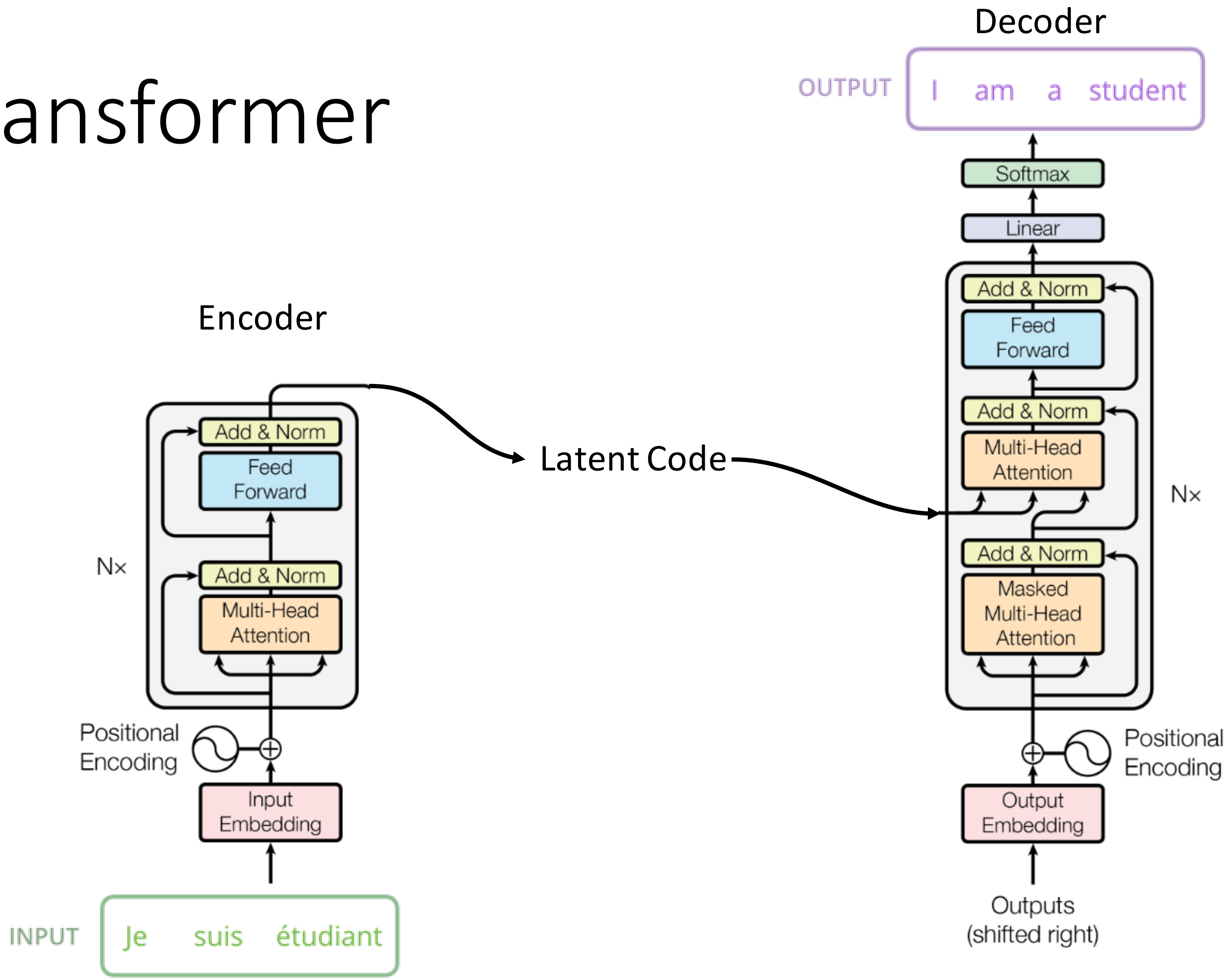
Neural Computation

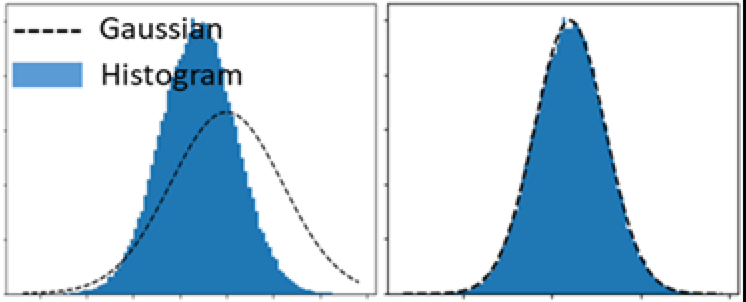
The Decoder - Part 1

Autoregressive Generative Models

The Transformer



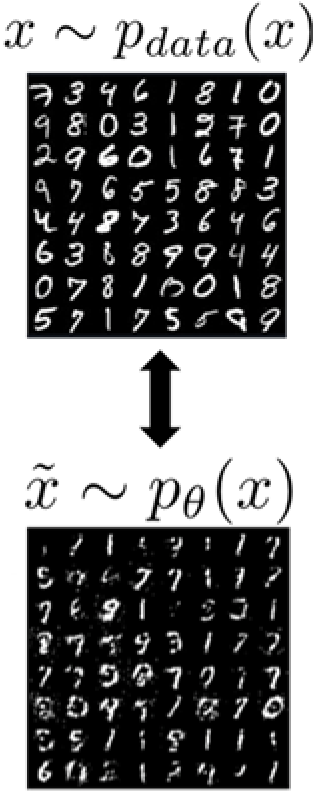
Probability Density Estimation

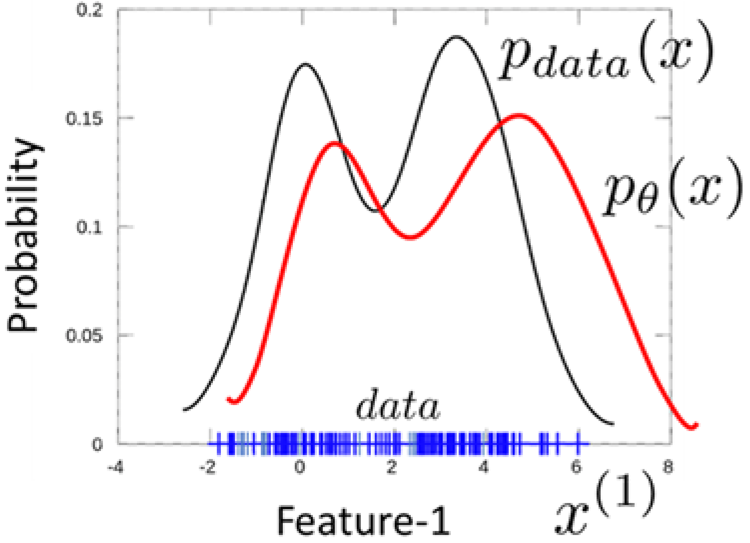


One of the main aims of unsupervised approaches and Generative Modelling.

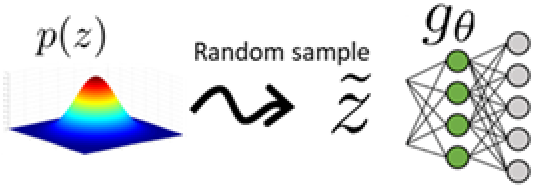
Goal of Density Estimation:

We could try to fit a probabilistic model $p_\theta(x)$ to the data,
to learn their underlying distribution $p_{data}(x)$.
How? By learning its parameters θ so that: $p_\theta(x) \approx p_{data}(x)$





But we cannot always do that directly.
Perhaps we cannot compute $p_{data}(x)$ or $p_\theta(x)$.
Instead, we could do PDE *indirectly:*
Enforce samples from model to be similar to real data instead:



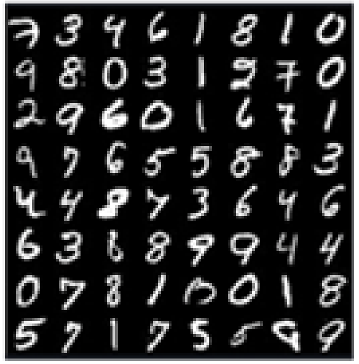
Both VAEs and GANs can be seen as following this approach.

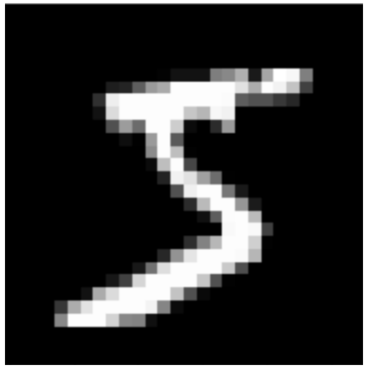
Autoregressive Models

Problem:

- Model high dimensional difficult distribution

$$p_\theta(\boldsymbol{x}) = p_{\text{data}}(\boldsymbol{x}), \text{ with } \boldsymbol{x} = (x_1, \dots, x_n)$$





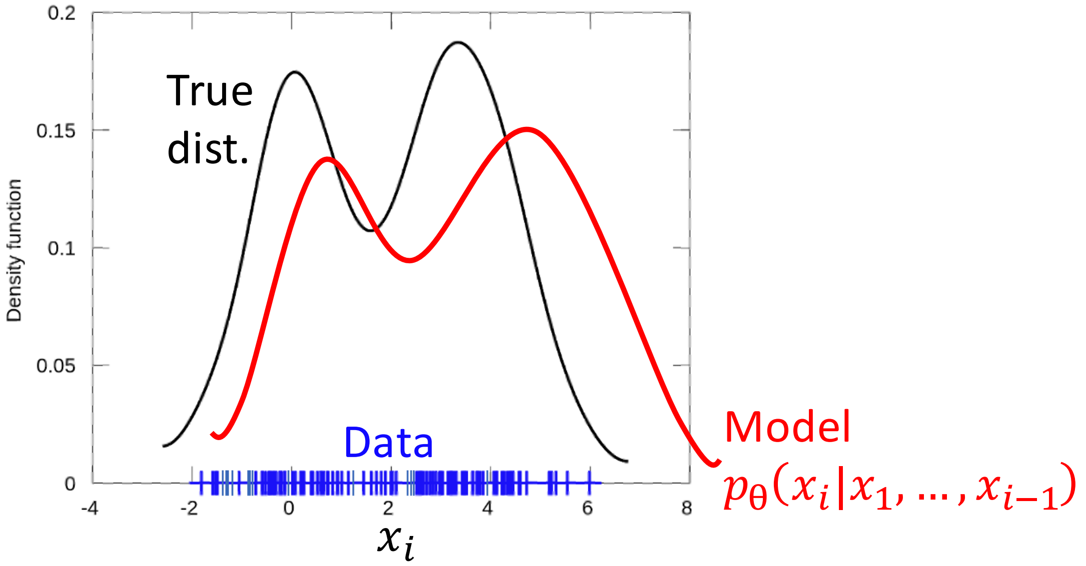
Idea:

- Factorise distribution

$$p_\theta(\boldsymbol{x}) = \prod_{i=1}^{n} p_\theta(x_i | x_1, \dots, x_{i-1})$$

Neural network:

- Parameters θ
- Input $x_1, \dots, x_{i-1}$
- Output dist. over x_i



WaveNet: A Generative Model for Raw Audio

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Karen Simonyan **Oriol Vinyals** **Alex Graves**

Nal Kalchbrenner **Andrew Senior** **Koray Kavukcuoglu**

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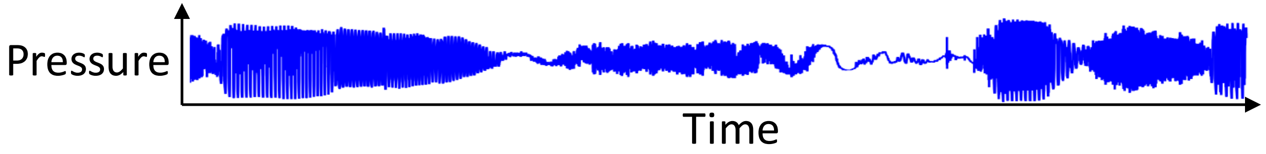

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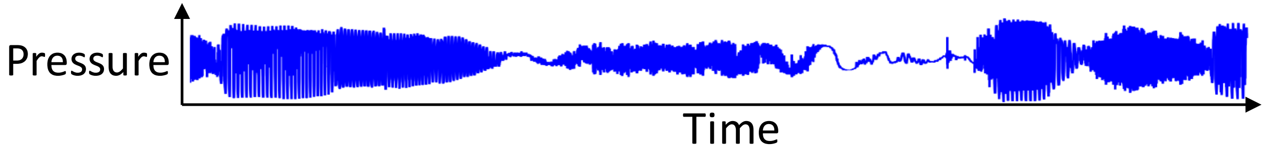
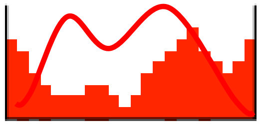
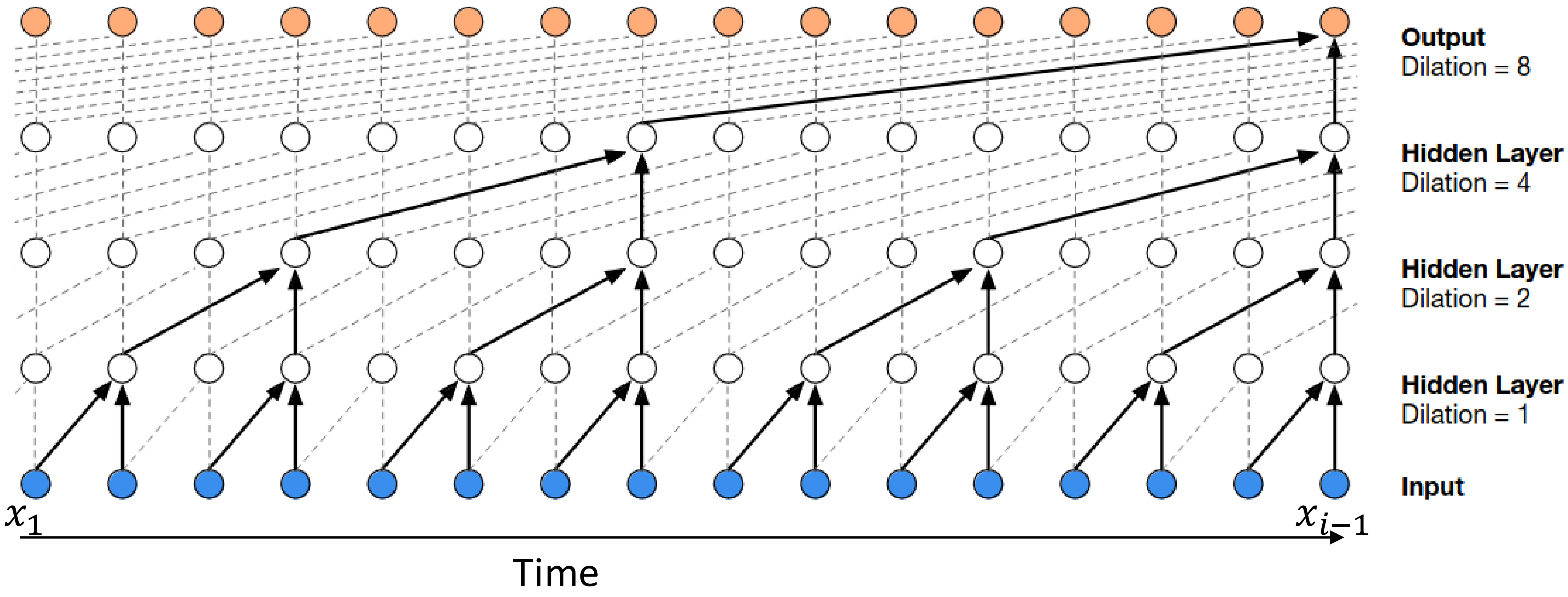


- Predict dist. for next audio sample



$p_\theta(x_i | x_1, \ldots, x_{i-1})$



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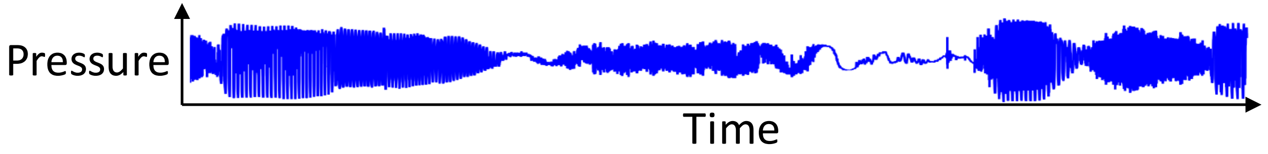
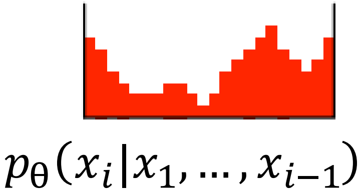
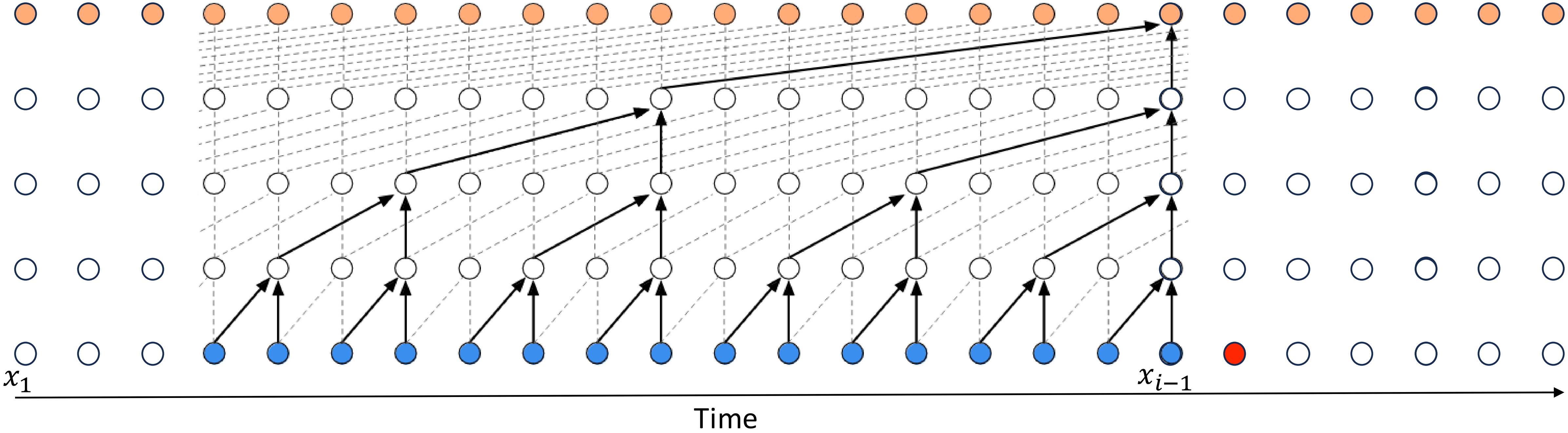


- Predict dist. for next audio sample
- Fully conv architecture:
  - Simultaneous pred. for all timepoints





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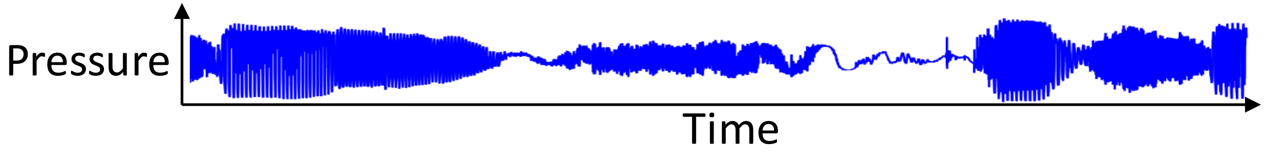

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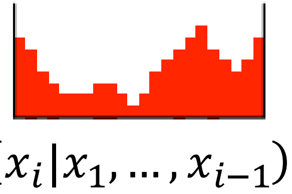

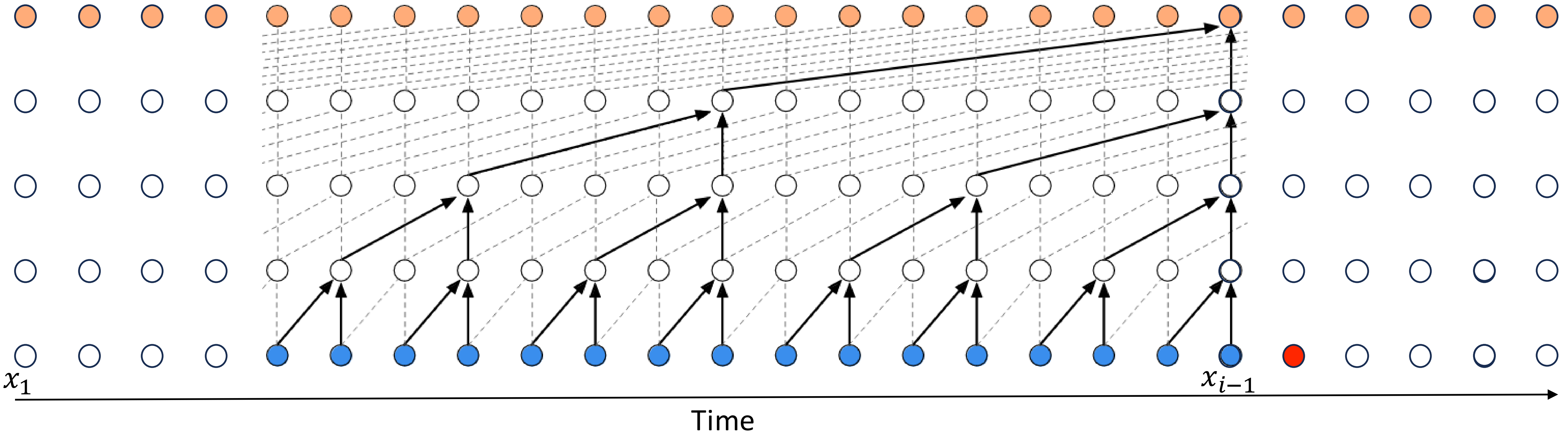

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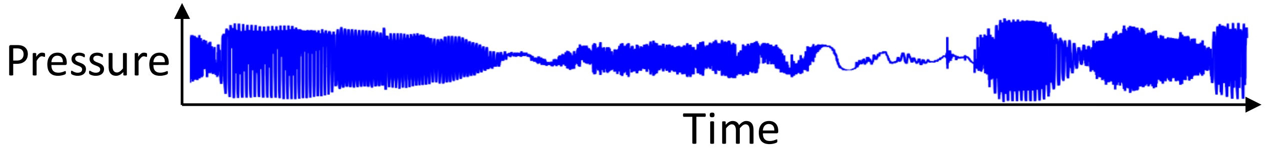

- Predict dist. for next audio sample
- Fully conv architecture:
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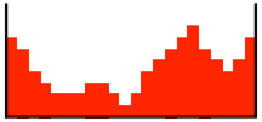
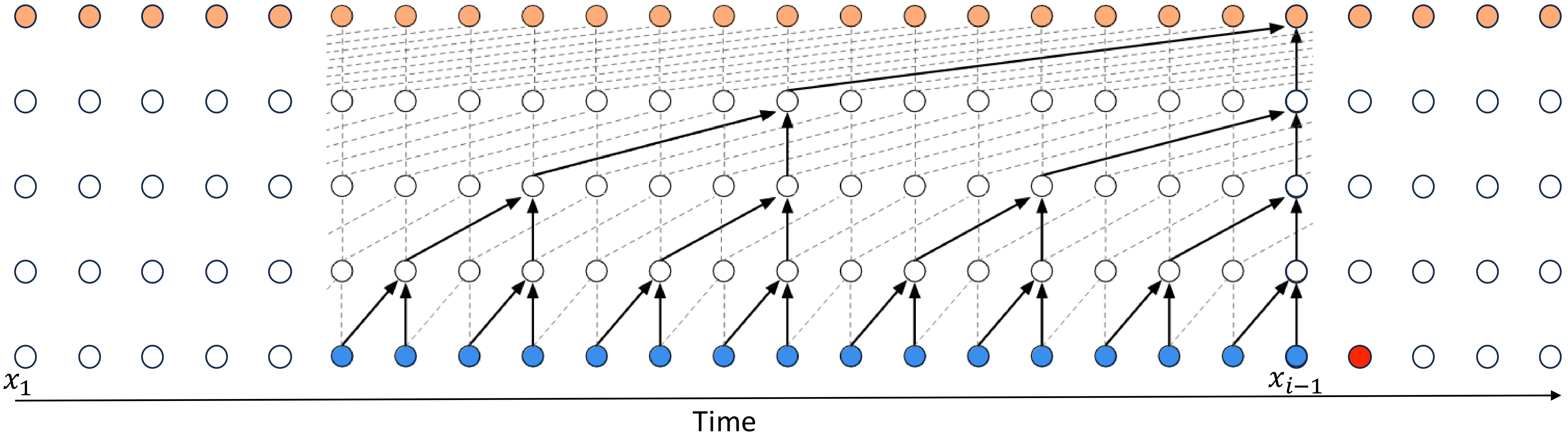
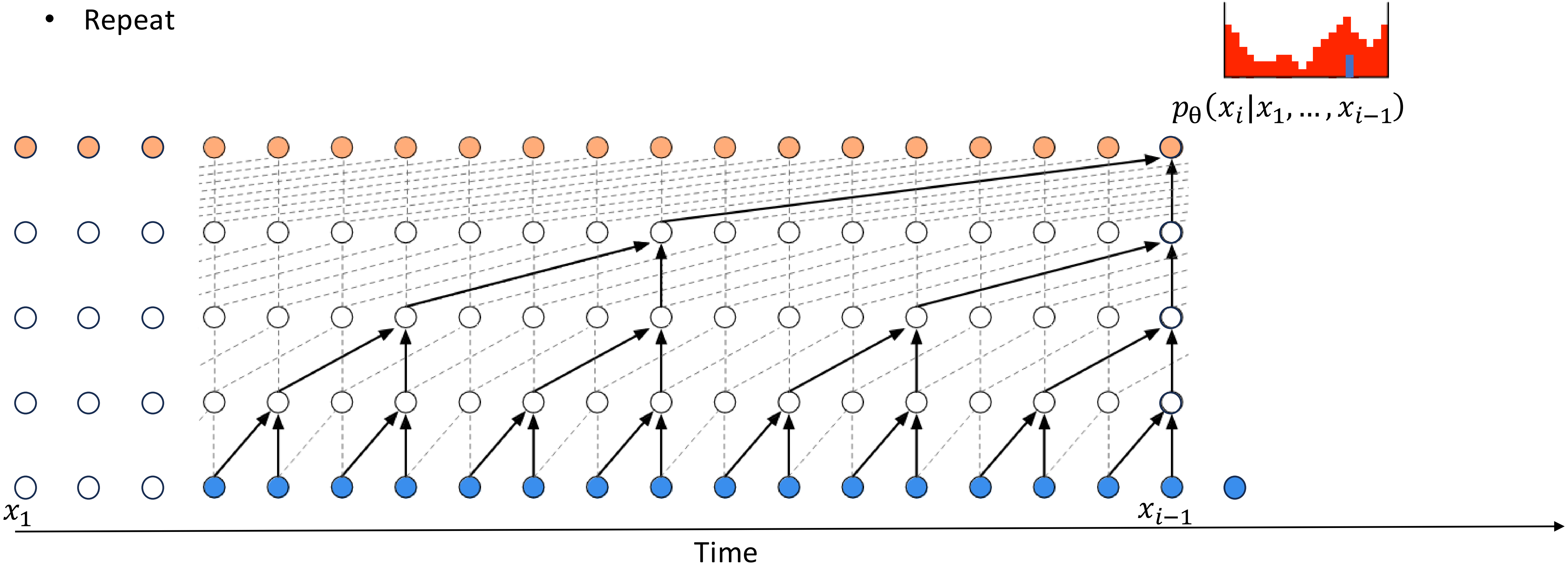




Sampling from the Model

- Predict dist. for next audio sample
- Sample from distribution
- Append new sample
- Repeat



Sampling from the Model

- Predict dist. for next audio sample
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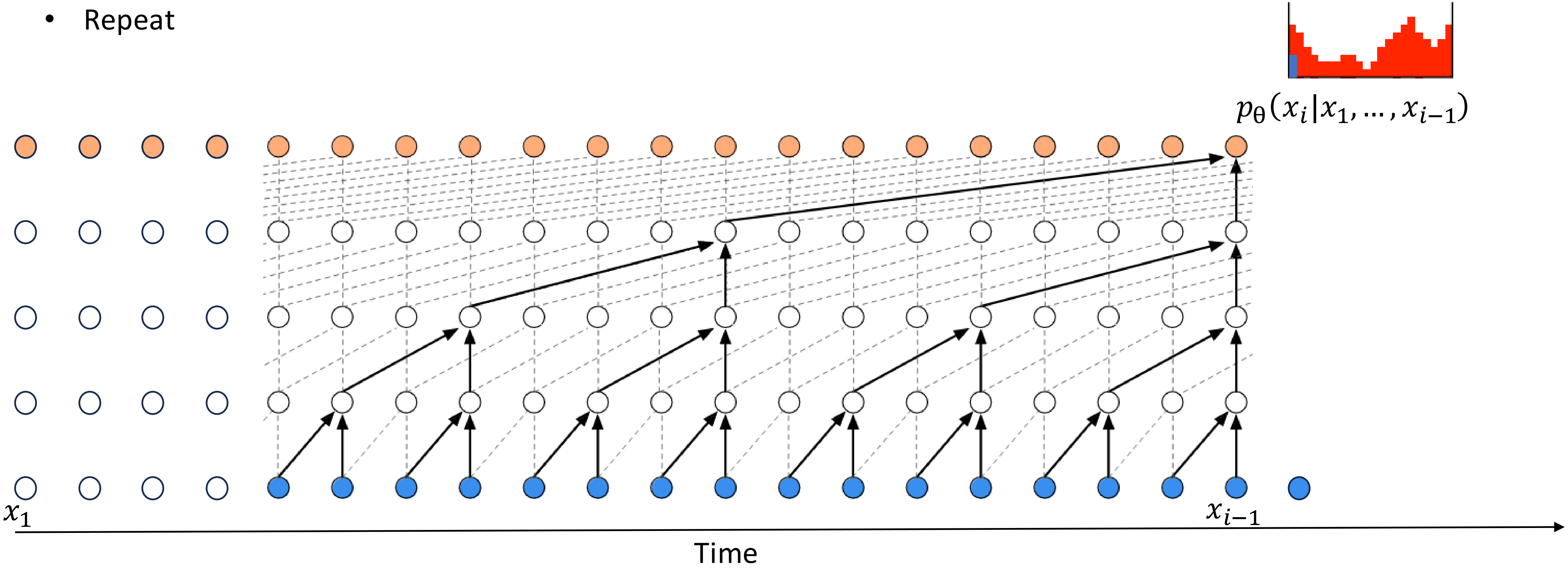

Pixel Recurrent Neural Networks

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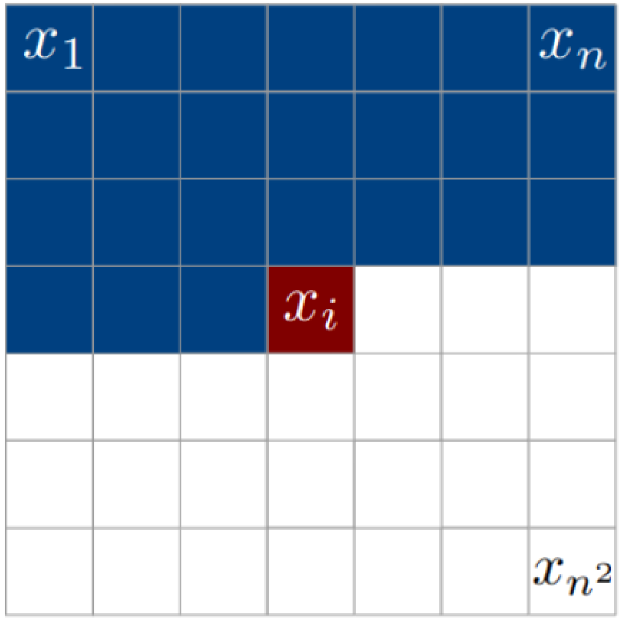

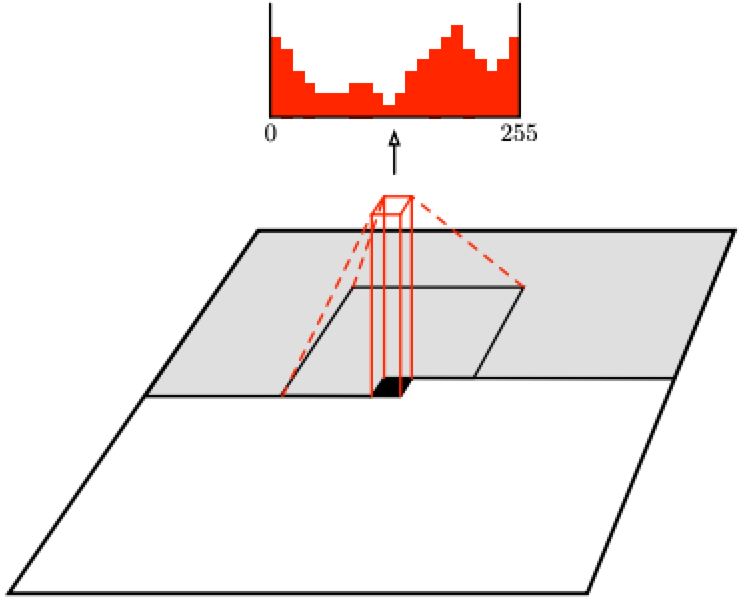

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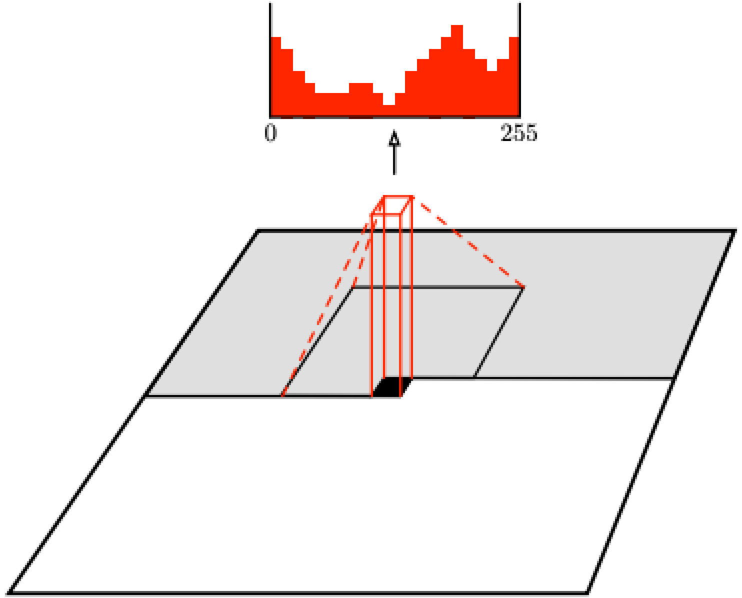
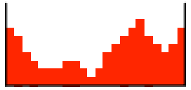
Image Generation:
- Sample one pixel
- Apply network
- Repeat

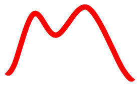


Summary

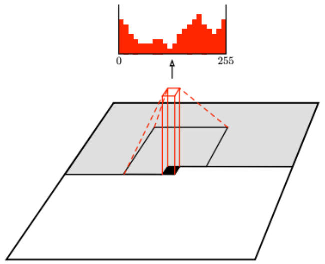
$$p_\theta(\boldsymbol{x}) = \prod_{i=1}^{n} p_\theta(x_i | x_1, \dots, x_{i-1})$$

- Interpret data as sequence
- Train neural network
  - Input: previous values $(x_1, \dots, x_{i-1})$
  - Distribution of possible next values $p_\theta(x_i | x_1, \dots, x_{i-1})$
    - E.g. as histogram
    - Or Parametric dist.





  - Ensure correct receptive field, e.g. special convolutions



- Sampling:
  - One sample at a time
  - Slow, involves repeated application of model

The Transformer