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Towards a Spatial Model of UWB Ranging Biases

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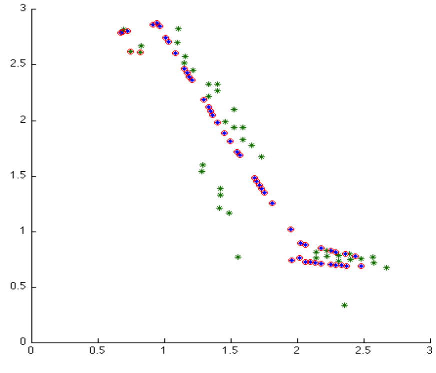
Ultra-wideband (UWB) technology has been one of the major developments in the wireless industry with potential for high data-rate communication and precise ranging. Due to their large bandwidths; UWB receivers can resolve individual multipath components (MPCs), which enable to accurately estimate the arrival time of the first signal path. Therefore the distance between a wireless transmitter and a receiver can be accurately determined, yielding high localization accuracy.

Locating a node in a wireless system includes the collection of information from radio signals travelling between a target node and a receiver. Various techniques have been proposed for wireless indoor localization making use of various types of measurements. In time based techniques the time of arrival (TOA) of the signal at a reference node or the time difference of arrival (TDOA) between the reference nodes is measured. Time based techniques are the most suitable for UWB systems as they provide centimeter accuracy by levering the large bandwidth that UWB systems offer.

However there are a number of error sources that may seriously degrade the performance of time based ranging techniques. Such error sources are multipath propagation, and non-line-of-sight (NLOS) propagation. In multipath propagation multiple replicas of the signal partially overlap and shift the position of the correlation peak. In the absence of the direct path the pulse travels an extra distance and therefore a positive bias is added when measuring the distance between the two nodes, leading to less accurate localization. UWB can mitigate the multipath with the availability of excess bandwidth but NLOS propagation needs to be further investigated.

For the mitigation of the localization error, we investigated the creation of a spatial model of UWB ranging biases and an error mitigation algorithm that exploits those TOA bias estimations in order to achieve more accurate localization. Given a set of ground truth positions of the target node and the TDOA measurements from the base stations, we can obtain an estimation of the TOA biases experienced from each receiver. The statistics derived from these biases are used for the creation of a stochastic spatial bias model for the untrained locations of the area of interest. The area of interest is divided into cells, and every cell is assigned a bias value according to the bias estimations of the training positions within the particular cell. Once the node is located using the biased TDOA values, its position can be mapped to the respective cell in the spatial bias model. Then the corresponding bias estimations can be used for the correction of the biased TDOA values and the localization algorithm runs again leading to improved accuracy. For the purposes of the project we considered four base stations generating three TDOA values and a moving target that we want to locate in 2D. For the localization of the target we implemented Chan's algorithm, which we extended to include 3D localization in order to consider the height of the base stations and that of the moving target. The case where all receivers have the same height and the target does not move on the z-axis was also investigated.

Finally the 3D algorithms were used to plot the trajectory of a moving robot given real TDOA measurements from the lab and the localization results were compared with its ground truth positions. Results show that by using the mitigation algorithm, the actual position of the robot is obtained, if the bias estimation is good.



Initial and corrected estimations of the robot's trajectory