Object Detection

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Part 1
1. What is an Object Detection?

2. Traditional Object Detector

3. Deep Learning-based Object Detector
What is an Object Detection?

Subset of **Object Recognition**
What is an Object Detection?

Object Categorization (Classification)
- Car
- Pedestrian
- Bus
- Tree

Object Segmentation

Object Detection
- Car
- Pedestrian
- Bus

Scene Categorization
- Urban/Intersection

Object Recognition
What is an Object Detection?

- Find a target object in a given image.

**Input**

- Image Sequence

**Output**

- Object Class
- Object Location \((x, y, \text{width}, \text{height})\)

1. Car, \((0, 250, 120, 125)\)
2. Car, \((80, 256, 60, 40)\)
3. Car, \((140, 245, 130, 120)\)
4. Pedestrian, \((400, 247, 20, 70)\)
5. Bus, \((520, 0, 110, 320)\)
How can we know *where* objects are and *what* they are?

- Traditional approach
  
  Input Image $\rightarrow$ Feature Extraction $\rightarrow$ Candidate Generation $\rightarrow$ Classification $\rightarrow$ Detection Output

- Deep Learning-based approach
  
  Input Image $\rightarrow$ Deep Neural Network $\rightarrow$ Detection Output
Traditional Object Detection
Traditional Object Detection

- **Input Image**
- Feature Extraction
- Candidate Generation
- Classification
- Detection Output

Target Object
Traditional Object Detection

Input Image → Feature Extraction → Candidate Generation → Classification → Detection Output

Target Object
Traditional Object Detection

Input Image → Feature Extraction → Candidate Generation → Classification → Detection Output

Target Object
Traditional Object Detection

Input Image → Feature Extraction → Candidate Generation → Classification → Detection Output

Sliding window

"Image Pyramid"
Traditional Object Detection

Input Image → Feature Extraction → Candidate Generation → Classification → Detection Output

- Pedestrian
Traditional Object Detection

Input Image → Feature Extraction → Candidate Generation → Classification → Detection Output

[Feature Extraction]
- Color / Brightness / Gradient
- Haar Feature
- Scale Invariant Feature Transform (SIFT)
- Local Binary Pattern (LBP)
- Histogram Oriented Gradient (HOG)

[Candidate Generation]
- Sliding Window Search
- Selective Search
- Multiscale Combinatorial Grouping (MCG)
- Edge-Box
- Binarized Normed Gradient (BING)
Traditional Object Detection

- **Input Image**
- **Feature Extraction**
- **Candidate Generation**
- **Classification**
- **Detection Output**

**[Classification]**
- AdaBoost
- Random Forest
- Support Vector Machine (SVM)
- Latent Support Vector Machine (L-SVM)
Traditional Object Detection (Demo)

Target Object: REAR Vehicle
Feature: LBP    Classifier: Cascade Classifier
Deep Learning-based Object Detection
Deep Learning-based Object Detection

1. Input Image
2. Candidate Generation
3. Deep Neural Network (Classification)
4. Detection Output

Regions with CNN features (R-CNN), 2013

Apply image classification network to each object candidates
Deep Learning-based Object Detection

How convolutional neural network is worked on the image?

Input Image

1\textsuperscript{st} Feature Map

2\textsuperscript{nd} Feature Map

Conv. Filter
Deep Learning-based Object Detection

Fast Region-based Conv. Neural Net. (Fast R-CNN), April, 2015

1. Input image
2. Generate object candidates
3. Image Classification (AlexNet)
4. Detection Output

Computational cost is proportionally increased according to the number of candidates.
Deep Learning-based Object Detection

Faster Region-based Conv. Neural Net. (Faster R-CNN), June, 2015

1. Input image
2. Base model: AlexNet / VGG
3. Detection Output

Input Image → Deep Neural Network → Detection Output

Base model: AlexNet / VGG

Deep Conv Net. → Region Proposal Net. → ROI Pooling → Fully Conn. → Feature Maps
Deep Learning-based Object Detection

**You Only Look Once (YOLO)**

**Single Shot MultiBox Detector (SSD)**
Next Presentation

Part 2: Traditional Object Detection from Scratch

Design Basic Object Detector
- Feature: HOG Features
- Classification: SVM
- Practice with toy example

Part 3: Deep Learning-based Object Detection I

Part 4: Deep Learning-based Object Detection II
Thank You