**Wireless Geo-location and Tracking**

Our focus here is on geo-location and tracking of targets in mixed line-of-sight (LOS) / non-line-of-sight (NLOS) environments such as in an urban city with high-rise buildings. The problem formulation involves handling mobile/stationary sensors which can carry out one or more of the following measurements,

1. Time of arrival (TOA) / Time difference of arrival (TDOA)
2. Angle of arrival (AOA)
3. Frequency difference of arrival (FDOA)

**Signal Strength**

The target/sensor dynamics together with various physical constraints forms the main focus of our research. Our algorithms are built upon the ubiquitous Gauss-Markov state space models such as Kalman filtering, extended Kalman filtering, particle filtering and variants of these techniques. We also look into multi-target tracking where we utilize the random finite set theory with algorithms such as the probability hypothesis density (PHD) filter.

**Robust Array Processing**

Our Robust Adaptive Array Processing research aims to develop methods to improve signal detection and reception performance. Because of the high sensitivity of adaptive arrays to the errors in the array characteristics or environments, one of our research focuses is to develop algorithms which can offer robustness against various errors or imperfections in practical applications. Furthermore, we also look into the robustness issue of sparse array comprising of small sub-arrays that has the potential to offer a more practical antenna array deployment. In addition, we also study and attempt to exploit the special properties of communication signal and environmental noise to enhance the reception capability and DOA resolution of adaptive arrays.

**Parsimonious Array Processing**

In Parsimonious array processing, we are attempting to develop a reliable low cost, low complexity, lightweight direction finder. The proposed approach exploits the pattern diversity of a single antenna and estimates the direction-of-arrival of multiple transmission sources from a vector of power measurements. Our approach offers high resolution direction finding using only low resolution directional antenna. It is also applicable to any signal modulation and not restricted by the transmission signal...
bandwidth as long as the un-correlation property of the signal from different sources is maintained. The efficacy of our approach has been demonstrated in simulation study as well as experimental environment.

Another approach that we pursue in parsimonious array processing research is to design passive coupling matrix to overcome the performance limitation of array processing using small aperture array. This approach is inspired by the sound localization acuity of a parasitic fly, attributing to the mechanical coupling of its eardrums. With the coupling mechanisms, we are able to design a compact aperture antenna array with much improved resolution performance for direction-of-arrival estimation.

**Advanced Front-End**

Our focus here is on developing software and hardware to further advance the front-end receiving framework in RF-array communications systems. This includes formulating novel approaches to exploit sparsity of the received spectrum, using prior information of the modulation schemes and improving the computational efficiency and reconfigurability of filter banks in array processing. We also look into developing algorithms for automatic modulation detection and parameter estimation. Techniques of interest are statistical methods, sparse signal processing and Bayesian signal processing. Another area of interest is the robustness of the receiver arrays under adverse or hostile RF environments. Our interest here is on novel algorithms with hardware modifications that allows direction finding(DF) and beamforming(BF) even under adverse or saturated receiver conditions.