be seen in Figure 3.1 below.

Method

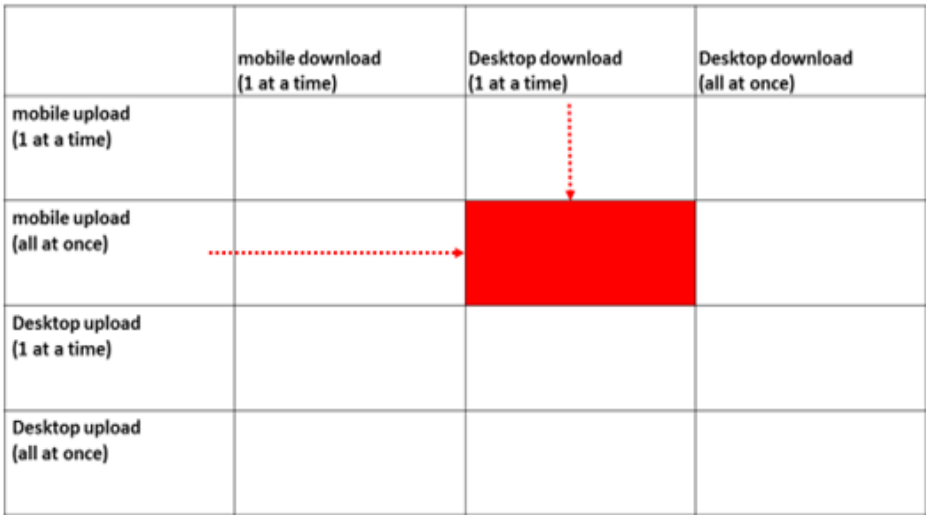

Figure 3.1: Test One Data Matrix

While considering the avenues above, five original images in the same portrait orientation were obtained from the cellphone to be used in the first test. The embedded data from each photo was retrieved for comparison against the processed images. Main folders were created to represent each image and each permutation of mobile and desktop uploading and downloading were given their own subfolders. This was used to keep all obtained data separate for analysis that will later be explained in Chapter 4.

SECOND TEST SETUP

The second test was composed of taking a single image that originated from an Apple iPhone 6S and rescaling it into 56 common image dimensions. These sizes ranged from the smallest, 640 x 480, to the largest, 5120 x 3200. Each image was uploaded, both

from a desktop and mobile device, and downloaded to a desktop computer to observe the pattern Facebook uses to resize uploaded images.

CHAPTER IV

RESULTS

TEST ONE

After analyzing the data from the first test it was determined that there is no difference in changes to an image between uploading it individually or in an album. The main deviations occur through three main schemas present throughout the five images. The first pattern is that mobile downloaded images, regardless of how they are uploaded, are recompressed with specific quantization tables using Baseline encoding and produce a distinct but repeated metadata structure composed of 65 elements. The other two schema relate to images downloaded to a desktop computer. The first of these, the second overall schema, was seen in images that were uploaded from a mobile device then downloaded to a desktop computer; these are recompressed with distinct quantization tables using Progressive encoding and a metadata structure of 67 elements. Finally, images were uploaded and downloaded from a desktop computer are Progressive encoded as well but have variable quantization tables roughly equivalent to a JPEG quality factor of 87 along with a repeated metadata structure of 81 elements. A summary of these can be found in Table 4.1 below. The size, quantization tables, and metadata dump for an investigated image (the same presented in Chapter 3, page 12 above) in each of these three scenarios follows.

Results	mobile download (1 at a time)	Desktop download (1 at a time)	Desktop download (all at once)
mobile upload (1 at a time)	Baseline DCT JPEG Quality: 93	Progressive DCT JPEG Quality: 64	Progressive DCT JPEG Quality: 64
mobile upload (all at once)	Baseline DCT JPEG Quality: 93	Progressive DCT JPEG Quality: 64	Progressive DCT JPEG Quality: 64
Desktop upload (1 at a time)	Baseline DCT JPEG Quality: 93	Progressive DCT JPEG Quality: 87*	Progressive DCT JPEG Quality: 87*
Desktop upload (all at once)	Baseline DCT JPEG Quality: 93	Progressive DCT JPEG Quality: 87*	Progressive DCT JPEG Quality: 87*
	65 Metadata Entries	67 Metadata Entries	81 Metadata Entries

* Variable for different images but same for one image

Table 4.1: Results Matrix for Mobile and Desktop Processing

In each of the following tables all three schemas and their respective filename, image dimension, quantization tables and Exiftool Metadata dump. The first table shows the mobile downloaded image, the second depicts the desktop downloaded output and the final image will display the desktop downloaded pattern.

Table 4.2: Mobile Downloaded Schema; Facebook Filename, Image Dimension, Exiftool Metadata Dump and Quantization Tables

Facebook Filename: 14238300_137157913404958_5593732394586807444_n.jpg
Image Dimension: 528 x 960
ExifToolVersion = 10.25 FileName = 14238300_137157913404958_5593732394586807444_n.jpg Directory = C:/Users/megan_000/Desktop/Mobile Upload, Mobile Download FileSize = 147946 FileModifyDate = 1473541535.57959 FileAccessDate = 1480564817.46776 FileCreateDate = 1480564817.46776 FilePermissions = 33206 FileType = JPEG FileTypeExtension = JPG

Table 4.2: Mobile Downloaded Schema; Facebook Filename, Image Dimension, Exiftool Metadata Dump and Quantization Tables, Cont'd

```
  MIMEType = image/jpeg
JPEG APP2 (538 bytes):
  ICC_Profile chunk 1 of 1
  + [ICC_Profile directory with 10 entries, 524 bytes]
  | ProfileHeader (SubDirectory) -->
  | + [BinaryData directory, 128 bytes]
  | | ProfileCMMType = lcms
  | | ProfileVersion = 528
  | | ProfileClass = mntr
  | | ColorSpaceData = RGB
  | | ProfileConnectionSpace = XYZ
  | | ProfileDateTime = 2012 1 25 3 41 57
  | | ProfileFileSignature = acsp
  | | PrimaryPlatform = APPL
  | | CMMFlags = 0
  | | DeviceManufacturer =
  | | DeviceModel =
  | | DeviceAttributes = 0 0
  | | RenderingIntent = 0
  | | ConnectionSpaceIlluminant = 0.9642 1 0.82491
  | | ProfileCreator = lcms
  | | ProfileID = 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
  | 0)  ProfileDescription = c2
  | 1)  ProfileCopyright = FB
  | 2)  MediaWhitePoint = 0.9642 1 0.82491
  | 3)  MediaBlackPoint = 0.01205 0.0125 0.01031
  | 4)  RedMatrixColumn = 0.43607 0.22249 0.01392
  | 5)  GreenMatrixColumn = 0.38515 0.71687 0.09708
  | 6)  BlueMatrixColumn = 0.14307 0.06061 0.7141
  | 7)  RedTRC = curv.....c...k...?.Q.4!.).2.;.F.Qw].kpz....|.i.}...0..
  | 8)  GreenTRC = curv.....c...k...?.Q.4!.).2.;.F.Qw].kpz....|.i.}...0..
  | 9)  BlueTRC = curv.....c...k...?.Q.4!.).2.;.F.Qw].kpz....|.i.}...0..
JPEG APP0 (14 bytes):
  + [BinaryData directory, 9 bytes]
  | JFIFVersion = 1 1
  | ResolutionUnit = 0
  | XResolution = 1
  | YResolution = 1
JPEG APP13 (52 bytes):
  + [Photoshop directory, 38 bytes]
```

Table 4.2: Mobile Downloaded Schema; Facebook Filename, Image Dimension, Exiftool Metadata Dump and Quantization Tables, Cont'd

```
  | IPTCData (SubDirectory) -->
  | + [IPTC directory, 25 bytes]
  | | CurrentIPTCDigest = ....B..V.F.W....
  | | -- IPTCApplication record --
  | | OriginalTransmissionReference = dr8ylh8EV8yvmIHXOYQb
JPEG DQT (65 bytes):
JPEG DQT (65 bytes):
JPEG SOF2 (15 bytes):
  ImageWidth = 528
  ImageHeight = 960
  EncodingProcess = 2
  BitsPerSample = 8
  ColorComponents = 3
JPEG DHT (26 bytes):
JPEG DHT (25 bytes):
JPEG SOS
```

3	2	3	3	4	5	10	14
2	2	3	3	4	7	13	18
2	3	3	4	7	11	16	19
3	4	5	6	11	13	17	20
5	5	8	10	14	16	21	22
8	12	11	17	22	21	24	20
10	12	14	16	21	23	24	21
12	11	11	12	15	18	20	20

3	4	5	9	20	20	20	20
4	4	5	13	20	20	20	20
5	5	11	20	20	20	20	20
9	13	20	20	20	20	20	20
20	20	20	20	20	20	20	20
20	20	20	20	20	20	20	20
20	20	20	20	20	20	20	20
20	20	20	20	20	20	20	20

Table 4.2: Mobile Downloaded Schema; Facebook Filename, Image Dimension, Exiftool Metadata Dump and Quantization Tables, Cont'd

Table 4.3: Mobile Upload, Desktop Download Schema; Facebook Filename, Image Dimension, Exiftool Metadata Dump and Quantization Tables

Facebook Filename: 14199208_132277663892983_6048687515817584365_n(1)
Image Dimension: 528 x 960
ExifToolVersion = 10.25 FileName = 14199208_132277663892983_6048687515817584365_n(1).jpg Directory = C:/Users/megan_000/Desktop/Mobile Upload, Desktop Download FileSize = 147946 FileModifyDate = 1473352812.10288 FileAccessDate = 1480563970.24043 FileCreateDate = 1480563970.24043 FilePermissions = 33206 FileType = JPEG FileTypeExtension = JPG MIMEType = image/jpeg JPEG APP2 (538 bytes): ICC_Profile chunk 1 of 1 + [ICC_Profile directory with 10 entries, 524 bytes] | ProfileHeader (SubDirectory) --> | + [BinaryData directory, 128 bytes] | | ProfileCMMType = lcms | | ProfileVersion = 528 | | ProfileClass = mntr | | ColorSpaceData = RGB | | ProfileConnectionSpace = XYZ | | ProfileDateTime = 2012 1 25 3 41 57 | | ProfileFileSignature = acsp | | PrimaryPlatform = APPL | | CMMFlags = 0 | | DeviceManufacturer = | | DeviceModel = | | DeviceAttributes = 0 0 | | RenderingIntent = 0 | | ConnectionSpaceIlluminant = 0.9642 1 0.82491 | | ProfileCreator = lcms | | ProfileID = 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 0) ProfileDescription = c2 | 1) ProfileCopyright = FB | 2) MediaWhitePoint = 0.9642 1 0.82491

Table 4.3: Mobile Upload, Desktop Download Schema; Facebook Filename, Image Dimension, Exiftool Metadata Dump and Quantization Tables, Cont'd

```
  | 3)  MediaBlackPoint = 0.01205 0.0125 0.01031
  | 4)  RedMatrixColumn = 0.43607 0.22249 0.01392
  | 5)  GreenMatrixColumn = 0.38515 0.71687 0.09708
  | 6)  BlueMatrixColumn = 0.14307 0.06061 0.7141
  | 7)  RedTRC = curv.....c...k...?.Q.4!.).2.;.F.Qw].kpz....|.i.}...0..
  | 8)  GreenTRC = curv.....c...k...?.Q.4!.).2.;.F.Qw].kpz....|.i.}...0..
  | 9)  BlueTRC = curv.....c...k...?.Q.4!.).2.;.F.Qw].kpz....|.i.}...0..
JPEG APP0 (14 bytes):
  + [BinaryData directory, 9 bytes]
  | JFIFVersion = 1 1
  | ResolutionUnit = 0
  | XResolution = 1
  | YResolution = 1
JPEG APP13 (52 bytes):
  + [Photoshop directory, 38 bytes]
  | IPTCData (SubDirectory) -->
  | + [IPTC directory, 25 bytes]
  | | CurrentIPTCDigest = E:8^^z..x.a..3.
  | | -- IPTCApplication record --
  | | OriginalTransmissionReference = uADamwBoBHvuzc185-ha
JPEG DQT (65 bytes):
JPEG DQT (65 bytes):
JPEG SOF2 (15 bytes):
  ImageWidth = 528
  ImageHeight = 960
  EncodingProcess = 2
  BitsPerSample = 8
  ColorComponents = 3
JPEG DHT (26 bytes):
JPEG DHT (25 bytes):
JPEG SOS
```

3	2	3	3	4	5	10	14
2	2	3	3	4	7	13	18
2	3	3	4	7	11	16	19
3	4	5	6	11	13	17	20
5	5	8	10	14	16	21	22
8	12	11	17	22	21	24	20
10	12	14	16	21	23	24	21
12	11	11	12	15	18	20	20

3	4	5	9	20	20	20	20
4	4	5	13	20	20	20	20
5	5	11	20	20	20	20	20
9	13	20	20	20	20	20	20
20	20	20	20	20	20	20	20
20	20	20	20	20	20	20	20
20	20	20	20	20	20	20	20
20	20	20	20	20	20	20	20

Table 4.3: Mobile Upload, Desktop Download Schema; Facebook Filename, Image Dimension, Exiftool Metadata Dump and Quantization Tables, Cont'd

Table 4.4: Desktop Upload, Desktop Download Schema; Facebook Filename, Image Dimension, Exiftool Metadata Dump and Quantization Tables

Facebook Filename: 14249740_137075313413218_424651193658018534_o
Image Dimension: 1152 x 2048
ExifToolVersion = 10.25 FileName = 14249740_137075313413218_424651193658018534_o.jpg Directory = C:/Users/megan_000/Desktop/Desktop Upload, Desktop Download FileSize = 363398 FileModifyDate = 1473538212.92549 FileAccessDate = 1480564002.64724 FileCreateDate = 1480564002.64724 FilePermissions = 33206 FileType = JPEG FileTypeExtension = JPG MIMEType = image/jpeg JPEG APP0 (14 bytes):

Table 4.4: Desktop Upload, Desktop Download Schema; Facebook Filename, Image Dimension, Exiftool Metadata Dump and Quantization Tables, Cont'd

+ [BinaryData directory, 9 bytes]
| JFIFVersion = 1 2
| ResolutionUnit = 0
| XResolution = 1
| YResolution = 1
JPEG APP13 (154 bytes):
+ [Photoshop directory, 140 bytes]
| IPTCData (SubDirectory) -->
| + [IPTC directory, 128 bytes]
| | CurrentIPTCDigest = -R/f.?:...#F.K..
| | -- IPTCApplication record --
| | OriginalTransmissionReference = O40Kf62SC2BFo1gP3P00
| | SpecialInstructions =
FBMD01000a9e0d0000b28200009e2e0100b63b0100ac4b010075df01000[snip]
JPEG APP2 (3062 bytes):
ICC_Profile chunk 1 of 1
+ [ICC_Profile directory with 16 entries, 3048 bytes]
| ProfileHeader (SubDirectory) -->
| + [BinaryData directory, 128 bytes]
| | ProfileCMMType =
| | ProfileVersion = 512
| | ProfileClass = mntr
| | ColorSpaceData = RGB
| | ProfileConnectionSpace = XYZ
| | ProfileDateTime = 2009 3 27 21 36 31
| | ProfileFileSignature = acsp
| | PrimaryPlatform =
| | CMMFlags = 0
| | DeviceManufacturer =
| | DeviceModel =
| | DeviceAttributes = 1 0
| | RenderingIntent = 0
| | ConnectionSpaceIlluminant = 0.9642 1 0.82491
| | ProfileCreator =
| | ProfileID = 41 248 61 222 175 242 85 174 120 66 250 228 202 131 57 13
| 0) ProfileDescription = sRGB IEC61966-2-1 black scaled
| 1) BlueMatrixColumn = 0.14307 0.06061 0.7141
| 2) BlueTRC = curv.....#(-27;@EJOTY^chmrw|.....%[snip]
| 3) DeviceModelDesc = IEC 61966-2-1 Default RGB Colour Space – Srgb
| 4) GreenMatrixColumn = 0.38515 0.71687 0.09708

Table 4.4: Desktop Upload, Desktop Download Schema; Facebook Filename, Image Dimension, Exiftool Metadata Dump and Quantization Tables, Cont'd

| 5) GreenTRC = curv.....#(-27;@EJOTY^chmrw|.....[snip]
| 6) Luminance = 0 80 0
| 7) Measurement (SubDirectory) -->
| + [BinaryData directory, 36 bytes]
| | MeasurementObserver = 1
| | MeasurementBacking = 0 0 0
| | MeasurementGeometry = 0
| | MeasurementFlare = 0
| | MeasurementIlluminant = 2
| 8) MediaBlackPoint = 0.01205 0.0125 0.01031
| 9) RedMatrixColumn = 0.43607 0.22249 0.01392
| 10) RedTRC = curv.....#(-27;@EJOTY^chmrw|.....%.[snip]
| 11) Technology = CRT
| 12) ViewingCondDesc = Reference Viewing Condition in IEC 61966-2-1
| 13) MediaWhitePoint = 0.9642 1 0.82491
| 14) ProfileCopyright = Copyright International Color Consortium, 2009
| 15) ChromaticAdaptation = 1.04791 0.02293 -0.0502 0.0296 0.99046 -0.01707 -0.00925
[snip]
JPEG DQT (65 bytes):
JPEG DQT (65 bytes):
JPEG SOF2 (15 bytes):
ImageWidth = 1152
ImageHeight = 2048
EncodingProcess = 2
BitsPerSample = 8
ColorComponents = 3
JPEG DHT (25 bytes):
JPEG DHT (24 bytes):
JPEG DHT (24 bytes):
JPEG SOS

6	4	4	6	10	16	20	24
5	5	6	8	10	23	24	22
6	5	6	10	16	23	28	22
6	7	9	12	20	35	32	25
7	9	15	22	27	44	41	31
10	14	22	26	32	42	45	37
20	26	31	35	41	48	48	40
29	37	38	39	45	40	41	40

7	7	10	19	40	40	40	40
7	8	10	26	40	40	40	40
10	10	22	40	40	40	40	40
19	26	40	40	40	40	40	40
40	40	40	40	40	40	40	40
40	40	40	40	40	40	40	40
40	40	40	40	40	40	40	40
40	40	40	40	40	40	40	40

Table 4.4: Desktop Upload, Desktop Download Schema; Facebook Filename, Image Dimension, Exiftool Metadata Dump and Quantization Tables, Cont'd

TEST TWO RESULTS: DESKTOP RESIZED

After examining the images resized by Facebook, it was determined in the particular test that in these scenarios with these devices, the dimension cutoff for mobile picture width is 1440 pixels and desktop picture width is 2048 pixels. The following table depicts the sizes subjected to Facebook upload from a desktop computer in order of smallest file dimension to the largest. The desktop dimension cutoff can be seen at 2048 with the line differentiating them and the difference in image width and height. The colored areas are the measured aspect ratios of each dimension. Highlighted in light pink, 1.333 is common for traditional television dimensions. Sizes colored in green represent 1.77 which is associated with High Definition video, 1.600 in red is linked to common computer screen ratios. Finally, colored yellow, 1.500 is typically found in Google Chromebook/ Microsoft Surface Pro 3 devices. As shown, images with an original width above 2048 pixels are resized by Facebook to 2048 pixels while retaining the original aspect ratio.

Table 4.5: Resized Images Spreadsheet with Aspect Ratios

UP Width	UP Height	Ratio	DL Width	DL Height	Diff in Width	Diff in Height
640	480	1.333	640	480	0	0
768	480	1.600	768	480	0	0
800	600	1.333	800	600	0	0
832	624	1.333	832	624	0	0
854	480	1.779	854	480	0	0
960	540	1.778	960	540	0	0
960	640	1.500	960	640	0	0
960	720	1.333	960	720	0	0
1024	576	1.778	1024	576	0	0
1024	640	1.600	1024	640	0	0
1024	768	1.333	1024	768	0	0
1136	640	1.775	1136	640	0	0
1152	720	1.600	1152	720	0	0
1152	768	1.500	1152	768	0	0
1152	864	1.333	1152	864	0	0
1280	720	1.778	1280	720	0	0
1280	800	1.600	1280	800	0	0
1280	960	1.333	1280	960	0	0
1334	750	1.779	1334	750	0	0
1366	768	1.779	1366	768	0	0
1400	1050	1.333	1400	1050	0	0
1440	900	1.600	1440	960	0	-60
1440	960	1.500	1440	960	0	0
1440	1080	1.333	1440	1080	0	0
1600	900	1.778	1600	900	0	0
1600	1200	1.333	1600	1200	0	0
1680	1050	1.600	1680	1050	0	0
1776	1000	1.776	1776	1000	0	0
1792	1344	1.333	1792	1344	0	0
1856	1392	1.333	1856	1392	0	0
1920	1080	1.778	1920	1080	0	0
1920	1200	1.600	1920	1200	0	0
1920	1280	1.500	1920	1280	0	0
1920	1440	1.333	1920	1440	0	0
2048	1152	1.778	2048	1152	0	0
2048	1280	1.600	2048	1280	0	0
2048	1536	1.333	2048	1536	0	0
2160	1440	1.500	2048	1365	-112	-75
2304	1440	1.600	2048	1280	-256	-160

UP Width	UP Height	Ratio	DL Width	DL Height	Diff in Width	Diff in Height
2304	1728	1.333	2048	1536	-256	-192
2560	1440	1.778	2048	1152	-512	-288
2560	1600	1.600	2048	1280	-512	-320
2560	1700	1.506	2048	1360	-512	-340
2560	1920	1.333	2048	1536	-512	-384
2736	1824	1.500	2048	1365	-688	-459
2800	2100	1.333	2048	1536	-752	-564
2880	1800	1.600	2048	1280	-832	-520
3000	2000	1.500	2048	1365	-952	-635
3200	1800	1.778	2048	1152	-1152	-648
3200	2400	1.333	2048	1536	-1152	-864
3840	2160	1.778	2048	1152	-1792	-1008
3840	2400	1.600	2048	1280	-1792	-1120
4096	2304	1.778	2048	1152	-2048	-1152
4096	3072	1.333	2048	1536	-2048	-1536
5120	2880	1.778	2048	1152	-3072	-1728
5120	3200	1.600	2048	1280	-3072	-1920

Table 4.5: Resized Images Spreadsheet with Aspect Ratios, Cont'd

TEST TWO RESULTS: MOBILE RESIZED

Once the desktop analysis was completed, a smaller group of sizes was selected to process through a mobile device. 12 different sizes were uploaded to Facebook. Table 4.6, below shows the same information as above but these are resulting sizes from the mobile processing. This table also shows the cutoff dimension of 1440 and the aspect ratios that were consistent with those mentioned above. Most these ratios are not common desktop or television monitors, which is consistent with a mobile processing.

Table 4.6: Aspect Ratios for Mobile Uploaded Resized Image Sizes

Mobile Upload Size		Aspect	Download Size		Diff in Width	Diff in Height
640	480	1.333	640	480	0	0
800	480	1.667	800	480	0	0
960	540	1.818	960	528	0	-12
1024	1024	1.000	1024	1024	0	0
1024	768	1.333	1024	768	0	0
1152	768	1.500	1152	768	0	0
1400	1050	1.346	1400	1040	0	-10
1600	900	1.800	1440	800	-160	-100
2304	1440	1.607	1440	896	-864	-544
2800	2100	1.343	1440	1072	-1360	-1028
4096	2304	1.800	1440	800	-2656	-1504
5120	3200	1.607	1440	896	-3680	-2304

ADDITIONAL OBSERVATIONS

During this research, there was an additional observation related to how Facebook gives hosted images filenames. When an image is uploaded, either as a single image or as an album, Facebook removes any previous filename that is provided and allows you to input your own name. But, once the image is downloaded the given filename does not transfer. Instead, there is a string of numbers that accompanies the image. The following table shows the filenaming pattern, images that are smaller than 1024 pixels result in a filename ending in "_n" and files larger than 1024 end in "_o".

Table 4.7: Facebook Filename with Ending Variables and Image Dimensions

Facebook Filename	**File Height**	**File Width**
14606261_171049506682465_7659861344040417242_n	640	480
14725616_171051096682306_7490145527690776057_n	640	512
14705798_171060090014740_4736085576596930_n	768	480
14716085_171062426681173_6167163997369377713_n	800	480
14708146_171066800014069_3999517150370107387_n	800	600
14666031_171067920013957_8179131341331876227_n	832	624
14563588_171068510013898_9057441696503493076_n	848	480

14642395_171122626675153_3371192182059220701_n	854	480
14657278_171124130008336_4882842056698807867_n	960	540
14479817_171124653341617_2314511886844732288_n	960	544
14716200_171125273341555_6404543742962279837_n	960	640
14718609_171125593341523_780674529347943217_n	960	720
14691427_171126130008136_1274289947829898777_o	1024	576
14682179_171127633341319_2909700528195634371_o	1024	600
14714846_171128420007907_1536095147209096540_o	1024	640
14708047_171129080007841_5277984069627771666_o	1024	768
14753459_171130103341072_135969008382315551_o	1024	800
14700768_171130696674346_1405553320647029812_o	1024	1024
14700890_171131473340935_6017210988428949073_o	1080	1200
14682113_171132020007547_1541663541361619100_o	1120	832
14706862_171132540007495_2934281638814907577_o	1136	640
14711185_171133660007383_2636344962224353594_o	1152	720
14700997_171134123340670_5081340380920779830_o	1152	768
14753756_171135110007238_6992619365143712932_o	1152	864
14753914_171135916673824_9121976801749768309_o	1152	900
14633386_173871909733558_6675736714468206228_o	1280	720
14712478_173872723066810_122167938317306009_o	1280	768
14612406_173873519733397_6106772829617656390_o	1280	800
14753495_173878616399554_8584070896963507744_o	1280	854
14706791_173879643066118_5269638416668567012_o	1280	960
14682135_173880293066053_4437180080076288302_o	1280	1024
14589977_173880773066005_963340077428580666_o	1334	750
14712513_173881903065892_1269520307219485632_o	1366	768
14682149_173883026399113_829923068123835390_o	1400	1050
14713078_174823156305100_7596506905553723884_o	1440	900
14681010_174824396304976_489873779676078849_o	1440	960
14712920_173887056398710_4551942151696058904_o	1440	1024
14691379_173887746398641_8957004741688044114_o	1440	1080
14615717_173888563065226_5473719157032050189_o	1600	768
14608784_173889006398515_8633918321371155614_o	1600	900
14691409_173890853064997_2722807948570474530_o	1600	1024
14633178_173891483064934_4747248546977408025_o	1600	1200
14706924_173892249731524_4476169264367838658_o	1600	1280
14615791_173893139731435_1185552378688184095_o	1680	1050
14691361_173893899731359_2854693465666411016_o	1776	1000
14691437_173894289731320_6627944137283334531_o	1792	1344
14681993_173894756397940_3430965673716753687_o	1800	1440
14711064_173895256397890_6065145293086472500_o	1856	1392

14682179_173895686397847_378153592677772147_o	1920	1080
14753718_173896463064436_975367263671377477_o	1920	1200
14707827_173897933064289_3862273431261348758_o	1920	1280
14711107_173898956397520_9197608778520528756_o	1920	1400
14714860_173899636397452_5940471284363883874_o	1920	1440
14543703_173900363064046_2316545056323288976_o	2048	1152
14753223_173908293063253_220597512020849299_o	2048	1280
14753381_173909553063127_5124466290378692774_o	2048	1536
14712572_173910729729676_8538574900395768131_o	2160	1440
14692105_173911283062954_1274641796107498291_o	2304	1440
14707010_173913263062756_1622449704346333317_o	2304	1728
14692122_173913569729392_6670188716681293260_o	2538	1080
14589953_173914149729334_6956274026427452684_o	2560	1080
14713093_173915099729239_6481259652049035234_o	2560	1440
14753348_173915693062513_1524924099733716226_o	2560	1600
14633204_173916179729131_1342697296373069749_o	2560	1700
14680867_173917016395714_6401213935393268669_o	2560	1800
14753197_173917573062325_4654743316038574176_o	2560	1920
14633595_173918073062275_1049286623655939816_o	2560	2048
14712767_173943136393102_2195393490275745802_o	2732	2048
14608763_173943793059703_511838646661087015_o	2736	1824
14706981_173945643059518_4401544997433701240_o	2800	2100
14691936_173946393059443_3837396610021786855_o	2880	900
14682171_173947039726045_2056195719809512504_o	2880	1800
14691291_173947849725964_5939741390186389714_o	3000	2000
14714957_173948813059201_1088149077070216294_o	3200	1800
14712970_173949323059150_2618835148265976661_o	3200	2048
14680862_173949796392436_2118268057472328063_o	3200	2400
14708006_173951626392253_2393911118619360305_o	3440	1440
14691943_173952683058814_3415801008302557676_o	3840	2160
14712627_173954316391984_2679064586028443444_o	3840	2400
14707781_173954983058584_6151962065799383493_o	4096	2304
14567464_173955546391861_7288819382589088815_o	4096	3072
14715026_173955946391821_3963479491714816446_o	5120	2160
14713086_173956346391781_5716767949075741631_o	5120	2880
14615727_173957133058369_5471907928923142878_o	5120	3200

Table 4.7: Facebook Filename with Ending Variables and Image Dimensions, Cont'd

CHAPTER V

DISCUSSION

The results from the first test have revealed that regardless of an image being uploaded one at a time or in an album, the observed variables are affected in unique ways based on the following three upload and download combination scenarios: 1) image is downloaded to a mobile device, 2) a mobile device uploads an image that is downloaded to a desktop computer, and 3) image is both uploaded and downloaded from desktop computers.

It was observed that images downloaded to a mobile device were Baseline encoded while images downloaded to a desktop computer were Progressively encoded. Progressive DCT is indicative of images that are loaded as full images and then progressively become clearer as the image moves from a low-resolution to a high-resolution image. Baseline DCT is typical encoding for smaller images and are loaded from top to bottom, pixel by pixel. These results from each schema are indicative of how the images were processed for viewing on various devices. Mobile devices have a smaller viewing window and are easier to load via Baseline DCT. In regards to Progressive DCT and its presence in remaining patterns, both were processed and downloaded via desktop. A desktop has a larger viewing area and can take slightly longer to load unlike a mobile. The image quality suffered slightly in the second schema, this is because the image was uploaded on a smaller screen and then forced to download to a larger viewing device.

After processing 56 different image dimensions it was concluded that the cutoff image dimension of a picture uploaded to Facebook from a mobile device is 1440 pixels, while images uploaded from a desktop computer is 2048 pixels.

FUTURE RESEARCH

Some ideas for future research would be to examine the possibility of mobile album download when, and if, it becomes available to users. Although it did not show any signs of significance through this research it should still be examined for validity and embedded metadata analysis. This research was carried out on images with a portrait orientation. The same research should be performed on landscape images and determine any similarities and aspect ratio sizes. Facebook is a popular social media site, but there are several others that billions of people use daily. These sites should be explored in a similar manner and analyzed for embedded content. There may be similarities between this research and Instagram since it was bought by Facebook in April of 2012 [J]. These sites are not all the same but they allow for the fundamental ability to share and download images.

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