Supplementary Material: Representative-Discriminative Learning for Open-set Land Cover Classification of Satellite Imagery

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Supplementary Contents

Section A presents a visual comparison of data used for open-set recognition among the three spaces, i.e., the image space (X), the embedding space (Z_f), and the abundance space (S). Section B shows the performance of open-set recognition if conducted on the image space (X) or the embedded space (Z_f).

A A visual comparison among spaces X, Z_f, and S

Figures 1, 2, and 3 illustrate the mean of samples belonging to different classes in spaces X, Z_f, and S, respectively, using the PU dataset. The feature vectors learned through F and E, shown in Figs. 2 and 3, respectively, are sparse due to the sparsity constraint.

It can be seen from Fig. 1 that the spectrum of samples belonging to class 3 and 8 are close. However, the feature vectors, learned through F, corresponding to class 3 and 8 are more discriminative. Further, the discriminative and representative characteristics of the features are enhanced through encoder E, as illustrated in Fig. 3.

B Comparison of open-set recognition performing on space X and Z_f

To better compare the effectiveness of performing open-set recognition in spaces X and Z_f, we show the results of performing in each space separately using the PU dataset in Table 1.

Comparing the results of $AE + CLS$ and $AE + CLS + Dirichlet$ approaches performed on spaces X and Z_f, it can be seen that discriminative features learned

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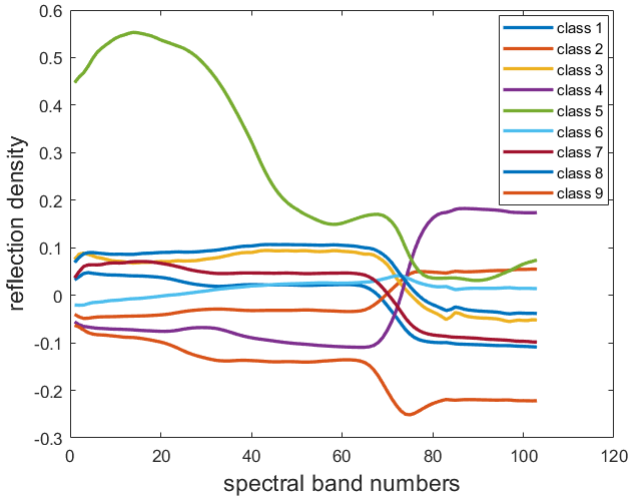

Fig. 1: Mean of samples in space X, belonging to classes 1 to 9, using the PU dataset

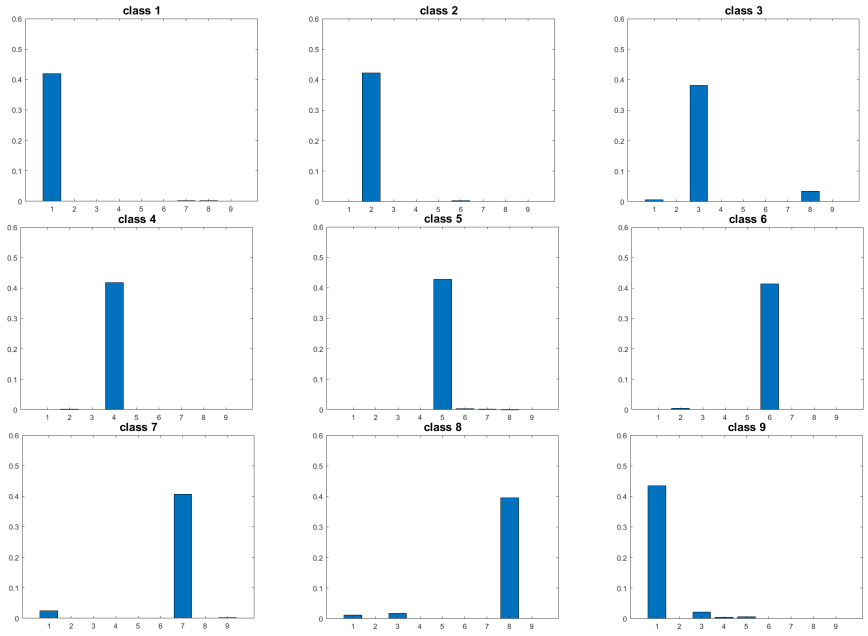

Fig. 2: Mean of samples in space Z_f, belonging to classes 1 to 9, using the PU dataset

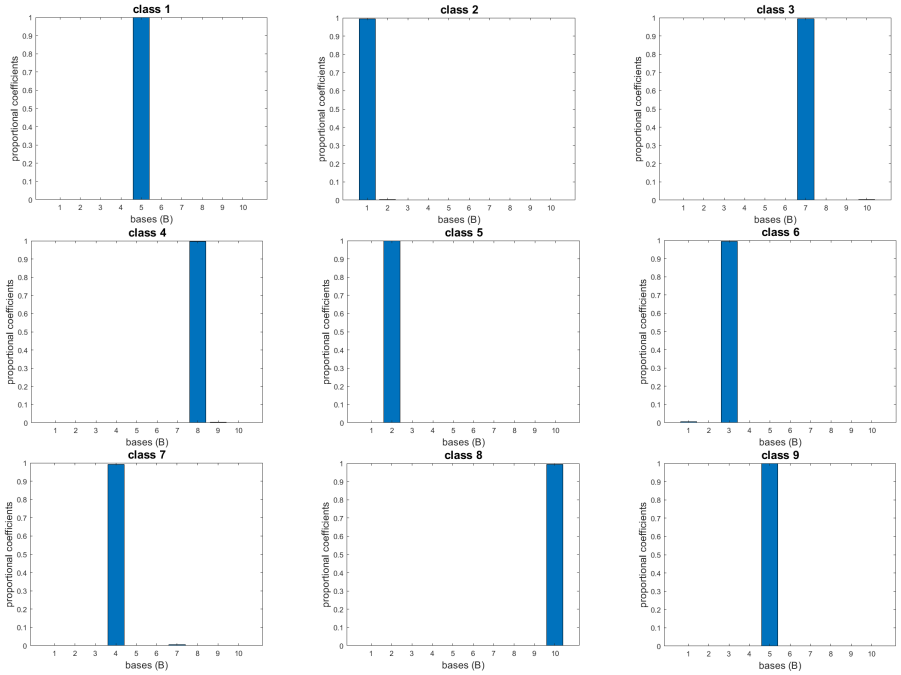

Fig. 3: Mean of samples in space S, belonging to classes 1 to 9, using the PU dataset

Table 1: Area under the ROC curve for open-set recognition. Results are from partitioning PU dataset to $L-1$ known and the mentioned unknown classes, (openness=2.99%). Note that L denotes the number of classes in the original PU dataset

Space	**Method**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Avg.**
X	SoftMax	0.54	0.52	0.51	0.42	0.14	0.38	0.23	0.64	0.09	0.39
	OpenMax [26]	0.67	0.37	0.45	0.40	0.99	0.35	0.12	0.57	0.04	0.44
	AE+CLS [30]	0.51	0.53	0.54	0.83	1.0	0.46	0.48	0.46	0.46	0.59
	AE+CLS+Dirichlet	0.79	0.69	0.47	0.90	1.0	0.64	0.47	0.48	0.97	0.71
Z_f	AE+CLS	0.91	0.70	0.68	0.72	1.0	0.62	0.46	0.66	0.94	0.74
	AE+CLS+Dirichlet	0.91	0.70	0.71	0.72	1.0	0.68	0.51	0.80	0.93	**0.77**

through the classifier F contribute to a substantial improvement. In addition, the Dirichlet network plays more critical role when performing open-set recognition in space X as compared to space Z_f.