On the Design and Analysis of Antenna Patterns for Localization with Smart Devices

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Source localization is a well-studied topic in the area of statistical signal processing. Several pertinent application scenarios exist for this problem, mainly derived from the type of observations available at the fusion center to conduct the estimation task. This work revisits some of the approaches and algorithms proposed for localization, albeit in the context of smart devices. A distinguishing feature of smartphones and emerging monitoring platforms is the fact that each device comes equipped with an embedded global positioning system (GPS) unit and an inertial measurement unit (IMU). These devices can therefore estimate in a very precise manner their own location, and they can infer their current orientation. In certain cases, derived estimates, which act as side information, can significantly improve the performance of a source localization algorithm.

This contribution focuses on the case where source localization must be performed based on received signal strength. This type of algorithm relies on the fact that signal strength decays with distance. By collecting received signal strengths at multiple geographical locations, it is possible to identify the most likely coordinates for the emitter. The maximum-likelihood algorithm and its many approximations for this problem have been discussed in the literature. However, in deriving these algorithms, the fact that most antennas are not omnidirectional is often overlooked. In particular, the orientation of a device will affect the value of a received signal strength indicator and, hence, can alter the performance of the algorithm. Since many smart devices are orientation-aware and radiation patterns are fixed for static antennas, it is desirable to store locally the antenna gain as a function of azimuth and elevation for possible polarizations. This information, together with receiver orientation, can be incorporated into the statistical signal processing algorithm to improve performance. Compensating for the directional gain of the antenna system leads to significant performance improvements in certain scenarios. These findings raise important questions. What are good antenna designs for orientation-aware localization systems? Furthermore, what are the potential gains associated with agile antennas and dynamic radiation patterns in this context?

The results presented in this study are obtained using numerical simulations and testbed implementations. Sensing devices are based on the Android™ platform, with its rich application programming interface (API). The measurement campaign is performed in the industrial, scientific and medical (ISM) radio bands. Moreover, experimentation is conducted outdoors in an open area suitable for GPS signal acquisition. Nevertheless, the concepts discussed herein extend to much broader inference scenarios.