Final Project Topics

CS6550 Computer Vision

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List of Final Topics

Image Classification

Image Saliency Detection

Image Segmentation (Learning Based)

Image Restoration

Object Detection

Facial Expression Recognition

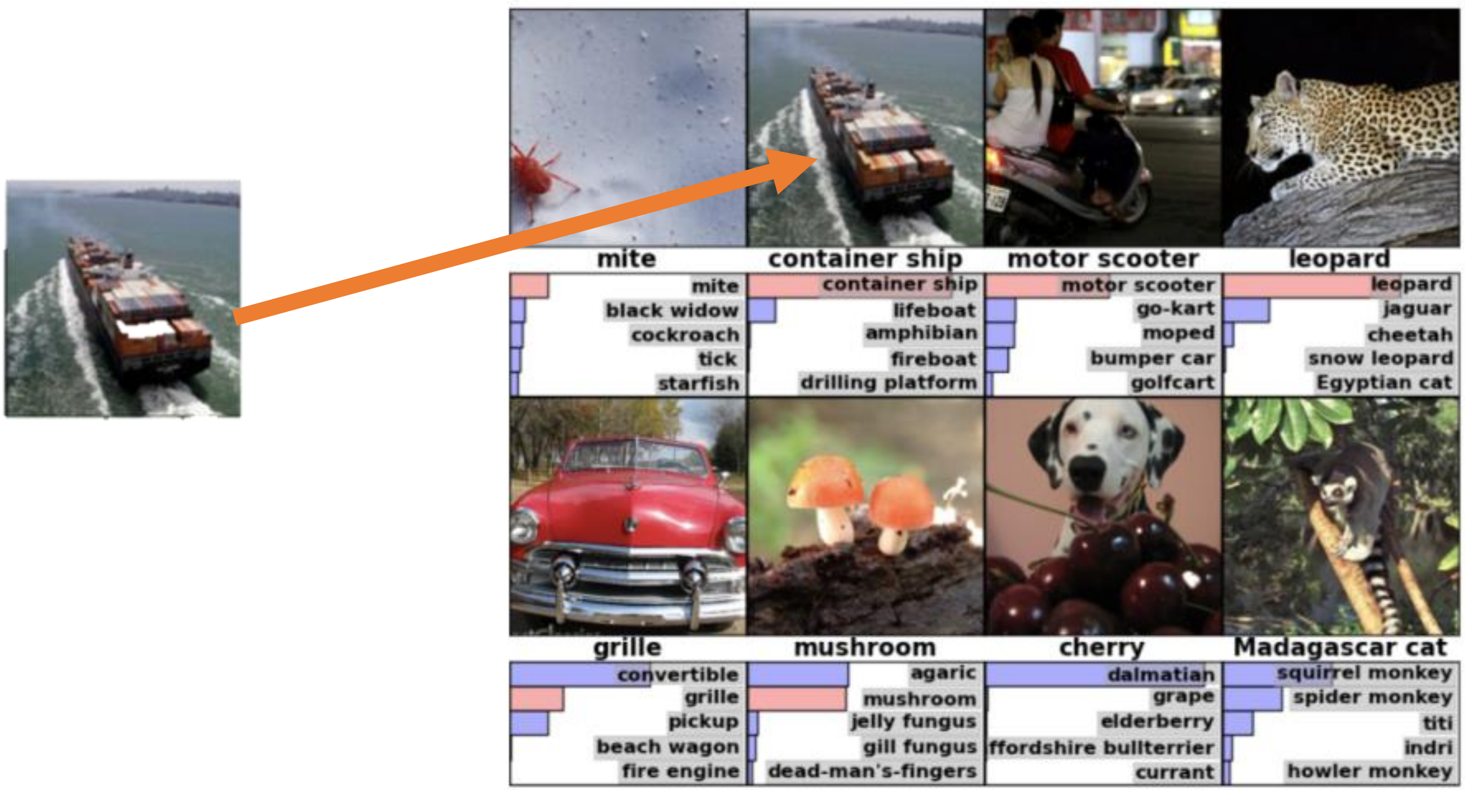
Gesture Recognition

Stereo Matching

Image Classification

Image Classification

- Categorize or detect text in the picture.



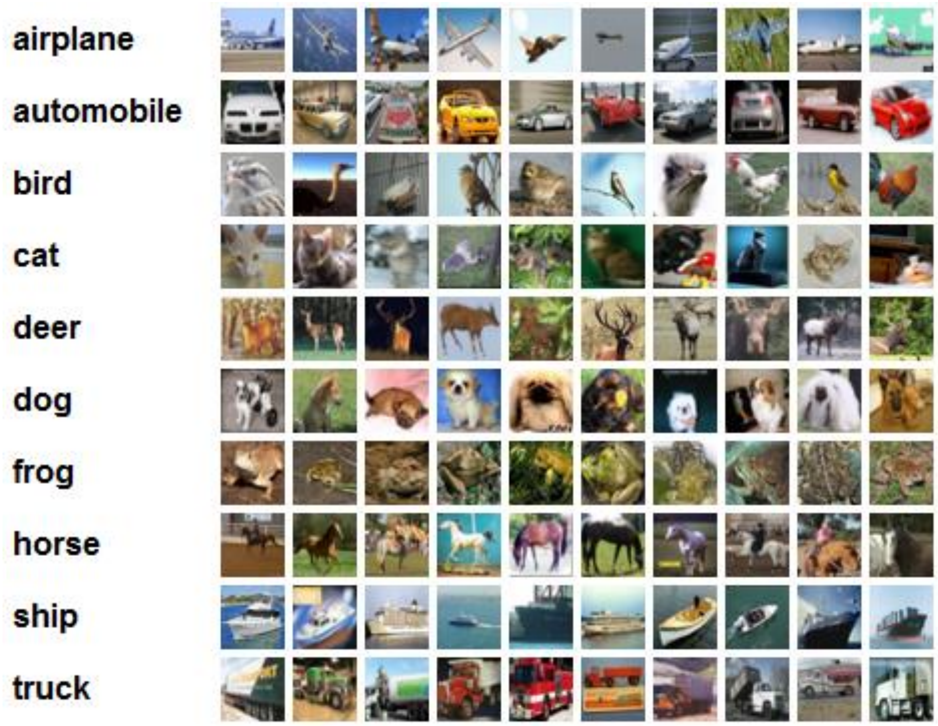
References: https://blog.acolyer.org/2016/04/20/imagenet-classification-with-deep-convolutional-neural-networks/

Image Classification

- How to do “Classification” ?
  1. Preprocessing
  2. Feature extraction
  3. Modeling
     - Description of each class in mathematical form
  4. Classification
     - The classifier divides the feature space into class regions

Image Classification

- Datasets
  - ImageNet : http://image-net.org/
  - CIFAR : https://www.cs.toronto.edu/~kriz/cifar.html



References: https://www.cs.toronto.edu/~kriz/cifar.html

Image Classification

- References
  - https://papers.nips.cc/paper/4824-imagenet-classification-with-deep-convolutional-neural-networks.pdf
  - http://vision.cse.psu.edu/seminars/talks/2009/random_tff/bosch07a.pdf
  - http://cs.utsa.edu/~qitian/seminar/Spring11/02_18_11/ECCV10.pdf

Image Saliency Detection

Image Saliency Detection

- Finding salient objects in the source image.

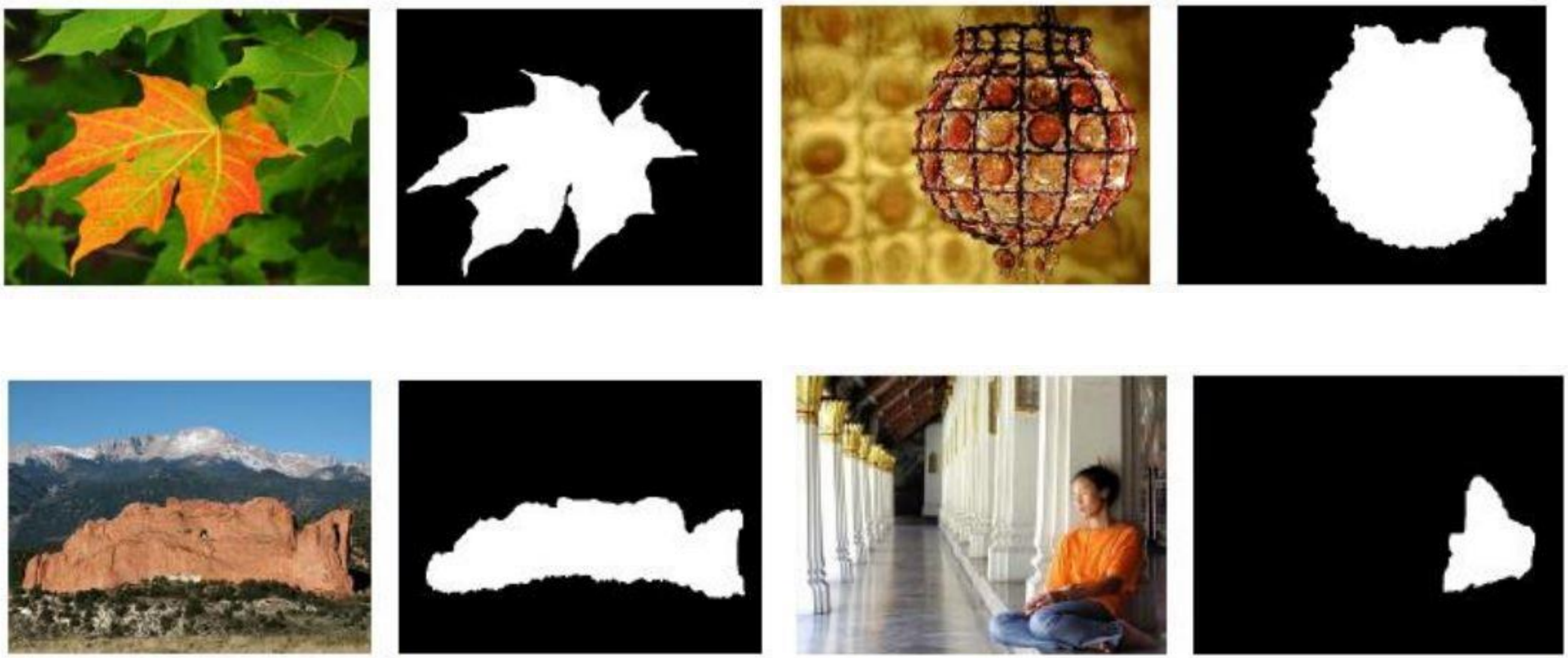


Image Saliency Detection

- Contrast Based Filter Saliency
  - Abstraction : decomposes an image into compact represented by their mean color.
  - Uniqueness : regions which stand out from other regions should be labeled more salient.
  - Distribution : foreground objects are generally more compact, thus we measure the spatial distribution.

(a) Source image. (b) Abstraction. (c) Uniqueness. (d) Distribution. (e) Saliency.

References: https://graphics.ethz.ch/~perazzif/saliency_filters/

Image Saliency Detection

- Datasets
  - https://graphics.ethz.ch/~perazzif/saliency_filters/files/SF_maps.zip
  - http://saliency.mit.edu/datasets.html


Image Saliency Detection

- References
  - https://graphics.ethz.ch/~perazzif/saliency_filters/files/saliency_filters_cvpr_2012.pdf
  - http://www.cse.cuhk.edu.hk/leojia/projects/hsaliency/papers/hsaliency.pdf
  - https://arxiv.org/pdf/1505.01173v1.pdf

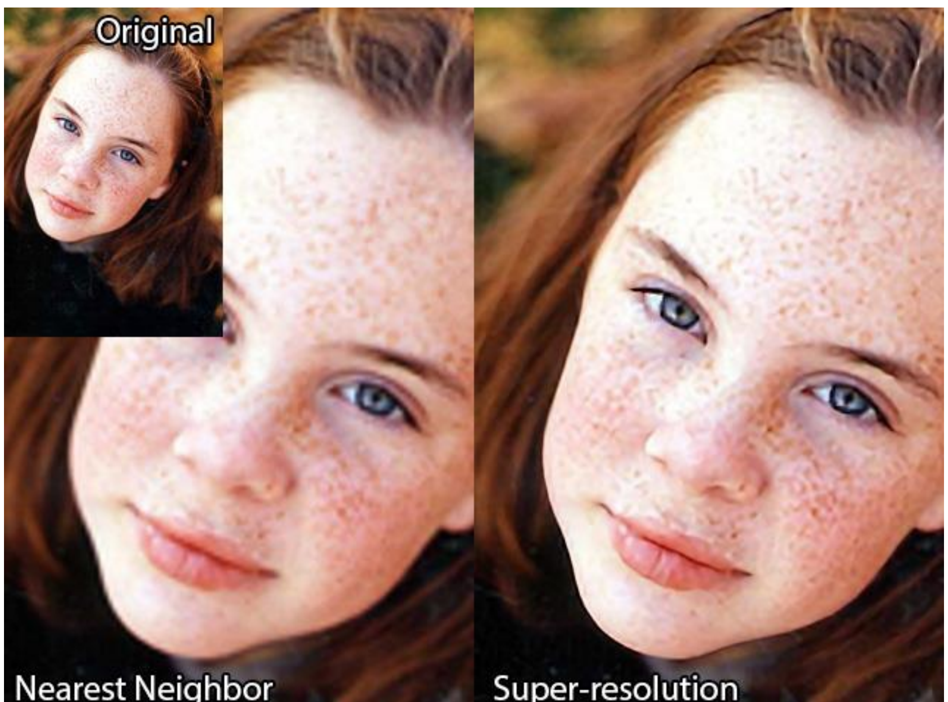
Image Restoration

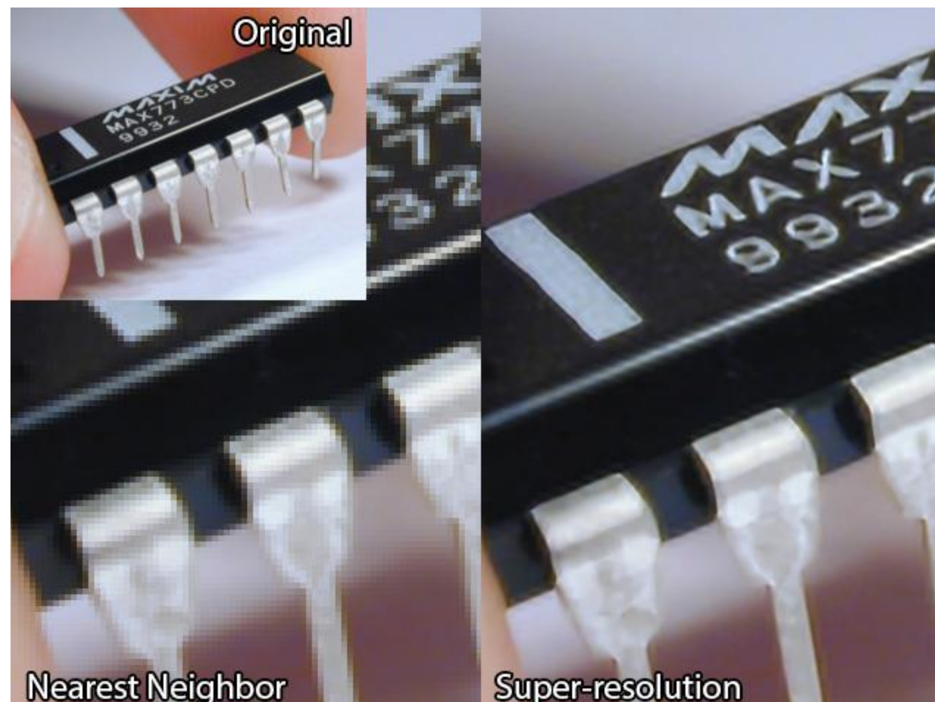
Super-Resolution

Inpainting / Completion

Image Restoration — Super-Resolution

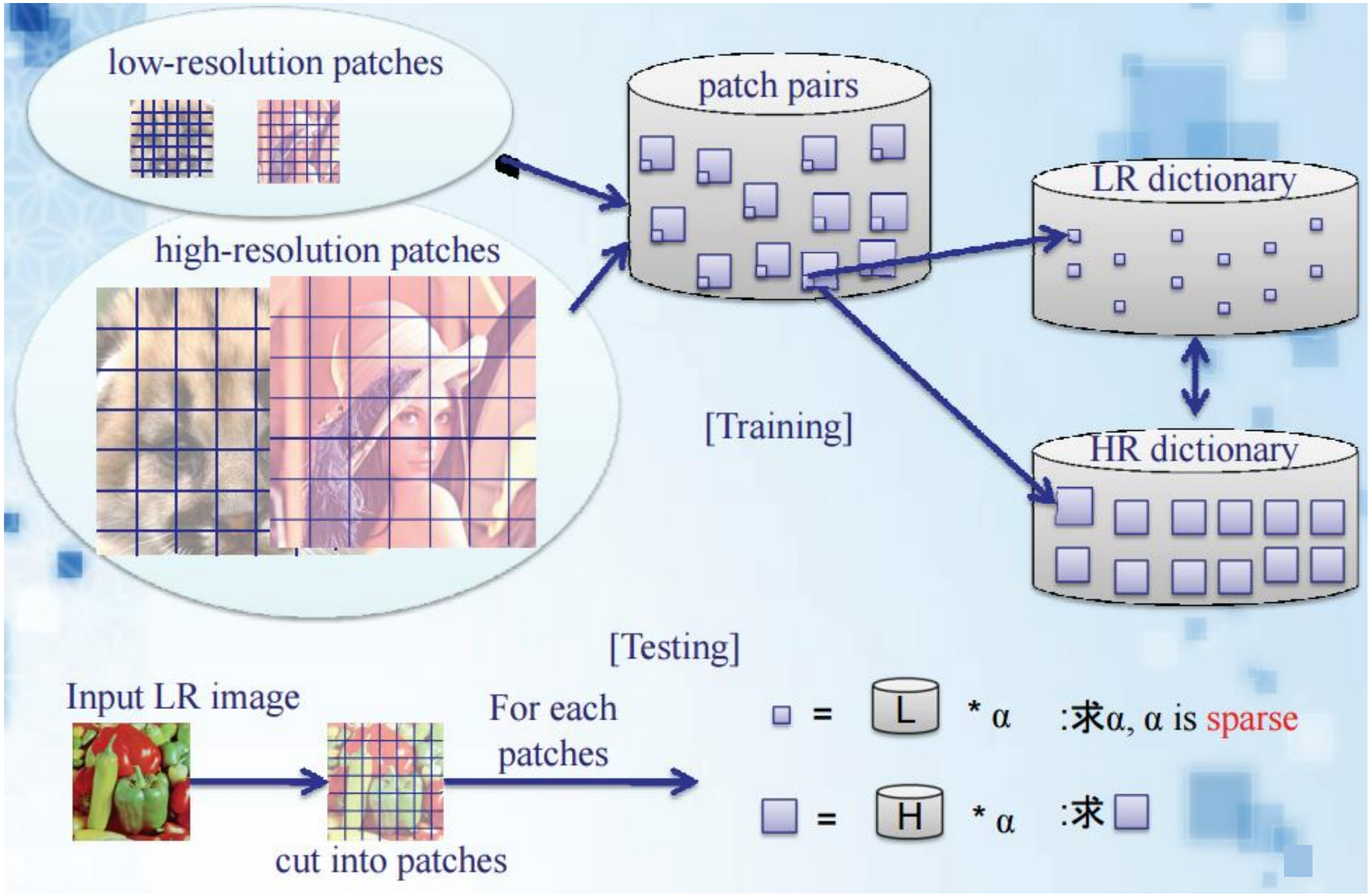
- What is Super-Resolution ?
  - Upscale the image to desire size (x2, x4, x8…)
- Possible solutions
  - Interpolations: Nearest Neighbor / Bicubic / Bilinear
  - Learning-based: Sparse Representation / Deep Learning



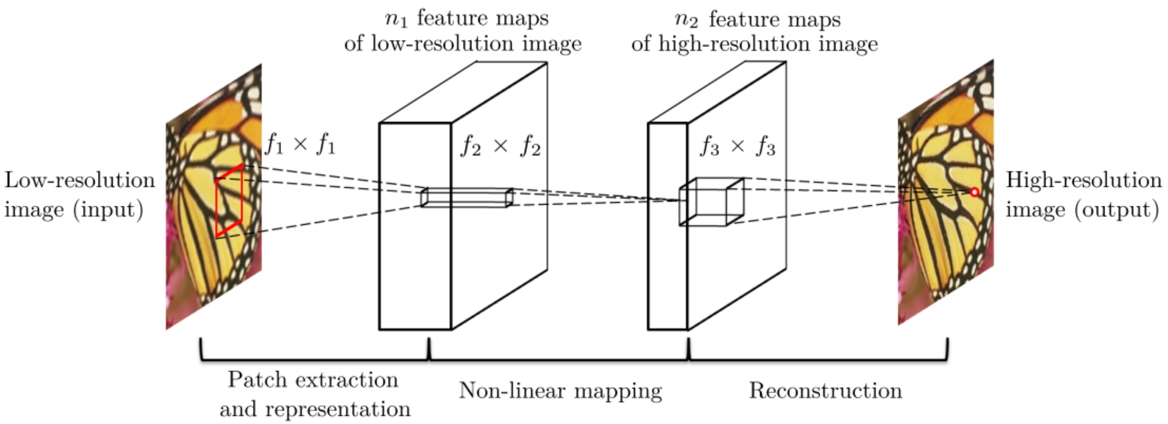


- Sparse Representation [1]
  1. Training: Learned HR-LR pair dictionaries
  2. Testing: Solve the sparse coding
  3. Reconstruct HR image

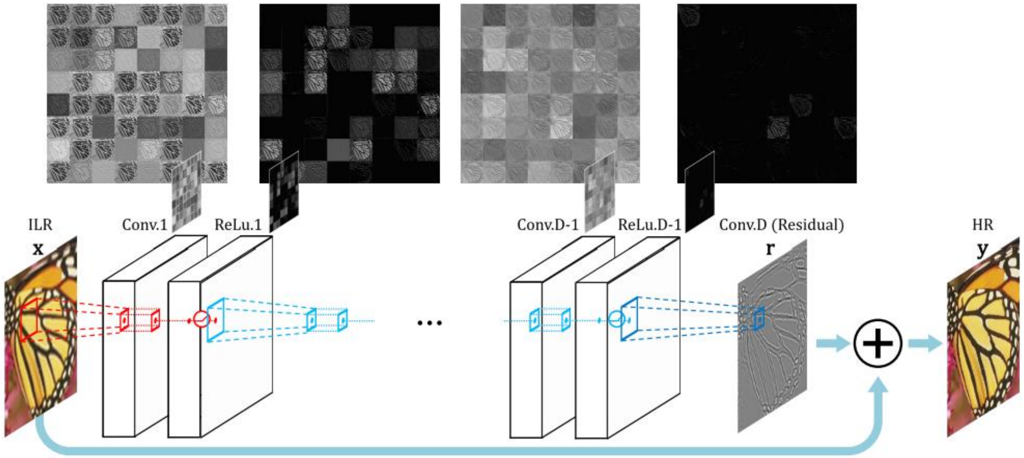
References
[1] Image Super-Resolution via Sparse Representation



- Deep Learning
  - SRCNN [2] [Image Super-Resolution Using Deep Convolutional Networks]



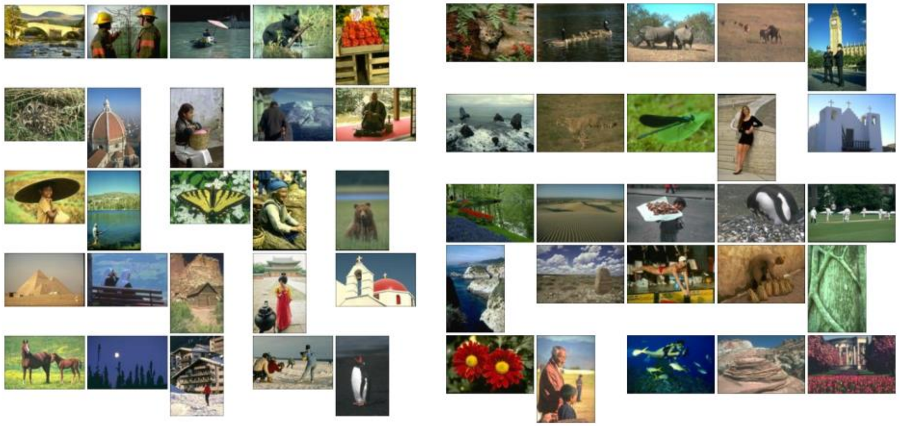
  - VDSR [3] [Accurate Image Super-Resolution Using Very Deep Convolutional Networks]



Super-Resolution

- Training Datasets

The Berkeley Segmentation Dataset and Benchmark (BSD 200)



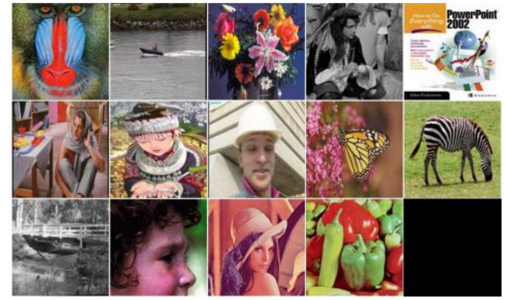
Yang 91 Images

ImageNet (Not Suggested)

Image Restoration | Super-Resolution

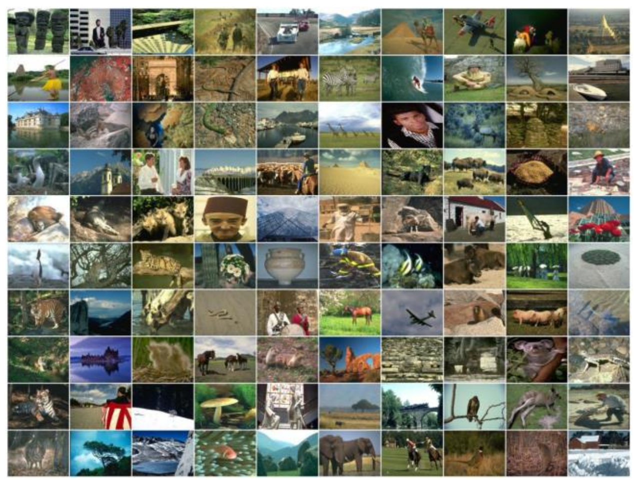
- Testing Datasets

Set 5



Set 14

Urban 100



BSD 100

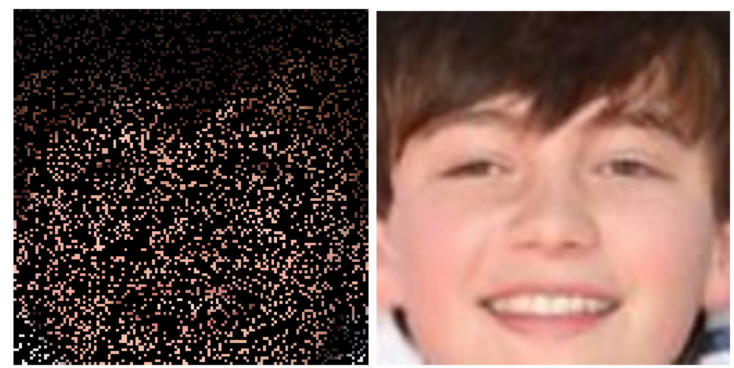
Sun-Hays 80

GitHub Resources:

- **Comparison with the [state-of-the-art datasets]()**
- **[Super-Resolution-Benchmarks]()**

Image Restoration — Inpainting / Completion

- What is Inpainting or Completion ?
  - To fill or complete the lost or unwanted regions in the images
- Related solutions
  - Vision-based (Patch Inpainting) / Numerical Optimization (TNNR)
  - MRF (Field of Experts) / Autoencoders / Deep Learning



- Autoencoders / Deep Learning
  - Conditional GANs
  - Context Encoder [1] [Context Encoders: Feature Learning by Inpainting]

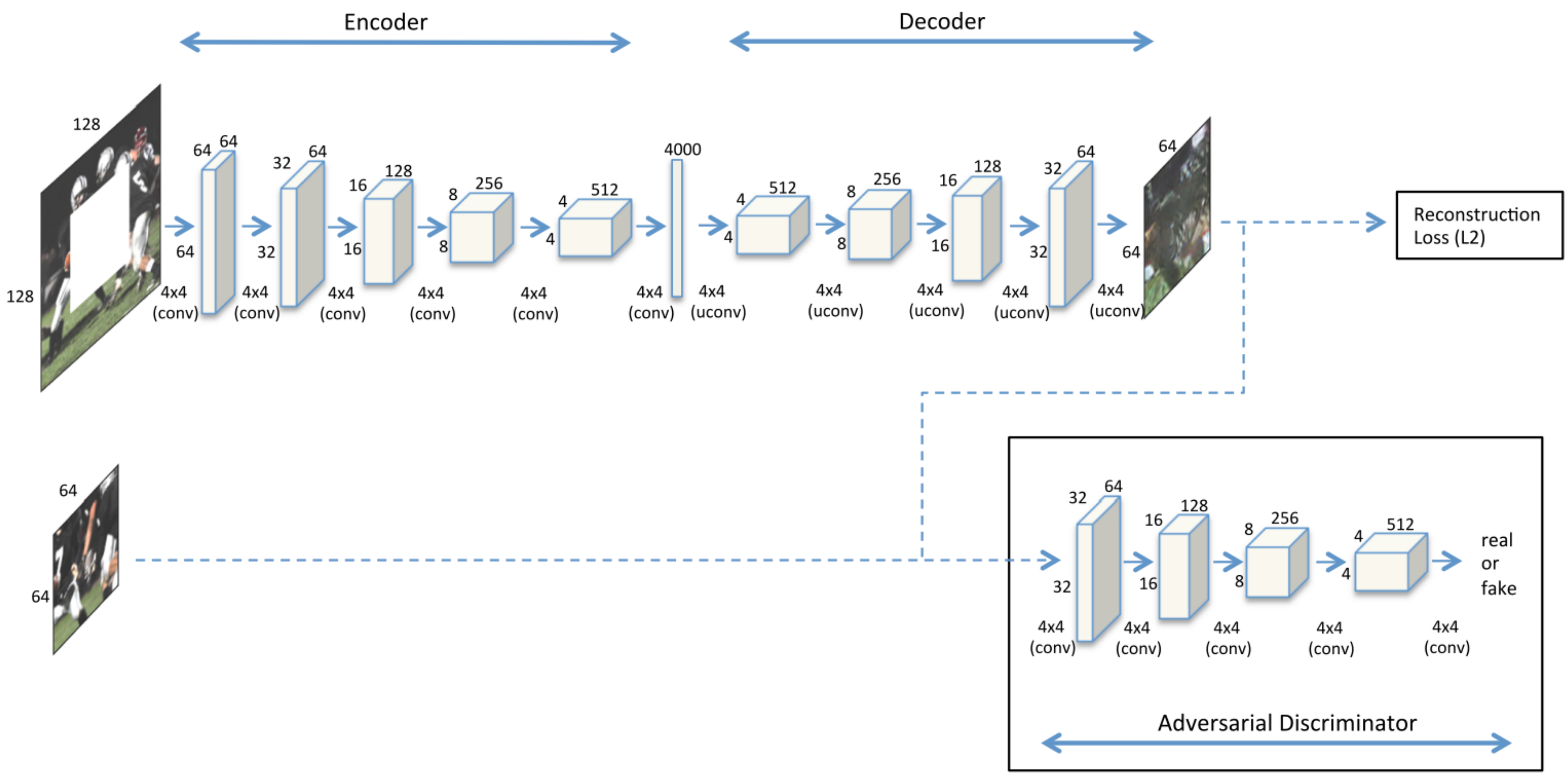
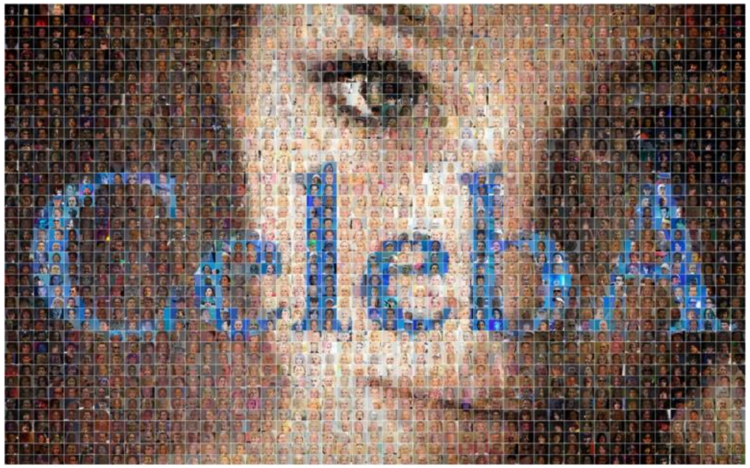


Image Restoration — Inpainting / Completions

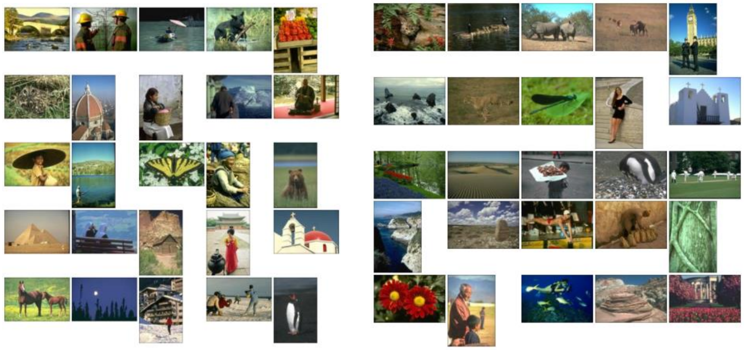
- Datasets

[TUM-Image Inpainting Database]()



[CelebA Datasets]()

[Google Street View Data Set]()



[The Berkeley Segmentation Dataset and Benchmark]() (BSD 200)

Image Segmentation

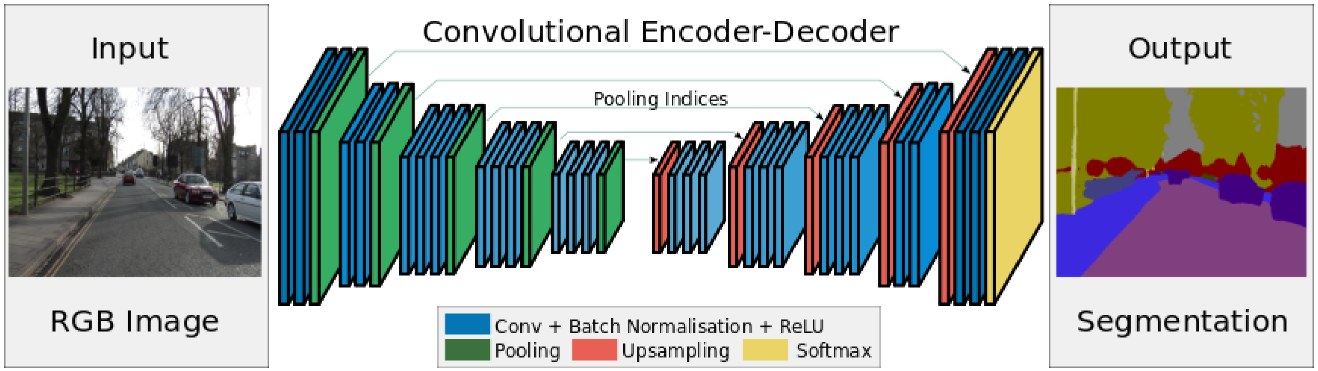
Focusing on Learning-based methods

Image Segmentation

- What is Image Segmentation ?
  - the process of partitioning a digital image into multiple segments (sets of pixels, also known as super-pixels).
  - The goal of segmentation is to simplify and/or change the representation of an image into something that is **more meaningfu**l and **easier to analyze**.
- Related solutions
  - Grouping Super-Pixels / Kmeans
  - Deep Learning

Image Segmentation

- Deep Learning Methods: Directly generate segmentation results
    - SegNet [1]



- Fully Convolutional Networks for Semantic Segmentation [2]

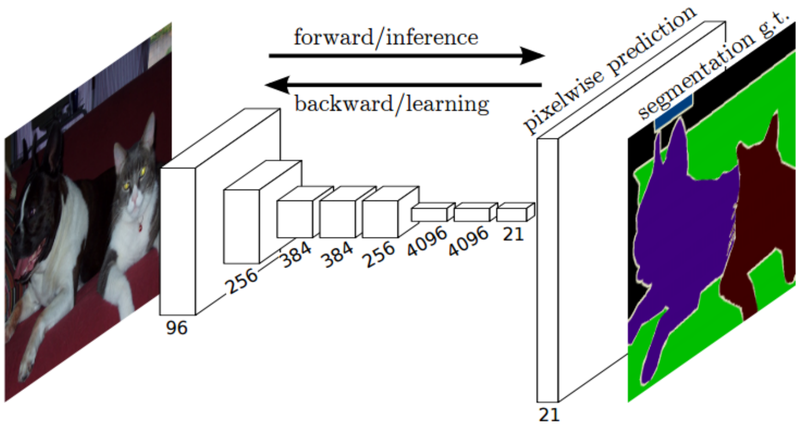
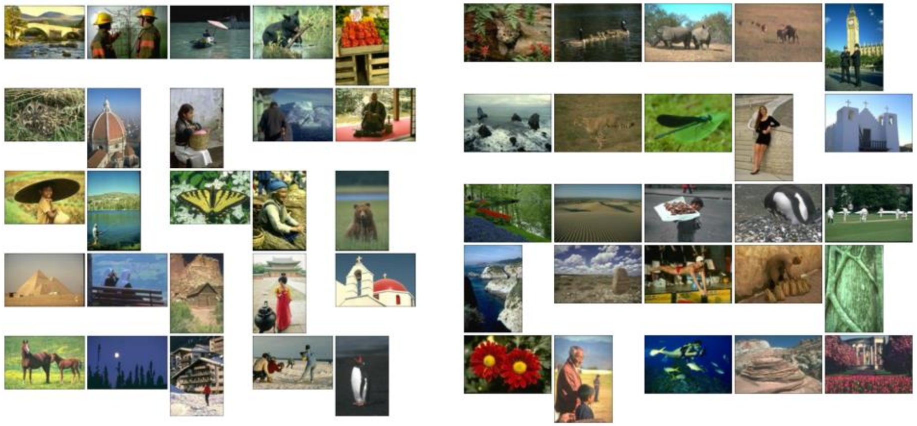


Image Segmentation

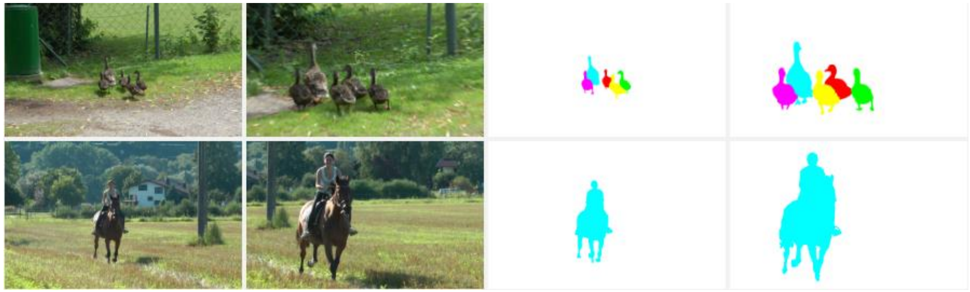
- Datasets

The Berkeley Segmentation Dataset and Benchmark (BSD 200)



Visual Object Classes Challenge 2012

Freiburg-Berkeley Motion Segmentation Dataset (FBMS-59)



Object Detection

Object Detection

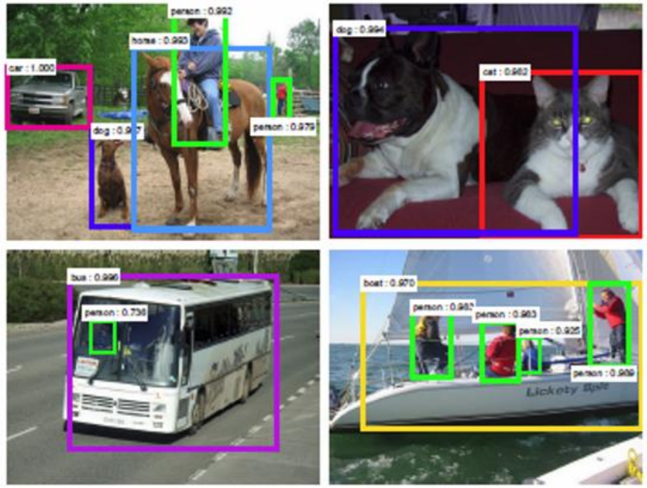
- Problem

–Given an image, find all objects and mark them up with bounding boxes and categories

- Sub-problems

–Object proposal

–Image Classification

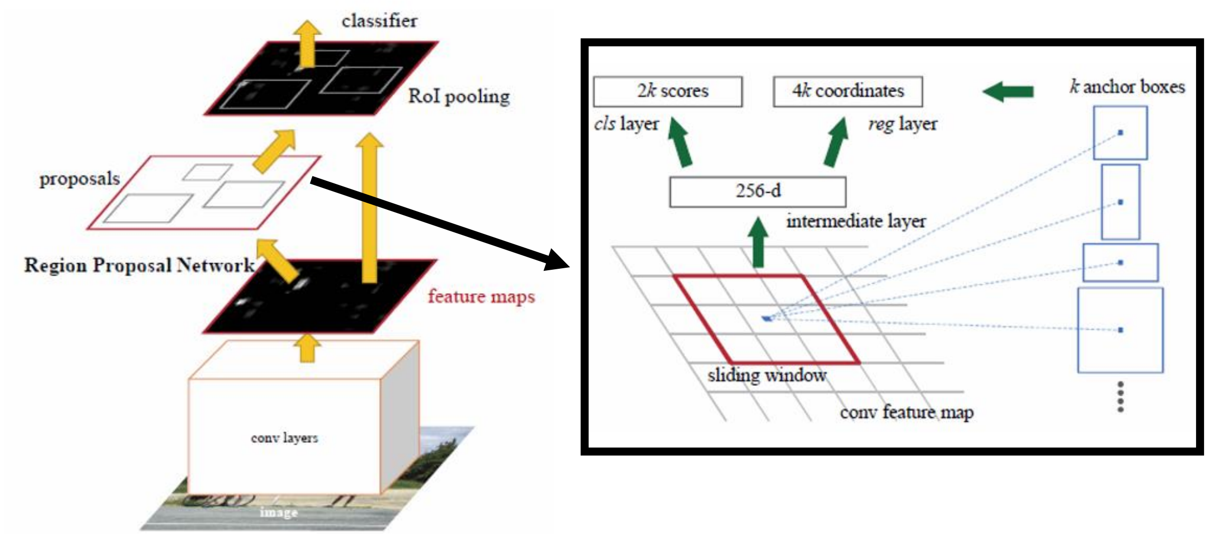


Example of detection results

Basic framework of object detection (FER)

Object Detection

- Framework of Faster R-CNN
  - Deep learning model
  - Shared CNN
  - Region Proposal Network
  - RoI pooling



Faster R-CNN, NIPS2015

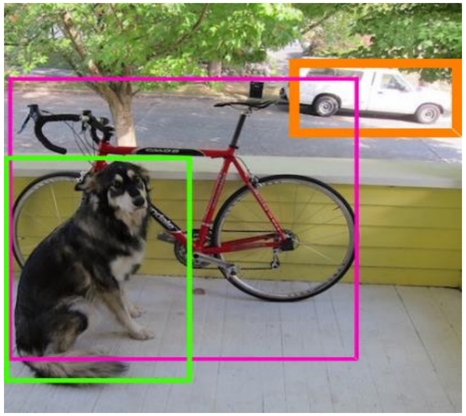
Object Detection

- Evaluation dataset
  - MIT Street Scenes

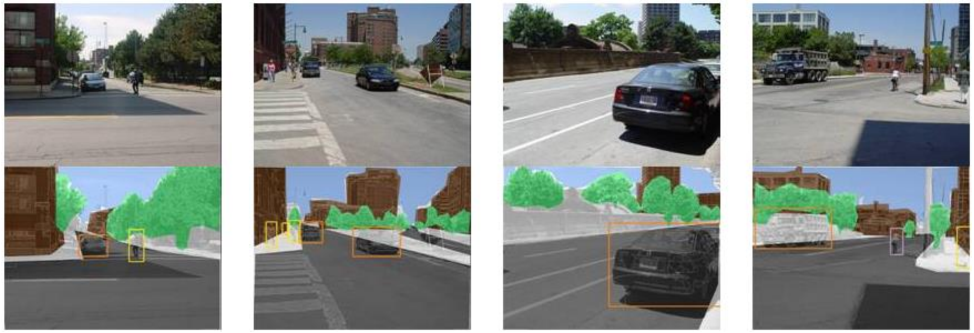
    http://cbcl.mit.edu/software-datasets/streetscenes/
  - PASCAL VOC dataset

    http://host.robots.ox.ac.uk/pascal/VOC/
  - KITTI dataset

    http://www.xrce.xerox.com/Our-Research/Computer-Vision/Proxy-Virtual-Worlds



Example of PASCAL VOC



Example of MIT Street Scenes

Example of KITTI

Object Detection

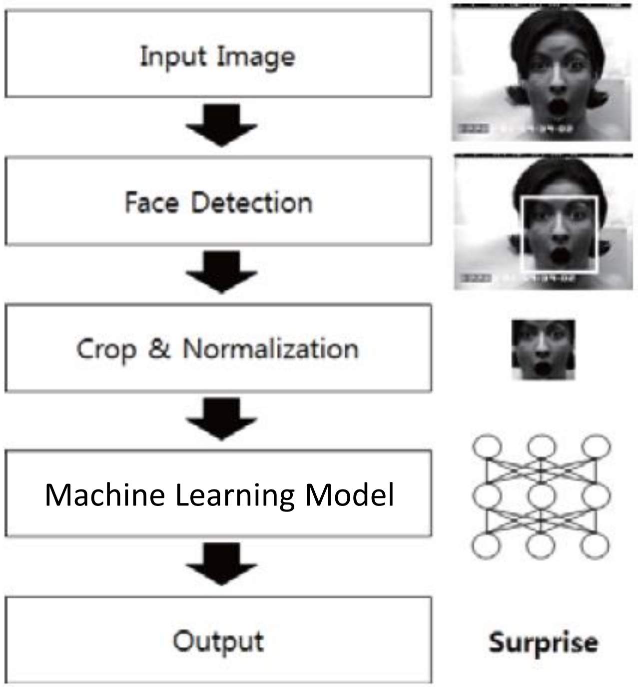
- Reference
  - Redmon, Joseph, et al. "You only look once: Unified, real-time object detection." *arXiv preprint arXiv:1506.02640* (2015).
  - Girshick, Ross. "Fast r-cnn." *Proceedings of the IEEE International Conference on Computer Vision*. 2015
  - Kye-Hyeon Kim, et al. "PVANET: Deep but Lightweight Neural Networks for Real-time Object Detection" arXiv:1608.08021.
  - Dai, Jifeng, et al. "R-FCN: Object Detection via Region-based Fully Convolutional Networks." *arXiv preprint arXiv:1605.06409* (2016).

- Tools
  - Caffe http://caffe.berkeleyvision.org/
  - Tensorflow https://www.tensorflow.org/
  - Torch http://torch.ch/

Facial Expression Recognition

Facial Expression Recognition

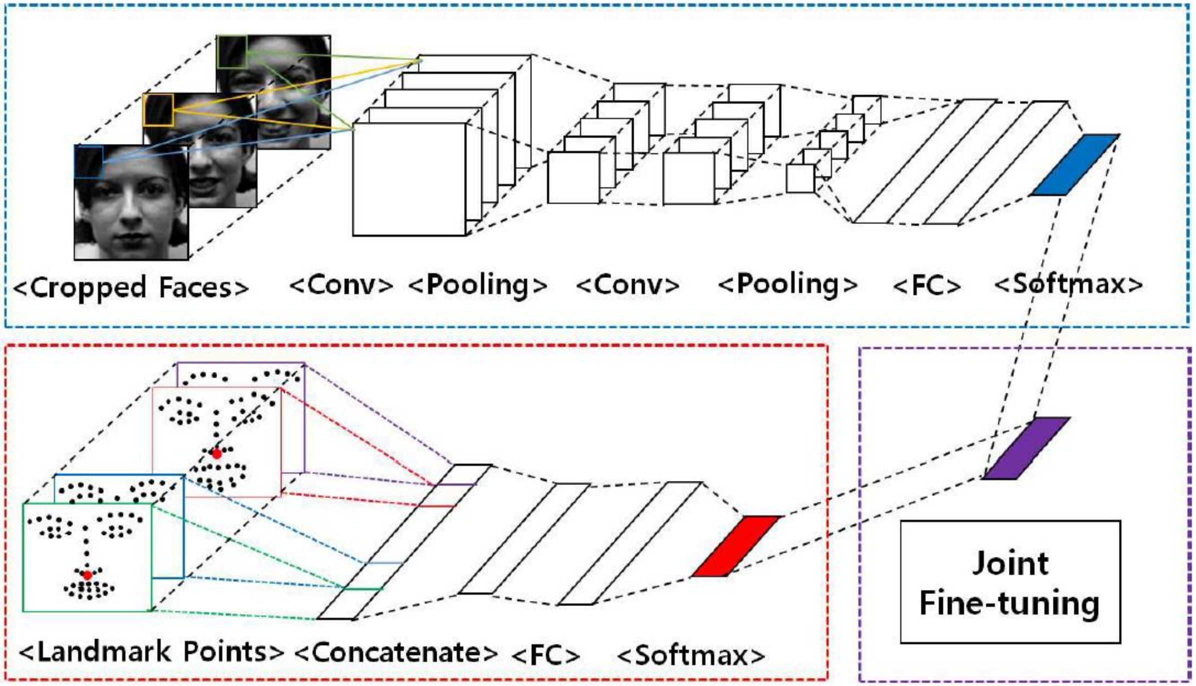
- Problem
  - Predict the emotion category (Anger, Disgust, Fear, Happiness, Sadness or Surprise) from a still-image or an image sequence
- Approaches
  - Image based framework
  - Sequence based framework
- Preprocess
  - Face detection
  - Face alignment



Basic framework of facial expression recognition (FER)

Facial Expression Recognition

- Framework of image sequence approach
  - Deep learning model
  - Appearance feature(CNN)
  - Geometry feature(NN)
  - Joint fine-tuning



Joint Fine-Tuning Method, ICCV2015

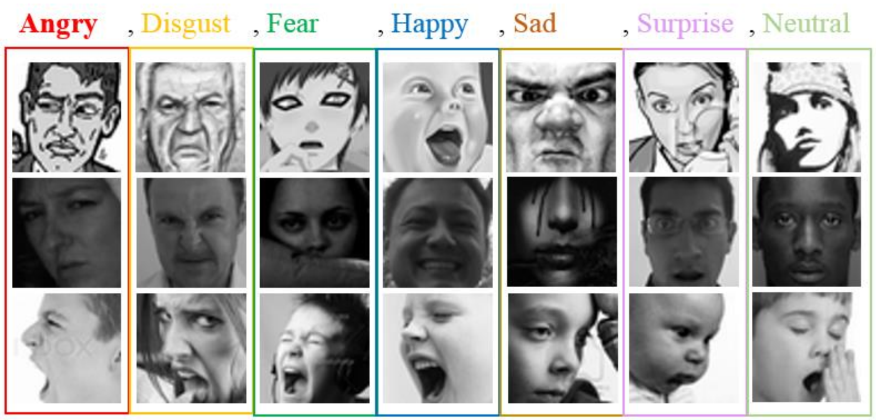
Facial Expression Recognition

- Evaluation dataset
  - JAFFE database

    http://www.kasrl.org/jaffe.html
  - The CK+ database

    http://www.consortium.ri.cmu.edu/ckagree/
  - FER2013 dataset

    https://www.kaggle.com/c/challenges-in-representation-learning-facial-expression-recognition-challenge/data



Example of the FER2013 dataset

Example of the JAFFE dataset

Example of the CK+ dataset

Facial Expression Recognition

- References

– Jung, Heechul, et al. "Joint fine-tuning in deep neural networks for facial expression recognition." *Proceedings of the IEEE International Conference on Computer Vision*. 2015.

– Zhao, Xiangyun, et al. "Peak-piloted deep network for facial expression recognition." *European Conference on Computer Vision*. Springer International Publishing, 2016.

– Fabian Benitez-Quiroz, C., Ramprakash Srinivasan, and Aleix M. Martinez. "EmotioNet: An accurate, real-time algorithm for the automatic annotation of a million facial expressions in the wild." *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*. 2016.

– Liu, Ping, et al. "Facial expression recognition via a boosted deep belief network." *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*. 2014.

- Tools

– Dlib C++ Library http://dlib.net/

– OpenCV http://opencv.org/

Gesture Recognition

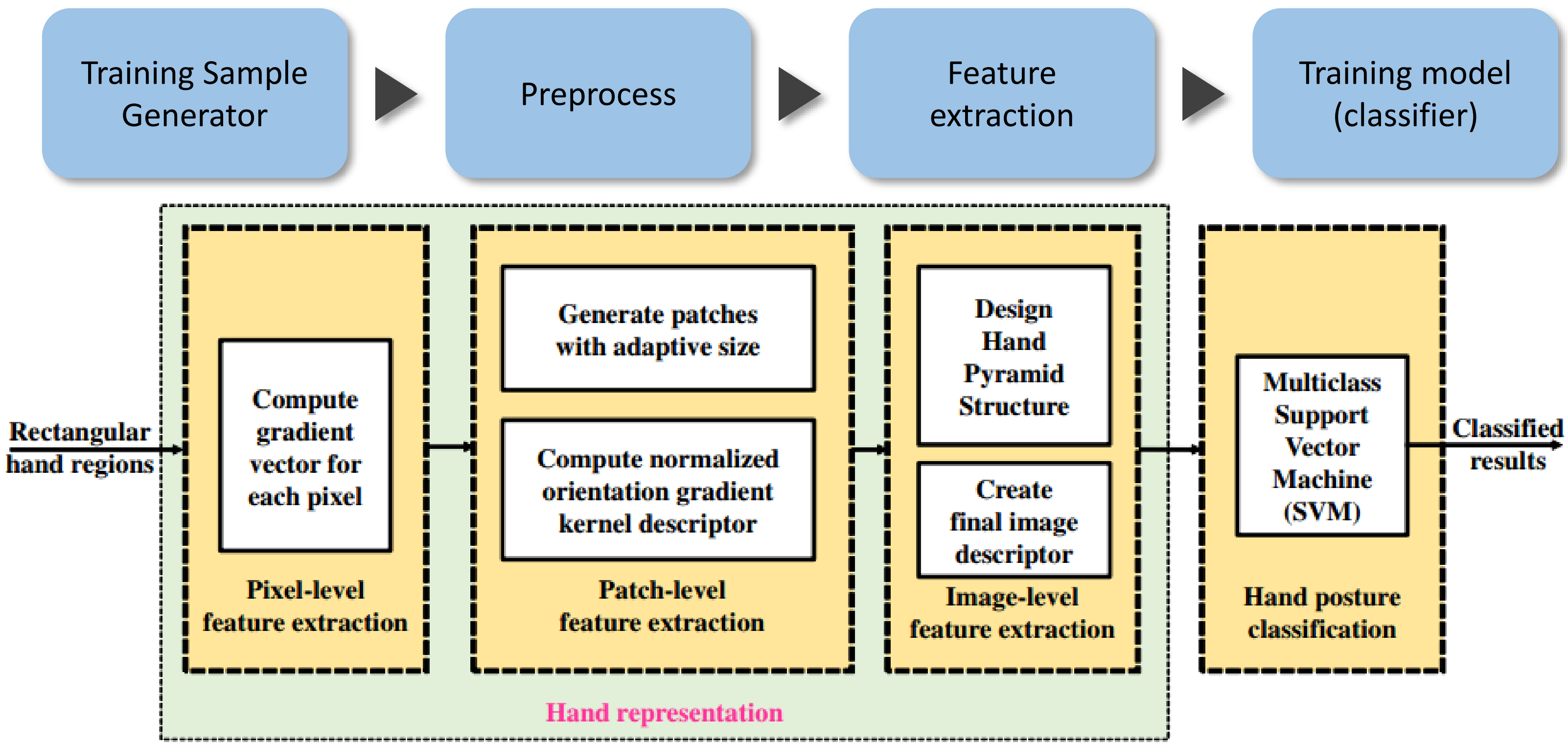
Gesture Recognition

- Problem description
  - Given depth or RGB images with a specific hand pose
  - The goal is to solve a classification problem that seeks the pre-defined gesture classes which is most similar to the input data

  - Sensor-based approach
  - Vision-based approach
    - Model-based approach
    - Appearance-based approach

Gesture Recognition

- Framework of hand posture recognition
  - Components
    - Training images
    - Testing images
    - Model



Gesture Recognition

- Datasets
  - Multimedia Technology and Telecommunications Laboratory, University of Padova
    - http://lttm.dei.unipd.it/downloads/gesture/
  - ICVL Hand Posture Dataset
    - http://www.iis.ee.ic.ac.uk/~dtang/hand.html
  - IEEE Computer Society Workshop on Observing and understanding hands in action (HANDS 2015)
    - http://www.ics.uci.edu/~jsupanci/HANDS-2015/#

Gesture Recognition

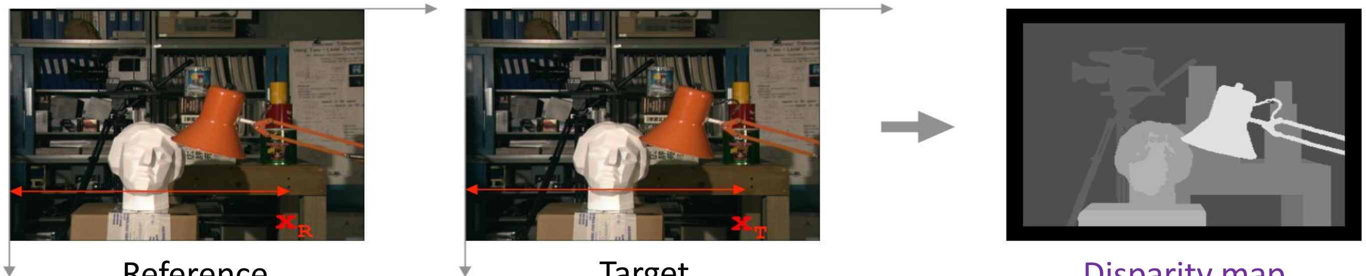
- References

  - G. Marin, F. Dominio, P. Zanuttigh, "Hand gesture recognition with Leap Motion and Kinect devices", IEEE International Conference on Image Processing (ICIP), Paris, France, 2014
  - G. Marin, F. Dominio, P. Zanuttigh, "Hand Gesture Recognition with Jointly Calibrated Leap Motion and Depth Sensor", Multimedia Tools and Applications, 2015
  - D. Tang, H.J. Chang*, A. Tejani*, T-K. Kim
    Latent Regression Forest: Structured Estimation of 3D Hand Posture, Proc. of IEEE Conf. on Computer Vision and Pattern Recognition (CVPR)
  - D. Tang, T.H. Yu and T-K. Kim
    Real-time Articulated Hand Pose Estimation using Semi-supervised Transductive Regression Forests, Proc. of IEEE Int. Conf. on Computer Vision (ICCV), Sydney, Australia, 2013
  - Van-Toi NGUYEN et al,A New Hand Representation Based on Kernels for Hand Posture Recognition

Stereo Matching

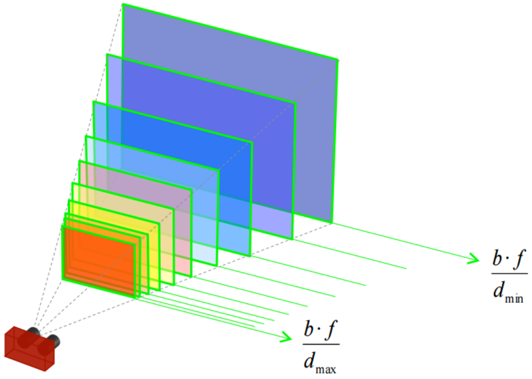
Stereo Matching

- Problem description
  - It is a technique aimed at inferring **depth** from two or more cameras.
  - The **disparity** is the difference between the $\mathbf{x}$ coordinate of two corresponding points.
    - It is typically encoded with greyscale image (closer points are brighter).



Reference Target Disparity map

- Depth measured by a stereo vision system is discretized into parallel planes (one for each disparity value)



Stereo Matching

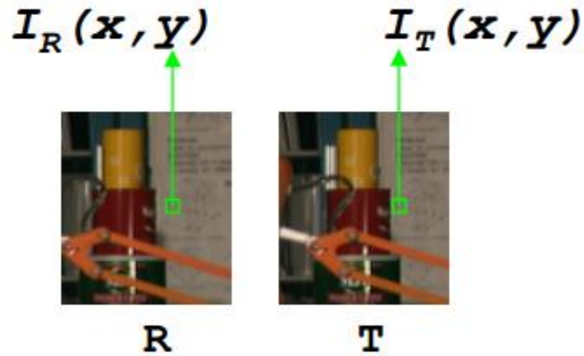
- According to [1] most stereo algorithms perform these steps:
    1. Matching cost computation
    2. Cost aggregation
    3. Disparity computation/optimization
    4. Disparity refinement
- Local algorithms
- Global algorithms

[1] System flowD. Scharstein and R. Szeliski, A taxonomy and evaluation of dense two-frame stereo correspondence algorithms Int. Jour. Computer Vision, 47(1/2/3):7–42, 2002

Stereo Matching

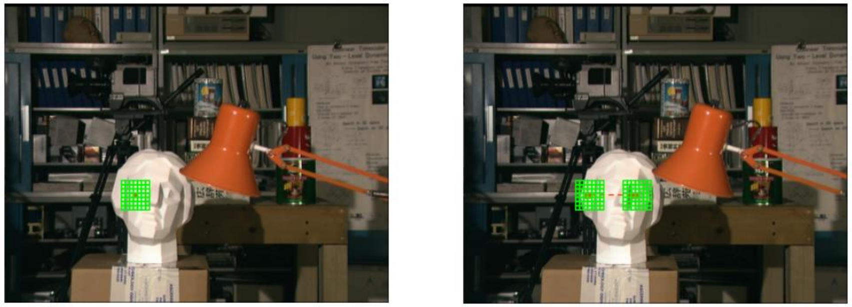
- Matching cost computation
  - Pixel-based matching costs
    - E.g. squared differences

$$E(x, y, d) = (I_R(x, y) - I_T(x + d, y))^2$$



- Cost aggregation
  - Sum of squared differences (SSD)
    - E.g. squared differences

$$\sum_{(x,y) \in w} (I_R(x, y) - I_T(x + d, y))^2$$



Reference Target

Stereo Matching

- Disparity computation/optimization
  - Energy function $E(d) = E_{data}(d) + E_{smooth}(d)$
  - Relevant approaches are:
    - Graph Cuts
    - Belief Propagation
- Disparity refinement
  - Raw disparity maps computed by correspondence algorithms contain outliers that must be identified and corrected
    - Sub-pixel interpolation
    - Image filtering techniques
    - Bidirectional Matching

Stereo Matching

- Evaluation & Datasets
  - Middlebury Stereo Datasets :
    - http://vision.middlebury.edu/stereo/data/
  - MPI Sintel Datasets :
    - http://sintel.is.tue.mpg.de/stereo

Stereo Matching

- References
  - Q. Yang, L. Wang, R. Yang, H. Stewénius, and D. Nistér. Stereo matching with color-weighted correlation, hierarchical belief propagation and occlusion handling. PAMI 2008.
  - X. Mei, X. Sun, M. Zhou, S. Jiao, H. Wang, and X. Zhang. On building an accurate stereo matching system on graphics hardware. GPUCV 2011.
  - Z. Wang and Z. Zheng. A region based stereo matching algorithm using cooperative optimization. CVPR 2008.
  - D. Scharstein and R. Szeliski, A taxonomy and evaluation of dense two-frame stereo correspondence algorithms
  - http://vision.deis.unibo.it/~smatt/Seminars/StereoVision.pdf
  - H. Ha. et al High-quality Depth from Uncalibrated Small Motion Clip

End

You can still choose other interesting topics