OPTIMIZATION OF MEDICAL IMAGE STEGANOGRAPHY USING N-DECOMPOSITION GENETIC ALGORITHM

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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.

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Table of Contents

Permission to Use i

Abstrak ii

Abstract iii

Acknowledgments iv

Table of Contents v

List of Tables ix

List of Figures xi

List of Abbreviations xiv

CHAPTER ONE INTRODUCTION 1

1.1 Introduction 1

1.2 Background of Research 1

1.3 Research Motivation 4

1.4 Operation Definition 6

1.5 Problem Statement 8

1.6 Research Questions 11

1.7 Research Objectives 11

1.8 Scope of The Research 12

1.9 Significance of Research 13

1.10 Thesis Organization 14

1.11 Summary 16

CHAPTER TWO LITERATURE REVIEW 17

2.1 Introduction 17

2.2 Telemedicine Application Domain 17
2.3 Information Security 20
2.3.1 Cryptography and Information Hiding 21
2.3.2 Steganography and Watermarking 23
2.4 Steganography Systems.. 25
2.5 Steganography Methods 29
2.5.1 Types of Medium (Cover-Type) 29
2.5.2 Embedding Domain.. 32
2.5.3 Embedding Methods.. 39
2.5.4 Extraction Methods 41
2.6 Least Significant Bit (LSB) Technique 42
2.7 Image Steganography 48
2.7.1 Format of Image 50
2.7.2 Segmentation of Image.. 54
2.7.3 Optimization Technique 56
2.8 Evaluation Criteria for Steganography.. 64
2.8.1 Evaluation of Imperceptibility Criteria 65
2.8.2 Evaluation of Capacity Criteria 69
2.8.3 Evaluation of Security Criteria 69
2.8.4 Evaluation of Robustness Criteria 70
2.9 Medical Image Dataset.. 71
2.10 Related Work... 72
2.11 Summary 75
CHAPTER THREE RESEARCH METHODOLOGY 76
3.1 Introduction 76

3.2 Research Methodology 77
3.2.1 Phase 1: Initial Investigation 78
3.2.2 Phase 2: Formulation of an Embedding Scheme 79
3.2.3 Phase 3: Decomposition Algorithm 82
3.2.4 Phase 4: Integrate the Proposed Schemes into a Technique 86
3.2.5 Phase 5: Evaluation 91
3.3 Implementation Design 94
3.4 Datasets 94
3.5 Summary 96
CHAPTER FOUR PROPOSED TECHNIQUE: n-DECOMPOSITION GENETIC ALGORITHM-BASED STEGANOGRAPHY SCHEME.97
4.1 Introduction 97
4.2 The Proposed Technique 97
4.3 Preparation Stage 99
4.4 Embedding Process Stage 100
4.4.1 Scheme 1: Decision Variables and Solution Space 101
4.4.2 Scheme 2: n-Decomposition Genetic Algorithm 108
4.4.3 Embedding based on n-DGA (The Proposed Technique) 111
4.5 Extraction Process Stage 113
4.6 Validation Stage 115
4.6.1 Tracing Tests 115
4.6.2 Messages Parts Validation 119
4.7 Summary 123
CHAPTER FIVE EVALUATION AND ANALYSIS 125
5.1. Introduction 125

5.2. Experimental Results and Analysis 125
5.2.1 Imperceptibility 126
5.2.2 Security 154
5.3 Discussion 163
5.4. Summary 165
CHAPTER SIX CONCLUSIONS AND FUTURE WORK 166
6.1 Introduction 166
6.2 Revisiting Research Objectives 166
6.2.1 Objective 1: Formulation of an Embedding Scheme for Avoiding the Non-Valid Implicit Constraints 167
6.2.2 Objective 2: Propose a Decomposition Controlling Parameter Scheme to Cater Lack of Convergence and Address the Application's Customizability 167
6.2.3 Objective 3: Integrate the Two Proposed Schemes into a Single Technique 168
6.2.4 Objective 4: Evaluate the Proposed Technique Using Standard Evaluation Metrics and Compare It with Suitable Benchmark Studies 168
6.3 Research Results Summary 169
6.4 Contributions 169
6.5 Limitations of the work 170
6.6 Future Works and Recommendations 171
REFERENCE 172

List of Tables

Table 2.1 Comparison between Information Security Categories 22
Table 2.2 Definition Terms..28
Table 2.3 Spatial Domain Schemes 35
Table 2.4 Spatial Domain Techniques in Image Steganography 38
Table 2.5 Studies Related to k-LSBs Steganography 43
Table 2.6 Medical Image Steganography based on the LSB Technique 46
Table 2.7 Description of Various Image Formats...52
Table 2.8 Characteristics of Optimization Algorithms 58
Table 2.9 The Quality Criteria in an Image Steganography 67
Table 2.10 The Capacity Criteria in An Image Steganography 69
Table 2.11 The Robustness Criteria in An Image Steganography 71
Table 3.1 Research Methodology 77
Table 3. 2 The Representation of Kanan & Nazeri (2014) That is Used for Encoding the Bits Insertion Within One Block..80
Table 3.3 Possible Values for Direction Gene 80
Table 3.4 Possible Values for Bit-Planes Gene 81
Table 3.5 Possible Values for SB-Pole, SB-Dire, and BP-Dire Genes 81
Table 3.6 Parameters of n-DGA- Parameters of n-DGA 84
Table 3.7 The Requirements for Hardware and Software...94
Table 3.8 The Details of Dataset Images 95
Table 4. 1 The Embedding Information as Part of the Chromosome in the Proposed Algorithm..103
Table 5.1 MSE results for n-DGA and comparison to the benchmark 128
Table 5.2 Improvement of the MSE value for the n-DGA Chest Dataset 129
Table 5.3 PSNR results for n-DGA and comparison to the benchmark 130
Table 5.4 Improvement of the PSNR value for the n-DGA Chest Dataset....................132
Table 5.5 Correlation results for n-DGA and comparison to the benchmark 133
Table 5.6 Improvement of the Correlation value for the n-DGA Chest Dataset 135
Table 5.7 MSE results for n-DGA and comparison to the benchmark 137

Table 5.8 Improvement of the MSE value for the n-DGA Retina Dataset 138
Table 5.9 PSNR results for n-DGA and comparison to the benchmark 139
Table 5.10 Improvement of the PSNR value for the n-DGA Retina Dataset 141
Table 5.11 Correlation results for n-DGA and comparison to the benchmark 142
Table 5.12 Improvement of the Correlation value for the n-DGA Retina Dataset 144
Table 5.13 MSE results for n-DGA and comparison to the benchmark 146
Table 5.14 Improvement of the MSE value for the n-DGA Brain Dataset....................147
Table 5.15 PSNR results for n-DGA and comparison to the benchmark 148
Table 5.16 Improvement of the PSNR value for the n-DGA Brain Dataset..................150
Table 5.17 Correlation results for n-DGA and comparison to the benchmark 151
Table 5.18 Improvement of the Correlation value for the n-DGA Brain Dataset..........153
Table 5.19 Comparison of the Chest Image Histogram Analysis for the n-DGA and the Benchmark Algorithm..160
Table 5.20 Comparison of the Retina Image Histogram Analysis for the n-DGA and the Benchmark Algorithms 161
Table 5.21 Comparison of the Brain Image Histogram Analysis for the n-DGA and the Benchmark Algorithms 162

List of Figures

Figure 1.1 The Problem Statement 10
Figure 1. 2 Scope of Research...13
Figure 2.1 Information Security System (Subhedar & Mankar, 2014; Cheddad el at., 2010) 20
Figure 2.2 Information Hiding Properties (Mohamed, M. H., & Mohamed, L. M., 2016; Al-Ataby & Al-Naima, 2011) 24
Figure 2.3 Watermarked Currency..24
Figure 2.4 Information Hiding Branches (Shih, 2017) 25
Figure 2.5 Schematic Description of Steganography Framework (Khalind, 2015).........27
Figure 2.6 Schematic Description of Steganography Method (Al-dmour, 2018; Khalind, 2015; Rashid, 2015) 29
Figure 2.7 The Cover Files Used in the Steganography Applications 32
Figure 2.8 The Genetic Algorithm Framework (Höschel & Lakshminarayanan, 2019) .63
Figure 3.1 Embedding Methodology of n-DGA 83
Figure 3.2 Block Diagram for Showing the Functionality of the n-Decomposer Algorithm for Variable-Length Embedding...85
Figure 3.3 Design of n-DGA...86
Figure 3.4 Secret Message Preparation...87
Figure 3.5 Methodology of Evaluation of Fitness Function 89
Figure 3.6 Extraction Process 91
Figure 3.7 The Datasets Used in the Proposed Framework, (a) Chest, (b) Retina, and (c) Brain Images 95
Figure 4.1 The Framework of the Proposed Technique......................................98
Figure 4.2 The Different 16 Directions Based on the Configuration.................104
Figure 4.3 Bit-Planes Distribution in Greyscale and Color Images...................105
Figure 4.4 The Binary Representation of One Grey Pixel.................................107
Figure 4.5 Flowchart for Genetic Searching Based on Single Decomposition 1-DGA 109
Figure 4.6 Flowchart of Genetic Algorithm for Multiple Decompositions 111

Figure 4.7 (a) The Fitness Convergence Curve and the Corresponding Embedding Blocks in the Chest Dataset 116
Figure 4.7 (b) The Host Image for the Chest and the Embedding Blocks 116
Figure 4.8 (a) The Fitness Convergence Curve and the Corresponding Embedding Blocks in the Retina Dataset 117
Figure 4.8 (b) The Host Image for the Retina and the Embedding Blocks 117
Figure 4.9 (a) The Fitness Convergence Curve and the Corresponding Embedding Blocks in the Brain Dataset 118
Figure 4.9 (b) The Host Image for the Brain and the Embedding Blocks 118
Figure 4. 10 (a, b, and c) Message Parts Validation After Embedding and the Direction for the Chest Dataset and the Corresponding Convergence Curve 120
Figure 4. 11 (a, b, and c) Message Parts Validation After Embedding and the Direction for the Retina Dataset and the Corresponding Convergence Curve 121
Figure 4. 12 (a, b, and c) Message Parts Validation After Embedding and the Direction for the Brain Dataset and the Corresponding Convergence Curve 122
Figure 5.1 MSE Measure for Chest Dataset 128
Figure 5.2 PSNR Measure for Chest Dataset 131
Figure 5.3 Correlation Measure for Chest Dataset 134
Figure 5.4 Imperceptibility evaluation metrics for n-DGA and its comparison with the benchmark for the Chest dataset 136
Figure 5.5 MSE Measure for Retina Dataset 137
Figure 5.6 PSNR Measure for Retina Dataset 140
Figure 5.7 Correlation Measure for Retina Dataset 143
Figure 5.8 Imperceptibility evaluation metrics for n-DGA and its comparison with the benchmark for the Retina dataset 145
Figure 5.9 MSE Measure for Brain Dataset 146
Figure 5.10 PSNR Measure for Brain Dataset 149
Figure 5.11 Correlation Measure for Brain Dataset 152
Figure 5.12 Imperceptibility evaluation metrics for n-DGA and its comparison with the benchmark for the Brain dataset 154

Figure 5. 13 (a) RS analysis for n-DGA and Its Comparison with the Benchmark for the Chest Dataset.....156

Figure 5. 13 (b) RS analysis for n-DGA and Its Comparison with the Benchmark for the Retina Dataset 156

Figure 5. 13 (c) RS analysis for n-DGA and Its Comparison with the Benchmark for the Brain Dataset… 158

Figure 5.14 (a) Histogram Evaluation for n-DGA and Its Comparison with the Benchmark for the Chest Dataset….....159

Figure 5.14 (b) Histogram Evaluation for n-DGA and Its Comparison with the Benchmark for the Retina Dataset… 159

Figure 5.14 (c) Histogram Evaluation for n-DGA and Its Comparison with the Benchmark for the Brain Dataset…..... 160

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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