Coursework EE401: Advanced Comm. Theory
Part-B
“Localisation of Wireless Signals”

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1 Aim

The aim of this coursework is to implement and compare the main classical & modern localisation algorithms of wireless signals.

2 Software

- PC (operating system Windows 10 or Mac OS)
- MATLAB
- Personal data file that should be downloaded from the shared Box link.

3 Tasks

With reference to Figure 1, consider a transmitter (Tx) located at an unknown location $\underline{r}_m \in R^{3\times 1}$ on the x-y plane (i.e., unknown range ρ and azimuth θ). Furthermore, consider 4 receivers (Rx) at known locations with Cartesian coordinates $\underline{r}_1, \underline{r}_2, \underline{r}_3, \underline{r}_4$ given in meters as follows

$$[\underline{r}_1, \underline{r}_2, \underline{r}_3, \underline{r}_4] = \begin{bmatrix} 0 & 60 & 100 & 60 \\ 0 & -88 & 9 & 92 \\ 0 & 0 & 0 & 0 \end{bmatrix}. \tag{1}$$

The objective is to estimate $\underline{r}_m$ or (ρ, θ) based on the environment described in the following 4 tasks under the line-of-sight (LOS) condition.

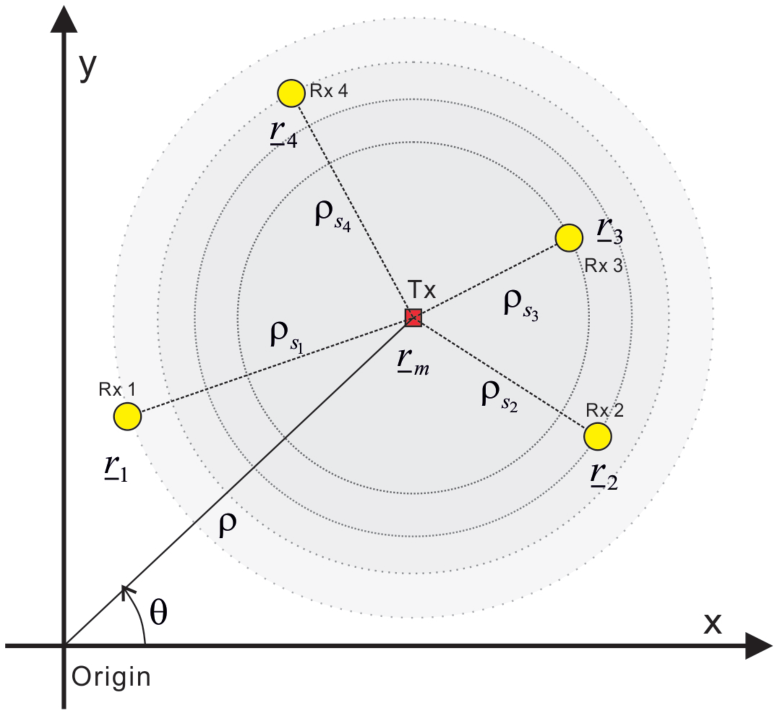

Figure 1: Illustration of $\mathcal{R}^2$ localisation with distributed Rxs

Some of the system parameters used for the provided data are summarised below:

Parameter		Value	Parameter		Value
Carrier frequency	F_c	2.4 GHz	Propagation speed	c	3×10^8 m/s
Symbol duration	T_{cs}	5 ns	Path Loss exponent	α	2
Number of Rx	N	4	SNR		20 dB
Noise power	σ_n^2	5 dB	Sampling period	T_s	5 ns

Task-1: Time-based Localisation

Consider that all 4 Rxs use a single isotropic antenna with unity gain:

- Time of Arrival (TOA) Localisation

  Assume the transmission time instant t_0 of the Tx signal is known by the Rxs, i.e. Tx & Rxs are synchronised. Provided with a data set of 256 samples and the transmission time instant $t_0 = 20T_s$, estimate the Tx's location using TOA localisation.

- Time Difference of Arrival (TDOA) Localisation

  Assume the transmission time instant t_0 is unknown and cannot be estimated. Using the same data file as above, estimate the Tx's location using TDOA localisation.

Task-2: Received Signal Strength (RSS) Localisation

Consider that all 4 Rxs use a single isotropic antenna with unity gain and the transmit power $P_{\mathrm{Tx}} = 150$ dBm. Using the data file provided for this task, estimate the Tx's location using RSS localisation.

Task-3: Direction of Arrival (DOA) Localisation

Consider that all 4 Rxs use a Uniform Circular Array (UCA) formed by 6 omnidirectional antennas (see Figure 2) whose geometry with respect to its own reference point is given below in meters

$$\mathbf{r}_{\mathrm{UCA}} = \begin{bmatrix} 0.1250 & 0.0625 & -0.0625 & -0.1250 & -0.0625 & 0.0625 \\ 0 & 0.1083 & 0.1083 & 0 & -0.1083 & -0.1083 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}. \tag{2}$$

Using the data file provided for this task, estimate the Tx's location using DOA localisation.

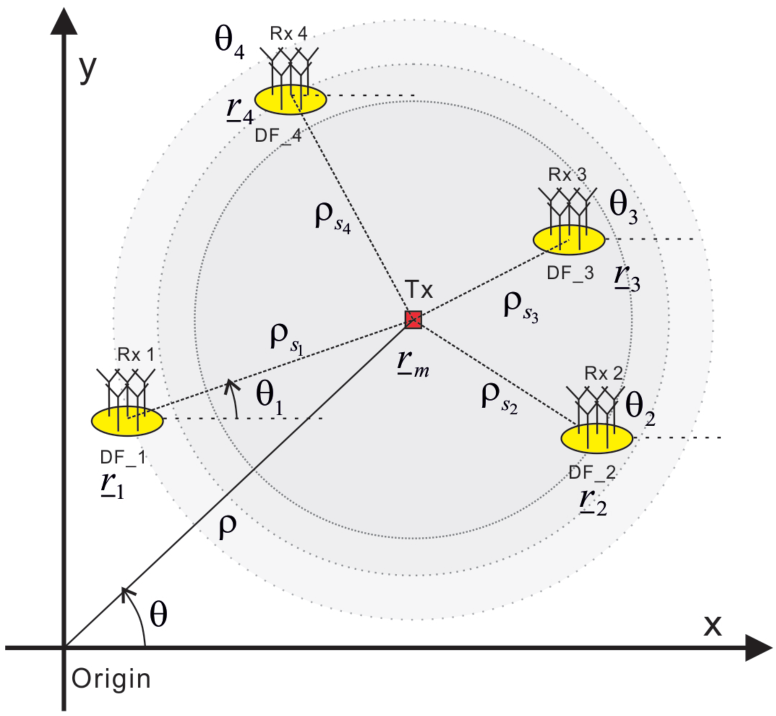

Figure 2: Illustration of $\mathcal{R}^2$ DOA localisation with distributed UCAs

Task-4: Large Aperture Array Localisation

Consider that all 4 Rxs use a single isotropic antenna with unity gain, they form a distributed array of 4 elements. Using the data file provided for this task, estimate the Tx's location using large aperture array localisation.

4 Deliverables

1. MATLAB file(s) - with brief comments. That is four MATLAB script files (one per task) where the system parameters are defined and a number of MATLAB functions (with comments) are called.

2. A pdf file with the results, including positioning circles/hyperbolic curves, of the above four tasks supported by 2-5 lines of brief comments per task.

3. Comments, if any, of how to run the programs to observe the results of the four tasks.

4. Please upload a zip file (including all the files) named by your login name (e.g., kl209.zip).

5 N.B.:

1. Personal data file: Please download your personal data file from the shared Box link.

2. In folders of Tasks 1 and 2, the "Rx1.mat", "Rx2.mat", "Rx3.mat" and "Rx4.mat" files contain the received signal sample vector at each Rx (antenna) in the following form:

$$[x[1], x[2], \ldots, x[l], \ldots, x[L]] \in \mathcal{C}^{1\times L} \tag{3}$$

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3. In folder of Task 3, the "Xmatrix_i_DFarray.mat" file contains the received signals in the form of the following matrix:

$$[\underline{x}_i[1], \underline{x}_i[2], \ldots, \underline{x}_i[l], \ldots, \underline{x}_i[L]] \in \mathcal{C}^{6\times L} \tag{4}$$

where $\underline{x}_i[l] \in \mathcal{C}^{6\times 1}$ is the l-th signal snapshot of the the antenna array in the i-th Rx ($\forall i = 1, 2, 3, 4$).

4. In folder of Task 4, the "Xmatrix_LAA.mat" file contains the large aperture array received signals in the form of the following matrix:

$$[\underline{x}[1], \underline{x}[2], \ldots, \underline{x}[l], \ldots, \underline{x}[L]] \in \mathcal{C}^{4\times L} \tag{5}$$

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6 References

1. Lecture Notes on Advanced Communication Theory

2. Your own references