Part C Project Notes

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October 31, 2018

Contents

Chapter 1

Task Documentation

All timings mentioned here are approximate. The specific results can be found in Section 3.2.

1.1 Image Curation

1.1.1 Initial Image Selection

The first step was selecting which images to use for the experiments. Flickr released a massive database of millions of images and we will use those taken by one user, referred to as `actor00003`. There are $13,349$ images taken by this user and they are on the server under `/array/vlasov/actor00003`. The largest image size in this directory is 3072×2304 pixels and information about all the images is in a file called `metadata.txt` in the same directory.

I wrote a script called `initial_curation.py` to do the initial image filtering. The script uses the metadata file to identify the images that are 3072×2304 pixels, makes all of these images grayscale, rotates the portrait ones to landscape, and places the resulting images in a new subdirectory called `size3072`. The script took just under 20 minutes to run and 9539 grayscale, 3072×2304 pixel landscape images were produced.

Chapter 2

Meeting Notes

2.1 24/10/18

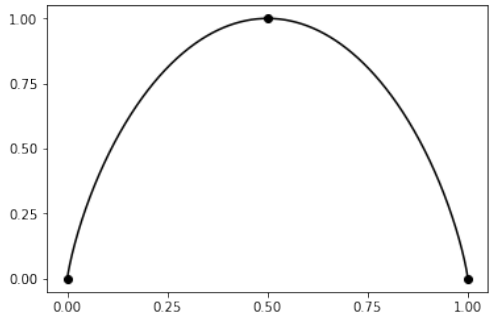
- What I did:
  - Read Chapter 3 of the Advanced Security notes on steganography
  - Wrote a script (`initial_curation.py`) to find all the largest images in the `actor00003` directory and then make them all grayscale and landscape
    - Wasn't quite working due to "`Empty input file`" error when performing multiple `jpegtran` operations
- Action plan:
  1. Calculate image sizes
     - Preserve the 4:3 aspect ratio, not because we have to but because we can and it means we can keep things as similar as possible
     - The largest image size we'll use is 3072×2304 since that's the size of the largest `actor00003` images.
     - The smallest size will be 320×240 since that's a relatively common image size (and it has a 4:3 aspect ratio)
     - The short-edge dimensions will be computed by hand by calculating $240x$ (where $x = \sqrt{1}, \sqrt{2}, ..., \sqrt{10}$) and then rounding to the nearest multiple of 24. Then the long-edge dimensions are calculated such that the 4:3 ratio is maintained.
  2. Create the directory structure on the server in `/array/vlasov/`
     - Keep a copy of all the original images in `actor00003/`
     - Create one directory per image size, called `size3072` (for instance)
     - For each size, create two subdirectories:

(a) One for the unaltered images, called `cover`
(b) One per number of payload bits, called `stego-1234bits`
- Each `cover` subdirectory will have three files per cover image:
  (a) `image12345.jpg`: the unaltered image
  (b) `image12345.costs`: the costs computed by J-UNIWARD
  (c) `image12345.fea`: the features computed by JRM
- Each `stego-1234bits` subdirectory will have one file per stego image:
  (a) `image12345.jpg`: the stego image, which is the cover image `sizeXXXX/cover/image12345.jpg` with a 1234-bit message embedded in it

3. Crop the 3072×2304 cover images to the sizes calculated in task 1. Do this by cropping 8×8 pixel blocks evenly from the top/bottom and right/left.
4. Generate the costs (using Dr. Ker's slighty modified J-UNIWARD code) and features (using JRM) for all the cover images of all the different sizes.
   - JRM produces 22510 real numbers (the features)
   - Up to me how to store them, but ASCII is probably the most portable
5. Use J-UNIWARD to embed 0.4 bits per non-zero AC coefficient in some of the covers
6. Write a function that takes a payload size (as the number of bits) as input and computes the probabilities with which each coefficient changes during (binary) embedding.
   - Goal: given the costs $c_1, c_2, ...c_N$ (where N is the total number of coefficients) of changing each coefficient (by adding/subtracting one), compute the probabilities $\pi_1, \pi_2, ..., \pi_N$ of making each of these changes
   - Size of the payload: $\sum_{i=1}^{N} H_2(\pi_i)$
     * H_2 is the "entropy" and is defined as:

$$H_2(x) = -x \times \log_2 x - (1-x) \times \log_2(1-x)$$

     * Graph of H_2:



- Average total cost: $\sum_{i=1}^{N} c_i \pi_i$
- Two (equivalent) optimization problems for computing the payload size:
  (a) Distortion-limited sender (DLS)

$$\text{Maximize } \sum_{i=1}^{N} H_2(\pi_i) \text{ such that } \sum_{i=1}^{N} c_i \pi_i \leq C$$

  (b) Payload-limited sender (PLS)

$$\text{Minimize } \sum_{i=1}^{N} c_i \pi_i \text{ such that } \sum_{i=1}^{N} H_2(\pi_i) \geq M$$

- For some fixed λ, we can compute the probabilities:

$$\pi_i = \frac{1}{1 + e^{\lambda \cdot c_i}}$$

- We'll use PLS, where M is the payload size.
  * The optimal solution is when $\sum_{i=1}^{N} H_2(\pi_i) = M$
  * $\sum_{i=1}^{N} H_2(\pi_i)$ is actually monotonically increasing, so we can find a value of λ such that $\sum_{i=1}^{N} H_2(\pi_i) = M$ for any M we choose. Then, we can compute the probabilities $\pi_1, \pi_2, ..., \pi_N$ using this value of λ.
  * The end goal is to do the embedding ourselves by modifying each coefficient with these probabilities.

- *Is 80 a standard JPEG quality factor (QF)?* In the massive image database released by Flickr, the most common QFs were 100, the QF used by iPhones, and 80. So we're using 80 because that gives us a greater selection of images.

2.2 17/10/18

- What I did:
  - Read Chapters 1 and 2 of the Advanced Security notes on steganography
  - Read the 2008 paper "The Square Root Law of Steganographic Capacity"
- Discussed questions I had about Chapter 1 (Steganography) and Chapter 2 (Steganalysis) of the Advanced Security notes and about the 2008 paper.
  - *What is downsampling?* Shrinking
  - *When you take a pictures on your phone, what happens?* Captures raw image, immediately compresses it as a JPEG, and discards the raw image
  - *What determines a cover's "source"?* Primarily the camera. The camera's ISO setting, in particular, is very important. The subject of the photos don't make much of a difference.
  - *In JPEG compression, don't you lose some information when dividing the image into 8×8 pixel blocks?* No, the DCT is linear (i.e. 1-to-1 mapping from 8×8 blocks to coefficients)
  - *Is a JPEG decompressed every time you view it on a computer?* Yes
  - *When LSBR is used on RGB images, which bit(s) are changed?* Good question - it depends, but usually the LSBs of all three components (in sync)
- After embedding a payload, the original cover is destroyed. Otherwise, two nearly identical images would be floating around and Alice could easily be outed if someone got their hands on both versions.

2.3 03/10/18

- What I did: N/A
- Discussed software to be used for embedding (J-UNIWARD), feature extraction (JRM), and detection (ensemble of linear classifiers)
  - All the software is here
- Server's IP: 163.1.88.150
- Amounts of payload to embed: $O(1)$, $O(\sqrt{n})$, $O(\sqrt{n}\log n)$, $O(n)$

- $m \sim \frac{\sqrt{DC}}{2} \log \frac{C}{D}$
- TIME EVERYTHING
- I will test new embedding and new detecting methods and I could also try old embedding and new detecting methods
- Total amount of space needed (assuming around 10,000 images are used):
  - Images: $2MB \times 10000 \times 9 \approx 180GB$
  - Costs: $8B \times 5M \times 10000 \approx 400GB$
  - Features: $170KB \times 10000 \times 9 \approx 17GB$

Chapter 3

Notes to Self

3.1 Useful Commands

- Run a command in the background so that you can keep using the terminal or close it
  - `nohup python script.py &> script_output.out &`
- Check on processes that are running
  - `ps aux | grep vlasov`

3.2 Script Timings

- `initial_curation.py`
  - $1131.18478608s \approx 18m51s$ (30/10/18)

3.3 Lessons Learned

- The input and output file to `jpegtran` can't be the same, otherwise you get an "`Empty input file`" error.