Learning image representations tied to ego-motion

Dinesh Jayaraman and Kristen Grauman
(experiment presentation)

Presented by Ruohan Gao
UTCS CS381V
Visual Recognition
2016 Spring
Outline

• Feature Embedding using Siamese Network
• Visualization of Learnt Features
• Fine-tuning on New Task
Feature Embedding using Siamese Network
Feature Embedding using Siamese Network

- Motion-pattern image pairs
  - $X_i \rightarrow \mathbf{Z}_\theta(X_i)$
  - $X_j \rightarrow \mathbf{Z}_\theta(X_j)$

- Class-labelled
  - $X_k \rightarrow \mathbf{Z}_\theta(X_k)$
  - $\mathbf{W}$

- Replicated layers $\mathbf{Z}_\theta$
  - $M_1 \rightarrow d_1(.)$
  - $M_g \rightarrow d_g(.)$

- Overall loss
  - $(G)$
  - $\sigma(.)$
Feature Embedding using Siamese Network

Contrastive Loss:

\[ d_g(a, b, c) = \mathbb{1}(c = g)d(a, b) + \mathbb{1}(c \neq g) \max(\delta - d(a, b), 0) \]
Toy Example of MNIST Dataset
Toy Example of MNIST Dataset
Toy Example of MNIST Dataset

LeNet5
Toy Example of MNIST Dataset

Generated using Caffe tool: draw_net.py
Toy Example of MNIST Dataset

Generated using Caffe tool: draw_net.py
Toy Example of MNIST Dataset

\[ d_g(a, b, c) = \mathbb{1}(c = g)d(a, b) + \mathbb{1}(c \neq g)\max(\delta - d(a, b), 0) \]
Toy Example of MNIST Dataset

- Settings of Training Phase:
  - Base Learning Rate: 0.01
  - Momentum: 0.9
  - Weight Decay: 0
  - Learning Rate Policy: “inv”
  - gamma: 0.0001
  - power: 0.75
  - Training Data: 10,000 pairs
  - Batch Size: 64
  - Number of Iterations: **20,000**

Modified from Caffe official Tutorial: http://caffe.berkeleyvision.org/
Toy Example of MNIST Dataset

• Feature Embedding Setting:
  • Number of Testing Digits: 10,000
  • mnist_siamese_iter_20000.caffemodel
  • Embed in two-dimensional feature space

Modified from Caffe official Tutorial: http://caffe.berkeleyvision.org/
Toy Example of MNIST Dataset

• To Compare -&gt; a dimensionality reduction algorithm: t-SNE (t-distributed stochastic neighbor embedding)
• Reduce the number of dimensions to two

Ref: http://lvdmaaten.github.io/tsne/
Toy Example of MNIST Dataset
Invariance vs Equivariance

Right Turn

Zoom

Left Turn
Invariance vs Equivariance
Invariance vs Equivariance
Invariance vs Equivariance
Invariance vs Equivariance
Invariance vs Equivariance
Invariance vs Equivariance
Invariance vs Equivariance

- Right Turn
- Zoom
- Left Turn
Visualization of Learnt Features

Two work about feature learning using ego-motion at ICCV 2015

Learning Image Representations Tied to Ego-motion
  - Dinesh Jayaraman and Kristen Grauman, UT Austin

Learning to See by Moving
  - Pulkit Agrawal, Joao Carreira and Jitendra Malik, UC Berkeley
Visualization of Learnt Features

• KITTI Dataset

• Learning Image Representations Tied to Ego-motion
  • Ego-motion pattern: K-means clustering based on “yaw” and “forward position”

• Learning to See by Moving
  • Binning based on three dimensions of camera transformation
Visualization of Learnt Features

Conv1 Features learnt from KITTI Videos using ego-motion as supervisory signals
Visualization of Learnt Features

Conv1 Features learnt from labeled images in IMAGENET

Conv1 Features of Pre-trained Alexnet
Visualization of Learnt Features
Fine-tuning on New Task

- Task: Assignment 2
- Three Models:
  - AlexNet using randomly initialized weights for all layers
  - AlexNet with the first five layers initialized with features learnt from KITTI Dataset
  - Pre-trained AlexNet model using all ImageNet images
- Fine-tuning setting:
  - Batch size: 50
  - Iterations: 5,000
  - Learning Rate: 0.001
  - momentum: 0.9
Fine-tuning on New Task

2,500 training images

31,500 training images
Reference

2. Pulkit Agrawal, Joao Carreira and Jitendra Malik, Learning to See by Moving, ICCV 2015
3. Laurens van der Maaten and Geoffrey Hinton, Visualizing Data using t-SNE
5. KITTI: http://www.cvlibs.net/datasets/kitti/

Thanks!