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Improving Indoor Localization by Fusing Active Acoustic Location Sensing and WiFi Localization

1. Introduction

- Indoor localization can have a multitude of use cases
  - Navigating office spaces or museums
  - Locating patients within a hospital
  - Navigating robotic units within a building [1]
- GPS is the most widely used method for localization but underperforms indoors due to signal blocking [2]
- Many indoor localization approaches exist, but they underperform under certain conditions
  - changing room environment [3]
  - reliance on infrastructure [4]
- A combination of localization methods enables more unique feature extraction from the environment

2. Background

- Indoor localization methods can be split into two broad categories
  - Infrastructure-dependant
    - WiFi
    - Bluetooth
    - FM-based
  - infrastructure-free
    - Barometric pressure patterns
    - Geomagnetism
    - Acoustic (Passive and Active)
- There are multiple ways that classifiers can be fused together to improve accuracy
  - Weighted averaging
  - Multi-step localization
  - Ensemble stacking

3. Objective

Combining active acoustic location sensing and WiFi localization to further increase the accuracy of classifying rooms or positions in open indoor spaces.

4. Methodology

- Implement acoustic localization according to RoomRecognize [3]
- Implement WiFi localization by using received signal strength (RSSI) as fingerprints
- Fusing the localization methods together with weighted averaging, two-step localization, and ensemble stacking

5. Experimental setup

- The measurements were taken in the university building Pulse.
- This building provides:
  - Many rooms that do not require employee access
  - An abundance of WiFi access points
  - A small amount of human traffic

6. Results

- Accuracies of all classifiers and combinations can be seen in **Figure 1**
- Confusion matrices of individual classifiers can be seen in **Figure 2** and can be compared to combined classifiers in **Figure 3**
- Combinations are able to reduce certain classification errors
- Combinations can introduce completely new misclassification errors
- The correct label was almost always present in the top 3 predictions

Classifier	Split 1	Split 2	Split 3	Average
WiFi	88%	90%	88%	89%
Acoustic	82%	88%	92%	87%
Weighted average	98%	90%	94%	94%
2-step localization	89%	92%	92%	91%
Stacking	92%	81%	94%	89%
WiFi top 3	100%	100%	100%	100%
Acoustic top 3	100%	98%	100%	99%

Figure 1: Test set localization accuracies obtained from 3 different train-test splits

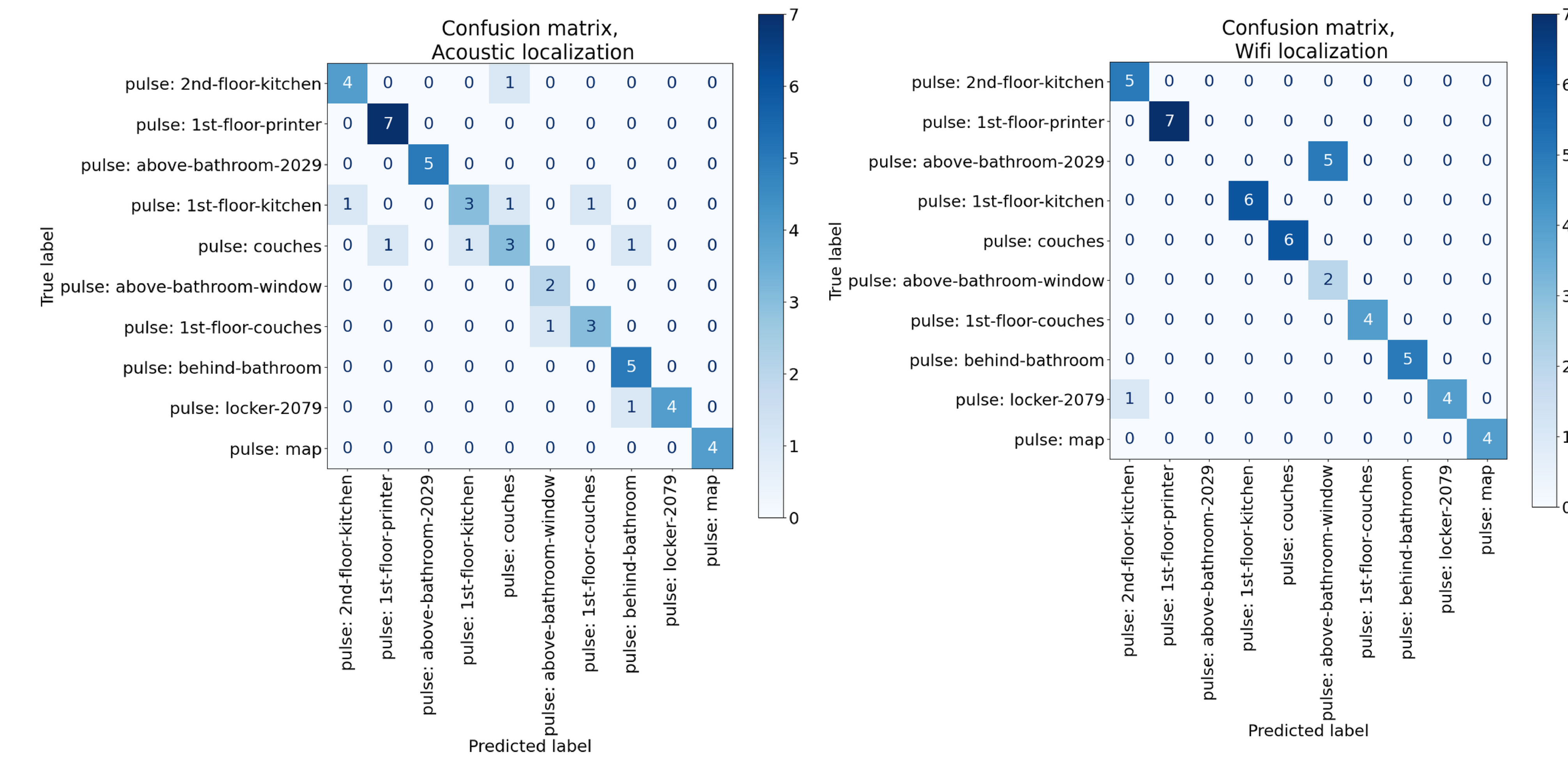

Figure 2: Confusion matrices of individual classifiers

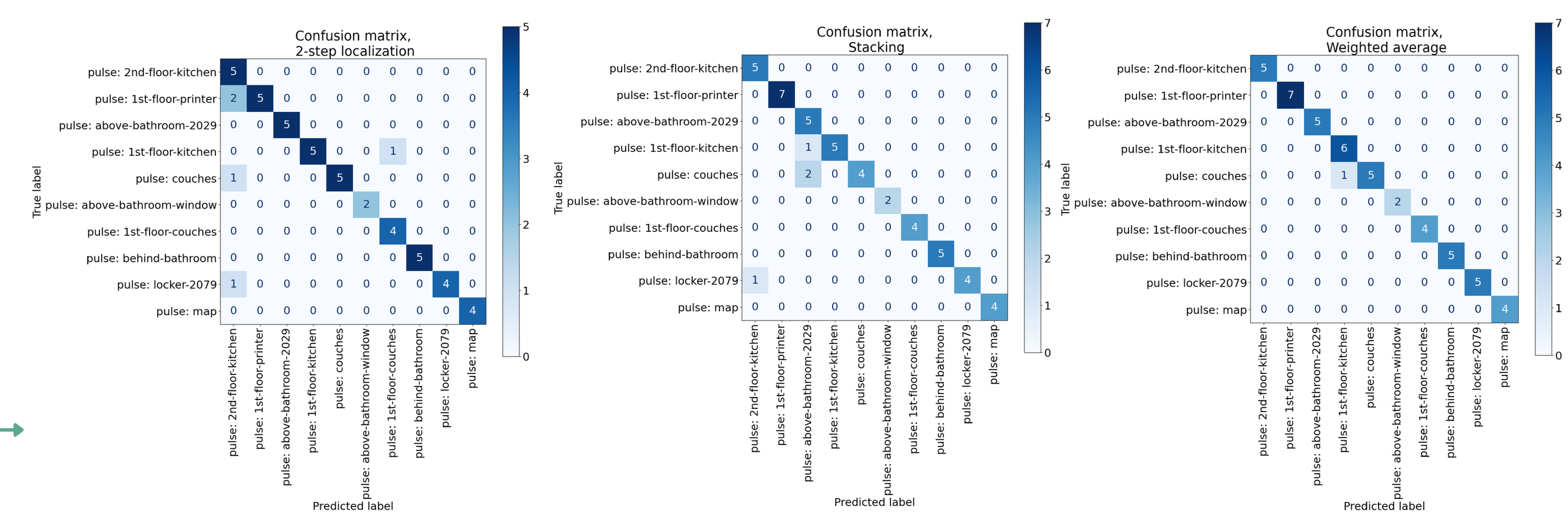

Figure 3: Confusion matrices of combined classifiers

7. Conclusion and Future work

- It is possible to improve indoor localization accuracy by combining active acoustic sensing and WiFi localization
- Combined classifier misclassification tends to overlap with individual classifier mistakes
  - But can introduce new errors
- A larger dataset should be taken to determine the improved accuracy
- Can add additional classifier to the fusion

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