Label Calibration in Source Free Domain Adaptation

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Introduction

Source Free Domain Adaptation (SFDA) techniques generate pseudo labels from the pre-trained source model, but these pseudolabels often contain noise due to domain discrepancies between the source and target domains.

Traditional self-supervised SFDA techniques rely on deterministic model predictions using the softmax function, leading to unreliable pseudolabels.

Figure 1: MNIST & MNIST-M

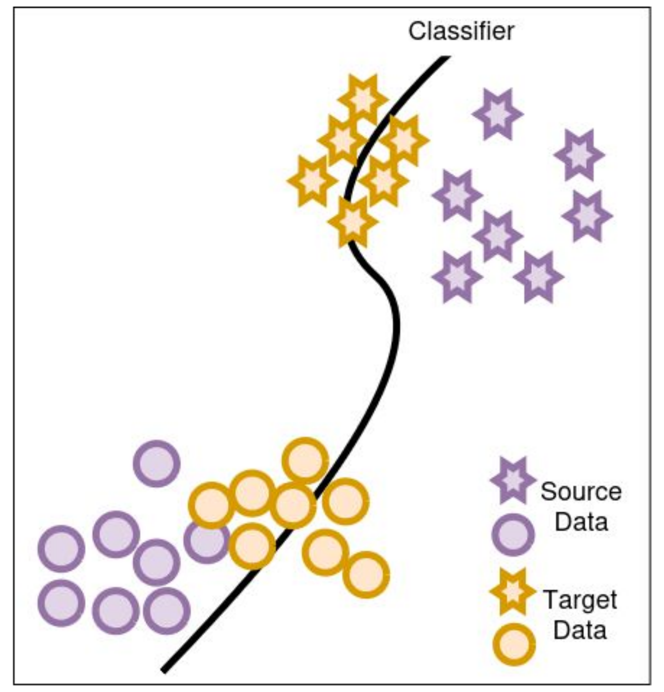

Figure 2: Source Trained Classifier

In this work, we propose to introduce predictive uncertainty and softmax calibration for pseudolabel refinement using evidential deep learning.

Drichilet Distribution:
The Dirichlet-based model predicts class probability by placing a dirichlet distribution over the class probabilities on target model, rather than treating prediction as single point estimate.

$$\mathrm{p}(\rho|x_i^t, \theta) = \mathrm{Dir}(\rho|\alpha_i) = \begin{cases} \frac{\Gamma(\sum_{k=1}^{K}\alpha_{i_k})}{\prod_{k=1}^{K}\Gamma(\alpha_{i_k})}\prod_{k=1}^{K}\rho_k^{\alpha_{i_k}-1}, & \text{if } \rho \in \Delta^K \\ 0, & \text{otherwise} \end{cases}$$

References

[1] Liang, J., Hu, D., & Feng, J. (2020, November). Do we really need to access the source data? source hypothesis transfer for unsupervised domain adaptation. In International conference on machine learning (pp. 6028-6039). PMLR.
[2] Sun, T., Lu, C., & Ling, H. (2022, October). Prior knowledge guided unsupervised domain adaptation. In European conference on computer vision (pp. 639-655). Cham: Springer Nature Switzerland.
[3] Yang, G., Tang, H., Zhong, Z., Ding, M., Shao, L., Sebe, N., & Ricci, E. (2021). Transformer-based source-free domain adaptation. arXiv preprint arXiv:2105.14138.

Method

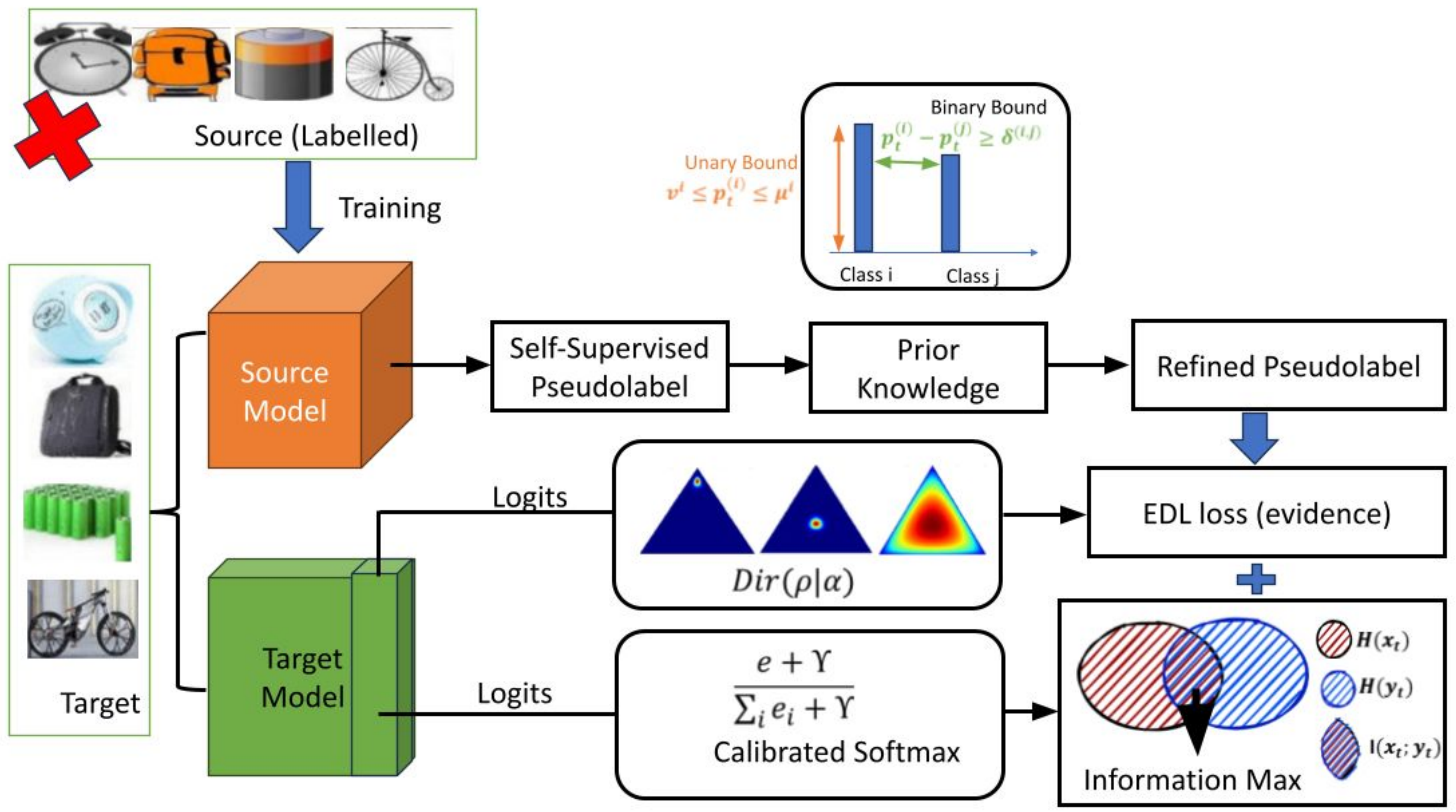

Figure 3: Overview of the proposed EKS method.

Discussion

- Table 1 shows results of ES and EKS on benchmarks Domainnet40 dataset. **EKS** and **ES** consistently achieve better classification accuracies on the target domain.
- To validate the generalizability of proposed approach, it is integrated into TransDA [3], consistent improvement in accuracy across all domains is observed.
- Table 3 validates the effectiveness of integrating the calibrated softmax function.
- Table 4 validates the result of the proposed framework. Information maximization (IM) complements EDL by encouraging diversified predictions among classes.
- Figure 4 shows the ECE curve where dashed line (x = y) represents ideal calibration. The **EKS** curve is closer to the dashed line compared to KSHOT [2] and **ES** curve is closer to the dashed line than SHOT [1].

Result

Method	κ	σ	C→S	C→P	C→R	R→S	R→C	R→P	S→C	S→P	S→R	P→S	P→C	P→R	Avg.
SHOT [1]	-	-	75.50	74.00	88.40	**72.80**	**79.40**	75.40	**80.50**	70.80	**88.30**	76.20	**77.70**	**89.90**	79.10
ES	-	-	**75.51**	**77.69**	**90.16**	72.13	79.23	**80.03**	79.50	**79.09**	88.17	**76.30**	75.42	89.71	**80.24**
KSHOT[2]	UB	0.0	77.00	76.40	91.50	75.30	**83.60**	77.50	80.20	70.30	**89.70**	76.30	82.30	91.70	81.00
EKS	UB	0.0	**78.69**	**82.91**	**91.82**	**77.30**	83.54	**84.37**	**81.88**	**81.44**	88.77	**78.56**	**83.62**	**92.05**	**83.74**
KSHOT[2]	BR	-	76.40	73.70	89.10	**74.30**	82.10	76.80	79.10	70.20	**88.88**	75.90	80.60	**91.70**	79.90
EKS	BR	-	**77.34**	**80.90**	**91.08**	74.16	**83.27**	**83.52**	**80.28**	**79.90**	87.75	**76.88**	**80.96**	91.53	**82.30**

Table 1:Classification accuracies on Domainnet40

Method	A → D	A → W	D → A	D → W	W → A	W → D	Avg.
TransDA [3]	97.20	95.00	73.70	99.30	79.30	99.60	90.68
E-TransDA (Ours)	**97.59**	**96.48**	**74.51**	98.87	**80.09**	**100.00**	**91.26**

Table 2:Classification accuracies on Office31 (E-TransDA)

κ	σ	EKS (Standard Softmax)	EKS (Calibrated softmax)
UB	0.0	73.93	**74.24**
UB	0.1	73.71	**73.98**
UB	0.5	72.76	72.72
UB	1.0	72.19	72.01
UB	2.0	71.92	71.66
BR	-	73.62	**73.94**

Table 3:Ablation study of calibrated softmax based IM loss

κ	σ	EKS with IM	EKS w/o IM
UB	0.0	**73.93**	71.99
UB	0.1	**73.71**	71.80
UB	0.5	**72.76**	70.64
UB	1.0	**72.19**	70.00
UB	2.0	**71.92**	69.71
BR	-	**73.62**	71.30

Table 4:Ablation study of IM loss on Office-Home

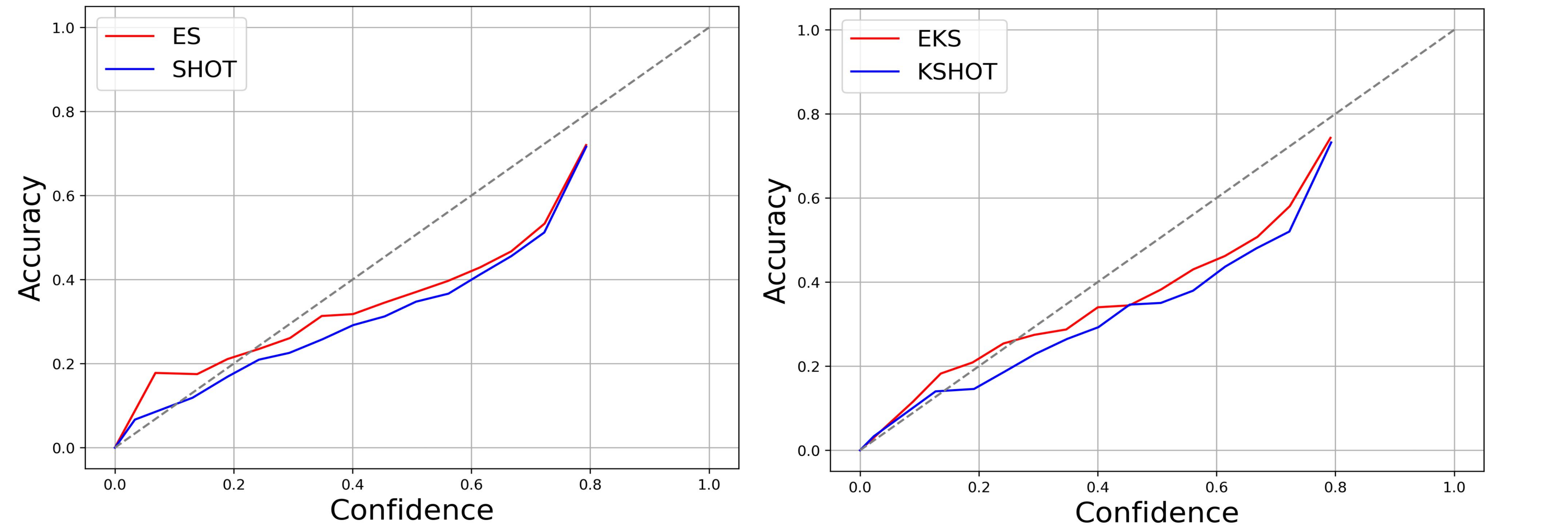

Figure 4: Expected Calibration Error (ECE) curve on the Domainnet40 dataset.

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