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Localization of Non-Cooperative Target with Distributed Binary Observations

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Abstract

This dissertation focus is on localization of a non-cooperative target with distrusted binary measurements. In a *non-cooperative* target localization unlike the *cooperative* one, we do not receive any assistance from the target on revealing its position. This type of localization has a lot of applications, for example, to identify the primary user in cognitive radio, spectrum cartography, identifying the location of an unauthorized user in a mobile network and identifying the location jammer in the battle field. *However, the non-cooperative assumptions make many localization techniques including the ones requiring time reference synchronization impractical*. Therefore, instead we rely on binary measurements of signal power from a large number of sensors scattered in the field which better lends itself to energy and complexity requirement of a Wireless Sensor Network realization. In other words, the location of the non-cooperative target would be carried out through processing of the data and locations of all sensors.

In this setting, the estimate of the target location is being affected by two different sources of uncertainty. One is the uncertainty involved in each sensor decision which can be the result of noise, fading or other random process effects on the received signal and shows itself in terms of false alarm or missed detection. The other one is the intrinsic error resulting from estimating a source transmitter location through scattered binary measurements which involves the density of sensor deployment, actual power of transmitter and threshold selection to convert the received signal power value to binary decisions. *The main contribution of this thesis is to provide a system- atic approach to separately investigate the effects of these sources of error on the target location estimate*. With that approach, it was possible to *establish fundamental limits on performance and accuracy of a non-cooperative target localization through distributed binary measurements.* A minimum variance unbiased (MVU) estimator for target estimation is also developed in noiseless regime which helped to establish a lower bound on the performance of all location estimators in the presence of noise and fading. The importance of such a development is that the usual Cramer Rao Bounds derivation fails in this case due to the fact that the likelihood function becomes dis- continuous. Furthermore, novel sub-optimal estimators have been developed based on the MVU estimator which performs close to optimal while requires much less resources to implement. Be- sides, the effect of density, power of transmission and threshold selection on the accuracy of location estimation have been investigated. In addition, the problem in the presence of noise and fading is investigated and it is shown that for *any isotropic propagation the minimum mean square location error achievable by an efficient estimator would become independent from its performance for estimation of the source power*. Moreover, formulas are derived to calculate *the optimum threshold to be selected by the scattered binary sensors based on propagation characteristic to achieve the best performance for location estimation*. Finally, methods are developed to quantify and compare how much location accuracy will be lost if the non-detecting sensors' data are censored before the estimation process.