A Novel Hybrid Approach For Path Loss Exponent Estimation In Vanet Application

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Abstract

An innovative and rapidly emerging class of ad hoc communication system is vehicular ad hoc network (VANET) is important field in engineering research. The measurement & estimation of distances between the nodes is important parameter in VANET application. The Received Signal Strength (RSS) based location technique is very popular research interest due to its simplicity. The RSS based location technique has two categories namely the distance estimation based & the RSS profiling based techniques. The path loss exponent (PLE) is key parameter in the distance measurement & estimation based technique, were the distance is estimated from RSS. In this paper we propose a method for dynamic path loss exponent estimation in VANET using Doppler Effect & RSS. This method uses measured power & Doppler shift over a period of time assuming constant path loss factor. The simulation results show that estimation error variance decreases with increasing relative speed. This research is useful for cooperative positioning in VANET where GPS signals are not available.

Keywords- Received Signal Strength, Doppler Effect, Intelligent transport system, vehicular Network.

1. Introduction

Millions of people around the world die every year in car accidents and many more are injured. Implementations of safety information such as speed limits and road conditions are used in many parts of the world but still more work is required. Measurement of distance between the nodes of an vanet is a key method in location based applications. There are different types of radio range measurement systems like Time of arrival , Angle of arrival & Time difference of arrival, and Received Signal Strength (RSS) are considered for different applications. Free space propagation model or equivalently path loss model can be represented as[1]

$$p(d) = p(d_0)(\frac{do}{d})2 \qquad (1)$$

where, d0 is a reference distance in which the received power P(d0) is measured, d is the distance between sender and receiver. Knowing d0 and P (d0) the equation (1) can be simplified to

$$p(d) = k - 20\log(d)dBm \qquad (2)$$

Where, K is a constant

$$k = 10\log(\frac{p(d_0)}{0.001w}) + 20\log(d_0) \qquad (3)$$

The equation (2) gives the distance d between sender and receiver & it is used as the path loss model in free space. In real situations in urban or suburban areas, the surrounding environment causes decrease in channel power. The path loss model for such environments is given by [2]:

$$p(d) = k - 10\alpha\log(d)dBm \qquad (4)$$

The path loss exponent, α, has minimum value 2 & maximum value 5 depending on the environment as well as Coherence Bandwidth in a non-free space area , path loss may vary for varies frequencies in the signal [1]

Using RSS for distance measured in a non-free space area, as it is seen in (4), is not useful without knowing the path loss exponent which is changing upon the environment changes.

The rest of paper is arranged as follows. The Section 2 gives literature survey around the estimation of path loss exponent. The new concept for path loss exponent is explained in section 3. In Section 4 simulation results are given & section 5 focused on conclusion.

2. Related Work

In reference [2], two separate formulas for path loss exponent in indoor & outdoor environments are given. Taimoor Abbas [3] has explained a simple shadow fading model for measurement of path loss in urban & highway scenarios. This method also uses a markov chain based transition diagram to model transitions for LOS obstruction by vehicles (OLOS), it induce an additional loss of about 10db, in the received signal. In [4] a cooperative positioning method based on radio ranging technique like Received signal strength is presented. The global positioning system estimates inter node range rates in vehicles with different speeds based on Doppler effect for dedicated short range communication 5.9 GHZ. Masaharu Hata [5] focused on an empirical formula from okumura model to find out propagation loss in an urban area. The useful formula is A+Blog10R, where R is the distance 1-10m; A is frequency range like 100-1500MHZ & B is the base station antenna height 30-200m.But this technique is not used for dynamic environment. Paper [6] describes the received signal is used to find a statistical path loss model in the range between 100m to 2km. The propagation measurement observed at 3.5GHZ in urban area.

3. Distance Measurement & Path Loss Exponent

Vehicular Network used Dedicated Short Range Communication (DSRC) with the range of frequencies from 5.85GHz to 5.925GHz is assumed for the simulations [7]. The RSS are used as observables for path loss exponent & Doppler shift for distance estimation also there is no need to a prior knowledge of any node position.

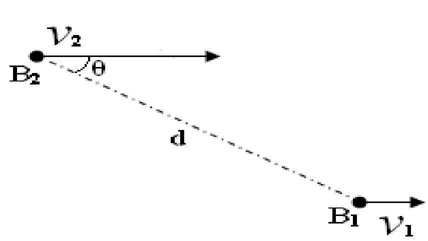

Figure 1. Two moving beacons (vehicles)

Two moving beacons are shown as two vehicles on a street as shown in figure 1. These nodes are varying with different speeds of v1 and v2 and distance of d between them is unknown. Consider two vehicles are moving in one street, and for more generality, in different lanes. If B2 assumed as transmitter and B1 as receiver, the Doppler frequencies Δf Hz in B1 can be modeled with [8]:

$$\frac{\Delta f}{x} \cong \frac{(v2-v1)\cos(\theta)}{c} = -\frac{v\cos(\theta)}{c} \quad (5)$$

Where f is the carrier frequency, c is the light speed, and v is the relative speed of moving beacons along the street.

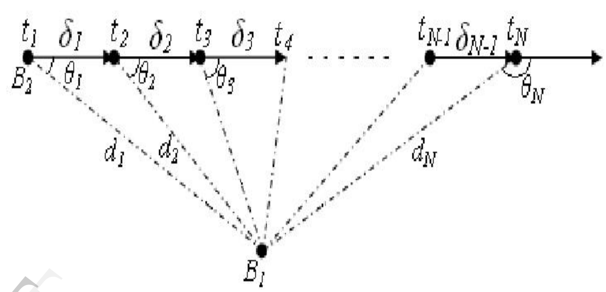

Figure 2. Relative movement over the time

The situation for *N* time intervals of time period *T* is depicted. $\delta i = viT$ is the amount of *B2* relative displacement with consider constant relative speed of vi in ith interval. as shown in figure 2.

The Doppler shift, formulated in (5), RSS, and the path loss model of (4) for estimation of path loss exponent and distance between B1 and B2. In continue we take N intervals into consideration with di as the instant distance between the vehicles in ith interval:

$$\begin{cases} pi = K - 10\alpha\log(d_1 + x_i) + \xi i, i = 1 \\ pi \approx K - 10\alpha\log(d_1 + x_i) + \xi i, 2 \le i \le N \end{cases} \quad (6)$$

Where,

$$xi = \begin{cases} 0 & ,i=1 \\ -\sum_{j=1}^{i-1} Tvj\cos(\theta j), 2 \le i \le N \end{cases} \quad (7)$$

Where, T is sampling period, K is a known constant, Pi is measured RSS in each interval, ζi is the Gaussian noise of power measurement in dBm, and xi can be calculated from Doppler shift with regard to (5)

$$xi = \begin{cases} 0, & i=1 \\ \sum_{j=1}^{i-1} T \frac{c\Delta fj}{f}, & 2 \le i \le N \end{cases} \tag{8}$$

And

$$\Delta f_j = \frac{-f v_j \cos(\theta_j)}{c} \tag{9}$$

Assuming path loss exponent to be constant over NT, there are N equations and two unknown parameters, α and d1. With N>2 and defining an appropriate cost function, it is possible to estimate the parameters α and d1.

Assumption of a constant path loss exponent over NT can be viable if NT is considered small enough.

Now, considering the unknown vector of $\rho = \begin{bmatrix} \alpha \\ d1 \end{bmatrix}$ a cost function J can be defined as follows

$$J = -\sum_{i=1}^{N-1} ri2(\rho, x_i, y_i) \tag{10}$$

where

$$ri = f(x_i, \rho) - y_i \tag{11}$$

and

$$\begin{cases} f(x_i, \rho) = 10\alpha \log(d_1 + x_i) \\ y_i = K - P_i \end{cases} \tag{12}$$

Using a nonlinear Least Square methods like Gauss-Newton or Levenberg-Marquardt [14], the best value of path loss exponent and initial distance between the nodes which minimizes J can be estimated

$$\hat{\rho} = \arg\min(J) \tag{13}$$

Knowing d1, all distances over N intervals can be calculated.

4. Simulation and Results

A two-lane street with lane width of 4.5 m is assumed for simulation. The two vehicles move with two different speeds. The sampling time period T is considered 0.05 s and N=25 is taken for simulation. The power measurement Gaussian noise of zero mean and 3dBm variance is assumed.

For simulation is implementation we take different relative speeds of 17 to 37 m/s. But each speed is repeated 1000 times each time with a path loss exponent is 5. Fig. 3 and 4 shows path loss estimation error in 17 & 37 m/s. With nearly zero mean estimation error PDF is Asymetric Gaussion.

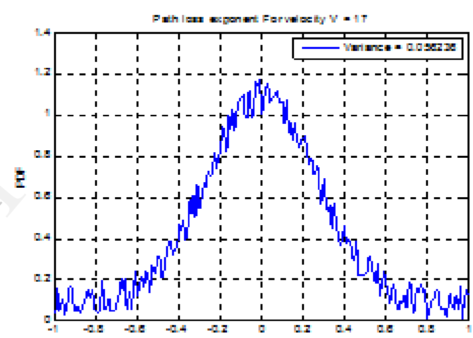

Figure 3. PDF of path loss exponent estimation error in v=17 m/s

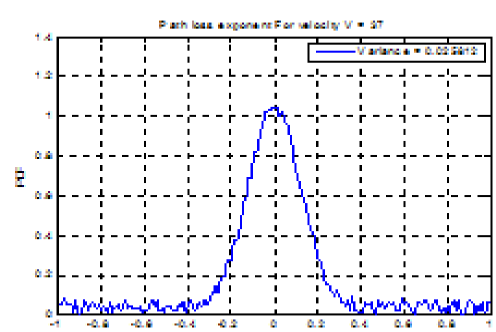

Figure 4. PDF of path loss exponent estimation error in v=37 m/s

The relative speed increases with variance of path loss decreases as shown in fig.5

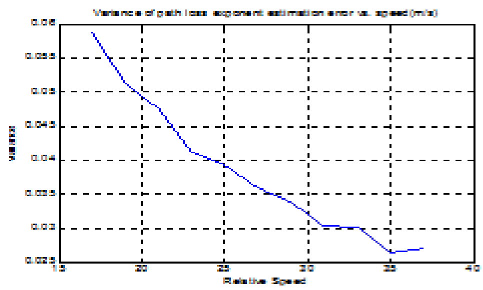

Figure 5. Variance of path loss exponent estimation error vs. speed

Fig. 6 & 7 show distance estimation error PDF in 17&37 m/s . PDF is Asymmetric Laplace.

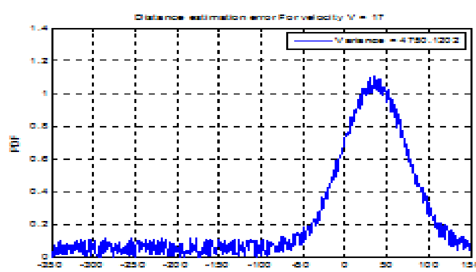

Figure 6. PDF of distance estimation error in v=17 m/s

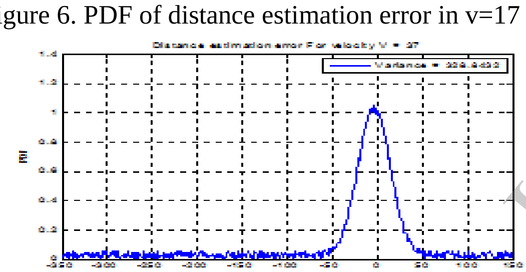

Figure 7. PDF of distance estimation error in v=37 m/s

Fig 8 also shows relative speed increases with variance of distance estimation error decreases & fig.9 shows the Doppler frequency increases with Velocity increases.

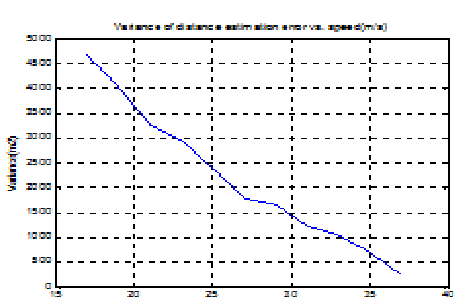

Figure 8. Variance of distance estimation error vs. Speed

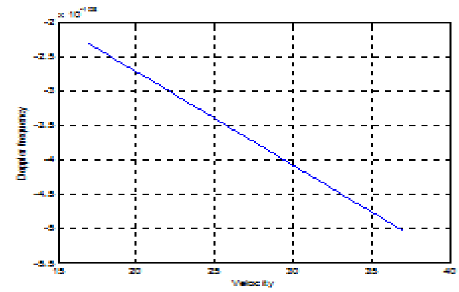

Figure 9. Doppler frequency vs. Velocity

5. Conclusion

In this paper we present A simple RSS method for measure the path loss exponent, power & Doppler shifts which path loss factor is 5. Our technique is used for vehicles with relative moment & improves with increasing relative speed between transmitter & receiver. The strength of this method is nearly zero estimation error mean. This method is applicable for vehicle to vehicle communication but GPS signal is not available. The Doppler frequency increases with Velocity increases. Hence concluded that this method is realistic & take effect of Doppler shift & RSS into account & easy to implement in VANET simulation.

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