ENHANCING INDOOR LOCALIZATION ESTIMATION USING RSS SIMILARITY-BASED *K*-NEAREST NEIGHBORS

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Overview

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- Dataset
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Introduction

- Indoor positioning is crucial for accurate location information in various indoor environments.
- Unlike outdoor GPS, indoor positioning faces challenges due to weak signals indoors.
- Fingerprint-based methods, using Wi-Fi signals, create unique location fingerprints for positioning.
- Machine learning (ML) algorithms like *k*-nearest neighbors (*k*-NN) and random forest enhance indoor positioning accuracy.

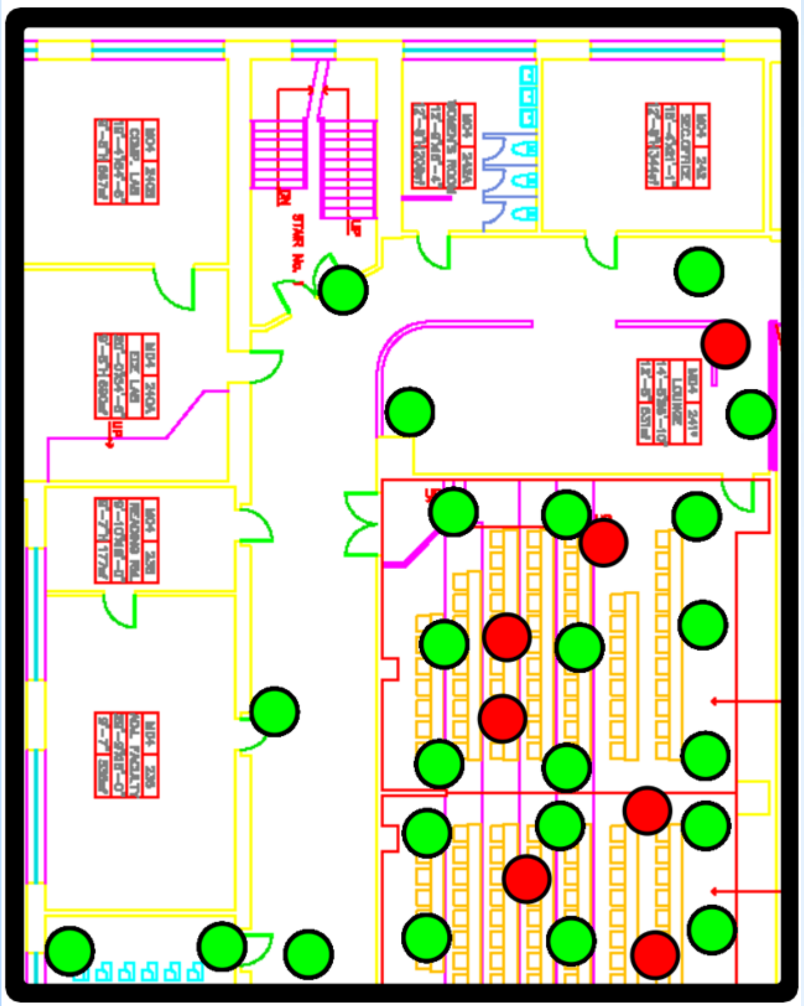
Related Work

- Existing research addresses GPS software limitations in indoor environments for localization accuracy.
- Various approaches like fingerprinting-based methods and neural networks enhance indoor localization.
- Studies explore *k*-NN algorithm and custom distance functions to improve indoor positioning.
- Can we create a framework that inherently considers received signal strength (RSS) data and performs well consistently?

Dataset

- Data collected from engineering building at University of Detroit Mercy across three floors.
- Fingerprints strategically distributed across entire floor area for comprehensive coverage.
- Encompasses diverse settings from small to large classrooms on multiple floors.
- The scope of this research did not address multifloor prediction.

Dataset



Dataset

Table I: AP Information.

xCoord	yCoord	MAC	roomNum
2806	1494	XX:XX:XX:XX:XX:XX	441
2352	1455	XX:XX:XX:XX:XX:XX	441
1959	632	XX:XX:XX:XX:XX:XX	437
2813	873	XX:XX:XX:XX:XX:XX	437

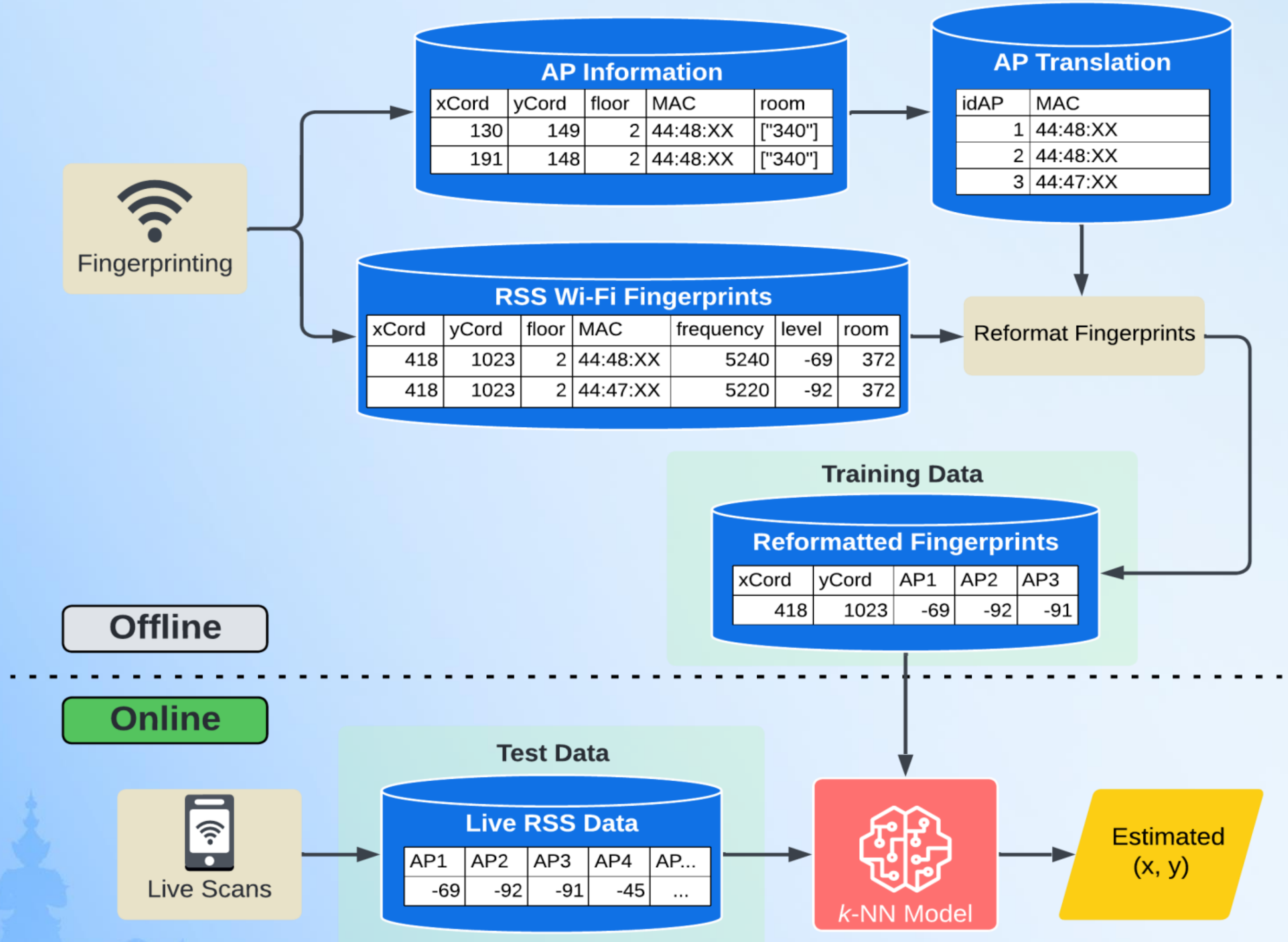
Table II: RSS's mapped to identified APs.

xCoord	yCoord	Floor	AP1	AP2	AP3	AP#
413	94	2	-81	-80	-39	...
531	93	2	-100	-83	-41	...
642	92	2	-85	-86	-46	...

Methodology

- The indoor localization framework consists of offline and online phases for accuracy.
- In the offline phase, data such as access point (AP) positions and RSS levels are collected.
- The online phase involves collecting live Wi-Fi scans for user location estimation.
- The *k*-NN model is utilized to output an estimated user location.

Methodology



Methodology

- U: test point.
- R_j: training fingerprint reference point.
- Percentile.
- Weighting scheme.

Algorithm 1 RSS Similarity

Require: Two arrays of RSS values from Wi-Fi APs: u and r_j

Ensure: Weighted similarity score between u and r_j

Calculate percentile: $per = \text{percentiles}((u \cup r_j), [96, 98, 99.5, 100])$
Initialize empty array: $rss\_weights = \text{zeros}(dimensions(u))$
for $i \in 0 \ldots dimensions(u) - 1$ **do**
  if $per_2 \leq u_i \leq per_3$ or $per_2 \leq r_{ji} \leq per_3$ **then**
    $rss\_weights_i = 1$
  else if $per_1 \leq u_i < per_2$ or $per_1 \leq r_{ji} < per_2$ **then**
    $rss\_weights_i = 0.75$
  else if $per_0 \leq u_i < per_1$ or $per_0 \leq r_{ji} < per_1$ **then**
    $rss\_weights_i = 0.30$
  else
    $rss\_weights_i = 0.15$
  end if
end for
Calculate absolute difference: $rss\_similarity = |u - r_j|$

Calculate weighted similarity: $weighted\_similarity = \sum_{i=0}^{dim(u)} (rss\_similarity \cdot rss\_weights)$
return $weighted\_similarity$

Results

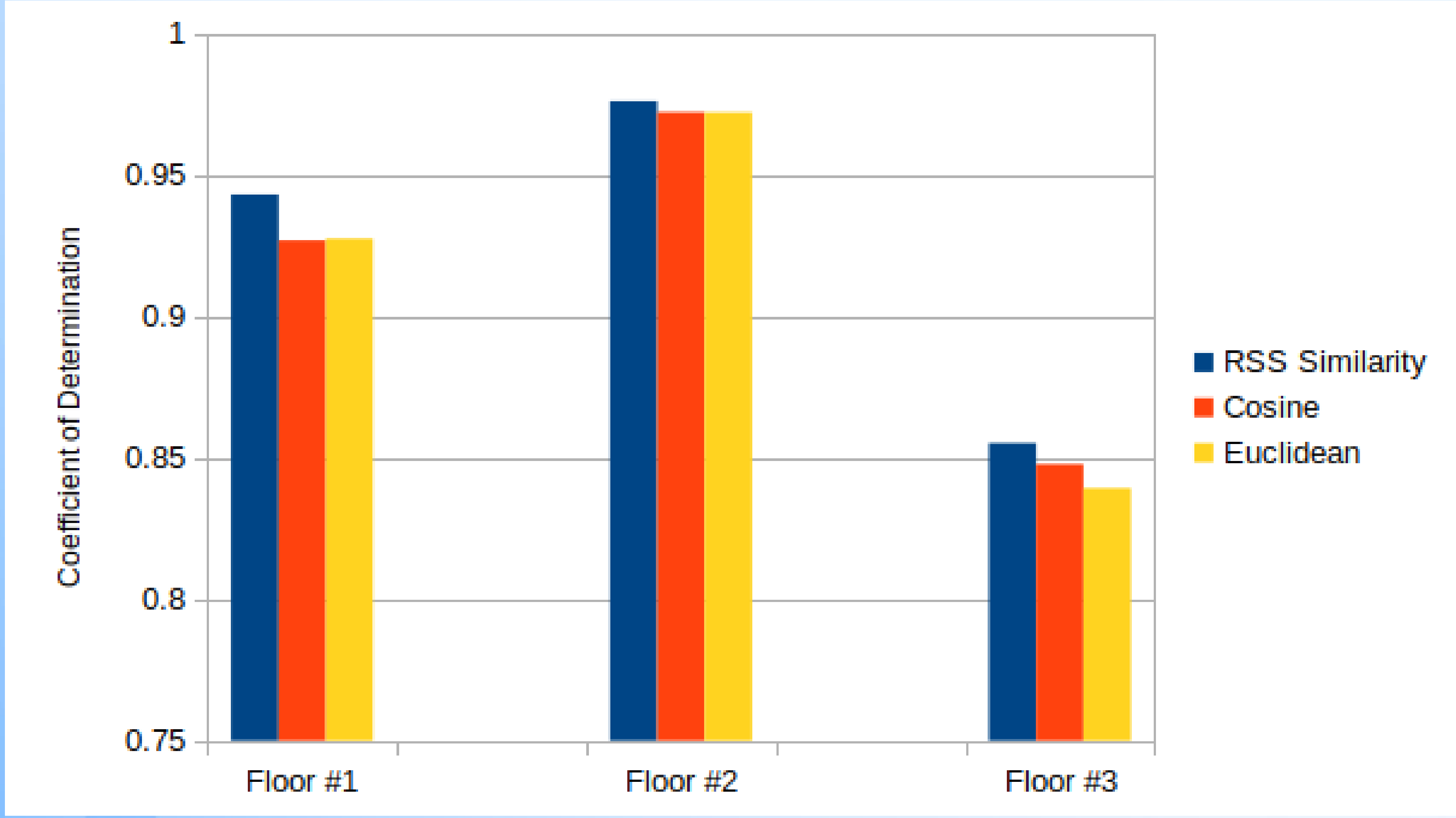
- RSS similarity outperformed cosine similarity and Euclidean distance functions across multiple floors.
- Weighted distances with $k = 5$ neighbors.
- Results show RSS similarity consistently excelled in R^2 values and MAE.

Results

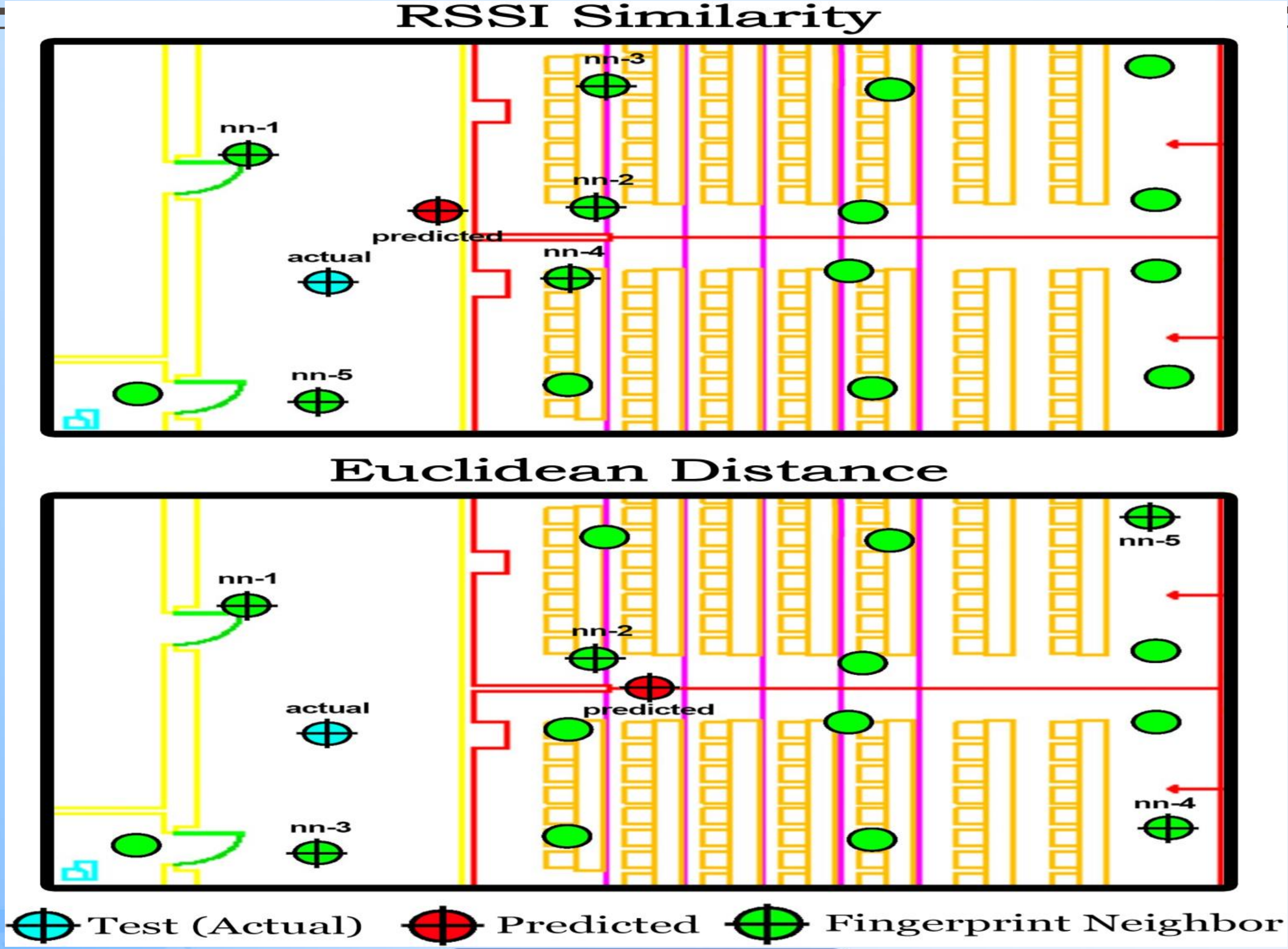
Table III: Comparison of *k*-NN regressor using different distance functions for different floors.

Floor	F1		F2		F3	
Distance Function	R^2	MAE	R^2	MAE	R^2	MAE
RSS Similarity	0.94	64	0.98	55	0.86	53
Cosine	0.93	73	0.97	61	0.85	54
Euclidean	0.93	75	0.97	61	0.84	57

Results


1
0.95
0.9
0.85
0.8
0.75
Coefficient of Determination
Floor #1
Floor #2
Floor #3
RSS Similarity
Cosine
Euclidean

Results


RSSI Similarity
nn-3
nn-1
nn-2
predicted
actual
nn-4
nn-5
Euclidean Distance
nn-5
nn-1
nn-2
predicted
actual
nn-4
nn-3
Test (Actual)
Predicted
Fingerprint Neighbor

Conclusion

- Achieved enhancement in R^2 score and reduction in distance errors.
- Effectiveness of the proposed approach to fundamentally consider the best fingerprint compared to traditional methods.
- Future work includes strategies to mitigate noisy RSS data and explore alternative algorithms.

Thank you for your time and attention!