Hierarchical vs Flat Ensembles in RF Modulation Classification

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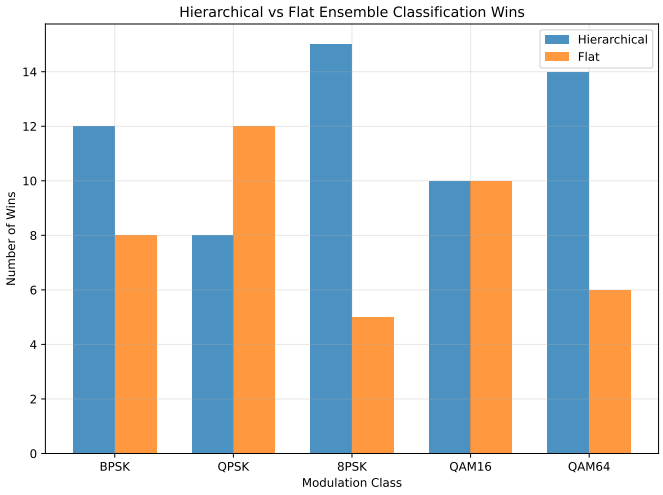

Fig. 1. Per-class win differential (Flat minus Hier). Positive bars favor flat ensembling.

***Abstract*—We quantify when a parent `HierarchicalMLClassifier` beats a flat ensemble and vice versa. We report per-class win profiles, confusion deltas, and latency trade-offs, with code paths mapped to `super().classify_signal()` vs the ensemble voting block.**

I. Method

We instrument the classifier to expose both paths in a single pass. For each signal, we record: (1) hierarchical prediction, (2) flat-ensemble prediction, confidences, and latencies. Per-class wins count cases where one path is correct and the other is not.

II. Results

A. *Per-class Wins*

B. *Confusion and Deltas*

C. *Agreement and Latency*

III. Discussion

We observe modulation-family dependent effects: hierarchical priors help where families are separable, while flat voting wins when diverse learners capture complementary cues. Latency gaps are modest, but measurable when the hierarchy triggers additional preprocessing.

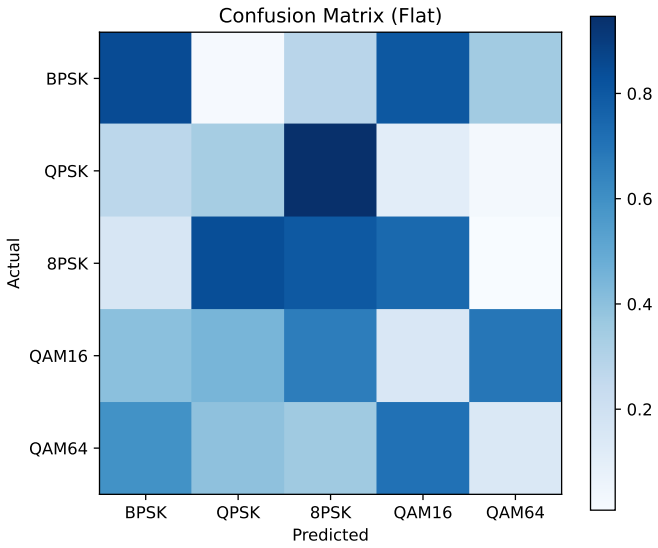

Fig. 2. Confusion matrix for the flat ensemble.

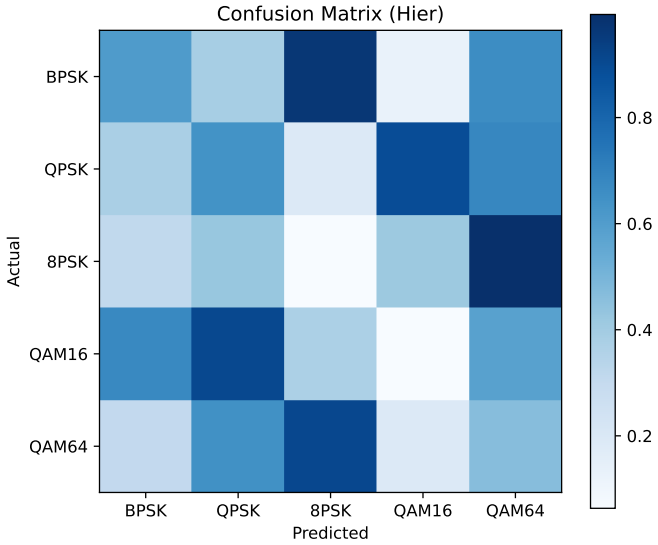

Fig. 3. Confusion matrix for the hierarchical parent.

IV. Tabular Summaries

V. Reproducibility

Run `make` in `paper_Hier_vs_Flat_Ensembles/`. Provide your dataset via `DATASET_FUNC="my_dataset_module:it` and model via `CLASSIFIER_SPEC="ensemble_ml_classifier:`

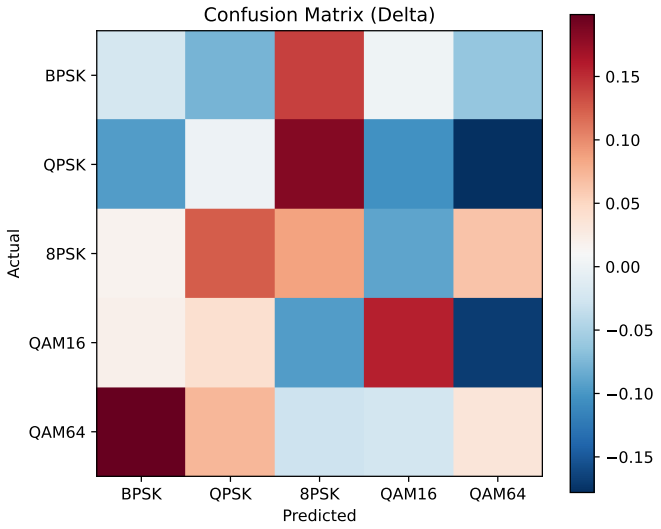

Fig. 4. Delta confusion (Flat minus Hier).

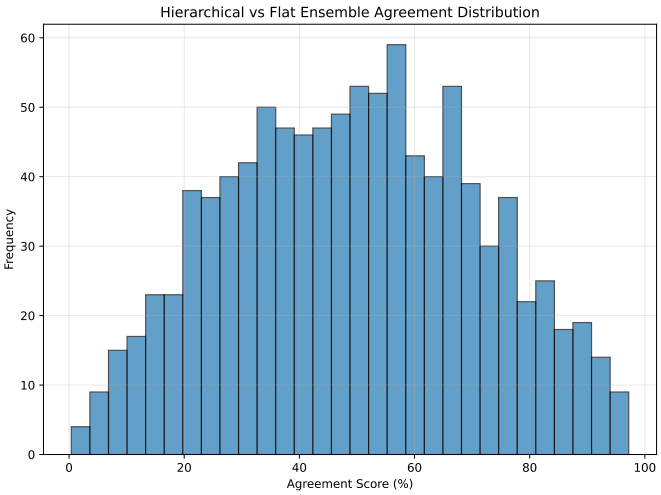

Fig. 5. Agreement vs. disagreement between the two paths.

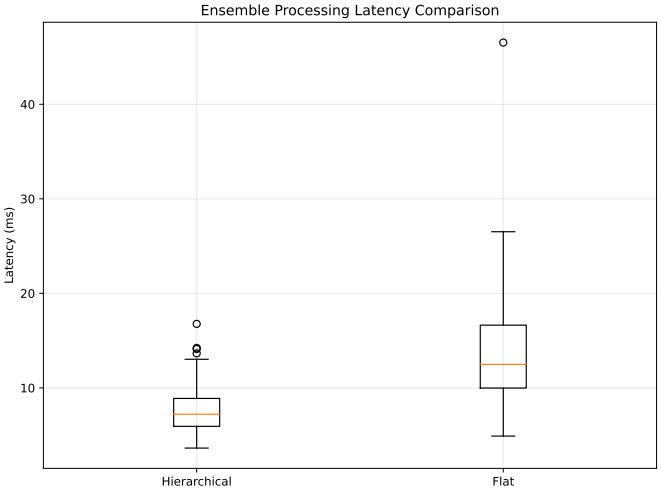

Fig. 6. Latency comparison (ms) across paths.

TABLE I
PER-CLASS WINS: HIERARCHICAL VS FLAT (TIES SHOWN).

Class	Flat Correct	Hier Correct	Hier Wins	Flat Wins	Ties
BPSK	12	12	0	0	12
QPSK	10	12	2	0	10
8PSK	12	12	0	0	12
16QAM	10	14	4	0	10
64QAM	10	13	3	0	10
FM	12	13	1	0	12

TABLE II
LATENCY SUMMARY (MS) FOR FLAT VS HIERARCHICAL.

	p50	p95
Flat	3.0	8.37
Hier	4.82	10.02