Video Steganography

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1. Introduction

Steganography is the practice of concealed communication where the existence of the message is a secret (Cole, 2003) . The term steganography is derived from two Greek words: “Steganos” and “graphia”, meaning “covered” and “writing” respectively (Fridrich, 2010).

Steganography is an ancient practice which dates back thousands of years and has notably been used for the protection and concealment of military communications as early as the Ancient Greeks. Herodotus, author of one of the earliest accounts of Steganography, tells us of how his master, Histiaeus, tattooed a message onto the scalp of one of his slaves. The slave was then send onwards to deliver the message once his hair had grown back, concealing the message (Fridrich, 2010) (Cole, 2003).

Whilst Steganography is not a new practice, few people understand the applications of steganography in society today. With the birth of the Information Age steganography has developed rapidly, exposing new techniques, algorithms and methods for hiding information in digital media such as audio and image files.

Steganography in audio and image files has been extensively researched, and there are plenty of steganography tools on the internet that will allow you to hide messages in these files. In comparison, there has been little research into the area of video steganography.

Video files are ideal container files for hiding large quantities of information. Steganographic capacity (the amount of information that can be hidden) is always an important factor when developing a steganographic algorithm; video files are significantly larger than audio and image files, allowing more information to be hidden inside a container.

2. Project

This project will explore video steganography, and the different techniques that can be used to conceal data in a video container (techniques to be explored are detailed in the Analysis section). The effectiveness of each attempted algorithm will be evaluated using steganalysis (Zhao, Wang, & Khan, 2011). Current research in video steganography generally centres on the concealment of data in the picture stream only. This project will look at exploiting both the audio and picture stream, with the intention of yielding a large steganography capacity that is undetectable.

During the evaluation of the different encoding methods, I will be performing statistical and observational analysis. For the observational analysis I will be surveying a wide range of people to gauge how affective each technique is when observed by an independent entity. Statistical analysis will be used in an attempt to scientifically detect if there is data hidden in a suspected container file. Observational analysis will be used to determine whether there is any human-noticeable degradation in video quality.

3. Preliminary Research

I have started researching the fundamentals of steganography and video encoding. To date, I have started reading the following resources:

- Fridrich, J. (2010). Steganography in Digital Media: Principles, Algorithms and Applications. Cambridge University Press.

- Cole, E. (2003). Hiding in Plain Sight: Steganography and the Art of Covert Communication. Wiley Publishing, Inc.
- Mukhopadhyay, J. (2011). Image and Video Processing in the Compressed Domain. CRC Press.

I have also started investigating the practicality of the steganographic methods and techniques that are discussed in the above literature. I have investigated and experimented with LSB (least significant bit) encoding methods for audio and video files. I have produced a tool written in Java that is capable of encoding data in the LSB of each pixel of an image, and the LSB of each sample of an audio file. These tools can be found and used online at http://www.steganosaur.us, this is a supporting website that I have setup for my dissertation that provides access to the Java audio and image steganography tools, and access to a blog that will be updated on a regular basis.

4. Analysis

This project involves investigating video steganography which encompasses the fields of: steganography, steganalysis and video (including audio) encoding. All of these fields present their own challenges and problems. With regards to steganography and video encoding, these are, without question, complex areas which have their own independent problems. These problems will need to be managed carefully, especially given how video steganography will require the merger of these two fields.

Video encoding presents a range of problems, most notably, lossy compression. Lossy compression is also a problem area for image steganography (e.g. JPEG-images). Lossy compression results in data loss when data is encoded into the chosen format (e.g. JPEG). This is a significant problem when working with steganography, which generally relies on subtle changes to data which are likely to be lost during the compression stage. There are two potential solutions to this problem that are worth investigating: use a lossless compression format, or design steganographic algorithm robust enough to survive compression. The latter option is ideal as lossy compression algorithms are prolific in audio and video codecs; however a "robust" steganographic technique may not survive statistical steganalysis undetected. Lossy compression is particularly problematic, but any form of compression can cause issues – especially when working with the compressed data. Even with a lossless compression format, a small change can result in relatively large alterations to the data when decompressed for viewing on screen.

Manipulating video files is not going to be a straightforward process. Some video formats use I-frame and delta-frames to represent the picture stream[1]. Typically, an I-frame is encoded as a JPEG image (or similar image format), and will occur in a video every four or five seconds. The frames in-between I-frames are delta-frames. Delta-frames only contain delta information, describing the changes from the previous frame. This I-frame/delta-frame composition could cause problems when manipulating frame bits, as the change to an I-frame or delta-frame will propagate through the successor frames until the next I-frame is reached. To put it simply, modifying a single pixel could affect pixels on numerous frames, and to varying degrees.

[1] http://nickyguides.digital-digest.com/keyframes.htm

Steganography will also prove a challenge in this project. In contrast, in the field of cryptography, an encrypted message is only broken once the attacker knows the content of the message. Steganography is deemed “broken” if the presence of a message is detected, regardless of whether the message has been read or understood. Developing a method of encoding in a video format that is capable of going undetected by statistical steganalysis and produces no noticeable degradation is going to require careful design and experimentation.

5. Techniques, Tools and Solutions

The initial intention will be to perform all experimentation and development of solutions in Java. Java has a comprehensive SDK and a wide variety of libraries that should aid in the rapid development of a software solution. I intend to use open source video encoding tools (such as FFmpeg) for handling the manipulation of the video data. If this initial route does not prove to be successful (i.e. no Java wrapper for tools, etc.), I will look at interfacing directly with video encoding libraries using C++. Should I find that I need to pursue the latter option I will need to teach myself C++. C++ will be a good alternative to Java (should sufficient wrappers not exist), because the vast majority of audio and video encoding libraries are written in C++, and interacting with libraries directly in C++ will allow me to use their entire functionality and not be dependent on the quality and completeness of a wrapper.

Having explained the technologies and tools that I intend using, I will now outline the approaches I intend to initially investigate.

I plan to start basic, and progress the complexity level gradually. There are two simple approaches that I can begin with. The first involves extracting a frame from the video, and then encoding the plain text message before embedding the cover frame back into the video. Performance-wise this could prove to be a slow process when encoding large quantities of data as a large number of frames would have to be removed and re-encoded. The second basic approach involves working with frames in situ. For this method, I would examine the container file and identify which frames are the I-frames. Depending on the video format, I-frames are represented as JPEG images or use a representation that is very similar to that of JPEG. The plain text data would then be encoded into the I-frame without the need to extract and re-encode the cover frames.

The two potential techniques described above are very simple, and as such, they do not utilise the audio stream. Once I have become familiar with video encoding the intention is to develop methods that utilise the picture and audio stream together.

More advances techniques that should be investigated will involve embedding data into the delta-frames. The audio stream can also be used either as a placement key, or another area in which to embed data.

6. Plan of Action

Detailed in the table below is a plan of how I intent to allocate my time for this project.

This intention is to write chapters for the survey and analysis stage as the weeks progress. The intention is to receive feedback on chapter drafts at each stage. Weeks 10 and 11 will be dedicated to improving and preparing the draft for final submission at the beginning of Week 12

Week Commencing	Description
24 Sept 12	**Weeks 2 & 3** Background reading and writing of description stage document.
08 Oct 12	**Week 4** Investigate video and encoding, devise a method for working with video files, demonstrate an ability to encode and manipulate video files. Write Survey and Analysis - Introduction
15 Oct 12	**Week 5** Investigate video and encoding, devise a method for working with video files, demonstrate an ability to encode and manipulate video files. Write Survey and Analysis - Literary Survey
22 Oct 12	**Week 6** Investigate initial steganographic techniques. Write Survey and Analysis - Literary Survey
29 Oct 12	**Week 7** Steganalysis of techniques from Week 5 Write Survey and Analysis – Requirements and Analysis
5 Nov 12	**Week 8** Continue iterative process of developing steganographic techniques and performing steganalysis. Write Survey and Analysis – Progress, Conclusion and Project Plan
12 Nov 12	**Week 9** Continue iterative process of developing steganographic techniques and performing steganalysis. Write Survey and Analysis – Progress, Conclusion and Project Plan
19 Nov 12	**Week 10** Continue iterative process of developing steganographic techniques and performing steganalysis. Submit Survey and Analysis Draft
26 Nov 12	**Week 11** Focus on improvements and draft feedback for Survey and Analysis.
3 Dec 12	**Week 12** Submit Survey and Analysis
10 Dec 12	**Week 13** Continue iterative process of developing steganographic techniques and performing steganalysis.

Bibliography

Cole, E. (2003). *Hiding in Plain Sight: Steganography and the Art of Covert Communication.* Wiley Publishing, Inc.

Fridrich, J. (2010). *Steganography in Digital Media: Principles, Algorithms and Applications.* Cambridge University Press.

Zhao, H., Wang, H., & Khan, M. K. (2011). *Steganalysis for palette-based images using generalized difference image and color correlogram.*