Optimization of Perceptual Steganography Capacity Using the Human Visual System and Evolutionary Computation

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Dedication

I dedicate this to my parents Abdullah and Afnan for their endless support, sincere prayers and encouragements throughout my life and my PhD

I dedicate this to my husband Abdulrahman and my son Battal for their continuous love, sacrifices and patience throughout my years of study

اهداء

لحظات يقف فيها المرء حائرا عاجزا عن التعبير كما يختلج في صدره من صدره من تشكرات لأشخاص أمدوه بالكثير و الكثير ، لحظات صار لابد أن ينطق بهما اللسان و يعترف بفضل الآخرين اتجاهه لأنهم و بصراحة كانوا الأساس المتين الذي بني عليه صرح العلم و المعرفة لديه، و أناروا سبيل بلوغهما

فأهدي ثمرة جهدي التي طالما تمنيت إهدائها و تقديمها في أحلى طبق

إلى التي حملتني وهنا على وهن، و قاست و تألمت لألمي، إلى من رعتني بعطفها وحنانها و سمعت طرب الليل من أجلي، إلى أول كلمة نطقت بها شفتاي أمي الغالية أفنان.

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إلى صغيري الذي كان دافعي و مصدر اصراري و قوتي، إلى ابني و فلذة كبدي بتال

وإلى رياحين حياتي في الشدة و الرخاء إخوتي وأسرتي جميعاً.

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وفي الأخير أشكر كل من ساهم في إنجاح هذه الرسالة من بعيد أو من قريب.

Originality Statement

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signed .....

Date .....

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Abstract

Efficient solutions for the purpose of delivery of information are called for by the revolution of internet. However concerns and problems over security, distribution of digital content and encapsulation of media artifacts have arisen as a result of these phenomenal developments. Hence, it has become necessary to seek capabilities to transport and secure multimedia with its meta-data in a safe way. Steganography has evolved as an enabler of multimedia applications keeping secret communication and embedded captioning secure.

There is a tolerable outcome that occurs between imperceptibility and steganographic capacity that fit right into the mix. For instance, the more subtle elements are hidden within the cover object having higher capacity, the more degradation is exhibited towards the carrier file, resulting in an increase in the distortion attributed to the information being concealed and at the same time, decreasing the stego file quality.

Suitable use of Evolutionary Algorithm and effective use of the weaknesses of Human Visual System in steganography are investigated in this thesis. Firstly, two high capacity steganography approaches are developed with the use of aforementioned features. The first method aims to overcome the limit capacity of edge based steganography in the spatial domain. The second method proposes a proper threshold selection for each coefficient which increase the capacity of transform domain. An estimate of the embedding rate based on image complexity is also proposed. Moreover, since peak signal-to-noise ratio (PSNR) is largely used as a measure of quality of images of stego, the reliability of current quality assessment metrics for stego images is also

evaluated at the third stage. Follow by developing an Anticipatory Quality Assessment Metric for effective imperceptibility measurement.

All proposed methods are aimed to assist the optimization of the statical and visual characteristics in the cover images while hiding large size of information. To reveal impressive imperceptibility and capacity of the proposed method over the existing dilemmas, a broad range of requirements have been carried out. To indicate the utility and value of all techniques proposed, they all have been empirically validated. The main aspects of image steganography are improved by the suggestions and methods, and are revealed by the results.

Nomenclature

AQAM Anticipatory Quality Assessment Metric

BPCS Bits Plan Complexity Structure

BPP Bits per pixel

CSF Contrast Sensitivity Function

DCT Discrete Cosine Transform

DFT Discrete Fourier Transform

DoG Differences of Gaussian

DWT Discrete Wavelet Transform

EA Evolutionary Algorithm

EBE Edges based data embedding method

GA Genetic Algorithm

GP Genetic Programming

HVS Human Visual System

IQM Image Quality Metric

JND Just Noticeable Distortion

LOG Laplacian of Gaussian

LSB Least Significant Bits Substitution

LSBMR LSB Matching Revisited

MOS Mean Opinion Scores

MSE Mean Square Error

NVF Noise Visibility Function

OPAP Optimal Pixel Adjustment Process

PLCC Pearson Linear Correlation Coefficient

PM1 Plus Minus 1 Algorithm

PSNR Peak Signal to Noise Ratio

PSO Particle Swarm Optimization Algorithm

PVD Pixel Value Differencing

ROI Region of Interest

RPF Random pixel embedding method

SDoG Summation of Differences of Gaussian

SQE Subjective Quality Evaluation

SROCC Spearman Rank Order Correlation Coefficient

SSIM Structural Similarity Index

UIQI Universal Image Quality Index

WPM Watson's Perceptual Model

wPSNR Weighted Peak Signal to Noise Ratio

Terms and Definitions

- **Steganography** is the science of concealing information within another non-secret information in an invisible way. It is derived from the Greek “steganos”, meaning "covered”. Graphos is also Greek meaning "writing". Steganography mainly aims to hide the presence of the message.
- **Steganoalysis** is the science of detecting hidden message using steganography.
- **Watermarking** is a pattern of bits inserted into a digital image, audio or video file that identifies the file’s copyright information (author, rights, etc.).
- **Cryptography** is the science of transforming information into an unreadable format.
- **Embedding/Insertion** is the process of mapping one file into another.
- **Extracting** is the process of obtaining the hidden message.
- **Cover-image/carrier** is the name of the original file that used to hide the message inside it.
- **Stego-image** is the name of the file after the embedding process. The cover image and the stego image must be identical.
- **Multi-dimensional media** is the integration of several types of media into one.
- **Encapsulation** is the process of packing multi-media into a single media.
- **Imperceptibility** is the quality of non perceptibility of the hidden file.
- **Capacity** is the number of allowable bits which can be inserted safely without any visible or statistical degradation.

- **Secret Message** is the name of the file or information that is hidden from general view.
- **Metadata** is a set of data that gives details about other data.
- **Optimization** is the process of enhancing and improving the stored results as best possible.
- **Fitness Function** is an objective measure of how close one is to a given solution.
- **Perception** is the ability of noticing something through the senses.

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