

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

Name:  
Andrew ID:  
Room: DH - 2210  
Seat: O3  
Exam Number: 204

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**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

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## 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  $\theta$  and  $\phi$  that optimize a minimax problem for a generator  $G_\theta$  and a discriminator  $D_\phi$ :

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

$\mathbf{x}^{(i)}$  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.  $\hat{\theta} = \arg \max \sum_{i=1}^N \log p_{\theta}(\mathbf{x}^{(i)})$  where  $p_{\theta}$  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