

# National University of Singapore

School of computing



# **Randomized Transferable Machine**

#### **Background and Motivation**

- **Problem:** unsupervised domain adaptation
- **Objective**: propose a new transfer model learning strategy that boosts the conventional transfer model learning
- Method: propose a randomized transferable machine

### **Motivation and Key Idea**











- is hard to achieve.
- Domain divergence metric is not unique.
- Zero-valued domain divergence is ideal •
- The conventional transfer model learning strategy, i.e., train a transfer model using source new features, is problematic lacksquareas small divergence still exists across domains.
- Enlarge the source training population by random corruptions so that the small divergence can be well covered.
- **Propose a marginalized solution to simulate the infinite corruption case without conducting any corruption.**

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### **Randomized Transferable Machine (RTM)**

**Linear logistic regression model:** 

 $f_z(\mathbf{z}) = \mathbf{W}^\mathsf{T} \mathbf{z},$ 

The objective function: 

 $\min_{\mathbf{W}} \quad \mathbb{E}_{\mathbf{z}} s_{\sim \mathbf{Z}} s [|| \mathbf{W}^{\mathsf{T}} \mathbf{z}^{\mathcal{S}} - \mathbf{y}^{\mathcal{S}} ||_{l_2}] + \alpha || \mathbf{W} ||_{l_2},$ 

• Assuming J different versions of corruptions:

 $\mathbb{E}_{\epsilon}[\widehat{\mathbf{Y}}^{\mathcal{S}}(\widetilde{\mathbf{Z}}^{\mathcal{S}})^{\mathsf{T}}] = (1-p)\mathbf{Y}^{\mathcal{S}}(\mathbf{Z}^{\mathcal{S}})^{\mathsf{T}}$ For  $\mathbb{E}_{\epsilon}[\widetilde{\mathbf{Z}}^{\mathcal{S}}(\widetilde{\mathbf{Z}}^{\mathcal{S}})^{\mathsf{T}}]$ , when  $\alpha \neq \beta$ ,  $[\mathbb{E}_{\epsilon}[\widetilde{\mathbf{Z}}^{\mathcal{S}}(\widetilde{\mathbf{Z}}^{\mathcal{S}})^{\mathsf{T}}]]_{\alpha,\beta} = (1-p)^{2}[\mathbf{Z}^{\mathcal{S}}(\mathbf{Z}^{\mathcal{S}})^{\mathsf{T}}]_{\alpha,\beta},$ and when  $\alpha = \beta$ ,

$$\min_{\mathbf{W}} \frac{1}{nJ} \sum_{i=1}^{n} \sum_{j=1}^{J} ||\mathbf{W} \widetilde{\mathbf{z}}_{i,j}^{\mathcal{S}} - \mathbf{y}_{i}^{\mathcal{S}}||_{l_{2}} + \alpha ||\mathbf{W}||_{l_{2}}$$

Using trace form and simplifying notations:

 $\min_{\mathbf{W}} \frac{1}{n I} tr([\mathbf{W}\widetilde{\mathbf{Z}}^{\mathcal{S}} - \widehat{\mathbf{Y}}^{\mathcal{S}}][\mathbf{W}\widetilde{\mathbf{Z}}^{\mathcal{S}} - \widehat{\mathbf{Y}}^{\mathcal{S}}]^{\mathsf{T}}) + \alpha ||\mathbf{W}||_{l_{2}},$ 

**Setting J to infinite:**  $\bullet$ 

$$\min_{\widetilde{f}_z} \frac{1}{n} tr(\mathbf{W}^\mathsf{T} \mathbb{E}_{\epsilon} [\widetilde{\mathbf{Z}}^{\mathcal{S}} (\widetilde{\mathbf{Z}}^{\mathcal{S}})^\mathsf{T}] \mathbf{W} - 2 \mathbb{E}_{\epsilon} [\widehat{\mathbf{Y}}^{\mathcal{S}} (\widetilde{\mathbf{Z}}^{\mathcal{S}})^\mathsf{T}] \mathbf{W}) + \alpha ||\mathbf{W}||_{l_2}.$$

• The closed form solution is:

 $\mathbf{W} = (\mathbb{E}_{\epsilon}[\widehat{\mathbf{Y}}^{\mathcal{S}}(\widetilde{\mathbf{Z}}^{\mathcal{S}})^{\mathsf{T}}])(\mathbb{E}_{\epsilon}[\widetilde{\mathbf{Z}}^{\mathcal{S}}(\widetilde{\mathbf{Z}}^{\mathcal{S}})^{\mathsf{T}}] + \alpha \mathbf{I})^{-1}.$ 

• With the dropout noise:

**Definition** 1: **Dropout** noise: given a data point x, each feature dimension of x is randomly corrupted by a noise  $\epsilon$ Mean || 77.16 | 77.32 || 77.80 | 79.03 || 68.14 | 76.55 || 77.05 | 77.08 || 77.17 | 77.46 || 73.85 | 79.22 || 78.07 | 78.36 || 76.99 | 77.38 that draws a Bernoulli distribution with a probability p. That is to say, each feature is corrupted to 0 with the probability p**RTM** is superior to the conventional transfer model using new feature representation learned from subspace methods. and retains with the probability 1-p.

$$[\mathbb{E}_{\epsilon}[\mathbf{Z}^{\mathcal{S}}(\mathbf{Z}^{\mathcal{S}})^{\mathsf{T}}]]_{\alpha,\alpha} = (1-p)[\mathbf{Z}^{\mathcal{S}}(\mathbf{Z}^{\mathcal{S}})^{\mathsf{T}}]_{\alpha,\alpha},$$

#### **Empirical Evaluations**

Tack	ТСА		GEK		SΔ		TIM		ΙDΔ		CORAL		IGSA		MMIT	
Task					SA N C						COKAL		JUSA			
Model	$\mathcal{M}_z$	$\mathcal{M}_z$	$\mathcal{M}_z$	$\mathcal{M}_{z}$	$\mathcal{M}_z$	$\mathcal{M}_{z}$	$\mathcal{M}_z$	$\mathcal{M}_z$	$\mathcal{M}_z$	$\mathcal{M}_{z}$						
C-A	53.44	53.65	55.32	54.07	28.29	46.24	51.77	51.77	49.27	49.69	35.07	54.18	51.67	54.28	51.98	52.82
C-W	50.51	51.86	49.49	51.19	23.39	37.63	49.49	49.49	48.14	50.17	31.19	48.14	45.42	49.49	49.15	50.85
C-D	47.77	49.04	43.95	49.04	21.66	45.22	41.40	42.04	47.13	49.68	31.85	46.50	40.76	45.86	47.13	48.41
A-C	42.83	43.54	41.94	44.52	26.54	39.63	44.97	44.70	38.91	42.39	28.50	43.72	42.65	44.17	42.56	43.81
A-W	38.98	41.02	40.68	43.73	16.27	36.61	45.08	45.76	46.78	48.81	25.42	41.69	35.59	41.36	40.00	41.02
A-D	40.13	43.31	38.85	48.41	23.57	39.49	43.95	44.59	48.41	48.41	28.66	43.31	37.58	42.68	41.40	43.31
W-C	36.69	37.22	36.69	36.87	24.49	34.28	39.36	39.09	32.32	33.30	30.01	35.80	34.55	35.17	38.11	37.13
W-A	40.29	40.50	37.79	40.81	19.73	37.47	39.98	40.19	36.12	35.91	33.92	39.87	38.31	39.46	40.29	40.40
W-D	77.71	78.98	74.52	78.34	41.40	65.61	70.06	70.70	74.52	75.80	77.71	84.08	82.80	83.44	76.43	78.98
D-C	35.62	36.60	30.45	36.78	20.66	35.89	33.13	33.93	32.50	32.32	29.74	35.53	32.95	33.48	35.71	34.73
D-A	38.83	38.83	40.40	41.02	26.62	36.01	35.18	35.07	35.59	35.39	33.72	38.10	35.91	36.12	39.35	38.10
D-W	80.34	82.03	73.90	80.00	37.29	64.75	74.58	76.27	77.63	77.63	80.00	85.08	84.07	84.07	79.32	79.66
Mean	48.60	49.72	47.00	50.40	25.82	43.24	47.41	47.80	47.28	48.29	38.82	49.67	46.86	49.13	48.45	49.10
		1				1		1					1			
B-D	77.64	78.49	79.64	79.49	71.99	76.74	76.89	77.19	76.39	76.54	76.04	79.49	78.69	78.84	78.49	79.34
B-E	76.48	76.48	78.23	78.28	67.67	75.88	79.73	79.58	78.33	78.38	72.52	79.03	77.03	77.28	75.48	75.38
B-K	78.19	78.14	79.24	80.64	60.68	76.64	79.09	79.14	78.84	80.04	74.04	80.84	79.39	79.39	76.99	77.74
D-B	78.05	78.60	78.05	79.20	66.50	75.70	78.05	77.60	76.60	76.45	75.90	79.90	78.80	79.85	77.80	78.30
D-E	78.18	78.13	77.63	80.08	70.87	77.48	79.53	79.73	80.48	80.48	69.57	78.98	76.68	77.38	77.58	76.98
D-K	78.44	78.29	78.84	80.64	65.93	79.19	79.54	79.29	79.49	79.74	72.54	81.34	79.44	80.29	78.79	78.84
E-B	73.75	73.85	73.70	75.05	58.75	71.30	72.55	73.65	73.60	73.60	70.25	75.55	74.45	74.65	72.75	73.35
E-D	74.84	74.99	74.34	76.74	62.68	74.54	75.49	75.69	75.64	75.44	69.88	74.94	74.09	74.34	74.39	74.84
E-K	81.79	81.84	82.74	83.59	76.29	82.84	81.64	81.79	81.29	81.39	81.24	84.94	84.79	85.04	82.79	83.04
K-B	73.45	73.45	75.60	76.35	64.35	71.80	71.85	71.45	73.05	73.85	71.15	76.25	75.75	75.70	73.50	74.20
K-D	74.44	74.39	73.89	76.14	73.34	74.79	72.99	72.54	73.19	73.99	71.79	76.09	74.39	74.34	74.29	75.29
K-E	80.68	81.23	81.68	82.13	78.63	81.68	77.23	77.38	79.18	79.63	81.23	83.33	82.33	83.18	81.03	81.33
Maan	77.16	77.00	77.00	70.02	(0.14	7655	77.05	77.00	77 17	77.46	72.05	70.00	70.07	70.00	76.00	77.00

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