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Re-assessing Accuracy Degradation: A Framework for Understanding DNN Behavior on Similar-but-non-identical Test Datasets

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Introduction (1/3)

DNN Evaluation Trends

- **Established**: Use well-known benchmarks
- **Emerging**: Create replicate test datasets to assess generalization
- **Challenge**: Unexpected top-1 accuracy gap on similar test datasets

Introduction (2/3)

Test Dataset Examples

Established Benchmarks

ImageNet-1k Val. Set

50,000 Images | 1,000 Classes

Published in 2009

CIFAR-10 Test Set

10,000 Images | 10 Classes

Published in 2009

Replicate Test Datasets

ImageNetV2

10,000 Images

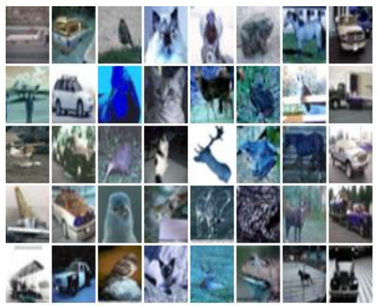
Published in 2019

CIFAR-10.1

2,000 Images

Published in 2019

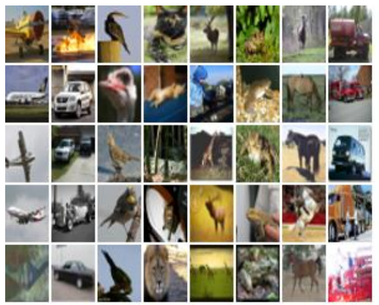
CIFAR-10.2



10,000 Images

Published in 2020

CINIC

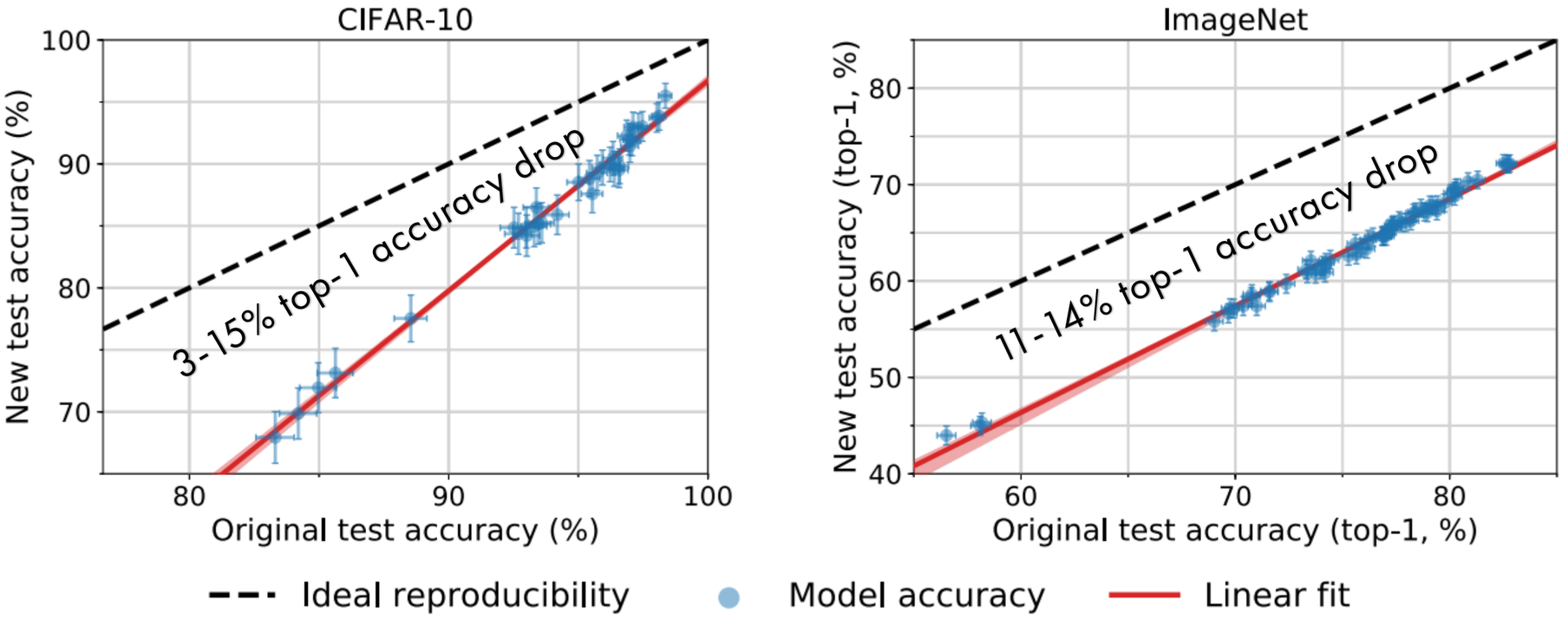


90,000 Images

Published in 2018

Introduction (3/3)

Recht et al: Do ImageNet Classifiers Generalize to ImageNet?

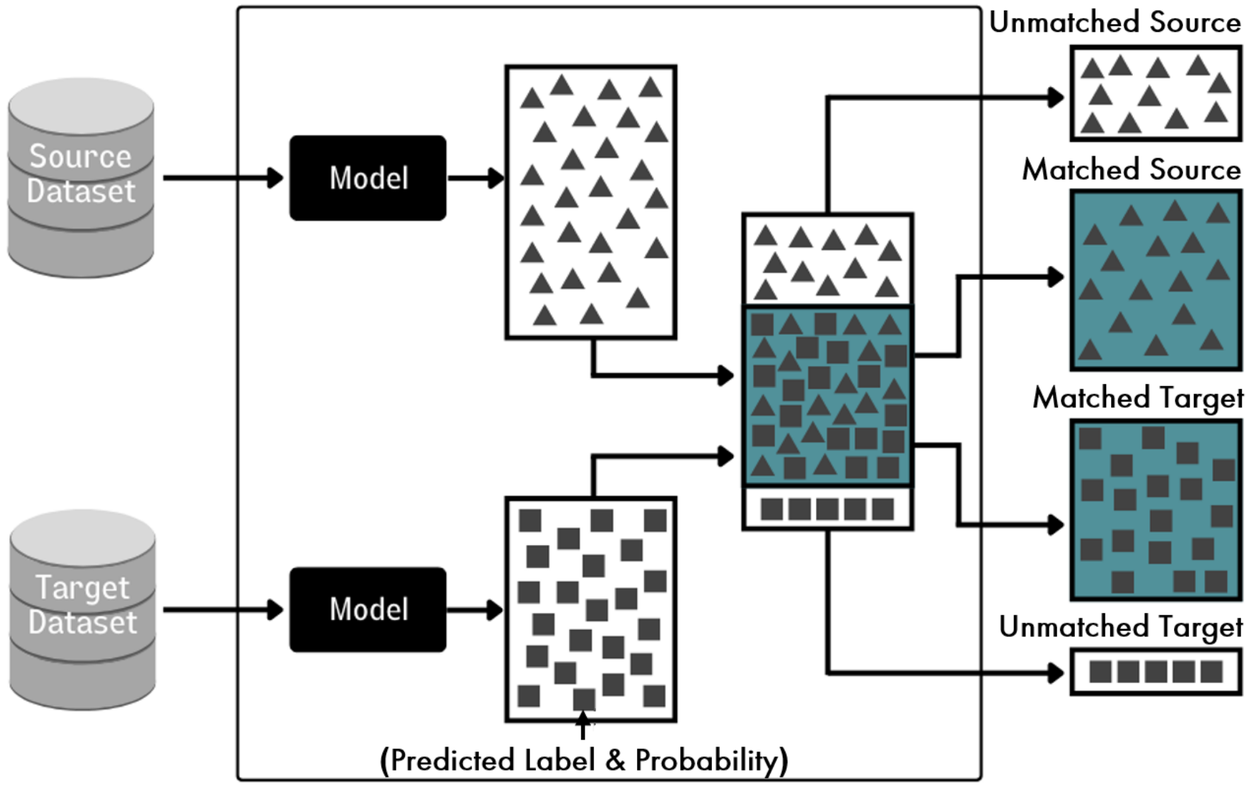


The Challenge:

- Similar dataset curation protocol
- Yet, unexpected and unexplained top-1 accuracy degradation

Proposed Framework (1/2)

Leverage DNN Uncertainty in Model Assessment



1. Get model predictions

2. Match predictions & generate test subsets

3. Assess the test subsets

Model Behavior is similar on Source and Target Datasets

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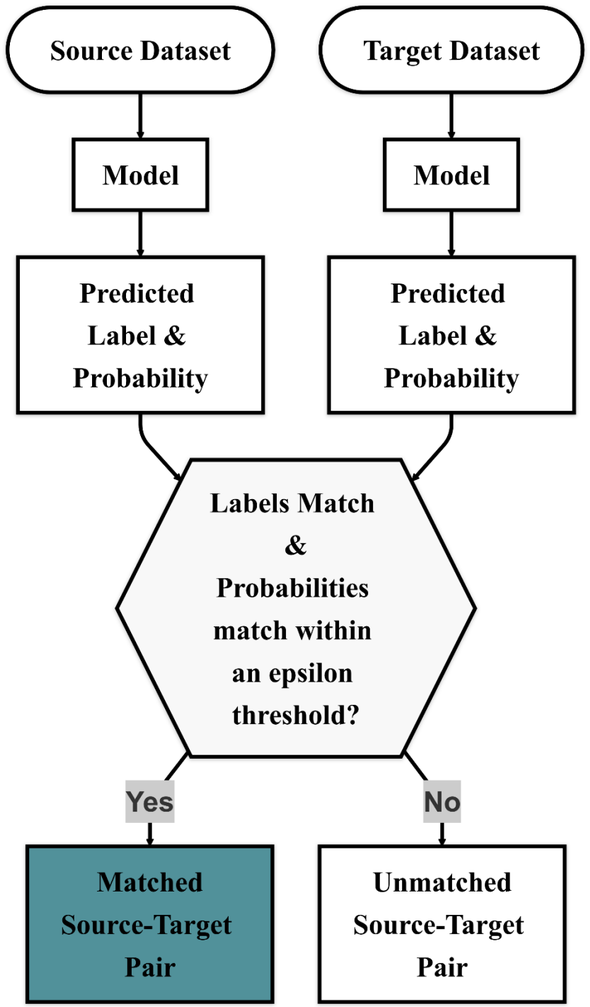
- ❑ Accuracy gap on matched subsets is substantially smaller
- ❑ All subsets have similar accuracy versus uncertainty relationship

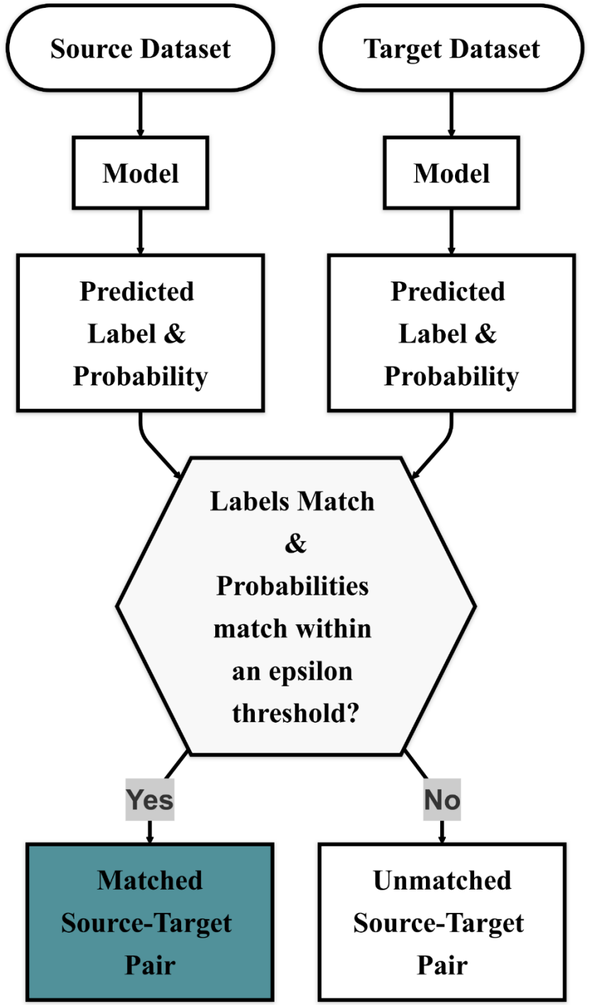
Proposed Framework (2/2)

Leverage DNN Uncertainty in Model Assessment



Proposed Framework (2/2)

Leverage DNN Uncertainty in Model Assessment



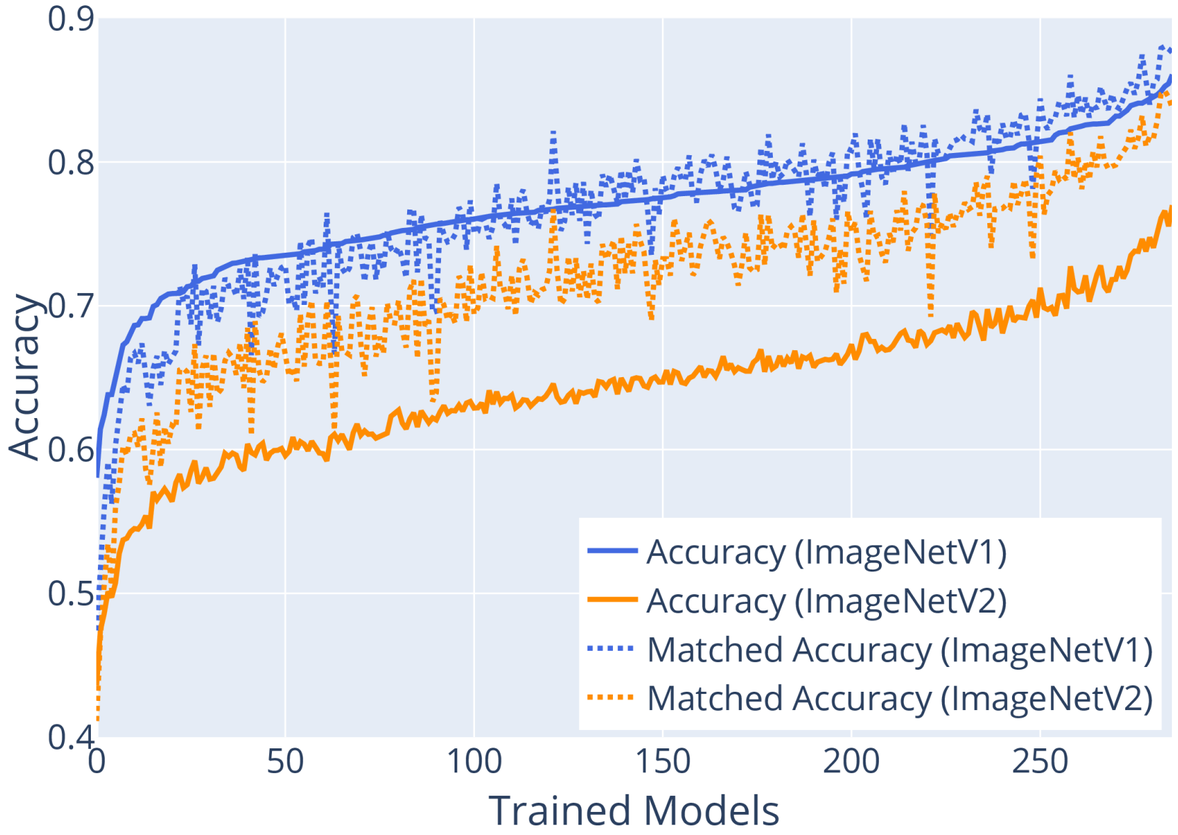
Conventional top-1 Accuracy Assessment		Proposed Evaluation Framework
➢ Uses all datapoints		➢ Matches similar predictions
➢ Treats all predictions equally	VS	➢ Creates fair comparison subsets
➢ Ignores model uncertainty		➢ Leverages model uncertainty
➢ Assumes dataset characteristics are the same		➢ Accounts for differences in dataset characteristics

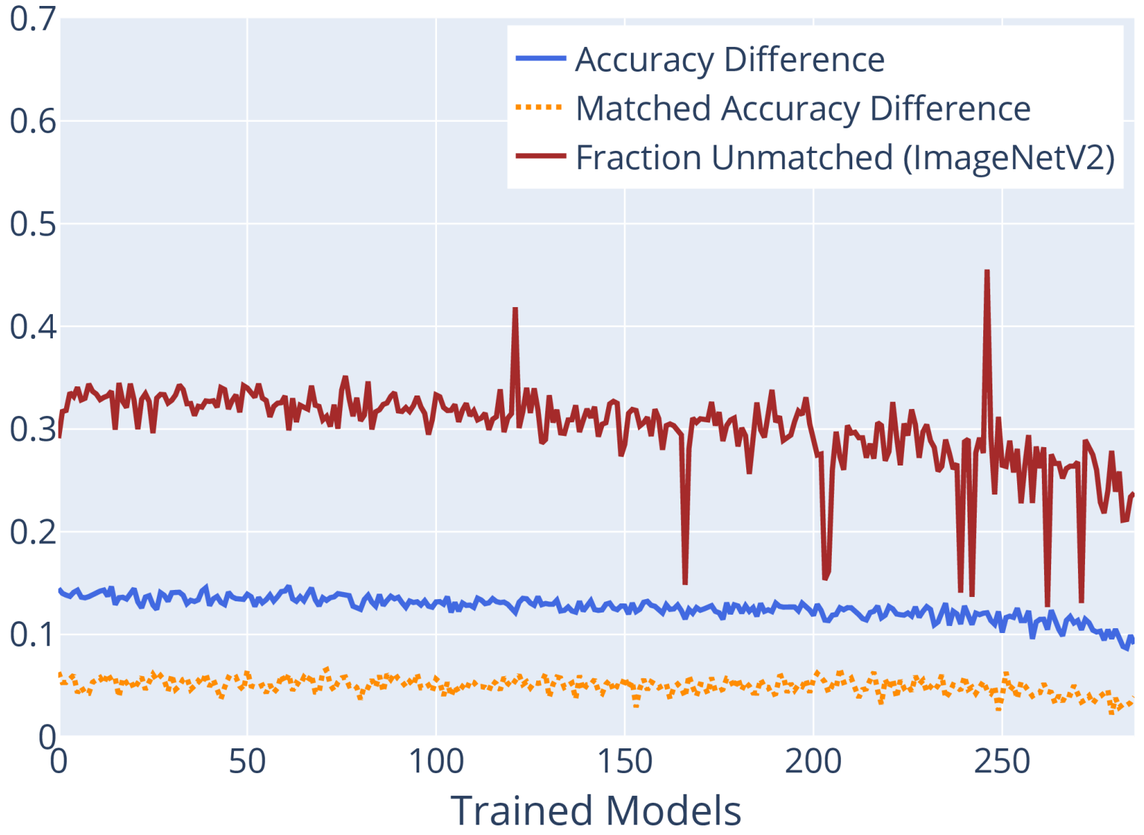
Experimental Setup

Extensive Assessment

- ❑Test dataset pairs: ImageNetV1/V2;CIFAR-10/10.1, CIFAR-10/10.2, CINIC/CIFAR-10 (278 models)
- ❑286 pre-trained ImageNet model
  - Diverse Architectures: ResNet, EfficientNet, MobileNet, ConvNeXt V2, ViTs, etc.
  - Baseline training dataset is ImageNet-1K
    - Some models were pre-trained on larger datasets like ImageNet-22k and JFT-300M

Results (1/2)

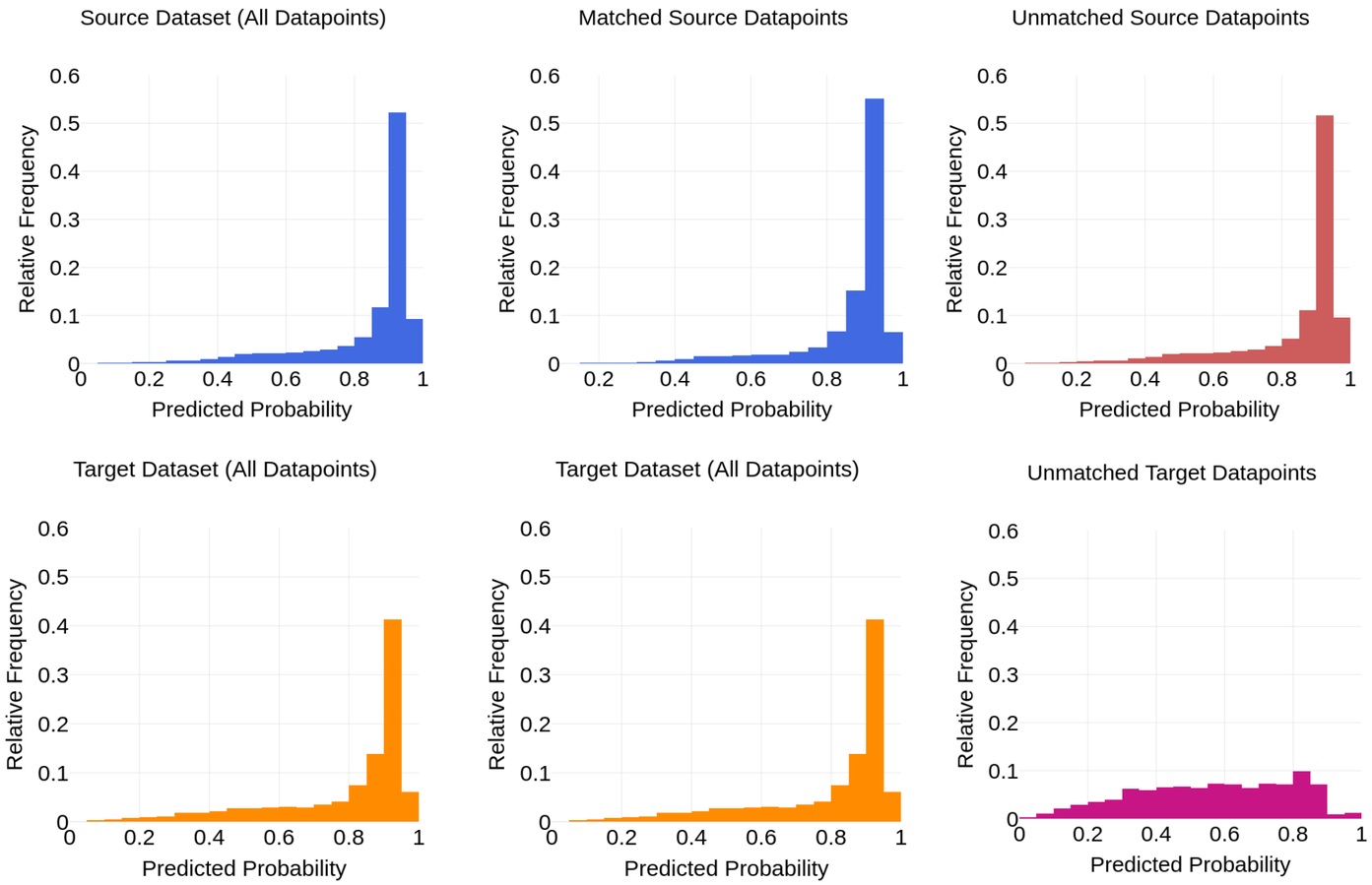


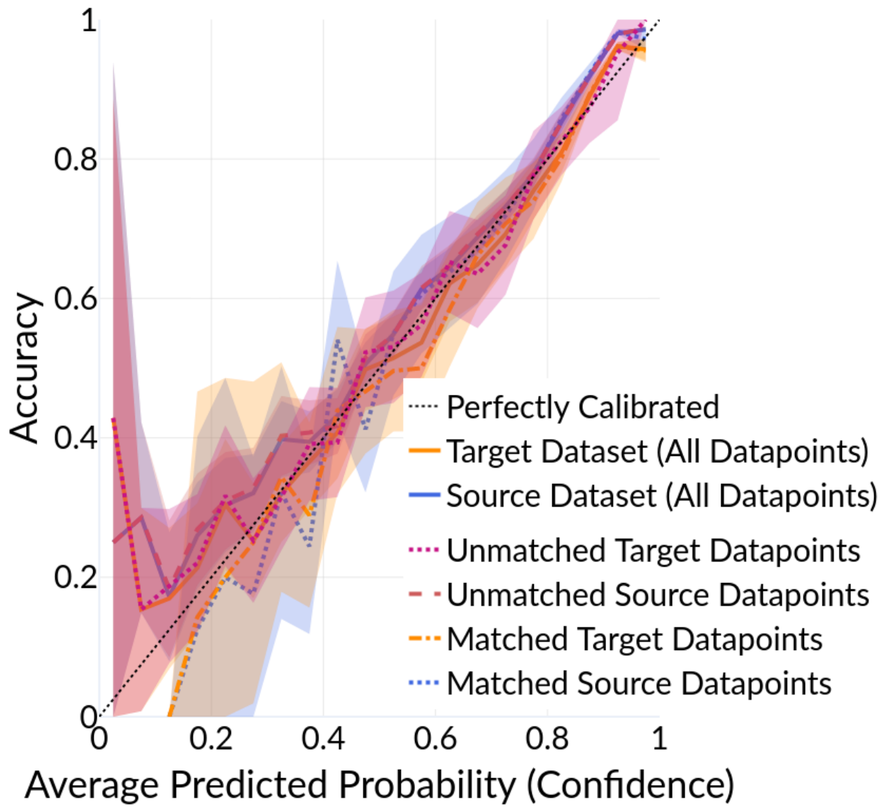


Take-away Message:

Leveraging uncertainty leads to significantly lower top-1 accuracy gap

Results (2/2)





Take-away Messages:

- Different test subsets with different accuracies and uncertainty distributions
- Yet, similar accuracy-uncertainty relationship

Conclusions

- Top-1 accuracy gaps are substantially lower than earlier reported
- Accuracy-uncertainty profiles are consistent across matched and unmatched subsets
- DNNs demonstrated better robustness on replicate test datasets than earlier reported
- Test and replicate datasets differ in subtle ways that warrants further investigation

Thank You!

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