Source Separation with Deep Generative Priors

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Bayesian Source Separation

Unobserved Components: $\mathbf{x} = (\mathbf{x}_1, \ldots, \mathbf{x}_k)$

Observed Mixture: $\mathbf{m}$

Prior (deep generative model): $\mathbf{x} \sim p$

Likelihood: $\mathbf{m} \sim \mathcal{N}\left(\sum_{i=1}^{n} \mathbf{x}_i, \gamma^2 I\right)$

Posterior likelihood: $p(\mathbf{x}|\mathbf{m}) = \dfrac{p(\mathbf{m}|\mathbf{x})p(\mathbf{x})}{p(\mathbf{m})}$

Sampling with Langevin Dynamics

Smoothed prior (convolve with Gaussian): $p_\sigma(\mathbf{x})$

Smoothed posterior: $p_\sigma(\mathbf{x}|\mathbf{m}) = \dfrac{p(\mathbf{m}|\mathbf{x})p_\sigma(\mathbf{x})}{p(\mathbf{m})}$

Innovation Noise: $\varepsilon \sim \mathcal{N}(0, I)$

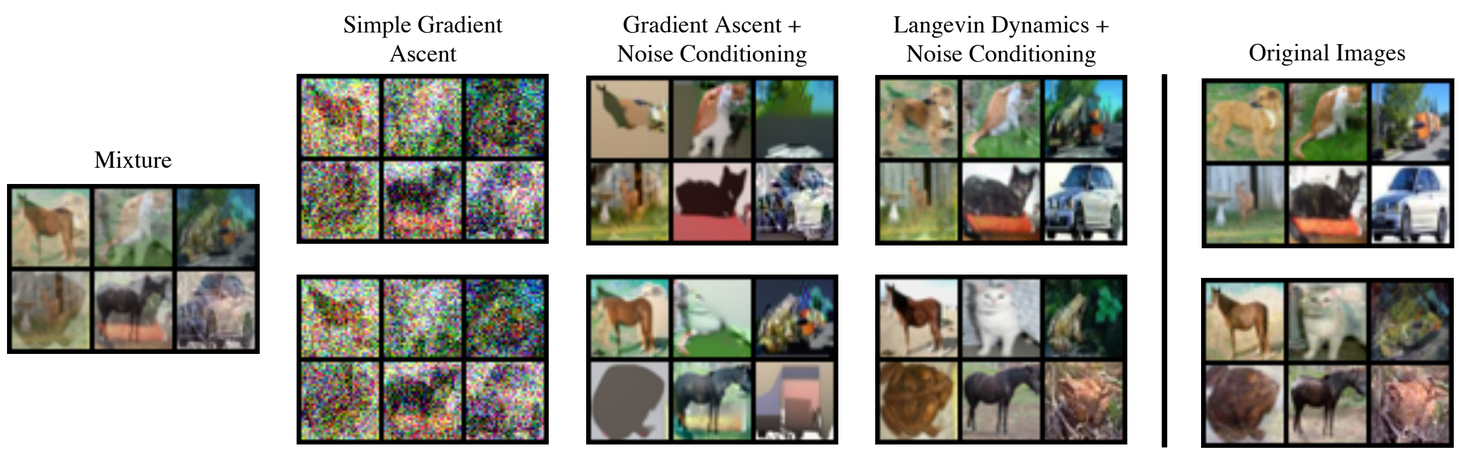
Noise-Annealed Langevin Dynamics:

$$\mathbf{x}^{(t+1)} \equiv \mathbf{x}^{(t)} + \eta \nabla_{\mathbf{x}} \log p_\sigma(\mathbf{x}^{(t)}|\mathbf{m}) + 2\sqrt{\eta}\varepsilon_t$$

A Robust Practical Algorithm, with a Qualitative Ablation Study

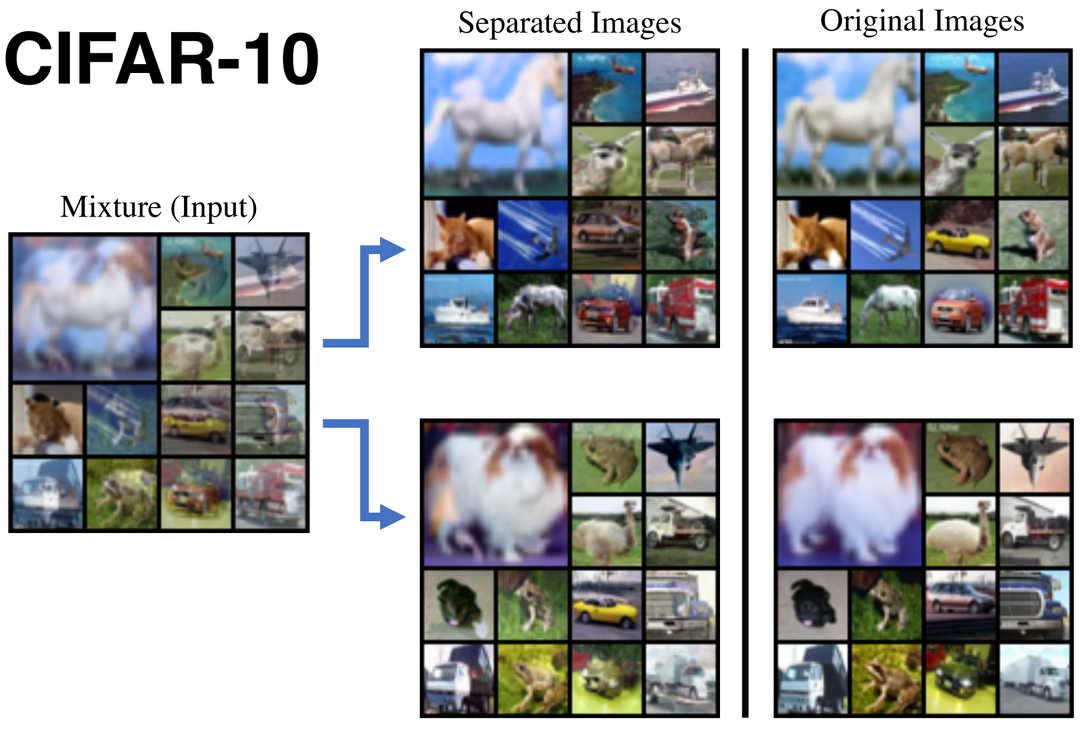
Algorithm 1 BASIS Separation

Input: $\mathbf{m} \in \mathcal{X}$, $\{\sigma_i\}_{i=1}^{L}$, δ, T
Sample $\mathbf{x}_1, \ldots, \mathbf{x}_k \sim \text{Uniform}(\mathcal{X})$
for $i \leftarrow 1$ **to** L **do**
  $\eta_i \leftarrow \delta \cdot \sigma_i^2 / \sigma_L^2$
  for $t = 1$ **to** T **do**
    Sample $\varepsilon_t \sim \mathcal{N}(0, I)$
    $\mathbf{u}^{(t)} \leftarrow \mathbf{x}^{(t)} + \eta_i \nabla_{\mathbf{x}} \log p_{\sigma_i}(\mathbf{x}^{(t)}) + 2\sqrt{\eta}\varepsilon_t$
    $\mathbf{x}^{(t+1)} \leftarrow \mathbf{u}^{(t)} - \frac{\eta_i}{\sigma_i^2}\left[\mathbf{m} - g(\mathbf{x}^{(t)})\right]$
  end for
end for



Preliminary Separation Results

CIFAR-10



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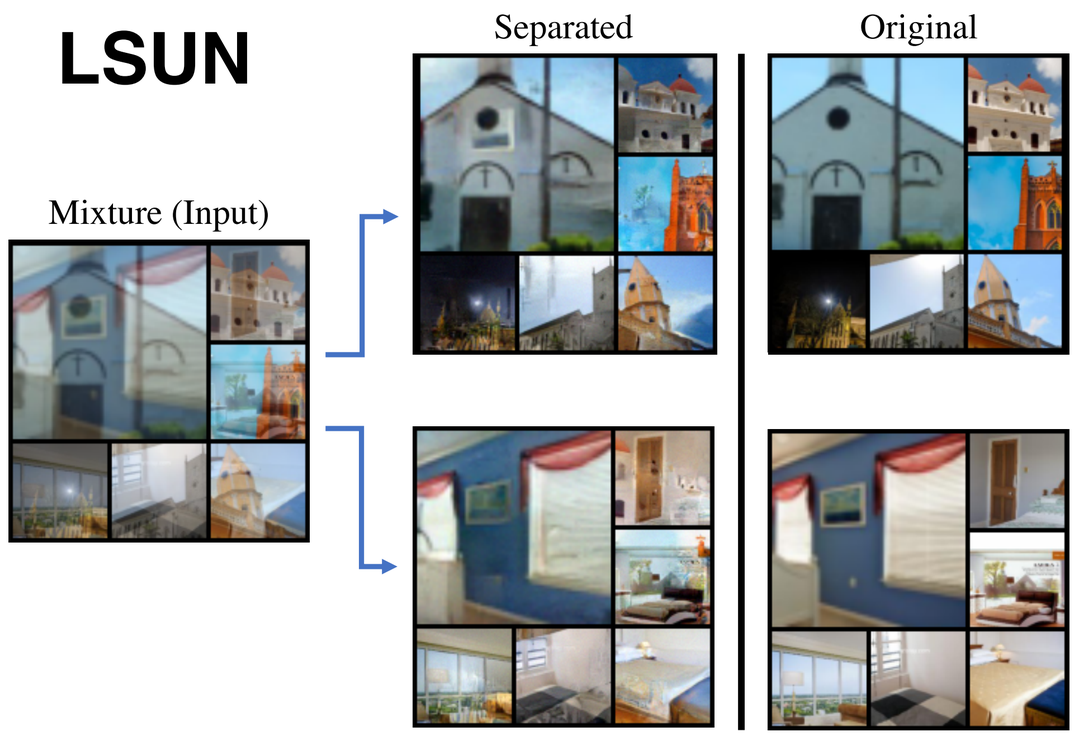


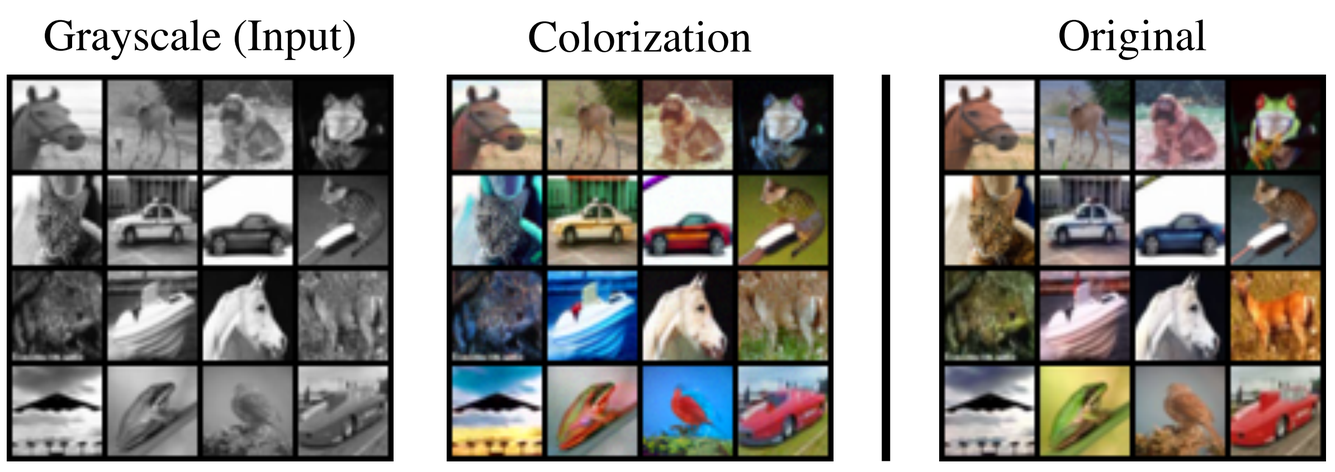
Image Colorization

Image Colorization is a corollary of our work

Color Image: $\mathbf{x} = (\mathbf{x}_r, \mathbf{x}_g, \mathbf{x}_b)$

Grayscale Image: $\mathbf{m} = \dfrac{\mathbf{x}_r + \mathbf{x}_g + \mathbf{x}_b}{3}$

It may be possible to adapt our work to other conditional generation problems



Preliminary Work: https://arxiv.org/abs/2002.07942

GitHub Repo: https://github.com/jthickstun/basis-separation