ReFeree: Radar-based efficient global descriptor using a Feature and Free space for Place Recognition

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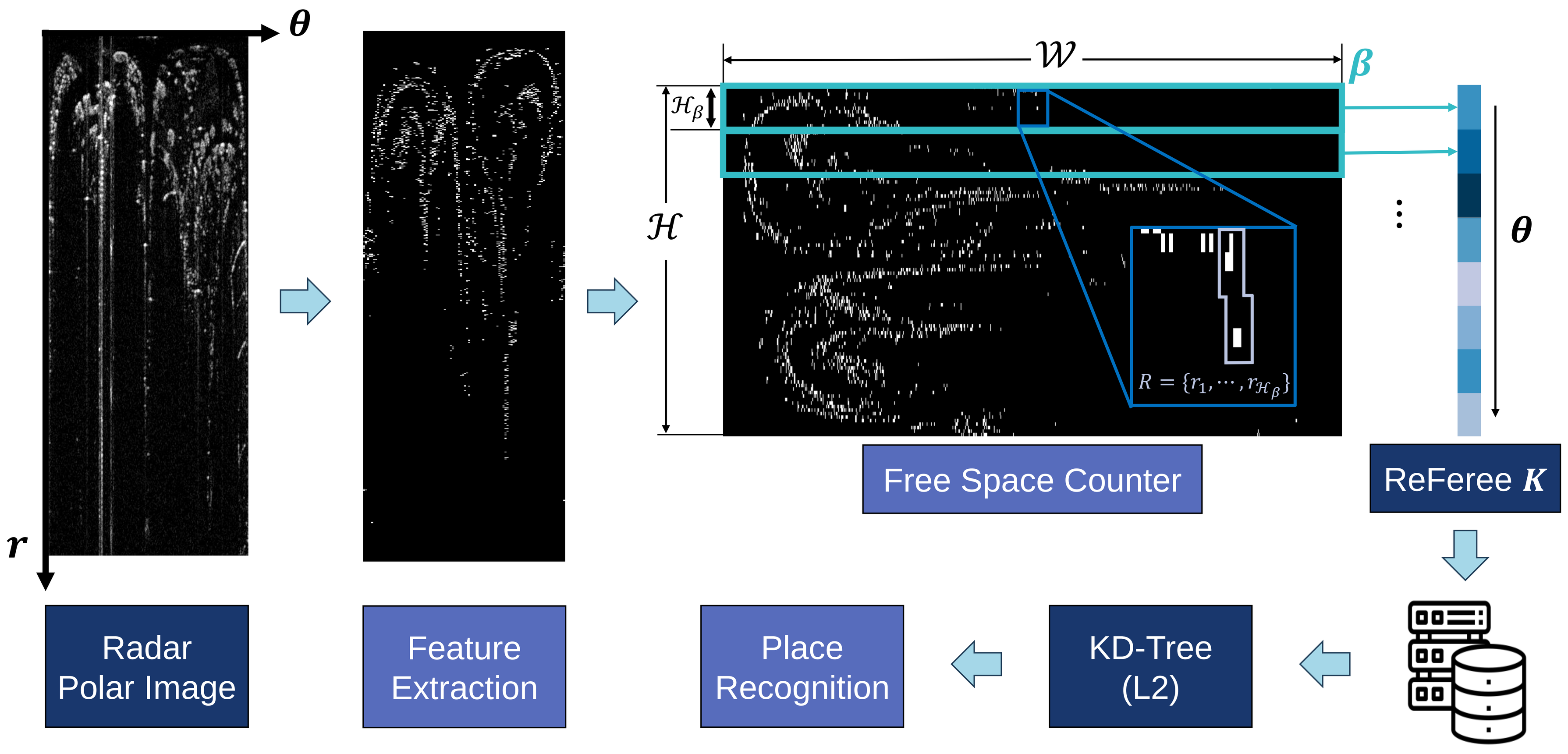
Introduction

- Radar is highlighted for robust sensing capabilities in severe weather conditions which camera or LiDAR become stuck.
- We propose lightweight and efficient Radar place recognition descriptor that compress vacancy information.
- Our method is validated the performance in three single session scenarios and three multi session scenarios.

Method

Proposed Pipeline



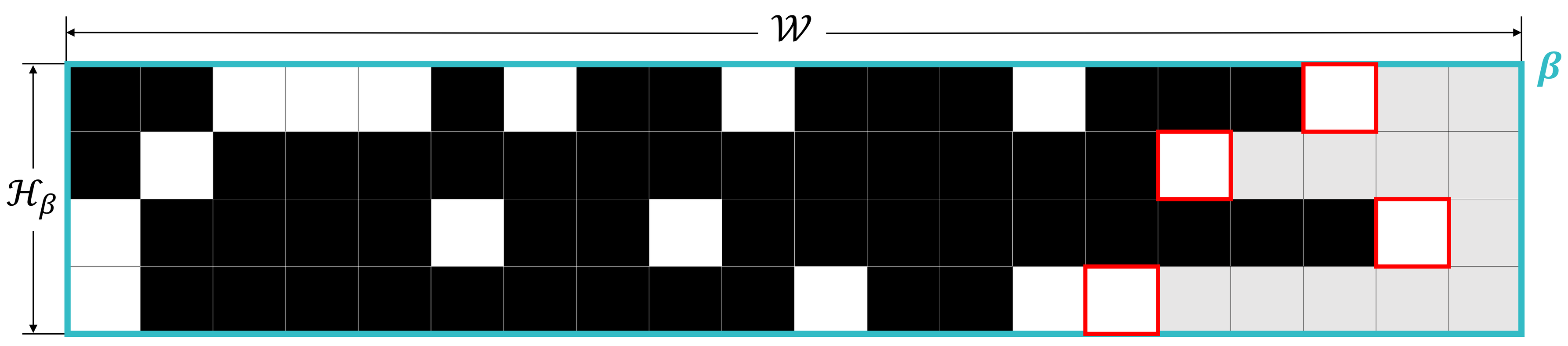
- **Feature extraction** for identifying valid signal from Radar intensity image we selected is algorithm proposed by Cen at el, which process three steps:
  - Decompose signal by high and low-frequency
  - Integrate signals according to Gaussian scaling factor
  - Thresholding integrated signal
- **ReFeree *K*** is α-dimensional vector that generated by free-space information from feature-extracted Radar image.

$$\boldsymbol{K} = \{K_1, \cdots, K_\alpha\}$$

- K is free-space density in subsection β of Radar image.

$$K_i = \frac{\sum_{j=1}^{H_\beta}(\sum_{k=1}^{r_j} s(b_{jk}))}{H_\beta W}$$

  - H_β, W: height and width of subsection β
  - r_j: max range index of angle j in subsection β
  - b_{jk}: state of angle j, range k in subsection β(free or feature)
  - $s(b_{jk})$: free-space classifier(if b_{jk} is free 1, else 0)
- Figure below simply presents generating K in subsection β.



$$K_i = \frac{\#\ of\ free\ space\ \blacksquare}{\mathcal{H}_\beta \times \mathcal{W}}$$

Feature, $s(b)=0$
Free Space, $s(b)=1$
Max Range Feature r_j

- ReFeree ***K*** matches loops by distance from KD-Tree and utilizes Euclidean distance threshold.

Experiment Results

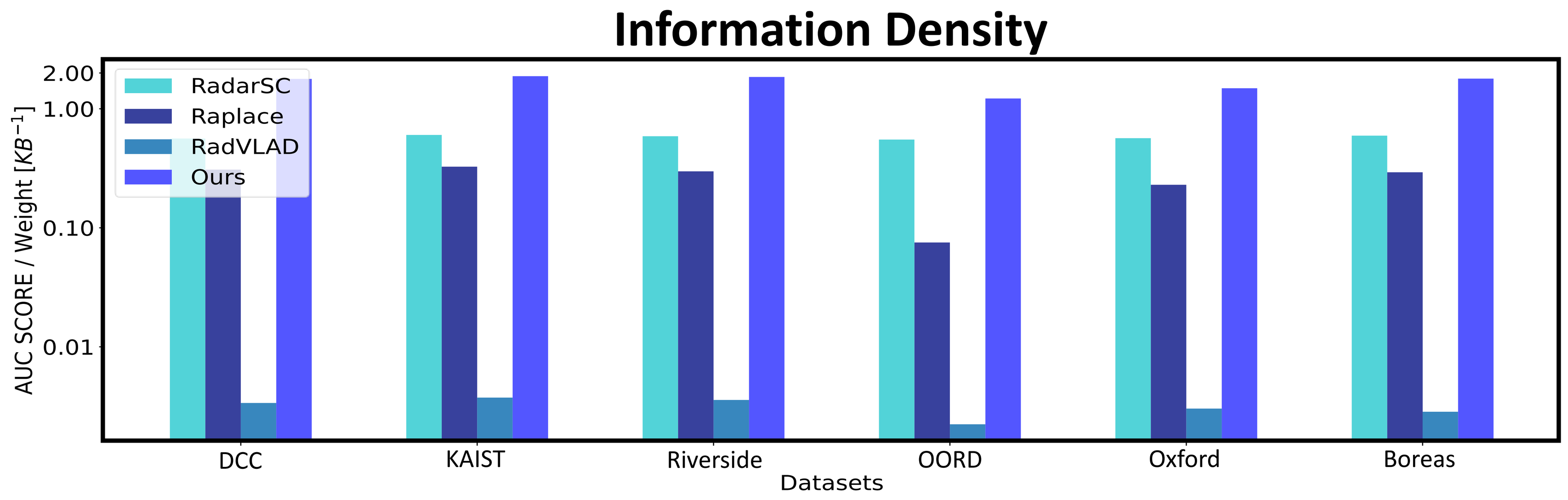
Datasets

Mulran Boreas Oxford RobotCar OORD

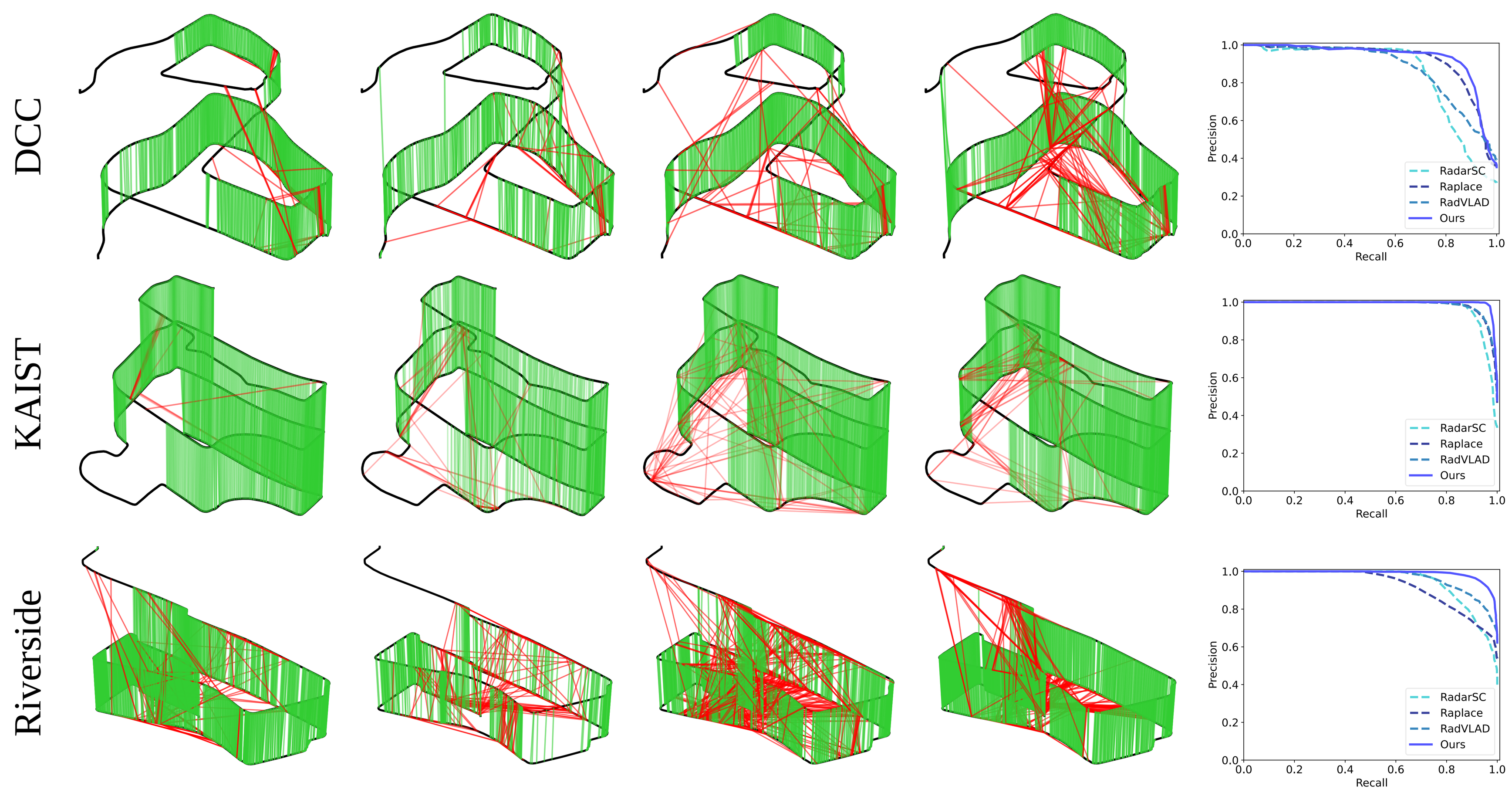
Comparison of Descriptor

- We compare our method with *Radar Scan Context* (RadarSC), *Raplace*, and *Open-RadVLAD* (RadVLAD).
- Figure below represents the information density of each descriptor, indicating how efficiently data is compressed per Byte.
- ReFeree shows the highest information density in tested datasets.

Information Density

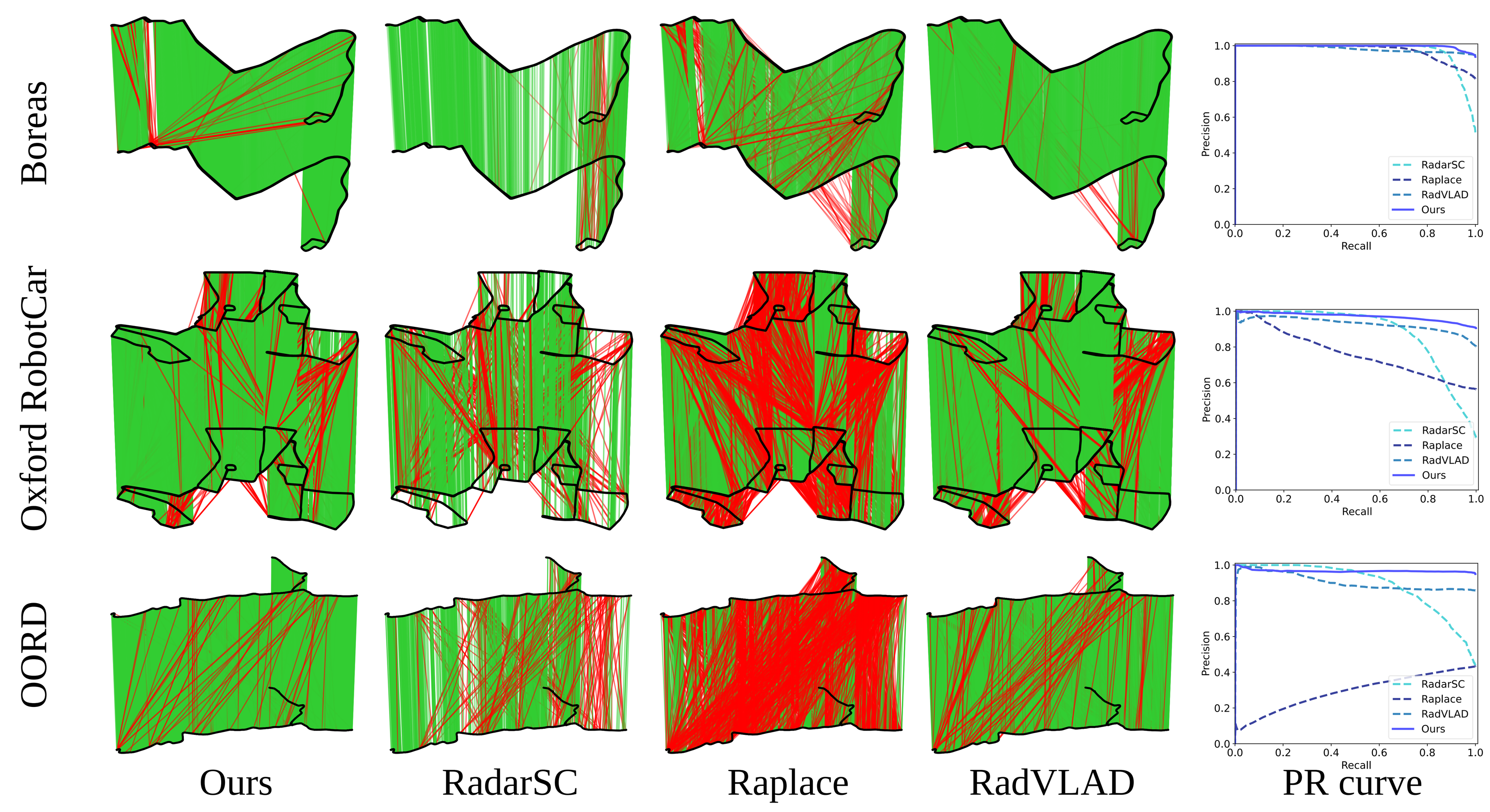


Single session Evaluation



Ours RadarSC Raplace RadVLAD PR curve

Multi-session Evaluation



Ours RadarSC Raplace RadVLAD PR curve

Conclusion

- We validate the performance of our method with other methods on various dataset and scenarios.
- However, our method lacks solution about reverse loop and validation by our own dataset.
- In future work, we plan to enhance our descriptor for SLAM pipeline by incorporating rotation invariance.