DEEPLY ACTIVE LEARNING:
Approximating Human Learning with Smaller Datasets Combined with Human Assistance
Agenda

1. Motivation
2. Deep Active Learning Approach
3. Experiment Results
4. Lessons Learned
DEEP LEARNING REQUIRES

HUGE Amount of Labeled Data + Computations

50K people worked on Amazon Mechanical Turk 2007–2009

DEEP LEARNING REQUIRES HUGE Amount of Labeled Data + Computations

GPU-BASED DNNS

HUMAN PERFORMANCE

2010 2011 2012 2013 2014 2015 Today

AlexNet  ZF  VGG  ResNet  GoogLeNet-v4
Active Learning

**UNLABELED DATA**

**LABEL A SUBSET**

**TRAIN A LEARNER ON LABELED DATA**

**PICK THE BEST NEXT POINTS TO LABEL**

**RE-TRAIN THE LEARNER ON LABELED DATA**

Most uncertain
Deep Active Learning framework

![Diagram of Deep Active Learning framework]

- **Learned Embeddings**
- **Silhouette**
  \[
  \text{Silhouette}(x_i) = 1 - \frac{a}{b}
  \]
  - **Cluster-based Query**
  - **Samples w/ Lowest Silhouette Scores**

**Steps:**
1. **Labeled Data**
2. **Learned Embeddings**
3. **Silhouette Calculation**
4. **Cluster-based Query**
5. **Labeling**
6. **Samples w/ Lowest Silhouette Scores**
Generate Online Product Titles
Deep Active Learning framework

Cluster-based Query of Next Samples to Labels

Silhouette($x_i$) = 1 - $a/b$

Labeled Data → Learned Embeddings → Samples w/ Lowest Silhouette Scores

Labeling
LSTM-based Caption Generator

Impress guests with lemon pattern fresh look stoneware ensures lasting use dishwasher safe
EXPERIMENT
The Setup

## PRODUCT TITLE GENERATOR

<table>
<thead>
<tr>
<th>Train Data</th>
<th>Test Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000 Product Images</td>
<td>100 Product Images-Caption Pairs</td>
</tr>
</tbody>
</table>

## PRODUCT TITLE GENERATOR

<table>
<thead>
<tr>
<th>Deep Active Learning</th>
<th>Random Labeling</th>
<th>Fully Supervised</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train on 500 Samples Labeled Actively</td>
<td>Train on 500 Samples Labeled Randomly</td>
<td>Train on 2000 Labeled Samples</td>
</tr>
</tbody>
</table>
The Result

Performance comparison

Test Perplexity

Perplexity

Fully Supervised  Deep Active Learning  Random Learning

SEP 26, 2016  @ARIMOINC
The result

Test perplexity

- ▲ Deep Active Learning
- ■ Random Learning

Perplexity vs Number of samples seen
<table>
<thead>
<tr>
<th>Product Image</th>
<th>Reconstructed Image</th>
<th>100 Samples</th>
<th>300 Samples</th>
<th>500 Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="hand_cream.png" alt="Hand cream" /></td>
<td><img src="hand_cream_reconstructed.png" alt="Reconstructed Image" /></td>
<td>Hand cream stirs senses refreshing seashore breeze scent moisturize soften skin</td>
<td>Hand cream stirs senses refreshing eucalyptus and mint scent moisturize and soften your skin</td>
<td>Hand cream stirs your senses with a refreshing seashore breeze scent moisturize and soften your skin</td>
</tr>
<tr>
<td><img src="dishwasher.png" alt="Dishwasher" /></td>
<td><img src="dishwasher_reconstructed.png" alt="Reconstructed Image" /></td>
<td>You’ll always wake beautiful day cute dishwasher microwave safe mug</td>
<td>Impress guests with lemon pattern fresh look stoneware ensures lasting use dishwasher safe</td>
<td>Impress guests with lemon pattern fresh look stoneware ensures lasting use dishwasher safe</td>
</tr>
<tr>
<td><img src="little_girls_dress.png" alt="Little girls dress" /></td>
<td><img src="little_girls_dress_reconstructed.png" alt="Reconstructed Image" /></td>
<td>Little girls dress featuring trendy drop waist silhouette crewneck short tulip fully lined knit bodice lends</td>
<td>Soft sophisticated essential bath towel quick dry holds lovely look rich color use benzoyl peroxide</td>
<td>Soft sophisticated hand towel quick dry highly absorbent benzoyl peroxide friendly</td>
</tr>
</tbody>
</table>
Summary & Future Work

1. Successfully applied active learning in our DL framework

2. Demonstrated an improvement of 3x in perplexity score btw DAL vs. DRL

3. It turns out DAL works for text generation & not just classification!
   - It’s effective when your data has clustering structure

4. **Future work**: Work on larger scale dataset
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