Image Steganography Analysis and Detection

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Presentation Outline

Image Steganography

- Steganography is the process of hiding a secret message within a larger one in such a way that someone can not know the presence or contents of the hidden message
- Aim - To develop a detection system which is capable of detecting the alteration in image both its format and signature thereby predicting the actual type of forged file

Challenges in Forged File Discovery

- Images without watermarking as digital signatures can be easily manipulated.
- With the advent of new photo editing software - hiding critical informations are easy and unpercievable
- Task to detect mix of scaled or compressed images as one is difficult
- Incorporating machine learning techniques for feature analysis and decision making to classify the image to be forged or not
- Tamper detection to check for change in the file format extension

Presentation Outline

Image Steganography Based on Modified LSB Substitution Method and Data Mapping [1]

- Steganographic method working on the principle of Modified LSB Technique with specific intend of reducing the number of 1's in the secret data
- Methods:Each pixel value of host image is changed if value of secret bit is 1 otherwise the LSB of each pixel value will remain unchanged
- Limitation :
  - Less secure
  - Limited pixel quality
- State-of-the-art methods in terms of PSNR,SSIM
- Future work:Better data mapping mechanism for reduced storage and computational performance

Digital Image Steganography Using Modified LSB and AES Cryptography[3]

- This method ensures enhanced security of digital images
- Steps involved:
  - The secret message is transformed to cipher text by AES cryptography [
  - The cipher text is hidden inside the image using the modified LSB method
- Methods:Replacing LSB of cover image with the bits of the concealed message and manipulating the LSB plane of the cover image
- Limitation :
  - Less secure:Easy to decrypt secret message
  - Less performance
- Modified LSB shows improved performance based on PSNR,SSIM metrics
- Future work:Performance Improvement based on storage or computatational time

Image Steganography with Modified LSB and AES Encryption standards

Couple		
House		

Figure: Image Steganography with Modified LSB and AES

Boundary-based Image Forgery Detection by Fast Shallow CNN[4]

- Network (SCNN) capable of distinguishing the boundaries of forged regions from original edges in low resolution images SCNN is designed to utilize the information of chroma and saturation
- Methods:Based on SCNN:
  - Sliding Windows Detection (SWD)
  - Fast SCNN
- Methodology:
  - SWD: We start by picking a certain window of an image
  - Window is feed into SCNN and compute a confidence score to predict whether it is tampered
  - Confidence score and probablity map is maintained
  - Then the window slides over and outputs another confidence score
  - After sliding the window through the entire image, a complete probability map is constructed

Boundary-based Image Forgery Detection by Fast Shallow CNN[4]

- Fast SCNN :
  - Takes entire image as the input
  - Produces feature maps by processing the entire image with Conv layers
  - Extract feature vectors with dimension from feature maps and feed them into fully-connected layers
  - The parameters of Fast SCNN are all trained by SCNN on the patch dataset
- Limitation :
  - Less secure:Easy to decrypt secret message
  - Less performance
- Modified LSB shows improved performance based on PSNR,SSIM metrics
- Future work:Performance Improvement based on storage or computatational time

A Review on Deep Learning based Image Steganalysis [5]

- Steganalysis based on deep learning approach
- Classified as the following categories:
  - Spatial Image Steganalysis
  - JPEG Domain Steganalysis
- Deep Learning based Steganalysis
  - Spatial Domain Steganography Steganalysis based on Deep Neural Network Design
    - Spatial Rich model(SRM)
    - Steganalysis Based on Fusion Approach
    - Steganalysis methods based on Learning Strategy
  - Jpeg Domain Steganography Steganalysis based on Deep Learning
    - Convolutional Neural Network(CNN) with 20 layers
    - CNN with 32 layers combined with SCA-GFR
    - CNN with four 5 x 5 high pass filters, which include a KV filter, a point filter, and 2 Gabor filters, are used to detect stego noise introduced by JPEG-domain embedding scheme

A Review on Deep Learning based Image Steganalysis [5]

- Limitation and Mitigation:
- Acquisition and representation of statistical characteristics: Using Generative Adversarial Network(GAN)
- Low payload steganographic image detection: Combination of neural neteork design and various other techniques like training sample creation and learning
- Generalization of steganalysis: Combine Transfer Learning and Deep Learning
- Quantitative and locating image steganalysis based on deep learning
- Future work: Challenges resolution by adapting new learning and training sample techniques

Large-Scale JPEG Image Steganalysis Using Hybrid Deep-Learning Framework[7]

- Deep Learning in Image Steganalysis is still in its initial stage-A generic hybrid deep-learning framework for JPEG steganalysis incorporating the domain knowledge behind rich steganalytic models
- Stages in JPEG Steganalysis:
  - The first stage is hand-crafted, corresponding to the convolution phase followed by for rich model :
    - Quantization phase
    - Truncation phase
  - The second stage is a compound deep-neural network containing multiple deep subnets, in which the model parameters are learned in the training procedure

Large-Scale JPEG Image Steganalysis Using Hybrid Deep-Learning Framework[7]

- Proposed Model:
  - Preliminaries:
    - The principal part of CNN is a cascade of alternating convolutional layers, regulation layers (eg. BN layers) and pooling layers
- Working :
  - Each neuron unit receives inputs from a previous layer, performs a dot product with weights and optionally follows it with a nonlinear point-wise activation function
  - CNNs can be trained using backpropagation
- Quantisation and Truncation in Steganalysis:
  - Convolution with series of kernal to derive varied noise residuals
  - Quantisation
  - Truncation
  - Aggregation

Large-Scale JPEG Image Steganalysis Using Hybrid Deep-Learning Framework[7]

- Hybrid Deep Learning Approach :
  - Takes Decompressed JPEG images and performes Convolution and Quantisation,Truncation
  - The second stage is a compound deep CNN network in which the model parameters are learned in the training procedure
- Future Work :
  - Incorporation of Adversarial Machine Learning into current hybrid framework
  - Exploration of the application of hybrid framework in the field of multimedia forensics

Large-Scale JPEG Image Steganalysis Using Hybrid Deep-Learning Framework[7]

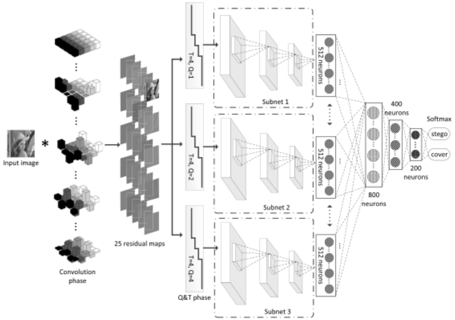


Fig. 1. Conceptual architecture of one implementation of our proposed hybrid deep-learning framework with twenty-five 5 × 5 DCT basis patterns and three Q&T combinations.

Figure: Hybrid Deep Learning Framework

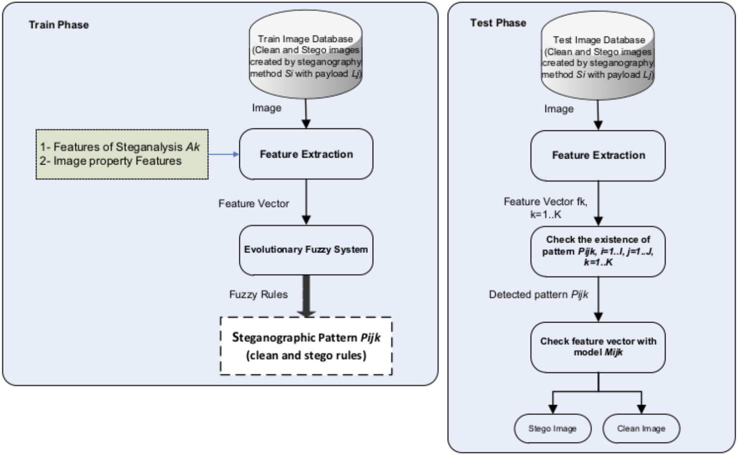
Steganalysis based on Steganography Pattern Discovery[8]

- SPD Approach:
  - Evolutionary method Steganalysis to extract the signature of stego images against clean images via fuzzy ifthen rules
  - Blind steganalysis on the discovered knowledge, suitable trained models for steganalysis can be employed and stego images will be detected with high accuracy
  - Using SPD, we can predict the type of steganography method from a stego image [Employing SPD can enhance the approaches, which assume that a special steganography method is used
  - The effect of SPD before applying steganalysis methods has been investigated by some steganography and steganalysis techniques and it has been validated using some image databases
  - The second stage is a compound deep CNN network in which the model parameters are learned in the training procedure

Steganalysis based on Steganography Pattern Discovery[8]

- Steps carried out in SPD :
  - Image Feature Selection, Two Groups as methods:
    - Filtering :Select feature subsets independently from the learning classifiers and do not include learning
    - Wrapping :Wrap around a certain learning algorithm that can assess the selected feature subsets in terms of estimated classification errors and then build the final classifiers
  - Fuzzy rule generation : Iterative Rule Learning approach, each individual codes one rule and in each iteration of Genetic Algorithm (GA) a new rule is adapted and added to the rule set, iteratively

The block diagram of Steganography pattern discovery [8]



Steganalysis based on Steganography Pattern Discovery[8]

- Feature vector generation
  - 274 dimension Steganalyser
  - 324 dimension Feature Vector - First order and second order histograms.
  - Wavelet based Steganalysis
  - 14 dimensional Feature Vector

Steganalysis based on Steganography Pattern Discovery[8]

- Fuzzy rule generation - Evolutionary method searches for a relatively smaller if-then-rules
- Certinity Factor for Fuzzy Rules :
  - Calculate the compatibility of each training sample
  - For clean and stego images, calculate the relative sum of the compatibility grades of training samples with rule R_j [
  - The grade of certainty CF_j for clean images [
- Evolutionary Fuzzy Algorithm
  - Initiation.
  - Generation.
  - Replacement.
  - Inner Cycle Termination Test.
  - Outer Cycle Termination Test.
  - Weight Adjustement.

Steganalysis based on Steganography Pattern Discovery[8]

- Evolutionary Method :
  - Extracts signature of stego images against clean images using Fuzzy if-then-rules statements
  - The Steganalyzer trained to detect only one steganography method at once
- Limitations :
  - Using Fuzzy rules increases computational complexicity
  - Only 4 Class Feature Classification - Limited Features

A Novel Image Steganography Method via Deep Convolutional Generative Adversarial Networks[9]

- A novel Steganography without Embedding (SWE), which does not need to modify the data of the carrier image, appeared to overcome the detection of machine-learning-based steganalysis algorithms
- SWE method based on deep convolutional generative adversarial networks.
  - Generative Adversarial Network (GAN)
    - GAN and discriminative model [
    - The henerative model deceives the discriminative model via generated images that appear like real images while the discriminative model judges whether the images are real or unreal.
  - Deep Convolutional Generatice Adversarial Network (DGAN)
    - Deep convolutional generative adversarial networks (DCGANs) are an extension of GANs in which the models are deep convolutional networks
    - Currently, GANs are widely used for the following works:

A Novel Image Steganography Method via Deep Convolutional Generative Adversarial Networks[9] [

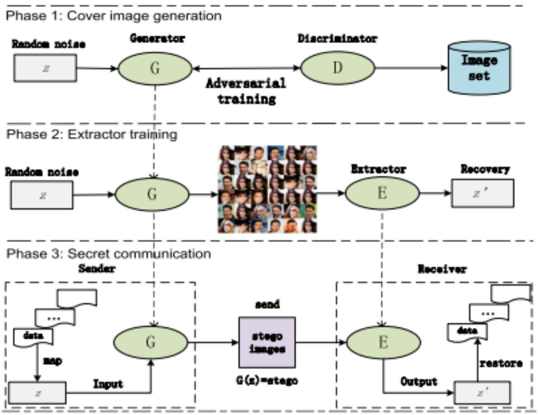


FIGURE 1. The proposed steganography framework using DCGANs for SWE.

Figure: Steganography Framework using DCGAN and SWE.

A Novel Image Steganography Method via Deep Convolutional Generative Adversarial Networks[9]

- The Proposed Image Steganography without embedding:
  - Train DCGANs on an image set and obtain generator G after DCGANs convergence.
  - Train a CNN's model, called the extractor E, based on the recovery errors from a large number of random noise vectors.
  - The sender and the receiver hold the network and parameters of G and E, respectively.
- Cover Image Generation
  - Secret message is segmented S_i and then map each segment S_i to noise vector z_i .
  - Generate a cover image stegoi from the noise vector z_i with the help of DCGANs
- Training of the Extractor
  - We design the CNNs, called the extractor E, to recover the secret data from stego images generated by G .
  - Has four convolutional fully connected layer .

A Novel Image Steganography Method via Deep Convolutional Generative Adversarial Networks[9]

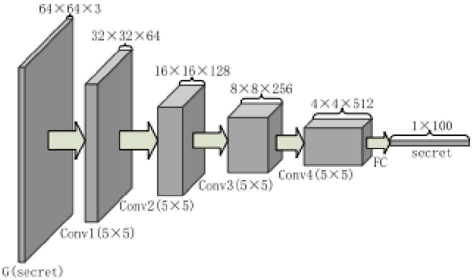


FIGURE 3. **The structure of extractor E.**

Figure: The structure of Extractor - E.

A Novel Image Steganography Method via Deep Convolutional Generative Adversarial Networks[9]

- leak-Relu activation function and batch normalization in each layer with no pooling layer or dropout operation
- Afully connected layer is used after last convolutional layer
- Train E to extract information from the generated stego images from G
- The training procedure of the extractor is,

Formula

$$L(E) = \sum_{i=1}^{n}(z - E(stego)^2) \quad (1)$$

A Novel Image Steganography Method via Deep Convolutional Generative Adversarial Networks[9]

- Secret Communication
  - Sender holds the CNNs model G and the corresponding network parameters of G and the receiver holds the CNNs model E and the corresponding network parameters of E

Presentation Outline

- **Digital Image Steganography Using Modified LSB and AES Cryptography[1]** , International Journal of Computer Science and Network Security(IJCSNS) ,Subhash Panwara , Shreenidhi Damanib , Mukesh Kumar DOI.

- **Boundary-based Image Forgery Detection by Fast Shallow CNN [4] [** , 2018 24th International Conference on Pattern Recognition (ICPR) , Zhongping Zhang , Yixuan Zhang , Zheng Zhou , Jiebo Luo , DOI.

- **A Review on Deep Learning based Image Steganalysis [5].** , 2018 IEEE 3rd Advanced Information Technology, Electronic and Automation Control Conference (IAEAC) ,Yong-he TANG, Lie-hui JIANG, Hong-qi HE, Wei-yu DONG , DOI.

- **Large-Scale JPEG Image Steganalysis Using Hybrid Deep-Learning Framework[7]** , IEEE Transactions on Information Forensics and Security , Jishen Zeng , Shunquan Tan , Bin Li , Jiwu Huang , DOI.
- **Steganalysis based on steganography pattern discovery[8]** , Journal of Information Security and Applications , Hedieh Sajedi , DOI.
- **A Novel Image Steganography Method via Deep Convolutional Generative Adversarial Networks[9].** , IEEE Access , Donghui Hu 1 , Liang Wang1 , Wenjie Jiang , Shuli Zheng , Bin Li , DOI.

- **Steganography Algorithms Recognition based on Match Image and Deep Features Verification[10].** , Multimedia Tools and Applications Journal ,Xu Xiaoyu ,Sun Yifeng Wu, Jiang , Sun Yi DOI.