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Variable length data

- Traditional feed forward neural networks can only handle fixed length data.

- Variable length data (e.g., sequences, time-series, spatial data) leads to a variable # of parameters.

- Solutions:
  - Recurrent neural networks
  - Recursive neural networks
Recurrent Neural Network (RNN)

- In RNNs, outputs can be fed back to the network as inputs, creating a recurrent structure that can be unrolled to handle varying length data.

\[
h^t = f(h_{t-1}, x_t) = \sigma(W_h h_{t-1} + W_x x_t)
\]
Training

- Recurrent neural networks are trained by backpropagation on the unrolled network
  - backpropagation through time

- Weight sharing:
  - Combine gradients of shared weights into a single gradient

- Challenges
  - Gradient vanishing (and explosion)
  - Long range memory
  - Prediction drift