Self-supervised Learning Framework

Self-supervised Learning Framework

Pre-train

Self-supervised Learning Framework

Auto-encoder

Self-supervised

Learned by tasks not requiring label data

Model for Task 1

Model for Task 2

Model for Task 3

Downstream Tasks
Outline

Basic Idea of Auto-encoder

Feature Disentanglement

Discrete Latent Representation

More Applications
Auto-encoder

Unlabeled Images

Sounds familiar? We have seen the same idea in Cycle GAN. 😊

As close as possible (reconstruction)

high dim

old feature

NN Encoder

Vector

NN Decoder

low dim (bottleneck)

Dimension reduction

Embedding, Representation, Code

New feature for downstream tasks
More Dimension Reduction

(not based on deep learning)

https://youtu.be/iwh5o_M4BNU

PCA

https://youtu.be/GBUEjkpoxXc

t-SNE
Why Auto-encoder?
Why Auto-encoder?

As close as possible (reconstruction)

3 x 3 → NN Encoder → 2 dim → NN Decoder → 3 x 3

Find pattern, and then compress
Why Auto-encoder?
Auto-encoder is not a new idea

De-noising Auto-encoder

As close as possible

Add noises

NN Encoder

vector

NN Decoder

The idea sounds familiar? 😊

Review: BERT

A de-noising auto-encoder

Encoder

Decoder

Add noise

Embedding

Linear

Reconstruction

minimize cross entropy

softmax
Outline

Basic Idea of Auto-encoder

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More Applications
Representation includes information of different aspects

**Encoder** → **Decoder**

- **input image**: object, texture ...
- **input audio**: content, speaker ...
- **input sentence**: syntax, semantic ...

**reconstructed**
Feature Disentangle

input audio → Encoder → Decoder → reconstructed
content, speaker ...

input audio → Encoder → Decoder → reconstructed
content information
speaker information

https://arxiv.org/abs/1804.02812
Application: Voice Conversion
In the past

Speaker A
How are you?
Good morning

Speaker B
How are you?
Good morning

Today

Speaker A
天気真好
再見囉

Speaker B
How are you?
Good morning

Speakers A and B are talking about completely different things.
Application: Voice Conversion

Encoder

How are you?

Decoder

Hello

Encoder

Hello

Decoder

Hello
Application: Voice Conversion

How are you?

Encoder

Encoder

Decoder

Hello

How are you?
Application: Voice Conversion

Encoder

Do you ... Ph.D.?

Decoder

Japanese

Do you ... Ph.D.?

感謝解正平同學提供實驗結果

Do you ... Ph.D.?
Application: Voice Conversion

Do you … Ph.D.?

感谢解正平同学提供实验结果
Outline

Basic Idea of Auto-encoder

Feature Disentanglement

Discrete Latent Representation

More Applications
Discrete Representation

Real numbers

One-hot

Binary

glasses
female

Real numbers

Female
glasses
class
Discrete Representation

- Vector Quantized Variational Auto-encoder (VQVAE)

For speech, the codebook represents phonetic information.
Text as Representation

Only need a lot of documents to train the model

Unsupervised Summarization

https://arxiv.org/abs/1810.02851

Seq2seq2seq

auto-encoder

document

word sequence

Summary?

document

Seq2seq

Seq2seq
Text as Representation

Human written summaries

Let discriminator considers my output as real

Real or not

Discriminator

document

Seq2seq

word sequence

Readable

Summary?

Seq2seq

document

This is cycle GAN 😊
Text as Representation

• **Document:** 澳大利亞今天與13個國家簽署了反興奮劑雙邊協議，旨在加強體育競賽之外的藥品檢查並共享研究成果 ......

• **Summary:**
  - **Human:** 澳大利亞與13國簽署反興奮劑協議
  - **Unsupervised:** 澳大利亞加強體育競賽之外的藥品檢查

• **Document:** 中華民國奧林匹克委員會今天接到一九九二年冬季奧運會邀請函，由於主席張豐緒目前正在中南美洲進行友好訪問，因此尚未決定是否派隊赴賽 ......

• **Summary:**
  - **Human:** 一九九二年冬季奧運會函邀我參加
  - **Unsupervised:** 奧委會接獲冬季奧運會邀請函
Text as Representation

• **Document:** 據此間媒體27日報道,印度尼西亞蘇門答臘島的兩個省近日來連降暴雨,洪水泛濫導致塌方,到26日為止至少已有60人喪生,100多人失蹤 ..... 

• **Summary:**
  • **Human:** 印尼水災造成60人死亡
  • **Unsupervised:** 印尼門洪水泛濫導致塌雨

• **Document:** 安徽省合肥市最近為領導幹部下基層做了新規定:一律輕車簡從,不準搞迎來送往、不準搞層層陪同 ..... 

• **Summary:**
  • **Human:** 合肥規定領導幹部下基層活動從簡
  • **Unsupervised:** 合肥領導幹部下基層做搞迎來送往規定:一律簡
Tree as Embedding

Inference Model $q_\phi(z | x)$

Reconstruction Model $p_\theta(x | z)$

Structured Latent Semantic Space (MRs)

Sort my list in descending order

https://arxiv.org/abs/1806.07832

Outline

- Basic Idea of Auto-encoder
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- More Applications
Generator

As close as possible

Is it a generator?

Randomly generate a vector from a distribution

With some modification, we have **variational auto-encoder (VAE)**.
Compression

As close as possible

NN Encoder → vector → NN Decoder → Decompression

Compression

Low-dim

Lossy

https://arxiv.org/abs/1708.00838
https://arxiv.org/abs/1703.00395
Anomaly Detection

• Given a set of training data \( \{x^1, x^2, \ldots, x^N\} \)
• Detecting input \( x \) is *similar* to training data or not.

\[ x \text{ similar to training data} \rightarrow \text{Anomaly Detector} \rightarrow \text{normal} \]

\[ x \text{ different from training data} \rightarrow \text{Anomaly Detector} \rightarrow \text{outlier, novelty, exceptions anomaly} \]
Anomaly Detection

Training Data:

Training Data:

Training Data:
Anomaly Detection

• Fraud Detection
  • Training data: credit card transactions, $x$: fraud or not
  • Ref: https://www.kaggle.com/ntnu-testimon/paysim1/home
  • Ref: https://www.kaggle.com/mlg-ulb/creditcardfraud/home

• Network Intrusion Detection
  • Training data: connection, $x$: attack or not

• Cancer Detection
  • Training data: normal cells, $x$: cancer or not?
  • Ref: https://www.kaggle.com/uciml/breast-cancer-wisconsin-data/home

Binary Classification?
We only have one class.
Training auto-encoder
Approach: Auto-encoder

**Training**
Using **real human faces** to learn an **autoencoder**

**Testing**
Can be reconstructed
**Approach: Auto-encoder**

**Training**

Using **real human faces** to learn an **autoencoder**

**Testing**

Large reconstruction loss $\rightarrow$ anomaly
cannot be reconstructed
More about Anomaly Detection

• Part 1: https://youtu.be/gDp2LXGnVLQ
• Part 2: https://youtu.be/cYrNjLxkoXs
• Part 3: https://youtu.be/ueDlm2FkCnw
• Part 4: https://youtu.be/XwkHOUPbc0Q
• Part 5: https://youtu.be/Fh1xFBktRLQ
• Part 6: https://youtu.be/LmFWzmn2rFY
• Part 7: https://youtu.be/6W8FqUGYyDo
Concluding Remarks

- Basic Idea of Auto-encoder
- Feature Disentanglement
- Discrete Latent Representation
- More Applications