Part C Project Notes

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Chapter 1

Task Documentation

Chapter 2

Meeting Notes

2.1 24/10/18

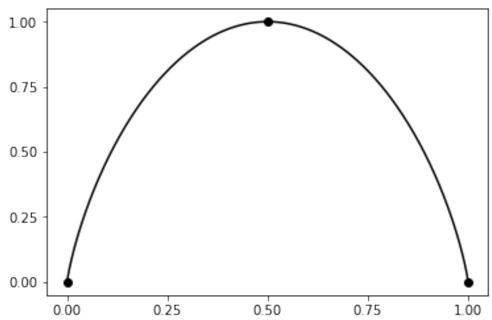
- What I did:
  - Read Chapter 3 of the Advanced Security notes on steganography
  - Wrote a script (`initial_curation.py`) to find all the largest images in the `actor00003` directory and then make them all grayscale and landscape
    - Wasn't quite working due to "`Empty input file`" error when performing 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.