Unsupervised Deep Learning by Neighbourhood Discovery

ICML-2019

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Related Works & Motivation

- Related Works
  - Clustering Analysis: Caron et al., ECCV, 2018
  - Sample (Instance) Specificity Learning: Wu et al., CVPR, 2018
  - Self-supervised Learning: Zhang et al., CVPR, 2017
  - Generative Model: Donahue et al., ICLR, 2016

- Motivation

(a) Clustering analysis:
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(a) Clustering analysis: class-consistent boundaries?
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(a) Clustering analysis: class-consistent boundaries?

(b) Sample specificity learning:
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(c) Ours: Anchor Neighbourhood Discovery
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- Motivation

(a) Clustering analysis: class-consistent boundaries?
(b) Sample specificity learning: correlation between samples?
(c) Ours: Anchor Neighbourhood Discovery Training with neighbourhoods of high-confidence only
Neighbourhood Discovery & Selection

Without ground-truth labels

\( k \)-Nearest neighbourhood structure

Consistent?
Neighbourhood Discovery & Selection

- Observation: Consistency v.s. Similarity Distribution Entropy
Neighbourhood Discovery & Selection

\[ k\text{-nearest neighbours} \]

Similarity

Low Entropy

Sample Index
Neighbourhood Discovery & Selection

\( k \)-nearest neighbours

Sample Index

Low Entropy

Similarity

Selection

Class-consistent Neighbourhoods
Neighbourhood Discovery & Selection

$k$-nearest neighbours

Low Entropy

Sample Index

Selection

Class-consistent Neighbourhoods
Neighbourhood Discovery & Selection

Class-consistent Neighbourhoods

$k$-nearest neighbours

Sample Index

Low Entropy

Sample Index

High Entropy

Selection
Training Objectives & Strategy

- Neighbourhood Supervision

- Curriculum Learning

1st Round
Training Objectives & Strategy

- Neighbourhood Supervision

- Curriculum Learning

1st Round

2nd Round
Training Objectives & Strategy

- Neighbourhood Supervision

- Curriculum Learning

1st Round

2nd Round

Last Round
Experiments

- Small scale Image Classification (kNN)
- Small scale Image Classification (LC)

<table>
<thead>
<tr>
<th>Dataset</th>
<th>DeepCluster ECCV’18</th>
<th>Instance CVPR’18</th>
<th>AND (Ours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIFAR10</td>
<td></td>
<td></td>
<td>+6.0%</td>
</tr>
<tr>
<td>CIFAR100</td>
<td></td>
<td></td>
<td>+6.0%</td>
</tr>
<tr>
<td>SVHN</td>
<td></td>
<td>-0.3%</td>
<td>+1.7%</td>
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</tbody>
</table>
Experiments

- Small scale Image Classification ($k$NN)  
  - CIFAR10
  - CIFAR100
  - SVHN

- Small scale Image Classification (LC)
  - CIFAR10
  - CIFAR100
  - SVHN

- Large scale Image Classification
  - ILSVRC2012

Accuracy metrics for each dataset with different methods and improvements:

- DeepCluster ECCV’18
- Instance CVPR’18
- AND (Ours)

Improvement:

- CIFAR10: +12.5%
- CIFAR100: +8.8%
- SVHN: +6.0%

- CIFAR10: -0.3%
- CIFAR100: +12.5%
- SVHN: +1.7%

- CIFAR10: +6.0%
- CIFAR100: +6.0%
- SVHN: +1.7%

Accuracy comparison across different layers for ILSVRC2012:

- CONV1
- CONV2
- CONV3
- CONV4
- CONV5
- FC

Accuracy improvement: +5.6%
Experiments

- Small scale Image Classification ($k$NN)  
  - CIFAR10: +12.5%  
  - CIFAR100: +8.8%  
  - SVHN: +6.0%  
  - DeepCluster ECCV’18  
  - Instance CVPR’18  
  - AND (Ours)

- Small scale Image Classification (LC)  
  - CIFAR10: -0.3%  
  - CIFAR100: +6.0%  
  - SVHN: +1.7%

- Large scale Image Classification

- Fine-grained Image Classification ($k$NN)  
  - CONV1: +5.6%  
  - CONV2: +5.6%  
  - CONV3: +5.6%  
  - CONV4: +5.6%  
  - CONV5: +5.6%  
  - FC: +5.6%  
  - ILSVRC2012

- CUB200: +2.8%  
- DOGS: +5.3%
Unsupervised Deep Learning by Neighbourhood Discovery

Thank You!

Code: https://github.com/Raymond-sci/AND

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