Time Reversal for Source Localization in Urban Environments Considering the Effects of Doppler Shift

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Time reversal can be used as a secure communication means between two terminals without knowing their locations. In this case, the time reversed signal will focus at the targeted terminal automatically. This same mechanism can also be used in the determination of the source location of a transmitted signal, especially in complex urban environments. The complex structure of streets, buildings, and other elements of an urban area are difficult to model and prove especially difficult for source detection. For this purpose, time reversal is a viable method which is well suited for the rich multipath domain provided by a complex urban setting. Time reversal has been employed in numerical methods, such as FDTD, for source localization. These methods are accurate and convenient for time reversal as they operate in the time domain. However, these methods are not well suited for simulation of the physically and electrically large sizes of urban areas. Ray tracing is a suitable method which can provide fast and accurate performance in modelling such environments.

In previous works, we demonstrated the use of ray tracing and time reversal for localization of a stationary source within a typical urban environment. In practical applications, it should be considered that a transmitter or receiver may be moving which will result in a Doppler shift. We are interested in the impact these frequency shifts may have on the ability to determine a source's location using time reversal when compared to a stationary target.

In the demonstration of ray tracing and time reversal for detection of source location, the environment and antenna locations were well defined. In some cases, determination of the source location could be made to within an accuracy of one wavelength. For real applications we are interested in the challenging task of localization where proximity (initial guess) of source location is unknown. In the worst case, the search domain could be an entire urban model which is difficult and unrealistic to achieve. The required search domain can be decreased and many areas can be eliminated by exploiting some parameters from ray tracing propagation modeling data. Time delay, angle of arrival, and other information about the received signal can be utilized to determine possible source locations and eliminate impossible locations. Details about the environment itself can also be utilized to limit the search domain and further pinpoint source locations.

Further investigations in these areas will be carried out. More comprehensive results on time reversal and source localization including effects of Doppler shift from moving sources will be presented and discussed.