Test-time Adaptation for Regression by Subspace Alignment

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Test-time Adaptation (TTA)

- Adapt a pre-trained model to the target domain with unlabeled target data
- Not accessing the source data

Pre-training



TTA for Regression

- TTA for regression has not been explored
- TTA methods for classification rely on entropy minimization
- Entropy cannot be computed for regression models (scalar outputs)
- TTA for regression not relying on entropy is necessary







Classification

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Significant-subspace Alignment

 $\alpha_d = 1 + |\mathbf{w}^\top \mathbf{v}_d^{\mathrm{s}}|$

<u>Subspace dimensions</u>

regression

	Class	sification	Regression			
Dataset	#Valid dims	#Subspace dims.	#Valid dims	#Subspace dims.		
SVHN	1946	64	353	14		
CIFAR10	1521	86	561	50		
UTKFace	2048	1471	2041	76		
Biwi Kinect (mean)	2048	277	713	34.5		
California Housing (100 dims.)	100	100	45	40		

Regression performance

Table 2. SVHIN-IVIINIST									
Method	$R^2(\uparrow)$	RMSE (\downarrow)	MAE (\downarrow)						
Source	0.406	2.232	1.608						
DANN TTT	$\begin{array}{c} 0.307_{\pm 0.09} \\ 0.288_{\pm 0.02} \end{array}$	$2.406_{\pm 0.16}$ $2.443_{\pm 0.03}$	$\frac{1.489_{\pm 0.09}}{1.597_{\pm 0.03}}$						
BN-adapt	$0.396_{\pm 0.00}$	$2.251_{\pm 0.01}$	$1.458_{\pm 0.00}$						
Prototype	$0.491_{\pm 0.00}$	$2.065_{\pm 0.01}$	$1.479_{\pm 0.01}$						
FR	$0.369_{\pm 0.01}$	$2.300_{\pm 0.02}$	$1.631_{\pm 0.02}$						
VM	$-685.1_{\pm 27.63}$	$75.83_{\pm 1.52}$	$75.78_{\pm 1.52}$						
RSD	$0.252_{\pm 0.12}$	$2.497_{\pm 0.20}$	$1.703_{\pm 0.20}$						
SSA (ours)	$0.511_{\pm 0.03}$	$2.024_{\pm 0.06}$	$1.209_{\pm0.04}$						
Oracle	$0.874_{\pm 0.00}$	$1.028_{\pm 0.00}$	$0.575_{\pm 0.00}$						

Table 3. UTKFace (age prediction, R^2)

Method	Defocus blur	Motion blur	Zoom blur	Contrast	Elastic transform	Jpeg comp.	Pixelate	Gaussian noise	Impulse noise	Shot noise	Brightness	Fog	Snow	Mean
Source	0.410	0.159	0.658	-3.906	0.711	0.069	0.595	-2.536	-2.539	-2.522	0.661	-0.029	-0.544	-0.678
DANN TTT	$\begin{array}{c} 0.512\\ 0.748\end{array}$	$0.586 \\ 0.761$	$0.637 \\ 0.773$	$-0.720 \\ 0.778$	$0.729 \\ 0.826$	$0.698 \\ 0.772$	$0.807 \\ 0.861$	$-4.341 \\ 0.525$	$-3.114 \\ 0.532$	$-3.744 \\ 0.477$	$0.590 \\ 0.775$	$-0.131 \\ 0.397$	$-0.425 \\ 0.493$	$-0.609 \\ 0.671$
BN-Adapt Prototype FR VM RSD SSA (ours)	0.727 -1.003 0.794 -2.009 0.789 0.803	0.759 -1.020 0.839 -1.991 0.833 0.839	$\begin{array}{r} 0.763 \\ -1.016 \\ 0.849 \\ -2.037 \\ 0.851 \\ \hline 0.851 \end{array}$	$\begin{array}{r} 0.702 \\ -0.719 \\ 0.756 \\ -1.889 \\ 0.749 \\ 0.792 \end{array}$	0.826 -0.967 0.899 -1.918 0.897 0.899	0.778 -0.908 0.825 -1.918 0.825 0.829	$\begin{array}{c} 0.850 \\ -0.974 \\ \textbf{0.946} \\ -1.751 \\ 0.941 \\ 0.943 \end{array}$	$\begin{array}{r} 0.510 \\ -0.514 \\ 0.509 \\ -2.181 \\ 0.502 \\ \hline 0.580 \end{array}$	$\begin{array}{r} 0.510 \\ -0.512 \\ 0.522 \\ -2.207 \\ 0.503 \\ \hline 0.592 \end{array}$	$\begin{array}{r} 0.446 \\ -0.512 \\ 0.458 \\ -2.176 \\ 0.445 \\ 0.560 \end{array}$	0.790 -1.004 0.861 -1.927 0.862 0.863	$\begin{array}{r} 0.392 \\ -0.823 \\ 0.408 \\ -2.250 \\ 0.419 \\ \hline 0.440 \end{array}$	$\begin{array}{r} 0.452 \\ -0.822 \\ 0.428 \\ -2.197 \\ 0.500 \\ \hline 0.517 \end{array}$	0.654 -0.830 0.700 -2.035 0.701 0.731
Oracle	0.856	0.890	0.889	0.862	0.917	0.873	0.960	0.635	0.652	0.635	0.895	0.519	0.671	0.789







Experiment

Smaller than appearance (2048 dims.) in

Much smaller than in classification

Table 1. Number of feature dimensions

Table 2 CV/LINE MANUCT