A HYBRID APPROACH FOR RSS IN VEHICULAR NETWORK

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ABSTRACT *: Vehicular Adhoc Network (VANET) is important field in engineering research. The measurement & estimation of distances between the nodes is key parameter in VANET application. The Received Signal Strength (RSS) based location technique is very popular research interest due to its simplicity. Using RSS for distance estimation is meaningless without knowing path loss exponent of the environment. This parameter may be less dynamic in some applications with stationary sensors and static environment and may be highly variable in some others like vehicular networks.*
One major challenge of developing VSC systems is to ensure that the reliability of such mission-critical systems is adequate. It is a well-known fact that the broadcast mechanism of IEEE 802.11 – a fundamental building block of VSC systems – cannot provide reliable broadcasting services. The path loss exponent (PLE) is key parameter in the distance measurement & estimation based technique, were the distance is estimated from RSS. This method is proposed 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 shows that Path Loss Exponent increases with increasing relative speed & estimation error variance decreases with increasing relative speed.

Keywords- Received Signal Strength, Doppler Effect, Vehicular Network, DSRC

I. INTRODUCTION

Traffic accidents and traffic jam remain a major social issue. The emergent IEEE 802.11p-based Dedicated Short Range Communication standard (in trial-use) – one of the IEEE 802.11 standards customized for highly mobile, severe fading vehicular environments – paves a new direction for creating cooperative Vehicle Safety Communications (VSC) systems: on the road, each vehicle periodically broadcasts its current kinematic information (e.g., GPS position, velocity, acceleration, etc.) and other sensor information (e.g., braking, stability control, etc.), so that all neighboring vehicles within the transmission range (typically, 300 m) would receive the message. Using appropriate virtual situation-awareness algorithms, a receiving vehicle quickly evaluates whether there is a dangerous driving situation caused by other communicating vehicles. If necessary, VSC systems provide safety alerts to drivers. DSRC-based VSC systems – albeit simple from a network engineer's viewpoint (i.e., single-hop periodic broadcast of vehicle kinematic information) – have attracted great attention from the automotive industry and government agencies, because of their simplicity and low cost.

. The free space power received by a receiver antenna which is separated from a radiating transmitter antenna by a distance d, is given by the Friis free space equation, [1]

$$p(d) = p(d_0)\left(\frac{d_o}{d}\right)2 \qquad (1)$$

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

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

Where, K is a constant

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

If the received power is measured, equation (2) gives the distance d between transmitter and receiver. The path loss model for such environments is given by [2]:

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

For a non-free space area, path loss exponent, α, is varying between 2 to 5 depending on the environment. Also depending on Coherence Bandwidth, path loss may vary for different frequencies in the signal [1].

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

II. LITERATURE SURVEY

A mathematical method is proposed which assumes the position knowledge of at least four reference nodes for estimation of path loss exponent between these nodes and a target node. The main weakness of their technique is considering the same path loss factor for all of the links which is generally false [3]. Two other techniques have been proposed based on pattern matching and using offline data bases for path loss exponent estimation. These methods also assume the same loss factor for all links [4]. RSS based location estimation with unknown path loss exponent is discussed and again the same loss factor for all links is considered [5].

III. PATH LOSS EXPONENT & DISTANCE MEASUREMENT

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 vehicles position.

Two moving beacons are shown as two vehicles on a road as shown in figure 1. These vehicles are varying with different speeds of v1 and v2 and distance of d between them is unknown. Assume two vehicles are moving in one road, and for more generality, in different lanes. If B2 assumed as sender and B1 as receiver, the Doppler frequencies Δf Hz in B1 can be designed with [4].

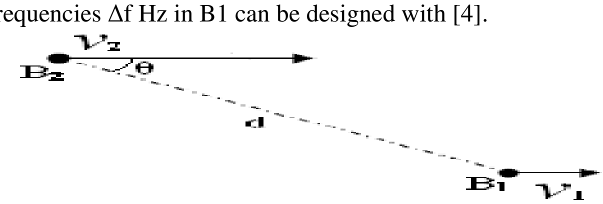

Figure 1. Two moving beacons (vehicles)

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

Where, f is the carrier frequency, c is the light speed, and v is the relative speed of moving vehicles along the road. The situation for N time intervals of duration T is depicted in figure 2. In this figure, δi= viT is the amount of B2 relative displacement with assuming constant relative speed of vi in ith interval.

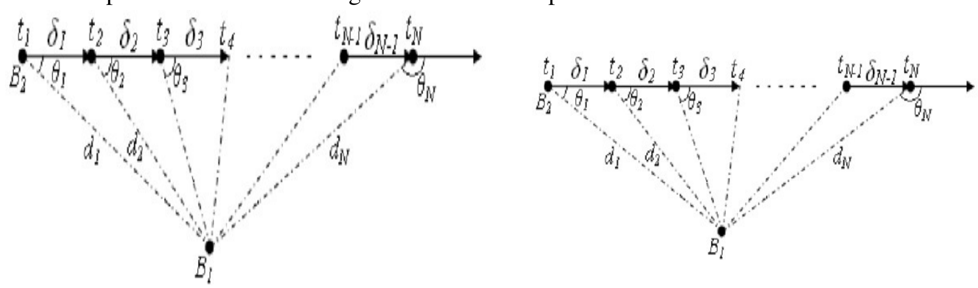

Figure 2. Relative movement over the time

The main idea of the technique is using 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. Taking N intervals into consideration with di as the instant distance between the vehicles in ith interval.

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

Where,

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

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 (4)

0, i=0

$$xi = \sum_{j=1}^{i-1} T \frac{c\Delta fj}{f}, 2 \le i \le N \quad (8)$$

And

$$\Delta f_j = \frac{-fv_j \cos(\theta_j)}{c} \quad (9)$$

Now, if path loss exponent consider 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 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

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

Where,

$$ri = f(x_i, \rho) - y_i \quad (11)$$

and

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

Using a nonlinear Least Square methods like Gauss-Newton or Levenberg-Marquardt [7], the best value of path loss exponent and initial distance between the nodes which minimizes J can be estimated

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

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

IV. SIMULATION AND RESULTS

For the simulation, a two-lane street with lane width of 5 m is consided. Also, two vehicles in two different lanes and relative speed of v are assumed. The sampling time T is assumed to be 0.1 s and N=35 is taken into account. The simulation is implemented through different relative speeds of 21 to 41 m/s. Simulation in each speed is repeated 10200 times each time with a random path loss exponent between 2.5 and 4.5. In figure 3 shows the variation of path loss with respect to distance of transmitter-receiver (Transceiver) has been given. In this resulting figure the variation of path loss has been measured for different exponential value. The overall path loss increases with increase in intermodal distance or Transmitter-receiver inter-node distance

Fig. 4 and 5 depict the Probability Density Function, PDF, of path loss estimation error in 21 and 41 m/s respectively.

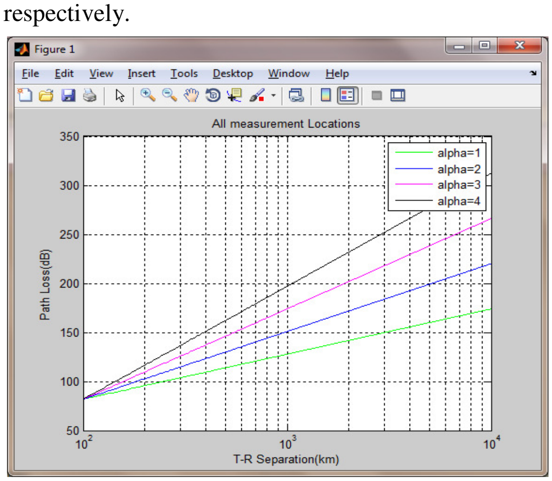

Figure 3 Variation of Path loss Vs Transceiver separations

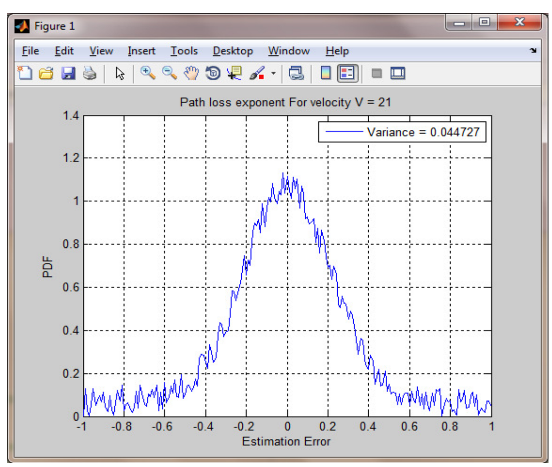

Figure 4. PDF of path loss exponent estimation error in v=21 m/s

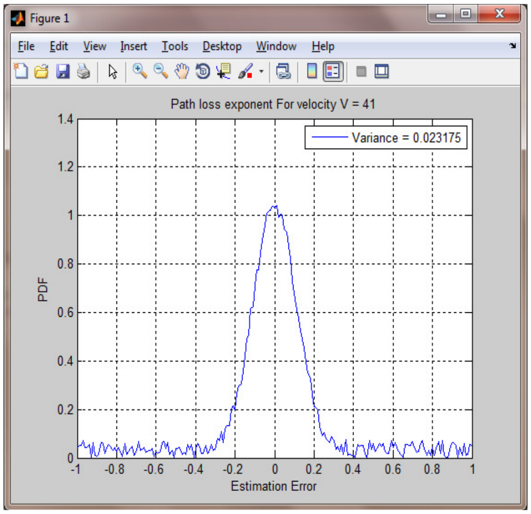

Figure 5. PDF of path loss exponent estimation error in v=41 m/s

Fig. 6 and 7 show the distance estimation error PDF in two speeds of 21 and 41 m/s respectively. As it is seen, PDFs is almost asymmetric Laplace [9].

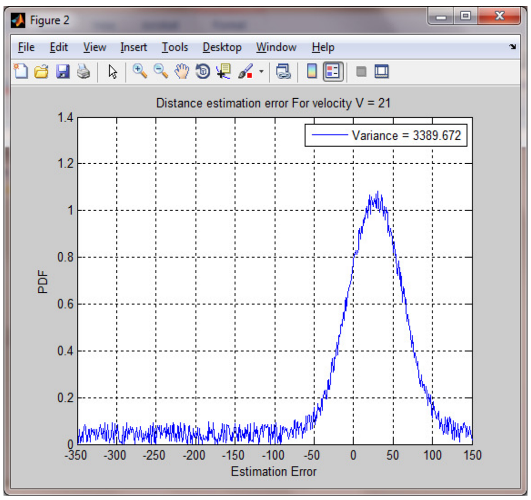

Figure 6. PDF of distance estimation error in v=21 m/s

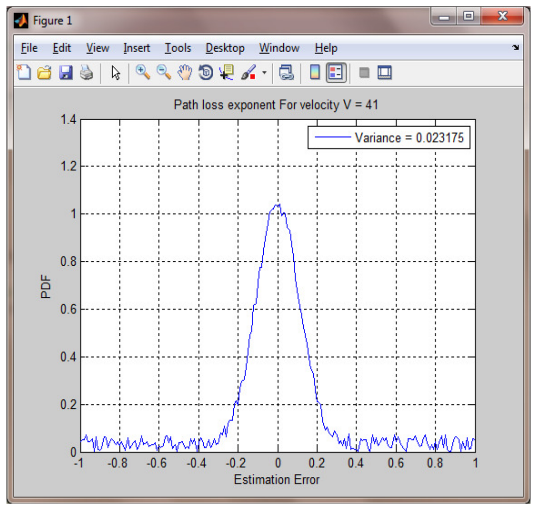

Figure 7. PDF of distance estimation error in v=41 m/s

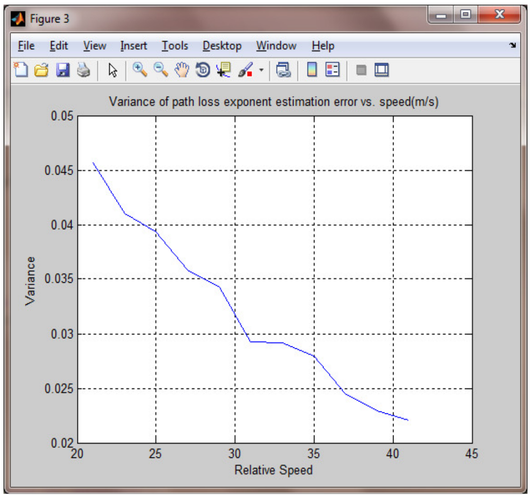

Figure 8. Variance of path loss exponent estimation error vs. speed

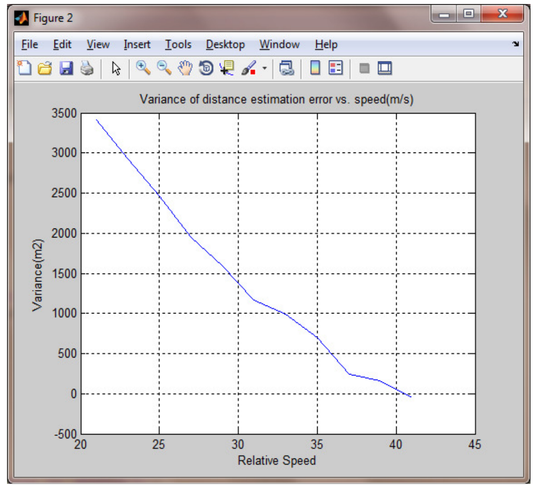

Figure 9. Variance of distance estimation error vs. speed

Above Fig. 8 presents the decrement of distance estimation error with increasing relative speed.

The above presented figure 9 represents the variation of distance estimation error with respect to relative speed of node movement. Here, it can be found that in the developed system the variance for distance estimation error decreases as per increase in velocity.

V. CONCLUSION

This is innovative method for dynamic Estimation of path loss exponent and distance of two dynamics vehicles in a vanet equipped with DSRC. Knowledge of path loss exponent with its dynamic estimation is important and inevitable if one wants to use RSS for distance measurement & estimation. This technique basically uses measured powers and Doppler shifts over a period of time during which path loss factor assumed to be constant.

In this research we have presented a simple RSS method to measure the path loss exponent, power & Doppler shifts with path loss factor is 4. 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. The overall path loss increases with increase in intermodal distance or Transmitter-receiver inter-node distance.

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