INVESTIGATION OF 3D COVERAGE FOR LTE NETWORK USING DRONE

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

Special dedication to my beloved parents, Goh Chin Huat and Ng Swee Li, my beloved supervisor, Associate Professor Dr. Lim Kim Chuan and my friends. Thank you for all your support, care and trust in me.

ABSTRACT

The use of mobile LTE network has grown exponentially in recent years. Therefore, it is important to constantly maintain both the performance and service quality of mobile network operation at top level to maximize customer satisfaction. The main goal of this project is to obtain regression models for path loss exponents and shadowing for radio channel between airborne UAV and cellular networks. The use of unmanned aerial vehicles (UAVs) to autonomously survey LTE network performance parameters and subsequently approximate the signal strength on ground level with regression model is developed in this research. LTE network performance parameters such as Received Signal Strength Indicator (RSSI) and Reference Signal Received Power (RSRP) are autonomously collected with the predefined fly path and analysed to approximate ground signal strength from 15m to 30m above ground. The data is then used to fit with commonly used path loss models (Log-distance Alpha-Beta, SUI/Erceg, Cost 231 Hata). The R-square value, R^2, is subsequently calculated to obtain the well fit of the model to the data. The R-square value, R^2, obtain is 48%, 8.41%, and 4.65% for 1m, 20m, and 30m respectively. The R-square value, R^2, indicates that the model does not fit with the collected data well enough which is typically above 80% shows good fit.

ABSTRAK

Penggunaan rangkaian LTE mudah alih telah berkembang pesat dalam beberapa tahun ini. Oleh itu, pengendali rangkaian mudah alih harus memastikan prestasi, kualiti perkhidmatan dan kepuasan pelanggan. Matlamat utama projek ini adalah untuk mendapatkan model regresi bagi "Path Loss Model" dan saluran radio antara drone dan rangkaian selular. Penggunaan kenderaan udara tanpa pemandu (UAVs) untuk menyelidik parameter prestasi rangkaian LTE dan kekuatan isyarat pada aras tanah dengan model regresi dibangunkan dalam kajian ini. Parameter prestasi rangkaian LTE seperti Penunjuk Kekuatan Isyarat Diterima (RSSI) dan Rujukan Isyarat Kuasa yang Diterima (RSRP) dikumpul secara autonomi dengan laluan yang dipratentukan dan dianalisis untuk menganggar kekuatan isyarat tanah dari 15m hingga 30m di atas tanah. Kemudian, data ini digunakan untuk disesuaikan seperti model "path loss" (Log-distance Alpha-Beta, SUI/Erceg, Cost 231 Hata) yang biasa digunakan. Seterusnya, nilai R-square, R^2, dikira untuk mendapatkan model yang baik untuk data. Nilai R-square, R^2 yang diperolehi ialah 48%, 8.41%, dan 4.65% untuk 1m, 20m, dan 30m. Nilai R-square, R^2, menunjukkan bahawa model tidak sesuai dengan data yang dikumpulkan dengan baik yang lazimnya di atas 80%.

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LIST OF SYMBOLS AND ABBREVIATIONS

PL	:	Path Loss
PLE	:	Path Loss Exponent
RSSI	:	Received Signal Strength Indicator
RSRP	:	Reference Signal Received Power
FSPL	:	Free Space Path Loss
LoS	:	Line of Sight
NLoS	:	No Line of Sight

CHAPTER 1

INTRODUCTION

1.1 Introduction

A decade ago, it was unthinkable that UAVs could reach such success in civil and even in commercial industries. Nowadays, it is mandatory to think that not only smartphones or laptops can depend on cellular mobile networks, but also these vehicles. However, the existent propagation models do not yet consider this possibility, which is why it is so important to create or redefine some of these models to establish a solution since the UAV's market is growing exponentially, justified by the large amount of applications related to it.

Most of these UAVs establish a connection to the user provided by radio communication (RC) but it is not reliable when there is no line of sight (LoS) between the two intervenient. However, it is possible to establish a link between both but only by using satellite communication (SC) that is extremely expensive and only reachable for military purposes. To overtake this problem, cellular mobile networks are an alternative to RC and SC, where the LoS and high costs will no longer be an obstacle.

The cellular mobile networks considered use UMTS and LTE technologies since they are capable to reach faster data rates and permit lower latency, which is extremely important when applications like streaming is used, since it requires large sets of data in a short period.

The focus of this thesis is to obtain a regression models for Path Loss exponents and shadowing for radio channel between airborne unmanned aerial vehicles (UAVs) and cellular networks. By automating a drone to fly a path and record LTE receive signal strength data. Data is collected and analyzed to approximate ground signal strength at 1.5m, 10m, 20m and 30m above ground.

1.2 Problem Statement

The current method of obtaining such measurements include walk test, drive test and train test to collect and measure signal strength requires intensive human labor, too time consuming and unable to provide a good quality of service to the mobile data users. Thus, by making use of above ground drone survey, the signal strength data collected can be used to approximate the ground level signal strength. With UAV automation it will make the data collection more efficient and response to network change promptly. An UAV based above ground level LTE signal strength collection system which can promptly response to network disruption reported by user would help to improve the quality of telecommunication service.

1.3 Objective

The aim of this research is to model a Path Loss model which can be used to approximate the ground level signal strength.

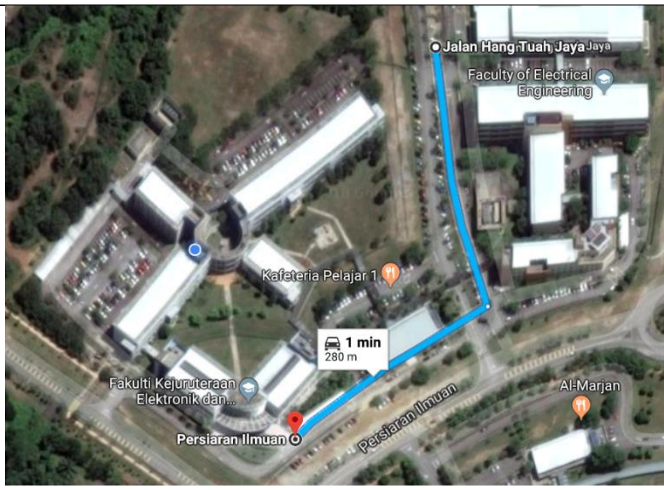
1. To build UAV system to collect the required data for Path Loss model estimation.
2. To analyze and determine the suitable Path Loss model for the radio channel between airborne UAV and LTE cellular network signal strength.

1.4 Scope of Project

This project is to build a system to collect required data and determine the suitable Path Loss model. The software, method, data to be collected, Path Loss models used, fixed values and area of measurement are shown in Table 1.1:

Table 1.1 Scope of project

Fixed value	• Frequency at 1800MHz which is at band 3 of LTE • The height of the Antenna will be assumed to be 50m
Place of measurement	A few spots in UTeM will be used to conduct the data collection.

1.5 Chapter Review

Chapter 1 describes the general overview of this project. The motivation to start this project, problem statements, objectives and the scope of the project will be firstly discussed in this chapter.

Previous studies on this field which uses relevant models to get the Path Loss model, models such as log-distance alpha beta model, Okumura model, Hata model, Cost 231 Hata, Cost 231 Walfisch Ikegami, LUI and Erceg model and the problems faced by the researcher will be subsequently discussed in Chapter 2.

Details on how the data collected is processed and compared with the existing models will be discussed in Chapter 3.

As for Chapter 4, How well the collected RSRP signal strength will fit with the identified Path Loss model will be analyzed and reported at the end of this chapter.

The achievement of this project will be concluded in Chapter 5. Suggestion of future work will be discussed at the end of this chapter.

CHAPTER 2

BACKGROUND STUDY

2.1 Cellular Networks

The cellular network infrastructure is based on cells/sectors. The distribution of the stations needs to consider the distance between each base station to provide a better planning of the placement of the base station. To avoid interference, save cost of for less overlapping of the base station signals and maintain an acceptable QoS.

There are several recognizable aspects in cellular networks:

- Capacity: capable to have more capacity because it uses more than a single transmitter, since the same frequency might be enabled for multiple links as long as they are in different cells;

- Power: with the large quantity of base stations that exist, it is possible to conclude that the distance between these and the user is not as big as if only single large transmitter is used. Considering this, it is possible to achieve that mobile devices use less power because they are closer to the cell towers due to their quantity;

- Coverage: when compared to a single terrestrial transmitter, this parameter can be improved anytime since additional cell towers can be added indefinitely and are not limited by the horizon.

Mobile phone service carriers in Malaysia (e.g., Digi, Celcom, Maxis, Umobile) provide these networks and each one has their own antenna to transmit the mobile signals. The user might pick up a cell signal provided by one of the mentioned carriers, but the signal's strength might be different in distinct locations since it depends on the carriers' licenses that define the technology in use on each cell such as: -

- GPRS
  - Often marked as the letter G beside the signal bar. It's the slowest form of data connectivity. (114kbps)
- EDGE
  - Usually denoted as an 'E'. This the speed is in between 2G(GPRS) and 3G up to speeds of 400kbps (theoretical speed)
- 3G
  - This 3G signal is commonly displayed beside the signal bar as this is previously the top mobile speeds up to 384kbp.