Hyperdimensional Feature Fusion For Out-of-Distribution Detection

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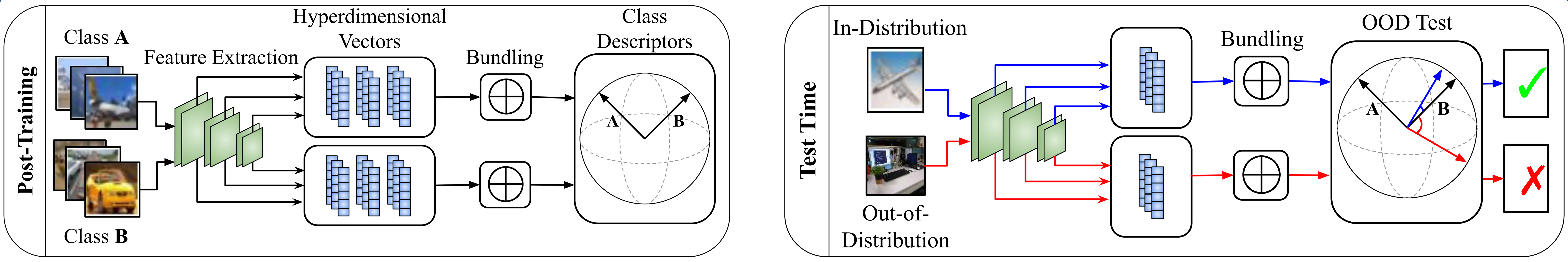
Find our code on GitHub!

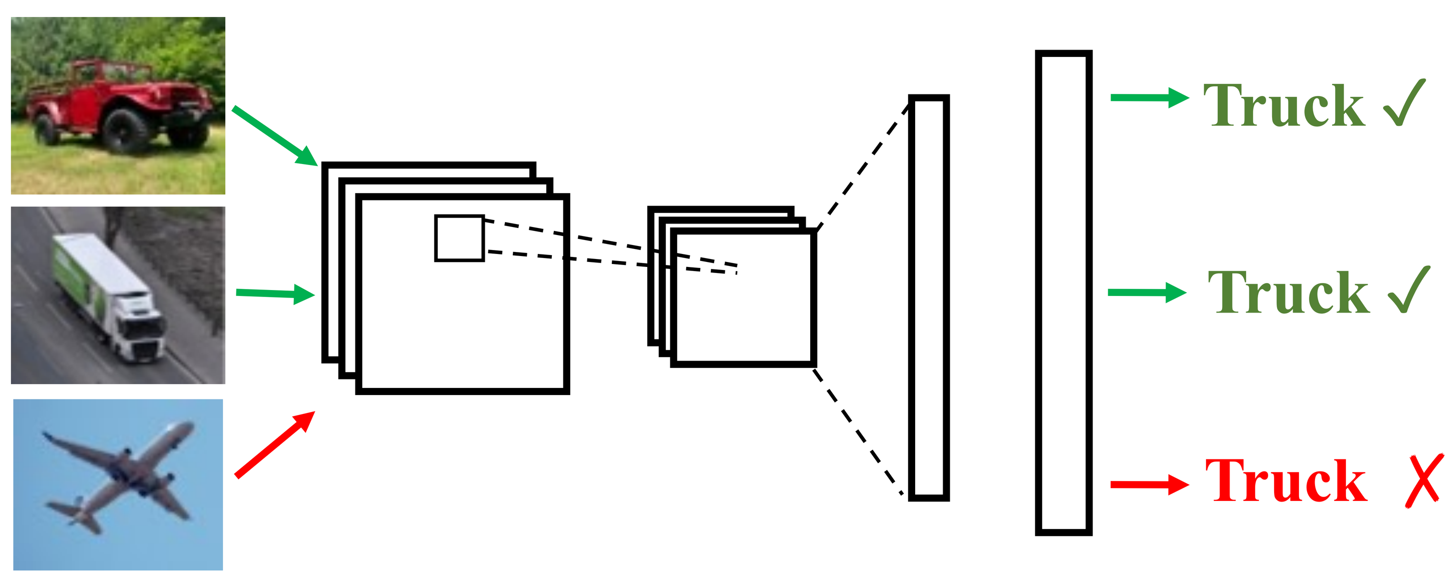
github.com/SamWilso/HDFF_Official

1) Method: Hyperdimensional Feature Fusion (HDFF)



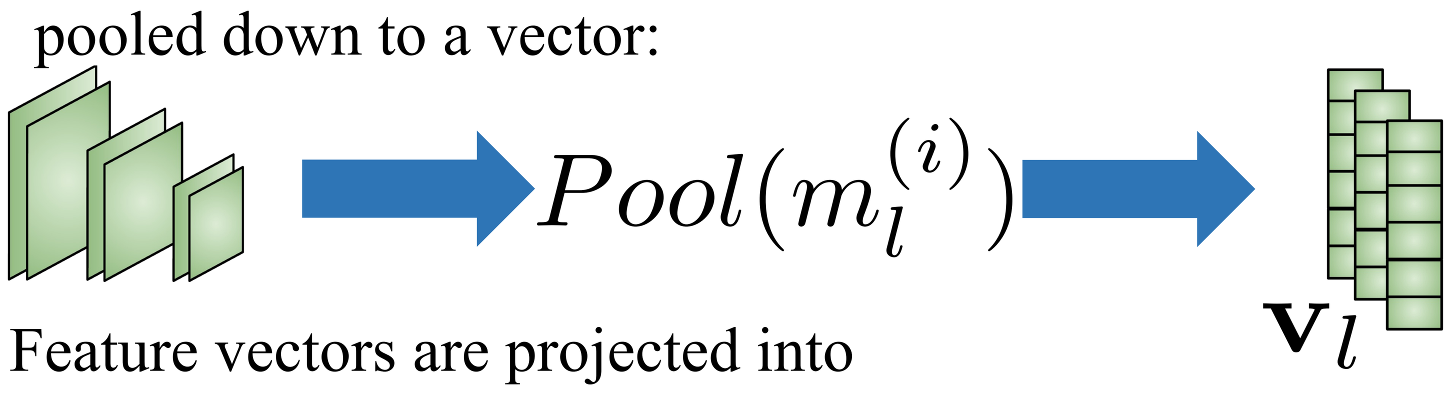
2) Task: Out-of-Distribution Detection

Out-of-**D**istribution (**OOD**) detection challenges deep networks to alert when test-time input samples do not belong to the training distribution.



3) Feature Extraction and Projection

Feature maps are extracted from all Conv layers and pooled down to a vector:



$$Pool(m_l^{(i)}) \rightarrow \mathbf{v}_l$$

Feature vectors are projected into **hyperdimensional vectors**:

$$\mathbf{h}_l = \mathbf{P}_l \mathbf{v}_l \qquad \mathbf{P}^\mathsf{T}\mathbf{P} = \mathbf{I}$$

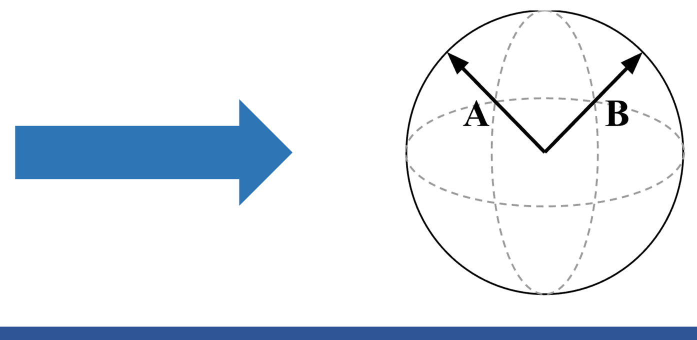
4) Feature Aggregation via Bundling

Image Descriptors are created by bundling over the multi-scale features for an input sample:

$$\mathbf{y}^{(i)} = \bigoplus_{l=1}^{L} \mathbf{h}_l^{(i)} = \bigoplus_{l=1}^{L} \mathbf{P}_l \cdot \mathbf{v}_l^{(i)}$$

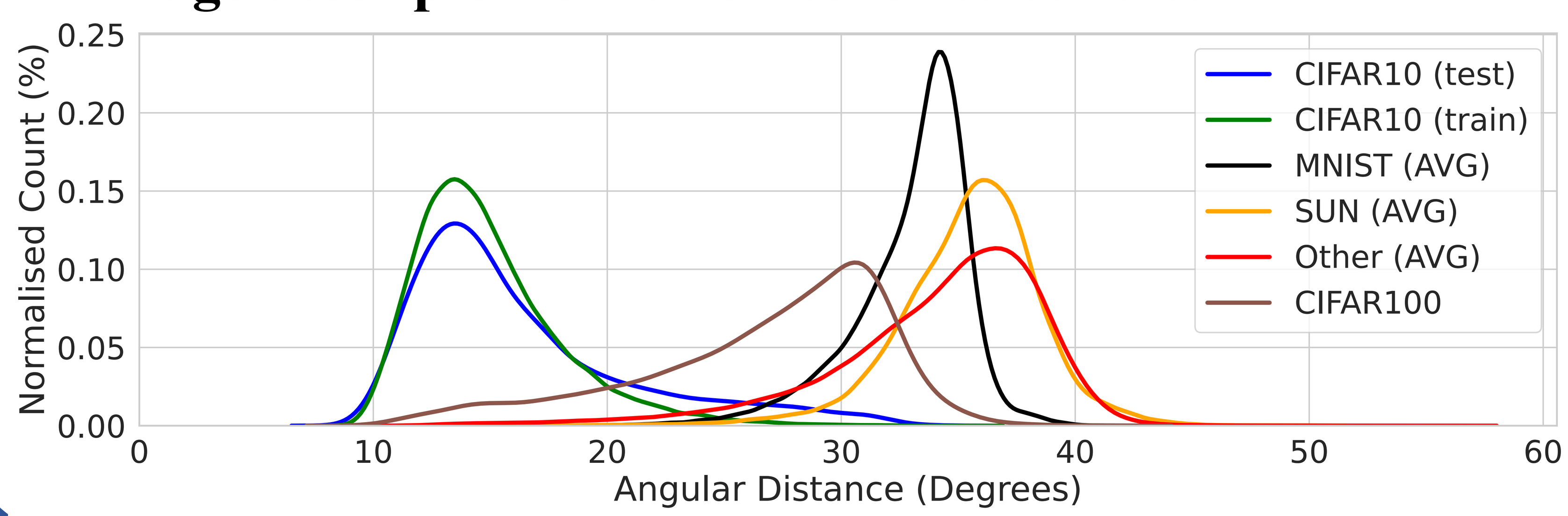
Class Bundles are the bundled image descriptors for each class:

$$\mathbf{d}_c = \bigoplus_{j \in \mathbb{I}_c} \mathbf{y}^{(j)}$$



5) Cosine Similarity Test

Test-time samples are scored based on the angle of their **image descriptor** to the **nearest class bundle:**



6) Experimental Results

HDFF outperforms baselines and produces competitive results against Gram with **~4.5x faster** inference time.

OOD Dataset	HDFF (Ours)	HDFF-Ens (Ours)	Gram [50]	MSP [19]	ML [18]	Energy [31]
iSun	99.2	*99.3*	**99.9**	96.4	97.8	92.6
TINc	98.3	*98.4*	**99.4**	95.4	96.8	-
TINr	99.2	*99.4*	**99.8**	95.0	96.5	-
LSUNc	96.2	96.8	*98.1*	95.7	97.1	**98.4**
LSUNr	99.2	*99.4*	**99.9**	96.5	98.0	94.2
SVHN	*99.4*	**99.5**	*99.4*	96.0	97.2	91.0
MNIST	99.6	*99.7*	**99.97**	89.4	90.6	-
KMNIST	99.0	*99.1*	**99.98**	92.7	93.4	-
FMNIST	98.7	*99.1*	**99.8**	93.6	95.2	-
Textures	94.5	*94.8*	**98.2**	92.7	93.5	85.2
CIFAR100	75.4	75.8	79.4	**87.8**	*87.3*	-

HDFF is compatible with OOD-based training paradigms and other post-hoc OOD detectors.

OOD Dataset	HDFF-MLP (Ours)	HDFF-1DS (Ours)	1DS [59]	NMD [10]	DDU [37]	MOOD [30]
iSun	**99.99**	*99.9*	-	*99.9*	-	93.0
TINc	**99.9**	*99.7*	98.1	99.2*	91.1*	-
TINr	**99.96**	*99.8*	98.5	-	91.1*	-
LSUNc	98.2	99.1	**99.4**	98.8	-	*99.2*
LSUNr	**99.99**	*99.9*	99.3	-	-	93.3
SVHN	84.8	*99.2*	-	**99.6**	97.9	96.5
MNIST	*99.4*	99.3	-	-	-	**99.8**
KMNIST	98.6	*99.3*	-	-	-	**99.9**
FMNIST	*99.6*	99.3	-	-	-	**99.9**
Textures	*97.4*	97.3	-	**98.9**	-	93.3
CIFAR100	69.9	*90.7*	-	90.1	**91.3**	-