Lecture 10 – Variational Autoencoders

Provide short answers (max. 25 words each) to the following questions.

- What is the goal of latent variable models?
- What does marginalization in latent variable models achieve?
- What is the prior distribution typically used for continuous latent variables in VAEs?
- What is Ancestral Sampling in generative models?
- What is the main challenge in training Latent Variable Models?
- What is ELBO and why is it used?
- What are the two main terms in ELBO?
- What does the KL divergence term enforce?
- What does the encoder in a VAE output?
- What does the decoder in a VAE do?
- Why is Monte Carlo estimation used in VAEs?
- What is the total VAE loss function?
- What does reconstruction loss measure?
- What does KL divergence measure in VAEs?
- How can VAEs generate new samples?
- What is disentanglement in VAEs?
- What is a Regularized Discriminative VAE?
- What additional term is added in Regularized Discriminative VAE loss?
- What does repulsive loss enforce?
- What are the components of the total loss in Regularized Discriminative VAE?
- How do VAEs differ from standard Autoencoders?
- Why are VAEs considered generative models?

Multiple-choice questions

What is the goal of Latent Variable Models?
- A) Predict labels directly
- B) Learn a probability distribution over observed data using hidden variables
- C) Remove noise from data
- D) Perform clustering only

What does marginalization in Latent Variable Models achieve?
- A) Computes latent variables directly
- B) Removes prior distribution
- C) Computes data likelihood by integrating over latent variables
- D) Normalizes embeddings

Which of the following is an example of a discrete Latent Variable Model?
- A) Variational Autoencoder
- B) GAN
- C) Mixture of Gaussians
- D) Normalizing Flow

What prior distribution is typically used for continuous latent variables in VAEs?
- A) Uniform distribution
- B) Standard Normal distribution
- C) Bernoulli distribution
- D) Exponential distribution

What is Ancestral Sampling?
- A) Sampling latent variables from the prior and generating data through the decoder
- B) Sampling noise from a GAN
- C) Sampling from posterior only
- D) Removing latent space

What is the main challenge in training Latent Variable Models?
- A) Lack of latent space
- B) Intractable integral for log-likelihood
- C) Too few parameters
- D) No reconstruction loss

What does ELBO stand for?
- A) Evidence Lower Bound
- B) Expected Latent Bound
- C) Encoder Latent Base Output
- D) Error Loss Bound

What are the two main terms in ELBO?
- A) Reconstruction term and KL divergence term
- B) Cross-entropy and hinge loss
- C) Reconstruction term and Wasserstein distance
- D) KL divergence and GAN loss

What does the KL divergence term enforce?
- A) Similarity between approximate posterior and prior
- B) Similarity between encoder and decoder
- C) Diversity in latent space

D) Removal of latent variables

What does the encoder in a VAE output?
A) Latent variable only
B) Mean and variance of approximate posterior
C) Reconstruction error
D) GAN discriminator score

What does the decoder in a VAE do?
A) Adds noise to latent variables
B) Generates data from latent variables
C) Computes KL divergence
D) Normalizes embeddings

Why is Monte Carlo estimation used in VAEs?
A) To approximate expectations in ELBO
B) To compute GAN loss
C) To normalize latent space
D) To enforce Lipschitz constraint

What is the reparameterization trick?
A) Express sampling as a deterministic function of parameters and noise
B) Remove latent space
C) Use GAN generator
D) Normalize embeddings

What is the total VAE loss function?
A) Reconstruction loss only
B) Negative ELBO = Reconstruction loss + KL divergence
C) GAN loss + KL divergence
D) Wasserstein loss

What does reconstruction loss measure?
A) Similarity between posterior and prior
B) How well the decoder reconstructs input data
C) Diversity in latent space
D) GAN discriminator accuracy

What does KL divergence measure in VAEs?
A) Difference between approximate posterior and prior
B) Difference between encoder and decoder

C) Reconstruction accuracy

D) GAN loss

How can VAEs generate new samples?

A) Sample latent variables from prior and decode them

B) Use GAN discriminator

C) Remove latent space

D) Apply clustering

What is resynthesis in VAEs?

A) Apply GAN loss

B) Remove KL divergence

C) Normalize embeddings

D) Modify latent representation and decode to create new variations

How can VAEs perform attribute manipulation?

A) By removing the latent space

B) By using GAN discriminator

C) By computing the difference vector in latent space and apply it

D) By applying Dropout

What is disentanglement in VAEs?

A) Learning latent dimensions that correspond to interpretable properties

B) Removing latent space

C) Using GAN loss

D) Applying random noise

What is a Regularized Discriminative VAE?

A) GAN variant

B) VAE variant that learns discriminative representations for classification

C) Autoencoder without latent space

D) Normalizing flow

What additional term is added in Regularized Discriminative VAE loss?

A) GAN loss

B) Repulsive loss

C) Wasserstein loss

D) Dropout penalty

What does repulsive loss enforce?

A) Minimum distance between latent clusters of different classes

B) Similarity between posterior and prior

C) Diversity in generated samples

D) Removal of latent space

What are the components of total loss in Regularized Discriminative VAE?

A) Reconstruction + Wasserstein loss

B) GAN loss + KL divergence

C) Reconstruction + KL + Repulsive loss

D) KL divergence only

How do VAEs differ from standard autoencoders?

A) VAEs remove latent space

B) VAEs learn probabilistic latent representations

C) VAEs use GAN loss

D) VAEs ignore reconstruction

Why are VAEs considered generative models?

A) They can sample new data points from learned distribution

B) They use GAN discriminator

C) They remove latent space

D) They apply clustering only