Adapted Deep Embeddings: A Synthesis of Methods for $k$-Shot Inductive Transfer Learning

Tyler R. Scott\textsuperscript{1,2}, Karl Ridgeway\textsuperscript{1,2}, Michael C. Mozer\textsuperscript{1,3}

\textsuperscript{1}University of Colorado, Boulder
\textsuperscript{2}Sensory Inc.
\textsuperscript{3}Presently at Google Brain
Inductive Transfer Learning

Source Domain Data

Target Domain Data

Target Domain Input

Model

Target Domain Prediction
Inductive Transfer Learning

Weight Transfer

Source Domain

Target Domain

Retrain output
Adapt weights to target domain

Yosinski et al. (2014)
Inductive Transfer Learning

Weight Transfer

Deep Metric Learning

Source Domain

Source & Target Domain Embedding

Histogram loss
(Ustinova & Lempitsky, 2016)

Within class

Between class

Distance
Inductive Transfer Learning

Weight Transfer

Deep Metric Learning

Few-Shot Learning

Source Domain & Target Domain Embedding

Prototypical nets
(Snell et al., 2017)
Inductive Transfer Learning

Weight Transfer
Deep Metric Learning
Few-Shot Learning

Adapted Deep Embeddings

1. Train network using embedding loss
   - Histogram loss, Prototypical nets

2. Adapt weights using limited target-domain data
Inductive Transfer Learning

Why hasn’t a comparison been explored?

<table>
<thead>
<tr>
<th>Method</th>
<th># labeled examples per target class $(k)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight Transfer</td>
<td>&gt; 100</td>
</tr>
<tr>
<td>Deep Metric Learning</td>
<td>agnostic</td>
</tr>
<tr>
<td>Few-Shot Learning</td>
<td>&lt; 20</td>
</tr>
</tbody>
</table>
MNIST

Source Domain

Target Domain

2200 labeled examples per class

$k$ labeled examples per class
Test Accuracy

Target Domain

Labeled Examples in Target Domain ($k$)

Baseline
Test Accuracy

Target Domain

Labeled Examples in Target Domain (k)

MNIST, n = 5

Weight Adaptation
Baseline

Test Accuracy
Target Domain Test Accuracy

MNIST

Labeled Examples in Target Domain ($k$)

Prototypical Net
Weight Adaptation
Baseline
Test Accuracy

MNIST, n = 5

Histogram Loss
Prototypical Net
Weight Adaptation
Baseline

Target Domain
Test Accuracy

Labeled Examples in Target Domain \((k)\)
Test Accuracy

Target Domain

MNIST

Labeled Examples in Target Domain ($k$)
Conclusion

• Weight transfer is the least effective method for inductive transfer learning

• Histogram loss is robust regardless of the amount of labeled data in the target domain

• Adapted embeddings outperform every static embedding method previously proposed