Joint Geometrical and Statistical Alignment for Visual Domain Adaptation

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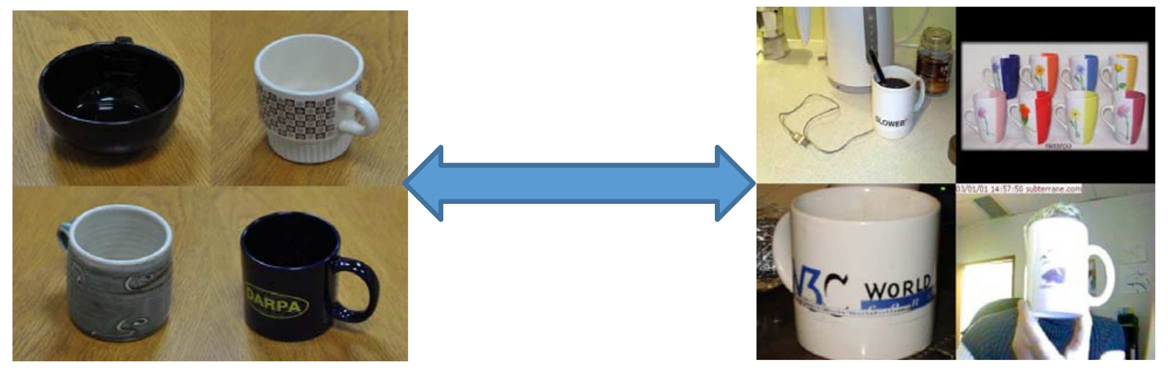
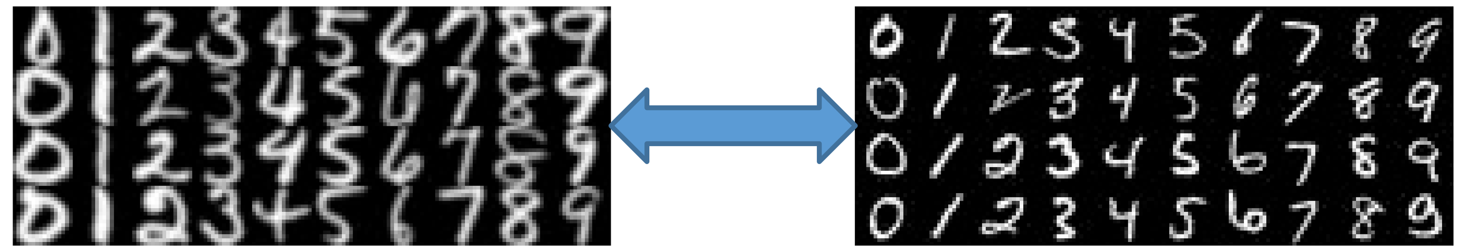
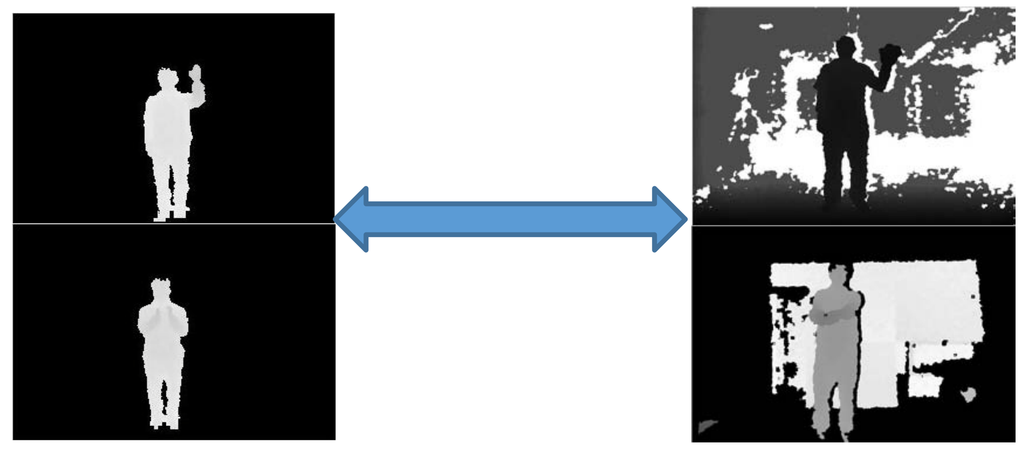
Introduction

Motivation

- ✓ Divergence between training and test data







Unsupervised Domain Adaptation

- ✓ Data: labelled source + unlabeled target
- ✓ Task: recognition on target domain
- ✓ Challenge: distribution discrepancy → performance degeneration

Solution

- ✓ Data centric approach
- ✓ Subspace centric approach

Proposed Method

Key Ideas: find two coupled subspaces to obtain new representations of respective domains such that

- ✓ the variance of target domain is maximized,

$$\max_{B} Tr(B^T S_t B)$$

- ✓ the discriminative information of source domain is preserved,

$$\max_{A} Tr(A^T S_b A), \quad \min_{A} Tr(A^T S_w A)$$

- ✓ the distribution shift is small,

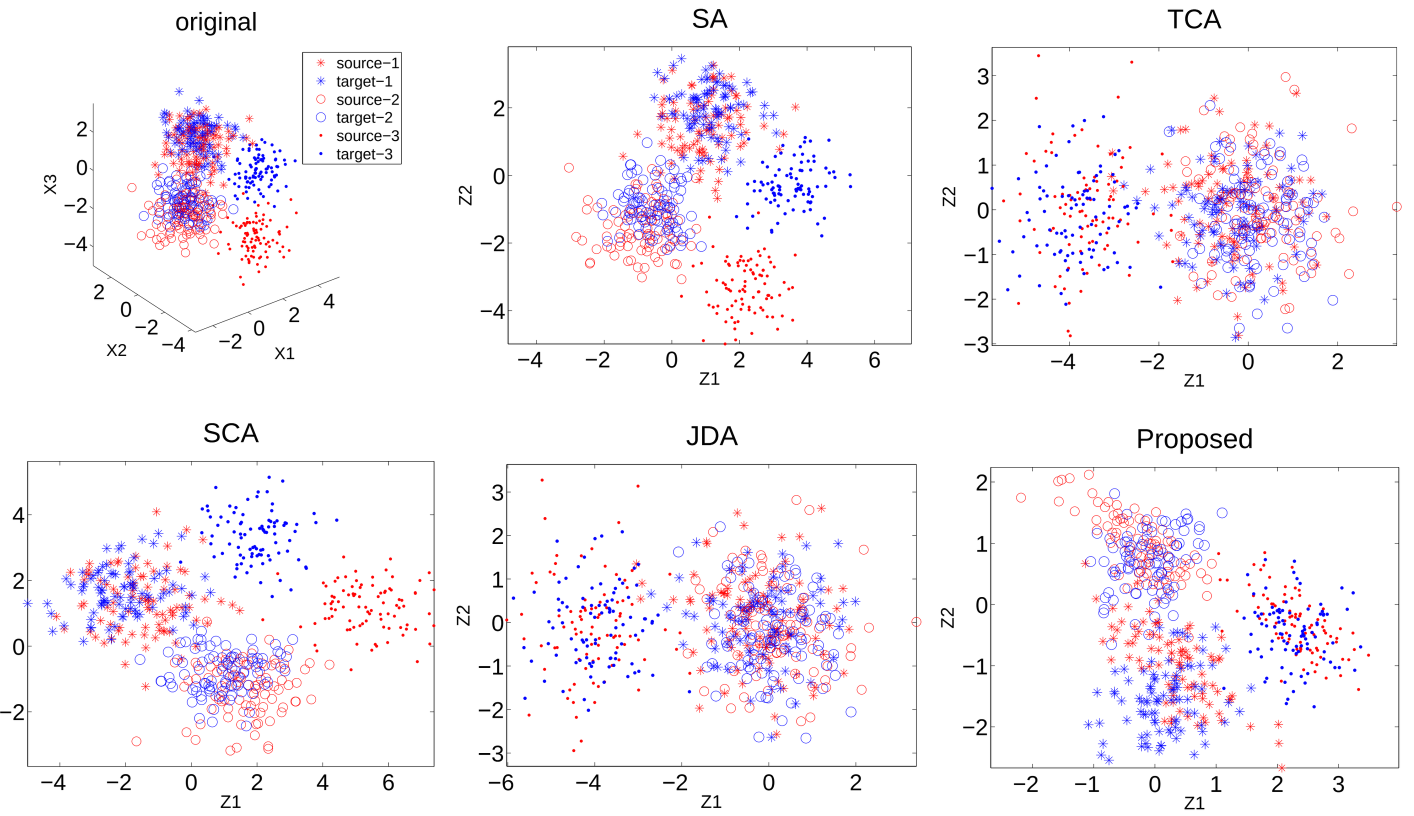
$$\min_{A,B} Tr\left(\begin{bmatrix} A^T & B^T \end{bmatrix} \begin{bmatrix} M_s & M_{st} \\ M_{ts} & M_t \end{bmatrix} \begin{bmatrix} A \\ B \end{bmatrix}\right)$$

- ✓ the subspace shift is small.

$$\min_{A,B} \|A - B\|_F^2$$

Overall: $$\max_{A,B} \frac{\{Var.^{target}\} + \{Var.^{between}\}}{\{Dist.shift\} + \{Sub.shift\} + \{Var.^{within}\}}$$

Results on Synthetic Data



Results on Real World Data

Results on Cross-domain Object Recognition (surf)

Feature	SURF										
data	Raw	SA	SDA	GFK	TCA	JDA	TJM	SCA	JGSA primal	JGSA linear	JGSA RBF
C→A	36.01	49.27	49.69	46.03	45.82	45.62	46.76	45.62	51.46	52.30	**53.13**
C→W	29.15	40.00	38.98	36.95	31.19	41.69	38.98	40.00	45.42	45.76	**48.47**
C→D	38.22	39.49	40.13	40.76	34.39	45.22	44.59	47.13	45.86	**48.41**	**48.41**
A→C	34.19	39.98	39.54	40.69	**42.39**	39.36	39.45	39.72	41.50	38.11	41.50
A→W	31.19	33.22	30.85	36.95	36.27	37.97	42.03	34.92	45.76	**49.49**	45.08
A→D	35.67	33.76	33.76	40.13	33.76	39.49	45.22	39.49	**47.13**	45.86	45.22
W→C	28.76	**35.17**	34.73	24.76	29.39	31.17	30.19	31.08	33.21	32.68	33.57
W→A	31.63	39.25	39.25	27.56	28.91	32.78	29.96	29.96	39.87	**41.02**	40.81
W→D	84.71	75.16	75.80	85.35	89.17	89.17	89.17	87.26	**90.45**	**90.45**	88.54
D→C	29.56	34.55	**35.89**	29.30	30.72	31.52	31.43	30.72	29.92	30.19	30.28
D→A	28.29	**39.87**	38.73	28.71	31.00	33.09	32.78	31.63	38.00	36.01	38.73
D→W	83.73	76.95	76.95	80.34	86.10	89.49	85.42	84.41	91.86	91.86	**93.22**
Average	40.93	44.72	44.52	43.13	43.26	46.38	46.33	45.16	50.04	50.18	**50.58**

Results on Cross-domain Object Recognition (Decaf)

Feature	$Decaf_6$				
data	JDA	OTGL	JGSA primal	JGSA linear	JGSA RBF
C→A	90.19	**92.15**	91.44	91.75	91.13
C→W	85.42	84.17	**86.78**	85.08	83.39
C→D	85.99	87.25	**93.63**	92.36	92.36
A→C	81.92	**85.51**	84.86	85.04	84.86
A→W	80.68	83.05	81.02	**84.75**	80.00
A→D	81.53	85.00	**88.54**	85.35	84.71
W→C	81.21	81.45	**84.95**	84.68	84.51
W→A	90.71	90.62	90.71	**91.44**	91.34
W→D	**100**	96.25	**100**	**100**	**100**
D→C	80.32	84.11	**86.20**	85.75	84.77
D→A	91.96	**92.31**	91.96	92.28	91.96
D→W	99.32	96.29	**99.66**	98.64	98.64
Average	87.44	88.18	**89.98**	89.76	88.97

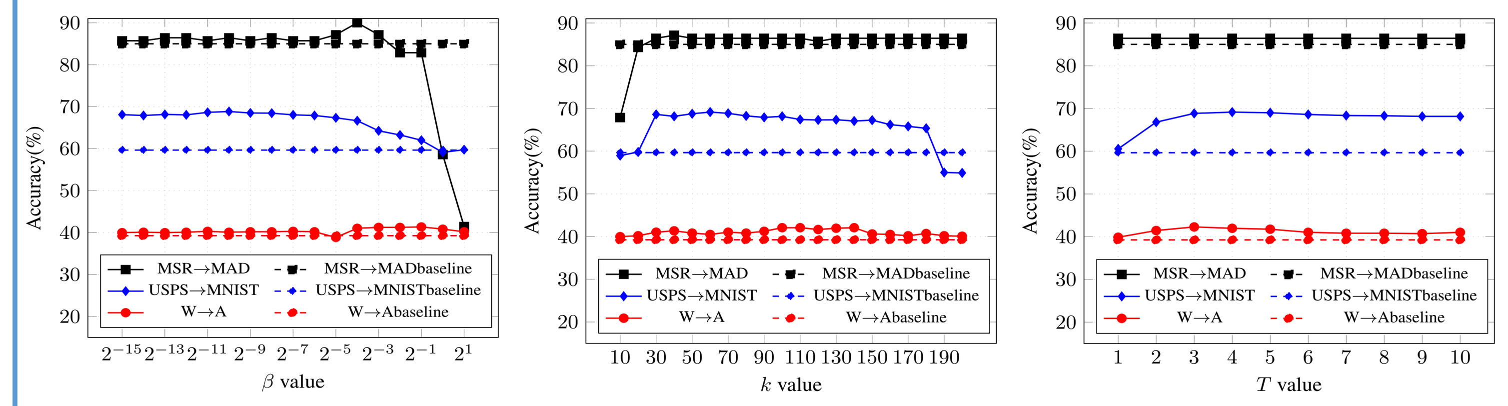
Results on Cross-domain Digit Recognition

data	Raw	SA	SDA	GFK	TCA	JDA	TJM	SCA	JGSA primal
MNIST→USPS	65.94	67.78	65.00	61.22	56.33	67.28	63.28	65.11	**80.44**
USPS→MNIST	44.70	48.80	35.70	46.45	51.20	59.65	52.25	48.00	**68.15**
Average	55.32	58.29	50.35	56.84	53.77	63.47	57.77	56.56	**74.30**

Results on Cross-dataset Action Recognition

data	Raw	SA	SDA	TCA	JDA	TJM	SCA	JGSA linear
MSR→G3D	72.92	77.08	73.96	68.75	82.29	70.83	70.83	**89.58**
G3D→MSR	54.47	**68.09**	67.32	50.58	65.37	63.04	55.25	66.93
MSR→UTD	66.88	73.75	73.75	65.00	**77.50**	65.00	64.38	76.88
UTD→MSR	62.93	**67.91**	66.67	57.63	61.06	60.12	55.14	61.37
MSR→MAD	80.71	85.00	83.57	79.29	82.86	82.14	78.57	**86.43**
MAD→MSR	80.09	81.48	80.56	81.02	83.33	79.63	79.63	**85.65**
Average	69.67	75.55	74.30	67.05	75.40	70.13	67.30	**77.81**

Parameter Sensitivity



Conclusions

A novel framework for unsupervised domain adaptation is proposed, where

- ✓ both geometrical and statistical shifts are reduced,
- ✓ both shared and specific features are exploited,
- ✓ the state-of-the-art results are obtained on both synthetic data and real world datasets.

References

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