AN LS LOCALISATION METHOD FOR MASSIVE MIMO TRANSMISSION SYSTEMS

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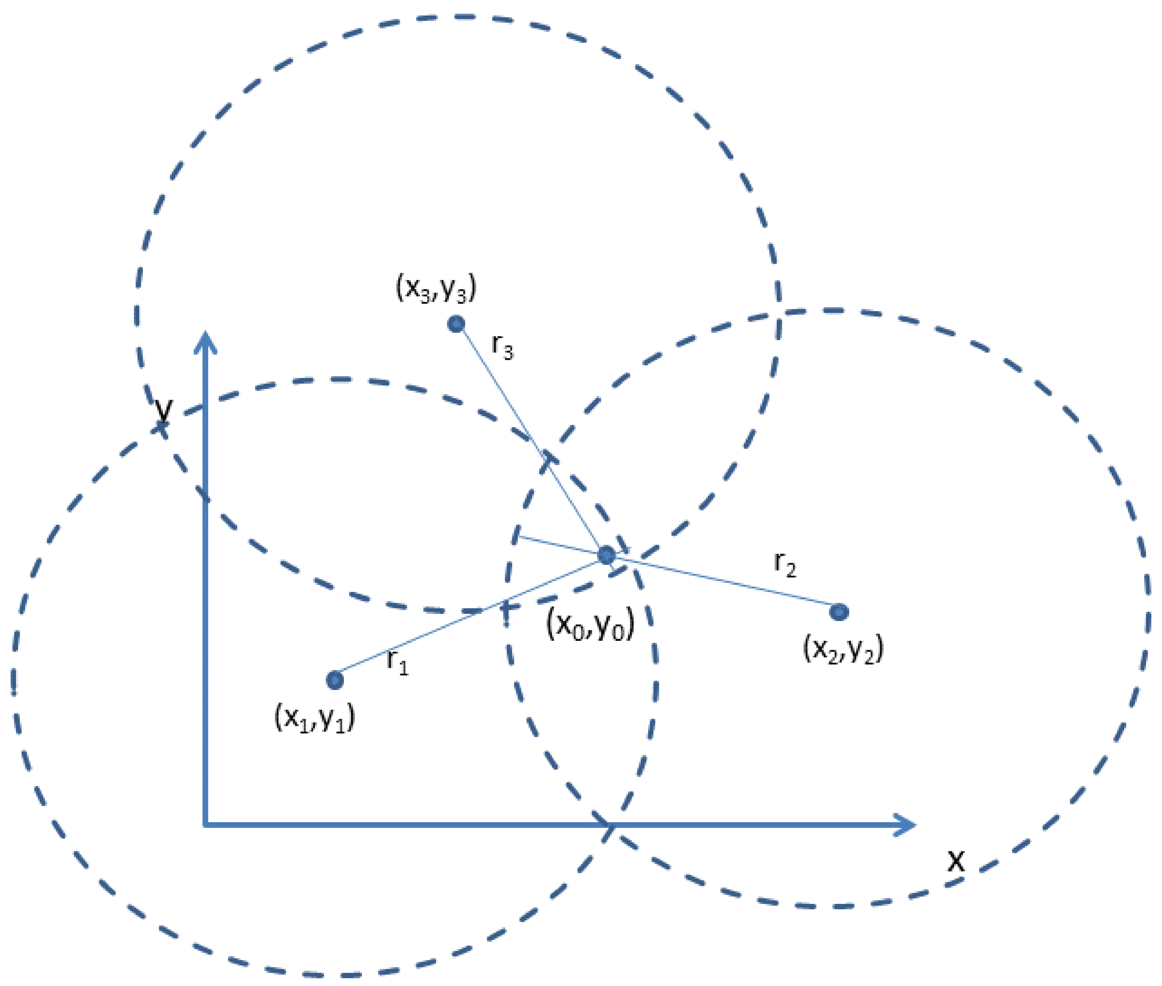
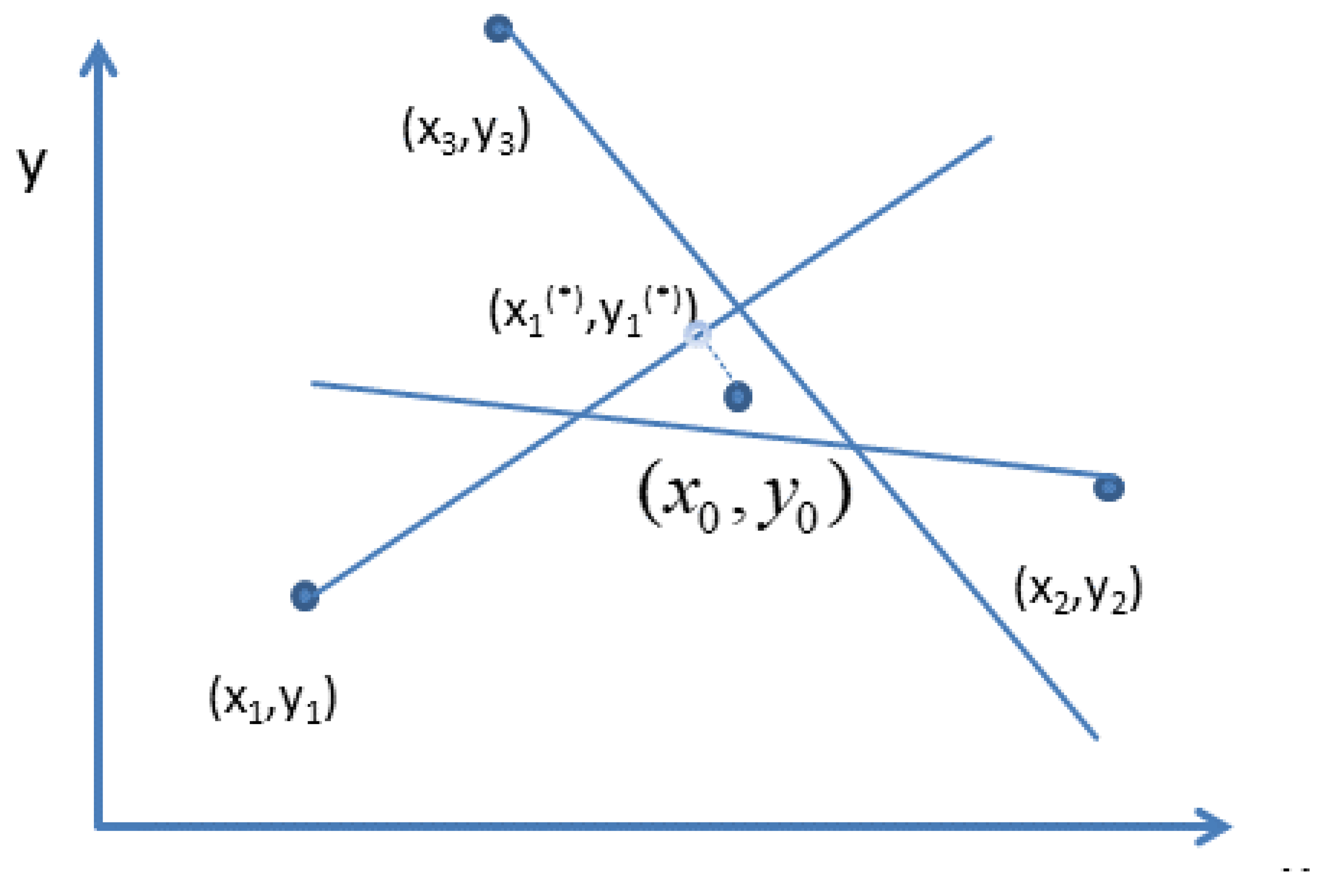
Motivation



Localisation scenario with $M = 3$ base stations to localise object at (x_0, y_0) by means of radius information.

Problem: find closest point to true location (x_0, y_0) in a LS sense by means of directional information as we expect in massive MIMO



Localization scenario with $M = 3$ base stations to localize object at (x_0, y_0) by means of direction information.

Contributions

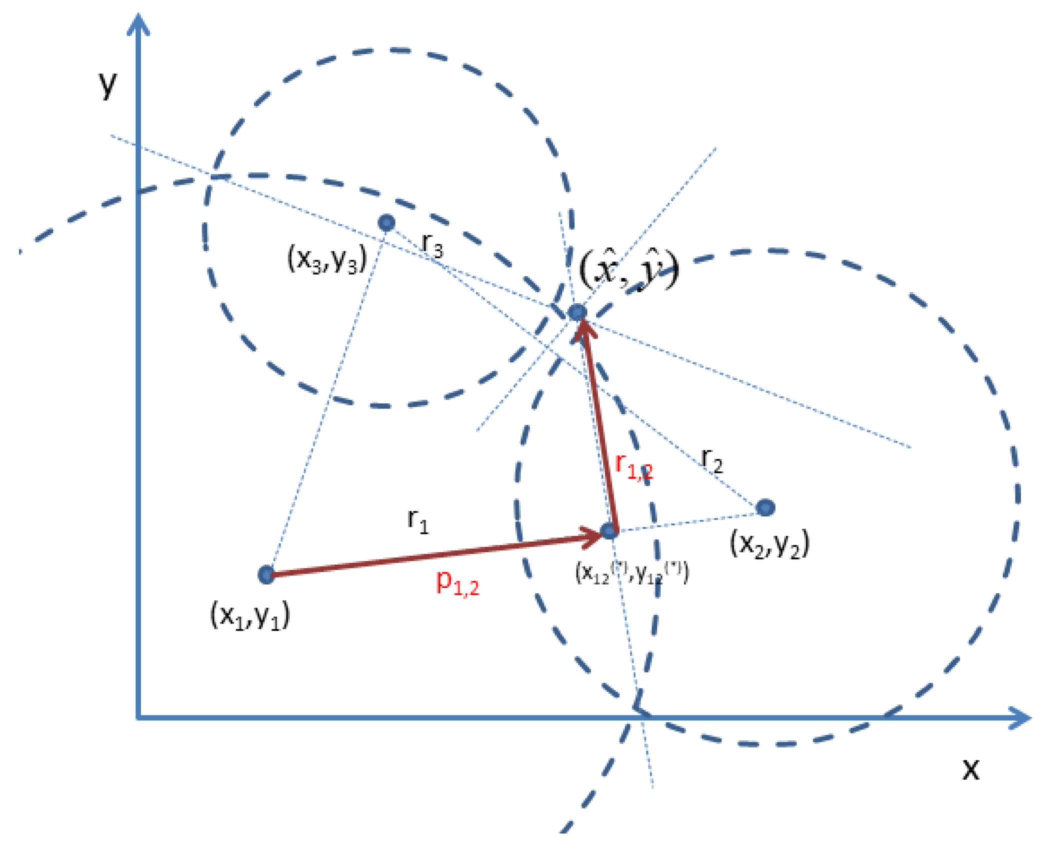
Lemma 2.1 Given point $(\hat{x}, \hat{y})$, point $\left(x_m^{(*)}, y_m^{(*)}\right)$ along a line $(y - y_m) = a_m(x - x_m)$ closest to $(\hat{x}, \hat{y})$ is given by

$$\begin{aligned} x_m^{(*)} &= \frac{1}{1+a_m^2}(\hat{x} + a_m\hat{y}) - \frac{a_m}{1+a_m^2}(y_m - a_m x_m), \\ y_m^{(*)} &= \frac{a_m}{1+a_m^2}(\hat{x} + a_m\hat{y}) + \frac{1}{1+a_m^2}(y_m - a_m x_m). \end{aligned}$$

Lemma 2.2 The minimum sum squared distance is found for point $(\hat{x}^{(B)}, \hat{y}^{(B)})$ that satisfies the following set of linear equations:

$$\begin{bmatrix} \sum_{m=1}^M A_{2,m} & -\sum_{m=1}^M A_{1,m} \\ -\sum_{m=1}^M A_{1,m} & \sum_{m=1}^M A_{0,m} \end{bmatrix} \begin{bmatrix} \hat{x}^{(B)} \\ \hat{y}^{(B)} \end{bmatrix} = \begin{bmatrix} -\sum_{m=1}^M A_{1,m} L_m \\ \sum_{m=1}^M A_{0,m} L_m \end{bmatrix}.$$

Virtual Base Stations



Localization scenario with $M = 3$ base stations to localize object at $(\hat{x}, \hat{y})$ by means of radius information, translated into direction information.

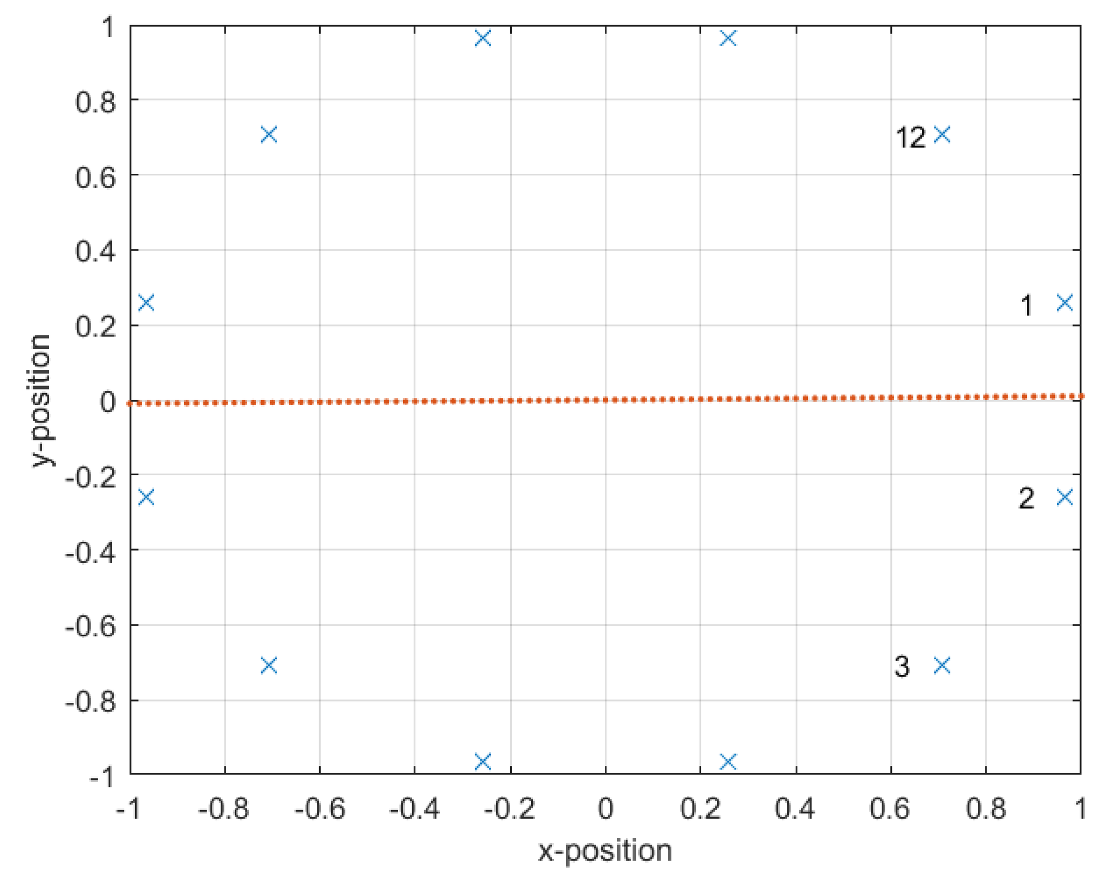
Lemma 3.3 The perpendicular line between two base stations at (x_i, y_i) and (x_k, y_k) is defined by

$$-\frac{x_i - x_k}{y_i - y_k}\left(x - x_{i,k}^{(*)}\right) = \left(y - y_{i,k}^{(*)}\right)$$

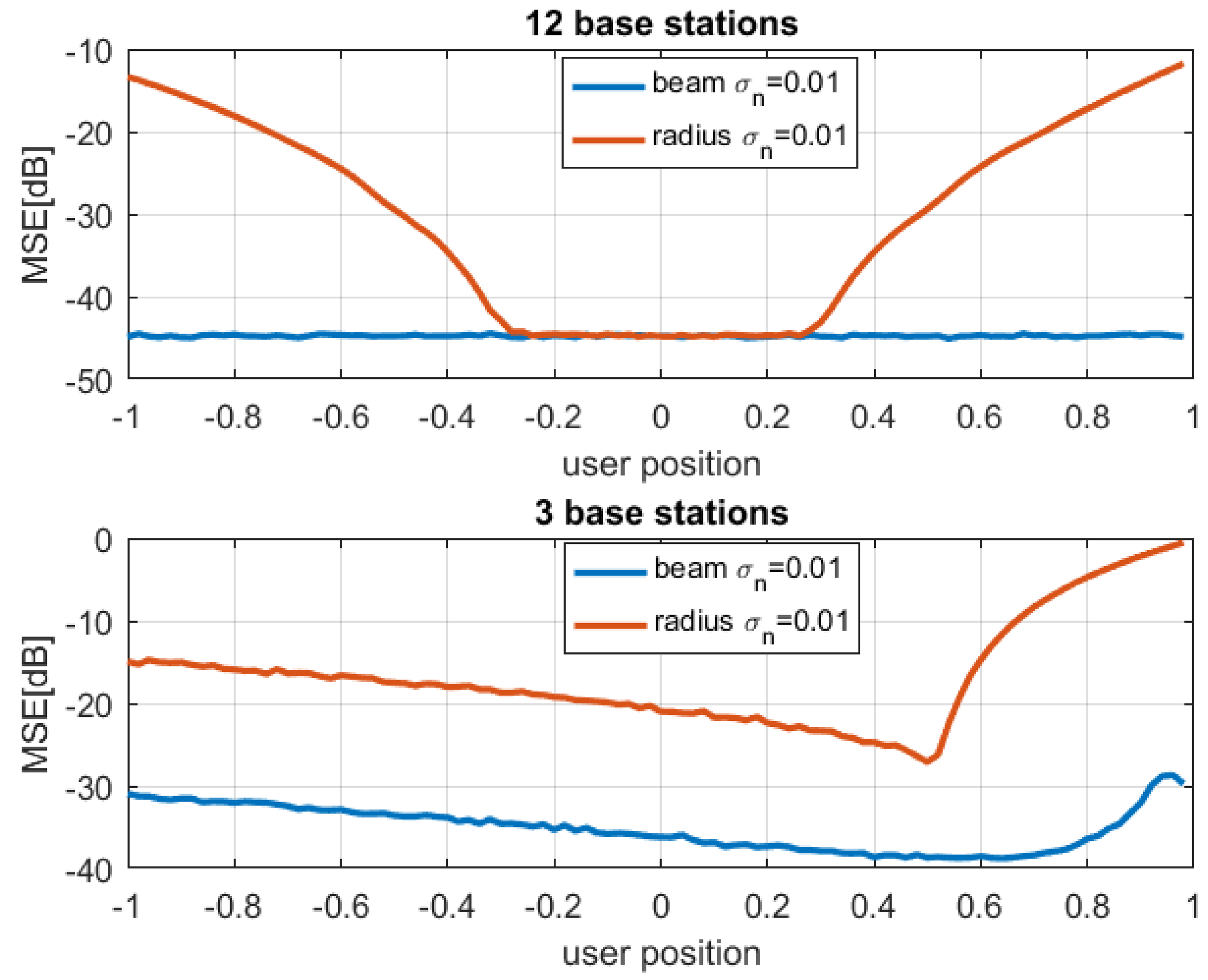
with the point

$$\begin{bmatrix} x_{i,k}^{(*)} \\ y_{i,k}^{(*)} \end{bmatrix} = \begin{bmatrix} x_i \\ y_i \end{bmatrix} + \frac{p_{i,k}}{d_{i,k}} \begin{bmatrix} x_k - x_i \\ y_k - y_i \end{bmatrix}.$$

Simulation Results



Experimental setup starting with three base stations (circles) on the right and gradually increasing their number. The receiver location is along the x axis (crosses).



Comparison of beam based and radius based method (converted into virtual beams).

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