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**OPTIMIZATION OF MEDICAL IMAGE STEGANOGRAPHY
USING N-DECOMPOSITION GENETIC ALGORITHM**



**DOCTOR OF PHILOSOPHY
UNIVERSITI UTARA MALAYSIA
2023**



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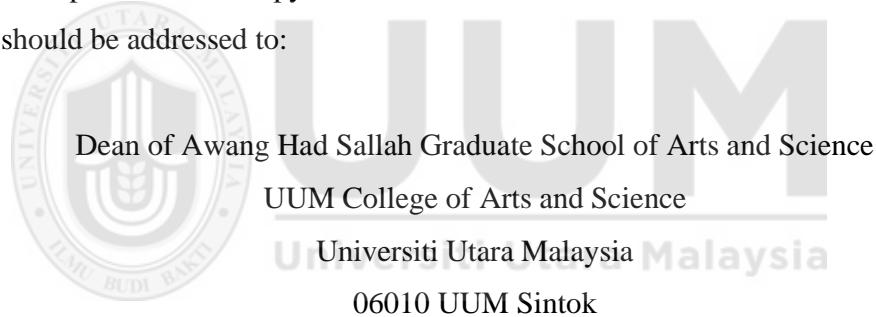
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Abstrak

Melindungi maklumat sulit pesakit adalah kebimbangan yang kritikal dalam steganografi imej perubatan. Teknik Least Significant Bits (LSB) telah digunakan secara meluas untuk komunikasi selamat. Walau bagaimanapun, ia mudah terdedah kepada ketidakjelasan dan risiko keselamatan disebabkan oleh manipulasi langsung piksel dan pengehadan corak ASCII. Akibatnya, maklumat perubatan yang sensitif terdedah kepada kehilangan atau perubahan. Walaupun terdapat percubaan untuk mengoptimumkan LSB, isu-isu ini terus berlaku disebabkan oleh (1) perumusan pengoptimuman mengalami kekangan tersirat yang tidak sah yang menyebabkan ketidakfleksibelan dalam mencapai pembenaman optimum, (2) kekurangan penumpuan dalam proses carian di mana panjang mesej memberi kesan ketara kepada saiz ruang penyelesaian, dan (3) isu kebolehsesuaian aplikasi di mana data berbeza memerlukan lebih fleksibiliti dalam mengawal proses pembenaman.

Untuk mengatasi kekangan-kekangan ini, kajian ini mencadangkan kaedah yang dikenali sebagai algoritma genetik penguraian-n. Algoritma ini menggunakan carian panjang boleh ubah untuk mengenal pasti lokasi terbaik untuk membenamkan mesej rahsia dengan memasukkan batasan bagi mengelakkan perangkap minimum tempatan. Metodologi kajian terdiri daripada lima fasa utama: (1) penyiasatan awal, (2) merumuskan skema pembenaman, (3) membina skema penguraian, (4) menyepadukan reka bentuk skema ke dalam teknik yang dicadangkan, dan (5) menilai prestasi teknik yang dicadangkan berdasarkan parameter menggunakan set data perubatan daripada kaggle.com. Teknik yang dicadangkan menunjukkan rintangan terhadap analisis statistik yang dinilai menggunakan analisis Statistik Boleh Balik (RS) dan histogram. Ia turut menunjukkan kelebihan kepada ketidakjelasan dan keselamatan yang diukur oleh MSE dan PSNR kepada set data Chest (0.0557, 0.0550) dan Retina (60.6696, 60.728). Namun, jika dibandingkan dengan keputusan yang diperoleh dari teknik yang dicadangkan, penanda aras mengatasi set data Brain oleh kerana sifat imej yang homogen dan latar belakang hitam yang luas.

Penyelidikan ini telah menyumbang kepada penguraian berasaskan genetik dalam steganografi imej perubatan dan menyediakan teknik yang menawarkan keselamatan yang lebih baik tanpa menjejaskan kecekapan dan penumpuan. Walau bagaimanapun, pengesahan lanjut diperlukan untuk menentukan keberkesanannya dalam aplikasi dunia sebenar.

Kata kunci: Teknik steganografi LSB, Algoritma genetik, Panjang berubah-ubah, Ketidakjelasan, Keselamatan.

Abstract

Protecting patients' confidential information is a critical concern in medical image steganography. The Least Significant Bits (LSB) technique has been widely used for secure communication. However, it is susceptible to imperceptibility and security risks due to the direct manipulation of pixels, and ASCII patterns present limitations. Consequently, sensitive medical information is subject to loss or alteration. Despite attempts to optimize LSB, these issues persist due to (1) the formulation of the optimization suffering from non-valid implicit constraints, causing inflexibility in reaching optimal embedding, (2) lacking convergence in the searching process, where the message length significantly affects the size of the solution space, and (3) issues of application customizability where different data require more flexibility in controlling the embedding process.

To overcome these limitations, this study proposes a technique known as an n -decomposition genetic algorithm. This algorithm uses a variable-length search to identify the best location to embed the secret message by incorporating constraints to avoid local minimum traps. The methodology consists of five main phases: (1) initial investigation, (2) formulating an embedding scheme, (3) constructing a decomposition scheme, (4) integrating the schemes' design into the proposed technique, and (5) evaluating the proposed technique's performance based on parameters using medical datasets from kaggle.com. The proposed technique showed resistance to statistical analysis evaluated using Reversible Statistical (RS) analysis and histogram. It also demonstrated its superiority in imperceptibility and security measured by MSE and PSNR to Chest and Retina datasets (0.0557, 0.0550) and (60.6696, 60.7287), respectively. Still, compared to the results obtained by the proposed technique, the benchmark outperforms the Brain dataset due to the homogeneous nature of the images and the extensive black background. This research has contributed to genetic-based decomposition in medical image steganography and provides a technique that offers improved security without compromising efficiency and convergence. However, further validation is required to determine its effectiveness in real-world applications.

Keywords: LSB steganography technique, Genetic algorithm, Variable-length, Imperceptibility, Security.

Acknowledgments

First and foremost, praise and thanks be to Allah, and may prayers and peace be upon His Messenger Muhammad (may Allah bless him and grant him peace). Then, to my dear supervisors, Assistant Professor Dr. Nur Haryani Zakaria, and Assistant Professor Dr. Nor Hazlyna Harun, I am highly grateful for the support and advice you have provided me throughout my research journey. I cannot thank you enough for your guidance and for sharing your wealth of knowledge. Experience has been invaluable and contributed significantly to my personal and professional development. Your advice and insight have helped shape my research and have given me the confidence to pursue new challenges and opportunities.

I interacted with many researchers, academics, and practitioners in preparing this thesis. Therefore, I would like to thank my colleagues without mentioning anyone's name for fear of forgetting one of them, but I believe Allah knows their efforts and puts them in the balance of their good deeds.

I want to thank my family and its members for their support and for enduring hardships throughout the study. To my father's soul, I am asking Allah to have mercy on him. Thanks to my mother's constant prayers, I ask Allah to bless her with health and wellness. Thanks to my brothers, thanks to my sisters, thanks to my nephews (Haider, Abdullah, Karrar). I wish you success and Allah's satisfaction.

I do not know whether the words are enough. My husband, although you are no longer physically with me, your soul and love have remained with me throughout my studies. I cannot thank you enough for the unwavering support and encouragement you have given me, even in your absence. I felt your presence every step of the way; I am grateful for the memories we shared and the strength and resilience you instilled in me. I ask Allah to place you in the position of Mahmud in the highest heavens.

Last, thanks and appreciation go to all the University of Utara Malaysia staff, especially the College of Computing team, for their support. Thank you all. Allah blesses you all.

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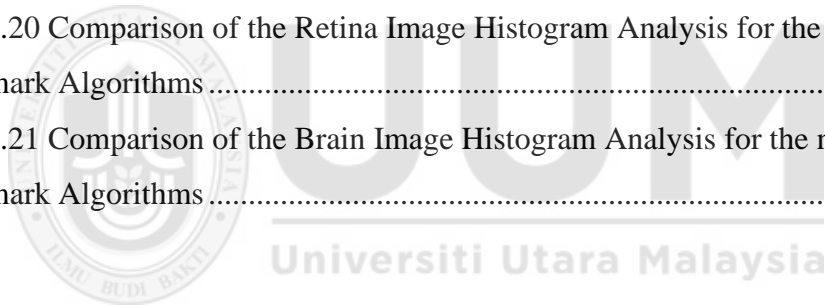
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List of Abbreviations

ABC	Artificial Bee Colony
ACO	Ant Colony Optimization
AD	Average Different
AI	Artificial Intelligence
AI	Adobe Illustrator
ALSB	Adaptive Least-Significant Bit
ATD	Adaptive Threshold Detector
BMP	BitMap
bpb	bits per byte
bpp	bits per pixel
DCT	Discrete Cosine Transform
DE	Diamond Encoding
DFT	Discrete Fourier Transform
DICOM	Digital Imaging and Communications in Medicine
DISB	Dual Intermediate Significant Bits
DWT	Discrete Wavelet Transform
EALSBMR	Edge Adaptive Least Significant Bit Matched Revisited
Em	Embedding Process
EMD	Exploiting Modification Direction
ePHI/R	electronic patient health information/records
EPRs'	electronic patient records'
EPS	Encapsulated Postscript
Ex	Extraction Process
GA	Genetic Algorithm
GIF	Graphic Interchange Format
GLM	Grey Level Modification
GUI	graphical user interfaces (GUI)
HAS	Human Auditory System
HER	Electronic Health Record

HIS	Hospital Information System
HS	Harmony Search
HVS	Human Visual System
ICT	Information and Communication Technologies
ISB	Intermediate Significant Bit
ISPs	Internet service providers
IWT	Integer Wavelet Transform
JPEG	Joint Photographer Expert Group
LSB	Least Significant Bit
MD	Maximum Difference
MIS	Medical Information System
MSB	Most Significant Bit
MSE	Mean Square Error
NAE	Normalized Absolute Error
NCC	Normalized Cross-Correlation
NP	Non-deterministic Polynomial
OPAP	Optimal Pixel Adjustment Process
PACS	Picture Archiving and Communication System
PCM	Parity Checker Method
PDF	Portable Document Format
PNG	Portable Network Graphics
PSNR	Peak to Signal Noise Ratio
PSO	Particle Swarm Optimization
PVD	Pixel Value Differencing
QoS	Quality of Service
RC4	Rivest Cipher4
RGB	Red-Green-Blue
RMSE	Root Mean Square Error
ROI	Region of Interest
RONI	Region of Non-Interest
RS	Reversible Statistical

SC	Structural Content
SSIM	Structural Similarity Index Metric
TIFF/TIF	Tagged Image File Format
TS	Tabu Search
VLC	Variable-Length Chromosome
VLC-GA	Variable Length Chromosome-Genetic Algorithm
WWW	World Wide Web
X2	Chi-square



CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter presents a background of information hiding as a means of information security, primarily technical steganography as a covert communication method. This chapter starts with the research knowledge in section 1.2 and the research motivation in section 1.3. The following section 1.4 includes the definition of the operation. Next, the problem statement, research questions, and objectives are introduced in sections 1.5, 1.6, and 1.7, respectively, followed by the research's scope and the significance behind the research in sections 1.8 and 1.9. This chapter ends with the thesis organization and summary to conclude the chapter presented in sections 1.10 and 1.11, respectively.

1.2 Background of Research

Since the beginning of time, there has been a distinct difference in how humans communicate; they desire communication secrecy. The digital age has ushered in a dramatic shift in how to communicate where interaction and the speedy sharing of information and messages between persons who are sometimes in separate time zones are made more accessible by communication technologies, opening up new options for protecting communication (Onyeator & Okpara, 2019; Kumar et al., 2011). Information security is protecting information from tampering, manipulating, or reducing the probability of risks. For example, money transfers to users' bank accounts and exchanging medical images have become the most security-demanding sectors over the Internet as they require protection services from attackers (Kadhim et al., 2019; Cheddad et al., 2010).

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