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# Weighted Multiple Linear Regression Model for Mobile Location Estimation in GSM Network

Longinus Sunday Ezema, Electrical and Electronic Department, University of Technology, Owerri, Imo State, Nigeria
Cosmas I. Ani, Electronic Department, University of Nigeria Nsukka, Enugu State, Nigeria

## ABSTRACT

The numbers of crimes and accidents, among other challenging issues, requiring a mobile application with localization capabilities are on the increase. Yet there is under-utilization of location information provided by mobile phones. The accuracy and cost of implementation of mobile position localization on cellular network have been an issue of research interest. In this paper, the statistical modelling of mobile station (MS) position location was carried out using weighted multiple linear regressions (WMLR) method. The proposed statistical modelling approach was based on received signal strength (RSS) technique. The model improved localization accuracy. The model's simulated results were analysed and compared with the existing MLR using real measured data collected from GSM network in a light urban environment in Enugu, Nigeria.

## KEYWORDS

Cellular Network, FCC USA, Mobile Station, Mobile Telecommunication Network, Nigeria, Radio Location, Received Signal Strength, Statistical Model

## INTRODUCTION

Mobile location estimation means defining the coordinates of a mobile station (MS) in two or three dimensions - latitude, longitude and altitude. Localization of mobile station has been attracting interests not only from the telecommunication system vendors, network operators and mobile network users. This is owing to its potential base and other associated location-based services. Such location base services include logistic, fleet management, entertainment, tourism, safety and security, and among others (Ezema & Ani, 2016). Therefore, mobile phones are not just used only for making calls and sending messages.

Localization can be carried out by the application of some measured signal properties as signal propagates from mobile station to base station (BS) or vice versa. Such notable signal properties include received signal strength (RSS), uplink-time of arrival (U-TOA), enhanced observed time difference (EOTD)/ observed time difference of arrival (OTDOA), time advance (TA)/ round trip time (RTT) and angle of arrival (AOA)/direction of angle (DOA) (Surendra, Reenu and Chun, 2019).

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Recently, the combinations of measured properties are used to enhance the accuracy of localization. Cell Identification (CID) as a parameter is mainly used in hybrid technique though it has relative low accuracy when used alone. These parameters are called location dependent parameters (LDP) (Ezema & Ani, 2017, Shang, et al., 2015, Venkatraman and Caffery, 2004). There are three different localization methods - geometric, artificial intelligent and statistical methods. The methods have been applied directly on the LDP for MS positioning with varying degree of accuracy.

There are two basic types of networks that originate the location parameters - the space segment (satellite in space) and the earth segment networks. The satellite in space usually referred to as global positioning system (GPS) is a conventional technique used for locating position over the years (Brena. et al. 2017). The improvements on the performance of the GPS brought about by the evolution of both A-GPS and D-GPS heavily relied on the cellular network infrastructure (Mukherjee & Biswas, 2018).

Most of the cellular traditional methods for localization have been developed to operate under line-of-sight (LOS) propagation mode. NLOS error mitigations have been the major challenge of localization in cellular network (Qi, Kobayashi, and Suda, 2006). Most of the performance criteria have been standardised by Federal Communication Commission (FCC) of United State of America (USA), a communication regulatory body in the US. The phase III of FCC accuracy requirements and regulations released in February 2015 are to be enforced on the USA mobile operators by 2021.The accuracy requirement of phase III is yet to be reached. The application such as emergency service (E-911 & E-112) with high demand for accuracy, unlike commercial applications, is the driving force for phase III accuracy requirement (Ezema & Ani, 2017; Zeytinci, Sari, Harmanci, Anarim and Akar, 2013; Tong, 2015).

## REVIEW OF RELATED WORKS

In the field of mobile application, location base services have been an interesting topic for researchers. The following research works in mobile location in GSM network have been reported in journal publication and reviewed in this section.

Mobile location estimation using an interpolative neural network was proposed in (Chien-Sheng, Jium-Ming, and Chin-Tan, 2013). It used three angles of arrival measurement to achieve a better result than the analytical (the weighted average and optimal position) in the presence of noisy and NLOS measurement error. The neural network uses its ability to memorize and generalize data to interpolate the measured angles to estimate the mobile position. In order to avoid over-fitting of the network, the training of the neural network was done with ideal patterns gotten from the mathematical relationship that exists between the angles of arrival and the mobile position. The performance of this technique is highly dependent on the noisy and NLOS measurements of AOA, and the mobile propagation environment.

In Caffery and Stuber (1998), the RSSI-based technique because of its coverage, availability, easy of measurement and requiring no additional hardware installation have become the ideal method for GSM and other cellular localization. Here, the author proposed a data fusion algorithm of Pearson's correlation coefficient (PCC) with RSSI and other basic BS information to estimate the position of a mobile station. The performance of the technique when implemented with an ordinary mobile phone showed a maximum error of 550m and mean error below 150m. This technique showed good robustness against change in environment. It was easy to be implemented with less mathematical complexity and required no previous statistical knowledge of the MS. The accuracy of this technique is below the accuracy requirement of FCC of United State of America and shouldn't be used for emergency services like E-911 and E-112.

A localization algorithm based on RSSI and basic BS information like the coordinate of the BS to determine the MS position was proposed by Takenga and Kyamakya (2007). In this research, the coordinates of the intersection of the line of bearing (LOB) was averaged out. Having more than two variable estimations based on other estimated values hampered the accuracy of the technique. This