# Autoencoders

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SLIDES ADAPTED FROM IAN GOODFELLOW

## Problems of Autoencoders

- Unsupervised
  - Lots of data
  - Need priors / regularization
- Probabilistic loss function
  - does not work well for discrete data (more later)
  - hard to explain hidden layer probabilistically

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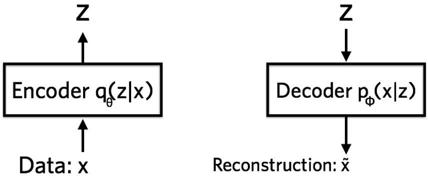
- So let's use variational inference

## Loss Function




$$\ell_i \equiv -\mathbb{E}_{z \sim q_\theta(z \mid x_i)}\left[\log p_\phi(x_i \mid z)\right] + \mathrm{KL}(q_\theta(z \mid x_i) \,||\, p(z)) \quad (1)$$

- Reconstruction error
- Variational representation distribution
- Regularization

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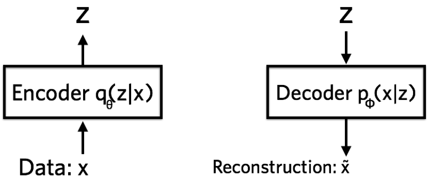


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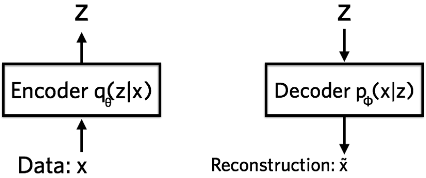


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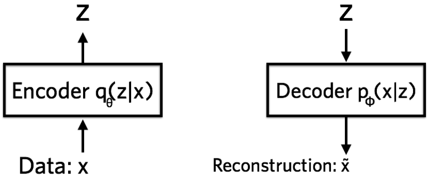


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### Interpretation

- Lower bound on reconstruction of decoder
- Keep representation constrained
- Probabilistic parameterization

## Make this Concrete

- $\text{KL}(q_\theta(z \mid x_i) \,||\, p(z))$
- $q(z \mid x_i)$: normal distribution with output of NN as mean [variational distribution]
- $p(z)$: standard normal distribution
- Decoder $p_\phi(x \mid z)$ depends on model / data:
  - Grayscale Image? Bernoulli distribution for each pixel
  - Words? Multinomial over vocabulary

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- Actually simpler than LDA
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  - Can minibatch the data
  - But what about $\phi$? (encoder)

## Variational EM

- Learn variational parameters
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- What if $x$ is discrete? (Later)