Wireless Localization for Next Generation Emergency Networks

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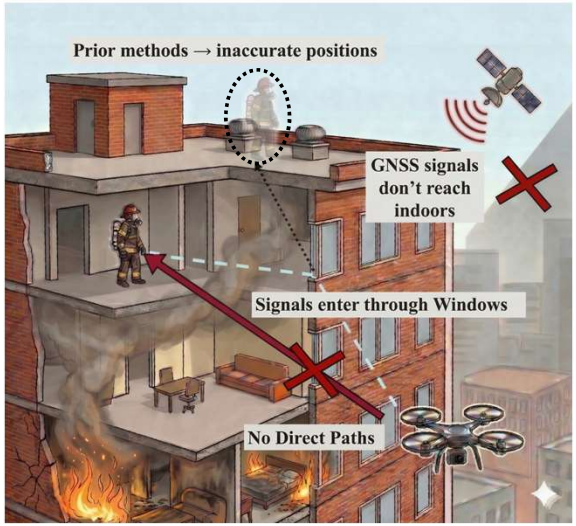
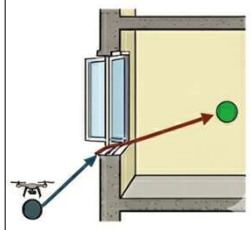
MOTIVATION & PRIOR ART



1. Critical need: Localizing indoor Emergency responders
2. GPS signal is weak indoors
3. UAV anchors deployed near building exteriors
4. Signals enter mainly through windows
5. Conventional techniques lead to large position errors

CONTRIBUTION & METHODOLOGY

Contribution 1: New Mathematical model



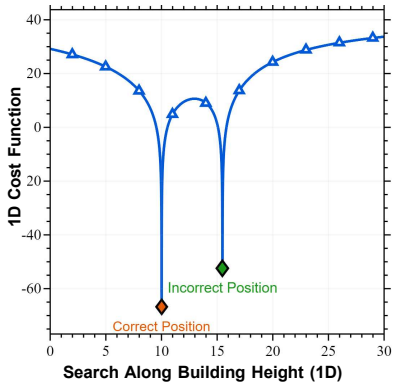
$$\sqrt{(x_k - x)^2 + \left(\sqrt{y_k^2 + (z_k - z)^2} + y\right)^2}$$

- Horizontal coordinates (x,y) symmetry
- Vertical coordinate (z) asymmetry

1. New mathematical model of the path length of the wireless signal bending around window edges derived using Electromagnetic wave physics. This phenomena is called Diffraction.
2. Fundamental limits on positioning accuracy achievable with this mathematical model.

Contribution 2: Low Complexity Optimal Localization Algorithm

Target localization is a non-convex optimization problem that requires minimizing a cost function over a dense three-dimensional search space of possible target locations, making it computationally expensive and not guaranteed to achieve the fundamental limit.

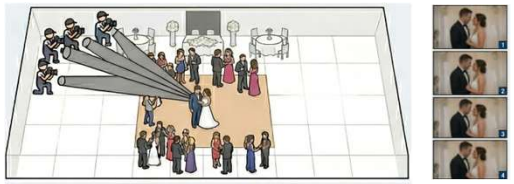


Step 1: For each fixed vertical height, we derive a closed-form solution to the 2D subproblem to compute the optimal horizontal position.

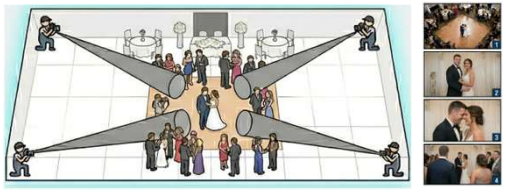
Step 2: Perform 1D search over z to find minimum cost

Final 3D position estimate (x,y,z)

Contribution 3: Optimal Placement of Localization Infrastructure (UAV anchors)



Poor photographer placement leads to redundant shots, potentially resulting in all poor photos.

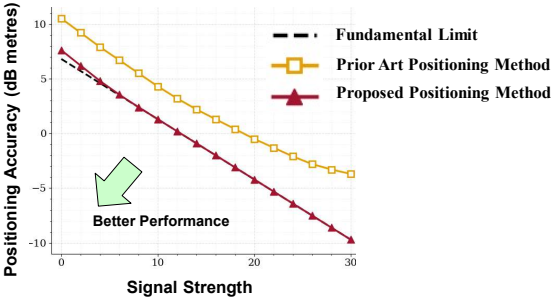


Good photographer positioning increases shot diversity and improves the chance of capturing a good photo.

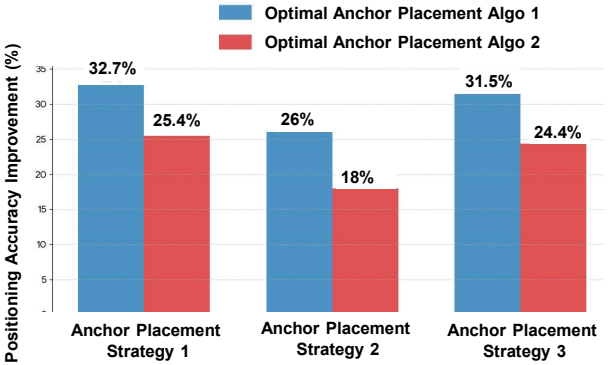
Extending the notion of Optimality

1. Classical anchor placement suffers from a chicken-and-egg problem: it assumes the target location is already known in order to place anchors optimally, even though the goal of localization is to estimate that unknown target location.
2. We develop the first mathematical framework to optimize anchor deployment over an entire region by formulating the problem as an exact combinatorial mixed-integer optimization problem, thereby ensuring positioning accuracy for all possible target locations within that region.

SIMULATION RESULTS



Proposed algorithm improves positioning accuracy by 35% over prior art across a range of signal strengths, and it meets the fundamental limit at moderate to high signal strengths, demonstrating optimal performance.



Our framework yields two optimal anchor placement algorithms that improve average positioning performance by 18–30% relative to three random anchor placement strategies.

FUTURE WORK

Future work will focus on building a wireless localization testbed and collecting real-world measurements to validate the proposed contributions in the field.