The Effect of Antenna Pattern Distortion on UWB Ranging Accuracy

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I. INTRODUCTION

Ultra-wideband (UWB) systems have the potential to realize accurate ranging using time-based techniques. Much work has been done on UWB time-of-arrival (ToA) estimation in general. However, the effect of the radiation patterns of antennas used in localization applications have not been considered. This report investigates the effect of user terminal (UT) antenna pattern on the detection of the direct path. It aims at presenting the ranging error in a typical industrial indoor environment for line-of-sight (LoS) scenario. Moreover, this report introduces a technique to synthesize the desired antenna patterns for the purpose of this study by employing spherical wave expansion (SWE) tool.

II. THRESHOLD-BASED RANGING

A threshold-based ToA estimation algorithm similar to [1] is applied to the measured data. The aim of the algorithm is to estimate the propagation delay of direct path by comparing received signal samples to the appropriate threshold values depending on the delay. The difference between real transmitter (Tx)-receiver (Rx) distance (known from Tx and Rx coordinates) and measured distance, i.e., ranging error, is used as a criteria to evaluate ranging performance.

A. Polarimetric UWB Channel Measurement

Two bicone antennas in Tx and Rx sides. Rx antenna is fixed. Tx antenna is mounted on a precise XYZ scanner. The channel transfer functions of cubical virtual array element locations, $5 \times 5 \times 5$ array elements with 2 cm enter spacing, were acquired in Tx side. The measurement were done for three orthogonal probe orientations in each sampling array location.

III. ANTENNA PATTERN SYNTHESIS

The starting point for the application of the virtual array principle for generating different radiating patterns is the fact that the radiation patterns of an antenna with a finite geometrical dimension can be expressed as truncated spherical wave expansion [2]. It is shown in [3] that with such cubical scanning as we performed the measurement, one can find out such a set of excitations for the probes on the cubical surface that this virtual array of the probes radiates any desired single spherical mode pattern. If we are able to generate all modes independently, we can then generate any arbitrary patterns as a weighted sum of these mode patterns (as basis patterns). For the case of this study, more realistic patterns with considering human head phantom effect is simulated using electromagnetic SEMCAD X simulator. Then the patterns are synthesized by using the spherical mode patterns as basis functions. The synthesized excitation coefficient of each array element is obtained by weighting the excitation coefficients of virtual bicone array for each spherical mode by spherical wave coefficients of desired pattern. Measured radiation pattern of biconal antenna in whole sphere is used.

The synthesized transfer function with having desired radiation pattern at the transmitter is derived by

$$H_{\text{syn}}(f) = \sum_{l=1}^{L} C_{\text{syn},l}(f) H_l(f)$$

where $H_l(f)$ is measured transfer function of frequency and $C_{\text{syn},l}$ is synthesized excitation coefficient of each $l$-th array element.

IV. RANGING RESULTS AND DISCUSSION

It was presented in [1] that considering that the antenna main-beam is pointing to a random direction, the overall performance of ranging degrades by having more main lobe directivity and narrower beam width (that is considering human head effect). This is because narrower beam-width decreases the opportunity to observe the receiver. Since neither the orientation of UT is fixed or traceable, nor the direction of access point (AP) is known for the UT, it is observed (in Fig. 1) that the overall performance of the ranging is dramatically decreased by having a more directive antenna due to the human head effect.

REFERENCES