

PERSONAL INDOOR/OUTDOOR CAMERA FOOTAGE AND THE LIMITATIONS OF
OBTAINING AND TRANSFERABILITY

by

JORDAN KANANI CASHWELL

B.A., University of Colorado Denver, 2016

A thesis submitted to the
Faculty of the College of Arts & Media of the
University of Colorado in partial fulfillment
of the requirements for the degree of
Master of Science
Media Forensics Program

2023

This thesis for the Master of Science degree by

Jordan Kanani Cashwell

has been approved for the

Media Forensics Program

by

Catalin Grigoras, Chair

Gregory Wales

Cole Whitecotton

Date: May 13, 2023

Cashwell, Jordan Kanani (M.S., Media Forensics Program)

Personal Indoor/Outdoor Camera Footage and the Limitations of Obtaining and Transferability

Thesis directed by Associate Professor Catalin Grigoras

ABSTRACT

The main purpose of this research is to see the limited number of ways to transfer video using a version of “petcams” compared to a well-known home security system such as Vivint. Petcams are more affordable and easily accessible. People can purchase these and receive them in a couple of days thanks to the Amazon company. In this research you will find that there are few ways to obtain and transfer these videos. The study started by taking 10 videos from the petcams and Vivint system and obtaining the original videos using Cellebrite and zipping the files to the computer to ensure validity. Next, hashes were computed to get the original video hash to compare later in the experiment. A study using stream hash, file hash, and the file format using Exiftool was used to compare the results. The next step was to transfer these videos on different platforms to see if any alterations have been made. Then, the hashes were computed after the transfers were completed and compared to the original video’s hashes. The study concluded that there were limited ways to transfer footage from petcams compared to the Vivint system. This is specifically shown when trying to transfer video footage via iMessage.

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

Approved: Catalin Grigoras

DEDICATION

I would like to dedicate this thesis to my family, especially my daughter Zyrah. Thank you for being the best gift in my life, all that I do is for you! I hope this helps show you that anything can be done if you put your mind to it. Jesse, thank you for pushing me to go back to school and get my masters. To all my family this is for you!

ACKNOWLEDGEMENTS

I would like to thank all the professors in the National Center for Media Forensics. They have all been so helpful in getting me where I am today. All that I know about media forensics is due to each of you. A special thanks to Professor Grigoras and Professor Wales for being there at any time of the day or night when I was struggling. Cole, thank you for being on my committee, and helping me fix necessary things to improve my thesis and experiment. I appreciate all of you very much and could not have done this without you.

TABLE OF CONTENTS

CHAPTER

I.	INTRODUCTION	1
	Background on Security Cameras	1
	How to Connect Cameras in the Home.....	1
	Problems with Footage Alterations.....	1
	Purpose of Research Study.....	2
	Significance of the Study.....	2
	Research Questions.....	2
	Scope and Limitations.....	3
	Previous Research.....	4
	Stream Hashing Research.....	4
	Difference in Video Structure.....	4
	Video Files Using Snapchat.....	5
	Introduction Summary.....	5
II.	MATERIALS	6
	Vivint Security System Application.....	6
	Petcube Camera System Application.....	7
	Wansview Security System Application.....	8
	Materials Summary.....	9
III.	METHODOLOGY	10
	Original Test Data and Sampling Strategy	10
	Original Video Collection Methods.....	11

Creation of Test Data.....	13
Data Analysis Methods.....	14
Methods Summary.....	17
IV. RESULTS	18
Results: Unusual	23
Results Summary.....	25
V. CONCLUSIONS	26
Future Research	26
REFERENCES	28
APPENDIX.....	29

LIST OF TABLES

TABLE

1. Camera Systems and Specs.....	10
2. Results of Exiftool	18
3. Stream Hash Results Found Using Each Camera System Using iMessage.....	19
4. Example of Hash File Results from Each Camera System.....	21

LIST OF FIGURES

FIGURE

1. Screenshots of the Third-Party App to Obtain/Transfer Vivint Footage.....	7
2. Snapshot Overview of the Petcube Application	8
3. Snapshot Overview of Wansview Cloud Application	9
4. Overview of Compressing Files on iPads.....	12
5. Stream Hash Command and Examples.....	14
6. Overview of FTK Imager Program.....	16
7. Overview of Exiftool	17
8. Transfer Options Using the Petcube Application	24
9. FFMPEG Change from MP4 to MOV After Downloading from Dropbox.....	24
10. Hash Change After iMessage Videos Format Change from MP4 to MOV	25

LIST OF ABBREVIATIONS

EXIF – Exchange Image File Format

FFmpeg – Fast Forward MPEG

MD5 – Message Digest 5

NCMF – National Center of Media Forensics

SWGDE – Scientific Working Group on Digital Evidence

CHAPTER I

INTRODUCTION

Background on Security Cameras

In recent years there has been a growth in people using personal security cameras in and around the home. The Vivint system is a well-known system that can be seen in homes across the country, but what if you do not own your home or do not have the money for the system or monthly fees? There are cameras in a decent price range for the security of seeing your home when everyone is out of the home. Pet lovers also get the chance to see their furry friends without having to spend hundreds of dollars. These cameras are easily accessible through Amazon, Target, Walmart. The price range can be under twenty dollars and goes up from there.

How to Connect Cameras in the Home

Once you get them home, these cameras are easy to set up; it usually only takes a plug and your phone to get started. Some of these cameras are connected to an application that you can download on your phone. They are as easy as connecting the account to your email and following the directions on the application itself to start viewing the cameras. This allows you to see a live stream of your home at the press of a button. Some of these apps allow you to record footage, or you can pay a monthly or yearly fee to get the recordings downloaded to your app or phone. When reviewing this, one may think this is a great, cost-efficient way to protect their homes. These cameras can have security uses as well. If something criminal happened to occur and your camera caught it, the video may help in a criminal investigation.

Problems with Footage Alterations

The problem then will be, how can we ensure that the camera footage is validated and unaltered? There are only certain ways to obtain footage from different “pet cams.” For instance,

would the video be altered if this footage were emailed to a law agency? According to SWGDE, the investigator should perform a direct download or screen capture from live stream and social media platforms to preserve video evidence. When feasible, the investigator should attempt to offload the embedded video directly from the web platform, which may provide the best quality video. [4]

Purpose of Research Study

There is a lack of research done with the transferability options and validity after the transfer of video footage using the petcams and other security cameras such as the Vivint system. The general objective is to determine if alterations are made to videos based on transfer options in each system. The specific objectives of this study are listed below:

- 1) To identify the video collection methods available for Vivint/Petcube/Wansview video camera systems.
- 2) To determine if the video collection methods associated with Vivint/Petcube/ Wansview video camera system alter the videos.

Significance of the Study

There are two areas of significance to the study. First would be to discover the gaps related to the three software programs listed and the available collections methods for each program. Secondly, filling the forensic community knowledge gap related to potential alteration of home camera videos related to the three programs.

Research Questions

- 1) What are the video collection methods available for the Vivint video camera system?
- 2) Do the video collection methods associated with the Vivint video camera system alter the videos?

- 3) What are the video collection methods available for the Petcube video camera system?
- 4) Do the video collection methods associated with the Petcube video camera system alter the videos?
- 5) What are the video collection methods available for the Wansview video camera system?
- 6) Do the video collection methods associated with the Wansview video camera system alter the videos?

Scope and Limitations

The scope of the study is to examine three different camera systems. Vivint system uses a 14-day video archiving system available to the user via the Vivant mobile application. The Petcube system uses a 90-day video archiving system available to download to the gallery in the user's phone. Lastly, the Wansview system has videos accessible by downloading them to the user's phone gallery. There was no option for an archiving system for the said number of days. The limitations of this study are identified by the different security systems. The Vivint security camera system offers cloud-based and local network storage drive back-up systems. These two Vivint security camera system options were not tested as part of this study. The Petcube camera system has options to save videos to the gallery or other programs such as text message and the Dropbox application. These were not tested as part of this study. The Wans view camera system only had the option to save directly to the gallery on the phone. If a subscription was purchased, there may be other ways to obtain to save the recorded videos. A subscription was not purchased for the Wansview system.

Previous Research

A keyword search of obtaining video from Vivint, Petcube, and Wansview systems was conducted. The scholarly platforms used to view were Google Scholar, WorldCat, and ProQuest. No published papers were found during the search. There were no exact studies shown about the subject matter. Next, a browse through the NCMF research website was completed to find previous studies on the transfer of media through applications, below are studies that were found.

Stream Hashing Research

A research paper written by Wales et al. titled “Multimedia stream hashing: A forensic method for content verification.” Here, the focus of the paper is the method of stream hashing and how it is used to show if the multimedia streams have changed. Stream hashing is valid and proves the integrity of the picture, video, or any multimedia. Our findings confirmed that stream hashing could accurately detect changes in multimedia streams during transcoding. [6] Stream hashing later in this thesis when there is verification of the MD5 hashing done to verify that no changes have been made to the videos after being sent and downloaded from different platforms.

Difference in Video Structure

Jacek Wolanin published an “Analysis of Facebook’s Video Encoders” paper in 2018. The research conducted was to take videos from Facebook and download them from his phone and computer and see if there were differences in the video structure after the download was complete. The results seemed that the file hashes were changed throughout, whether he downloaded the videos via a Samsung browser compared to the iPhone browser hashes. When hashes change, there has been an alteration in the video when the video is being transferred from its original place to another. Wolanin also used iPhone to conduct his research to see if there

were differences in downloading videos. Every video got the same encoding scheme even though they were all different from each other. [7]

Video Files Using Snapchat

Another research paper, “A Comparison Analysis of Saved Snapchat Video Files on Androids vs iPhones,” by Angela R. Malley, focused on discovering if alterations were made when recording videos on the Snapchat application, when using an Android phone compared to an iPhone. The paper resulted in changes in extracting content from Android to the iPhone. Different hashes were found, which means alterations have been made when transferring/downloading the video footage. Her findings when using iPhone showed no changes. The video files transferred via Dropbox had hash value matches to their counterparts extracted from the iPhone, meaning these files were not recompressed or changed. However, the files sent via Gmail and MMS messages were recompressed prior to sending. [3]

Introduction Summary

This section explained the purpose of the study and why it is necessary. Previous research was conducted and noted in this section as well. The next section will speak on the different materials used and how the research was obtained.

CHAPTER II

MATERIALS

There were three different camera systems used in this experiment to test, which will be explained later in this article. The main product to transfer videos was the iPad 9th generation (Model: MK2N3LL/A) with the most updated iOS version: 16.3. This was used to put the videos from the Petcube and Wansview cloud applications to obtain the video footage. The material for transmitting iMessage was the iPad listed above along with an iPhone 13 mini (Model: MLAL3LL/A) with the iOS version 16.2. An iPhone 12 Pro Max (Model: MG9P3LL) was also used to email videos with an iOS of 16.2. The HP Pavilion home computer was used with Windows 10 Home. Three different home security cameras were used in this experiment and are listed below along with an overview.

Vivint Security System Application

The first was the Vivint security system, an exceedingly popular home-based system. When using Vivint, a third-party application is used to download videos. Videos are kept on the application for 15 days and can be transferred from the app. When opening the application, you will see the cameras that are synchronized to the application. When clicking on the footage you want to view, there is an option called “events,” in which, after it is clicked, recorded videos can be seen. There will be three dots on the screen, which will allow download or send the footage to other applications or messages. Figure 1 below will show the methods to choose from on the third-party application connected to the Vivint system used.

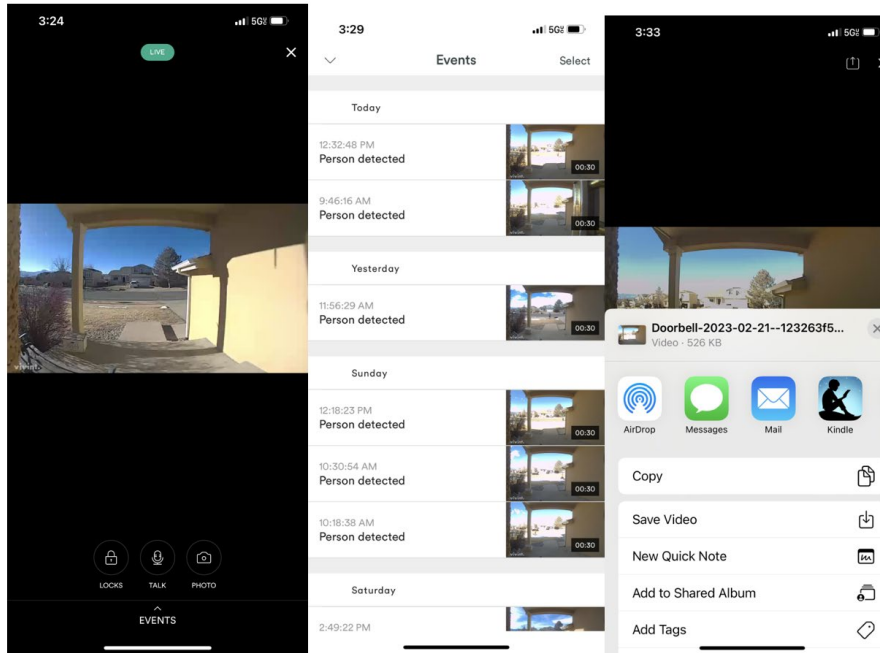


Figure 1. Screenshots of the Third-Party App to Obtain/Transfer Vivint Footage

Petcube Camera System Application

The next was a Petcube system, purchased from the Amazon website. These cameras run for about \$35 and connect to an application you can easily download on your phone. The camera model was 3.7.0, and the application version was 5.0.7. This application can keep recordings for certain days if you pay a monthly or yearly fee. If you choose not to, only live streams can be viewed. The experiments used a subscription was purchased for the video recordings to be accessible.

After the application is downloaded you will be on the home screen, where certain options exist. After clicking on the play button, there will be numerous videos that have been recorded previously. The camera is motion-sensing and records approximately 30 second clips saving them to the application. The videos can be viewed from there, or by clicking the three dots on the video there are options to delete, share, or save the video. In the experiment the saved

videos were used, which were then downloaded to the photo gallery in the iPad. Below in figure 2 shows the application as explained above.

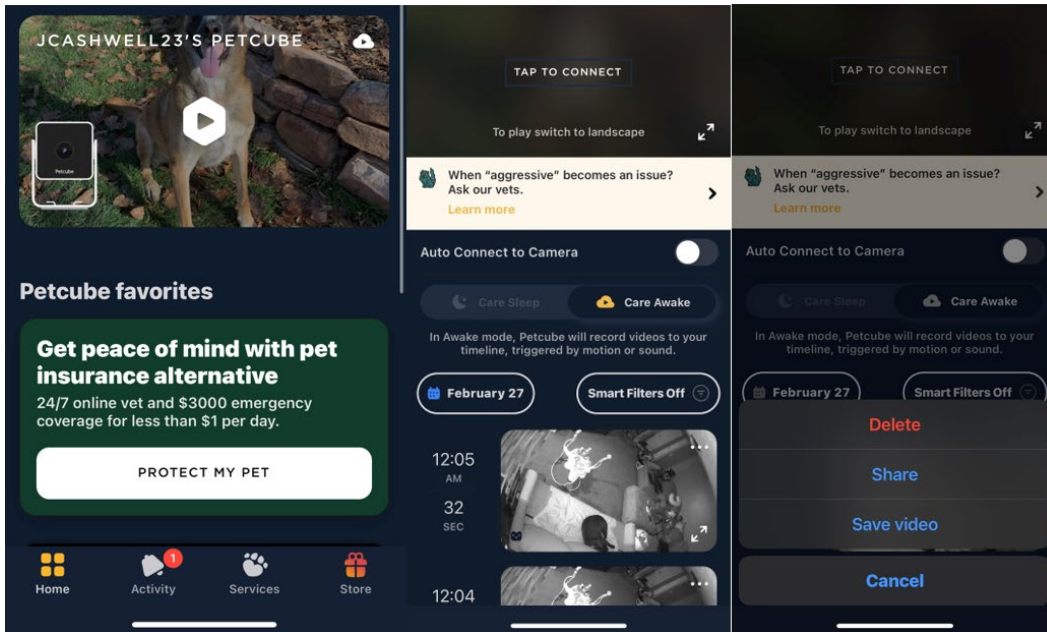


Figure 2. Snapshot Overview of the Petcube Application

Wansview Security System Application

The last camera system used is called Wansview Cloud. This system is another security camera that you can purchase on Amazon. The model for the camera used is a Q5 indoor camera. Again, this camera connects with an application you download to your phone. The application version used in this experiment is 2.0.23021502. When working on Wansview Cloud, there is an option to purchase a subscription to save a certain number of recordings to your phone.

Once inside the app it will show the camera(s) connected to the application. After clicking on the camera footage you would like to view, the app will show you a livestream from the camera(s). From here, you will have options to hear noise, speak into the camera, record the footage, or take a photo of the footage. The experiments used video recordings from select camera footage in the app. The recording was created manually by pressing the video button and

pressing it again to stop the recording. From there, you would select the back button and press the “Me” option at the bottom of the application.

The “local video” option allows the user to use one of the recordings. You can view the recording here, but the only option is to delete the photo. There is an option to see “downloading,” but nothing will be there when that option is clicked. Instead, the recorded video appears in the gallery on the iPad. Shown in figure 3 below is an overview of the application and what was explained previously.

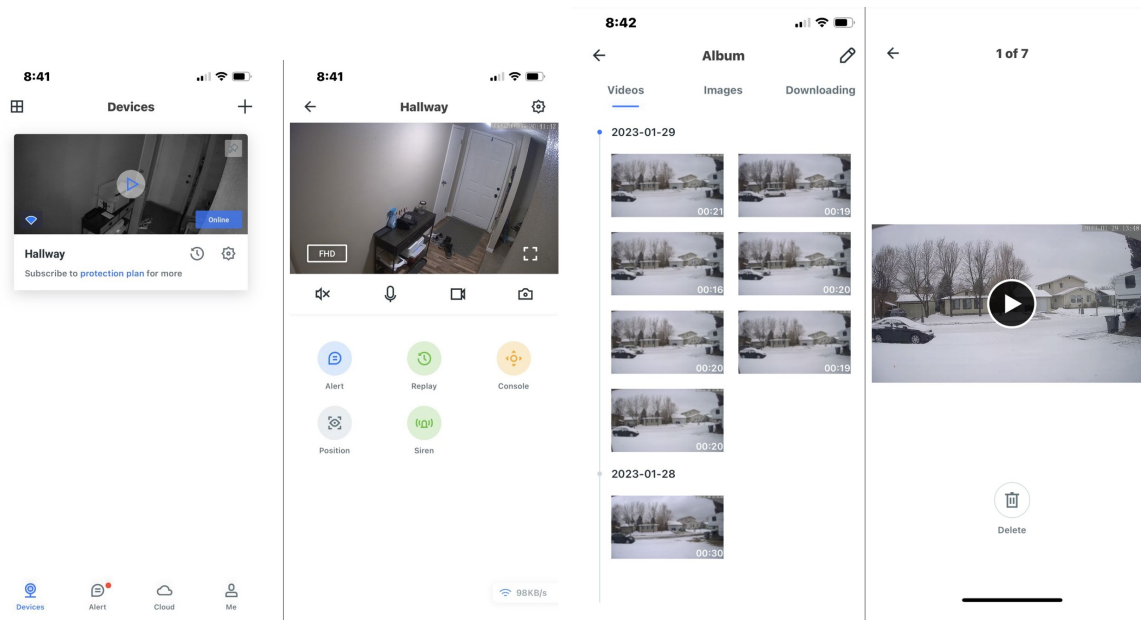


Figure 3. Snapshot Overview of Wansview Cloud Application

Materials Summary

Now that the applications have been explained, the next section will go into the methods for obtaining the videos and transferability of each video using the different camera system in the methodology section below.

CHAPTER III

METHODOLOGY

This study assesses the collection methods for the three different camera systems used in this research. When assessing the collection this study is observing the impact on the videos after using different transfer methods. The methodology chapter expands on the materials chapter by discussing the sampling method. This chapter will also provide application-specific techniques used to collect or transfer multimedia to important law agencies such as law enforcement. The methodology chapter will also discuss a data analysis application used to assess the collection of videos and determine if any alterations of the video content are present.

Original Test Data and Sampling Strategy

Original Test Data Development

Ten videos were created using each of the three camera systems noted in the Methods chapter above. A table of each camera system, along with video type and size is shown below.

Table 1: Camera System and Specs

Camera System	Video Type	Video Size
VIVINT	MP4	1920x1080
Petcube	MP4	1920x1080
Wansview	MP4	1920x1080

Sampling Strategy

The sampling strategy for this study was not random, but a nonprobability sampling method. The reason for the nonprobability sampling method was due to the limited availability of camera systems along with the limited number of ways to collect and transfer the videos.

There was a lack of time to conduct experiments and the practicalities necessary to conduct the experiments.

Original Video Collection Methods

Zip Collection Technique

The method for obtaining Petcube and Wansview were similar. As previously stated, the videos were saved to the gallery of the iPad. A paper by Zaib Ali titled, “How to Zip or Compress Files on iPhone and iPad Using Files App,” ensured that the videos in the gallery of my iPad did not change when being transferred. The paper was a step-by-step guide to compressing the files. There are many benefits to compressing or adding files to zip, as doing so can reduce their overall size and allow users to share multiple files over email more easily. [8]

In this experiment, the videos were moved from the gallery to a file on the iPad. The file was then zipped before sending. It is important to zip a file to ensure there are no alterations to the file. To do this, highlight the footage or file that needs to be zipped. There will be three dots on the screen and an option to “compress” the file. The folder was renamed to organize which files contained certain footage. These zipped files were emailed, downloaded, and unzipped to the computer. Working copies of the original footage were used for the experiments to protect the originals from being altered.

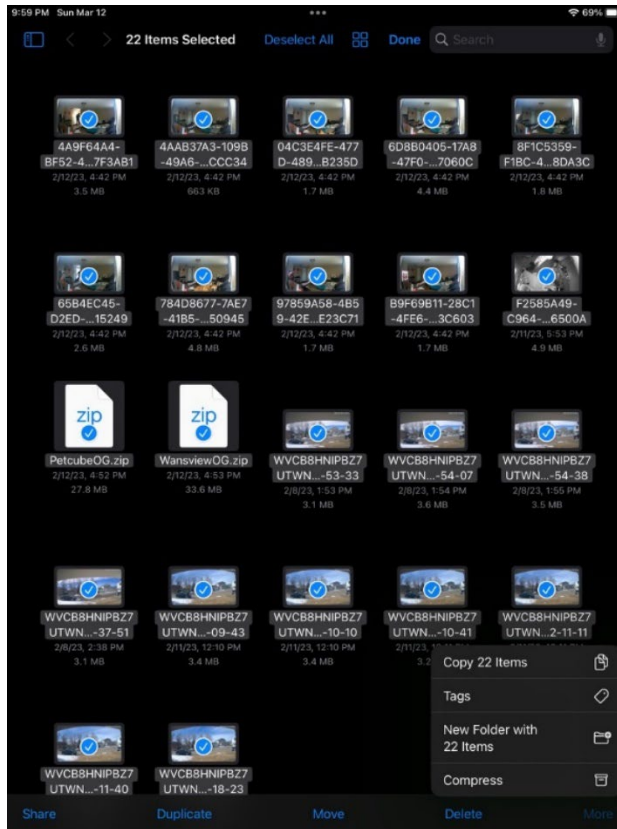


Figure 4: Overview of Compressing Files on iPads

Cellebrite Collection Method in Vivint

To collect the Vivint videos from the application, Cellebrite was used. Cellebrite is a program in which data and information can be collected from a phone or tablet. In this case, an iPhone was used. Once the phone is plugged into the computer, you can open the Cellebrite program, and it will find the phone. From there you can choose what information you would like to extract. To view the extracted information a program called Cellebrite UFED is used. Here, the user will be able to download the videos from the phone to the computer if the user pleases. In this instance the videos were obtained from the application straight the users google drive. From there the videos can be transferred via web-based email.

Creation of Test Data

To obtain the videos from the Vivant system, the method was different, as there were more ways to transfer the footage. The videos were obtained through google drive and then emailed in a zipped file to protect the original videos from being altered in any way. Then, just like the other footage, the videos were downloaded to the computer and unzipped. A working copy of this footage was made as well. There were three programs used to test the footage to ensure no alterations were made. Four different methods of transferring the footage were used in this experiment.

Email

After obtaining the information on the original videos, the videos were sent (unzipped) using other platforms. Email was used the videos were sent as attachments via outlook to outlook. The videos were downloaded to the computer in a separate folder and run through FFMPEG with the command listed above. The next transfer was from outlook to Gmail to see if the different platforms receive and alter footage. As said above, the videos were emailed and downloaded to the computer before being computed in FFMPEG to find the stream hash.

Dropbox

The original working copy videos were then sent via Dropbox. They were taken from the computer and sent to Dropbox. Once this was done the videos were obtained from the drobox website and downloaded into separate folders on the computer and again, run through FFMPEG to get the stream hash. Steps should be taken to ensure the integrity of the data acquired; this should include computing a hashing algorithm on the original submitted evidence and the working copy. Compare the two hash results to ensure that they are identical and that no changes have occurred during the copy process. [4]

iMessage

Lastly the videos were sent via iMessage from the iPad to the iPhone 13 mini. The videos that were saved on the iPad from the apps were sent to the iPhone 13 mini. These videos were sent in the iMessage form to ensure that the transfers would be identical. This helps the results be as valid as possible. When obtaining the stream hashes from the Wansview Cloud camera system, there was no noise on the video. The stream hash had that only of the video with no audio to be processed. When recording these videos, the mic was turned off, which is the reason for the difference.

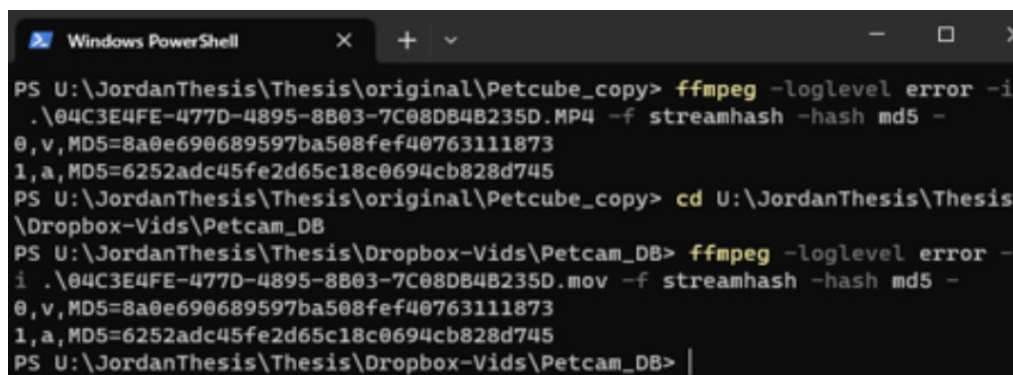
Data Analysis Methods

STREAM HASH

Stream has been calculated to the original videos along with the other 20 videos to cross check the hashes to the original hash. It is the most appropriate tool to apply the stream hashing technique, where a hash checksum is generated from decoded multimedia streams. [6] To find the stream hash for each video a program called FFMPEG was used. The data analysis used the following FFmpeg command line.

```
ffmpeg -loglevel error -i .\Name.MP4 -f streamhash -hash md5 -
```

This command was used for all 30 working copies of the original videos.



```
Windows PowerShell
PS U:\JordanThesis\Thesis\original\Petcube_copy> ffmpeg -loglevel error -i
.\04C3E4FE-477D-4895-8B03-7C08DB4B235D.MP4 -f streamhash -hash md5 -
0,v,MD5=8a0e690689597ba508fef40763111873
1,a,MD5=6252adc45fe2d65c18c0694cb828d745
PS U:\JordanThesis\Thesis\original\Petcube_copy> cd U:\JordanThesis\Thesis
\Dropbox-Vids\Petcam_DB
PS U:\JordanThesis\Thesis\Dropbox-Vids\Petcam_DB> ffmpeg -loglevel error -
i .\04C3E4FE-477D-4895-8B03-7C08DB4B235D.mov -f streamhash -hash md5 -
0,v,MD5=8a0e690689597ba508fef40763111873
1,a,MD5=6252adc45fe2d65c18c0694cb828d745
PS U:\JordanThesis\Thesis\Dropbox-Vids\Petcam_DB> |
```

Figure 5: Stream Hash Command and Examples

As shown in the figure above, once the command is input, the hashes will compute. There will be separate hashes for video (0,v) and for audio (1,a). All the hashes that were computed in FFMPEG were then obtained in a table. This table was made to track differences, if any, in hash algorithms. All the hashes were recorded on a table to review later to see if any changes have been made to the stream hashes. This will be discussed in the Results section of this paper.

FILE HASH

The next method that was used was the file hash. A file hash is another way one can compute the hash of the video. A hash value is a calculated numeric/alphanumeric value that acts as a digital “fingerprint” and is used to identify digital files. Hash values are used for validating evidence. [5] To ensure no alterations were made, hashes are calculated through different hashing applications. The MD5 was calculated in this experiment. This form of hashing is widely accepted when validating multimedia in the Media Forensic Community. After an offending audio, image, or video is identified (either manually or automatically), a distinct digital signature is extracted from the content (the digital signature is often referred to as a fingerprint, message digest, hash value, hash code, hash sum, or, simply, hash) [2]. When testing the videos' transmission, three programs were used to test validity before and after the transfer.

To obtain the information a program called FTK Imager was used. Once inside the program you would add the evidence (videos) to the program. Once the videos have been highlighted on the left, a right click led to the options needed. There is an “Export File Hash List” shown and when clicked, will give you the excel report saved to the desired location with the hashes of the videos. The report saved will be the hashes for the file of each video. Again, this was done on the four distinct categories of transferability. (Original, Outlook, Gmail, and iMessage) The information was then made into a table and viewed side by side.

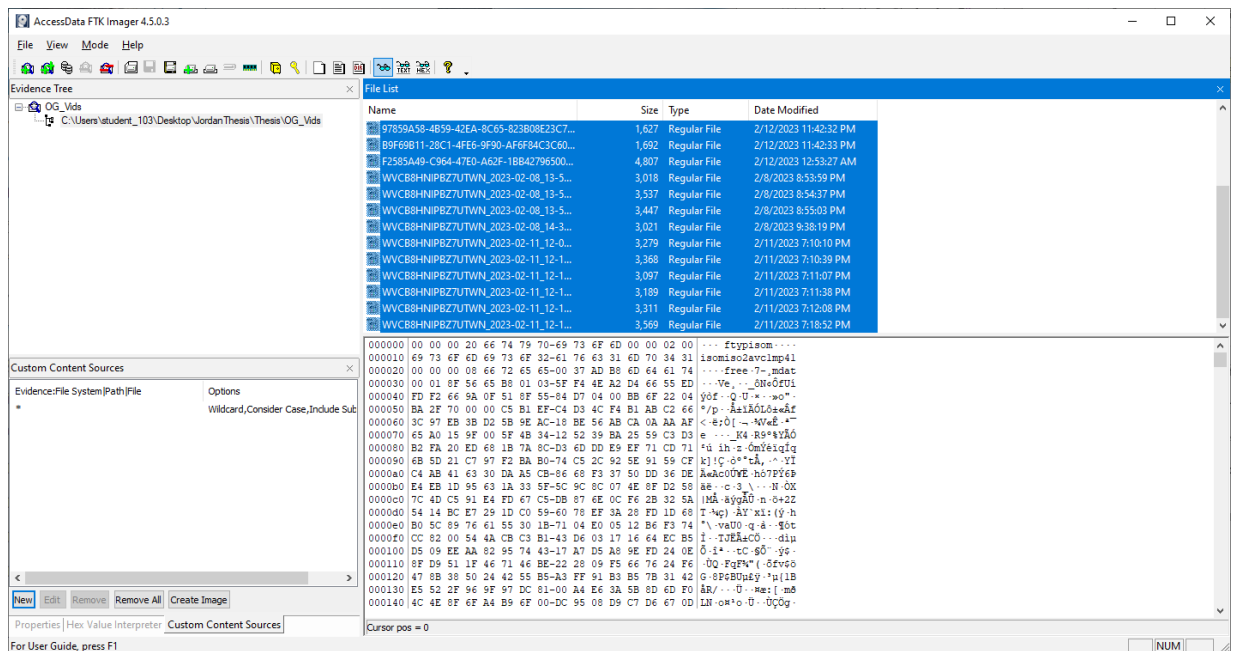


Figure 6: Overview of FTK Imager Program

EXIFTOOL

The last method used to obtain the information on the videos was the Exif tool program. This tool helps the user see the inner workings of multimedia. The exchange image file format (Exif) standard defines the specification for how to store metadata for image, video, and audio files. Typically, this is the output format generated by digital cameras (including smart phones) and scanners. [1] Using the PowerShell application, the command below was used to get information of all the videos and exported to an excel report. To get one report for all videos the “*” was used to get all mp4 videos into one text file.

Command: Exiftool -s “*.mp4 > “Name.txt”

```
Windows PowerShell
udent_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Gmail\PETCAM_Gmail
PS C:\Users\student_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Gmail\PETCAM_Gmail> exiftool -s "*.mp4" > "Exif_PC_GM.txt"clear
Error: File not found - clear
PS C:\Users\student_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Gmail\PETCAM_Gmail> cd C:\Users\student_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Gmail\Wansview_Gmail
PS C:\Users\student_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Gmail\Wansview_Gmail> exiftool -s "*.mp4" > "Exif_WV_GM.txt"clear
Error: File not found - clear
PS C:\Users\student_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Gmail\Wansview_Gmail> cd C:\Users\student_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Outlook\Doorbell
PS C:\Users\student_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Outlook\Doorbell> exiftool -s "*.mp4" > "Exif_DB_OL.txt"clear
Error: File not found - clear
PS C:\Users\student_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Outlook\Doorbell> cd C:\Users\student_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Outlook\Petcube
PS C:\Users\student_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Outlook\Petcube> exiftool -s "*.mp4" > "Exif_PC_OL.txt"clear
Error: File not found - clear
PS C:\Users\student_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Outlook\Petcube> cd C:\Users\student_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Outlook\Wansview
PS C:\Users\student_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Outlook\Wansview> exiftool -s "*.mp4" > "Exif_WV_OL.txt"clear
Error: File not found - clear
PS C:\Users\student_103\Desktop\JordanThesis\Thesis\Emailed-Vids\Outlook\Wansview> |
```

Figure 7: Overview of Exiftool

This text file was saved in separate folders to the corresponding transfer method. When this was complete the files were placed side by side to see if changes were made.

Methods Summary

The videos were all transferred using the different platforms to check the validity of the video footage. After this was done, the videos were compared to the original to see if alterations were made. This will be discussed in the results section of this paper.

CHAPTER IV

RESULTS

The results looked similar all around the board. There were some changes in one of the platforms used. When using the Exif tool, changes were found in the videos sent via text message in the access date and the modify date. This example is shown below for the Wansview Cloud home camera. The most changes were found when using the results in the Exif tool report. The figure below shows an example of some of the changes made from the original video to the transfers from iMessage. Although it may look similar there are differences such as the modified date. There are other files that changed such as the file type, handler type, and the average bit rate in the videos.

Table 2: Results of Exiftool

WVCB8HNIPBZ7UTWN_2023-02-08_13-53-33.MP4	File Size	File Create Date	Image Size	Avg Bit Rate	Handler Type:
Original	2.9 MiB	2023:02:12 18:08:47	1920x1080	987 kbps	Metadata
Outlook	2.9 MiB	2023:02:15 15:55:05	1920x1080	987 kbps	Metadata
Gmail	2.9 MiB	2023:02:17 17:18:51	1920x1080	987 kbps	Metadata
Dropbox	2.9 MiB	2023:02:17 18:46:43	1920x1080	987 kbps	Metadata
iMessage	6.3 MiB	2023:02:17 23:18:58	1280x720	2.11 Mbps	Metadata

As you can see in the above table, the highlighted area was where changes were made compared to the original video. The file has over doubled in size going from 2.9 MiB to 6.3 MiB. The image size went from 1920x1080 to 1280x720, which shows that iMessage has resized the video. Lastly, the average bit rate had changed dramatically faster from 987 kbps (kilobytes per second) to 2.11 Mbps (megabits per second). Although this was the only option that changed more so than the others, there were noticeable changes in the creation date. Even if the stream hash and file hash do not change, the creation date will. This is because it is not the original video, and it cannot have the same creation date.

Outlook to Outlook / Outlook to Gmail / Computer to Dropbox

There were no changes found in the videos in stream hash or file hashing. In Exif tool there were some changes to the modification date, but overall, it was all the same information.

iMessage to iMessage

Stream hash analysis of original and the test data sets videos revealed changes to some of the video streams when transferring the videos using iMessage. Below are a few examples showing the results of the experiment by system used.

Table 3: Stream Hash Results Found Using Each Camera System Using iMessage

FILE NAME	STREAM HASH (VIDEO AND AUDIO)
PETCUBE: 04C3E4FE-477D-4895-8B03- 7C08DB4B235D.MP4	<ul style="list-style-type: none"> • Original <ul style="list-style-type: none"> ○ 0,v,MD5=8a0e690689597ba508fef40763111873 ○ 1,a,MD5=6252adc45fe2d65c18c0694cb828d745 • Emailed (Outlook) <ul style="list-style-type: none"> ○ 0,v,MD5=8a0e690689597ba508fef40763111873 ○ 1,a,MD5=6252adc45fe2d65c18c0694cb828d745 • Email (Gmail): <ul style="list-style-type: none"> ○ 0,v,MD5=8a0e690689597ba508fef40763111873

Table 3: Continued

FILE NAME	STREAM HASH (VIDEO AND AUDIO)
<p>PETCUBE: 04C3E4FE-477D-4895-8B03- 7C08DB4B235D.MP4</p>	<ul style="list-style-type: none"> ○ 1,a,MD5=6252adc45fe2d65c18c0694cb828d745 • Dropbox 1-9 changed to an .MOV when downloading: <ul style="list-style-type: none"> ○ 0,v,MD5=8a0e690689597ba508fef40763111873 ○ 1,a,MD5=6252adc45fe2d65c18c0694cb828d745 • iMessage <ul style="list-style-type: none"> ○ 0,v,MD5=a60f87e3bc98f53228c812cda1ee65ad ○ 1,a,MD5=95a071a72f64dc21a7626dd1c912e435
<p>WANSVIEW CLOUD: WVCB8HNPBZ7UTWN_2023-02-08_13- 53-33.MP4</p>	<ul style="list-style-type: none"> • Original <ul style="list-style-type: none"> ○ 0,v,MD5=82f4d1f4f4b50f3736feda038e918ace • Emailed(Outlook) <ul style="list-style-type: none"> ○ 0,v,MD5=82f4d1f4f4b50f3736feda038e918ace • Email (Gmail): <ul style="list-style-type: none"> ○ 0,v,MD5=82f4d1f4f4b50f3736feda038e918ace • Dropbox: <ul style="list-style-type: none"> ○ 0,v,MD5=82f4d1f4f4b50f3736feda038e918ace • iMessage: <ul style="list-style-type: none"> ○ 0,v,MD5=609418eccc8124911c0da88334fdb79ec
<p>VIVINT: Doorbell-2023-01-18-- 081663c80d75e1096548dec6a07d.mp4</p>	<ul style="list-style-type: none"> • Original: <ul style="list-style-type: none"> ○ 0,v,MD5=71833e27261f61352fa9cd7eda568526 ○ 1,a,MD5=5514f2e0a7184eccc251a4b59c1f5173 • Emailed (Outlook): <ul style="list-style-type: none"> ○ 0,v,MD5=71833e27261f61352fa9cd7eda568526 ○ 1,a,MD5=5514f2e0a7184eccc251a4b59c1f5173

Table 3: Continued

FILE NAME	STREAM HASH (VIDEO AND AUDIO)
VIVINT: Doorbell-2023-01-18-- 081663c80d75e1096548dec6a07d.mp4	<ul style="list-style-type: none"> • Email (Gmail): <ul style="list-style-type: none"> ○ 0,v,MD5=71833e27261f61352fa9cd7eda568526 ○ 1,a,MD5=5514f2e0a7184ecef251a4b59c1f5173 • Dropbox: <ul style="list-style-type: none"> ○ 0,v,MD5=71833e27261f61352fa9cd7eda568526 ○ 1,a,MD5=5514f2e0a7184ecef251a4b59c1f5173 • iMessage: <ul style="list-style-type: none"> ○ 0,v,MD5=b71ccac00bbadedbff5dad2c2914fa99 ○ 1,a,MD5=2ed608f56b2848a4ef9ec80af712429a

Table 4: Example of Hash File Results from Each Camera System

FILE NAME	MD5	SHA1
PETCUBE: 04C3E4FE-477D-4895-8B03- 7C08DB4B235D.MP4	<ul style="list-style-type: none"> • Original: b6efd9ea056c5f2335ce18da6e5d24eb • Emailed (Outlook): b6efd9ea056c5f2335ce18da6e5d24eb • Email (Gmail): b6efd9ea056c5f2335ce18da6e5d24eb • Dropbox: b6efd9ea056c5f2335ce18da6e5d24eb • iMessage: 3cf4098d1f5cee6ccc3a798a0d5fa700 	<ul style="list-style-type: none"> • Original: 22368f0d4af6a11571913df07223b3338cddb13c • Emailed (Outlook): 22368f0d4af6a11571913df07223b3338cddb13c • Email (Gmail): 22368f0d4af6a11571913df07223b3338cddb13c • Dropbox: 22368f0d4af6a11571913df07223b3338cddb13c • iMessage: a0a2ef461590b4b660db8a40babbc0f2ffebb6b8

Table 4: Continued

FILE NAME	MD5	SHA1
WANSVIEW: WVCB8HNIPBZ7UTWN_2023-02-08_13-53-33.MP4	<ul style="list-style-type: none"> Original: edb338420cccd3e615824ca552a1ae93 Emailed (Outlook): edb338420cccd3e615824ca552a1ae93 Email (Gmail): edb338420cccd3e615824ca552a1ae93 Dropbox: edb338420cccd3e615824ca552a1ae93 	<ul style="list-style-type: none"> Original: 1f98ec2e911ffb919313cebb77174e975cf29e58 Emailed (Outlook): 1f98ec2e911ffb919313cebb77174e975cf29e58 Email (Gmail): 1f98ec2e911ffb919313cebb77174e975cf29e58 Dropbox: 1f98ec2e911ffb919313cebb77174e975cf29e58
WANSVIEW: WVCB8HNIPBZ7UTWN_2023-02-08_13-53-33.MP4	<ul style="list-style-type: none"> Text: 089940df12ae634a34b0e6cdbc32dd6d 	<ul style="list-style-type: none"> iMessage: 8efdb4f40350e13624b6bfb5f8f90437646bbab2
VIVINT: Doorbell-2023-01-23--085363ceadb6e1096548dec6a14e.mp4	<ul style="list-style-type: none"> Original: 69E71D719197F3FE245929E50CF7B0D5 Emailed (Outlook): 69e71d719197f3fe245929e50cf7b0d5 Email (Gmail): 69e71d719197f3fe245929e50cf7b0d5 Dropbox: 69e71d719197f3fe245929e50cf7b0d5 iMessage: b555a4fe5961d75107b41699f503ba6f 	<ul style="list-style-type: none"> Original: 8129F9CD4A3EDAB87D51CAA3E342073E686556B4 Emailed (Outlook): 8129f9cd4a3edab87d51caa3e342073e686556b4 Email (Gmail): 8129f9cd4a3edab87d51caa3e342073e686556b4 Dropbox: 8129f9cd4a3edab87d51caa3e342073e686556b4 iMessage: 3869f481e09e830c1a5a9bc295a92b87e3b1e769

From the table above you can see the highlighted areas were all different from the rest of the results. This shows a completely different hash algorithm than the rest of the others. As stated above, when the hashes do not match the original video that means the videos altered in some

way. An example of why this could have resulted is because iMessage could have changed the size of the video, changed the resolution, etc. The reasoning for these changes could be because iMessage tries to send the video the easiest way possible. Of course, it does not ask the user if it is okay to change the video properties and it is just done each time sending a video. Some of the hashes do not match, that proves that the video is now invalid.

Results: Unusual

What was noted at the end of the experiment, was when using Petcube footage, there is an option to share. When the share button was pressed there were options to share many transferrable applications that were on the iPad such as messaging and Facebook. There was also an option to share the files in your iPad just as you could in the Vivint system. If this had been known before the experiment, these could have been tested as well. My hypothesis if we used this would be that there would be the same results already shown in this study. Since no changes were made to several transferred videos, there should not have been for this one either. Although, I am not sure if there would have been changes when using iMessage. Below is a visual of the application when the share button was pressed.

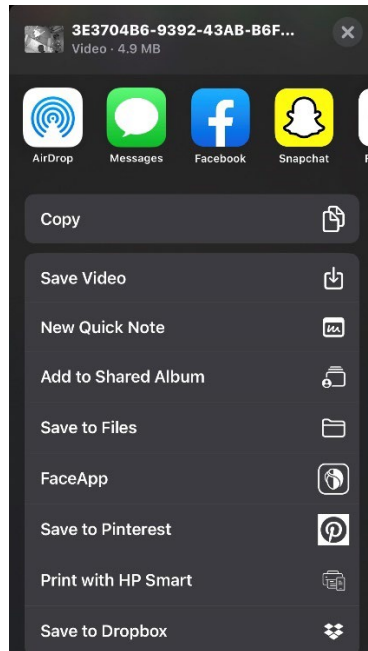


Figure 8: Transfer Options Using the Petcube Application

There were some things to notice with changes made to multimedia during the Dropbox transfer. Once the Petcube videos were downloaded from Dropbox to the computer there was a change. Instead of the videos remaining “.mp4,” nine of the videos changed to “.mov.” It is unknown why this would cause a change in the format. Although there was a noticeable change in format, there was no change in the stream hashes when being run in FFMPEG or FTK Imager. Below is an example of the video input for the original mp4 video and the next command shows the hashes for the mov video. Below shows that there was no difference detected.

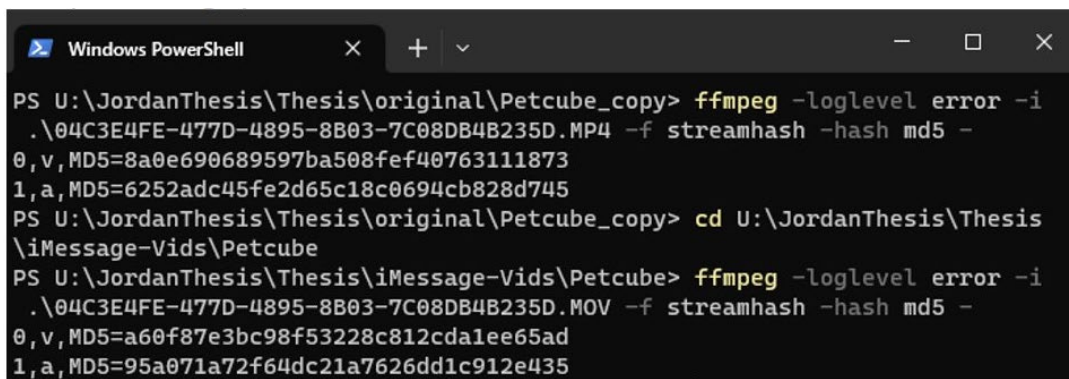
```

Windows PowerShell
PS U:\JordanThesis\Thesis\original\Petcube_copy> ffmpeg -loglevel error -i
.\04C3E4FE-477D-4895-8B03-7C08DB4B235D.MP4 -f streamhash -hash md5 -
0,v,MD5=8a0e690689597ba508fef40763111873
1,a,MD5=6252adc45fe2d65c18c0694cb828d745
PS U:\JordanThesis\Thesis\original\Petcube_copy> cd U:\JordanThesis\Thesis
\Dropbox-Vids\Petcam_DB
PS U:\JordanThesis\Thesis\Dropbox-Vids\Petcam_DB> ffmpeg -loglevel error -i
.\04C3E4FE-477D-4895-8B03-7C08DB4B235D.mov -f streamhash -hash md5 -
0,v,MD5=8a0e690689597ba508fef40763111873
1,a,MD5=6252adc45fe2d65c18c0694cb828d745
PS U:\JordanThesis\Thesis\Dropbox-Vids\Petcam_DB> |

```

Figure 9: FFMPEG Change from MP4 to MOV After Downloading from Dropbox

Another change that was made in the format of the videos was during the iMessage transfer. Once again, all the videos changed from mp4 to mov. After running the stream hash, the hashes indeed changed, which shows alterations were made to the videos after being texted. In the figure below, the input was using the original mp4 video. The next command, the hash algorithm was run with the new mov video after using iMessage to transfer it. As you can tell, the hashes changed, caused by an alteration or alterations when transferring.



```
Windows PowerShell
PS U:\JordanThesis\Thesis\original\Petcube_copy> ffmpeg -loglevel error -i
.\04C3E4FE-477D-4895-8B03-7C08DB4B235D.MP4 -f streamhash -hash md5 -
0,v,MD5=8a0e690689597ba508fef40763111873
1,a,MD5=6252adc45fe2d65c18c0694cb828d745
PS U:\JordanThesis\Thesis\original\Petcube_copy> cd U:\JordanThesis\Thesis
\iMessage-Vids\Petcube
PS U:\JordanThesis\Thesis\iMessage-Vids\Petcube> ffmpeg -loglevel error -i
.\04C3E4FE-477D-4895-8B03-7C08DB4B235D.MOV -f streamhash -hash md5 -
0,v,MD5=a60f87e3bc98f53228c812cda1ee65ad
1,a,MD5=95a071a72f64dc21a7626dd1c912e435
```

Figure 10: Hash Change After iMessage Videos Format Change from MP4 to MOV

Results Summary

As shown above there are some instances where the video footage does not change when transferring from different platforms. There have been some instances where transferring video footage can alter videos, especially when it comes to using iMessage. In the next section, conclusions will be made about the results.

CHAPTER V

CONCLUSIONS

In conclusion, the videos were only altered when using a text message platform. iMessage changed the format of the videos to .MOV. This is what leads the cameras to have a change in the hashes found. The other platforms being used did not change the videos, which showed the same hashes no matter what platform was being used. Instead of changing the properties outlook, Gmail and the Dropbox application copied the files and directed it to the next destination, causing no change.

Although using the Exif tool it showed some alterations to the file, it did not change the video itself. This conclusion was reached after running the hashes for all the videos. This was not a surprise and was expected as was found in multiple other research. The problem that lies is there is a limited number of ways that footage can be transferred using certain applications. There is the saying that you get what you paid for, and this just proves that point more.

Future Research

There are many things that can be researched in the future when it comes to home surveillance cameras. A study using different cameras such as the ring camera system, a blink system, or even other versions of the “petcam” systems to see the transfer options. There is also an option to order a subscription to the Petcube application, which helps save videos, rather than recording the livestream. This was not obtained when using the lower budget cameras.

This could have changed the outcome of the hashes, by being able to be sent from another application. It could have given more ways to transfer or save videos rather than saving straight to your phone or iPad. Finally, there can be an experiment done in which the footage can be obtained through a program such as Cellebrite. This would help extracting the original videos,

to ensure that the footage is unaltered when obtaining them. It would be helpful if there was more research on the limited amount of transferability from certain systems compared to others.

REFERENCES

- [1] B. Toevs, "Processing of Metadata on Multimedia Using ExifTool: A Programming Approach in Python," *2015 Annual Global Online Conference on Information and Computer Technology (GOCICT)*, Louisville, KY, USA, 2015, pp. 26-30, doi: 10.1109/GOCICT.2015.14.
- [2] Farid, H. An Overview of Perceptual Hashing. J Online Version 1.13.2 (TeX Live 2021) [View of An Overview of Perceptual Hashing | Journal of Online Trust and Safety \(tsjournal.org\)](#)
- [3] Malley, A. A Comparison Analysis of Saved Snapchat Video Files on Androids vs iPhones. M.S., University of Colorado at Denver, 2012
- [4] SWGDE Guidelines for Video Evidence Canvassing and Collection Version 1.0 (January 14, 2021.)
- [5] Wilson, R., Chi, H. A Framework for Validating Aimed Mobile Digital Forensics Evidences. ACM SE '18. March 29-31, 2018.
- [6] Wales, GS, Smith, JM, Lacey, DS, Grigoras, C. Multimedia stream hashing: A forensic method for content verification. *J Forensic Sci.* 2023; 68: 289– 300. <https://doi.org/10.1111/1556-4029.15148>
- [7] Wolanin, J. Analysis of Facebook's Video Encoders. M.S., University of Colorado at Denver, 2018.
- [8] Ali, Zaib. How to Zip or Compress Files on iPhone and iPad Using Files App. June 30, 2019.

Appendix A – Hash Stream Results

PETCUBE VIDEOS

04C3E4FE-477D-4895-8B03-7C08DB4B235D.MP4

- ORIGINAL
 - 0,v,MD5=8a0e690689597ba508fef40763111873
 - 1,a,MD5=6252adc45fe2d65c18c0694cb828d745
- Emailed (Outlook)
 - 0,v,MD5=8a0e690689597ba508fef40763111873
 - 1,a,MD5=6252adc45fe2d65c18c0694cb828d745
- Email (Gmail):
 - 0,v,MD5=8a0e690689597ba508fef40763111873
 - 1,a,MD5=6252adc45fe2d65c18c0694cb828d745
- Dropbox 1-9 changed to an .MOV when downloading:
 - 0,v,MD5=8a0e690689597ba508fef40763111873
 - 1,a,MD5=6252adc45fe2d65c18c0694cb828d745
- iMessage
 - 0,v,MD5=a60f87e3bc98f53228c812cda1ee65ad
 - 1,a,MD5=95a071a72f64dc21a7626dd1c912e435

4A9F64A4-BF52-48CC-9D83-B41B647F3AB1.MP4

- Original
 - 0,v,MD5=5b74445886ebcaa1b01821cdfd7d86f5
 - 1,a,MD5=c2c02ee95dbb8482ec2e8bf87ec191a4
- Emailed (Outlook)
 - 0,v,MD5=5b74445886ebcaa1b01821cdfd7d86f5
 - 1,a,MD5=c2c02ee95dbb8482ec2e8bf87ec191a4
- Email (Gmail):
 - 0,v,MD5=5b74445886ebcaa1b01821cdfd7d86f5
 - 1,a,MD5=c2c02ee95dbb8482ec2e8bf87ec191a4
- Dropbox:
 - 0,v,MD5=5b74445886ebcaa1b01821cdfd7d86f5
 - 1,a,MD5=c2c02ee95dbb8482ec2e8bf87ec191a4
- iMessage
 - 0,v,MD5=3357c9fe3c6daebf4dad678022e8c52f
 - 1,a,MD5=c2c02ee95dbb8482ec2e8bf87ec191a4

4AAB37A3-109B-49A6-B3EA-6A75187CCC34.MP4

- Original
 - 0,v,MD5=b8e0aa2228423cfc3a26662c42879157
 - 1,a,MD5=c96f50013809c209c926df0bb43fbac3
- Emailed (Outlook)
 - 0,v,MD5=b8e0aa2228423cfc3a26662c42879157
 - 1,a,MD5=c96f50013809c209c926df0bb43fbac3
- Email (Gmail):
 - 0,v,MD5=b8e0aa2228423cfc3a26662c42879157
 - 1,a,MD5=c96f50013809c209c926df0bb43fbac3
- Dropbox (changed to .MOV):
 - 0,v,MD5=b8e0aa2228423cfc3a26662c42879157
 - 1,a,MD5=c96f50013809c209c926df0bb43fbac3
- iMessage
 - 0,v,MD5=28524deba5c698601208d7d9cbd2eb18
 - 1,a,MD5=f562eee9807e1b7d29a7f4a97f624985

6D8B0405-17A8-47F0-A792-A9F5DE87060C.MP4

- Original
 - 0,v,MD5=a943a0b23c0ff5f45c489ae6c5f01bc8
 - 1,a,MD5=64d6e8102871a1e030eb7f408998a802
- Emailed(Outlook)
 - 0,v,MD5=a943a0b23c0ff5f45c489ae6c5f01bc8
 - 1,a,MD5=64d6e8102871a1e030eb7f408998a802
- Email (Gmail):
 - 0,v,MD5=a943a0b23c0ff5f45c489ae6c5f01bc8
 - 1,a,MD5=64d6e8102871a1e030eb7f408998a802
- Dropbox (changed to .MOV):
 - 0,v,MD5=a943a0b23c0ff5f45c489ae6c5f01bc8
 - 1,a,MD5=64d6e8102871a1e030eb7f408998a802
- iMessage
 - 0,v,MD5=ded799413d12f99738f0deebba2b9a7b
 - 1,a,MD5=d27ebc1f17e0cd4baf340c33710a7b38

8F1C5359-F1BC-4017-A719-C7B87778DA3C.MP4

- Original
 - 0,v,MD5=f617d54569033af5102cb7bd02bd2b12
 - 1,a,MD5=e938b8803a95dd8dd2ca471972df4360
- Emailed (Outlook)
 - 0,v,MD5=e10050eb9be806ec9e8daa0733131b39
 - 1,a,MD5=24294224d387e9e53e8df63c3ed6a3a6
- Email (Gmail):
 - 0,v,MD5=f617d54569033af5102cb7bd02bd2b12
 - 1,a,MD5=e938b8803a95dd8dd2ca471972df4360
- Dropbox (changed to .MOV):
 - 0,v,MD5=f617d54569033af5102cb7bd02bd2b12
 - 1,a,MD5=e938b8803a95dd8dd2ca471972df4360
- iMessage:
 - 0,v,MD5=6a04c9439b77e3a2a49b95eecf88e34e
 - 1,a,MD5=5f7d506df5a68853f51c6f06fd251a52

65B4EC45-D2ED-4F89-9C41-3A0B69815249.MP4

- Original
 - 0,v,MD5=e10050eb9be806ec9e8daa0733131b39
 - 1,a,MD5=24294224d387e9e53e8df63c3ed6a3a6
- Emailed (Outlook)
 - 0,v,MD5=e10050eb9be806ec9e8daa0733131b39
 - 1,a,MD5=24294224d387e9e53e8df63c3ed6a3a6
- Email (Gmail):
 - 0,v,MD5=e10050eb9be806ec9e8daa0733131b39
 - 1,a,MD5=24294224d387e9e53e8df63c3ed6a3a6
- Dropbox (Changed to .MOV):
 - 0,v,MD5=e10050eb9be806ec9e8daa0733131b39
 - 1,a,MD5=24294224d387e9e53e8df63c3ed6a3a6
- iMessage:
 - 0,v,MD5=fcc416159e8b46dad3e9076ebc755541
 - 1,a,MD5=24294224d387e9e53e8df63c3ed6a3a6

784D8677-7AE7-41B5-8195-93CC4DA50945.MP4

- Original
 - 0,v,MD5=85215df88c76ace04b5bd11e5654d381

- 1,a,MD5=3801f76052cb58b5bd7fa172695828bd
- Emailed (Outlook)
 - 0,v,MD5=85215df88c76ace04b5bd11e5654d381
 - 1,a,MD5=3801f76052cb58b5bd7fa172695828bd
- Email (Gmail):
 - 0,v,MD5=85215df88c76ace04b5bd11e5654d381
 - 1,a,MD5=3801f76052cb58b5bd7fa172695828bd
- Dropbox (Changed to .MOV):
 - 0,v,MD5=85215df88c76ace04b5bd11e5654d381
 - 1,a,MD5=3801f76052cb58b5bd7fa172695828bd
- iMessage:
 - 0,v,MD5=6f92d501c9dae29c11c0c52491c2d70f
 - 1,a,MD5=d7940c42c92a03d3523e4a92bca216a2

97859A58-4B59-42EA-8C65-823B08E23C71.MP4

- Original
 - 0,v,MD5=4db256bfde710d4ffd77344f91342e7f
 - 1,a,MD5=34c92715053850214d5b7dac85944cef
- Emailed(Outlook)
 - 0,v,MD5=4db256bfde710d4ffd77344f91342e7f
 - 1,a,MD5=34c92715053850214d5b7dac85944cef
- Email (Gmail):
 - 0,v,MD5=4db256bfde710d4ffd77344f91342e7f
 - 1,a,MD5=34c92715053850214d5b7dac85944cef
- Dropbox (Changed to .MOV):
 - 0,v,MD5=4db256bfde710d4ffd77344f91342e7f
 - 1,a,MD5=34c92715053850214d5b7dac85944cef
- iMessage:
 - 0,v,MD5=5ac74230ed5f72b9b15ab7b590b68cb2
 - 1,a,MD5=6cb91de33fb759a358d525235087c040

B9F69B11-28C1-4FE6-9F90-AF6F84C3C603.MP4

- Original
 - 0,v,MD5=1b6a939b90178572cf8df828b5fc1e7b
 - 1,a,MD5=3c88b7378cfed00333baf291fd44e761
- Emailed (Outlook)
 - 0,v,MD5=1b6a939b90178572cf8df828b5fc1e7b
 - 1,a,MD5=3c88b7378cfed00333baf291fd44e761
- Email (Gmail):
 - 0,v,MD5=1b6a939b90178572cf8df828b5fc1e7b

- 1,a,MD5=3c88b7378cfed00333baf291fd44e761
- Dropbox (changed to .MOV):
 - 0,v,MD5=1b6a939b90178572cf8df828b5fc1e7b
 - 1,a,MD5=3c88b7378cfed00333baf291fd44e761
- iMessage:
 - 0,v,MD5=f867a21152accfb4c67356a361c9f3d9
 - 1,a,MD5=3c88b7378cfed00333baf291fd44e761

F2585A49-C964-47E0-A62F-1BB42796500A.MP4

- Original
 - 0,v,MD5=4fadb34df715ceee2f2bd22efd4f7256
 - 1,a,MD5=d5d887d990ed082c4c360ca8af5d2e6f
- Emailed (Outlook)
 - 0,v,MD5=4fadb34df715ceee2f2bd22efd4f7256
 - 1,a,MD5=d5d887d990ed082c4c360ca8af5d2e6f
- Email (Gmail):
 - 0,v,MD5=4fadb34df715ceee2f2bd22efd4f7256
 - 1,a,MD5=d5d887d990ed082c4c360ca8af5d2e6f
- Dropbox:
 - 0,v,MD5=4fadb34df715ceee2f2bd22efd4f7256
 - 1,a,MD5=d5d887d990ed082c4c360ca8af5d2e6f
- iMessage:
 - 0,v,MD5=52abbe0cef76460a4e16d53b00e36c67
 - 1,a,MD5=39370bbeda02fe233417adb1551379c3

WANSVIEW (had no audio)

WVCB8HNIPBZ7UTWN_2023-02-08_13-53-33.MP4

- Original
 - 0,v,MD5=82f4d1f4f4b50f3736feda038e918ace
- Emailed(Outlook)
 - 0,v,MD5=82f4d1f4f4b50f3736feda038e918ace
- Email (Gmail):
 - 0,v,MD5=82f4d1f4f4b50f3736feda038e918ace
- Dropbox:
 - 0,v,MD5=82f4d1f4f4b50f3736feda038e918ace
- iMessage:
 - 0,v,MD5=609418eee8124911c0da88334fdb79ec

WVCB8HNIPBZ7UTWN_2023-02-08_13-54-07.MP4

- Original
 - 0,v,MD5=98b79c9d88da40b7bb1b13b70df74eac
- Emailed(Outlook)
 - 0,v,MD5=98b79c9d88da40b7bb1b13b70df74eac
- Email (Gmail):
 - 0,v,MD5=98b79c9d88da40b7bb1b13b70df74eac
- Dropbox:
 - 0,v,MD5=98b79c9d88da40b7bb1b13b70df74eac
- iMessage:
 - 0,v,MD5=aebeebd447ad56c933880783c2618732

WVCB8HNIPBZ7UTWN_2023-02-08_13-54-38.MP4

- Original
 - 0,v,MD5=8f45e843ba5d4d2b5c9645b35d40ef5b
- Emailed(Outlook)
 - 0,v,MD5=8f45e843ba5d4d2b5c9645b35d40ef5b
- Email (Gmail):
 - 0,v,MD5=8f45e843ba5d4d2b5c9645b35d40ef5b
- Dropbox:
 - 0,v,MD5=8f45e843ba5d4d2b5c9645b35d40ef5b
- iMessage:
 - 0,v,MD5=f91539065521129e713a15f98023b1f0

WVCB8HNIPBZ7UTWN_2023-02-08_14-37-51.MP4

- Original
 - 0,v,MD5=e3921e8db2635b5a240f0bb72e3e8434
- Emailed(Outlook)
 - 0,v,MD5=e3921e8db2635b5a240f0bb72e3e8434
- Email (Gmail):
 - 0,v,MD5=e3921e8db2635b5a240f0bb72e3e8434
- Dropbox:
 - 0,v,MD5=e3921e8db2635b5a240f0bb72e3e8434
- iMessage
 - 0,v,MD5=e3921e8db2635b5a240f0bb72e3e8434

WVCB8HNIPBZ7UTWN_2023-02-11_12-09-43.MP4

- Original
 - 0,v,MD5=686eee5abd693d89e696b3b200e7ce2e
- Emailed(Outlook)
 - 0,v,MD5=686eee5abd693d89e696b3b200e7ce2e
- Email (Gmail):
 - 0,v,MD5=686eee5abd693d89e696b3b200e7ce2e
- Dropbox:
 - 0,v,MD5=686eee5abd693d89e696b3b200e7ce2e
- iMessage:
 - 0,v,MD5=f91539065521129e713a15f98023b1f0

WVCB8HNIPBZ7UTWN_2023-02-11_12-10-10.MP4

- Original
 - 0,v,MD5=38d9d8dd36300ec695a68b8bae13c8cd
- Emailed(Outlook)
 - 0,v,MD5=38d9d8dd36300ec695a68b8bae13c8cd
- Email (Gmail):
 - 0,v,MD5=38d9d8dd36300ec695a68b8bae13c8cd
- Dropbox:
 - 0,v,MD5=38d9d8dd36300ec695a68b8bae13c8cd
- iMessage:
 - 0,v,MD5=08c6e6f1df0b346800b4c4e909e656ed

WVCB8HNIPBZ7UTWN_2023-02-11_12-10-41.MP4

- Original
 - 0,v,MD5=c913de17029c0fd0142db27099cabfe7
- Emailed(Outlook)
 - 0,v,MD5=c913de17029c0fd0142db27099cabfe7
- Email (Gmail):
 - 0,v,MD5=c913de17029c0fd0142db27099cabfe7
- Dropbox:
 - 0,v,MD5=c913de17029c0fd0142db27099cabfe7
- iMessage:
 - 0,v,MD5=c7d25733341b416fae223295cbd0865c

WVCB8HNIPBZ7UTWN_2023-02-11_12-11-11.MP4

- Original
 - 0,v,MD5=5f12a97fb157fae5a006c4d3635ff630
- Emailed(Outlook)
 - 0,v,MD5=5f12a97fb157fae5a006c4d3635ff630
- Email (Gmail):
 - 0,v,MD5=5f12a97fb157fae5a006c4d3635ff630
- Dropbox:
 - 0,v,MD5=5f12a97fb157fae5a006c4d3635ff630
- iMessage:
 - 0,v,MD5=c07f08918ef8d378376d4c844ff3ed4e

WVCB8HNIPBZ7UTWN_2023-02-11_12-11-40.MP4

- Original
 - 0,v,MD5=23e5dc304daa2108635ba2f12b86162b
- Emailed(Outlook)
 - 0,v,MD5=23e5dc304daa2108635ba2f12b86162b
- Email (Gmail):
 - 0,v,MD5=23e5dc304daa2108635ba2f12b86162b
- Dropbox:
 - 0,v,MD5=23e5dc304daa2108635ba2f12b86162b
- iMessage:
 - 0,v,MD5=0b73452d8d80a44c7bdd68dbe14cbdbb

WVCB8HNIPBZ7UTWN_2023-02-11_12-18-23.MP4

- Original
 - 0,v,MD5=8269eced247d398b3beac9b396d31199
- Emailed(Outlook)
 - 0,v,MD5=8269eced247d398b3beac9b396d31199
- Email (Gmail):
 - 0,v,MD5=8269eced247d398b3beac9b396d31199
- Dropbox:
 - 0,v,MD5=8269eced247d398b3beac9b396d31199
- iMessage:
 - 0,v,MD5=b9d70253eda92397fb6a2207f9193b3d

VIVINT

Doorbell-2023-01-18--081663c80d75e1096548dec6a07d.mp4

- Original:
 - 0,v,MD5=71833e27261f61352fa9cd7eda568526
 - 1,a,MD5=5514f2e0a7184eecf251a4b59c1f5173
- Emailed(Outlook):
 - 0,v,MD5=71833e27261f61352fa9cd7eda568526
 - 1,a,MD5=5514f2e0a7184eecf251a4b59c1f5173
- Email (Gmail):
 - 0,v,MD5=71833e27261f61352fa9cd7eda568526
 - 1,a,MD5=5514f2e0a7184eecf251a4b59c1f5173
- Dropbox:
 - 0,v,MD5=71833e27261f61352fa9cd7eda568526
 - 1,a,MD5=5514f2e0a7184eecf251a4b59c1f5173
- iMessage:
 - 0,v,MD5=b71ccac00bbadedbff5dad2c2914fa99
 - 1,a,MD5=2ed608f56b2848a4ef9ec80af712429a

Doorbell-2023-01-18--105463c83290e1096548dec6a08c.mp4

- Original:
 - 0,v,MD5=42e76efb02c1aa69ad81078dfdff32c9
 - 1,a,MD5=04da7602d92a9868f8c07bb69943500e
- Emailed(Outlook):
 - 0,v,MD5=42e76efb02c1aa69ad81078dfdff32c9
 - 1,a,MD5=04da7602d92a9868f8c07bb69943500e
- Email (Gmail):
 - 0,v,MD5=42e76efb02c1aa69ad81078dfdff32c9
 - 1,a,MD5=04da7602d92a9868f8c07bb69943500e
- Dropbox:
 - 0,v,MD5=42e76efb02c1aa69ad81078dfdff32c9
 - 1,a,MD5=04da7602d92a9868f8c07bb69943500e
- iMessage:
 - 0,v,MD5=37af302323baa701bb6d304a63d41826
 - 1,a,MD5=27f7e630231677d867dc51f104f0c62d

Doorbell-2023-01-23--085363ceadb6e1096548dec6a14e.mp4

- Original:
 - 0,v,MD5=25ddbe08af3c7e846b54fa4f1d80ca2e
 - 1,a,MD5=ebe2b8df723a1a6d96b3035e4863960d
- Emailed(Outlook):
 - 0,v,MD5=25ddbe08af3c7e846b54fa4f1d80ca2e
 - 1,a,MD5=ebe2b8df723a1a6d96b3035e4863960d
- Email (Gmail):
 - 0,v,MD5=25ddbe08af3c7e846b54fa4f1d80ca2e
 - 1,a,MD5=ebe2b8df723a1a6d96b3035e4863960d
- Dropbox:
 - 0,v,MD5=25ddbe08af3c7e846b54fa4f1d80ca2e
 - 1,a,MD5=ebe2b8df723a1a6d96b3035e4863960d
- iMessage:
 - 0,v,MD5=9d6ab38c6cc45aef3a8725f98f8f2d4d
 - 1,a,MD5=9563e106725ade2cb445ded839b2aace

Doorbell-2023-01-23--091663ceb2e2e1096548dec6a155.mp4

- Original:
 - 0,v,MD5=9522c79335068ec663bb257120b2bcc0
 - 1,a,MD5=7b3bc2ca865461cccd3212c0c5e03ddb
- Emailed(Outlook):
 - 0,v,MD5=9522c79335068ec663bb257120b2bcc0
 - 1,a,MD5=7b3bc2ca865461cccd3212c0c5e03ddb
- Email (Gmail):
 - 0,v,MD5=9522c79335068ec663bb257120b2bcc0
 - 1,a,MD5=7b3bc2ca865461cccd3212c0c5e03ddb
- Dropbox:
 - 0,v,MD5=9522c79335068ec663bb257120b2bcc0
 - 1,a,MD5=7b3bc2ca865461cccd3212c0c5e03ddb
- iMessage:
 - 0,v,MD5=17aaeab17097e0437b5fa977b4db0683
 - 1,a,MD5=663d549026b7f6068ab7badd2cfd2715

Doorbell-2023-01-23--091863ceb380e1096548dec6a159.mp4

- Original:
 - 0,v,MD5=dbf7318562db0ce733a45f42d68b2559

- 1,a,MD5=497952f54089981788c901abf492b91e
- Emailed(Outlook):
 - 0,v,MD5=dbf7318562db0ce733a45f42d68b2559
 - 1,a,MD5=497952f54089981788c901abf492b91e
- Email (Gmail):
 - 0,v,MD5=dbf7318562db0ce733a45f42d68b2559
 - 1,a,MD5=497952f54089981788c901abf492b91e
- Dropbox:
 - 0,v,MD5=dbf7318562db0ce733a45f42d68b2559
 - 1,a,MD5=497952f54089981788c901abf492b91e
- iMessage:
 - 0,v,MD5=734693c726e422fe9f8b90f1934891cc
 - 1,a,MD5=401b7c75edbe28a55d7fe6fcd7632e39

Doorbell-2023-01-23--092263ceb452e1096548dec6a15c.mp4

- Original:
 - 0,v,MD5=5b31578399797852c944599e62841ee1
 - 1,a,MD5=4ba743c2260821ae02b270179e0466a8
- Emailed(Outlook):
 - 0,v,MD5=5b31578399797852c944599e62841ee1
 - 1,a,MD5=4ba743c2260821ae02b270179e0466a8
- Email (Gmail):
 - 0,v,MD5=5b31578399797852c944599e62841ee1
 - 1,a,MD5=4ba743c2260821ae02b270179e0466a8
- Dropbox:
 - 0,v,MD5=5b31578399797852c944599e62841ee1
 - 1,a,MD5=4ba743c2260821ae02b270179e0466a8
- iMessage:
 - 0,v,MD5=7452770c62d90ec61bf88e5ba7af4d3d
 - 1,a,MD5=663d2a134d9ddcd34cc7efc326616194

Doorbell-2023-01-23--144863cf0128e1096548dec6a164.mp4

- Original:
 - 0,v,MD5=bf2fe4e225e2c3cc444443532d1f4538
 - 1,a,MD5=9155d485e86d5c0ce521a2e4fd2e4cb7
- Emailed(Outlook):
 - 0,v,MD5=bf2fe4e225e2c3cc444443532d1f4538
 - 1,a,MD5=9155d485e86d5c0ce521a2e4fd2e4cb7

- Email (Gmail):
 - 0,v,MD5=bf2fe4e225e2c3cc444443532d1f4538
 - 1,a,MD5=9155d485e86d5c0ce521a2e4fd2e4cb7
- Dropbox:
 - 0,v,MD5=bf2fe4e225e2c3cc444443532d1f4538
 - 1,a,MD5=9155d485e86d5c0ce521a2e4fd2e4cb7
- iMessage:
 - 0,v,MD5=af306271904c30478b9b9035d5693688
 - 1,a,MD5=0982f902b014d3403b365add209a26f0

Doorbell-2023-01-24--113063d023d6e1096548dec6a180.mp4

- Original:
 - 0,v,MD5=3ed4ab5a35dabb1bd2e7369107e77c6e
 - 1,a,MD5=56bf4eb02b0a1523625074d72bd73a7e
- Emailed(Outlook):
 - 0,v,MD5=3ed4ab5a35dabb1bd2e7369107e77c6e
 - 1,a,MD5=56bf4eb02b0a1523625074d72bd73a7e
- Email (Gmail):
 - 0,v,MD5=3ed4ab5a35dabb1bd2e7369107e77c6e
 - 1,a,MD5=56bf4eb02b0a1523625074d72bd73a7e
- Dropbox:
 - 0,v,MD5=3ed4ab5a35dabb1bd2e7369107e77c6e
 - 1,a,MD5=56bf4eb02b0a1523625074d72bd73a7e
- iMessage:
 - 0,v,MD5=514f8bffce8b78c2e554ac234a1d7c04
 - 1,a,MD5=fd6e6deb00c03f00bd90d7d089a7ed08

Doorbell-2023-01-25--110063d16e4de1096548dec6a1a8.mp4

- Original:
 - 0,v,MD5=7d18177854f69359e035d1ff4a1b376c
 - 1,a,MD5=e3edc60ec529117ed8a122e4c3048592
- Emailed(Outlook):
 - 0,v,MD5=7d18177854f69359e035d1ff4a1b376c
 - 1,a,MD5=e3edc60ec529117ed8a122e4c3048592
- Email (Gmail):
 - 0,v,MD5=7d18177854f69359e035d1ff4a1b376c
 - 1,a,MD5=e3edc60ec529117ed8a122e4c3048592
- Dropbox:

- 0,v,MD5=7d18177854f69359e035d1ff4a1b376c
- 1,a,MD5=e3edc60ec529117ed8a122e4c3048592
- iMessage:
 - 0,v,MD5=d646b8ba4889f8a85b18387e868ef05d
 - 1,a,MD5=1917840736c07311d3882bd630d1bd84

Doorbell-2023-01-26--145663d2f748e1096548dec6a1e9.mp4

- Original:
 - 0,v,MD5=449a2a947057c3a443968593230a96b8
 - 1,a,MD5=8c0f97b26a9461970c8daadaa3ca06b8
- Emailed(Outlook):
 - 0,v,MD5=449a2a947057c3a443968593230a96b8
 - 1,a,MD5=8c0f97b26a9461970c8daadaa3ca06b8
- Email (Gmail):
 - 0,v,MD5=449a2a947057c3a443968593230a96b8
 - 1,a,MD5=8c0f97b26a9461970c8daadaa3ca06b8
- Dropbox:
 - 0,v,MD5=449a2a947057c3a443968593230a96b8
 - 1,a,MD5=8c0f97b26a9461970c8daadaa3ca06b8
- iMessage:
 - 0,v,MD5=0f46c6a00b088c1e9a5bf8b3978fbf3a
 - 1,a,MD5=976f5f63a22b9c2d05656e2e94a8f38f

Appendix B – Hash File Results

PETCUBE RESULTS:

FILE NAME	MD5	SHA1
04C3E4FE-477D-4895-8B03-7C08DB4B235D.MP4	b6efd9ea056c5f2335ce18da6e5d24eb	22368f0d4af6a11571913df07223b3338cddb13c
4A9F64A4-BF52-48CC-9D83-B41B647F3AB1.MP4	2a79a0e432a8dc56225118ce7db75732	f75a68a5c39c168effcc6b002ebaff8e7d09de10
4AAB37A3-109B-49A6-B3EA-6A75187CCC34.MP4	f54f83b403639c766c299b42c8a0f4ce	7f1b7a784d90698f4331532a55c03d3aa74d2683
65B4EC45-D2ED-4F89-9C41-3A0B69815249.MP4	16a2334b3da63b8da009f24bed4d7c4e	0cc85f1bf578559f1a85a22e65a3057e25d5a61b
6D8B0405-17A8-47F0-A792-A9F5DE87060C.MP4	0baf1102d6cbf15c4e1ae6cbab6f7f2a	1409c8dc32c79f65645f737623b767c1fb19985e
784D8677-7AE7-41B5-8195-93CC4DA50945.MP4	95929bbb60439bf992125dd72e30901a	b8f0402e74407d93712234a46cea4c5a40f4177c
8F1C5359-F1BC-4017-A719-C7B87778DA3C.MP4	6000514ef0b71efa82bd7d21b7b5e28b	18d7383aeba7a811fdd94515e4f4b19497ff6985

PETCUBE RESULTS: CONTINUED

FILE NAME	MD5	SHA1
97859A58-4B59- 42EA-8C65- 823B08E23C71.MP4	15fb5eb1b1fe1ec2b92c81932193eda2	cd902f0dd037c0716a711ef23dc63f0112a90504
B9F69B11-28C1- 4FE6-9F90- AF6F84C3C603.MP4	877cb9424b249f81763549761e20aea7	202051a1eeab3c51e1c34f99569006408c2dff6
F2585A49-C964- 47E0-A62F- 1BB42796500A.MP4	0b11675b5d552c238f734619bca80c52	b7226a7084bf2c59306f723e62b160d5062f758c

WANSVIEW RESULTS:

FILE NAME	MD5	SHA1
WVCB8HNIPBZ7UTWN_2023- 02-08_13-53-33.MP4	edb338420cccd3e615824ca552a1ae93	1f98ec2e911ffb919313cebb77174e975cf29e58
WVCB8HNIPBZ7UTWN_2023- 02-08_13-54-07.MP4	9a2d3b5e7a765b66c3506cd8411c6b18	b2d4f3d68befb3a5f5bf2929d36685f8d8cccf03
WVCB8HNIPBZ7UTWN_2023- 02-08_13-54-38.MP4	25316ed2f4dfd161da9799b2e3b0be4f	e40918d31e05b1ff732364f0e663a135d4aa345b
WVCB8HNIPBZ7UTWN_2023- 02-08_14-37-51.MP4	c680a8efb4102bd2063aa4a7e932c203	c66fadba065abe7e0f9c0825e161e815b62727c6

WANSVIEW RESULTS: COTINUED

FILE NAME	MD5	SHA1
WVCB8HNIPBZ7UTWN_2023-02-11_12-09-43.MP4	067d4b214fe34d70d4e2b6f75104c7da	7e58905fa4261865e85b2afe4a866cc25ea3009c
WVCB8HNIPBZ7UTWN_2023-02-11_12-10-10.MP4	2b5a95b3d0dcf956e05543ef763e1913	92efa8bf0b8895197ca04f155cee596e8995e4d0
WVCB8HNIPBZ7UTWN_2023-02-11_12-10-41.MP4	23d77e3a718deb8a0342902ba00fa964	df6f4d4f647e346f6f2172f5ea43a7fb69a5a227
WVCB8HNIPBZ7UTWN_2023-02-11_12-11-11.MP4	d6d7df8edcb0b45b11cf734b87260964	50c9f14782a2e272591246f8e7859362a7ca0366
WVCB8HNIPBZ7UTWN_2023-02-11_12-11-40.MP4	32cd810c5db7b72966ee5a224c58dd95	5d107e1416c603d15af2e8f54e7815b59a543343
WVCB8HNIPBZ7UTWN_2023-02-11_12-18-23.MP4	5176f2c790848884e3864babf540cb62	f84ffd5253a34c7e189bdf5ce3f9488727be79f5

VIVINT RESULTS:

FILE NAME	MD5	SHA1	SHA256
Doorbell-2023-01-23--085363ceadb6e1096548dec6a14e.mp4	69E71D719197F3FE245929E50CF7B0D5	8129F9CD4A3EDAB87D51CAA3E342073E686556B4	69A4830C22C977F0AE1F77B11378BE516064809944E55A600D74266965DFF754
Doorbell-2023-01-23--091663ceb2e2e1096548dec6a155.mp4	0097C8FE970DD49EBD5BA337C76A091C	F50305E2A9050C85BF6B2A96729E35E62B4DBC9A	41571A7F3D547B9FDF9A89938092FEA0964FA05C0B1FB905D817D383B3B2D20A
Doorbell-2023-01-23--092263ceb452e1096548dec6a15c.mp4	A1D79A1F7779CCA271A0471787A7EA8E	1EF0F525A02B855D658015B8F83DCE7C01531DFD	F4182381F63C6EF255E6B80381175C464896D718BDDDBDEB61A02D482A2A156A4
Doorbell-2023-01-26--145663d2f748e1096548dec6a1e9.mp4	67851798EC3C9491F53C71565BB1C61F	C46E6B8DCA9A884F704BD2F49238847194C94D0A	7B41027D3BB92291FF1D28AA8B576BF244558F9C5B786D4AC88F7107A0617EB2
Doorbell-2023-01-23--091863ceb380e1096548dec6a159.mp4	CCA320208A7047FC8623A0EEF5DD650A	3A211A355EA1421FD004466FBDB06BADF086CE11	3D6FD870044A5901977E3C425F8A4AB476881CB9FC3D45FC3F342BAB036E0B83

VIVINT RESULTS: CONTINUED

FILE NAME	MD5	SHA1	SHA256
Doorbell-2023-01-24--113063d023d6e1096548dec6a180.mp4	D048E6DC434BD438B CD574F53385B4B8	59917515A32802C474AB92 A89CD7BC021404C842	F5E27446B9BB664B0C91CBDEE2086AC619 D475201D55A5C37247B758F9BF1E88
Doorbell-2023-01-23--144863cf0128e1096548dec6a164.mp4	BD1989119A83FAC42 A5B5FE69F5A5230	02A74DFD0101A5D73317A 44726764582BF67CEA8	89D75768D37E3F96634CCDCCFF474953B7 826FE3F40E60E87996AF8E88E430C6
Doorbell-2023-01-25--110063d16e4de1096548dec6a1a8.mp4	6D81A5A9827029509 693286D856AB198	7A2E234CCD56B0993A8FC 61EB3DDD337CDCE2578	F5EB75860726EDE47D8DBD2F2655FB77FC 6ACEDAEE4DB945FBD999ABF564B30B
Doorbell-2023-01-18--105463c83290e1096548dec6a08c.mp4	591B39674747F94AF A10A42857CFCF48	C014D43B88CAFEF27B810E 13C1F2595CBE81D214	665A30A1911649CF1DB016328C3C163003 4448D745E04D01C782F59D4B3A5C6B
Doorbell-2023-01-18--081663c80d75e1096548dec6a07d.mp4	07C20DA451EFB91F6 D35962C771B97AB	B6D08CF7D011F5DA73EE5 9854A22BDC9F36562B7	E9EF9551A5A56CF7AE8B82CADA585DA84B EC432D31FDAF738D7F618E57AEF01E