OPTIMIZATION OF TELECOMMUNICATION TOWER FOR MAXIMUM COVERAGE USING GENETIC ALGORITHM

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OPTIMIZATION OF TELECOMMUNICATION TOWER PLACEMENT FOR MAXIMUM COVERAGE USING GENETIC ALGORITHM

MUHAMMAD NUR HASIF BIN ABU BAKAR

This report is submitted in partial fulfillment of the requirements for the Bachelor of [Computer Science (Artificial Intelligence)] with Honours.

FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I hereby declare that this project report entitled

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SUPERVISOR : Date:18 September 2023
(DR. NORHAZWANI BINTI MD YUNOS)

DEDICATION

I sincerely dedicate my study to the evaluator, supervisor, and all of the readers who helped shape and complete this research. Throughout this journey, your unfailing support, counsel, and encouragement have been vital.

I am eternally grateful to my great supervisor, Dr. Norhazwani Binti Md Yunos, for their constant support, mentorship, and advice. Their breadth of expertise, intelligent advice, and faith in my talents have all played an important role in influencing the direction and scope of my research. Their constant support and hard attempts to nurture intellectual progress have aided my personal and academic development.

I'd also like to express my deepest appreciation to all the readers who took the time and effort to critically assess this project. Their insightful observations, constructive criticism, and intelligent ideas have greatly aided in the refining and enhancement of this research. Their participation and interest in my work have been a source of encouragement and inspiration for me.

Furthermore, I'd like to thank Universiti Teknikal Malaysia Melaka (UTeM) for providing the essential resources, research atmosphere, and opportunities that allowed this project to be completed successfully. Their encouragement and dedication to supporting academic advancement and research excellence have been invaluable in my research endeavors.

Finally, I'd like to thank my friends, family, and loved ones for their unfailing support, understanding, and encouragement during this study project. Their unwavering faith in my skills, patience at difficult times, and love and support have given me the drive and motivation to overcome barriers and strive for success.

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In addition, I'd like to express my deepest gratitude to all of the readers who took the time to review and offer input on this project. Your insightful comments and recommendations have greatly aided in the improvement of this research.

I would also like to express my gratitude to Universiti Teknikal Malaysia Melaka (UTeM) for providing the essential resources and atmosphere for the completion of this project.

Last but not least, I want to express my gratitude to my friends, family, and loved ones for their constant support, understanding, and encouragement during this research journey.

ABSTRACT

Telecommunication tower location is critical for obtaining maximum coverage and optimizing network performance. Traditional tower placement methods frequently rely on human selection or heuristic approaches, which may not necessarily produce the best outcomes. In this study, we suggest using a genetic algorithm to optimize tower location in telecommunication networks for optimum coverage. To find the ideal subset of tower locations, the genetic algorithm-based technique evaluates coverage needs, infrastructure costs, and signal strength. The system repeatedly refines prospective tower placement options by utilizing natural selection and genetic evolution concepts. The goal of this research is to give an automated and systematic solution to the tower placement problem, which will result in greater coverage, improved network performance, and minimized telecommunication tower. The project's findings have important implications for telecommunications operators, network designers, and politicians, resulting in better network deployment plans and higher service quality.

ABSTRAK

Penempatan menara telekomunikasi yang berkesan adalah penting untuk mencapai liputan maksimum dan memaksimumkan prestasi rangkaian. Kaedah penempatan menara tradisional sering bergantung kepada pemilihan manual atau pendekatan heuristik, yang mungkin tidak memberikan hasil yang optimum. Dalam projek ini, kami mencadangkan penggunaan algoritma genetik untuk mengoptimumkan penempatan menara untuk liputan maksimum dalam rangkaian telekomunikasi. Pendekatan berdasarkan algoritma genetik ini mengambil kira keperluan liputan, kos infrastruktur, dan kekuatan isyarat untuk mengenal pasti subset terbaik lokasi menara. Dengan memanfaatkan prinsip pemilihan semulajadi dan evolusi genetik, algoritma ini secara berulang kali mengubah penyelesaian penempatan menara yang berpotensi. Kajian ini bertujuan untuk menyediakan penyelesaian automatik dan sistematik kepada masalah penempatan menara, yang menghasilkan liputan yang lebih baik, prestasi rangkaian yang ditingkatkan, dan meminimumkan menara telekomunikasi. Hasil kajian projek ini mempunyai implikasi yang signifikan kepada pengendali telekomunikasi, perancang rangkaian, dan pembuat dasar, membawa kepada strategi penyebaran rangkaian yang lebih baik dan kualiti perkhidmatan yang ditingkatkan.

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LIST OF ABBREVIATIONS

FYP	-	**Final Year Project**
GA	-	**Genetic Algorithm**
FCM	-	**Fuzzy C-Means**
UMTS	-	**Universal Mobile Telecommunication System**
SINR	-	**Signal-to-Interference and Noise Ratio**
DE	-	**Differential Evolution**
RGA	-	**Real-Coded Genetic Algorithm**
GIS	-	**Geographic Information System**
BS	-	**Base Station**
ACP	-	**Average Current Population**
BSF	-	**Best-So-Far**

LIST OF ATTACHMENTS

CHAPTER 1: INTRODUCTION

1.1 Introduction

As a result of the fast growth of telecommunications technology and the rising need for dependable and high-speed communication, the appropriate placement of telecommunication towers has become a vital part of network design and implementation. Tower location has a direct impact on network coverage, signal quality, and overall performance.

Traditional techniques for tower placement frequently rely on manual selection or heuristic methods, which may be time-consuming, subjective, and may not necessarily result in ideal coverage. To address these restrictions, this work suggests using a genetic algorithm to optimize tower location and attain maximum coverage.

1.2 Problem Statement

Telecommunication tower installation entails determining the best sites to offer continuous coverage to the target region. The difficulty is determining ideal tower placements that provide effective signal propagation, acceptable population coverage, and low infrastructure expenditures. Figure 1.1 shows the good and bad placement of the telecommunication tower, only the good placement with less overlapping can solve the problem, whereas the bad placement has a big overlapping, so it is a wasted tower. This is to make sure that the telecommunication tower can cover the signal in many areas with fewer telecommunication towers placed.

Various considerations, including population density, regional characteristics, existing infrastructure, regulatory rules, and coverage needs, must be considered in this complicated challenge. The goal is to find a balance between increasing coverage and lowering costs while remaining within technological and regulatory limits.

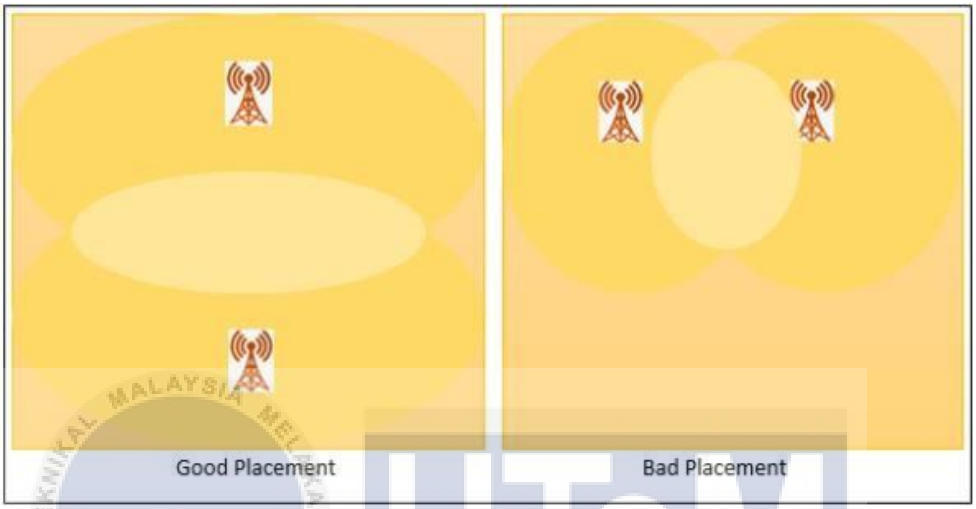

Figure 1.1 Telecommunication Tower Placement

1.3 Objectives of the Study

Our study endeavor seeks to create an optimization model with a genetic algorithm that focuses on resolving the tower placement predicament in telecommunication networks, leading to maximum coverage. Our specific objectives include:

1. To investigate optimal tower placement for maximum coverage and minimal service interruptions.
2. To design and implement an efficient and reliable tower placement system.
3. To evaluate the effectiveness of the system to determine the most suitable locations for tower placement.

1.4 Scope of the Study

The purpose of this study is to optimize the location of telecommunication towers within a specific geographical region. The scope includes coverage needs, infrastructure costs, signal strength concerns, legal limitations, and environmental variables in tower site optimization. The research will create a computer model based on the genetic algorithm technique and test its performance using simulations and experiments. A sensitivity study will also be performed to investigate the resilience of the proposed technique under various scenarios and network circumstances.

1.5 Significance of the Study

This study is significant because it has the potential to improve the efficiency and efficacy of tower placement in communications networks. The project intends to give a systematic and automated method to tower placement by harnessing the power of genetic algorithms, providing maximum coverage while minimizing expenses. The findings of this study may help to optimize network rollout, resulting in better service quality, a better user experience, and lower operational costs for telecommunications businesses.

The study's results may have far-reaching repercussions for telecommunications companies, network planners, and politicians. Improved coverage, less signal interference, higher network capacity, and better utilization of available resources can all result from optimized tower placement. The findings of the study can help with educated tower location decisions, allowing for efficient network development, greater connectivity, and better utilization of infrastructure expenditures.

1.6 Expected Outcome

This study is aimed at producing an optimized placement strategy for telecommunication towers that maximizes coverage within the specified region. The output will include a list of tower sites, as well as the coverage area and signal strength associated with each. The evolutionary algorithm-based strategy is predicted

to outperform previous heuristic methods, providing more efficient tower placement options. The results will give insights into the ideal tower distribution while accounting for coverage needs, signal propagation characteristics, and regulatory issues.

1.7 Conclusion

This study introduces an innovative technique that utilizes a genetic algorithm-based approach within an adaptive system framework to optimize telecommunication tower locations efficiently. We aim to determine an optimal set of locations based on multi-factor criteria such as coverage demands, infrastructure expenditure considerations, signal strength aspects, as well as regulatory limitations. Implementing our suggested framework would provide a quick and smart way for solving complex geographical optimization problems related to telecoms network design with very high potential performance-to-cost ratio benefits thus reducing operational expenses whilst boosting service level quality levels greatly.

This work has substantial implications both academically and for industry peers and practitioners who work in displaying the flexibility to factor in not only the objective but subjective factors as well which are highly intrinsic to a particular industry ensuring the application of this approach more widely.

CHAPTER 2: LITERATURE REVIEW AND PROJECT METHODOLOGY

2.1 Introduction

The following chapter embarks on an in-depth literature analysis concerning the use of genetic algorithms for optimizing telecommunication tower sitting which aims to attain maximum coverage. This study explores existing systems and procedures within this field whilst identifying gaps present in current research. It provides a detailed description of our proposed project approach that we shall employ in achieving our goals. Additionally, it outlines the requirements necessary for the project such as software, and hardware among other resources combined with a milestone-based timeline.

2.2 Facts and Findings

2.2.1 Domain

The review of literature focuses on communications network design and optimization. It discusses network coverage, signal strength, tower positioning, and infrastructure expenses. To understand the problems and improvements in tower location optimization, several research papers and industry publications have been reviewed.

2.2.2 Existing System

A comprehensive review of existing techniques and methodologies for optimizing tower location has been carried out. To understand the benefits and limits of these techniques, notable academic articles and industry publications have been analyzed.

According to Rafii, F. (2016) research, a combination of FCM (Fuzzy C-Means) and the GA (Genetic Algorithm) was used to reduce the number of telecommunications towers while maximizing coverage in a city region. The goal was to optimize base station placement, reducing the number of existing towers necessary while offering wide coverage. The new method sought to provide a system that could efficiently utilize existing base stations to cover the greatest feasible area.

Similarly, the objective of Garzia, F., Perna, C., and Cusani, R. (2005) research article was to optimize UMTS (Universal Mobile Telecommunications System) network design using Genetic Algorithms. The study's goal was to create a design tool that might aid in UMTS network planning. Genetic Algorithms were used to determine ideal tower placement options, considering parameters like coverage, interference, and capacity. Through intelligent planning, the objective was to increase the overall performance and efficiency of UMTS networks.

According to Munyaneza, J., Kurien, A., and Van Wyk, B. (2008), research proposes the use of Genetic Algorithms to optimize antenna location in the context of 3G networks. The goal was to find the best sites for base stations that would maximize coverage and quality of service while reducing the number of towers needed. The optimization approach included elements such as signal-to-interference and noise ratio (SINR), to improve network performance and lower infrastructure costs.

According to Sachan, R., Choi, T. J., & Ahn, C. W. (2016), a research article focused on the optimization of energy usage in 5G wireless networks. The research approached network design as an optimization issue, considering variables such as transmission power and base station placements. The authors investigated the use of

heuristic approaches such as the differential evolution (DE) algorithm and the real-coded Genetic Algorithm (RGA) to identify optimum solutions that may minimize energy usage while fulfilling coverage and capacity criteria.

A comprehensive strategy presented by Asassafeh, J., Akkaya, M., & AlTarawneh, M. (2020) article sought to use a multi-phase dynamic technique to discover the ideal placements for telecommunication towers. To attain high precision in tower placement, the study used frequent selection components, rules, and Geographic Information Systems (GIS). The suggested technique attempted to discover the optimal tower locations to maximize coverage efficiency by considering aspects such as coverage, population density, and topographical information.

Aside from the research described above, a paper published on ResearchGate by Arjun, V., Anjan, B. K., Kanmani, S. S., Umesha, and P. K. (2022) focuses on the optimization of antenna lattice towers using Genetic Algorithms. The research sought to create the best tower design configuration possible by considering elements such as the bracing system and cross-sectional characteristics of the tower parts. The goal was to reduce the weight of the tower while adhering to a set of limitations. The study used Genetic Algorithms to help designers come up with the most cost-effective and efficient tower design. The study dug into the mathematics and computational background involved with the optimization process, emphasizing the significant efforts put into establishing the essential approaches and algorithms.

Finally, according to Al-Hamami, A.H., & Hashem, S.H. (2011) publication, an algorithmic approach to strategic cell tower placement was provided. Geographic Information Systems (GIS) were used to gather satellite images, population density data, and topography information for the study. The purpose of combining various data sources was to find prospective tower locations strategically, considering aspects such as population distribution and topographical features, to provide optimal coverage and minimize coverage gaps.

These studies add to the continuing study and development of optimization approaches and algorithms for telecommunication tower locations. They address a