Artificial Intelligence
Advanced Topics in AI & ML
Deep Learning Applications: Computer Vision, Speech Recognition

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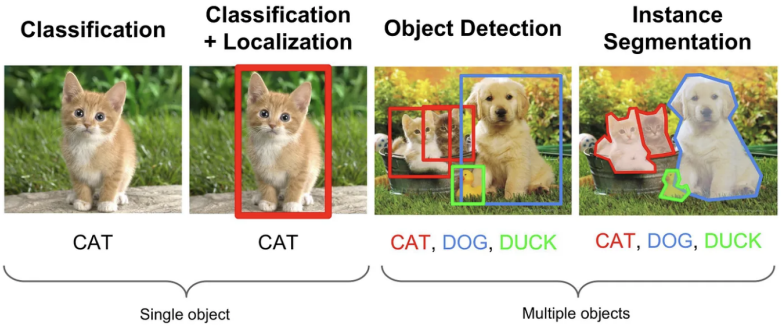
ML Research

Content

Content

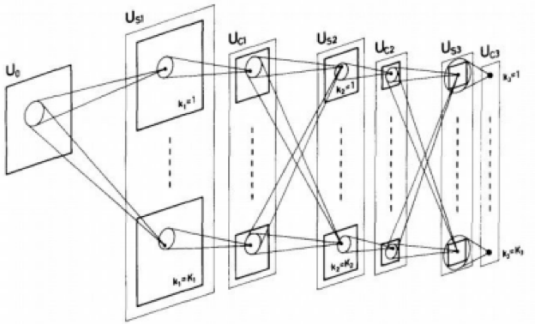
Computer Vision

- Computer Vision (CV): Direction targeted to analyze vision information: mostly images and videos
- Most common CV directions: **classification**, **detection**, **segmentation**
- Main research is concentrated around architectures of CV models: Convolutional Neural Networks (CNN)
- Read material: link



The CNN Basis: Neocognitron[1]

- Fukushima in **1979** proposed an almost modern method for constructing the architecture of neural networks, which he borrowed from the model of the primary visual cortex
- Two types of neurons:
  - Simple, responsible for local characteristics
  - Complex, responsible for compensating for distortion
  - Organized into a cascade structure SCSCSC...
  - In a convolutional network, S=convolution, C=subsampling

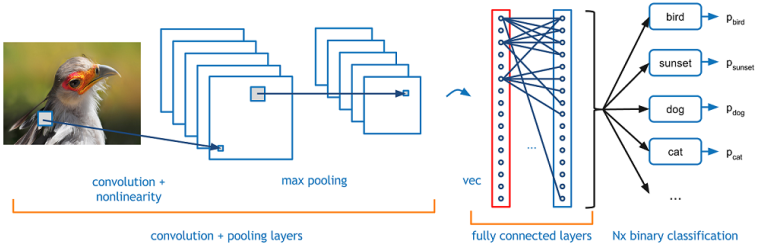


- The main disadvantage: no backpropagation method was proposed for training

[1] Wiki

CNNs

- CNN main operation: **Convolution** that is (spatially) translation-invariant
- CNN-related: Pooling operation, reducing the spatial size and keeping the most important features
- Now Visual Transformers (e.g., ViT[2]) ar on par with CNNs
- Read material: link



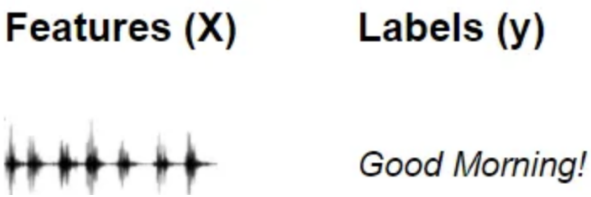
[2] An Image is Worth 16x16 Words: Transformers for Image Recognition at Scale

Image Enhancement

- A very important problem for many applications (e.g. in a smartphone): Image Enhancement
- Relevant tasks: image super-resolution, removal of blur (motion and defocus), image reconstruction (noise removal)
- Read material (*optional*): link

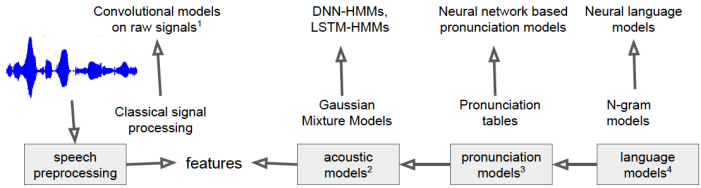
Speech Recognition

- Automatic Speech Recognition (ASR): Direction targeted to map a sequence of audio inputs to text outputs
- ASR mains differences with CV: 1) temporal sequence; 2) can benefit from signal pre-processing (like Fourier Transform, Mel-Frequency Cepstral Coefficients, etc.)
- Main research is concentrated around architectures of ASR models and how to omit pre-processing stage
- Read material: link



ASR History

- The first really working prototype was based on Hidden Markov Models[3] invented in 1960s and applied to speech recognition in 1970s
- ASR became popular after incorporation of Digital Assistants ("OK Google", Siri, Alexa, etc)
- Now the state-of-the-art models are based on Neural Nets
- Read material: link



[3] Wiki

Takeaway notes

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2. Computer vision is based on CNNs and Vision Transformers
3. Main tasks in CV are classification, detection, and segmentation
4. ASR has a long history starting with HMMs
5. CV and ASR are now working on par or better than human-based!

Thank you!