Blind Statistical Steganalysis of Additive Steganography Using Wavelet Higher Order Statistics

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Development of digital communications systems significantly extended possibility to perform covert communications (steganography). This recalls an emerging demand in highly efficient counter-measures, i.e. steganalysis methods. Modern steganography is presented by a broad spectrum of various data-hiding techniques. Therefore development of corresponding steganalysis methods is rather a complex problem and challenging task. Moreover, in many practical steganalysis tasks second Kerckhoff's principle is not applicable because of absence of information about the used steganography method. This motivates to use blind steganalysis, which can be applied to the certain techniques where one can specify at least statistics of the hidden data. This paper focuses on the class of supervised steganalysis techniques developed for the additive steganography, which can be described as $y = f(x, s, K) = x + g(s, K)$, where stego image y is obtained from the cover image x by adding a low-amplitude cover image independent (±1 embedding also known as LSB matching) or cover image dependent (LSB embedding) stego signals that may be also depended on secret stego key K and the secret data s. The function $g(.)$ represents the embedding rule.

The proposed method provides the stochastic interpretation of the blind steganalysis and consists of two main stages, i.e., data preprocessing and feature extraction. The data preprocessing targets at stego signal estimation that is performed in the wavelet domain from the mixture of cover image (presented by non-stationary Gaussian model) and stego signal (presented by stationary Gaussian model). Feature extraction is realized using model-based (polynomial) approximation of stego image pdf. In this case polynomial coefficients, which simultaneously are high order statistics, have created the feature set. Because the features are calculated from the estimated stego signal, they are more sensitive to steganographic modifications while suppressing the influence of the cover image.

The proposed method is tested on various classes of images that are known to pose problems for steganalysis – never compressed raw images from digital cameras. We test the methodology on the ±1 embedding paradigm and LSB embedding. On raw grayscale digital camera images for ±1 embedding, we obtained reliable detection results for message lengths above 0.5 bits per pixel (Fig. 1). For images coming from a homogenous source, such as raw grayscale images obtained using a single camera, relatively reliable detection is even possible at the embedding rate of 0.25 bits per pixel (for ±1 embedding).

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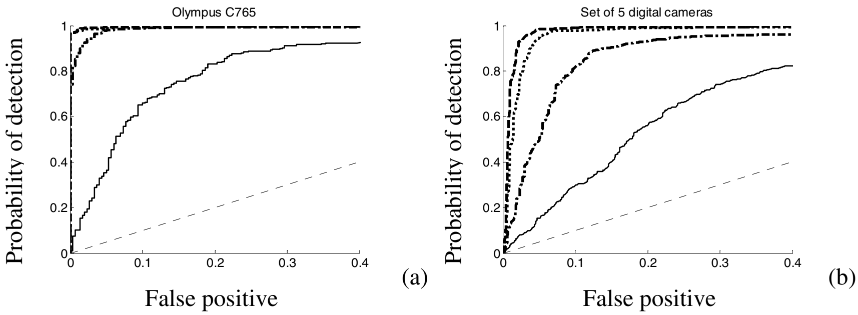

Fig. 1. ROCs for ±1 embedding for a single camera (Olympus C765) (a) and set of 5 digital cameras (Canon G2, Canon S40, Kodak DC290, Olympus C765, and Nikon D100) (b) with different embedding capacity: solid = 0.25 bits per pixel (bpp), dash-dotted = 0.5 bpp, dotted = 0.75 bbp, dashed = 1 bpp

The detection performance in decompressed JPEGs embedded with both cover image dependent and independent methods was nearly perfect even for embedding rates of 0.15 bits per pixel (Fig. 2).

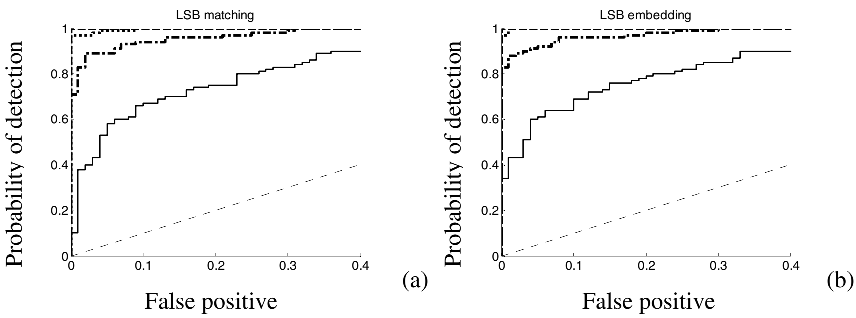

Fig. 2. ROCs for LSB matching (a) and LSB embedding (b) with different embedding capacity: solid = 0.05 bits per pixel (bpp), dash-dotted = 0.1 bpp, dotted = 0.15 bbp, dashed = 0.25 bpp in decompressed JPEG images

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