Steganalysis with Cover-Source Mismatch and a Small Learning Database

Steganalysis
Steganalysis is the study of detecting messages hidden in a support.

Eve's Job is:
1. to learn to distinguish cover images from stego images → learning step.
2. to do the steganalysis → testing step.

In the clairvoyant scenario, we decide that Eve knows:
• the algorithm(s) used by Alice,
• the payload (quantity of embedded bits) used by Alice,
• the sizes of images,
• quite well the distribution of Alice images.

The proposition to overcome the cover-source mismatch problem

• We refute the hypothesis that millions of images are necessary to overcome the problem of cover-source mismatch.
• Experiment show that EC with post-features selection (EC-FS) [4] allows to obtain better results with 100 fewer images than [2, 3].
• We introduce an additional preprocessing technique that overcomes the problem of cover-source mismatch (the islet approach).

Islet approach

Main Idea : Reducing the heterogeneity before the learning process.

Before the learning step, there are two stages:
1. Partitioning the image database in a few clusters; → K vectors {μk}Kk=1
2. Associating a classifier (EC-FS) to each cluster; → K classifiers.

During the learning step, each classifier learns and classifies only vectors that belong to its cluster.

During the testing step: Given a features vector x, to be classified:
1. A cluster k is selected such that k = arg min dist(x; μk, h)
2. The kth classifier (EC-FS) is used to classify x into cover or stego.

Results

• 1 million images from the TwitPic website,
• Images are decompressed, transformed, and cropped to 450×450,
• Spatial embedding with the HUGO [6] algorithm at 0.35 bpp,
• 3 steganalysis simulations,
• Features vector dimension is d = 34671 features [7],
• Average Pavg computed on 40 000 images never seen.

Steganalysis results:

<table>
<thead>
<tr>
<th>K islets</th>
<th>Training size per islet</th>
<th>Prediction rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>150 000</td>
<td>95.39</td>
</tr>
<tr>
<td>2</td>
<td>75 000</td>
<td>99.21% (+0.41%)</td>
</tr>
<tr>
<td>3</td>
<td>50 000</td>
<td>95.03% (+0.43%)</td>
</tr>
<tr>
<td>4</td>
<td>37 500</td>
<td>95.82% (+0.42%)</td>
</tr>
<tr>
<td>5</td>
<td>30 000</td>
<td>99.88% (+0.49%)</td>
</tr>
<tr>
<td>6</td>
<td>25 000</td>
<td>99.66% (+0.67%)</td>
</tr>
<tr>
<td>7</td>
<td>21 428</td>
<td>95.72% (+6.33%)</td>
</tr>
</tbody>
</table>

Table: Results of islets with EC-FS.

• Counter-performance of EC.
• EAP prediction rate converges around 93%.
• EC-FS prediction rate = 95% with only 50 000 learning.

Summary

• EC-FS is a very efficient tool for managing very heterogeneous data (overcomes the cover-source mismatch phenomenon),
• EC-FS prediction is better than EAP (+2.3%),
• EC-FS requires a learning set 100 times smaller than EAP (have required High Performance Computing Architectures),
• The islet approach is an additional efficient technique (+0.67%) that improves the homogeneity.

Ensemble algorithms

Definition: Cover-Source Mismatch phenomenon (= inconsistency)

Image model learned by Eve and image model used by Alice are different.

The two competing algorithms:

EAP [3] Ensemble Average Perceptron of Features

• was presented at IS&T/SPIE’2012 and MM&Sec’2012 [2, 3],
• use the very old notion of perceptron (1957) = simplest network neuron,
• has very low computational complexity O(d × L × N) and quasi null memory complexity (online algorithm),
• but necessitates million of images in the cover-source mismatch scenario.


• is scalable regarding the dimension of the features vector, has low computational complexity O(d × L × N) and low memory complexity.

Once a weak classifier is learned:

Algorithm :
1. Compute a score for each feature
2. Define an order of selection of the features
3. Find the best subset (lowest Pavg)
   → suppress the features in order to reduce Pavg

Order of complexity unchanged.

Results for Islet approach:

• Counter-performance of EC.
• EAP prediction rate converges around 93%.
• EC-FS prediction rate = 95% with only 50 000 learning.

Results for Islet approach:

1. A cluster k is selected such that k = arg min dist(x; μk, h)
2. The kth classifier (EC-FS) is used to classify x into cover or stego.

Reference: