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A Tutorial on WiFi-based Indoor Localization: Overview

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The task of localization:

- Aims to determine a user’s (or an object’s) position in space.

- Essential for a variety of applications (i.e emergency response, health care and public safety).

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- Aims to determine a user’s (or an object’s) position in space.
- Essential for a variety of applications (i.e emergency response, health care and public safety).
- The **outdoor** localization problem was solved by the **global navigation satellite systems** (GPS, GLONASS and GALILEO).
- The **indoor** localization still remains an **open problem**.

A WiFi-based approach for indoor localization

1. Record WiFi **received signal strength** (RSS) values at predefined **reference points** (RPs) to construct a radio map of an indoor area.

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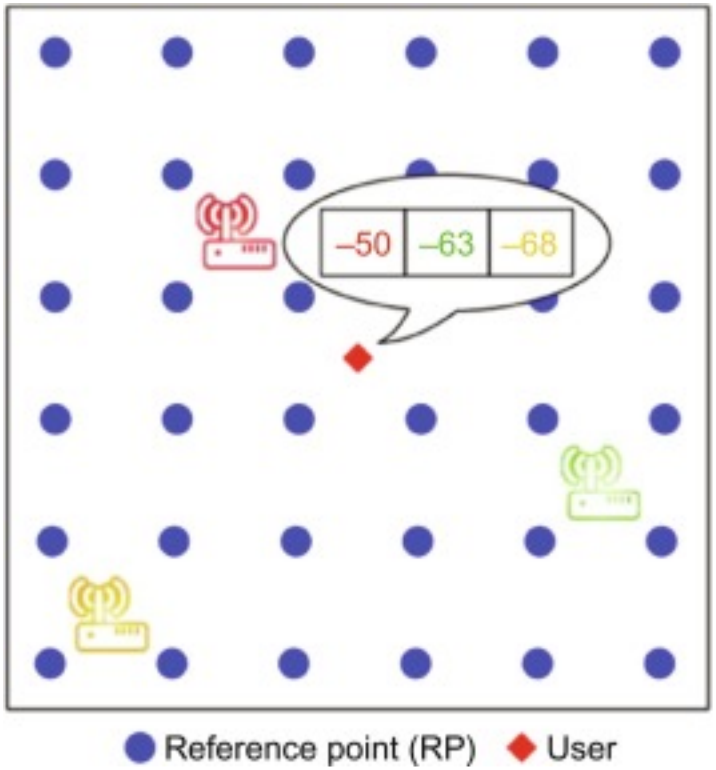
2. Using the radio map, train a location prediction model to map RSS values to RPs.

3. Determine a user's position in real-time using the pretrained model and the current WiFi signal values

Datasets

Most of the current WiFi datasets are **grid-based**:

- The indoor area is split into grids
- RPs are positioned in the center of these cells and then randomly assigned to training and testing sets



Conesa, Jordi, et al. "Geographical and Fingerprinting Data to Create Systems for Indoor Positioning and Indoor/Outdoor Navigation." (2018).

Datasets

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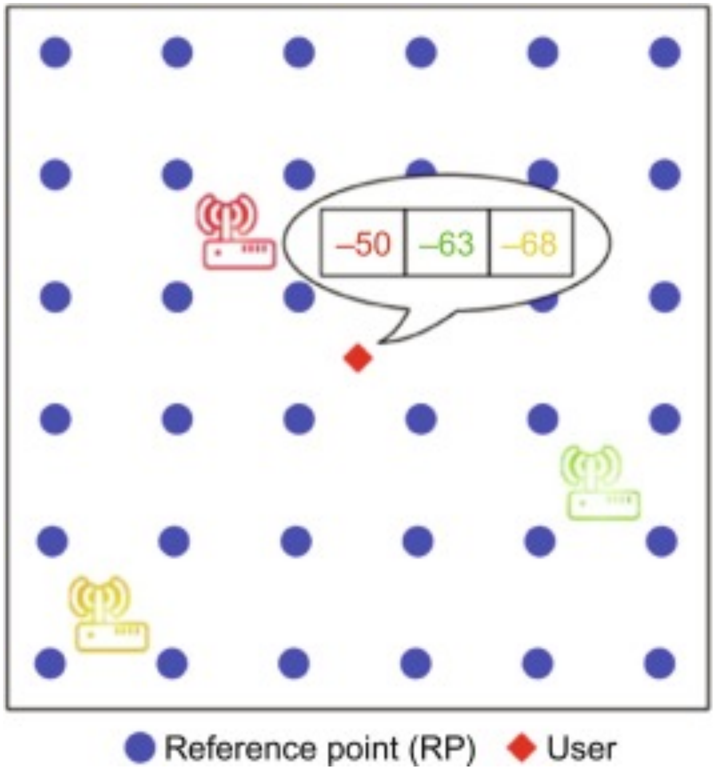
- The indoor area is split into grids
- RPs are positioned in the center of these cells and then randomly assigned to training and testing sets
- Not suitable for sequential localization as temporal information is not present.



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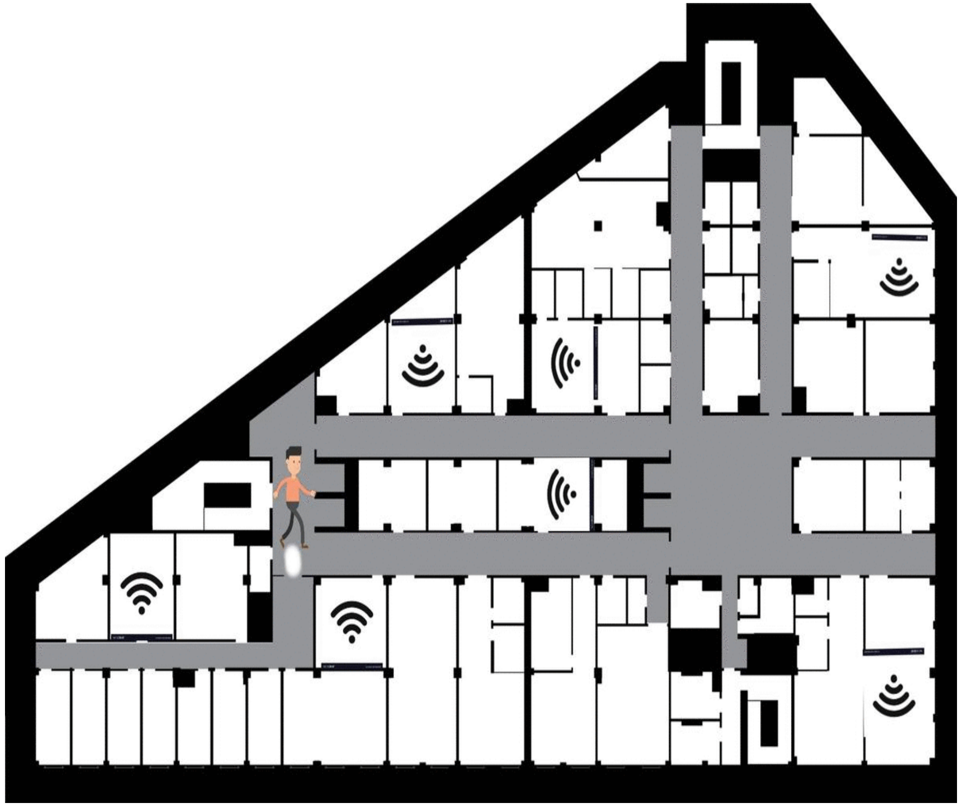
Datasets

In this tutorial we will use the simplified version of the **WiFine** dataset:

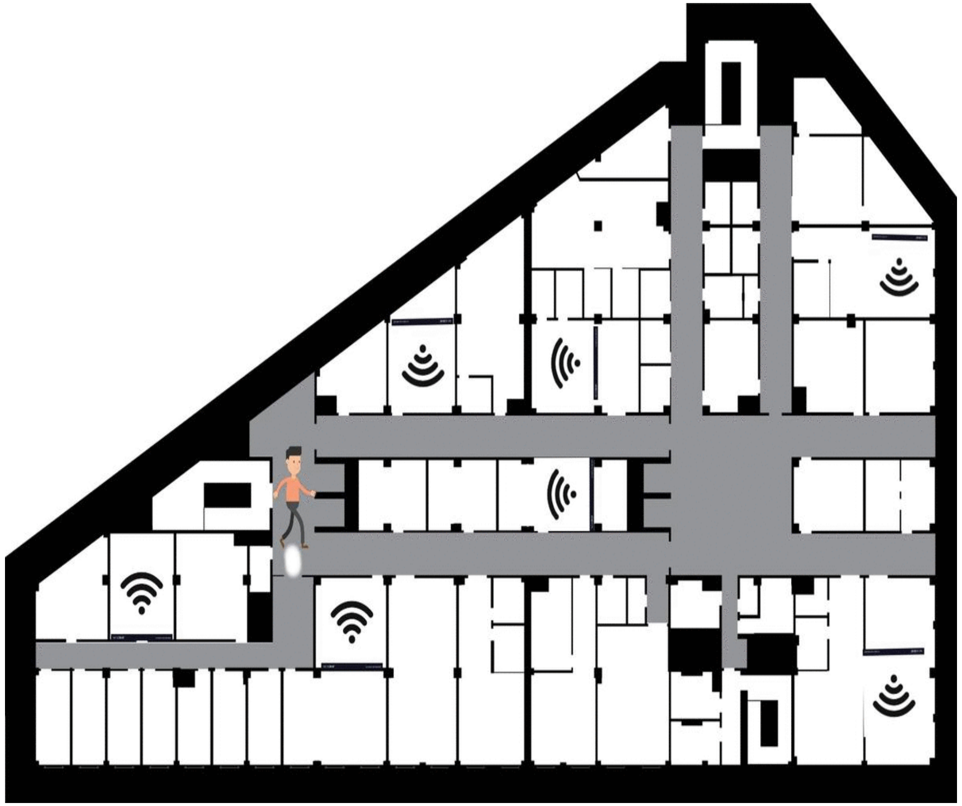
- RPs are scattered at random locations



Datasets

In this tutorial we will use the simplified version of the **WiFine** dataset:

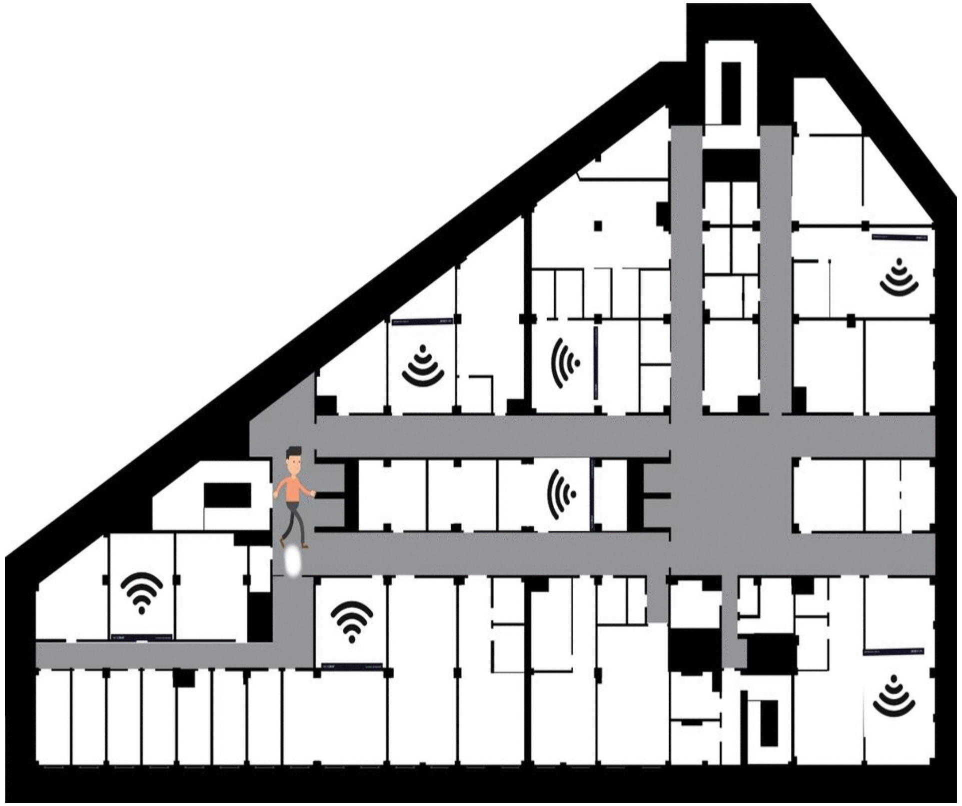
- RPs are scattered at random locations
- Recorded at finer granularity, across multiple floors, as a user moved in the building



Datasets

In this tutorial we will use the simplified version of the **WiFine** dataset:

- RPs are scattered at random locations
- Recorded at finer granularity, across multiple floors, as a user moved in the building
- Contains continuously recorded streams of RSS values



The dataset structure

- Each recorded trajectory of a user is stored in a separate CSV file.
- # of rows = # of recorded samples (checkpoints)

	0	1	2	3	4	5	6	7	8	9	...
0	-37.0	-36.0	-36.0	-32.0	-33.0	-61.0	-52.0	-52.0	-70.0	-77.0	...
1	-35.0	-35.0	-35.0	-41.0	-41.0	-70.0	-54.0	-69.0	-100.0	-78.0	...
2	-30.0	-36.0	-32.0	-40.0	-35.0	-61.0	-55.0	-57.0	-62.0	-79.0	...
3	-41.0	-42.0	-43.0	-42.0	-41.0	-56.0	-53.0	-52.0	-64.0	-77.0	...
4	-44.0	-44.0	-44.0	-35.0	-36.0	-53.0	-61.0	-61.0	-64.0	-77.0	...
...	...	...	...	...	...	...	...	...	...	...	...
80	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	...
81	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	...
82	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	...
83	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	...
84	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	...

85 rows × 223 columns

The dataset structure

- Each recorded trajectory of a user is stored in a separate CSV file.
- # of rows = # of recorded samples (checkpoints)
- The samples are listed in the **temporal** order:
  - The top row is the start of the trajectory
  - The bottom row is the end of trajectory

	0	1	2	3	4	5	6	7	8	9	...
0	-37.0	-36.0	-36.0	-32.0	-33.0	-61.0	-52.0	-52.0	-70.0	-77.0	...
1	-35.0	-35.0	-35.0	-41.0	-41.0	-70.0	-54.0	-69.0	-100.0	-78.0	...
2	-30.0	-36.0	-32.0	-40.0	-35.0	-61.0	-55.0	-57.0	-62.0	-79.0	...
3	-41.0	-42.0	-43.0	-42.0	-41.0	-56.0	-53.0	-52.0	-64.0	-77.0	...
4	-44.0	-44.0	-44.0	-35.0	-36.0	-53.0	-61.0	-61.0	-64.0	-77.0	...
...	...	...	...	...	...	...	...	...	...	...	...
80	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	...
81	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	...
82	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	...
83	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	...
84	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	...

85 rows × 223 columns

The dataset structure

	0	1	2	3	4	5	6	7	8	9	...	213	214	215	216	217	218	219	x	y	z
0	-37.0	-36.0	-36.0	-32.0	-33.0	-61.0	-52.0	-52.0	-70.0	-77.0	...	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	0.016694	7.741971	1.801771
1	-35.0	-35.0	-35.0	-41.0	-41.0	-70.0	-54.0	-69.0	-100.0	-78.0	...	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	0.042433	7.929269	1.801771
2	-30.0	-36.0	-32.0	-40.0	-35.0	-61.0	-55.0	-57.0	-62.0	-79.0	...	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-0.039225	8.876047	1.801771
3	-41.0	-42.0	-43.0	-42.0	-41.0	-56.0	-53.0	-52.0	-64.0	-77.0	...	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	0.032879	9.865795	1.801771
4	-44.0	-44.0	-44.0	-35.0	-36.0	-53.0	-61.0	-61.0	-64.0	-77.0	...	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	0.629612	10.710077	1.801771

5 rows × 223 columns

- # columns = 223
- Each sample contains RSS values coming from 220 APs.
  - 0-219: features (WiFi RSS values).
  - The 1st column (idx 0) represents the received data from the 1st AP.

The dataset structure

	0	1	2	3	4	5	6	7	8	9	...	213	214	215	216	217	218	219	x	y	z
0	-37.0	-36.0	-36.0	-32.0	-33.0	-61.0	-52.0	-52.0	-70.0	-77.0	...	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	0.016694	7.741971	1.801771
1	-35.0	-35.0	-35.0	-41.0	-41.0	-70.0	-54.0	-69.0	-100.0	-78.0	...	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	0.042433	7.929269	1.801771
2	-30.0	-36.0	-32.0	-40.0	-35.0	-61.0	-55.0	-57.0	-62.0	-79.0	...	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-0.039225	8.876047	1.801771
3	-41.0	-42.0	-43.0	-42.0	-41.0	-56.0	-53.0	-52.0	-64.0	-77.0	...	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	0.032879	9.865795	1.801771
4	-44.0	-44.0	-44.0	-35.0	-36.0	-53.0	-61.0	-61.0	-64.0	-77.0	...	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	-100.0	0.629612	10.710077	1.801771

5 rows × 223 columns

- # columns = 223
- Each sample contains RSS values coming from 220 APs.
  - 0-219: features (WiFi RSS values).
  - The 1st column (idx 0) represents the received data from the 1st AP.
- 220-222: target values, or the true X, Y, Z coordinates a reference point.

Next: practice with Jupyter Notebooks

1. Load the WiFine dataset
2. Train and test a Regression Tree to map RSS values to RPs.
3. Train and test a Multi Layer Perceptron to map RSS values to RPs.

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Follow up with Jupyter Notebooks

Accessed at
https://github.com/IS2AI/ISSAI-AUA-Summer-School

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A Tutorial on WiFi-based Indoor Localization: Programming Tasks

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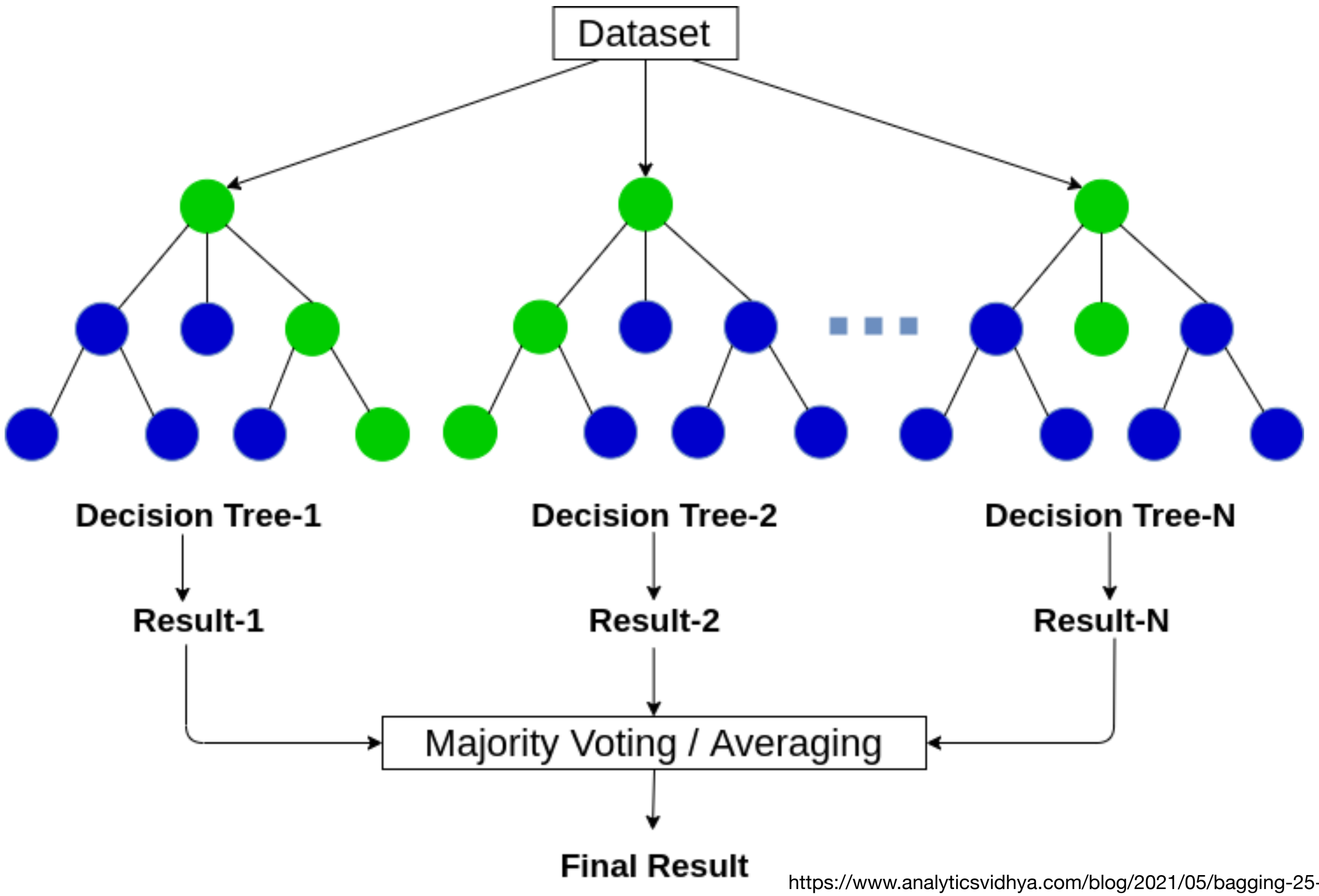
Random Forest Algorithm



https://www.analyticsvidhya.com/blog/2021/05/bagging-25-questions-to-test-your-skills-on-random-forest-algorithm/

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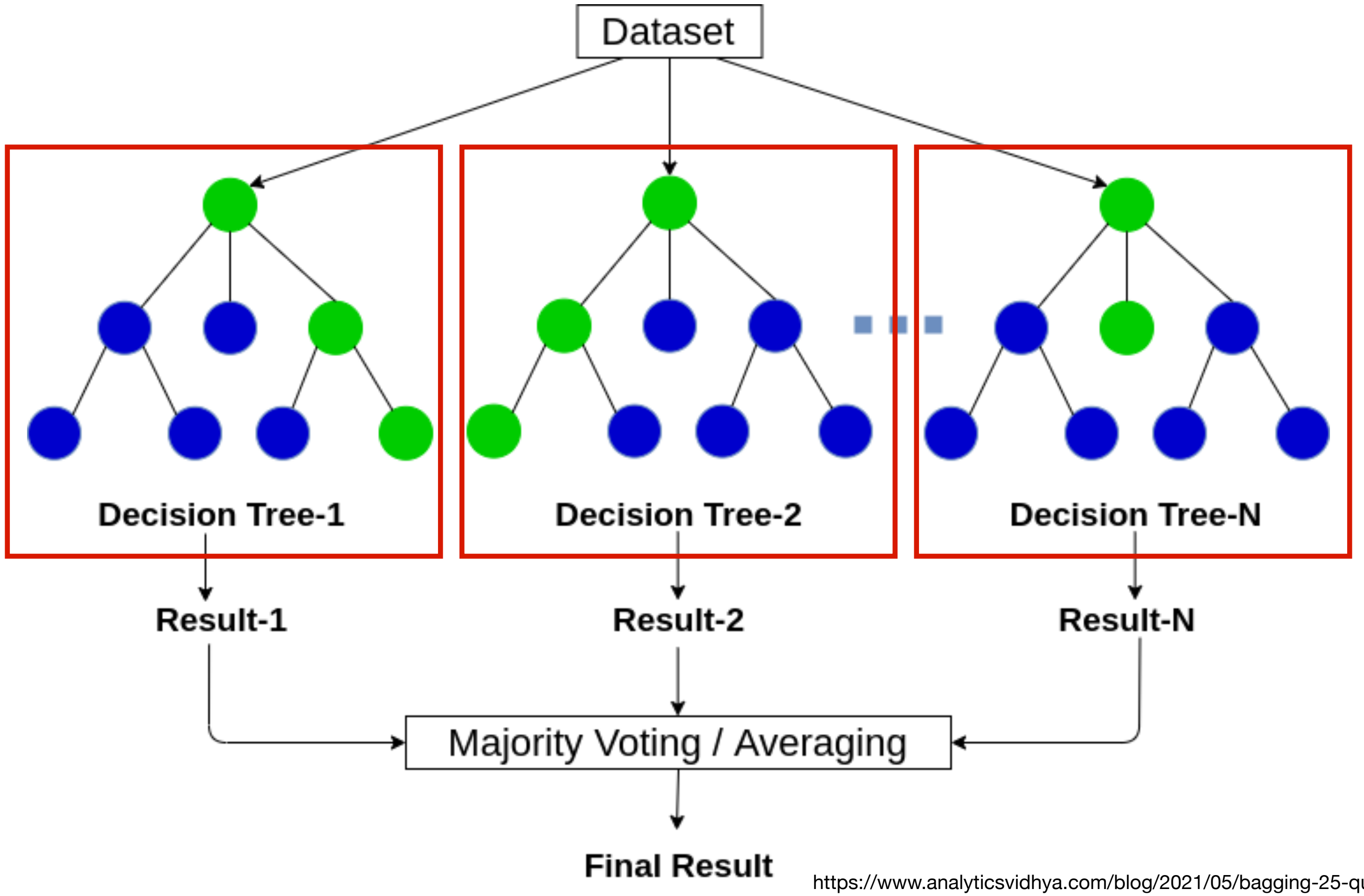

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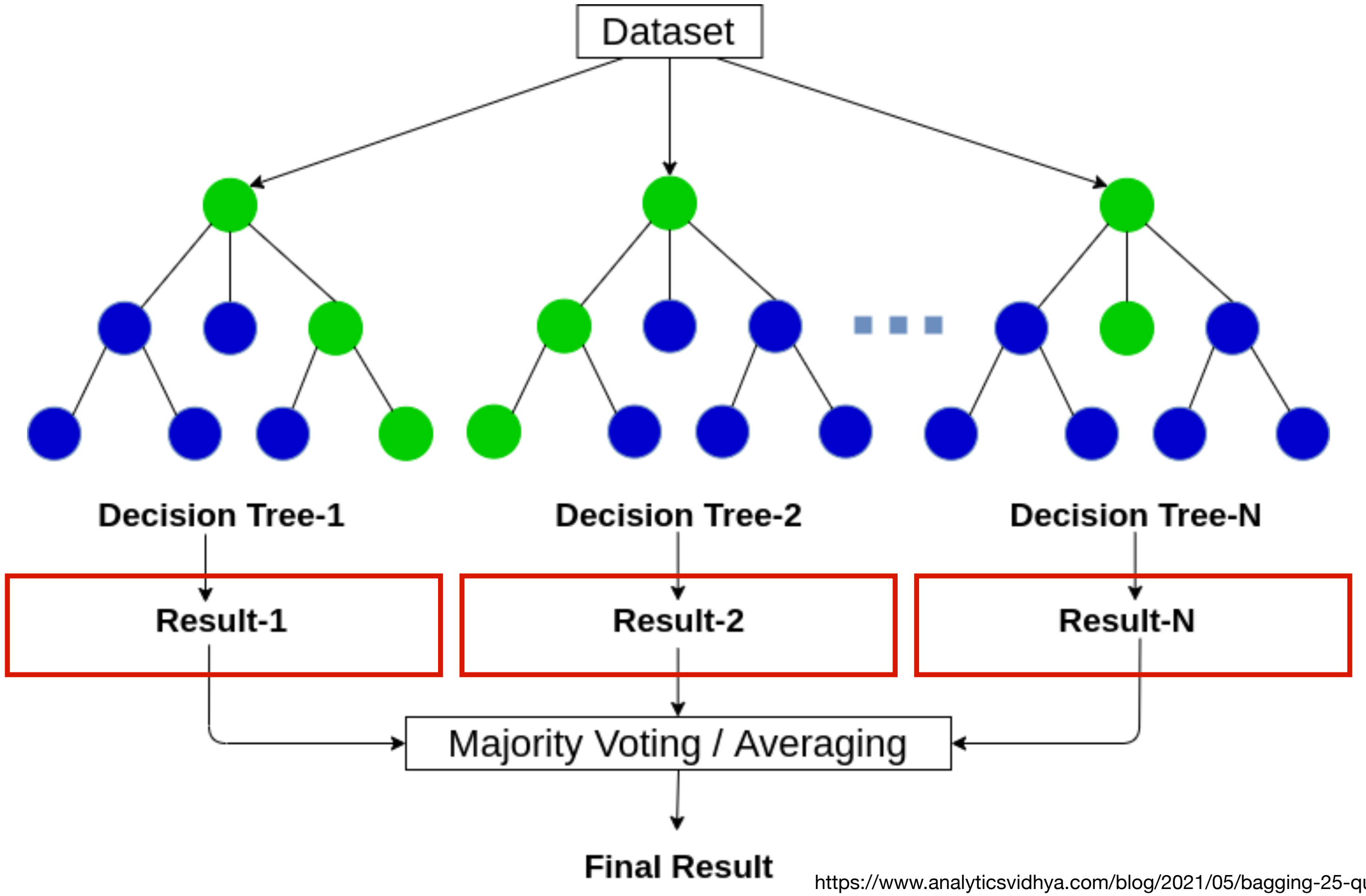

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