

Chapter XI

On Steganalysis and Clean Image Estimation

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ABSTRACT

Steganalysis is the art and science of detecting hidden information. Modern digital steganography has created techniques to embed information near invisibly into digital media. This chapter explores the idea of exploiting the noise-like qualities of steganography. In particular, the art of steganalysis can be defined as detecting and/or removing a very particular type of noise. This chapter first reviews a series of steganalysis techniques including blind steganalysis and targeted steganalysis methods, and highlights how clean image estimation is vital to these techniques. Each technique either implicitly or explicitly uses a clean image model to begin the process of detection. This chapter includes a review of advanced methods of clean image estimation for use in steganalysis. From these ideas of clean image estimation, the problems faced by the passive warden can be posed in a systematic way. This chapter is concluded with a discussion of the future of passive warden steganalysis.

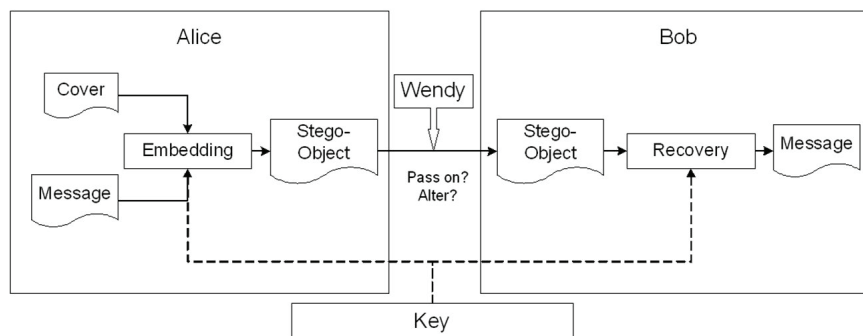
INTRODUCTION

The *prisoner's problem* was introduced in 1982 by Gus Simmons (Simmons, 1984),

Two accomplices in a crime have been arrested and are about to be locked in widely separated

cells. Their only means of communication after they are locked up will be the way of messages conveyed for them by trustees—who are known to be agents of the warden. The warden is willing to allow the prisoners to exchange messages in the hope that he can deceive at least one of them into accepting as a genuine communication from

Figure 1. Prisoner's problem



the other either a fraudulent message created by the warden himself or else a modification by him of a genuine message. However, since he has every reason to suspect that the prisoners want to coordinate an escape plan, the warden will only permit the exchanges to occur if the information contained in the messages is completely open to him—and presumably innocuous. The prisoners, on the other hand, are willing to accept these conditions, i.e., to accept some risk of deception in order to be able to communicate at all, since they need to coordinate their plans. To do this they will have to deceive the warden finding a way of communicating secretly in the exchanges, i.e. establishing a “subliminal channel” between them in full view of the warden, even though the messages themselves contain no secret (to the warden) information. Since they anticipate that the warden will try to deceive them by introducing fraudulent messages they will only exchange messages if they are permitted to authenticate them.

Thus began the modern study of steganography. The two prisoners have since been named Alice and Bob, the warden is Wendy or Eve. Figure 1 shows an illustration of the basic scenario.

The modern warden, Wendy, has a challenge. Wendy’s role is either to detect the presence of or to manipulate the message in order to prevent the undesirable escape of the two prisoners. Wendy

practices the art and science of steganalysis. The proliferation of electronic media has only increased the challenge of steganalysis.

In Wendy’s passive role, the passive warden, her primary goal is to detect the presence of steganography in a group of otherwise innocuous messages. In the modern scenario, the means of message conveyance now includes a wide array of electronic media such as the Internet and e-mail. All remain through *known agents of the warden*, that is, all messages are observable, but the number of messages and means of hiding due to the presence of electronic media has grown significantly. The sorting of legitimate messages from messages that would facilitate an escape remains a challenging problem. To do this Wendy must develop some basis for a *normal* message.

This chapter explores the role of the passive warden and how to exploit the noise-like properties of modern steganography for the purposes of steganalysis. Here the focus is on image-based digital steganography. An overview of the topics covered appears in Figure 2. The next section introduces various forms of steganalysis, highlighting how clean image estimation is currently used in each. The third section reviews several advanced techniques for image denoising. The final section shows how these approaches can be applied to the passive warden scenario. This chapter is concluded with some discussion of the

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