INDOOR LOCALIZATION SYSTEM USING COMMENSAL RADAR PRINCIPLE

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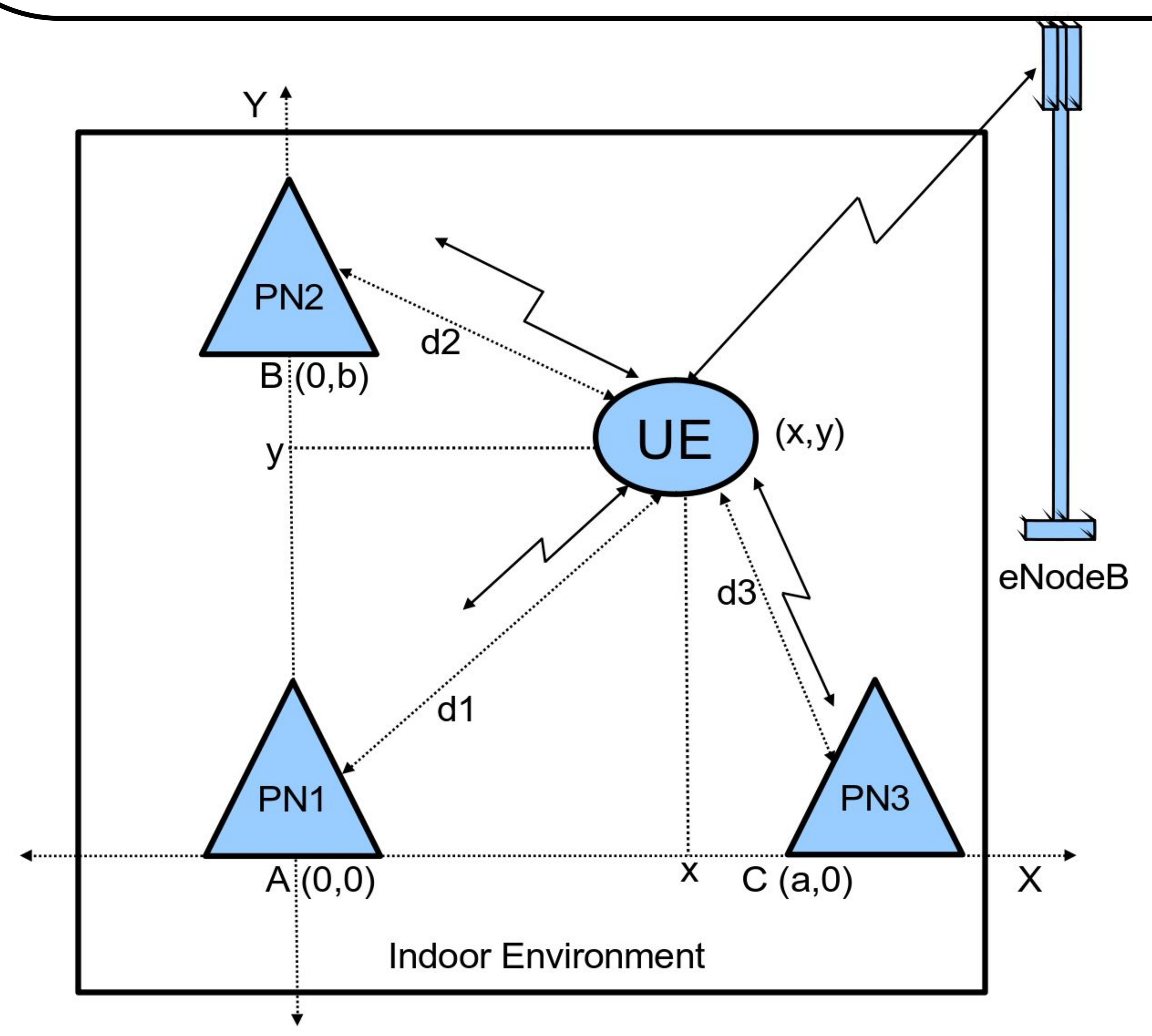
- Indoor localization: Wide applicability in personal health applications
- Need for specialized indoor localization methods: TOA, TDOA, AOA and RSSI due to limited usability of GPS
- Proposed: Novel commensal radar system, CommSense (inspired by biological inter-species coexistence)
- Uses LTE communication radiation as the illuminator
- The communication signal strength between LTE UE and eNodeB gets affected by the span of the channel
- Use 3 passive nodes (PN) for 2D indoor localization
- PNs determine respective distances of the UE by measuring incident signal power at the PNs
- After respective distances calculated, use them for trilateration to determine UE co-ordinate
- Depending on PN placements, the trilateration algorithm is modified to have less complexity
- 4 PNs required for 3D indoor localization
- **Novelty:** GNURADIO-SDR based practical localization experiment using LTE-CommSense



Experimental Setup for Indoor Localization using LTE-CommSense: Block diagram for 2D Localization

Log-normal shadowing model of Indoor Channel

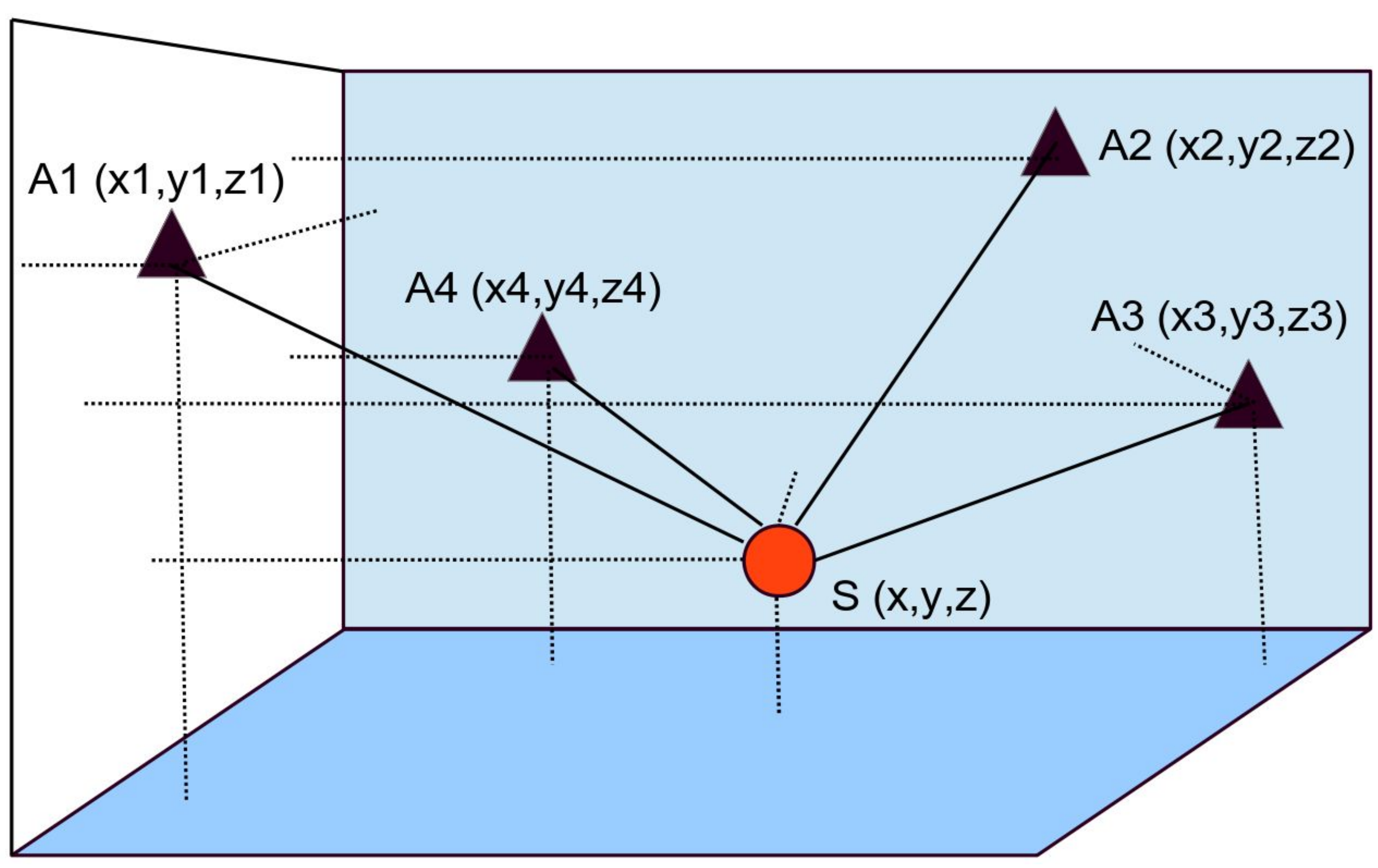
$$Pr_i(d) = A - 10\alpha\left[log\left(\frac{d}{d_0}\right)\right] - \psi$$

Derivation of UE Co-ordinate in 2D

$$(x, y) = \left(\frac{a^2 + d_1^2 - d_3^2}{2a}, \frac{b^2 + d_1^2 - d_2^2}{2b}\right)$$

SDR Board and GNURadio Parameter Setup for Indoor Localization Experiment

SL	Parameter	Value
1	USRP Model	URSP B210
2	Bandwidth	1.4 MHz
3	Operating Frequency	2.3 GHz
4	Sampling Rate	1.92 MSPS
5	FFT Points	128
6	Modulation Scheme	QPSK



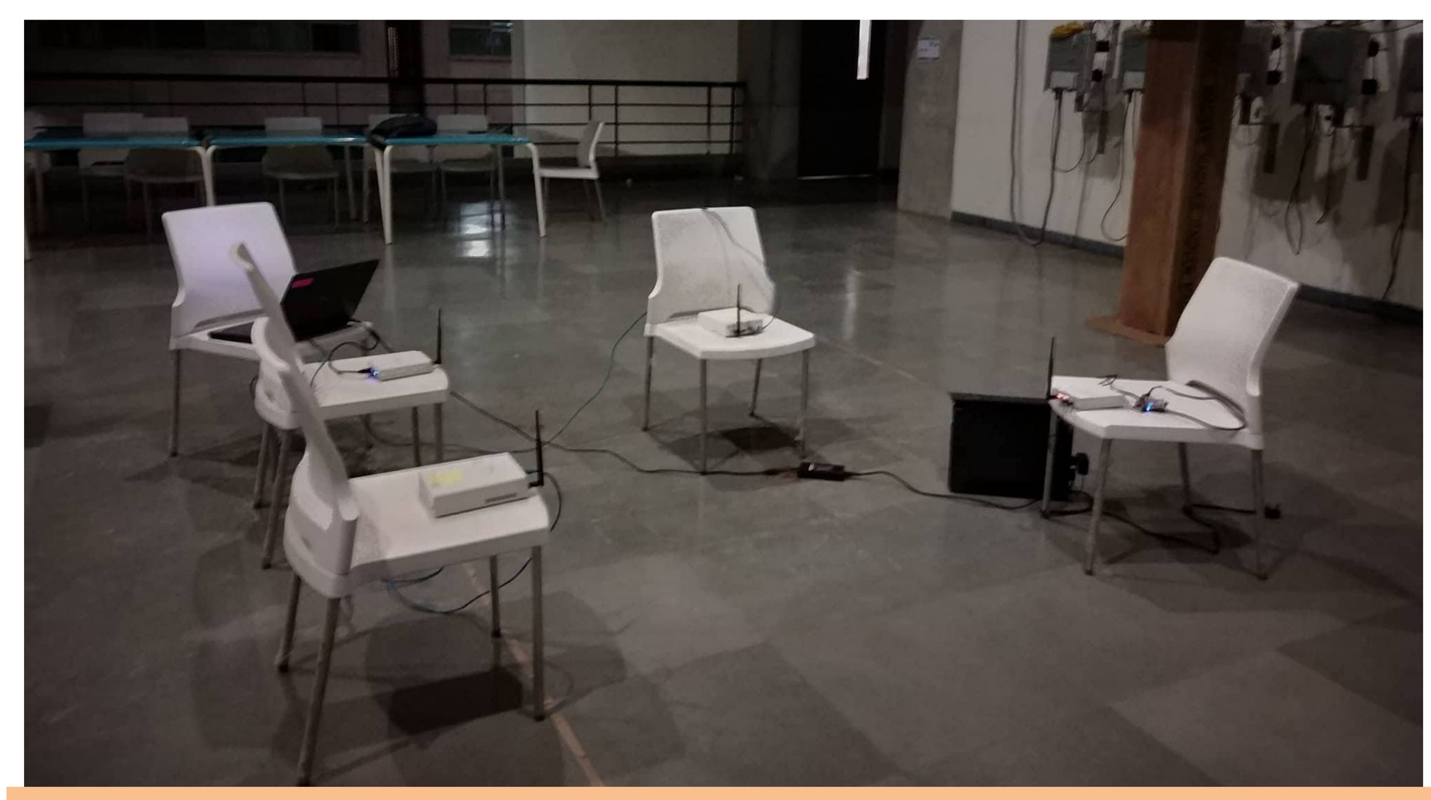
Experimental Setup for Indoor Localization using LTE-CommSense: Block diagram for 3D Localization

Derivation of UE Co-ordinate in 3D Using Cramer's Rule

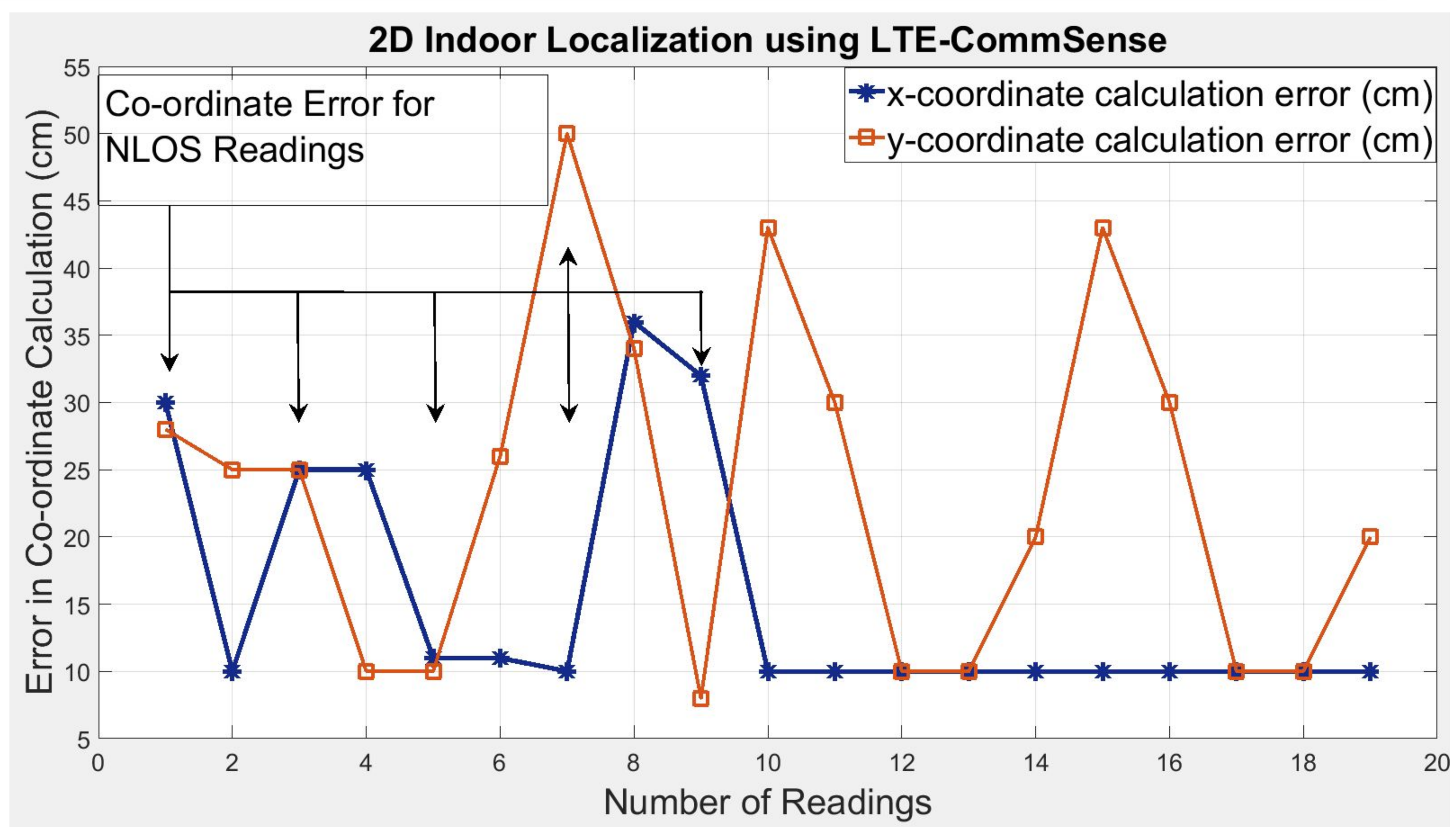
$$x = \frac{\begin{vmatrix} (d_1^2-d_2^2)-(x_1^2-x_2^2)-(y_1^2-y_2^2)-(z_1^2-z_2^2) & 2(y_2-y_1) & 2(z_2-z_1) \\ (d_1^2-d_3^2)-(x_1^2-x_3^2)-(y_1^2-y_3^2)-(z_1^2-z_3^2) & 2(y_3-y_1) & 2(z_3-z_1) \\ (d_1^2-d_4^2)-(x_1^2-x_4^2)-(y_1^2-y_4^2)-(z_1^2-z_4^2) & 2(y_4-y_1) & 2(z_4-z_1) \end{vmatrix}}{\begin{vmatrix} 2(x_2-x_1) & 2(y_2-y_1) & 2(z_2-z_1) \\ 2(x_3-x_1) & 2(y_3-y_1) & 2(z_3-z_1) \\ 2(x_4-x_1) & 2(y_4-y_1) & 2(z_4-z_1) \end{vmatrix}}$$

$$y = \frac{\begin{vmatrix} 2(x_2-x_1) & (d_1^2-d_2^2)-(x_1^2-x_2^2)-(y_1^2-y_2^2)-(z_1^2-z_2^2) & 2(z_2-z_1) \\ 2(x_3-x_1) & (d_1^2-d_3^2)-(x_1^2-x_3^2)-(y_1^2-y_3^2)-(z_1^2-z_3^2) & 2(z_3-z_1) \\ 2(x_4-x_1) & (d_1^2-d_4^2)-(x_1^2-x_4^2)-(y_1^2-y_4^2)-(z_1^2-z_4^2) & 2(z_4-z_1) \end{vmatrix}}{\begin{vmatrix} 2(x_2-x_1) & 2(y_2-y_1) & 2(z_2-z_1) \\ 2(x_3-x_1) & 2(y_3-y_1) & 2(z_3-z_1) \\ 2(x_4-x_1) & 2(y_4-y_1) & 2(z_4-z_1) \end{vmatrix}}$$

$$z = \frac{\begin{vmatrix} 2(x_2-x_1) & 2(y_2-y_1) & (d_1^2-d_2^2)-(x_1^2-x_2^2)-(y_1^2-y_2^2)-(z_1^2-z_2^2) \\ 2(x_3-x_1) & 2(y_3-y_1) & (d_1^2-d_3^2)-(x_1^2-x_3^2)-(y_1^2-y_3^2)-(z_1^2-z_3^2) \\ 2(x_4-x_1) & 2(y_4-y_1) & (d_1^2-d_4^2)-(x_1^2-x_4^2)-(y_1^2-y_4^2)-(z_1^2-z_4^2) \end{vmatrix}}{\begin{vmatrix} 2(x_2-x_1) & 2(y_2-y_1) & 2(z_2-z_1) \\ 2(x_3-x_1) & 2(y_3-y_1) & 2(z_3-z_1) \\ 2(x_4-x_1) & 2(y_4-y_1) & 2(z_4-z_1) \end{vmatrix}}$$



Indoor Localization Setup snapshot in indoor environment



- First accuracy of distance calculation of individual PNs evaluated
- Localization performance of nineteen different indoor location coordinates
- Proposed commensal radar based approach for indoor localization in health care application is proven in 2D
- LTE UE modeled using SDR platforms
- By incorporating more PNs and by enhancing trilateration algorithm, 2D localization can be extended for 3D