Successful applications

Examples of successful applications

Ckeck the State of the Art site (papers with code)

Examples of successful applications

- **Image Processing**
  - Image Classification and Detection
  - Object Detection
  - Image Segmentation
  - Style transfer
- **Natural Language Processing**
  - Language modeling
  - Text processing (translation, summarization, question answering, . . .)
- **Generative modeling**
  - generative models: GANs, VAEs, Cycle Gans, diffusion, . . .
  - conditional generation
  - representation learning, latent space exploration

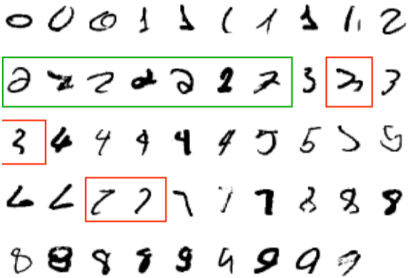
Next argument

Image Processing

MNIST

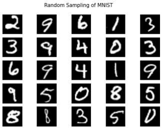
Modified National Institute of Standards and Technology database

- grayscale images of handwritten digits, 28×28 pixels each
- 60,000 training images and 10,000 testing images



MNIST

A comparison of different techniques



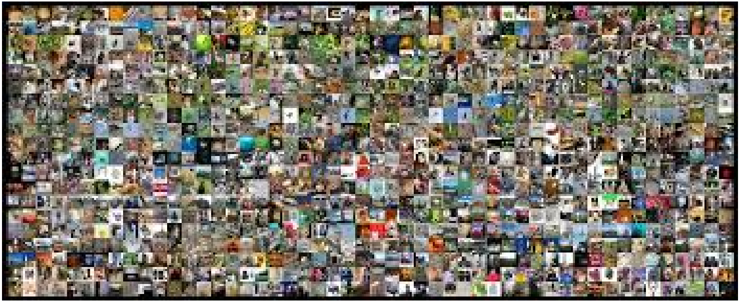
Classifier	**Error rate**
Linear classifier	7.6
K-Nearest Neighbors	0.52
SVM	0.56
Shallow neural network	1.6
Deep neural network	0.35
Convolutional neural network	0.21

See LeCun's page the mnist database for more data.

ImageNet

ImageNet (@Stanford Vision Lab)

- high resolution color images covering 22K object classes
- over 15 million labeled images from the web



ImageNet competition

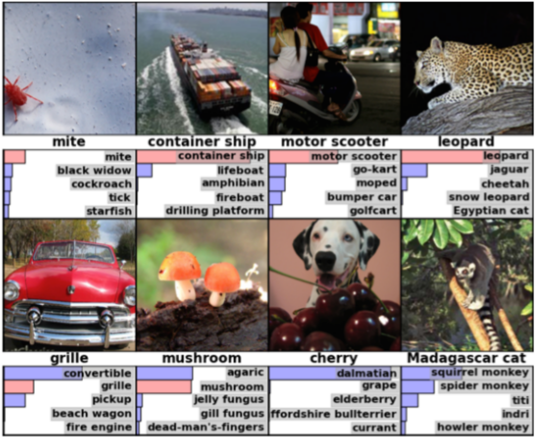
Annual competition of image classification: 2010-2017.

- 1.2 Million images, covering 1K different categories
- make five guesses about image label, ordered by confidence

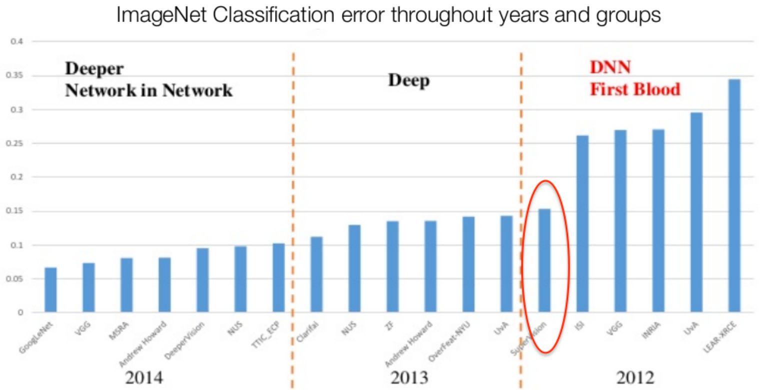
EntleBucher

Appenzeller

ImageNet samples



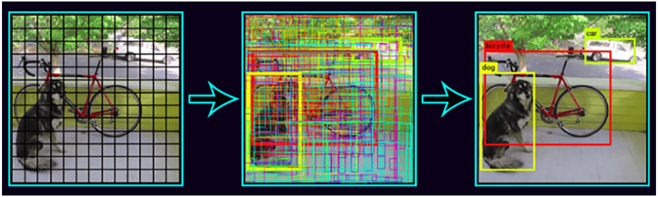
ImageNet results



Li Fei-Fei: ImageNet Large Scale Visual Recognition Challenge, 2014 http://image-net.org/

Object Detection

YOLO: Real-Time Object Detection



You only look once (YOLO) is a state-of-the-art, real-time object detection system. On a Pascal Titan X it processes images at 30 FPS and has a mAP of 57.9% on COCO test-dev.

First release in 2016, now at version 7.

Image Segmentation - Scene understanding

Video-to-Video Synthesis

Style Transfer

A neural algorithm of artistic style

L.A. Gatys, A.S. Ecker, M. Bethge

Change the style of an image, preserving the content.

Next argument

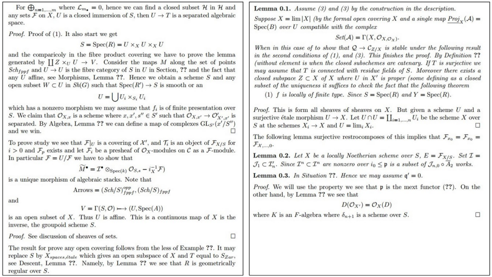
Natural Language Processing

Language Modeling

Predict the next character in a document (self-supervised)

First attempts with RNN (LSTM), now done with **Transformers**

Suggested reading: Andrej Karpathy's blog The Unreasonable Effectiveness of Recurrent Neural Networks (old but still inspiring)



For $\bigoplus_{n=1,\dots,m}$ where $\mathcal{L}_{m_\bullet} = 0$, hence we can find a closed subset $\mathcal{H}$ in $\mathcal{H}$ and any sets $\mathcal{F}$ on X, U is a closed immersion of S, then $U \to T$ is a separated algebraic space.

Proof. Proof of (1). It also start we get

$$S = \mathrm{Spec}(R) = U \times_X U \times_X U$$

and the comparicoly in the fibre product covering we have to prove the lemma generated by $\coprod Z \times_U U \to V$. Consider the maps M along the set of points Sch_{fppf} and $U \to U$ is the fibre category of S in U in Section, **??** and the fact that any U affine, see Morphisms, Lemma **??**. Hence we obtain a scheme S and any open subset $W \subset U$ in $Sh(G)$ such that $\mathrm{Spec}(R') \to S$ is smooth or an

$$U = \bigcup U_i \times_{S_i} U_i$$

which has a nonzero morphism we may assume that f_i is of finite presentation over S. We claim that $\mathcal{O}_{X,x}$ is a scheme where $x, x', s'' \in S'$ such that $\mathcal{O}_{X,x'} \to \mathcal{O}'_{X',x'}$ is separated. By Algebra, Lemma **??** we can define a map of complexes $\mathrm{GL}_{S'}(x'/S'')$ and we win. □

To prove study we see that $\mathcal{F}|_U$ is a covering of $\mathcal{X}'$, and $\mathcal{T}_i$ is an object of $\mathcal{F}_{X/S}$ for $i > 0$ and $\mathcal{F}_p$ exists and let $\mathcal{F}_i$ be a presheaf of $\mathcal{O}_X$-modules on $\mathcal{C}$ as a $\mathcal{F}$-module. In particular $\mathcal{F} = U/\mathcal{F}$ we have to show that

$$\widetilde{M}^\bullet = \mathcal{I}^\bullet \otimes_{\mathrm{Spec}(k)} \mathcal{O}_{S,s} - i_X^{-1}\mathcal{F})$$

is a unique morphism of algebraic stacks. Note that

$$\mathrm{Arrows} = (Sch/S)^{opp}_{fppf}, (Sch/S)_{fppf}$$

and

$$V = \Gamma(S, \mathcal{O}) \longmapsto (U, \mathrm{Spec}(A))$$

is an open subset of X. Thus U is affine. This is a continuous map of X is the inverse, the groupoid scheme S.

Proof. See discussion of sheaves of sets. □

The result for prove any open covering follows from the less of Example **??**. It may replace S by $X_{spaces,étale}$ which gives an open subspace of X and T equal to S_{Zar}, see Descent, Lemma **??**. Namely, by Lemma **??** we see that R is geometrically regular over S.

Lemma 0.1. *Assume (3) and (3) by the construction in the description.*

Suppose $X = \lim |X|$ *(by the formal open covering* X *and a single map* $\underline{Proj}_X(\mathcal{A}) = \mathrm{Spec}(B)$ *over* U *compatible with the complex*

$$Set(\mathcal{A}) = \Gamma(X, \mathcal{O}_{X,\mathcal{O}_X}).$$

When in this case of to show that $\mathcal{Q} \to \mathcal{C}_{Z/X}$ *is stable under the following result in the second conditions of (1), and (3). This finishes the proof. By Definition* **??** *(without element is when the closed subschemes are catenary. If* T *is surjective we may assume that* T *is connected with residue fields of* S. *Moreover there exists a closed subspace* $Z \subset X$ *of* X *where* U *in* X' *is proper (some defining as a closed subset of the uniqueness it suffices to check the fact that the following theorem*

(1) f *is locally of finite type. Since* $S = \mathrm{Spec}(R)$ *and* $Y = \mathrm{Spec}(R)$.

Proof. This is form all sheaves of sheaves on X. But given a scheme U and a surjective étale morphism $U \to X$. Let $U \cap U = \coprod_{i=1,\dots,n} U_i$ be the scheme X over S at the schemes $X_i \to X$ and $U = \lim_i X_i$. □

The following lemma surjective restrocomposes of this implies that $\mathcal{F}_{x_0} = \mathcal{F}_{x_0} = \mathcal{F}_{\mathcal{X},\dots,0}$.

Lemma 0.2. *Let* X *be a locally Noetherian scheme over* S, $E = \mathcal{F}_{X/S}$. *Set* $\mathcal{I} = \mathcal{J}_1 \subset \mathcal{I}'_n$. *Since* $\mathcal{I}^n \subset \mathcal{I}^n$ *are nonzero over* $i_0 \leq \mathfrak{p}$ *is a subset of* $\mathcal{J}_{n,0} \circ \overline{A}_2$ *works.*

Lemma 0.3. *In Situation* **??**. *Hence we may assume* $\mathfrak{q}' = 0$.

Proof. We will use the property we see that $\mathfrak{p}$ is the mext functor (**??**). On the other hand, by Lemma **??** we see that

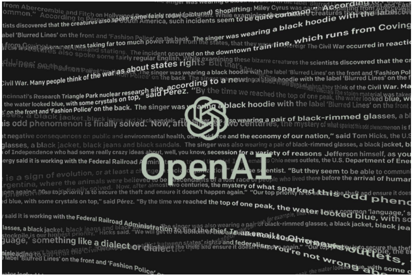
$$D(\mathcal{O}_{X'}) = \mathcal{O}_X(D)$$

where K is an F-algebra where δ_{n+1} is a scheme over S. □

Examples of fake algebraic documents generated by a RNN.

Transformers

RNNs have been replaced by **Transformers**, based on a mechanism called **attention**
See Bert, Albert, GPT, (now extended to ChatGPT) ...



GPT2 is a huge model, with 1.2 billion parameters, trained over 8 million web pages.

Other applications in NLP

- Sentiment analysis. Classify a document according to its "polarity"
- Machine Translation
- Text summarization/completion
- Text Generation: a truly generative task
- Speech recognition
- Dialog Systems - Chatboxes

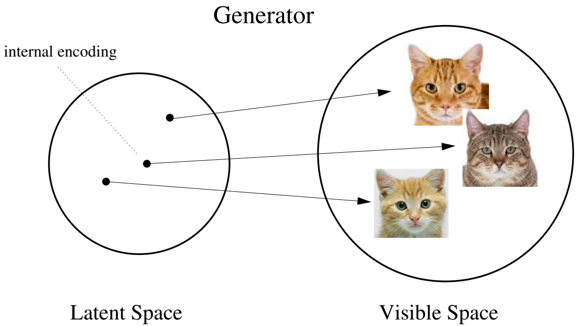
Generative Modeling

Generative Modeling

Goal: Generate new samples similar to training data.

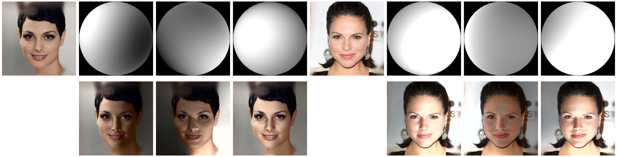
Face generation video by Nvidia

Latent space

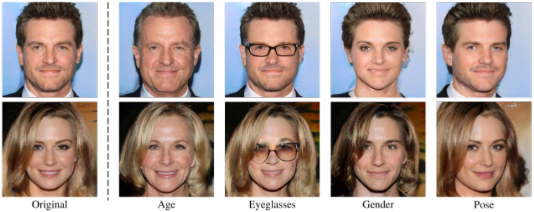


Suggested reading:
Comparing the latent space of generative models

Conditional generation

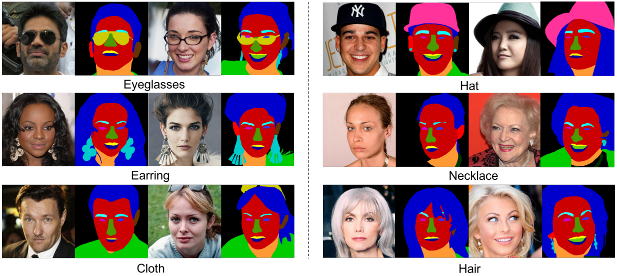


Deep Single Image Portrait Relighting



Interpreting the Latent Space of GANs for Semantic Face Editing

Conditional generation



MaskGAN: Towards Diverse and Interactive Facial Image Manipulation

Dall·E - OpenAI

Dall·E is a new AI system that can create realistic images and art from a description in natural language.