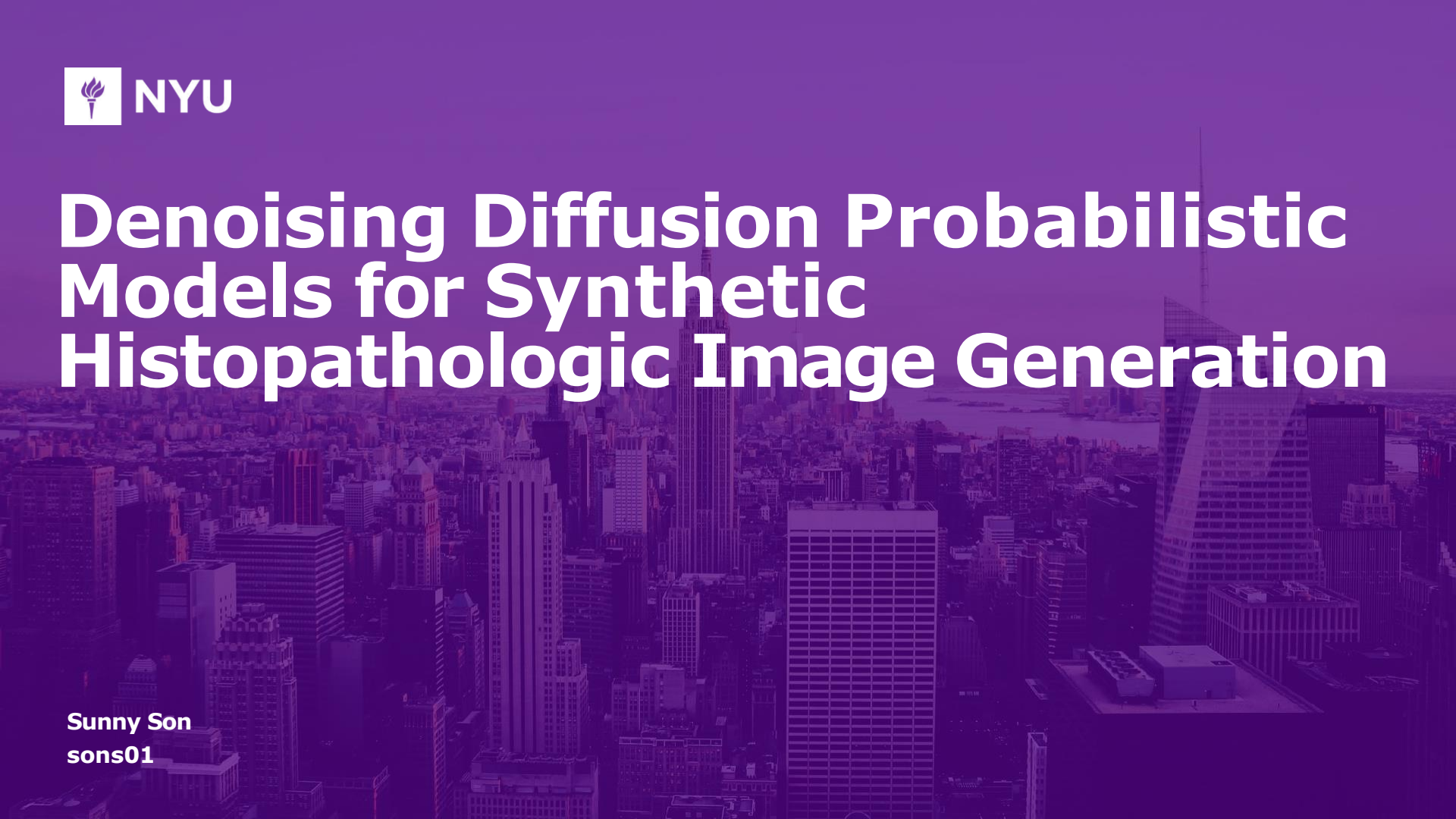
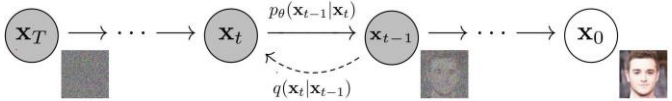


Denoising Diffusion Probabilistic Models for Synthetic Histopathologic Image Generation

Sunny Son
sons01



Diffusion process as described in Ho et. al

Cosine beta schedule (above)

Linear beta schedule (above)

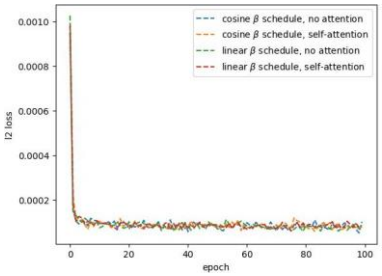
Algorithm 1 Training

1: **repeat**
2: $\mathbf{x}_0 \sim q(\mathbf{x}_0)$
3: $t \sim \text{Uniform}(\{1, ..., T\})$
4: $\boldsymbol{\epsilon} \sim \mathcal{N}(\mathbf{0}, \mathbf{I})$
5: Take gradient descent step on
6: $\nabla_\theta ||\boldsymbol{\epsilon} - \boldsymbol{\epsilon}_\theta \left(\sqrt{\bar{\alpha}}\mathbf{x}_0 + \sqrt{1-\bar{\alpha}_t}\boldsymbol{\epsilon}, t\right)||^2$
7: **until** converged

Algorithm 2 Sampling

1: $\mathbf{x}_T \sim \mathcal{N}(\mathbf{0}, \mathbf{I})$
2: **for** $t = T, ..., 1$ **do**
3: $\mathbf{z} \sim \mathcal{N}(\mathbf{0}, \mathbf{I})$ if $t > 1$, else $\mathbf{z} = \mathbf{0}$
4: $\mathbf{x}_{t-1} = \frac{1}{\sqrt{\alpha_t}}\left(\mathbf{x}_t - \frac{1-\alpha_t}{\sqrt{1-\bar{\alpha}_t}}\epsilon_\theta(\mathbf{x}_t, t)\right) + \sigma_t \mathbf{z}$
5: **end for**
6: **return** $\mathbf{x}_0$

$$\mathcal{L}_{\text{simple}} = \mathbb{E}_{t,\mathbf{x}_0,\epsilon}\left[\left|\left|\epsilon - \epsilon_\theta(\mathbf{x}_t, t)\right|\right|^2\right]$$
$$= \mathbb{E}_{t,\mathbf{x}_0,\epsilon}\left[\left|\left|\epsilon - \epsilon_\theta(\sqrt{\bar{\alpha}}\mathbf{x}_0 + \sqrt{1-\bar{\alpha}_t}\epsilon, t)\right|\right|^2\right]$$



x4

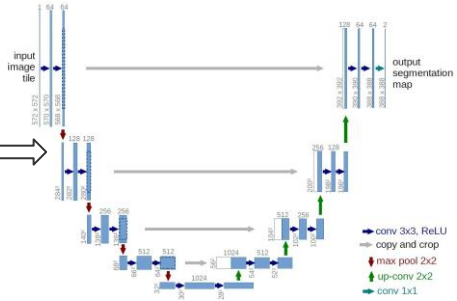
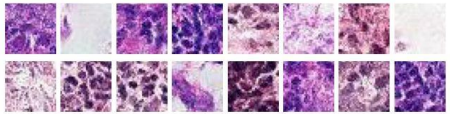


Table 2. Average SSIM & Maximum Likelihood Results

Sched.	Attn.	SSIM (↑)	Log. Likelihood (↓)
linear	none	0.00013885	0.01569078
linear	self	0.00010798	0.01568433
cosine	none	0.00026722	0.01448672
cosine	self	0.00015712	0.01710702



x5

$$\text{BCE} = -\sum_{s,b}[y \times \log(p) + (1-y) \times \log(1-p)]$$

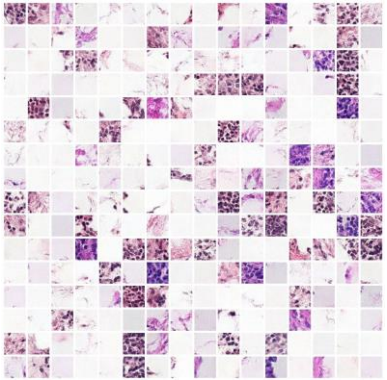
$$\text{SSIM}(\mathbf{x}, \mathbf{y}) = [l(\mathbf{x}, \mathbf{y})]^\alpha \cdot [c(\mathbf{x}, \mathbf{y})]^\beta \cdot [s(\mathbf{x}, \mathbf{y})]^\gamma$$

NYU

x2 Models Cancerous/ Non-Cancerous

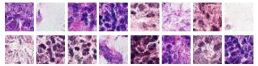
Generate 512 images of each class using selected architecture (cosine schedule, no attention)

Non-Cancerous

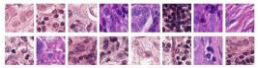


Cancerous

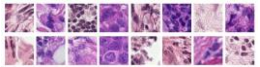
Visual inspection for 16 images from each class



Cancerous



Non-Cancerous



In addition to 16 positive/16 negative class ground truth samples

Combine to create

Table 3. *Four* Questions of +/- Class Matching

Correct (%)	Incorrect (%)
7 (58.3%)	5 (41.7%)

Table 4. *Four* Questions of +/- Class Identification

Class	Correct (%)	Incorrect (%)
+	4 (66.7%)	2 (33.3%)
-	2 (33.3%)	4 (66.7%)

Table 5. *Four* Questions of Generated/Ground-Truth Matching

Class	Correct (%)	Incorrect (%)
+	4 (66.7%)	2 (33.3%)
-	4 (66.7%)	2 (33.3%)

Table 6. *Four* Questions of Generated/Ground-Truth Identification

Class	Correct (%)	Incorrect (%)
GT +	3 (75%)	1 (25%)
GT -	3 (75%)	1 (25%)
Gen +	3 (75%)	1 (25%)
Gen -	4 (100%)	0 (0%)

Table 7. *Two* Questions of Overall Quality (Scores range from 1 to 5)

Class	Cellularity	Atypia	Color	Overall
+	4.33	4.67	4	3.33
-	3.67	4.67	4.67	3.67

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