
NLoS and LoS Link Identification For Improved Localisation

1 Introduction

Localisation is key to various applications such that annotating physical location of sensors with sensors data in wireless sensor network, localising personnel and objects for industrial automation, tracking personnel in working environments, contact tracing for maintaining social distance etc. Ultra-wide band is emerging as one of promising technology for localisation, it is a time-based localisation algorithm. UWB localisation is based on measuring the signal propagation time between a transmitter and a receiver.

Time-difference-of-arrival(TDOA) localisation algorithm requires precise clock synchronisation among all or reference nodes inside system but commonly TWR(Two-way ranging) method is used in UWB localisation as it doesn't require clock synchronisation and thus can be used in resource-constrained wireless devices.

UWB pulse radios have ultra-wide bandwidth(typically more than 500MHz) and short transmit pulses offer high temporal and spatial resolutions and great multi-path fading immunity with result in high localisation accuracy and location update rate. However high multi path resolvability alone does not eliminate the effects of multi-path and NLoS (Non-Line of sight) propagation.

TWR based UWB localisation requires a UWB anchor (reference node) network to track tags(node with tracked). TWR is used to calculate range between anchor and tags and then triangulation can be done to have precise location of tag (with reference to anchors).The localisation algorithm will lead to erroneous results when there is large ranging errors between anchors and tag(s). Multi-path propagation and NLoS propagation are primary source of ranging algorithm inaccuracies.

NLoS identification can be used to detect NLoS nodes which can latter be eliminated (or weighted according) from the pool of nodes used of localisation. This is useful when we have a large number of anchor nodes available with many of them with an LoS link to the localized node(s). NLoS and LoS links can be identified based on channel impulse response (CIR) characteristics. A binary hypothesis test, using CIR characteristics, can be formulated to detect NLoS and LoS link. NLoS detection at localized node/localization engine can help eliminate or reduce ranging inaccuracies which can result in more precise and robust UWB based localization system.

2 Problem Statement

Overview of Localisation

A network consists of two types of nodes: *anchors* are nodes with known positions, while *tags* are nodes with unknown positions. Let there be a network with single tag with unknown 2D position $\mathbf{p}(\mathbf{X}, \mathbf{Y})$ surrounded by N anchors with positions, $\mathbf{p}_i(\mathbf{x}_i, \mathbf{y}_i)$. The distance between the agent and anchor i is $d_i = \|\mathbf{p} - \mathbf{p}_i\|$.

The tag estimates the distance between itself and the anchors, using a ranging protocol such as Ultra-wide band based Two Way Ranging. Let \hat{d}_i denotes the estimated distanced between the agent and anchor i and $\epsilon_i = \hat{d}_i - d_i$ is the ranging error. Given a set of at least three distance estimate, the tag will be able to determine its position using triangulation. Tag can solve below equation to compute $\mathbf{p}(\mathbf{X}, \mathbf{Y})$.

$$\hat{d}_i = \|\mathbf{p} - \mathbf{p}_i\| \text{ for } i = 1, 2, 3... \quad (1)$$

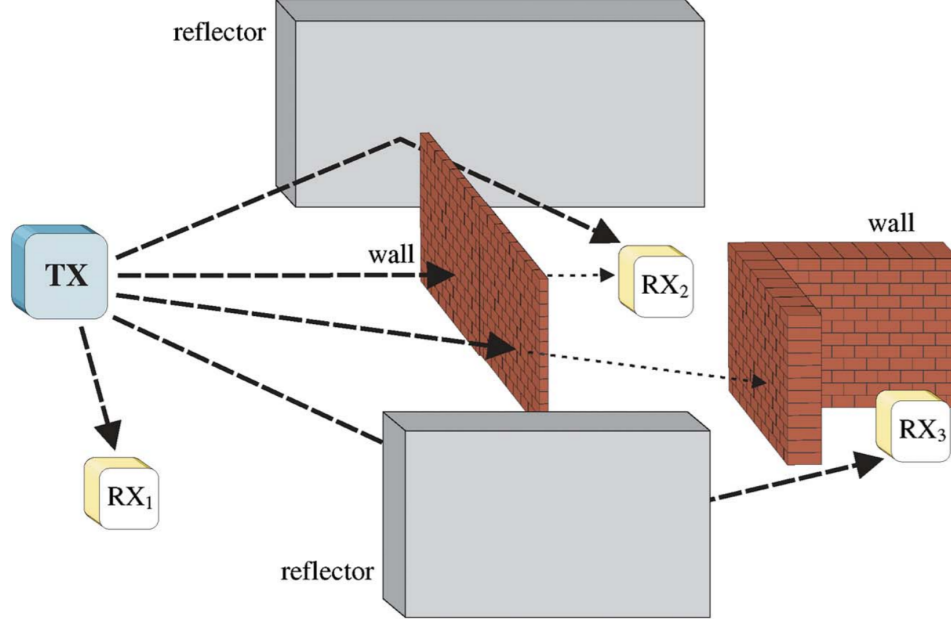


Figure 1: Possible LOS and NLOS conditions from transmitter TX to various receivers. RX1 is in LOS condition, RX2 and RX3 is in NLOS condition [4]

Ranging Error

The triangulation algorithm will lead to erroneous results when the ranging errors are large. In practice the estimated distances are not equal to the true distances, because of a number of effects including thermal noise, multi-path propagation, interference, and ranging algorithm inaccuracies. Additionally, the direct path between requester and responder may be obstructed, leading to NLOS propagation. In NLOS conditions, the direct path is either attenuated due to through material propagation (RX_2), or completely blocked (RX_3). In the former case, the distance estimates will be positively biased due to the reduced propagation speed (i.e., less than the expected speed of light, c). In the latter case the distance estimate is also positively biased, as it corresponds to a reflected path. In NLOS identification nodes (anchors) with NLOS characteristics are identified and distance estimates are not considered for triangulation. Figure 2 is the CDF plot of the ranging error for LOS and NLOS scenario based on the data collected as part of research in [4]. In LOS conditions a ranging error below one meter occurs in more than 95% of the measurements. On the other hand, in NLOS conditions a ranging error below one meter occurs in less than 30% of the measurements.

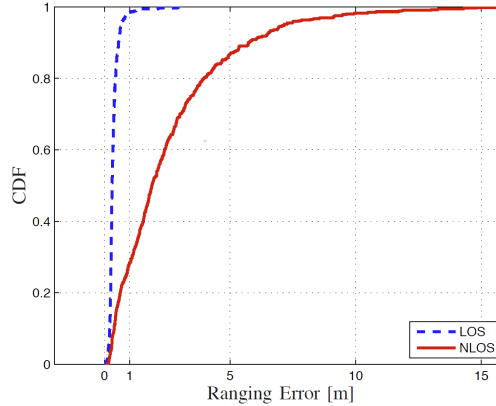


Figure 2: CDF of the ranging error for the LOS and NLOS condition[4]

3 References

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