Visual Domain Adaptation using Weighted Subspace Alignment

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Outline

- Motivation
- Previous Work
- Our Algorithm
- Experiments
- Conclusions

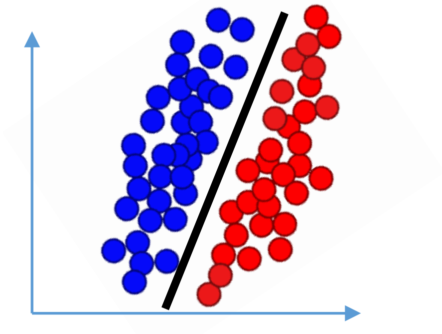
Motivation

- Mismatch between different datasets
- Background
  - Objective Recognition
- Domain Adaptation
  - learn a classifier on a labeled source domain and transfer it to a target domain

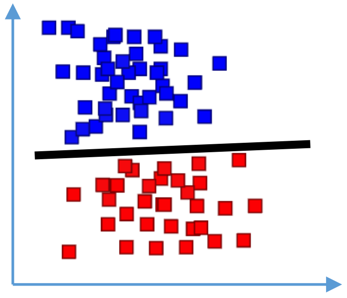
Previous Work

- Feature Transformation Techniques
  - GFK (Gong, CVPR 2012)-Geodesic Flow Kernel
  - SA (Fernando, ICCV 2013)-Subspace Alignment
  - LM (Gong, IJCV 2014)-Landmarks

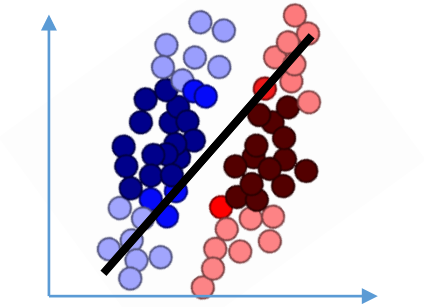
Our Algorithm



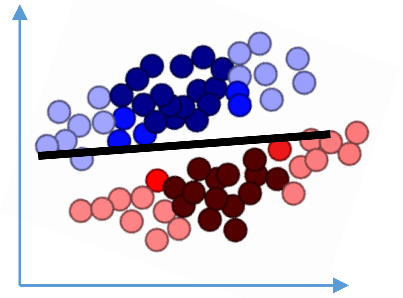
(a) Source Domain



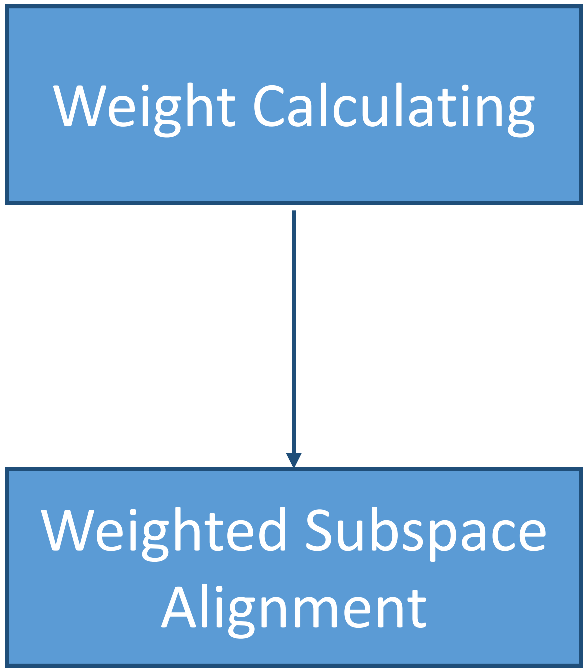
(b) Target Domain



(c) Weighted Subspace



(d) Subspace Alignment



* Deeper color means that the source sample has a higher weight.

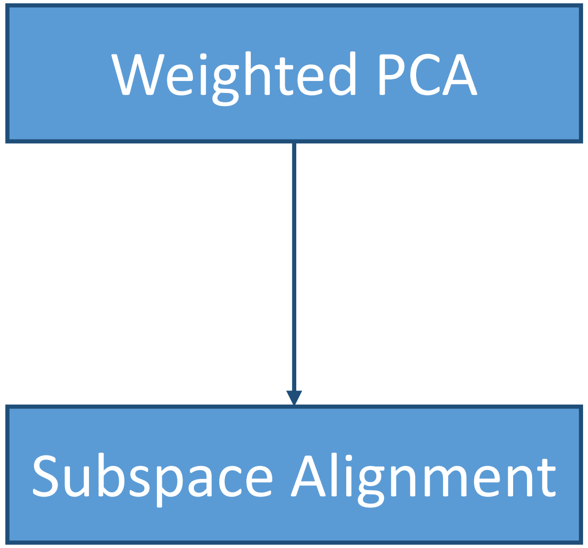
Weight Calculating

- Criterion: distance between source and target samples
- Weight function:

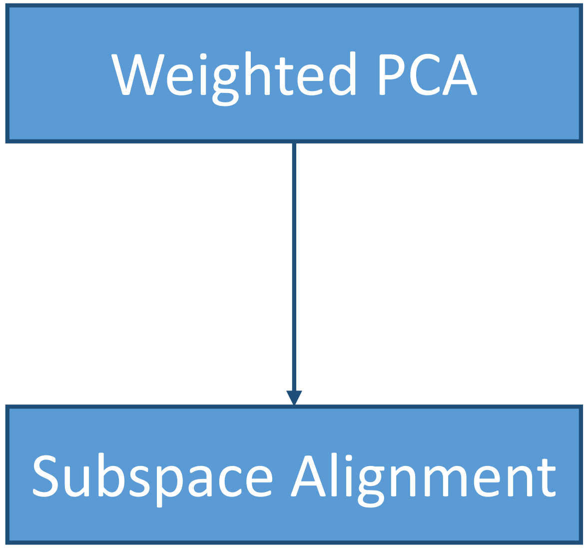
$$\omega_i = \omega^{(0)} + \sum_{j=1}^{n} \mu(v_j - d_{ji})$$

  - $\omega^{(0)}$ is the initial weight
  - $\mu(x) = \begin{cases} 1, x = 0 \\ 0, x < 0 \end{cases}$
  - $d_{ji} = \left\| \mathbf{t}_j - \mathbf{s}_i \right\|_2^2$ the distance between target sample and source sample
  - $v_j = \min_{i=1 \dots m} \{d_{ji}\}$ the minimum distance between the target sample and source samples

Weighted Subspace Alignment



Weighted Subspace Alignment



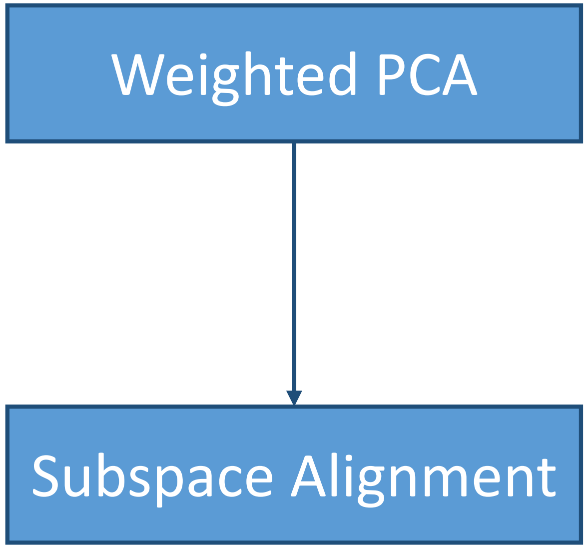
Weighted covariance matrix

$$\mathbf{C} = \frac{1}{m}\sum_{i=1}^{m}(\mathbf{s}_i - \bar{s})^T \omega_i (\mathbf{s}_\mathbf{i} - \bar{s})$$

$\bar{s}$ is the weighted mean

Eigen-decomposition on $\mathbf{C}$ and we get $\mathbf{X}_S$ and $\mathbf{X}_T$.
$\mathbf{X}_S$ and $\mathbf{X}_T$ lie in the subspace of the original feature space.

Weighted Subspace Alignment



We want to minimize:

$$F(\mathbf{M}) = \|\mathbf{X}_S\mathbf{M} - \mathbf{X}_T\|_F^2$$

$\mathbf{M}$ is the transformation matrix.

The Frobenius norm is invariant to orthonormal operations.

$$F(\mathbf{M}) = \left\|\mathbf{X}_S^T\mathbf{X}_S\mathbf{M} - \mathbf{X}_S^T\mathbf{X}_S\mathbf{X}_T\right\|_F^2$$

Finally, we get:

$$\mathbf{M} = \mathbf{X}_S^T\mathbf{X}_T$$

Weighted Subspace Alignment

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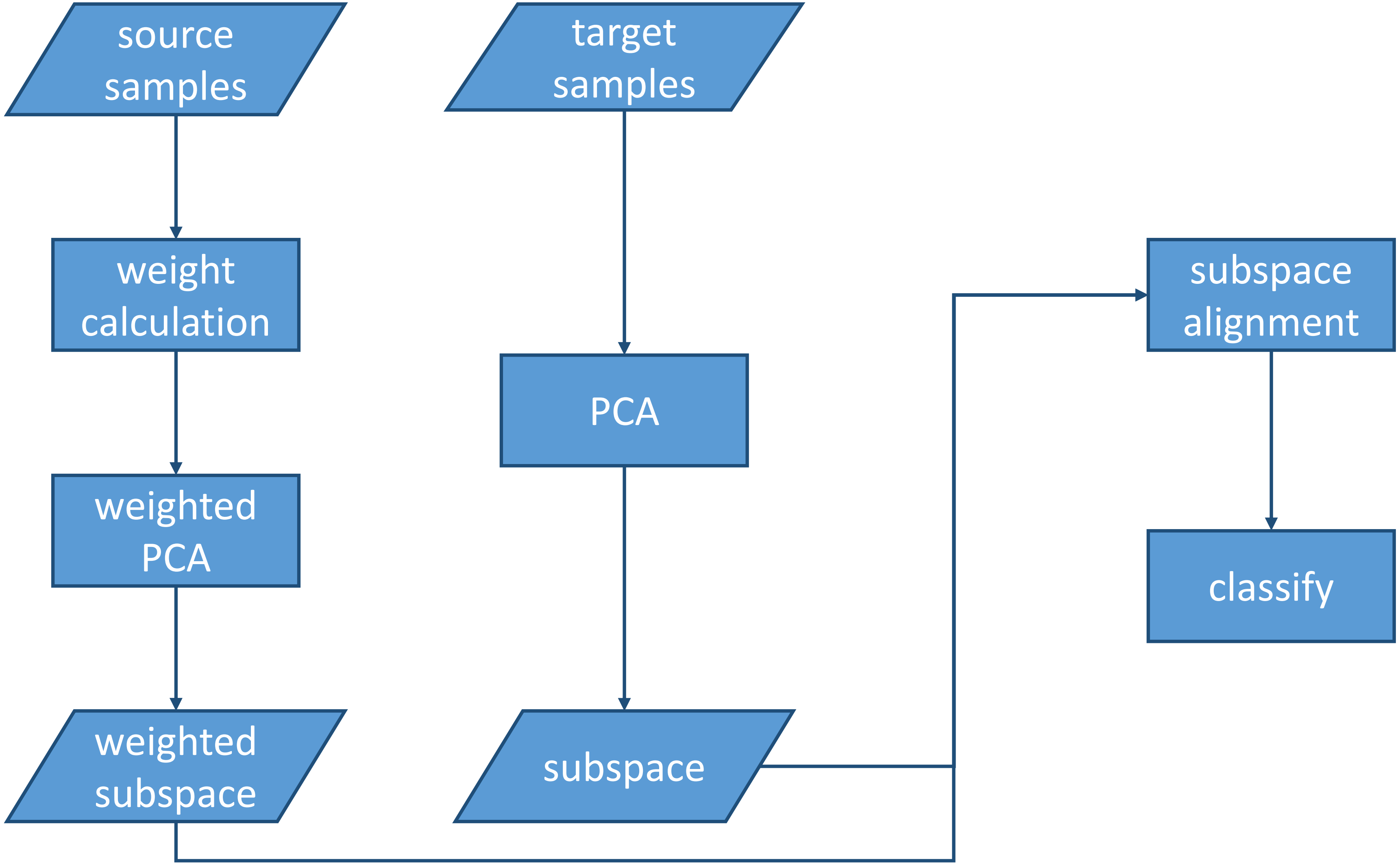
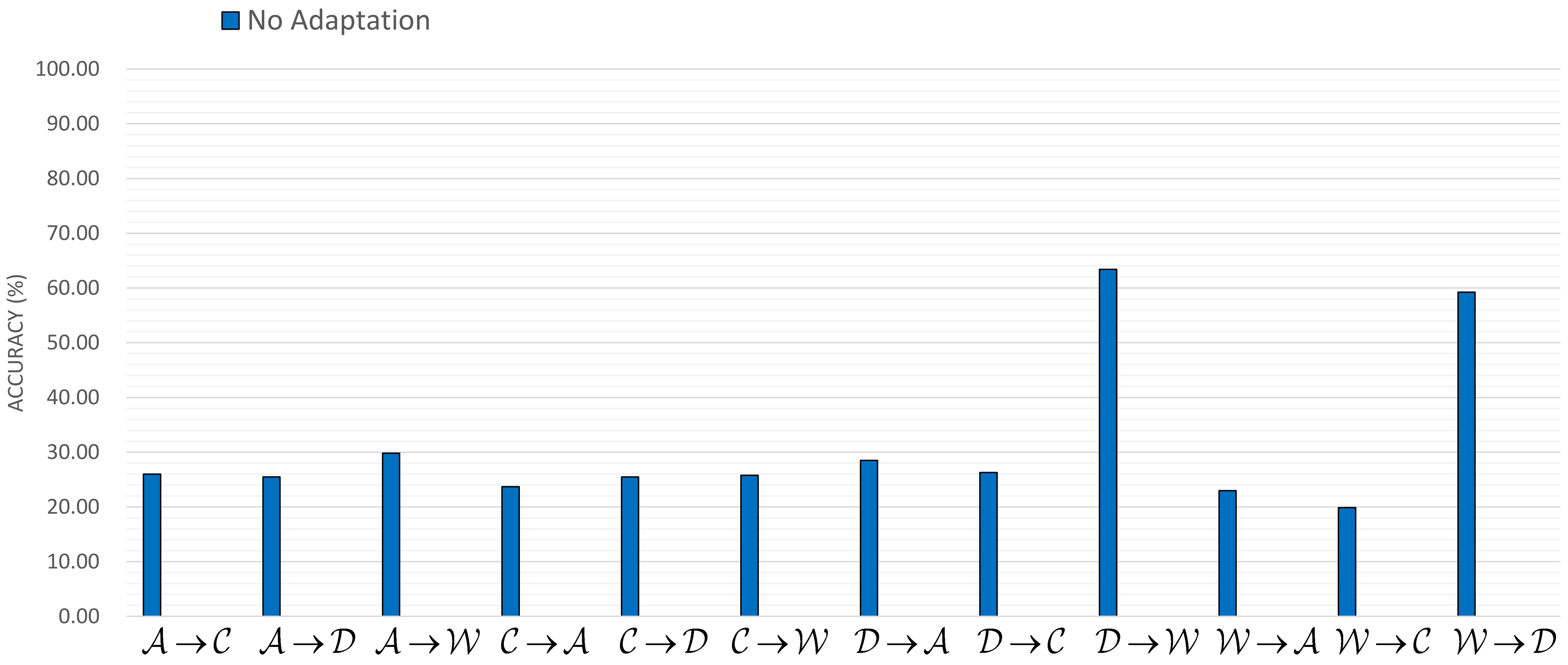


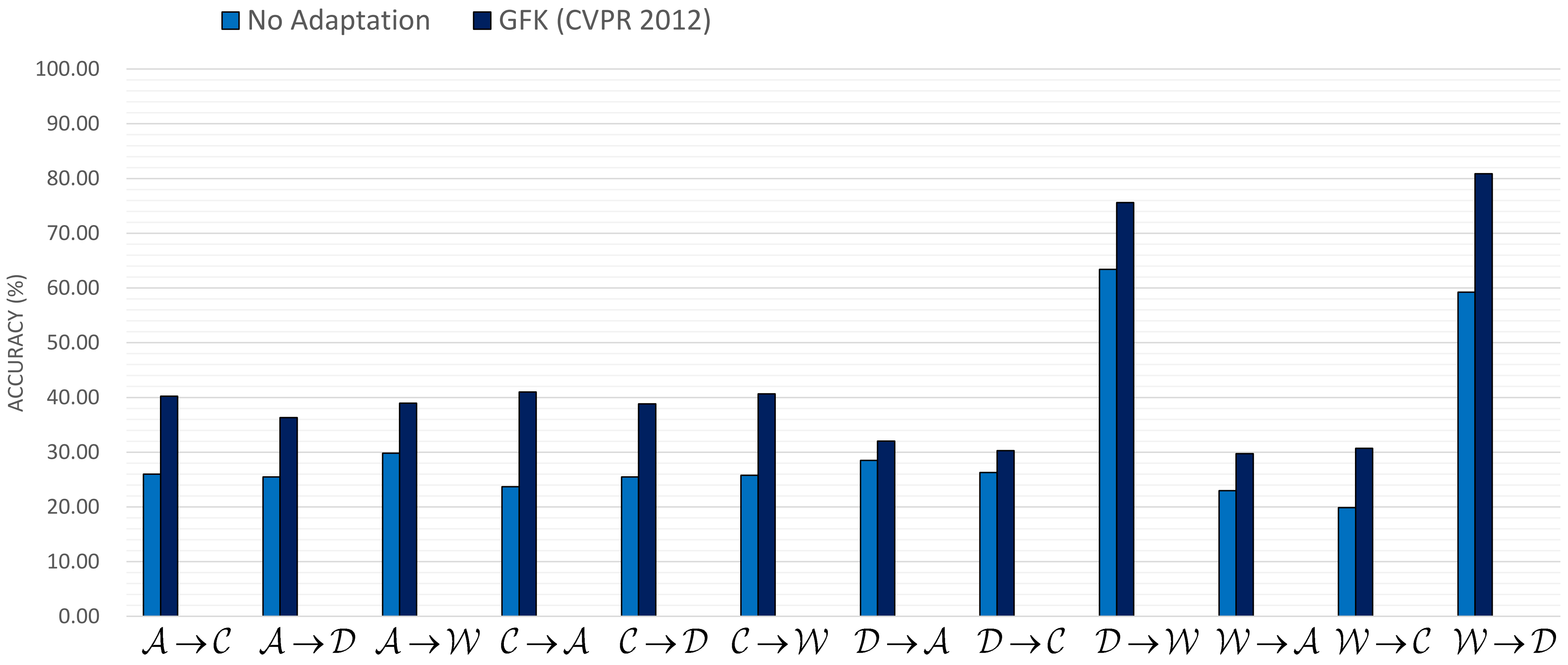
Experimental Setup

- Four domains
  - Amazon, Caltech, DSLR, Webcam
- Features (Saenko, ECCV 2010)
  - Bag-of-SURF
- Classifier: 1NN

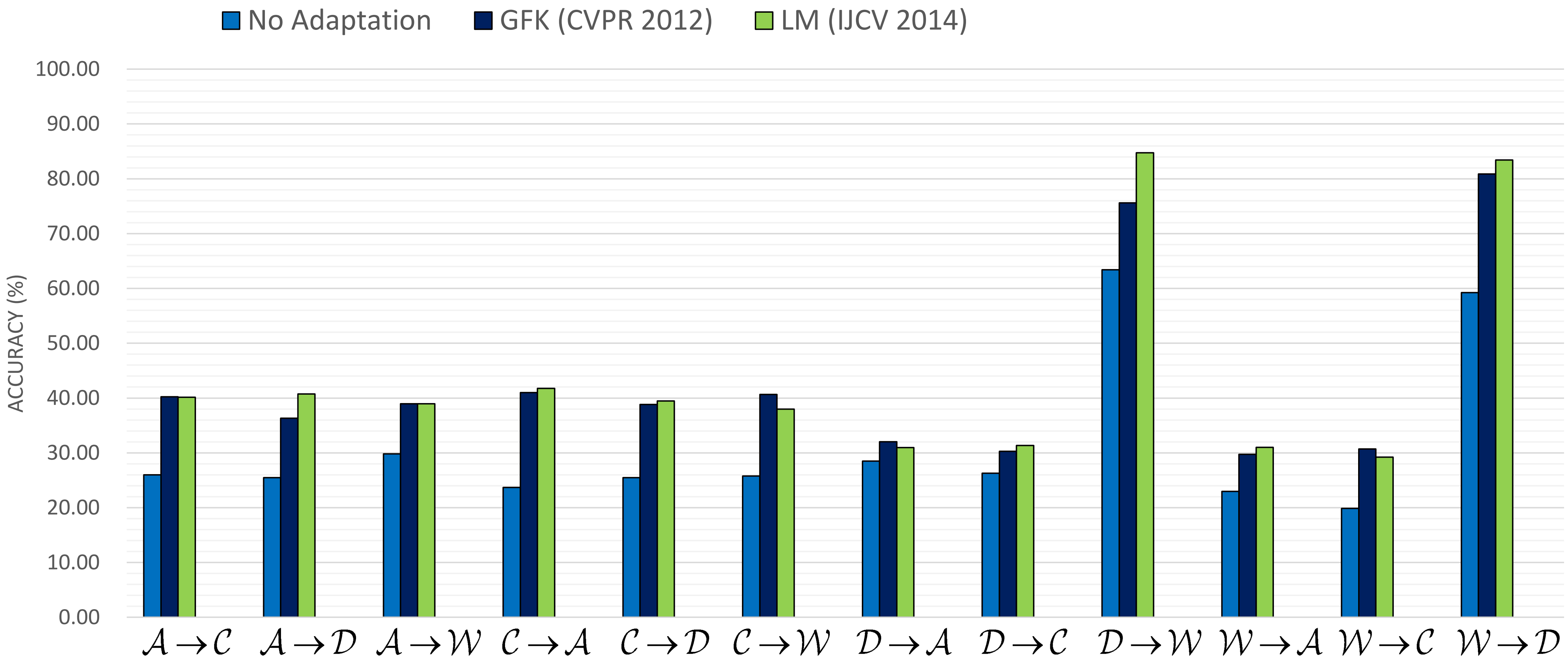
Experimental Results



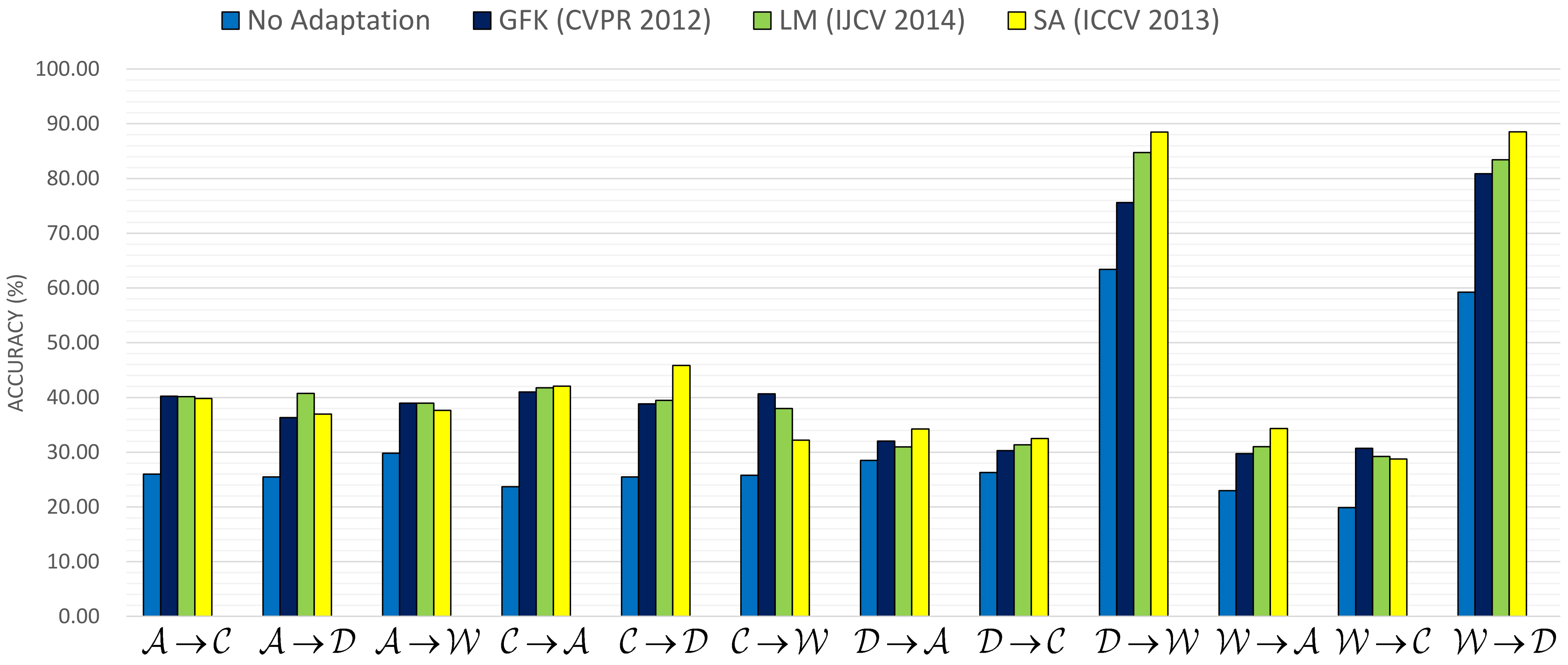
Experimental Results



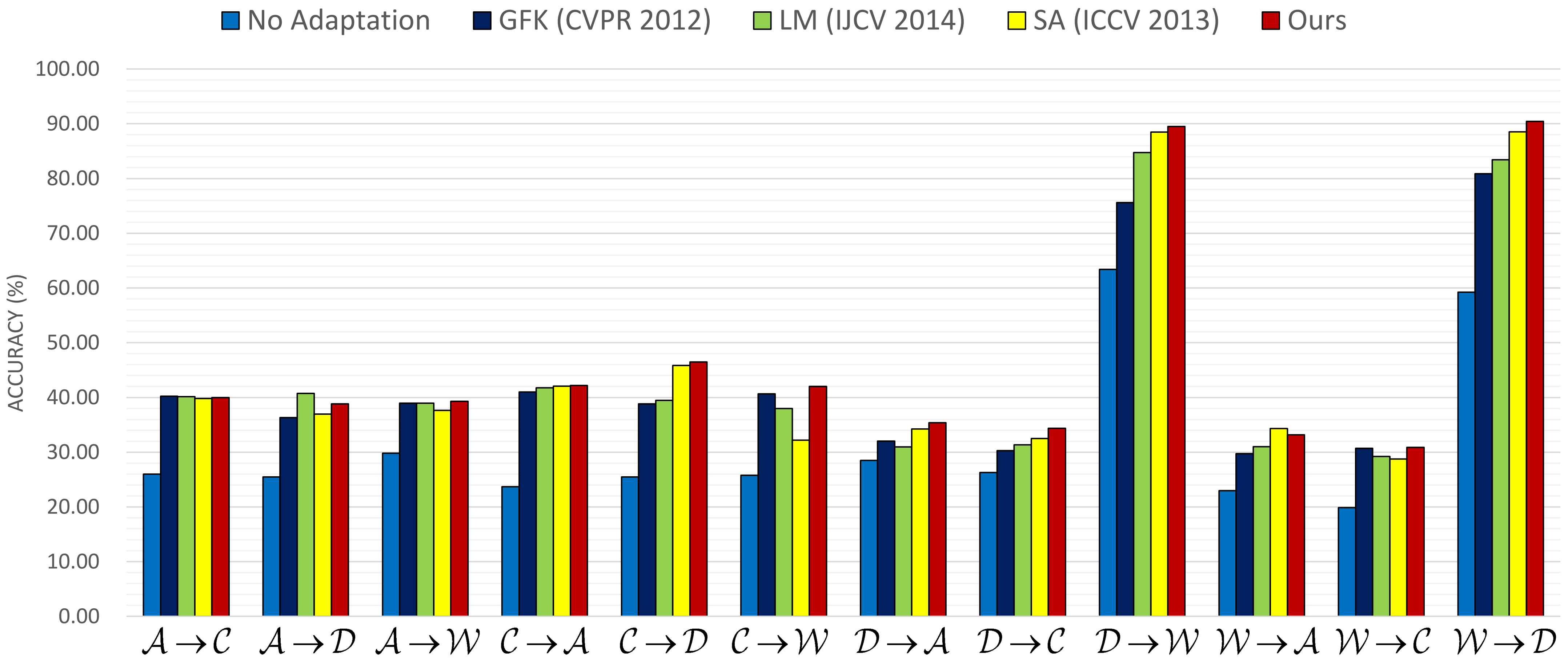
Experimental Results



Experimental Results



Experimental Results



Experimental Results

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Accuracy of target domains using 1NN classifier

Method	NN	GFK	LM	SA	Ours
$\mathcal{A} \rightarrow \mathcal{C}$	26.00	**40.25**	40.16	39.80	39.98
$\mathcal{A} \rightarrow \mathcal{D}$	25.48	36.31	**40.76**	36.94	38.85
$\mathcal{A} \rightarrow \mathcal{W}$	29.83	38.98	38.98	37.63	**39.32**
$\mathcal{C} \rightarrow \mathcal{A}$	23.70	41.02	41.75	42.07	**42.17**
$\mathcal{C} \rightarrow \mathcal{D}$	25.48	38.85	39.49	45.86	**46.49**
$\mathcal{C} \rightarrow \mathcal{W}$	25.76	40.68	37.97	32.20	**42.03**
$\mathcal{D} \rightarrow \mathcal{A}$	28.50	32.05	30.97	34.24	**35.38**
$\mathcal{D} \rightarrow \mathcal{C}$	26.27	30.28	31.34	32.50	**34.37**
$\mathcal{D} \rightarrow \mathcal{W}$	63.39	75.59	84.75	88.47	**89.49**
$\mathcal{W} \rightarrow \mathcal{A}$	22.96	29.75	31.00	**34.34**	33.19
$\mathcal{W} \rightarrow \mathcal{C}$	19.86	30.72	29.21	28.76	**30.89**
$\mathcal{W} \rightarrow \mathcal{D}$	59.24	80.89	83.44	88.54	**90.44**
Average	31.37	42.95	44.15	45.11	**46.88**

Conclusions

- We present an algorithm aligning the subspace generated on the reweighted samples.
- The source samples which distribute more similarly to target domain are given higher weights.
- The subspaces of reweighted source samples and target samples are aligned.
- See our paper for more details and our full algorithm.
- In future work, we plan to combine our method with deep neural network.

Thanks

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