

10-423/10-623 Gen AI
Spring 2025
Quiz 2
02/17/24
Time Limit: 15 minutes

Name:
Andrew ID:
Room: DH - 2210
Seat: O8
Exam Number: 208

Instructions:

- Verify your name and Andrew ID above.
- This exam contains 5 pages (including this cover page).
The total number of points is 14.
- Clearly mark your answers in the allocated space. If you have made a mistake, cross out the invalid parts of your solution, and circle the ones which should be graded.
- Look over the exam first to make sure that none of the 5 pages are missing.
- No electronic devices may be used during the exam.
- Please write all answers in pen or *darkly* in pencil.
- You have 15 minutes to complete the exam. Good luck!

Question	Points
1. Deep Models for Vision	3
2. GANs	4
3. Diffusion Models	4
4. VAEs	3
Total:	14

1 Deep Models for Vision (3 points)

- 1.1. (1 point) **True or False:** As we go deeper into a CNN, the weights of *later* convolutional layers learn to detect features of *larger* patches of the input images.

- ☐ True
☐ False

- 1.2. (1 point) **Select one:** Consider a 2D convolution layer with input image size $M \times M$ with C_{in} channels. Let N_W be the original number of weight parameters. If we double the input image width and height to be $2M \times 2M$ and change nothing else about the layer, what is total number of weights in this layer?

- ☐ $N_W/2$
☐ $N_W/4$
☐ $\sqrt{2}N_W$
☐ $2N_W$
☐ $4N_W$
☐ None of the above

- 1.3. (1 point) **Select all that apply:** Which aspects of an encoder-only Transformer model need to be substantially changed to convert it to a basic Vision Transformer (ViT) model?

Select as few options as necessary.

- ☐ Tokenization
☐ Position embedding
☐ Attention blocks
☐ Transformer blocks
☐ Optimization algorithm
☐ None of the above

2 GANs (4 points)

- 2.1. (1 point) **True or False:** The discriminator's role in a GAN is to determine whether the noise vector was obtained by adding noise to a real image or by sampling noise from the generator model.

- ☐ True
☐ False

- 2.2. (2 points) **Select all that apply:** GANs learn by trying to find a θ and ϕ that optimize a minimax problem for a generator G_θ and a discriminator D_ϕ :

$$\min_{\theta} \max_{\phi} J(\theta, \phi), \quad \text{where } J(\theta, \phi) = \log(D_\phi(\mathbf{x}^{(i)})) + \log(1 - D_\phi(G_\theta(\mathbf{z}^{(i)}))),$$

$\mathbf{x}^{(i)}$ is a random training image, and $\mathbf{z}^{(i)}$ is a random noise vector. Which of the following techniques could be used to optimize this learning problem?

- ☐ Alternate between a step in the direction of $\nabla_\phi J(\theta, \phi)$ and a step opposite the gradient of $\nabla_\theta J(\theta, \phi)$.
☐ Alternate between a step opposite the direction of $\nabla_\phi J(\theta, \phi)$ and a step in the gradient of $\nabla_\theta J(\theta, \phi)$.
☐ Jointly step in the direction $(\nabla_\phi J(\theta, \phi), -\nabla_\theta J(\theta, \phi))$
☐ Jointly step in the direction $(-\nabla_\phi J(\theta, \phi), \nabla_\theta J(\theta, \phi))$
☐ None of the above

- 2.3. (1 point) **Select one:** Which of the following best describes how an image is generated from a trained GAN?

- ☐ A neural network creates the mean and covariance parameters of a Gaussian, and an image is sampled from that Gaussian.
☐ Gaussian noise is repeatedly subtracted away from a randomly sampled noise vector until an image is left remaining.
☐ A noise vector is sampled from a Gaussian, then a deterministic neural network transforms the noise vector into an image.
☐ A noise vector is constructed by a neural network and then an image is sampled from a nonlinear distribution that conditions on that noise vector.

3 Diffusion Models (4 points)

- 3.1. (1 point) **True or False:** To train a diffusion model, we find the parameters for the reverse process model that maximize the sum of the log-likelihoods of the training images, i.e. $\hat{\boldsymbol{\theta}} = \arg \max \sum_{i=1}^N \log p_{\boldsymbol{\theta}}(\mathbf{x}^{(i)})$ where $p_{\boldsymbol{\theta}}$ is the reverse process, and $\mathbf{x}^{(1)}, \dots, \mathbf{x}^{(N)}$ are the N training images.
- ☐ True
- ☐ False
- 3.2. (1 point) **True or False:** The forward process of a diffusion model *and* the (learned) reverse process are both stochastic.
- ☐ True
- ☐ False
- 3.3. (2 points) **Select all that apply:** Why does the Denoising Diffusion Probabilistic Model (DDPM) use a UNet model? Recall that the structure of the exact reverse process $q(\mathbf{x}_{t-1} \mid \mathbf{x}_t, \mathbf{x}_0)$ is a Gaussian of the form $\mathcal{N}(\tilde{\mu}_q(\mathbf{x}_t, \mathbf{x}_0), \sigma_t^2 \mathbf{I})$.
- ☐ Because a UNet is a parameter efficient encoder-only Transformer model.
- ☐ Because the inputs and outputs of a UNet can be of the same dimension.
- ☐ In order to approximate $\tilde{\mu}_q(\mathbf{x}_t, \mathbf{x}_0)$ through various parameterizations.
- ☐ In order to approximate $\sigma_t^2 \mathbf{I}$ through various parameterizations.
- ☐ None of the above

4 VAEs (3 points)

- 4.1. (2 points) **Select all that apply.** Which of the following would we like to *minimize* when training a variational autoencoder, where $q_\phi(\mathbf{z} \mid \mathbf{x})$ is the encoder, $p_\theta(\mathbf{x} \mid \mathbf{z})$ is the decoder, $\mathbf{z}^{(i)} \sim q_\phi(\mathbf{z} \mid \mathbf{x}^{(i)})$, and $\hat{\mathbf{x}}^{(i)} \sim p_\theta(\mathbf{x} \mid \mathbf{z}^{(i)})$.

- ☐ $\frac{1}{N} \sum_{i=1}^N \|\mathbf{x}^{(i)} - \hat{\mathbf{x}}^{(i)}\|_2^2 - KL(q_\phi(\mathbf{z} \mid \mathbf{x}) \parallel \mathcal{N}(\mathbf{0}, \mathbf{I}))$
- ☐ $\mathbb{E}_{\mathbf{z} \sim q_\phi(\mathbf{z} \mid \mathbf{x})} [-\log p_\theta(\mathbf{x} \mid \mathbf{z})] - KL(q_\phi(\mathbf{z} \mid \mathbf{x}) \parallel p_\theta(\mathbf{z}))$
- ☐ $-\text{ELBO}(q_\phi)$
- ☐ None of the above

- 4.2. (1 point) **True or False:** The reparameterization trick is used to avoid having a random function on the computation path between the generator network weights and the objective.

- ☐ True
- ☐ False