Guide to Computer Forensics and Investigations Sixth Edition

Chapter 8

Recovering Graphics Files

Objectives

- Describe types of graphics file formats
- Explain types of data compression
- Explain how to locate and recover graphics files
- Describe how to identify unknown file formats
- Explain copyright issues with graphics

Recognizing a Graphics File

- Graphic files contain digital photographs, line art, three-dimensional images, text data converted to images, and scanned replicas of printed pictures
  - **Bitmap images**: collection of dots
  - **Vector graphics**: based on mathematical instructions
  - **Metafile graphics**: combination of bitmap and vector
- Types of programs
  - Graphics editors
  - Image viewers

Understanding Bitmap and Raster Images

- Bitmap images
  - Grids of individual **pixels**
- **Raster images** - also collections of pixels
  - Pixels are stored in rows
  - Better for printing
- Image quality
  - Screen **resolution** - determines amount of detail
  - Software contributes to image quality (drivers)
  - Number of color bits used per pixel

Understanding Vector Graphics

- Characteristics of vector graphics
  - Uses lines instead of dots
  - Store only the calculations for drawing lines and shapes
  - Smaller than bitmap files
  - Preserve quality when image is enlarged
- CorelDRAW, Adobe Illustrator

Understanding Metafile Graphics

- Metafile graphics combine raster and vector graphics
- Example
  - Scanned photo (bitmap) with text or arrows (vector)
- Share advantages and disadvantages of both types
  - When enlarged, bitmap part loses quality

Understanding Graphics File Formats (1 of 2)

- **Standard graphics file formats**
  - Standard bitmap file formats
    - -Portable Network Graphic (.png)
    - -Graphic Interchange Format (.gif)
    - -Joint Photographic Experts Group (.jpeg, .jpg)
    - -Tagged Image File Format (.tiff, .tif)
    - -Window Bitmap (.bmp)
  - Standard vector file formats
    - -Hewlett Packard Graphics Language (.hpgl)
    - -Autocad (.dxf)

Understanding Graphics File Formats (2 of 2)

- **Nonstandard graphics file formats**
  - Targa (.tga)
  - Raster Transfer Language (.rtl)
  - Adobe Photoshop (.psd) and Illustrator (.ai)
  - Freehand (.fh11)
  - Scalable Vector Graphics (.svg)
  - Paintbrush (.pcx)

Understanding Digital Photograph File Formats (1 of 8)

- Witnesses or suspects can create their own digital photos
- Examining the raw file format
  - **Raw file format**
    - Referred to as a digital negative
    - Typically found on many higher-end digital cameras
  - Sensors in the digital camera simply record pixels on the camera's memory card
  - Raw format maintains the best picture quality

Understanding Digital Photograph File Formats (2 of 8)

- Examining the raw file format (cont'd)
  - The biggest disadvantage is that it's proprietary
    - -And not all image viewers can display these formats
  - The process of converting raw picture data to another format is referred to as **demosaicing**
- Examining the Exchangeable Image File format
  - **Exchangeable Image File (Exif)** format
    - -Commonly used to store digital pictures
    - -Developed by JEITA as a standard for storing metadata in JPEG and TIF files

Understanding Digital Photograph File Formats (3 of 8)

- Examining the Exchangeable Image File format (cont'd)
  - Exif format collects metadata
    - -Investigators can learn more about the type of digital device and the environment in which photos were taken
  - Viewing an Exif JPEG file's metadata requires special programs
    - -Exif Reader, IrfanView, or Magnet Forensics AXIOM
  - Exif file stores metadata at the beginning of the file

Understanding Digital Photograph File Formats (4 of 8)

Exif picture file

JPEG picture file

Figure 8-1 Similar Exif and JPEG photos

Understanding Digital Photograph File Formats (5 of 8)

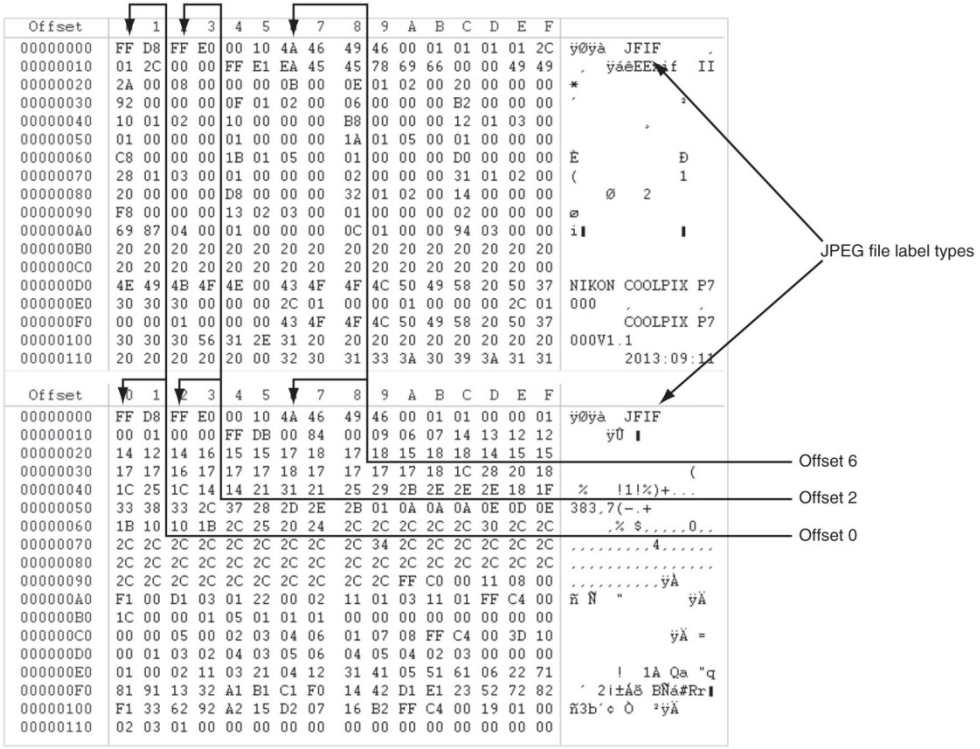


Figure 8-2 Differences in Exif and JPEG file header information

Source: X-Ways AG, *www.x-ways.net*

Understanding Digital Photograph File Formats (6 of 8)

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00019110	00	F8	B5	E0	F9	5B	A7	F4	AC	AC	A0	0F	7F	E9	05	BE
00019120	7F	FC	62	F8	7F	F9	0B	FD	2A	1B	AE	D0	A2	C0	C6	1D
00019130	5A	FE	49	71	E1	5D	8A	A0	9F	9E	2B	2B	28	02	AD	77
00019140	78	D7	32	BC	B7	0C	EE	EF	F7	99	8F	26	A1	EF	95	73
00019150	B4	64	7B	81	59	59	4C	46	C2	75	C7	DD	15	82	E3	3D
00019160	16	B2	B2	80	08	D3	F5	19	6C	AF	62	B8	87	EF	C6	D9
00019170	C7	A8	F3	1F	51	5D	4A	3B	D1	3C	09	22	16	D8	EA	18
00019180	67	D0	8A	CA	CA	00	A1	76	AA	C8	D8	DD	89	60	20	41
00019190	36	48	5F	F0	9F	31	F2	A4	5B	DF	FC	46	B2	B2	80	21
000191A0	37	60	1C	17	23	E9	5B	AC	84	91	86	AC	AC	A0	0D	BC
000191B0	47	D7	F1	AD	79	27	CC	7D	6B	2B	28	03	C2	39	C6	6B
000191C0	30	3D	7F	2A	CA	CA	00	F3	03	1E	75	E6	D1	E8	2B	2B
000191D0	28	03	49	19	63	5C	95	15	E2	C9	BB	EE	2E	01	F5	35
000191E0	95	94	08	90	92	46	09	3F	4A	D7	38	E8	2B	2B	28	02
000191F0	32	E7	38	C5	6A	4F	AF	E9	59	59	40	11	93	CD	65	65
00019200	65	00	7F	FF	D9											

JPEG file EOI marker

Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00001ED0	92	49	00	24	92	49	00	24	92	49	00	3A	9E	A3	C5	5A
00001EE0	A8	E1	1A	AA	6E	51	07	C5	C2	00	6F	1A	A3	9E	93	87
00001EF0	43	F2	5E	6F	86	EC	F4	D4	21	D3	E6	BD	1E	AD	72	87
00001F00	56	A7	72	63	CD	2E	CE	86	57	D8	3F	01	C3	5B	45	B6
00001F10	12	ED	91	36	B6	18	D1	37	26	66	53	18	35	E8	A3	AB
00001F20	75	89	C8	D6	C7	82	49	89	BE	CA	60	22	35	54	19	5C
00001F30	03	28	9D	33	9B	45	19	2B	8F	25	8A	34	5A	6E	2C	77
00001F40	5A	FE	CF	53	86	2C	7B	24	5D	6D	7B	37	7A	40	A7	FA
00001F50	7E	C5	5A	B0	83	4C	09	E1	45	29	ED	5A	CC	C4	81	25
00001F60	C6	94	94	A0	63	80	5D	01	36	57	42	00	EA	E8	0B	90
00001F70	9C	14	80	A1	25	D4	94	01	8C	49	24	94	12	03	5C	49
00001F80	24	00	92	49	24	00	92	49	24	00	9C	A0	7A	E2	48	02
00001F90	2A	8A	0A	FA	24	92	5D	9D	0C	AF	B2	3A	7A	15	13	F4
00001FA0	29	24	B0	4B	B3	5B	2B	3B	64	47	87	EA	12	49	4C	BA
00001FB0	2B	E0	26	DD	96	C3	B3	7F	E9	04	92	5A	3D	3F	91	57
00001FC0	74	15	4F	6A	EA	4B	62	32	B1	C1	75	71	25	08	96	75
00001FD0	3D	89	24	80	1C	92	49	20	0E	A4	92	4A	40	FF	D9	

Figure 8-3 EOI marker FFD9 for all JPEG files

Source: X-Ways AG, *www.x-ways.net*

Understanding Digital Photograph File Formats (7 of 8)

- Examining the Exchangeable Image File format (cont'd)
  - With tools such as Autopsy and Exif Reader
    -You can extract metadata as evidence for your case

Understanding Digital Photograph File Formats (8 of 8)

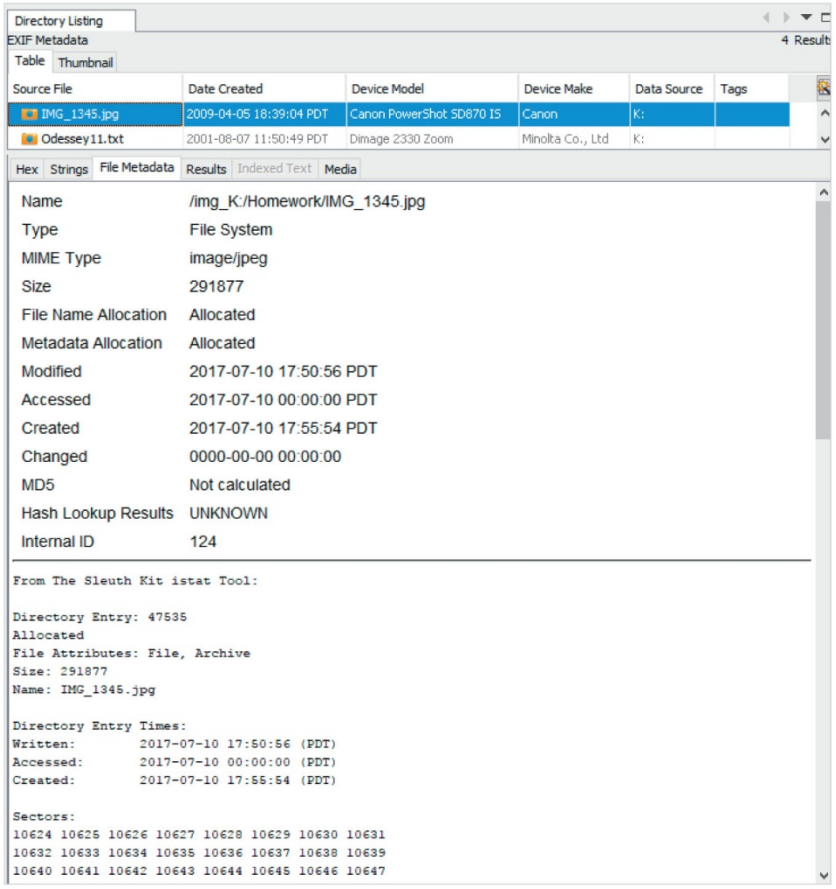


Figure 8-4 Autopsy displaying metadata from an Exif JPEG file

Source: *www.sleuthkit.org*

Understanding Data Compression

- Most graphics file formats compress their data
  - GIF and JPEG
- Others, like BMP, do not compress their data
  - Use data compression tools for those formats
- **Data compression**
  - Coding data from a larger to a smaller form
  - Types
    - Lossless compression and lossy compression

Lossless and Lossy Compression

- **Lossless compression**
  - Reduces file size without removing data
  - Based on Huffman or Lempel-Ziv-Welch coding
    - For redundant bits of data
  - Utilities: WinZip, PKZip, StuffIt, and FreeZip
- **Lossy compression**
  - Permanently discards bits of information
  - **Vector quantization (VQ)**
    - Determines what data to discard based on vectors in the graphics file
  - Utility: Lzip

Locating and Recovering Graphics Files

- Operating system tools
  - Time consuming
  - Results are difficult to verify
- Digital forensics tools
  - Image headers
    - -Compare them with good header samples
    - -Use header information to create a baseline analysis
  - Reconstruct fragmented image files
    - -Identify data patterns and modified headers

Identifying Graphics File Fragments

- **Carving** or **salvaging**
  - Recovering any type of file fragments
- Digital forensics tools
  - Can carve from file slack and free space
  - Help identify image files fragments and put them together

Repairing Damaged Headers (1 of 4)

- When examining recovered fragments from files in slack or free space
  - You might find data that appears to be a header
- If header data is partially overwritten, you must reconstruct the header to make it readable
  - By comparing the hexadecimal values of known graphics file formats with the pattern of the file header you found

Repairing Damaged Headers (2 of 4)

- Each graphics file has a unique header value
- Example:
  - A JPEG file has the hexadecimal header value FFD8, followed by the label JFIF for a standard JPEG or Exif file at offset 6
- Exercise:
  - Investigate a possible intellectual property theft by a new employee of Superior Bicycles, Inc.

Repairing Damaged Headers (3 of 4)

Chris Robinson

From: Bob Aspen <b_aspen@aol.com>
Sent: Monday, July 10, 2017 3:32 PM
To: cr-superior@outlook.com
Subject: FW: More info

Chris,
I got cc'd this odd message from Terry Sadler.
Do you have any projects that might need some capital investment?
Bob

-----Original Message-----
From: Terry Sadler [mailto:t_sadler@zoho.com]
Sent: Monday, July 10, 2017 3:28 PM
To: Jim Shu
Subject: Re: More info

Do you have a name for the project?

On 7/10/2017 3:04 PM, Jim Shu wrote:
> Terry,
>
> Here a few more photos from Tom.
>
> How much you willing to pay for these?
>
> Jim
>

Figure 8-5 An e-mail from Terry Sadler

Repairing Damaged Headers (4 of 4)

Chris Robinson

From: Tom Johnson <1060waddisonst@gmx.us>
Sent: Monday, July 10, 2017 2:40 PM
To: Jim Shu
Subject: You might be interested

Jim,

I had a tour of the new kayak factory. I think we can run with this to the other party interested in competing. I smuggled these files out, they are JPEG files I edited with my hex editor so that the email monitor won't pick up on them. So to view them you have to re-edit each file to the proper JPEG header of offset 0x FF D8 FF E0 and offset 6 of 4A. Then you have to rename them to a .jpg extension to view them.

Tom

Figure 8-6 The e-mail with attachments IT found

Searching for and Carving Data from Unallocated Space (1 of 6)

- Steps
  - Planning your examination
  - Searching for and recovering digital photograph evidence
    - -Use Autopsy for Windows to search for and extract (recover) possible evidence of JPEG files
    - -False hits are referred to as **false positives**

Searching for and Carving Data from Unallocated Space (2 of 6)

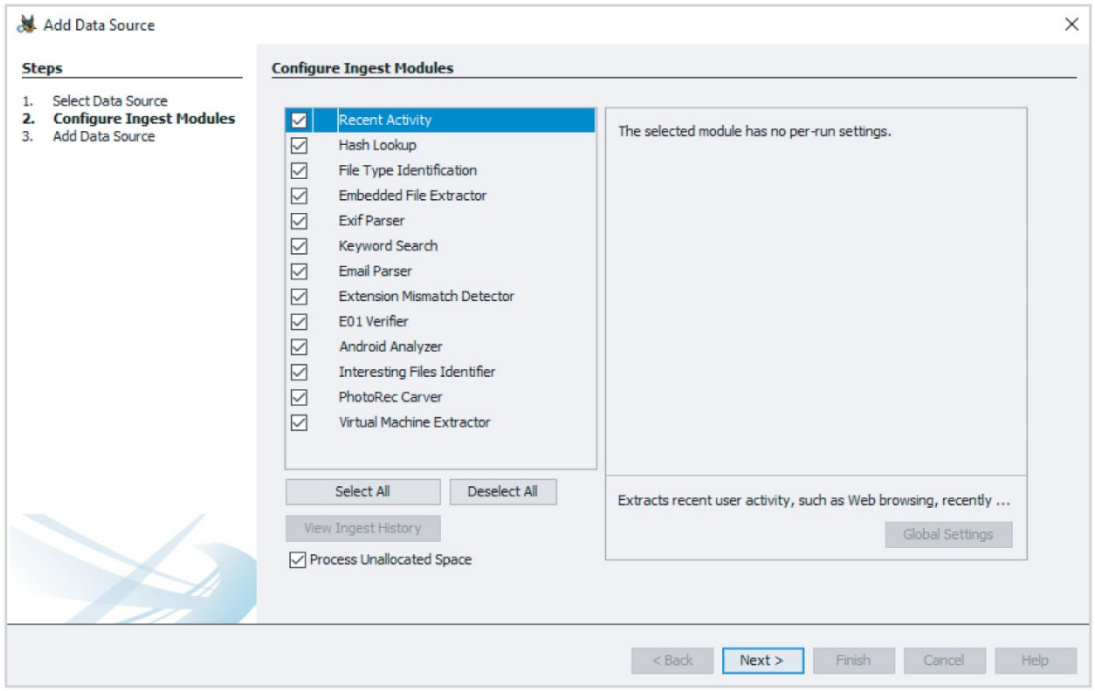


Figure 8-7 Processing options in the Configure Ingest Modules window

Source: *www.sleuthkit.org*

Searching for and Carving Data from Unallocated Space (3 of 6)

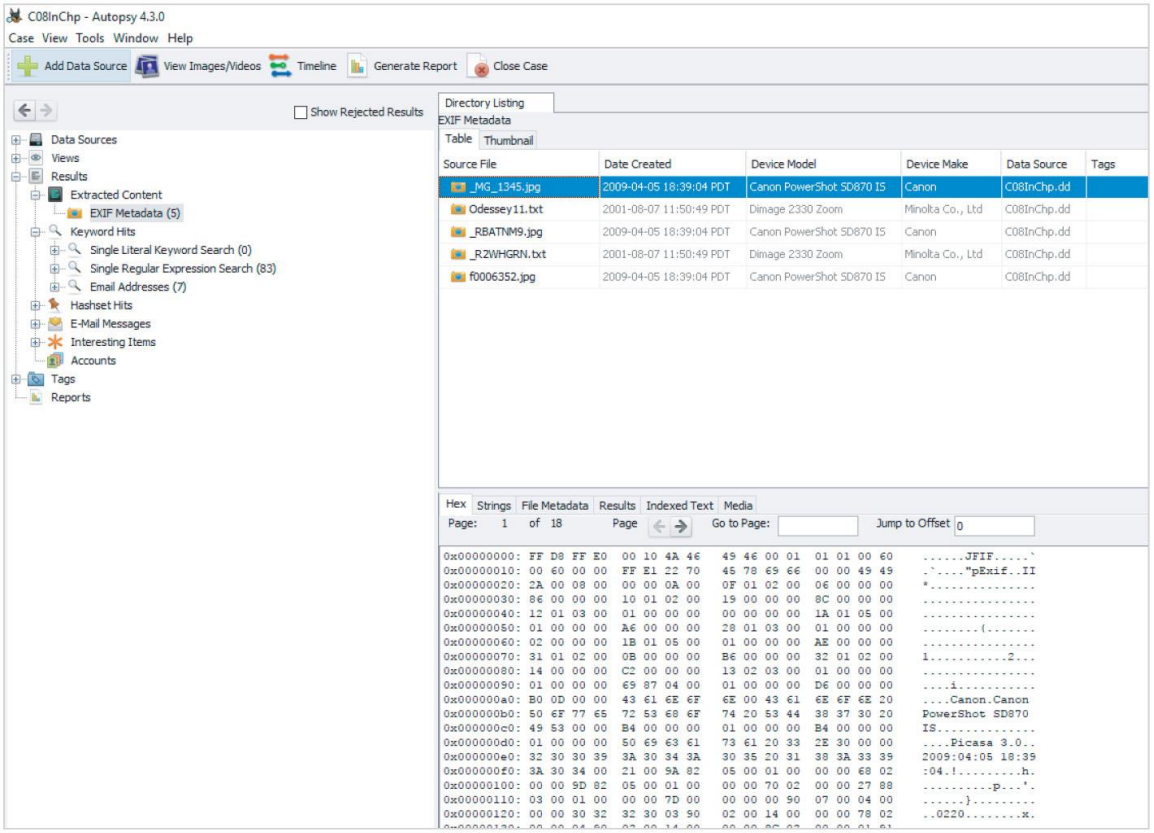


Figure 8-8 Parsing Exif metadata in Autopsy

Source: *www.sleuthkit.org*

Searching for and Carving Data from Unallocated Space (4 of 6)

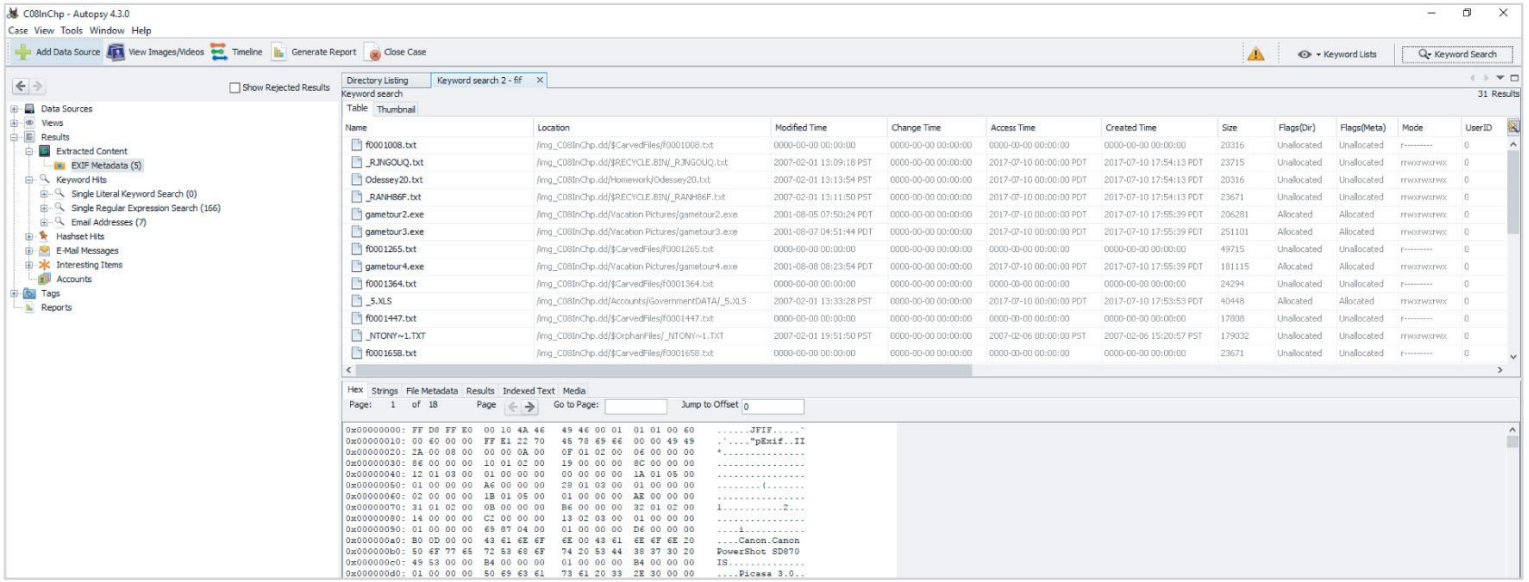


Figure 8-9 The results of searching for "fif"

Source: *www.sleuthkit.org*

Searching for and Carving Data from Unallocated Space (5 of 6)

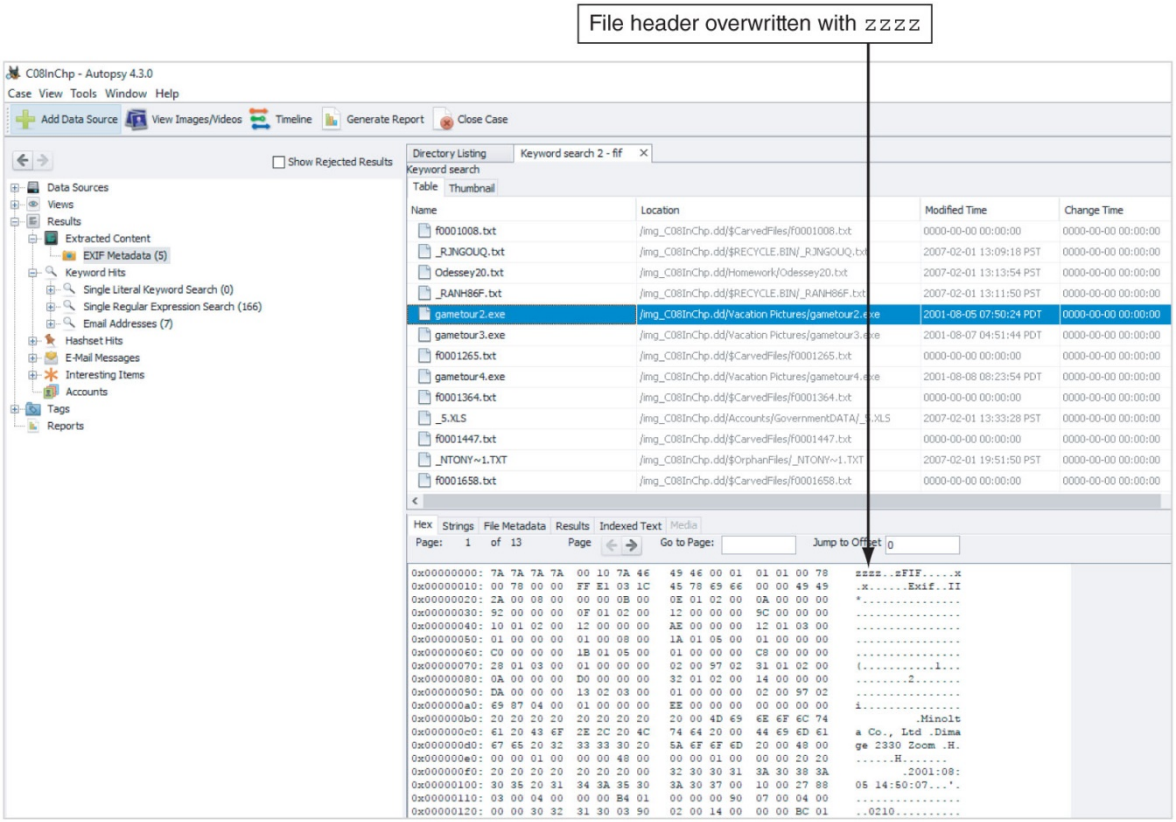


Figure 8-10 The altered file header

Source: *www.sleuthkit.org*

Searching for and Carving Data from Unallocated Space (6 of 6)

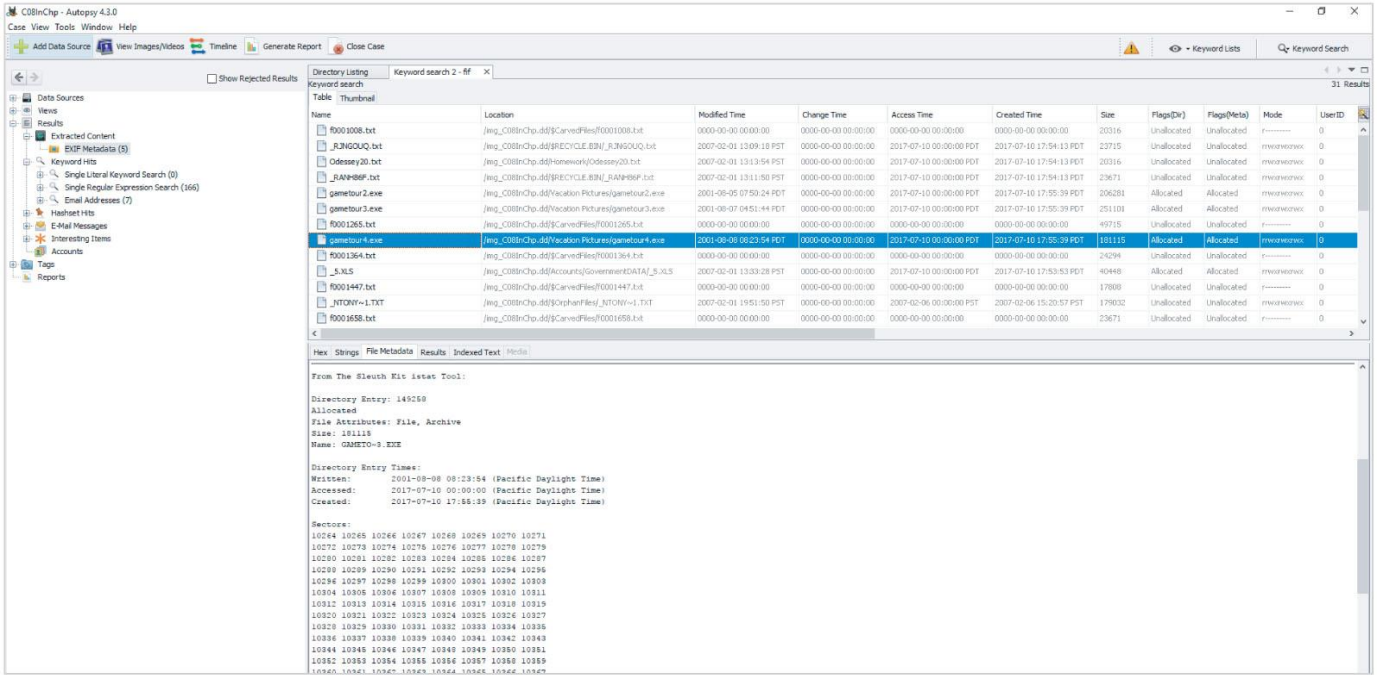


Figure 8-11 Viewing all sectors used by the `gametour2.exe` file

Source: *www.sleuthkit.org*

Rebuilding File Headers (1 of 6)

- Before attempting to edit a recovered graphics file
  - Try to open the file with an image viewer first
- If the image isn't displayed, you have to inspect and correct the header values manually
- Steps
  - Recover more pieces of file if needed
  - Examine file header
    - -Compare with a good header sample
    - -Manually insert correct hexadecimal values
  - Test corrected file

Rebuilding File Headers (2 of 6)

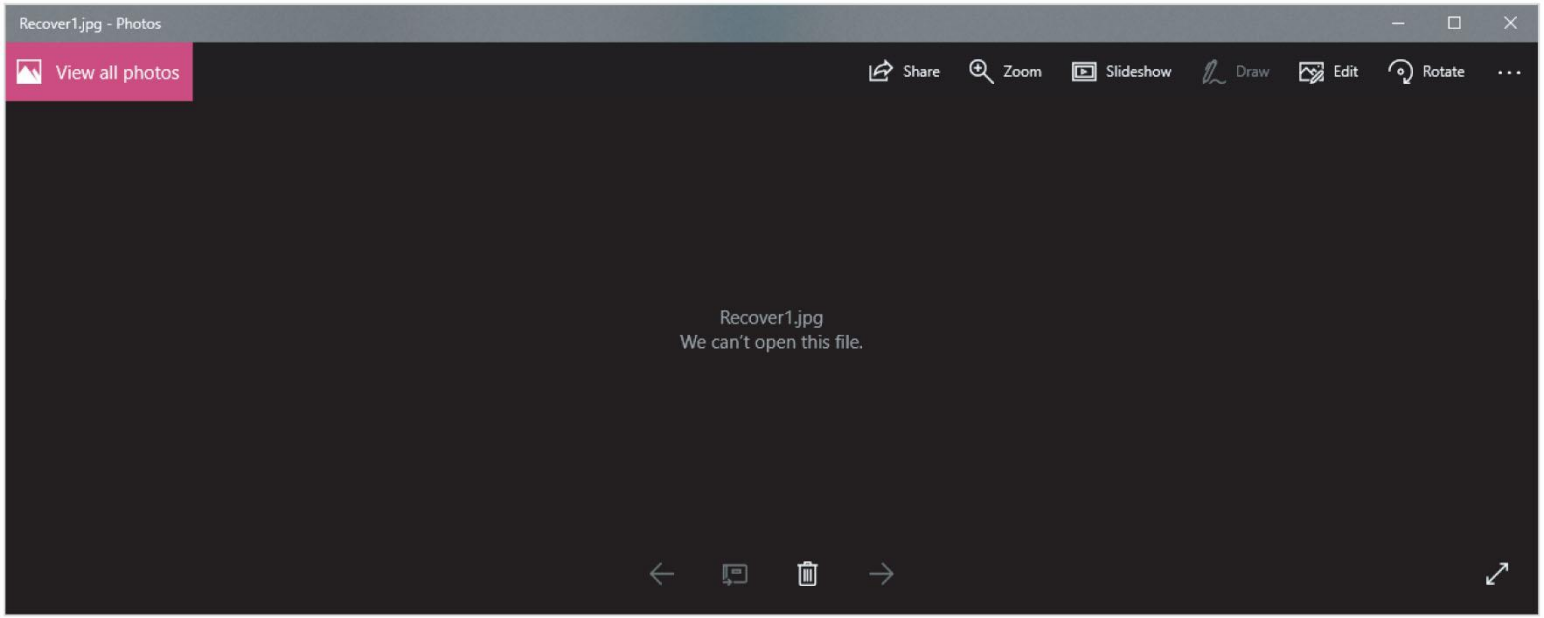


Figure 8-12 Error message indicating a damaged or an altered graphics file

Rebuilding File Headers (3 of 6)

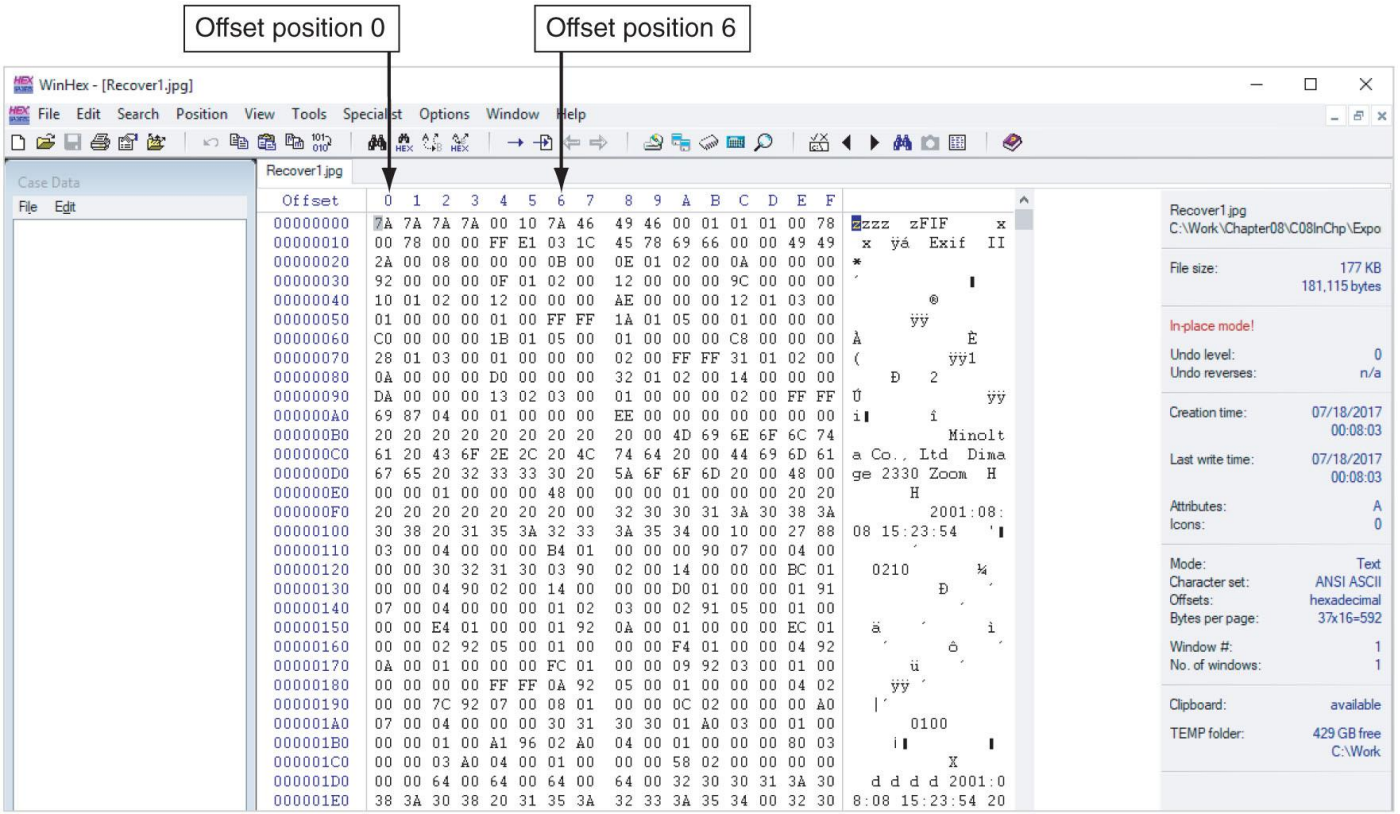


Figure 8-13 `Recover1.jpg` open in WinHex

Source: X-Ways AG, *www.xways.net*

Rebuilding File Headers (4 of 6)

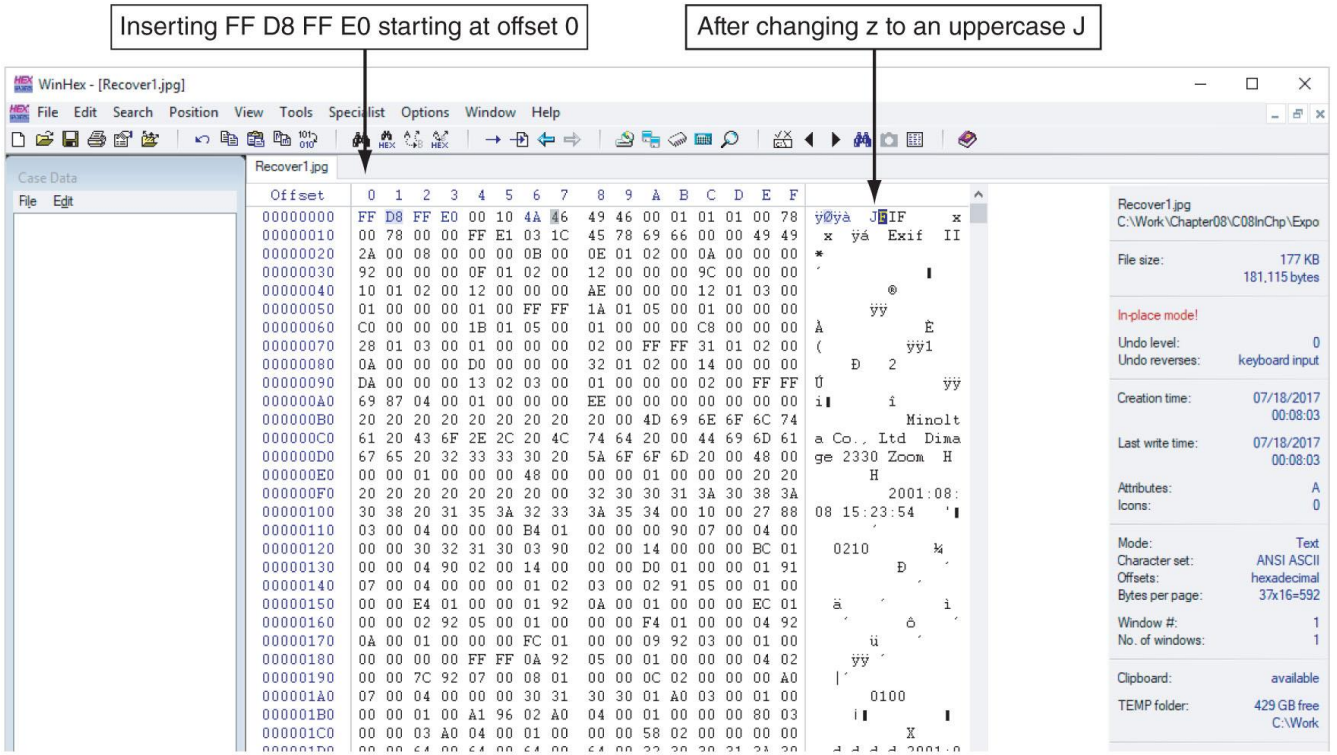
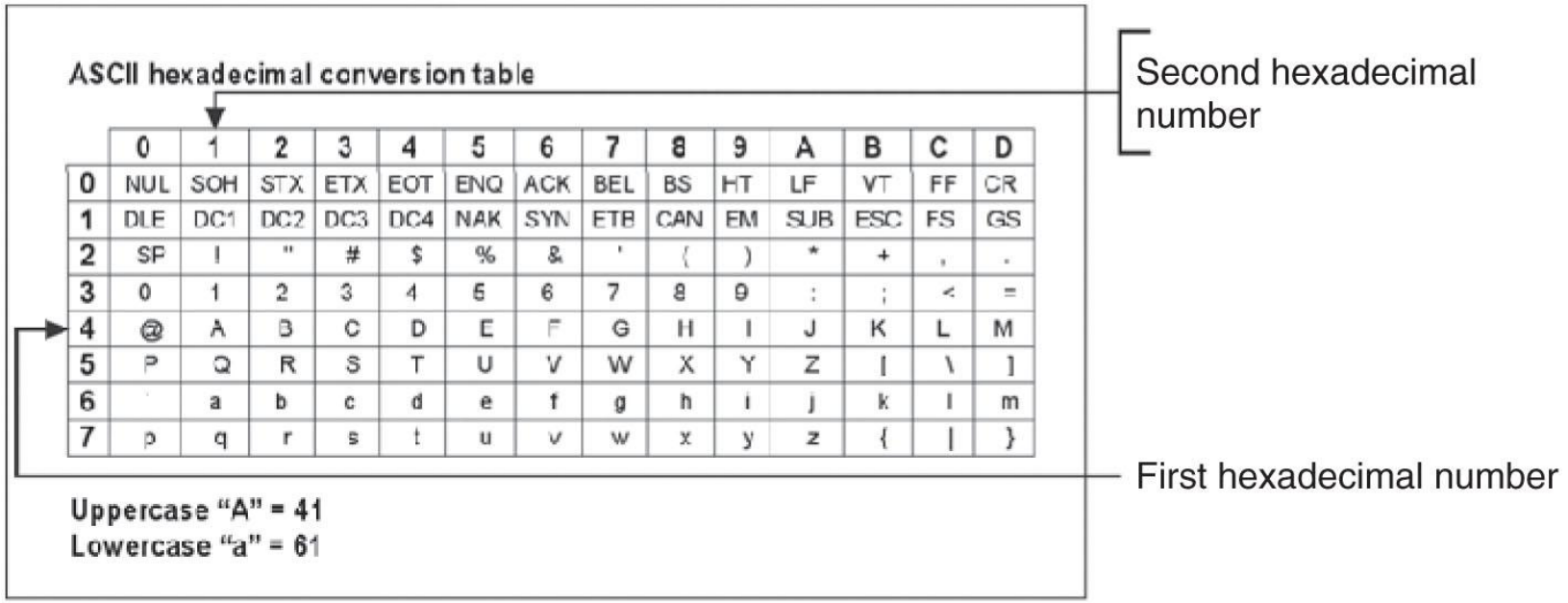


Figure 8-14 Inserting correct hexadecimal values for a JPEG file

Source: X-Ways AG, *www.xways.net*

Rebuilding File Headers (5 of 6)



	0	1	2	3	4	5	6	7	8	9	A	B	C	D
0	NUL	SOH	STX	ETX	EOT	ENQ	ACK	BEL	BS	HT	LF	VT	FF	CR
1	DLE	DC1	DC2	DC3	DC4	NAK	SYN	ETB	CAN	EM	SUB	ESC	FS	GS
2	SP	!	"	#	$	%	&	'	(	)	*	+	,	.
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m
7	p	q	r	s	t	u	v	w	x	y	z	{	|	}

Figure 8-15 ASCII equivalents of hexadecimal values

Rebuilding File Headers (6 of 6)

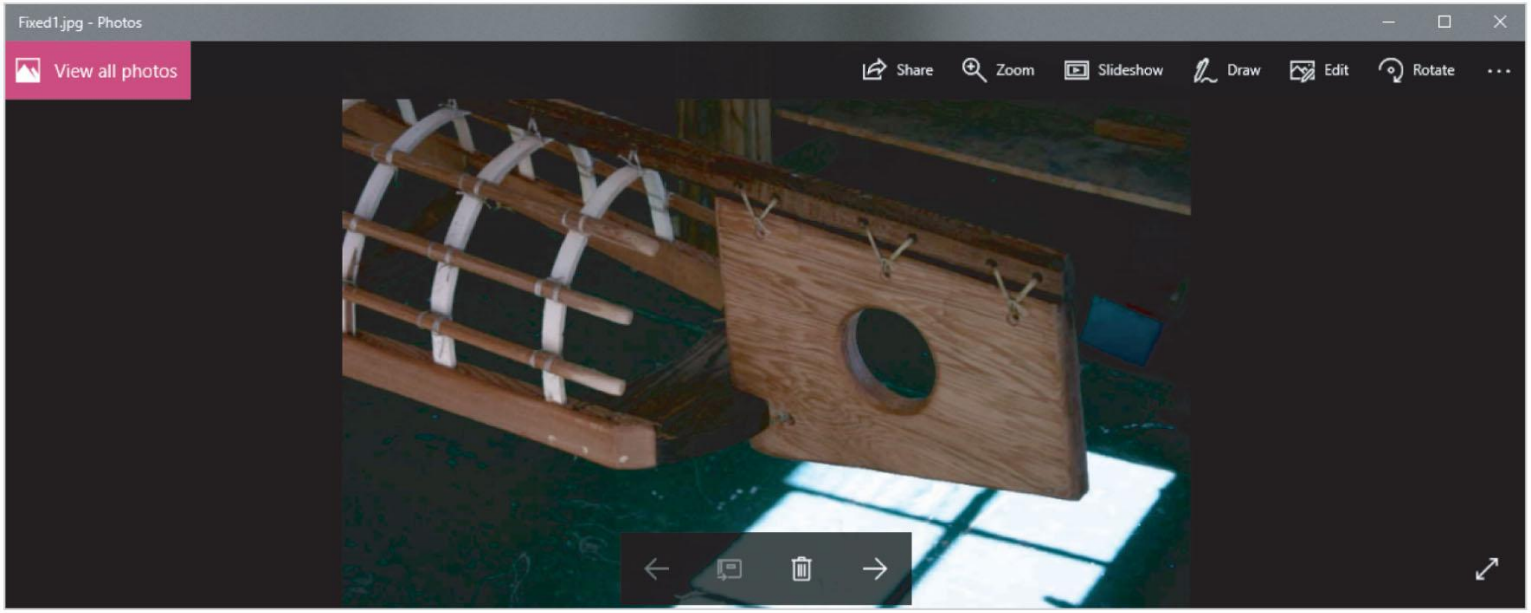


Figure 8-16 `Fixed1.jpg` open in an image viewer

Reconstructing File Fragments

- Locate the noncontiguous clusters that make up a deleted file
- Steps
  - Locate and export all clusters of the fragmented file
  - Determine the starting and ending cluster numbers for each fragmented group of sectors
  - Copy each fragmented group of sectors in their correct sequence to a recovery file
  - Rebuild the file's header to make it readable in a graphics viewer
  - Add a `.txt` extension on all the copied sectors

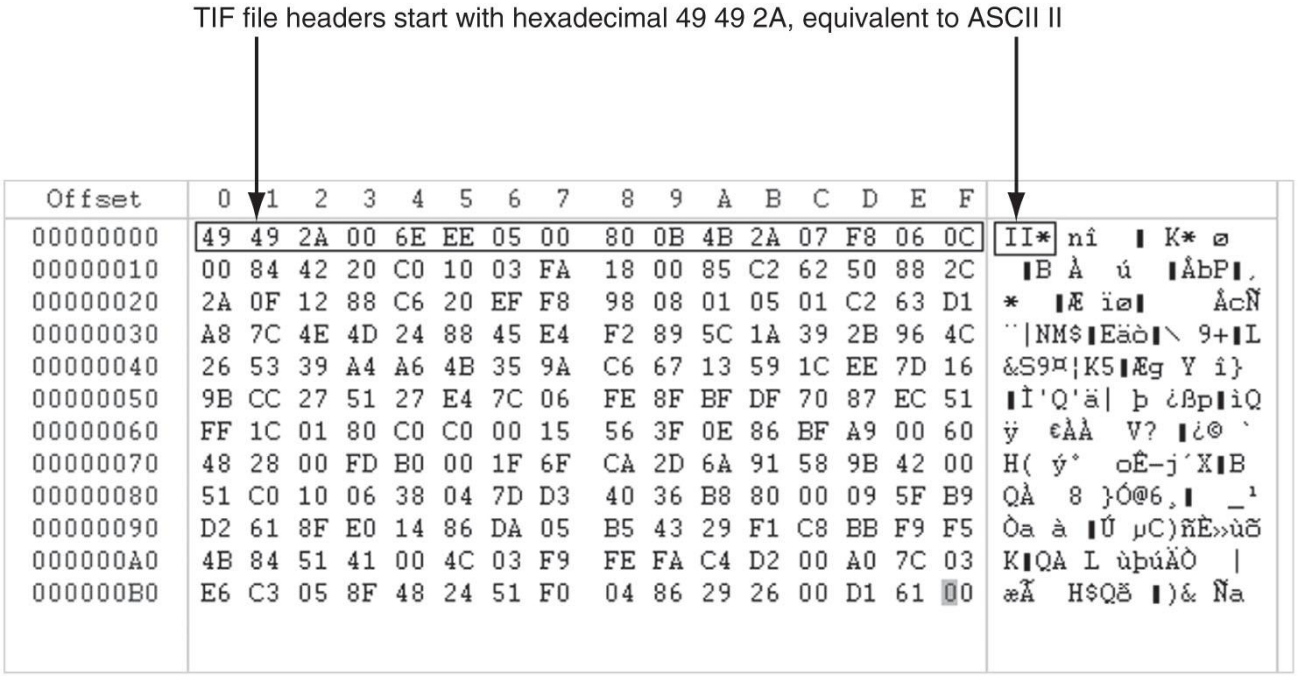
Identifying Unknown File Formats

- Knowing the purpose of each format and how it stores data is part of the investigation process
- The Internet is the best source
  - Search engines
  - Find explanations and viewers
- Popular Web sites
  - *FileFormat.info*
  - *Extension Informer*
  - *The Graphics File Formats Page*

Analyzing Graphics File Headers (1 of 3)

- Necessary when you find files your tools do not recognize
- Use a hexadecimal editor such as WinHex
  - Record hexadecimal values in the header and use them to define a file type
- Example:
  - XIF file format is old, little information is available
  - The first 3 bytes of an XIF file are the same as a TIF file
  - Build your own header search string

Analyzing Graphics File Headers (2 of 3)

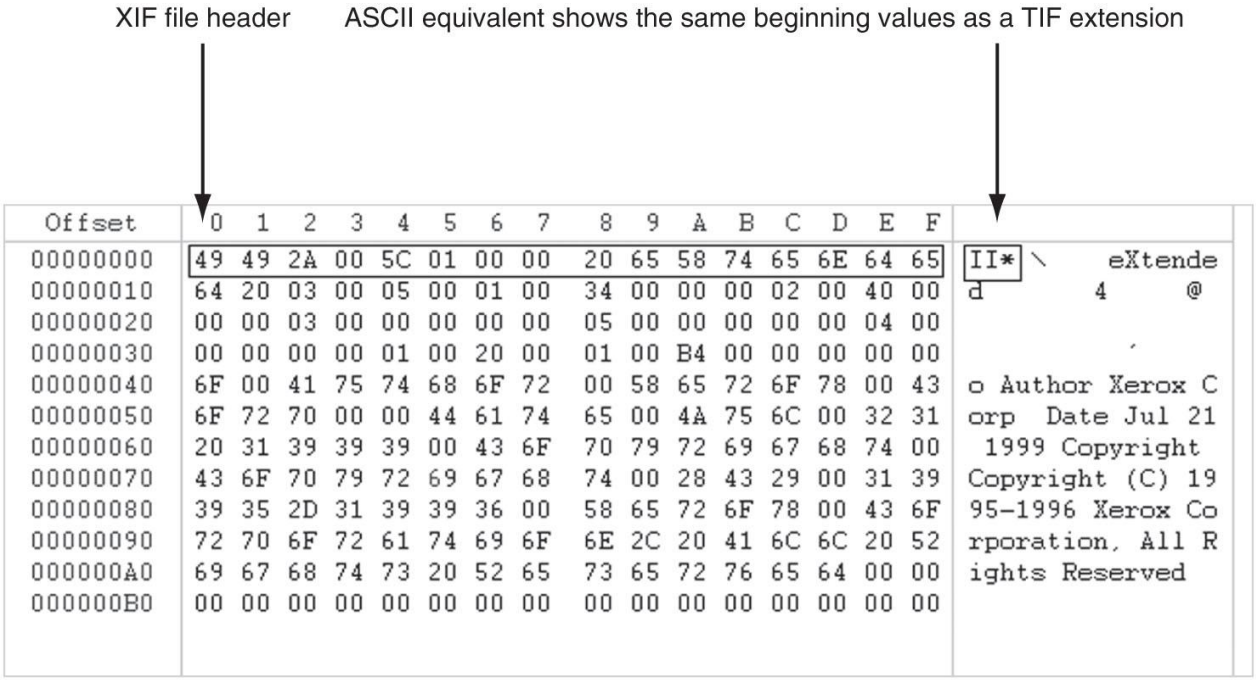


Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
00000000	49	49	2A	00	6E	EE	05	00	80	0B	4B	2A	07	F8	06	0C	II* nî ▌ K* ø
00000010	00	84	42	20	C0	10	03	FA	18	00	85	C2	62	50	88	2C	▌B À ú ▌ÅbP▌,
00000020	2A	0F	12	88	C6	20	EF	F8	98	08	01	05	01	C2	63	D1	* ▌Æ ïø▌ ÅcÑ
00000030	A8	7C	4E	4D	24	88	45	E4	F2	89	5C	1A	39	2B	96	4C	¨|NM$▌Eäò▌\ 9+▌L
00000040	26	53	39	A4	A6	4B	35	9A	C6	67	13	59	1C	EE	7D	16	&S9¤¦K5▌Æg Y î}
00000050	9B	CC	27	51	27	E4	7C	06	FE	8F	BF	DF	70	87	EC	51	▌Ì'Q'ä| þ ¿ßp▌ìQ
00000060	FF	1C	01	80	C0	C0	00	15	56	3F	0E	86	BF	A9	00	60	ÿ €ÀÀ V? ▌¿© `
00000070	48	28	00	FD	B0	00	1F	6F	CA	2D	6A	91	58	9B	42	00	H(ý° oÊ-j'X▌B
00000080	51	C0	10	06	38	04	7D	D3	40	36	B8	80	00	09	5F	B9	QÀ 8 }Ó@6¸▌ _¹
00000090	D2	61	8F	E0	14	86	DA	05	B5	43	29	F1	C8	BB	F9	F5	Òa à ▌Ú µC)ñÈ»ùõ
000000A0	4B	84	51	41	00	4C	03	F9	FE	FA	C4	D2	00	A0	7C	03	K▌QA L ùþúÄÒ |
000000B0	E6	C3	05	8F	48	24	51	F0	04	86	29	26	00	D1	61	00	æÃ H$Qð ▌)& Ña

Figure 8-17 A TIF file open in WinHex

Source: X-Ways AG, *www.x-ways.net*

Analyzing Graphics File Headers (3 of 3)



Offset	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
00000000	49	49	2A	00	5C	01	00	00	20	65	58	74	65	6E	64	65	II* \ eXtende
00000010	64	20	03	00	05	00	01	00	34	00	00	00	02	00	40	00	d 4 @
00000020	00	00	03	00	00	00	00	00	05	00	00	00	00	00	04	00	
00000030	00	00	00	00	01	00	20	00	01	00	B4	00	00	00	00	00	
00000040	6F	00	41	75	74	68	6F	72	00	58	65	72	6F	78	00	43	o Author Xerox C
00000050	6F	72	70	00	00	44	61	74	65	00	4A	75	6C	00	32	31	orp Date Jul 21
00000060	20	31	39	39	39	00	43	6F	70	79	72	69	67	68	74	00	1999 Copyright
00000070	43	6F	70	79	72	69	67	68	74	00	28	43	29	00	31	39	Copyright (C) 19
00000080	39	35	2D	31	39	39	36	00	58	65	72	6F	78	00	43	6F	95-1996 Xerox Co
00000090	72	70	6F	72	61	74	69	6F	6E	2C	20	41	6C	6C	20	52	rporation, All R
000000A0	69	67	68	74	73	20	52	65	73	65	72	76	65	64	00	00	ights Reserved
000000B0	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	

Figure 8-18 An XIF file open in WinHex

Source: X-Ways AG, *www.x-ways.net*

Tools for Viewing Images

- After recovering a graphics file
  - Use an image viewer to open and view it
- No one viewer program can read every file format
  - Having many different viewer programs is best
- Most GUI forensics tools include image viewers that display common image formats
- Be sure to analyze, identify, and inspect every unknown file on a drive

Understanding Steganography in Graphics Files (1 of 7)

- Steganography hides information inside image files
  - An ancient technique
- Two major forms: insertion and substitution
-
  - Hidden data is not displayed when viewing host file in its associated program
    -You need to analyze the data structure carefully
  - Example: Web page

Understanding Steganography in Graphics Files (2 of 7)

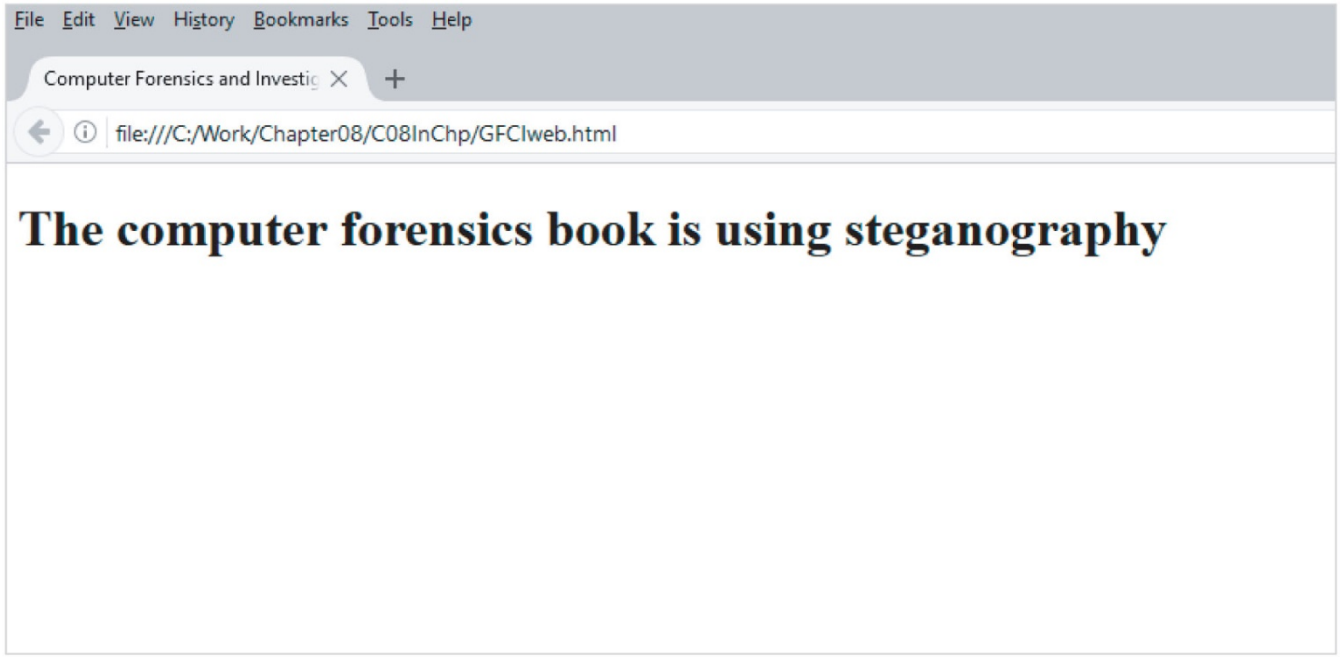


Figure 8-19 A simple Web page displayed in a Web browser

Source: The Mozilla Foundation, *www.mozilla.org*

Understanding Steganography in Graphics Files (3 of 7)

GFCIweb.html - Notepad

File Edit Format View Help

```
<html>
<head>
<title> Computer Forensics and Investigations </title>
</head>

<input type="hidden" name="message" value="This is an example of how you could communicate using web pages">
<body>
<h1> The computer forensics book is using steganography </h1>

</body>
</html>
```

Figure 8-20 The HTML code reveals hidden text

Source: The Mozilla Foundation, *www.mozilla.org*

Understanding Steganography in Graphics Files (4 of 7)

- Substitution
  - Replaces bits of the host file with other bits of data
  - Usually change the last two LSBs (**least significant bit**)
  - Detected with steganalysis tools (a.k.a - steg tools)
- You should inspect all files for evidence of steganography
- Clues to look for:
  - Duplicate files with different hash values
  - Steganography programs installed on suspect's drive

Understanding Steganography in Graphics Files (5 of 7)

Table 8-1	Bit breakdown of a secret message
Original Pixel	**Altered Pixel**
1010 1010	1010 1001
1001 1101	1001 1110
1111 0000	1111 0011
0011 1111	0011 1100

Understanding Steganography in Graphics Files (6 of 7)

Figure 8-21 Original and altered images

Understanding Steganography in Graphics Files (7 of 7)

My secret bank accounts:

Country	Bank	Account No.	Passcode	Currency Amt.
Swiss	Swiss National SA	26845622	Y1115AQ	1.2 million CHF
Caymen Is.	Caribbean Intn. Bank Ltd.	5589999	SAMMM242	5.82 million KYD
Malta	Valletta Nat. Bank Limited	57896165	558TF558	2.3 million EUR
Hong Kong	Chan Wag Bank	A5AA59	665308888	8.9 million HKD
South Africa	Rand Bank of Cape Town	6982543	AAF8	0.53 million ZAL

Figure 8-22 A hidden message in the altered image

Using Steganalysis Tools

- Use steg tools to detect, decode, and record hidden data
- Detect variations of the graphic image
  - When done correctly you cannot detect hidden data in most cases
- Check to see whether the file size, image quality, or file extensions have changed

Understanding Copyright Issues with Graphics

- Steganography has been used to protect copyrighted material
  - By inserting digital watermarks into a file
- Digital investigators need to aware of copyright laws
- Copyright laws for Internet are not clear
  - There is no international copyright law
- Check the U.S. Copyright Office
  - U.S. Copyright Office identifies what can and can't be covered under copyright law in U.S.
- **Fair use**
  - Another guideline to consider

Summary (1 of 3)

- Three types of graphics files
  - Bitmap
  - Vector
  - Metafile
- Image quality depends on various factors
- Standard file formats: .gif, .jpeg, .bmp, and .tif
- Nonstandard file formats: .tga, .rtl, .psd, and .svg
- Some image formats compress their data
  - Lossless compression
  - Lossy compression

Summary (2 of 3)

- Digital camera photos are typically in raw and EXIF JPEG formats
- Recovering image files
  - Carving file fragments
  - Rebuilding image headers
- The Internet is best for learning more about file formats and their extensions
- Software
  - Image editors
  - Image viewers

Summary (3 of 3)

- Steganography
  - Hides information inside image files
  - Forms
    - Insertion
    - Substitution
- Steganalysis
  - Finds whether image files hide information
- Fair use allows using copyrighted material for noncommercial or educational purposes without having to compensate the material's originator or owner