Generative Models - Autoencoders

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Outline

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- Introduction
- Autoencoder Representation
  - Usage of Autoencoders

Variational Autoencoders

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Introduction

- These help us encode data well, automatically
- A high level example
  1. Assume you're trying to introduce a course (STAT 697L) offering to a group of newly admitted grad students.
  2. You have only a couple of minutes to woo them given their current understanding of the subject matter.
  3. It's possible they've forgotten certain statistical concepts.
  4. In a sense, their learned transformation from latent space $h(x)$ into $g(h(x))$ has been randomly initialized.
  5. You'll have to briefly refresh their memory.
  6. That's you'll have to train their autoencoders by passing in concepts x and observing whether they managed to reproduce them$(g(h(x)))$ in a meaningful way.

Autoencoder Representation

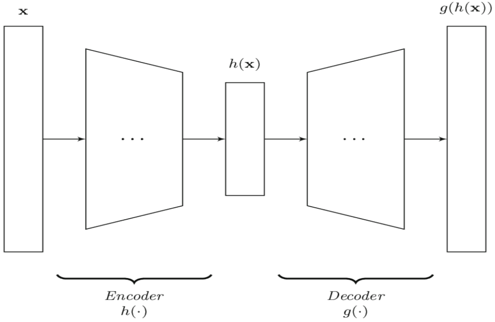

Figure: Autoencoder Representation

1. Encoder Network
   - Take a representation x^1 of say dimension m
   - Reduce it's dimension to d by using a learned[2] encoder $h(.)$

[1] e.g. image

[2] An example could be a MLP or NN

Autoencoder Representation

2. Latent Space
   - This is basically a representation of your input space in a smaller dimensional setting
   - For example, a CNN could transform a $256 \times 256 \times 3$ image into a $28 \times 28 \times 3$ representation
3. Decoder Network
   - Reconstruct the original object into the original dimension by using a decoder
   - The decoder is typically a mirror image of the encoder. We could use a MLP or NN

- At the end, you have an explicit objective function $L(x, g(h(x)))$
- The goal is now to find[3] the set of parameters for the encoder and decoder that will optimize this objective

[3] Often a variant of GD is applied depending on the problem domain

Usage & Importance of Autoencoders

1. Can be used to achieve good compression
2. It can model a given population in an intelligent way! This can assist in fake detection
3. Training Autoencoders does not require labelled data!
4. Autoencoders can be used to generate new data. More on that later!

- At this point it might sound like Autoencoders are glorified PCAs! To some extent yes.
  - If we stop at the hidden layer of AE, we potentially have a PCA

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Variational Autoencoders

- How is this different from Regular Autoencoders?
  - They differ in their representation of the latent space
  - Regular autoencoders represent the latent space as a "set of numbers"[4]
  - Variational autoencoders choose to represent the latent space as a distribution[5] with a set of learned parameters[6].
- We then sample from this latent distribution to get some numbers, which are then fed to the decoder
- We get an output that looks like the original input, except it has been created by the model
- In addition to the abilities of an AE, VAE has more parameters to tune that gives significant control over how we want to model our latent distribution

[4] Frequentist autoencoders

[5] Bayesian autoencoders

[6] Requires additional assumptions

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- Autoencoders are composed of encoders, latent space and decoders
- They're trained using a common objective function measure
- Autoencoders has many applications, example as generative models, compressors
- VAE, an improvement of AE has limitations. The development of GANs corrects for these limitations.

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References

1. GANs in Action $\sim$ Jakub Langr & Vladimir Bok
   - Chapter 2