Application of evolutionary computation to the advanced image processing

Farid Ghareh Mohammadi
Ph.D Student in Computer Science Department at University of Georgia
Outlines:

- Problem statement
- Curse of Dimensionality
- Steganography VS Steganalysis
- Preliminaries of Evolutionary algorithms
- Steganalysis Examples IFAB and RISAB
- Summary
Emerging problems:

High-Dimensional Data

- Multimedia
  - High-resolution images; High-resolution videos
  - Data from multiple sensors

- Bioinformatics
  - Expressions of genes
  - Neurons

- Social networks
  - Tweets/likes/friendships
  - Other interactions

- Weather and climate
  - Multiple measurements (e.g., temperature)
  - Time series data

- Finance
  - Stock markets
  - Time series data
Steganalysis Started getting important ...

September 11 2001
Work to be discussed

IFAB

Image steganalysis using a bee colony based feature selection algorithm
FG Mohammadi, MS Abadeh - Engineering Applications of Artificial ..., 2014 - Elsevier
Feature selection is one of the most significant phases of pre-analysis processing, which can influence the performance of steganalysis. In this paper, we have proposed a new feature-based blind steganalysis method for detecting stego images from the cover images in JPEG images using a feature selection technique based on artificial bee colony (IFAB). Most usual techniques for feature selection are wrapper methods and filter methods which IFAB is one of the wrapper based feature selection methods. Artificial bee colony (ABC) algorithm is ...

RISAB

Region based image steganalysis using artificial bee colony
FG Mohammadi, H Sajedi - Journal of Visual Communication and Image ..., 2017 - Elsevier
Steganalysis is the art and skill of discriminating stego images from cover images. Image steganalysis algorithms can be divided into two broad categories, specific and universal. In this paper, a novel universal image steganalysis algorithm is proposed which is called RISAB, Region based Image Steganalysis using Artificial Bee colony. The goal of the proposed method is to realize a sub-image from stego and cover images through ABC with respect to density according to the cover, stego and difference images. In our method, we ...
Introduction to Image Processing

The world of Computer Technology

Software

Hardware

Artificial Intelligence

Computer science

Data Mining

Image processing

Evolutionary computation

Machine Learning

Medical Imaging

Steganography & Steganalysis

ABC
Very Quick Shot

Steganography

Art of embedding messages

Art of detecting the hidden Messages

Steganalysis
Image Processing
Steganography VS Steganalysis
Steganography

WaterMarking

Cryptography

Steganography

Security level
Image Processing
Steganography VS Steganalysis

One Channel Image
- Binary
- Gray

Triple Channel Image
- RGB
- HSV

(0-255)
General Overview

Steganography VS Steganalysis

My friend Bob, until yesterday I was using binoculars for stargazing. Today, I decided to try my new telescope. The galaxies in Leo and Ursa Major were unbelievable! Next, I plan to check out some nebulae and then prepare to take a few snapshots of the new comet. Although I am satisfied with the telescope, I think I need to purchase light pollution filters to block the xenon lights from a nearby highway to improve the quality of my pictures.

Cheers,

Alice.

\[ \pi = 3.141592653589793... \]

Clear?
Preliminaries of Evolutionary algorithms

A sample solution: [20, 520, ..., 560, 34]

Solution 1
Solution 2
Solution 3
Solution 4
Solution 5
Solution 6
Solution 7
Solution 8
Solution 9
Solution 10

Parent Selection
Solution 3
Solution 7

Crossover

Offspring
New solution

Mutation
Mutated offspring
Updated solution

Replacement

Ghareh Mohammadi et al 2019
Preliminaries of Evolutionary algorithms

A sample solution: [20, 520, ..., 560, 34]

Current generation of population:
- Solution 1
- Solution 2
- Solution 3
- Solution 4
- Solution 5
- Solution 6
- Solution 7
- Solution 8
- Solution 9
- Solution 10

Generation t

Parent Selection:
- Solution 3
- Solution 7

Crossover

Offspring:
- New solution

Mutation

Mutated offspring:
- Updated solution

Next generation of population:
- Updated Solution 1
- Updated Solution 2
- Updated Solution 3
- Updated Solution 4
- Updated Solution 5
- Updated Solution 6
- Updated Solution 7
- Updated Solution 8
- Updated Solution 9
- Updated Solution 10

Generation t+1

Ghareh Mohammadi et al 2019
Preliminaries of Evolutionary algorithms

Cross over: regular combination through all generation

Mutation: Random updating solution, after crossover
Reproduction

Genome: ATTGC GCCCATGAT
ATTAA ACCCATAGT

Crossover: ATTG CGCCATGAT
ATTAA AACC CATAGT
ATTG AACC CATAGT

Mutation: ATTGAA CATAGT
ATTGAA CATCATGAT

Derived from evolutionary computation slides (Prof Rasheed)
Why Evolutionary algorithms?

AKA:  
Curse of Dimensionality (CoD) : too much information!

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Dimension</th>
<th>File</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRMQ1</td>
<td>12,753</td>
<td>SRMQ1.m</td>
<td>Spatial</td>
</tr>
<tr>
<td>SPAM</td>
<td>686</td>
<td>spam686.m</td>
<td>Spatial</td>
</tr>
<tr>
<td>CC-PEV</td>
<td>548</td>
<td>ccpev548.m</td>
<td>JPEG</td>
</tr>
<tr>
<td>J+SRM</td>
<td>35,263</td>
<td></td>
<td>Both</td>
</tr>
<tr>
<td>PSRM3 (PSRM8)</td>
<td>-34320</td>
<td>PSRM.m</td>
<td>Spatial</td>
</tr>
<tr>
<td>PSRM</td>
<td>12870</td>
<td>PSRM.m</td>
<td>Spatial</td>
</tr>
<tr>
<td>CSR</td>
<td>1183</td>
<td>CSR.m</td>
<td>Spatial</td>
</tr>
<tr>
<td>DCTR</td>
<td>8000</td>
<td>DCTR.m</td>
<td>JPEG</td>
</tr>
<tr>
<td>maxSRM</td>
<td>34,671 (12,753)</td>
<td>maxSRMq2d2.zip</td>
<td>Spatial</td>
</tr>
<tr>
<td>SCRMQ1, CRMQ1</td>
<td>12753 + 5404</td>
<td>SCRMQ1.m</td>
<td>Spatial, color</td>
</tr>
<tr>
<td>PHARM</td>
<td>12600</td>
<td>PHARM.m</td>
<td>JPEG</td>
</tr>
<tr>
<td>CFA-aware CRM</td>
<td>5514, 4146, 10323</td>
<td>SRMQ1CFA.m</td>
<td>Spatial, color</td>
</tr>
<tr>
<td>GFR</td>
<td>17000</td>
<td>GFR.m</td>
<td>JPEG</td>
</tr>
<tr>
<td>sigma-features</td>
<td>1980</td>
<td>sigma-spampSRM.m</td>
<td>spatial</td>
</tr>
</tbody>
</table>

(AKA: Curse of Dimensionality (CoD) : too much information!)
General procedure of Evolutionary algorithm

Start

Population of solutions

Selecting parents and reproduction

Met the stall condition

No

Yes

End

Ghareh Mohammadi et al 2019
General procedure of Evolutionary algorithm

1. Start
2. Pre-processing
3. Apply classification algorithms
4. Make models and test using 10CV
5. Feature extraction optimization
6. Population of solutions
7. Selecting parents and reproduction
8. Met the stall condition
   - Yes → End
   - No → Start

Ghareh Mohammadi et al 2019
Artificial Bee Colony

Presented by Karaboga in 2005

- Continues problems
- Exploring
- Exploiting
Task: gather nectars using Employed bee #=10
5 best places have been chosen by onlooker
Sending onlooker bees to be at the best places
Exploiting the best point in the environment
Choosing scout bee one at a time to explore
Goal is finding the global maximum
IFAB

Ghareh mohammadi et al 2014, 2019
IFAB

Ghareh mohammadi et al 2014
## IFAB-parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population size</td>
<td>$2 \times \text{Number of feature in data set (SPAM=686)}$</td>
</tr>
<tr>
<td>Food source</td>
<td>$\text{Number of feature in data set (SPAM=686)}$</td>
</tr>
<tr>
<td>Feature Dimension (D)</td>
<td>80</td>
</tr>
<tr>
<td>Lower Bound</td>
<td>1</td>
</tr>
<tr>
<td>Upper Bound</td>
<td>$N=\text{Number of feature in data set}$</td>
</tr>
<tr>
<td>No. of runs</td>
<td>20</td>
</tr>
<tr>
<td>Limit</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population size</td>
<td>$2 \times 548$</td>
</tr>
<tr>
<td>Food source</td>
<td>548</td>
</tr>
<tr>
<td>Feature Dimension (D)</td>
<td>80</td>
</tr>
<tr>
<td>Lower Bound</td>
<td>1</td>
</tr>
<tr>
<td>Upper Bound</td>
<td>$N=548$</td>
</tr>
<tr>
<td>No. of runs</td>
<td>20</td>
</tr>
<tr>
<td>Limit</td>
<td>100</td>
</tr>
</tbody>
</table>
IFAB

Ghareh Mohammadi et al 2014
Result-SPAM

Ghareh Mohammadi et al 2014
Result-CCPEV

Ghareh Mohammadi et al 2014
## Risab - Parameters

### Food source

RIS = Row image size  
CIS = Column image size  
PV = Pixel Value  

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population size(P)</td>
<td>$2^512$</td>
</tr>
<tr>
<td>Food source</td>
<td>$P/2$</td>
</tr>
<tr>
<td>Feature Dimension (D)</td>
<td>4</td>
</tr>
<tr>
<td>Lower Bound</td>
<td>1</td>
</tr>
<tr>
<td>Upper Bound</td>
<td>$N=548-PV$ (PV=159)</td>
</tr>
<tr>
<td>No. of runs</td>
<td>20</td>
</tr>
<tr>
<td>Limit</td>
<td>100</td>
</tr>
</tbody>
</table>
RISAB

- Training

Ghareh Mohammadi et al. 2017
RISAB

- Testing
Fig. 8. A sample of (a) test image, (b) the selected sub-image shown with a red rectangle. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
Result-SPAM

Ghareh Mohammadi et al 2017
Result - CC-PEV

Ghareh Mohammadi et al 2017
Summary

Possible image problems

Steganalysis VS Steganagrophy

ABC application

Evolutionary algorithms and Feature Extraction

Artificial Bee colony
References:

• http://ice.dlut.edu.cn/LiMing/research.html
• https://doi.org/10.1016/j.jvcir.2016.12.003
• https://www.redcom.com/introduction-to-cryptography/
• https://www.slideshare.net/ankushkr007/digital-watermarking-15450118
• Steganography in Digital Media, Principles, Algorithms, and Applications By Dr Jessica Fridrich
• http://www.ws.binghamton.edu/fridrich/
• https://www.sciencedirect.com/science/article/pii/S0952197613001905#f0010
• https://www.sciencedirect.com/science/article/pii/S1047320316302516#f0070