

SURF-2025-0217 Project Overview: GPS-Free Geolocation Based on LoRa

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Outline

- Localization
- Related Work
- Plan for This Year

Localization

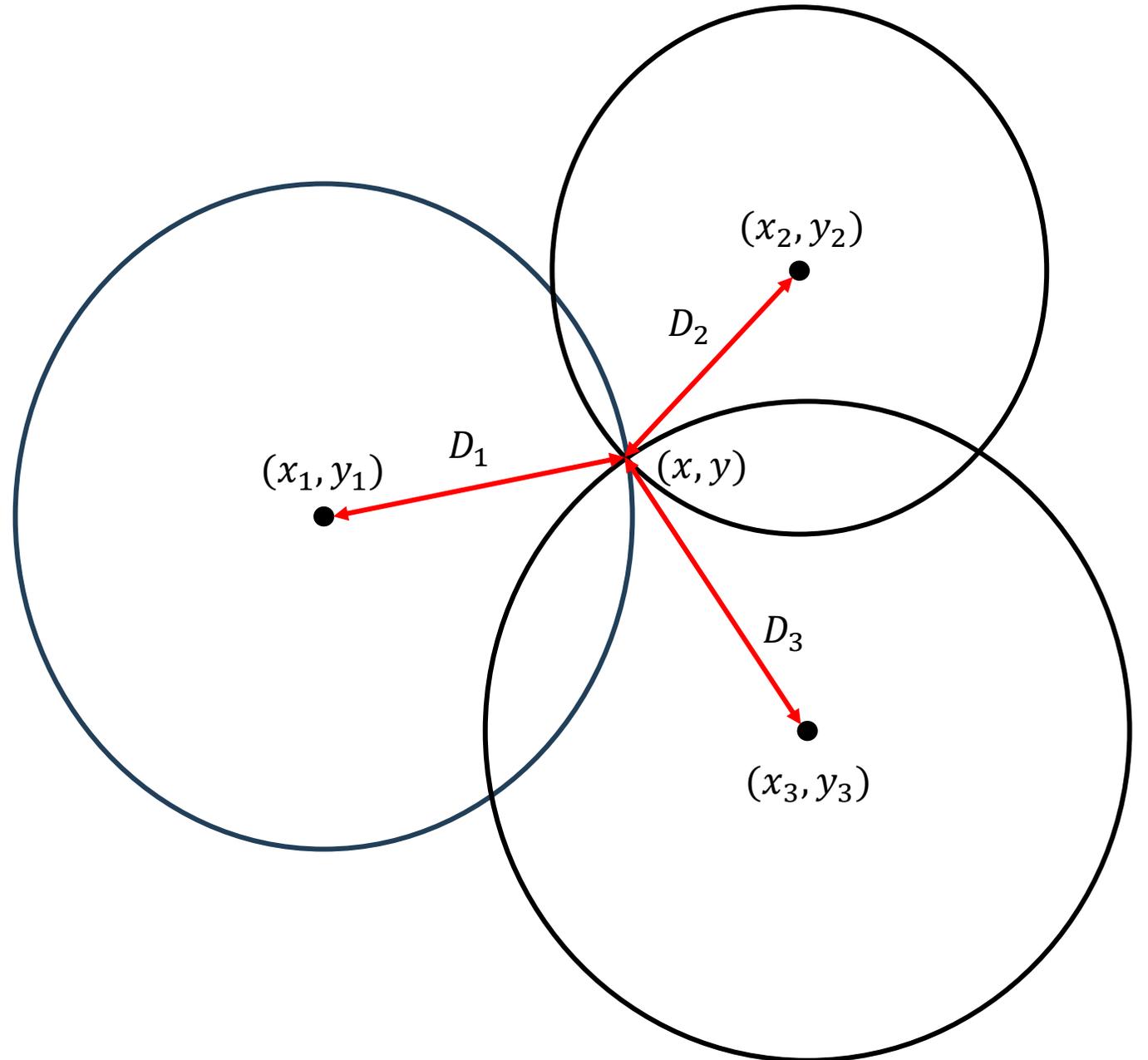
Tri/Multilateration

- The estimation of the distances D_i is a key to the estimation of the unknown location (x, y) , i.e.,

$$D_i = \sqrt{(x - x_i)^2 + (y - y_i)^2},$$

through

- Time of arrival (ToA)
- Time difference of arrival (TDoA)
- Angle of arrival (AoA)



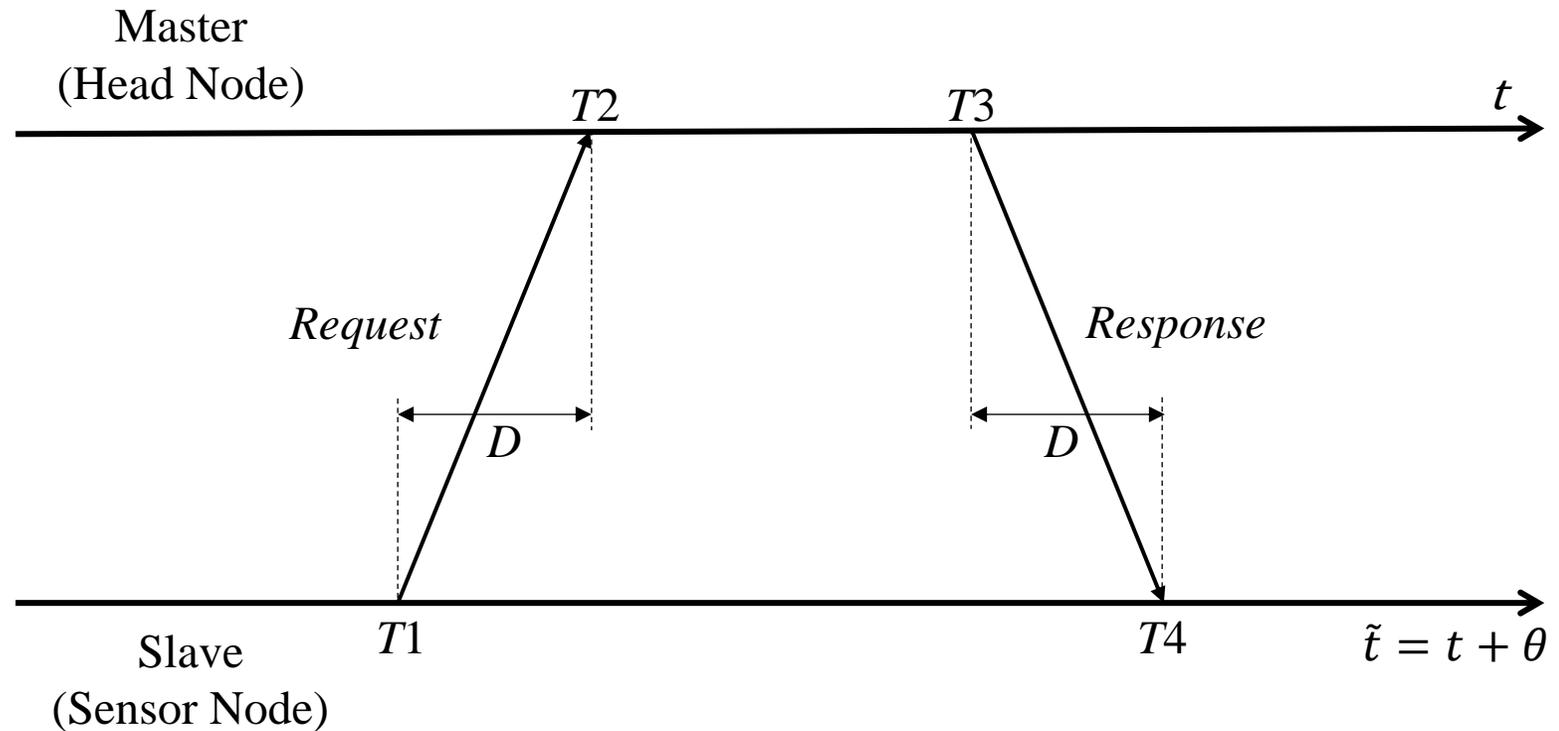
Two-Way Message Exchanges

- Propagation delay:

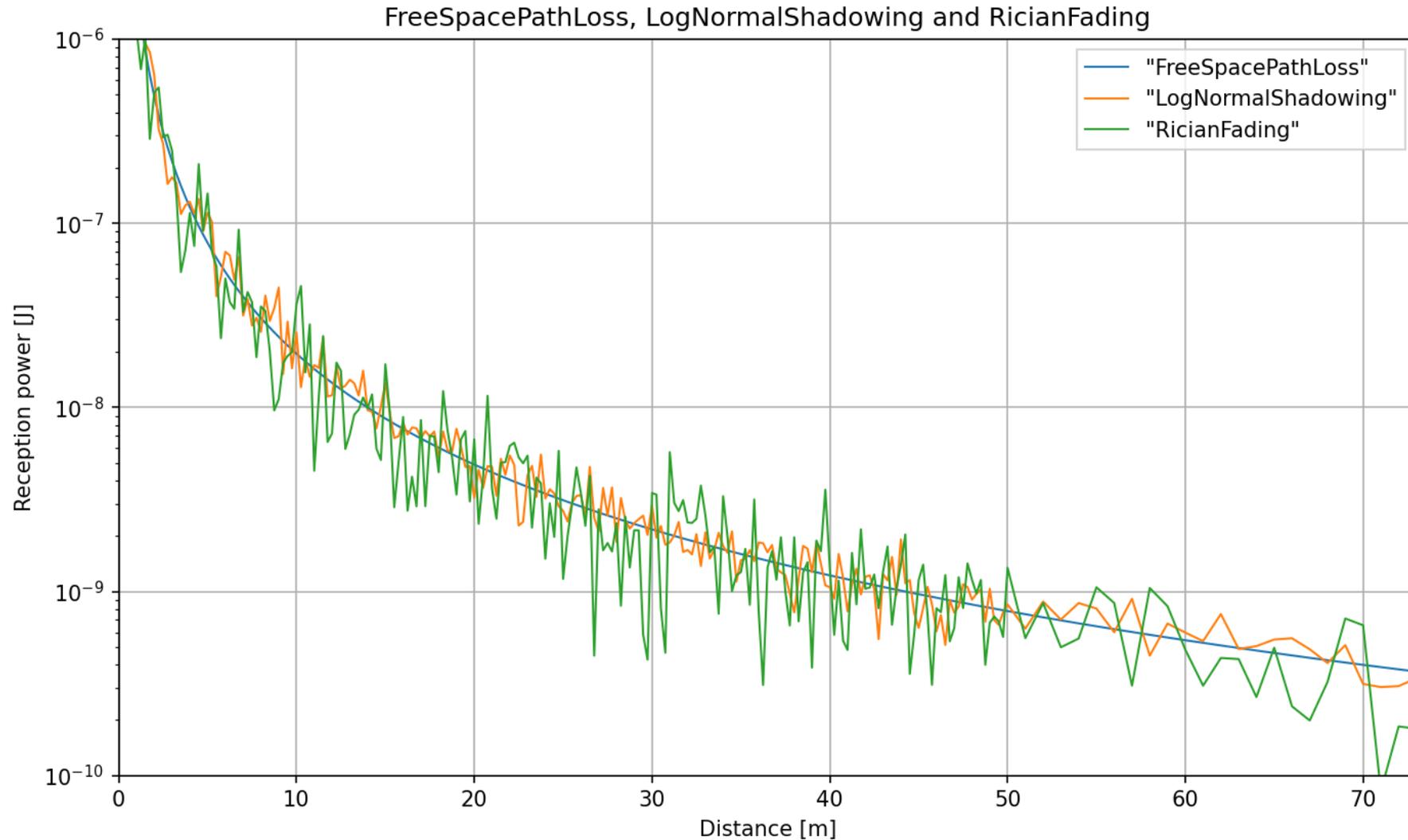
$$D = \frac{(T4 - T3) + (T2 - T1)}{2}$$

- Clock offset:

$$\theta = \frac{(T4 - T3) - (T2 - T1)}{2}$$



Path Loss Models: RSS vs. Distance*



* <https://inet.omnetpp.org/docs/showcases/wireless/pathloss/doc/index.html>

Related Work

Joint RSS and Ranging Fingerprint for LoRa Indoor Localization*

- This is one of the most closely related to our project but in a slightly different context of indoor localization.
 - Both distances to and RSSIs from LoRa gateways (GWs) are jointly used as location fingerprints.
- In our case, on the other hand, there is only one GW.
 - We need to exploit the time variation of distance and RSSI for a single GW, instead of those for multiple GWs.

Plans for This Year

Research Questions

- What kinds (e.g., RSSIs, distances, or raw timestamps) and types (e.g., static vectors or dynamic time series) of location fingerprints are the best for LoRa-based geolocation?
- What DNN architectures and training frameworks are the best for LoRa-based geolocation?

Project Plans

- WP1: Construction of location fingerprint database
 - To investigate what, where, and how to collect fingerprint data.
 - Include as many **raw data (e.g., timestamps)** as possible in the database.
 - The extraction of actual fingerprints from the raw data (e.g., distances from timestamps) is to be done during the pre-processing (e.g., prefiltering for excluding outliers and smoothing, clock adjustment, and battery level compensation).
 - To implement HW and SW for LoRa development boards.
- WP2: Development of DNN models for multi-modal fingerprint data.
 - To implement and evaluate the localization performance of DNN models based on various architectures for the proposed fingerprint datasets from WP1.
 - Consider the use of LLMs, too.