LOS/NLOS Channel Identification In WSN

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***Abstract*—The accuracy and effectiveness of a Wireless Sensor Network depends on how efficiently the nodes can be localized and thus the cognizant of their position is of utmost importance. The presence of Non Line of Sight (NLOS) channel condition between the sensor nodes is one of the major hindrances for accurate ranging and localization in WSN. As a result there is a need for low complexity and robust algorithm which can effectively identify the channel condition and help in further mitigation of NLOS rangingerrors byusing an appropriate method. In this paper, we have proposed a very low complexity algorithm that only requires the RSSI (requiring no complex external hardware) for estimating the channel condition which can either be LOS or NLOS.This gives us an advantage and freedom of tackling the NLOS ranging using any amongst various suitable methods developed so far with no extra cost to bear.**

***Keywords*—Wireless Sensor Network (WSN), Non Line Of Sight (NLOS) identification, ToA-Time of arrival, Received signal strength (RSS), multipath channel, localization.**

I.INTRODUCTION

There are many difficulties in monitoring inaccessibleareas or those secluded for purpose of national security. If we can somehow install sensors in these areas such that they can be monitored remotely, then the problem is solved. This can be seen in use in WSN with applications like area monitoring, forest fire detection, landslide detection, industrial monitoring, wastewater and structural monitoring. In addition, there are pressing needs for detection of military infiltration, mining, search N rescue in remote areas. This provided the encouragement to study WSN and look, for the various problems faced in this field, as this branch is in it incipient stage and we have a scope for improvement.Node localization is one of the fundamental tools in WSN [7]. There are many problems faced in node localization in WSN. These include finding out the first path of arrival which can be direct or indirect one. Furthermore, it comprises of detection of whether the signal arriving at a particular unsettled node is through a non-line-of-sight channel or line-of-sight channel.

Amongvarious range based and range free localization methods like TOA, AOA, RSSI; the performance of localization is highly dependent on the propagation channel conditions[2–6]. Using these localization methods, we have seen that the distance estimation for LOS channel condition is quite satisfactory, but using the same approach for NLOS channel condition accounts for a great deal of variation from the expected value, which is not desired [8]. Thus, in order to mitigate this problem, there is need to correctly identify the channel condition i.e. LOS or NLOS so that appropriate ranging technique could be used after channel identification.

In [1], the author combines ToA based range estimates and RSS measurements for NLOS channel identification and mitigation. The above approach requires TOA based range estimator along with RSSI for computing conditional probability, thus providing the channel condition. The disadvantage here is that first the distance estimate is calculated using conventional ToA method and further RSS is used to detect the channel condition which makes this a complex approach and thus overall NLOS mitigation becomes a lengthy process.

Authors in [9] provides an overview and performance comparison of several other NLOS detection algorithms for UWB localization. These comprise of running variance, confidence metric, channel statics (delay spread) and change of SNR. The running variance algorithm essentially computes the variance of subsequent range estimates and compares it against a predetermined threshold to decide between LOS and NLOS.

Above mentioned techniques including [1] involve complex approach of calculating the desired parameter, followed by localization and then applying correction according to NLOS/LOS condition detected in a later stage. Thus accumulating the error and then applying methods to mitigate the error. Considering such circumstances a novel approach would be firstly to detect the channel condition with minimal complexity and then make use of appropriate localization techniques according to the most probable channel condition detected.

In this paper we propose a very low complexity algorithm requiring no complex external hardware for estimating the channel condition. The channel condition thus detected may be used accordingly for localization and hasten the overall process compared to conventional approaches shown so far. We are using only RSS values for channel estimation. Since RSSI is already available in the WSN receiver node (i.e. AGC), that justifies our statement of not using any external hardware. Our approach comprises of two steps. First is mainly the estimation ofthreshold condition by calculating the RSS's variance for decision area which could be LOS or NLOS. This can be calculated for any given deployment environment like open ground, residential, urban and indoor office environment etc. Secondly, channel condition estimation is carried out by comparing the experimental value with the estimated value of variance. The results obtained were seen to go beyond 85% accuracy for different standard channels (using MATLAB R2010a as simulation environment).

The remainder of this paper is organized as follows: In section II, we present the detail of our RSS's variance based channel condition estimation algorithm. The simulation and results are reported and discussed in section III. Section IV concludes this paper.

II.RSS's VARIANCE BASED CHANNEL CONDITION ESTIMATION

- Our approach is as follows:
  - The latest Path loss models for NLOS/LOS in different scenarios (indoor/outdoor) in MATLAB, Version 7.10.0.499 (R2010a) was found out.
  - Using these models as the communication channel between beacon and unsettled node, the received power strengths for a pulse input repeatedly was determined.
  - This procedure was carried out for a number of path loss models thus accumulating our results.
  - Then RSS's Variance for the pulses sent from beacon node for LOS and NLOS models was calculated.
  - Then after experimentally determining the threshold value of variance (0.18 approx.), which gave the best results for both LOS and NLOS environment for different path loss models, equation (1) can be used to identify the channel condition as LOS or NLOS.

The various standard channels shown in table 1 are dynamic channels which give the various multipath fading effects in the simulation environment to proximity with the actual propagating medium. Several transmitted impulses are sent over these channels and at the receiver we can get the set of RSS values. Now, variance is calculated for each set of channel conditions. The idea here is that for a NLOS condition, there would be more variance compared to that of LOS condition because of absence of direct path which leads to a lot of variation in the travelled path for a number of pulses sent over time. This is in accordance with the fact that for NLOS the effect of multipath fading would be more prominent compared to LOS channel condition.

The calculation of threshold value of variance requires that it holds good for both LOS and NLOS condition as well as give the maximum efficiency for both cases. This is performed by repeated comparison of different variance values for different LOS and NLOS standard channels of those shown in table1.

Standard Channel	Channel Description
jtcInResA	Indoor residential A
jtcInOffA	Indoor office A
jtcInComA	Indoor commercial A
itur3GIAx	Indoor office, channel A
itur3GIBx	Indoor office, channel B
itur3GSAxLOS	Satellite, Channel A, LOS
itur3GSAxNLOS	Satellite, Channel A, NLOS
itur3GSBxLOS	Satellite, Channel B, LOS
itur3GSBxNLOS	Satellite, Channel B, NLOS
itur3GSCxLOS	Satellite, Channel C, LOS
itur3GSCxNLOS	Satellite, Channel C, NLOS

Table 1: Various Standard Channel models defined in Matlab

For each of the above standard channels, the percentage of correctly detected LOS and NLOS nodes is compared against various values of variance. Thus we can easily monitor this relationship and calculate the threshold value of variance for which we get best results for both LOS and NLOS. This can be seen in fig 1 and fig 2.

After calculation of threshold value of varianceσ_{th} , we can easily find out the channel condition from the following set of comparison equations. Thus for a given threshold value of variance σ_{th}, the channel conditions given as:

$\sigma_{calculated} > \sigma_{th}$: NLOS CONDITION
.... (1)

$\sigma_{calculated} < \sigma_{th}$: LOS CONDITION

Here, $\sigma_{calculated}$ is the calculated variance of the RSS values for given set of pulses sent over an unknown channel. From equation (1), we see that if variance value exceeds the threshold value indicating presence of NLOS channel condition and similarly for LOS condition as well. As a result the required unknown channel condition is projected and aids in localization process. The following section describes the simulations and corresponding results.

III. SIMULATION AND RESULTS

Simulations were carried out using MATLAB, Version 7.10.0.499 (R2010a).

A. Calculation of threshold value of variance

As discussed in our algorithm, various standard channels were used as path between beacon and unknown node, which on calculating the variance of the pulse of power received at the receiver node, gave σ_{th}= 0.18.
For:

$\sigma_{calculated}$> 0.18 Presence of NLOS Channel

$\sigma_{calculated}$<= 0.18 Presence of LOS Channel

This can be explained by the fact that, for NLOS channel condition, absence of direct path leads to lot of variation in the travelled path for a number of pulses sent over time and thus more variation of RSS. The following figures obtained justify the threshold calculation procedure.

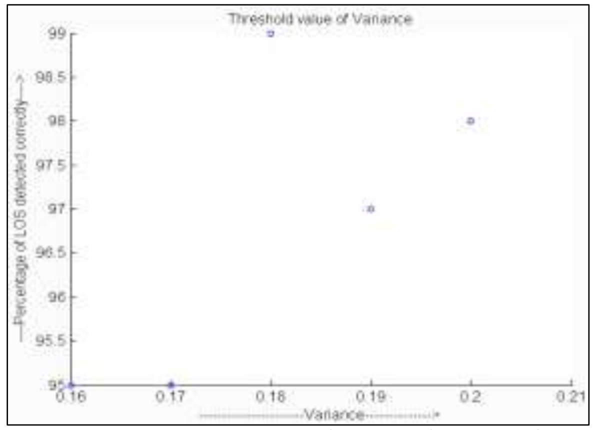

Figure 1: Determining Threshold of variance of RSS value for LOS condition

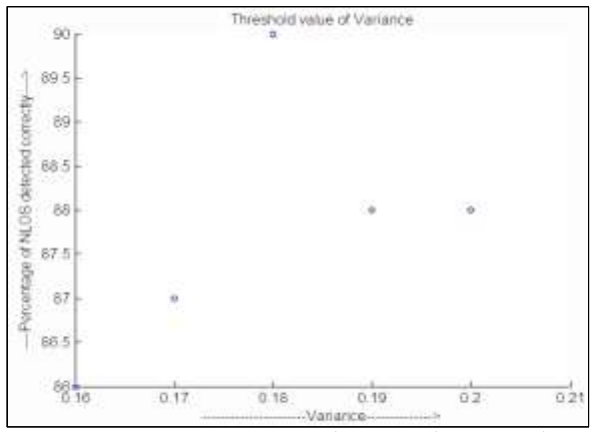

Figure 21: Determining Threshold of variance of RSS value for NLOS condition

The calculation of threshold value requires that it holds good for both LOS and NLOS condition as well, giving maximum efficiency in both cases (above 85 % approx.). From fig 3 and 4 it can be seen that corresponding to variance value of 0.18, both LOS and NLOS scenario's give best results.

B. LOS/NLOS Channel Detection

We used various standard channels discussed in previous section. The input to this Channel was the transmitted power from beacon node, consisting of 1000 pulses with constant amplitude. The channel provides the required behaviour as expected from the channel condition. The output, received power at the unknown node was calculated for every pulse of transmitted data and overall variance of these power levels was calculated. Testing these values against the threshold value calculated experimentally, as previous shown, gave the desired results. After confirming the obtained results for different standard channels, the conclusion was made that the

LOS/NLOS channel condition with efficiency above 85% was successfully detected.

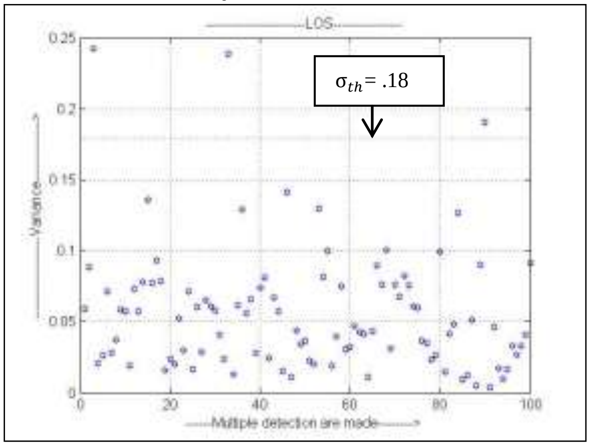

Figure 3: LOS Channel detection

This fig 3 shows detection of 97 LOS nodes out of 100 nodes taken, i.e. 97% efficiency corresponding to σ_{th}= .18. The standard channel used here is **"itur3GSAxLOS".**

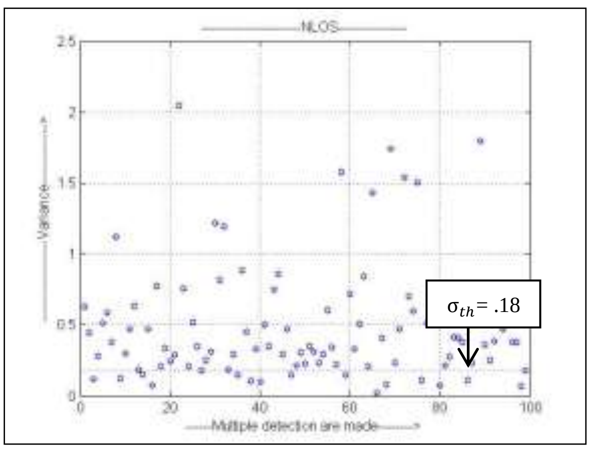

Figure 12: NLOS Channel detection

This fig 4 shows detection of 85 LOS nodes out of 100 nodes taken, i.e. 85% efficiency corresponding to σ_{th}= .18. The standard channel used here is **"itur3GIAx_NLOS".**

IV CONCLUSION

In this paper we have described very low complexity algorithm for NLOS/LOS channel condition detection using variance of RSS measurement for different environments. The variance value is more for NLOS than LOS due to additional propagation delay and increased multipath components. The efficiency of NLOS / LOS detection was seen to go beyond 85% for different standard channels.

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