Chuyên Đề Công Nghệ
Convolutional Neural Networks

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Slide & Code: https://github.com/chupibk/INT3414_22

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Giới thiệu môn học

Tuần 1

Big questions

WHAT: CNN là gì?

WHERE: Vị trí của CNN trong KHMT?

WHY: Tại sao học CNN?

WHEN: CNN có từ bao giờ và đang đi tới đâu?

HOW: CNN hoạt động như thế nào?

Q1- WHAT

- Convolutional networks are simply neural networks that use convolution in place of general matrix multiplication in at least one of their layers
  - Convolution is a mathematical operation having a linear form

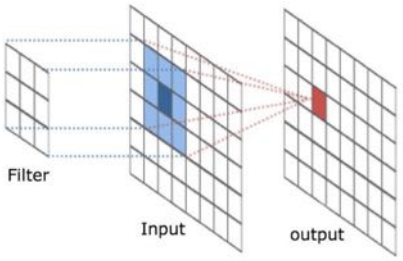

Image credit: internet

Q2- WHY

- Equip yourself with one of the most powerful and promising tools to solve various computer science tasks
- CNNs form the backbone of many modern AI systems

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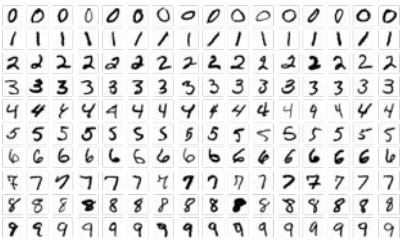
Q3- WHEN

- 1990s: LeCun et al. with MNIST



Graph Transformer Networks:
-> Gradient-based learning technique

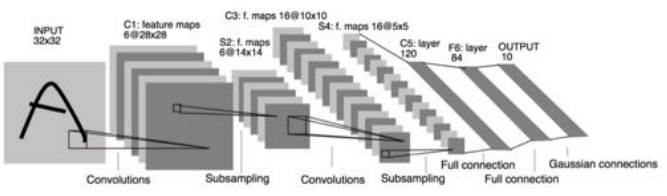


Fig. 2. Architecture of LeNet-5, a Convolutional Neural Network, here for digits recognition. Each plane is a feature map, i.e. a set of units whose weights are constrained to be identical.

Ref: LeCun, Yann, et al. "Gradient-based learning applied to document recognition." *Proceedings of the IEEE* 86.11 (1998): 2278-2324.

Q3 - WHEN

- 1990s – early 2000s: further work on CNN model
- 2012: a huge surge in popularity after AlexNet
  - Achieved state-of-the-art in ImageNet LSVRC-2010 challenge (1000 classes)
    - Krizhevsky, Alex, Ilya Sutskever, and Geoffrey E. Hinton. "Imagenet classification with deep convolutional neural networks." *Advances in neural information processing systems*. 2012.

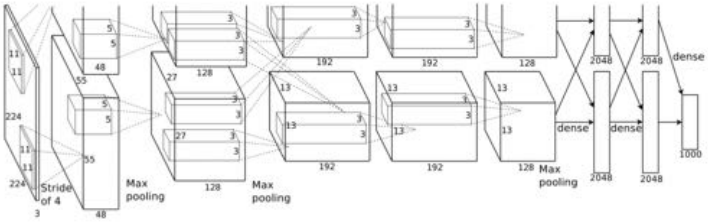
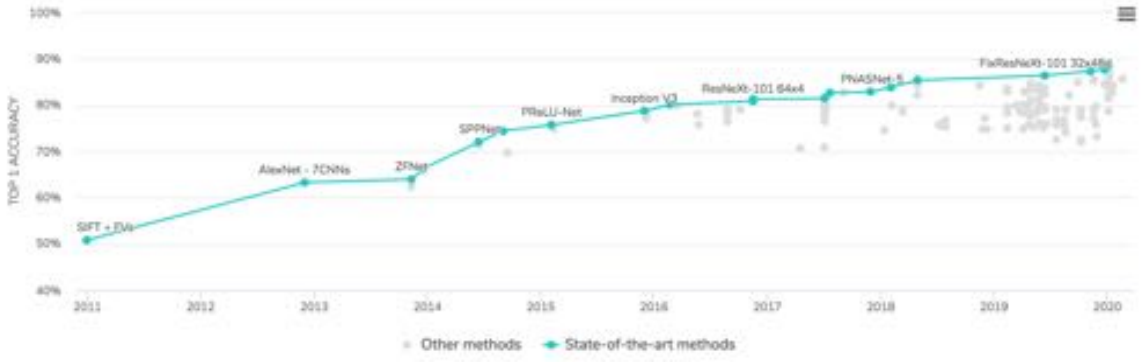


Image classification on ImageNet



Ref: https://paperswithcode.com/sota/image-classification-on-imagenet

Q4- WHERE

CNNs are everywhere

- Image retrieval
- Image classification
- Object detection
- Self-driving cars
- Semantic segmentation
- Face recognition
- Pose estimation
- Detect diseases
- Speech recognition
- Text processing
- Analyzing satellite data
- Music recommendation (e.g., Spotify)
- Photo Geolocation (Google's PlaNet)
- Etc...

Q5 – HOW: CNN hoạt động như thế nào?

- → là nội dung của môn học này

Mục tiêu môn học

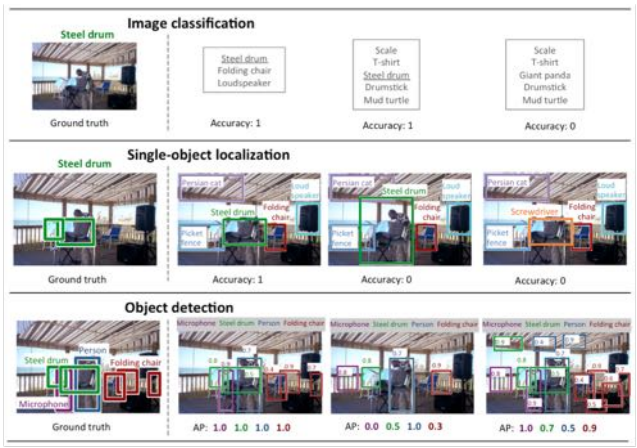
- Giới thiệu các mô hình học sâu end-to-end dùng trong thị giác máy
  - Image classification, Object detection, Segmentation
- Trang bị cho sinh viên khả năng cài đặt, huấn luyện và debug các mạng nơron

Schedule

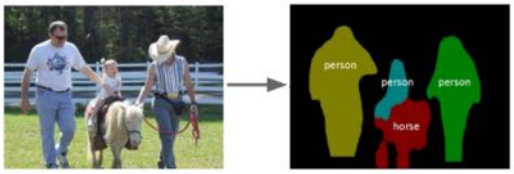
Week	Content	Class hour	Self-study hour
1	Introduction CNNs in Computer Vision	2	1
2	Foundations of CNNs Case study: Image classification problem	2	2-6
3	Training and tuning parameters Data augmentation - Data generator Model evaluation - Transfer learning	2	2-6
4	Object detection	2	2-6
5	Segmentation	2	2-6
6, 7	Mid-term presentations	2	2-6
8, 9	Advanced topics using CNNs	2	2-6
10, 11, 12	Final project presentations	1	2-6
13	Class summarization	1-3	open

Core tasks of Computer vision

Classification – Localization – Detection - Segmentation



Semantic segmentaiton



Instance segmentation

Ref: Russakovsky, Olga, et al. "Imagenet large scale visual recognition challenge." *International journal of computer vision* 115.3 (2015): 211-252.

Core tasks

Core CV Task	Task Description	Output	Metrics
Classification	Given an image, assign a label	Class Label	Accuracy
Localization	Determine the bounding box containing the object in the given image	Box given by (x1, y1, x2, y2)	Ratio of intersection to the union (Overlap) between the ground truth and bounding box
Object Detection	Given an image, detect all the objects and their locations in the image	For each object: (Label, Box)	Mean Avg Best Overlap (MABO,) mean Average Precision (mAP)
Semantic Segmentation	Given an image, assign each pixel to a class label, so that we can look at the image as a set of labelled segments	A set of image segments	Classification metrics, Intersection by Union overlap
Instance Segmentation	Same as semantic segmentation, but each instance of a segment class is determined uniquely	A set of image segments	

Classification + Localization task

Classification: C classes
Input: Image
Output: Class label
Evaluation metric: Accuracy

→ CAT

Localization:
Input: Image
Output: Box in the image (x, y, w, h)
Evaluation metric: Intersection over Union

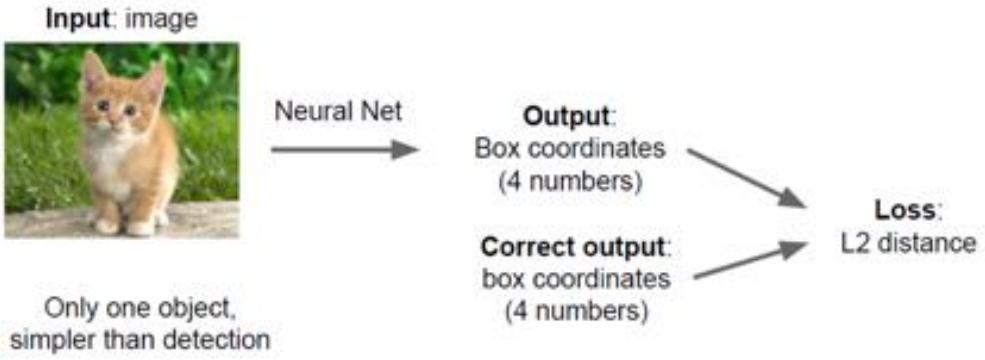
→ (x, y, w, h)

Classification + Localization: Do both

Slide Credit: A Karpathy, CS231n

How to do localization?

Idea: Localization as regression



Slide Credit: A Karpathy, CS231n

Học sâu vs học máy

Phương pháp cổ điển trong thị giác máy

- Color histogram
- Shape, texture feature vector
- Hashing
- Scale-invariant features (Haar-like)
- Deep learning features
- ...

Phương pháp học sâu: end-to-end

A CNN model

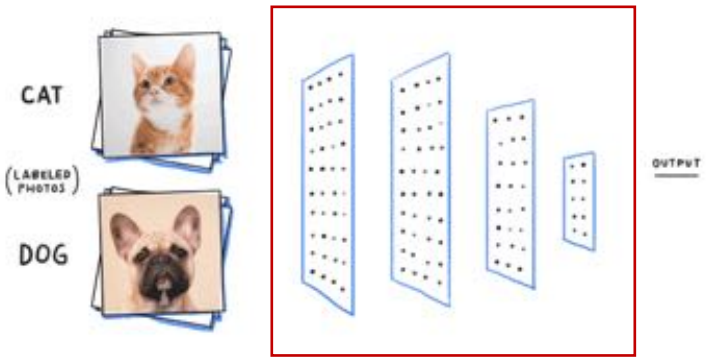


Image credit: https://becominghuman.ai/building-an-image-classifier-using-deep-learning-in-python-totally-from-a-beginners-perspective-be8dbaf22dd8

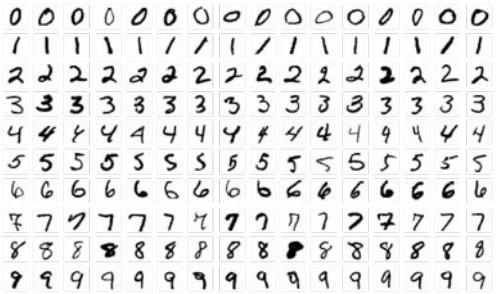
A quick demostration

https://playground.tensorflow.org/

Some applications

Image Classification: grayscale

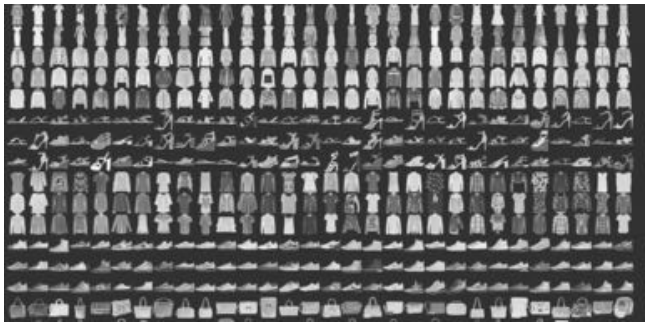
MNIST (LeCun et al., 1998)



10 classes

http://yann.lecun.com/exdb/mnist/

Fashion-MNIST (2017)



10 classes

https://github.com/zalandoresearch/fashion-mnist

Eyeglass detection

MeGlass, 2018

https://github.com/cleardusk/MeGlass

Dog breed identification

120 breeds

https://www.kaggle.com/c/dog-breed-identification

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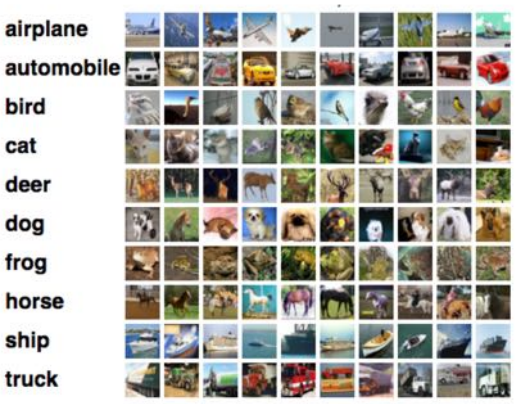
Image classification: tiny images

CIFAR-10 (Krizhevsky and Hinton, 2009)
32x32 size



CIFAR-100 (Krizhevsky and Hinton, 2009)

Superclass	Classes
aquatic mammals	beaver, dolphin, otter, seal, whale
fish	aquarium fish, flatfish, ray, shark, trout
flowers	orchids, poppies, roses, sunflowers, tulips
food containers	bottles, bowls, cans, cups, plates
fruit and vegetables	apples, mushrooms, oranges, pears, sweet peppers
household electrical devices	clock, computer keyboard, lamp, telephone, television
household furniture	bed, chair, couch, table, wardrobe
insects	bee, beetle, butterfly, caterpillar, cockroach
large carnivores	bear, leopard, lion, tiger, wolf
large man-made outdoor things	bridge, castle, house, road, skyscraper
large natural outdoor scenes	cloud, forest, mountain, plain, sea
large omnivores and herbivores	camel, cattle, chimpanzee, elephant, kangaroo
medium-sized mammals	fox, porcupine, possum, raccoon, skunk
non-insect invertebrates	crab, lobster, snail, spider, worm
people	baby, boy, girl, man, woman
reptiles	crocodile, dinosaur, lizard, snake, turtle
small mammals	hamster, mouse, rabbit, shrew, squirrel
trees	maple, oak, palm, pine, willow
vehicles 1	bicycle, bus, motorcycle, pickup truck, train
vehicles 2	lawn-mower, rocket, streetcar, tank, tractor

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

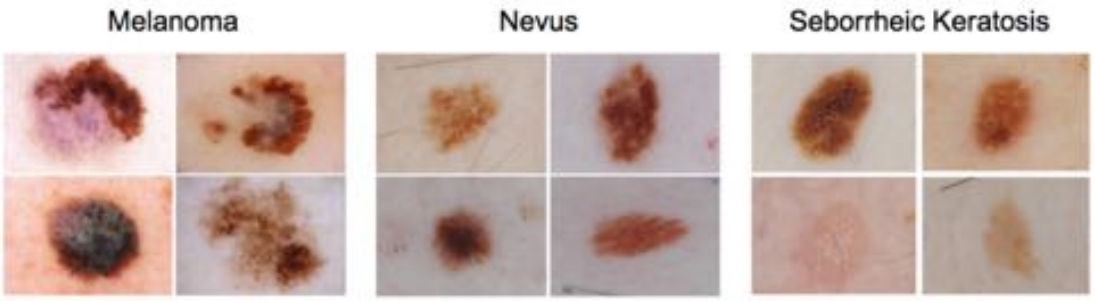
Image classification: large data

ImageNet (1000 classes) - Deng et al., 2009

http://www.image-net.org/

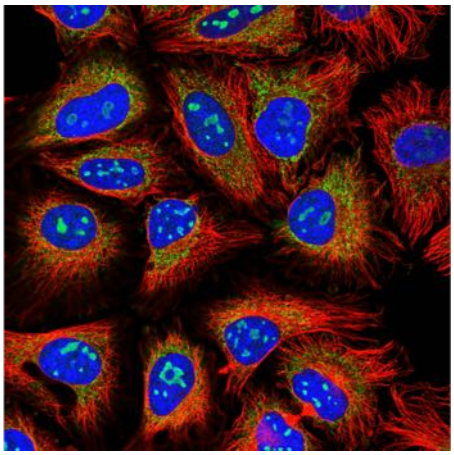
Image classification: medical image

ISIC2017, Skin lesion analysis toward melanoma detection



https://challenge.kitware.com/#phase/5840f53ccad3a51cc66c8dab

Human protein atlas image classification



28 classes:

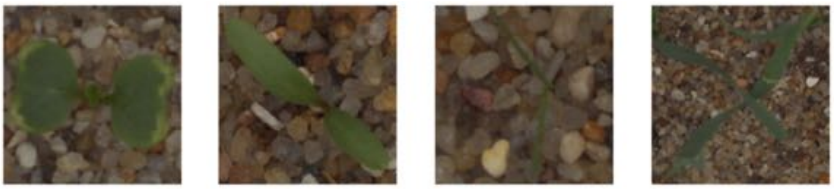
0. Nucleoplasm
1. Nuclear membrane
2. Nucleoli
3. Nucleoli fibrillar center
4. Nuclear speckles
5. Nuclear bodies
6. Endoplasmic reticulum
7. Golgi apparatus
8. Peroxisomes
9. Endosomes
10. Lysosomes
11. Intermediate filaments
12. Actin filaments
13. Focal adhesion sites
14. Microtubules
15. Microtubule ends
16. Cytokinetic bridge
17. Mitotic spindle
18. Microtubule organizing center
19. Centrosome
20. Lipid droplets
21. Plasma membrane
22. Cell junctions
23. Mitochondria
24. Aggresome
25. Cytosol
26. Cytoplasmic bodies
27. Rods & rings

https://www.kaggle.com/c/human-protein-atlas-image-classification/overview

Plant seedlings classification

Differentiate a weed from a crop seedling
960 plants, 12 species

1. Black-grass
2. Charlock
3. Cleavers
4. Common Chickweed
5. Common wheat
6. Fat Hen
7. Loose Silky-bent
8. Maize
9. Scentless Mayweed
10. Shepherds Purse
11. Small-flowered Cranesbill
12. Sugar beet



https://www.kaggle.com/c/plant-seedlings-classification/data

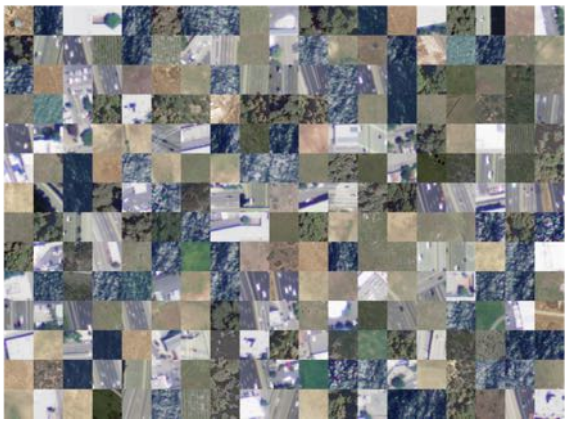
PlantDisease classification

38 classes

https://www.crowdai.org/challenges/1

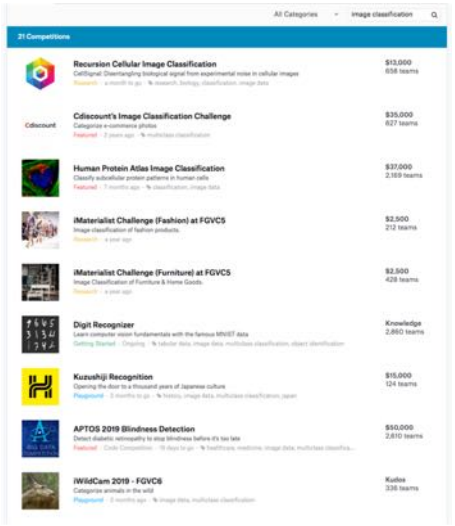
Image classification: satellite images

DeepSat SAT-4, four classes: barren land, trees, grassland, all land → red, green, blue and near infrared bands



https://www.kaggle.com/crawford/deepsat-sat4

And many others...



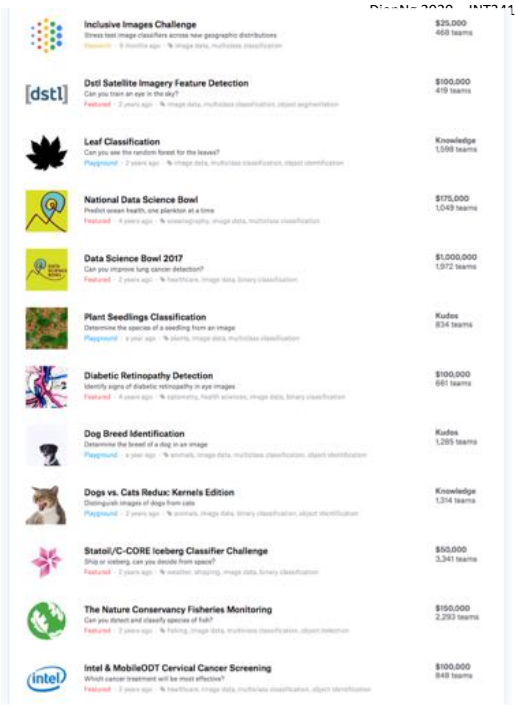
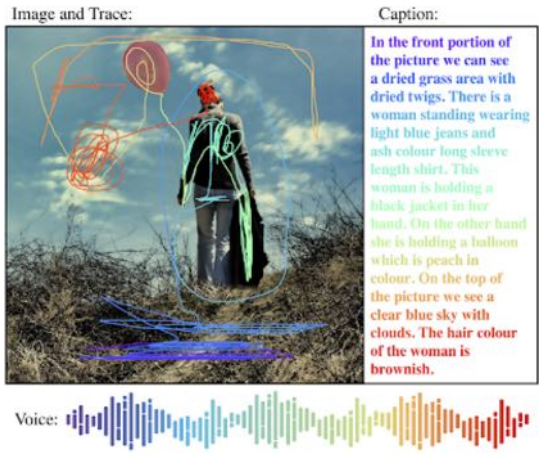


Image captioning



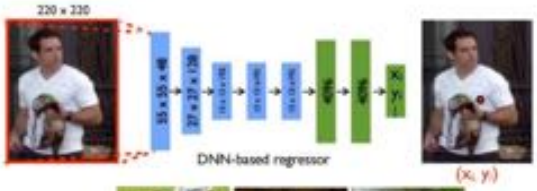
Source: https://ai.googleblog.com/

Human Pose Estimation

Represent a person by K joints

Regress (x, y) for each joint from last fully-connected layer of AlexNet

(Details: Normalized coordinates, iterative refinement)



Toshev and Szegedy, "DeepPose: Human Pose Estimation via Deep Neural Networks", CVPR 2014

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Object detection

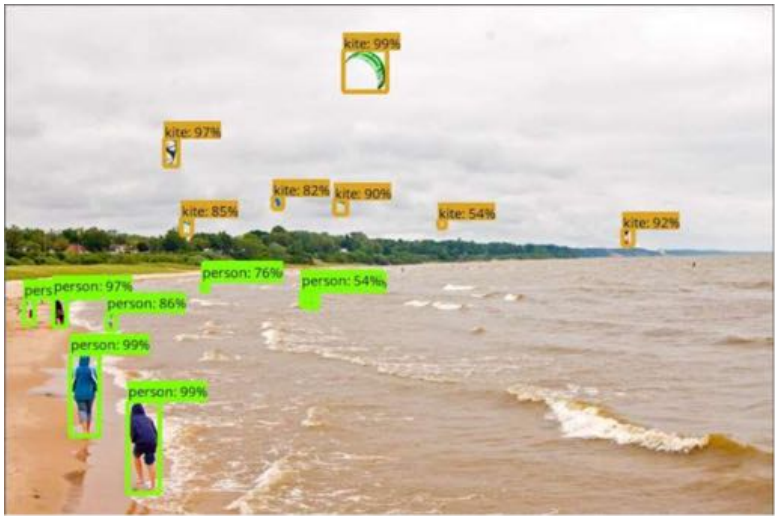


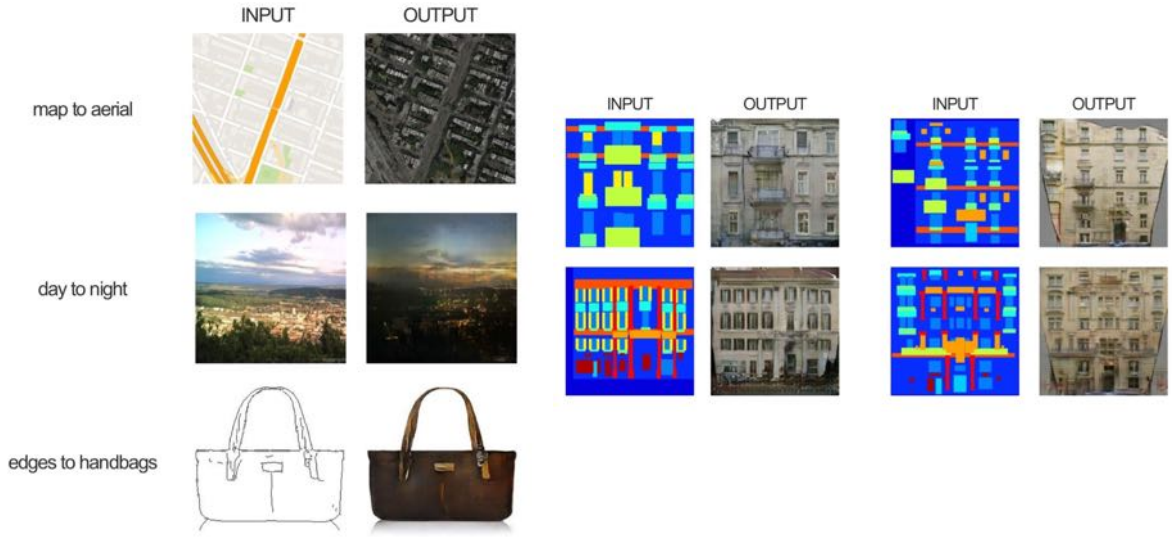
Image Q&A

https://arxiv.org/pdf/1612.00837.pdf

Video Q&A

https://www.youtube.com

Image-to-Image Translation



https://affinelayer.com/pix2pix/

Image generation

Style transfer

https://github.com/junyanz/CycleGAN

Thông tin về môn học

Chính sách đối với môn học

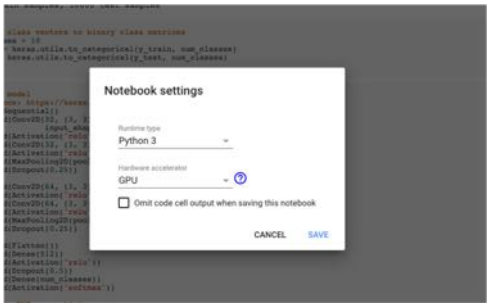
- Sinh viên nghỉ quá 20% số buổi học lý thuyết (3 buổi học) sẽ không được thi cuối kỳ
  - ~~Mỗi buổi học sẽ có điểm danh~~
- Sinh viên tích cực làm bài tập, tham gia thảo luận, trả lời câu hỏi sẽ được xem xét cộng điểm
- Với các nội dung liên quan tới bài tập giữa kì và đồ án môn học nếu sinh viên gian lận thì sẽ bị điểm môn học là 0

Trọng số điểm

Hình thức	Phương pháp	Mục đích	Trọng số
Đồ án môn học	Dự án nhỏ làm việc theo nhóm	Đánh giá kỹ năng lập trình, xây dựng hệ thống dịch vận dụng kiến thức đã học	50%
Chuyên cần	Điểm danh	Đánh giá tính chuyên cần của sinh viên	+
Bài tập giữa kỳ	Nộp bài luận	Kiểm tra khả năng tự học của sinh viên	50%
Tổng			100%

Thư viện và ngôn ngữ lập trình sử dụng

- Ngôn ngữ: Python
- Thư viện chính: Pytorch
- Tuy nhiên sinh viên có thể lựa chọn các thư viện mạng học sâu khác
  - Keras, Tensorflow, Theano, v.v...
- Khuyến khích
  - Sử dụng Google Colab
  - Lập trình với Jupyter Notebook



Tài liệu tham khảo

- CS231n Convolutional Neural Networks for Visual Recognition
  - http://cs231n.github.io/
- Jeremy Howard & Rachel Thomas
  - http://course.fast.ai
- Deeplearning.ai Course 4
  - https://www.youtube.com/watch?v=ArPaAX_PhIs&list=PLkDaE6sCZn6Gl29AoE31iwdVwSG-KnDzF
  - Or https://www.coursera.org/learn/convolutional-neural-networks
- https://pytorch.org/tutorials/