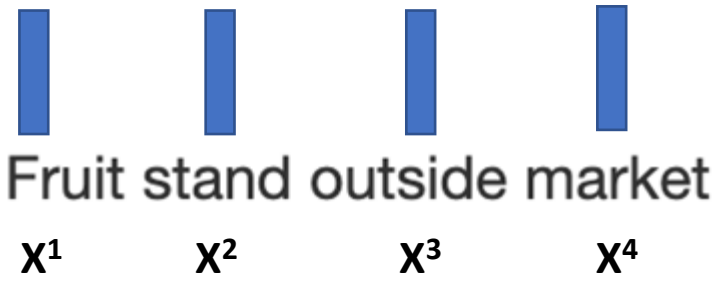
# Recurrent Neural Network

# Sequential Inputs

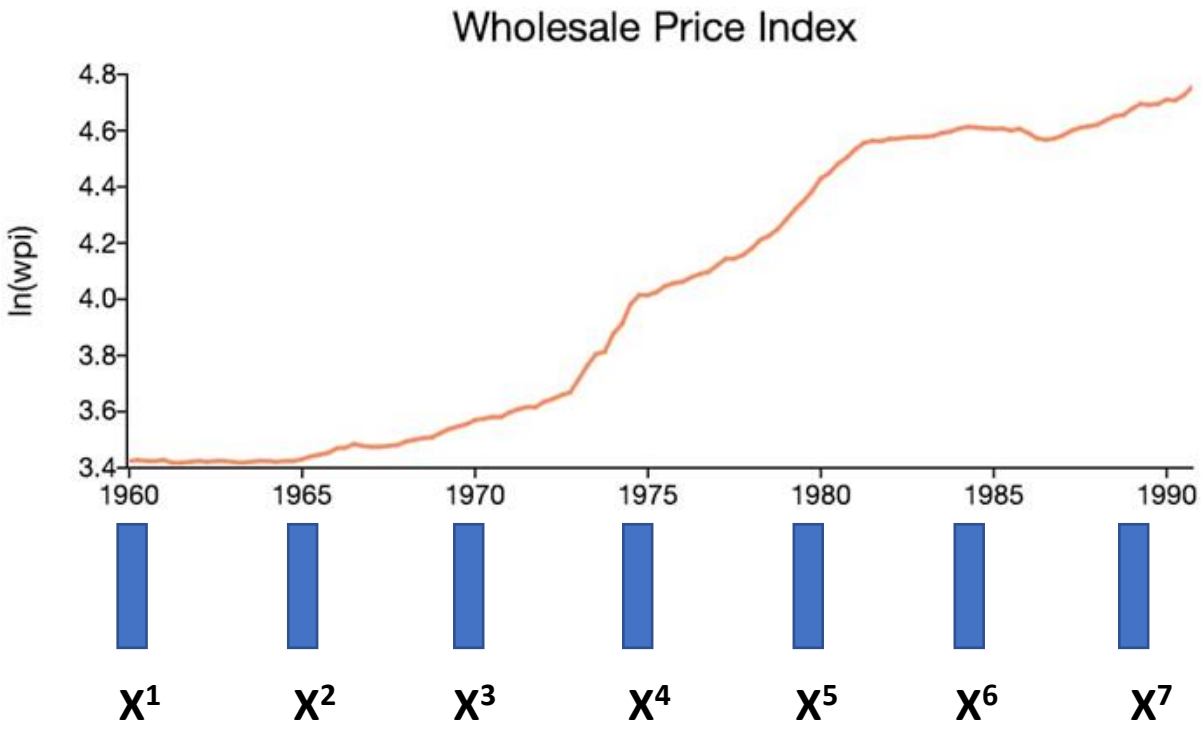

[Let us assume that we are dealing contextual with data. That mean, a sample is a sequence of vectors.]

# Sequential Inputs



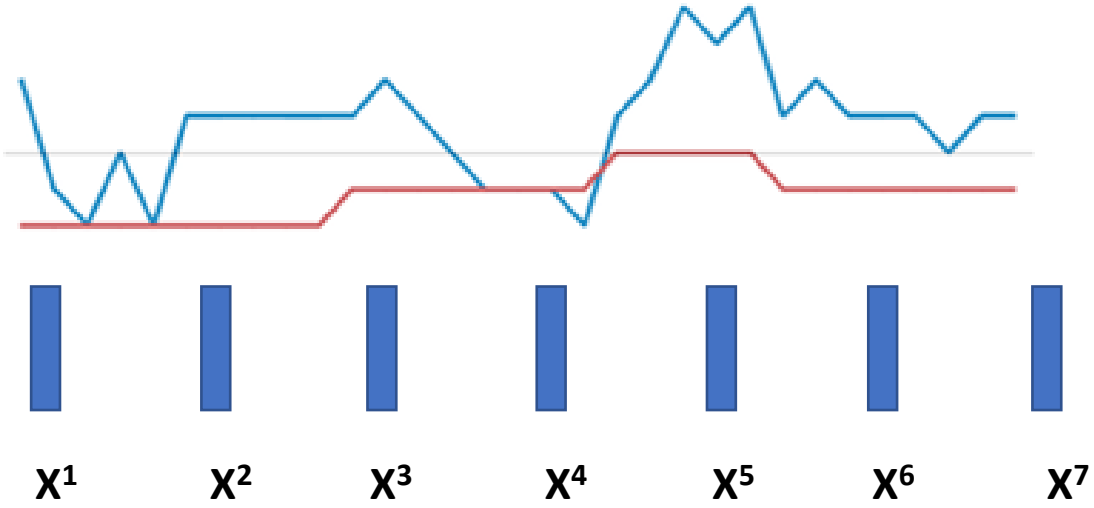

[ For example, a sentence which is defined by a sequence of words, and each word is defined by a vector.]

# Sequential Inputs



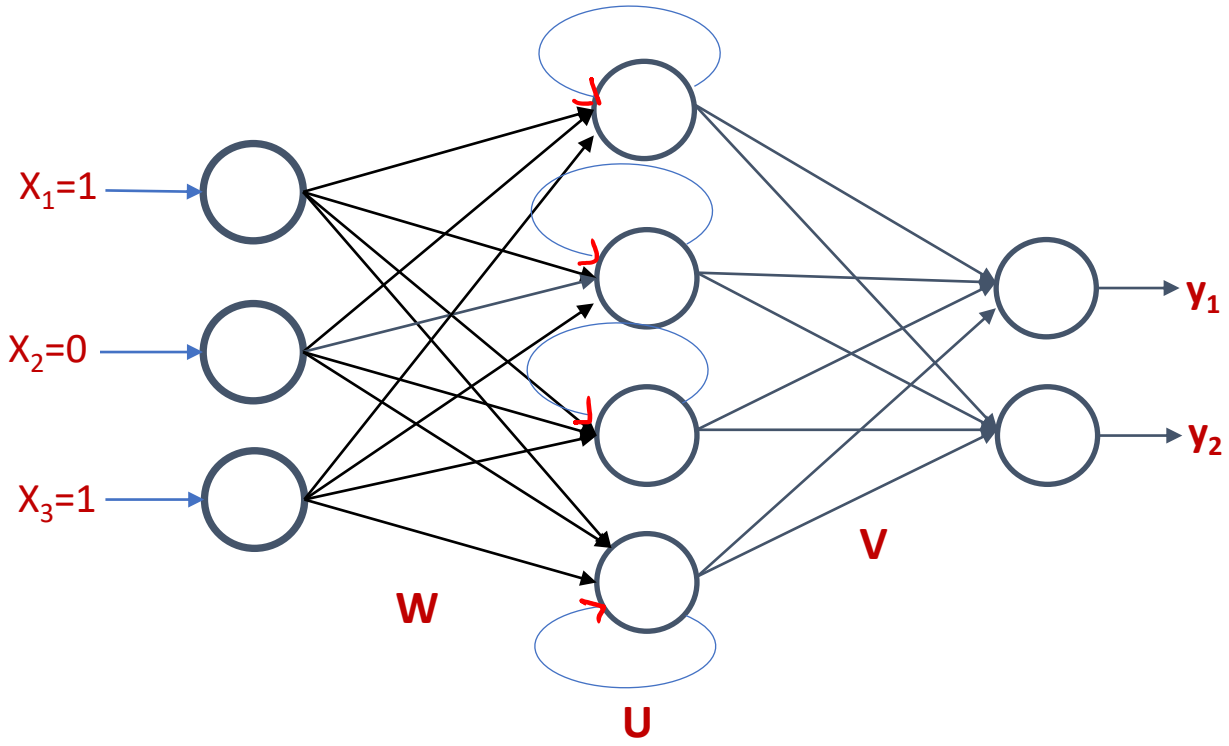

[ Or, a time series data.]

# Sequential Inputs



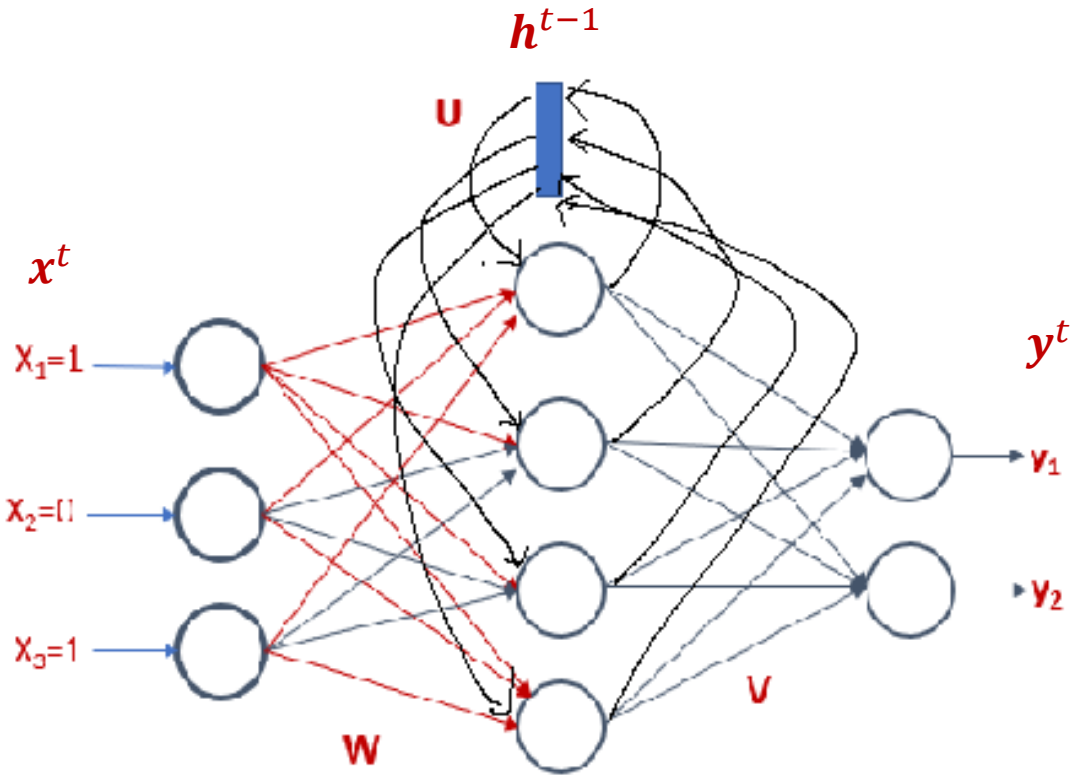

[ Or, Contextual Image. How to handle such samples.]

# Provide a feedback connection




[ One simple way of handling such data is to provide feedback connection in the hidden layer.]

# What if, there is a feedback?





$$\overline{h^1}^T = \sigma\left(\overline{x^1}^T W + \overline{h^0}^T U\right)$$

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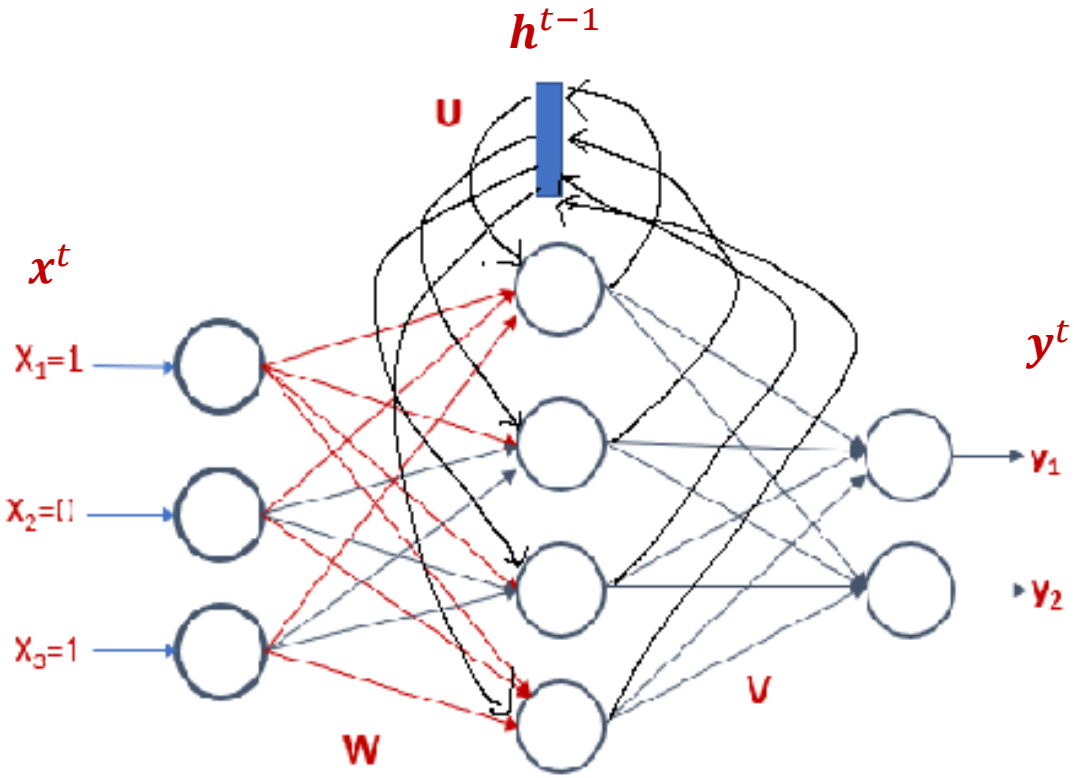



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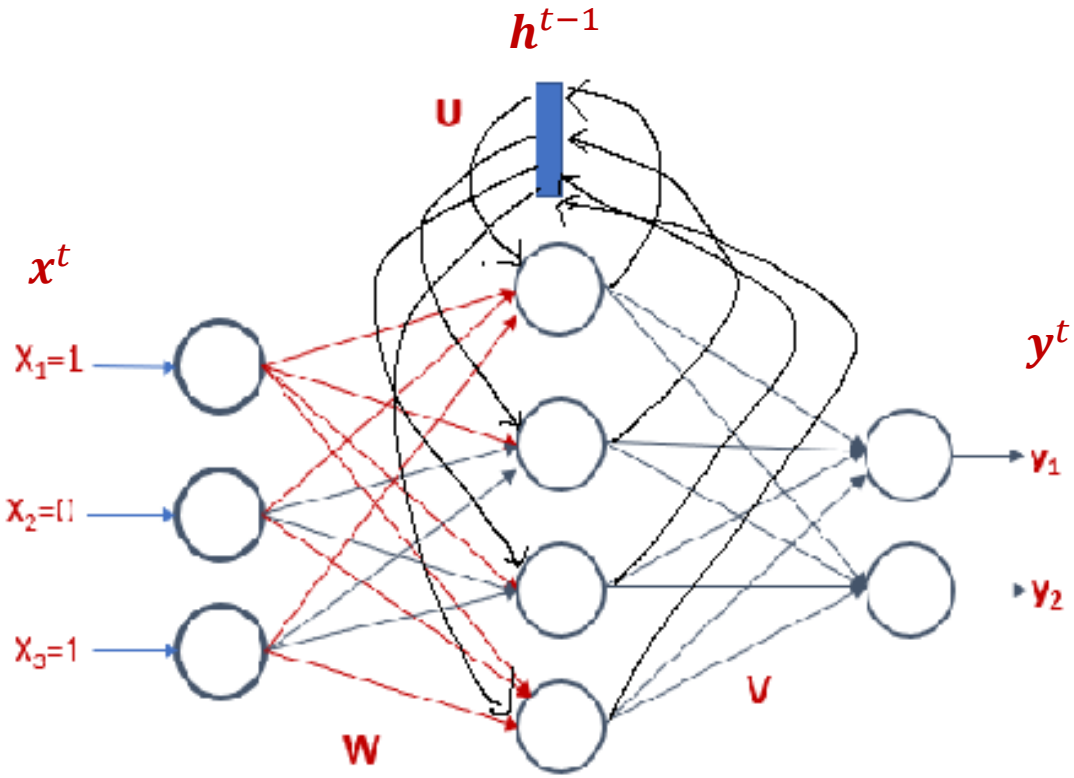



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$$= \sigma\left(\overline{x^3}^T W + \sigma\left(\overline{x^2}^T W + \overline{h^1}^T U\right) U\right)$$

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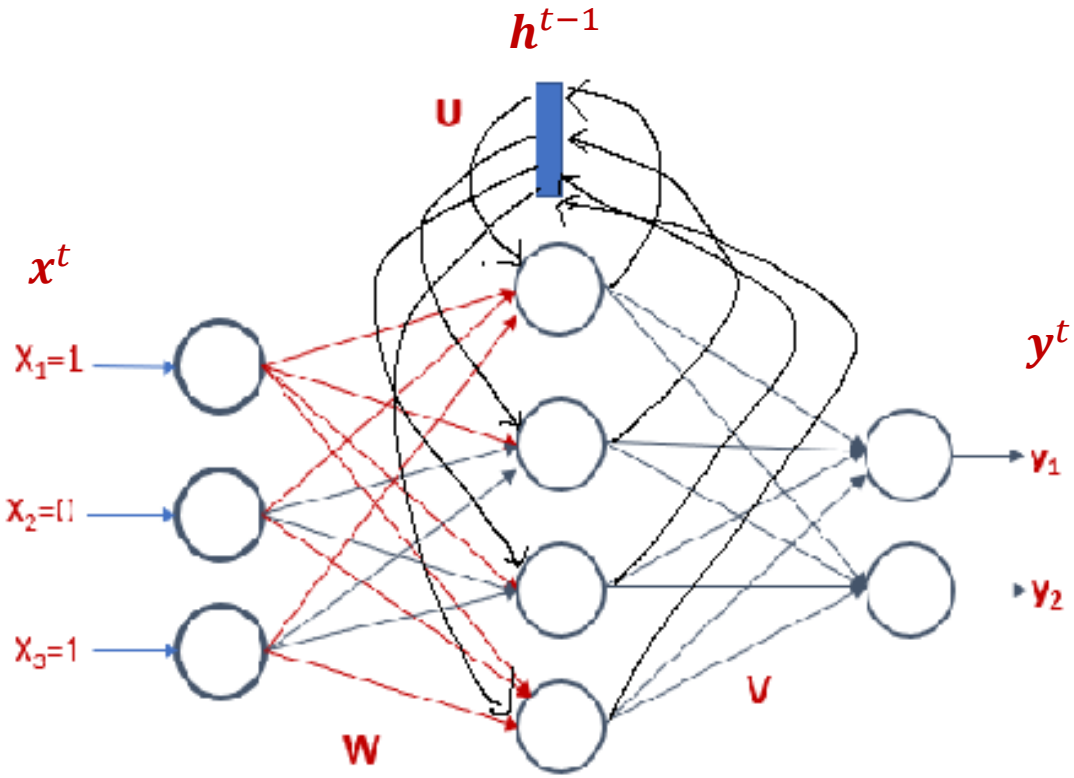



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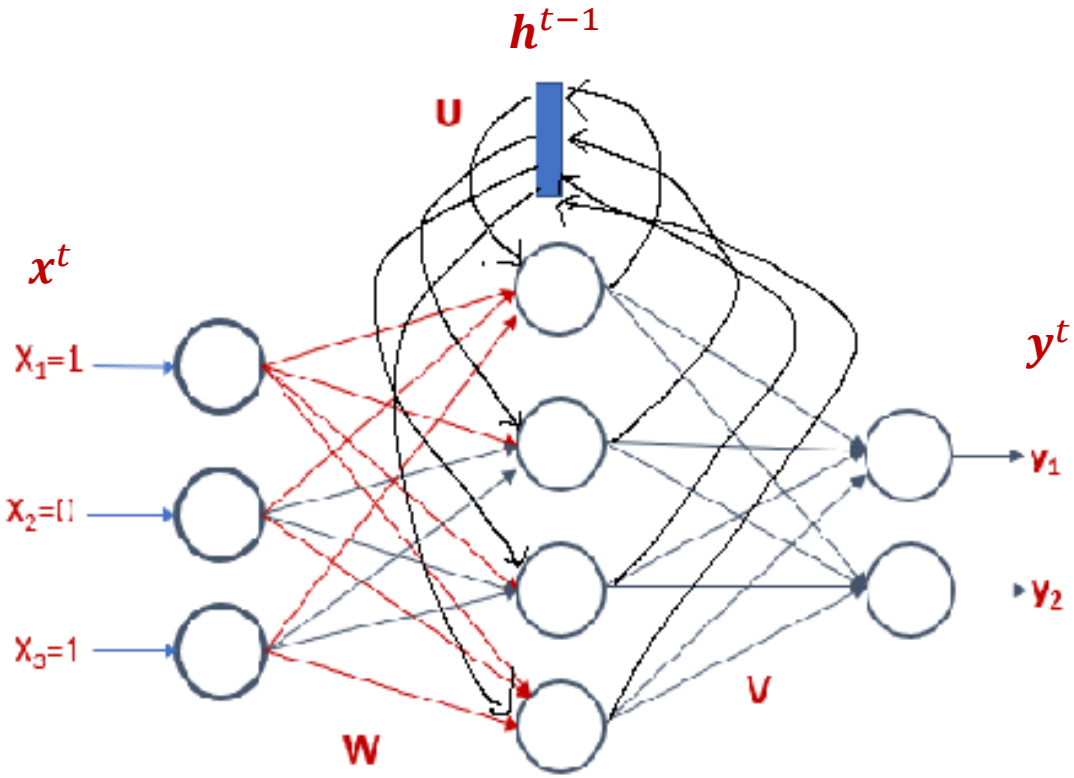



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The feedback is recursively defined. Such model with feedbacks is known as **Recurrent Neural Network.**

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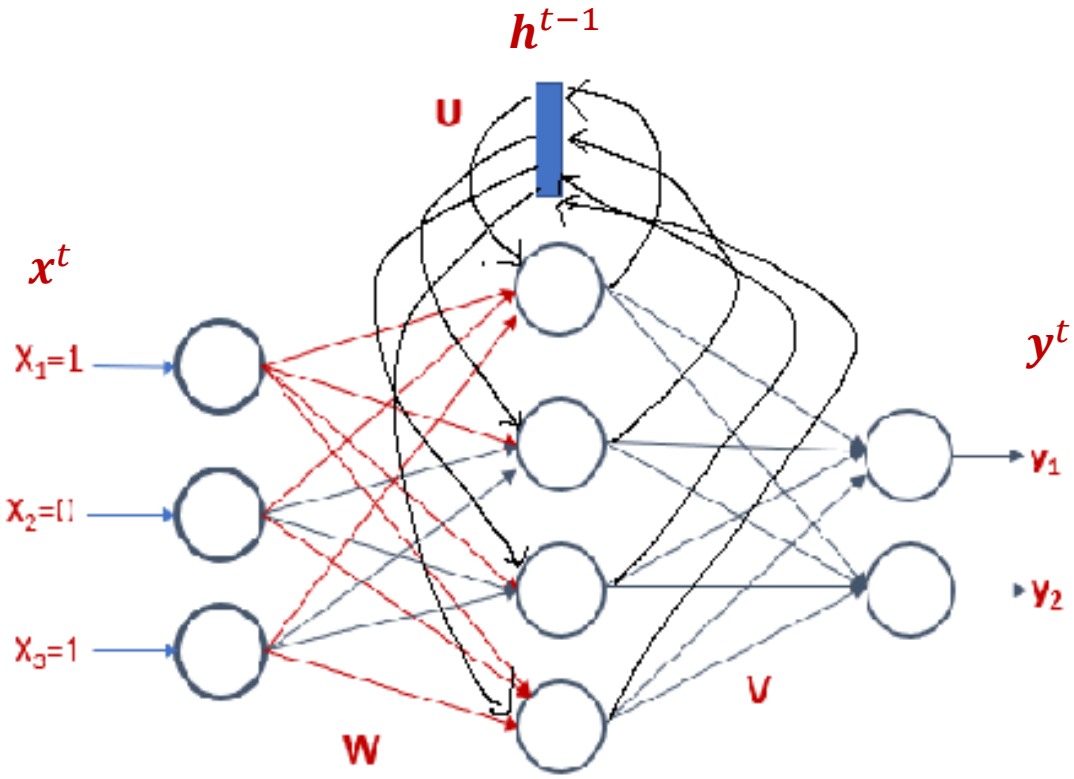



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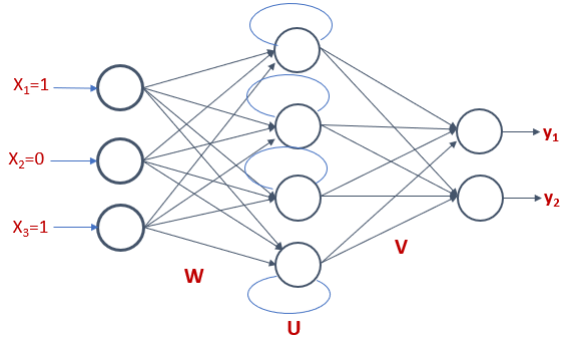
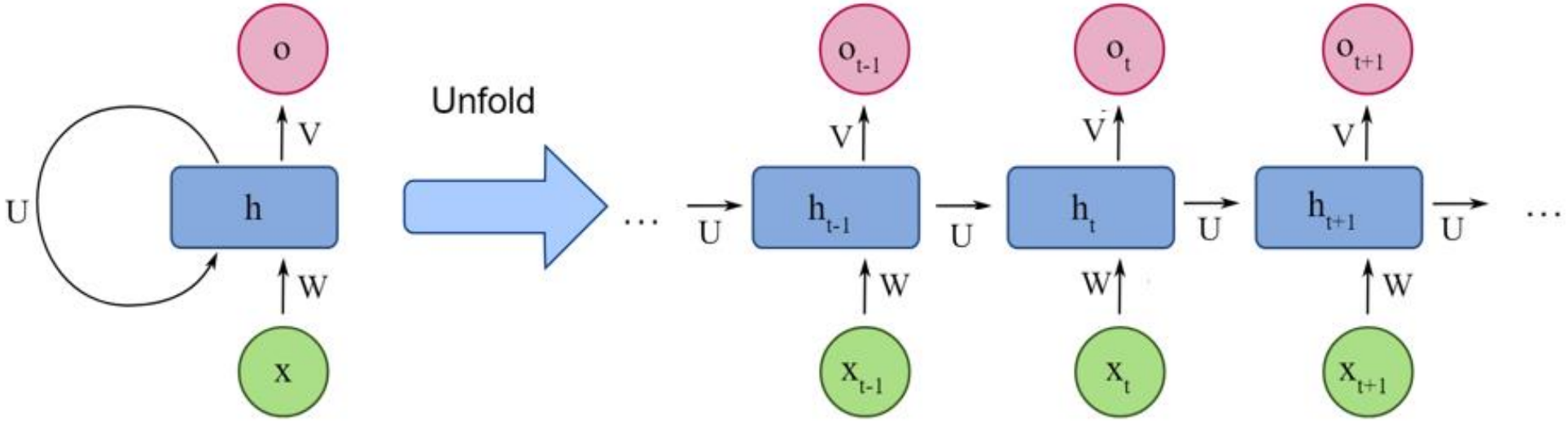
$$\overline{h^t}^T = \sigma\left(\overline{x^t}^T W + \overline{h^{t-1}}^T U\right)$$

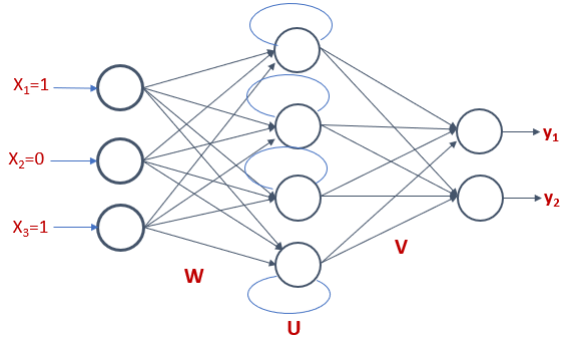
$$\overline{y^t}^T = \sigma\left(\overline{h^t}^T V\right)$$

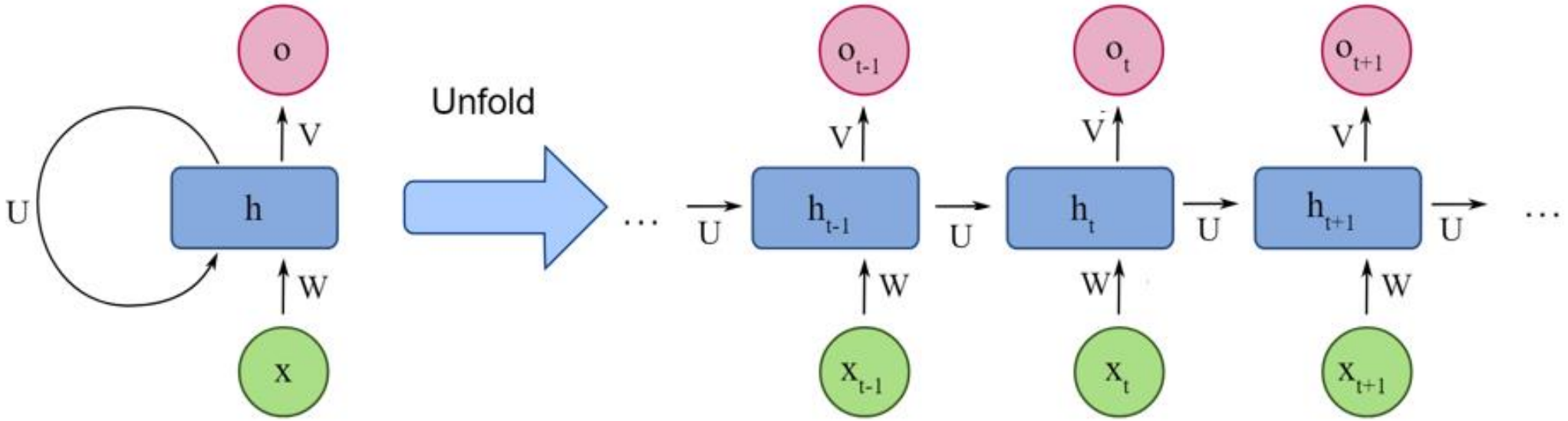
# Recurrent Neural Network



# Recurrent Neural Network



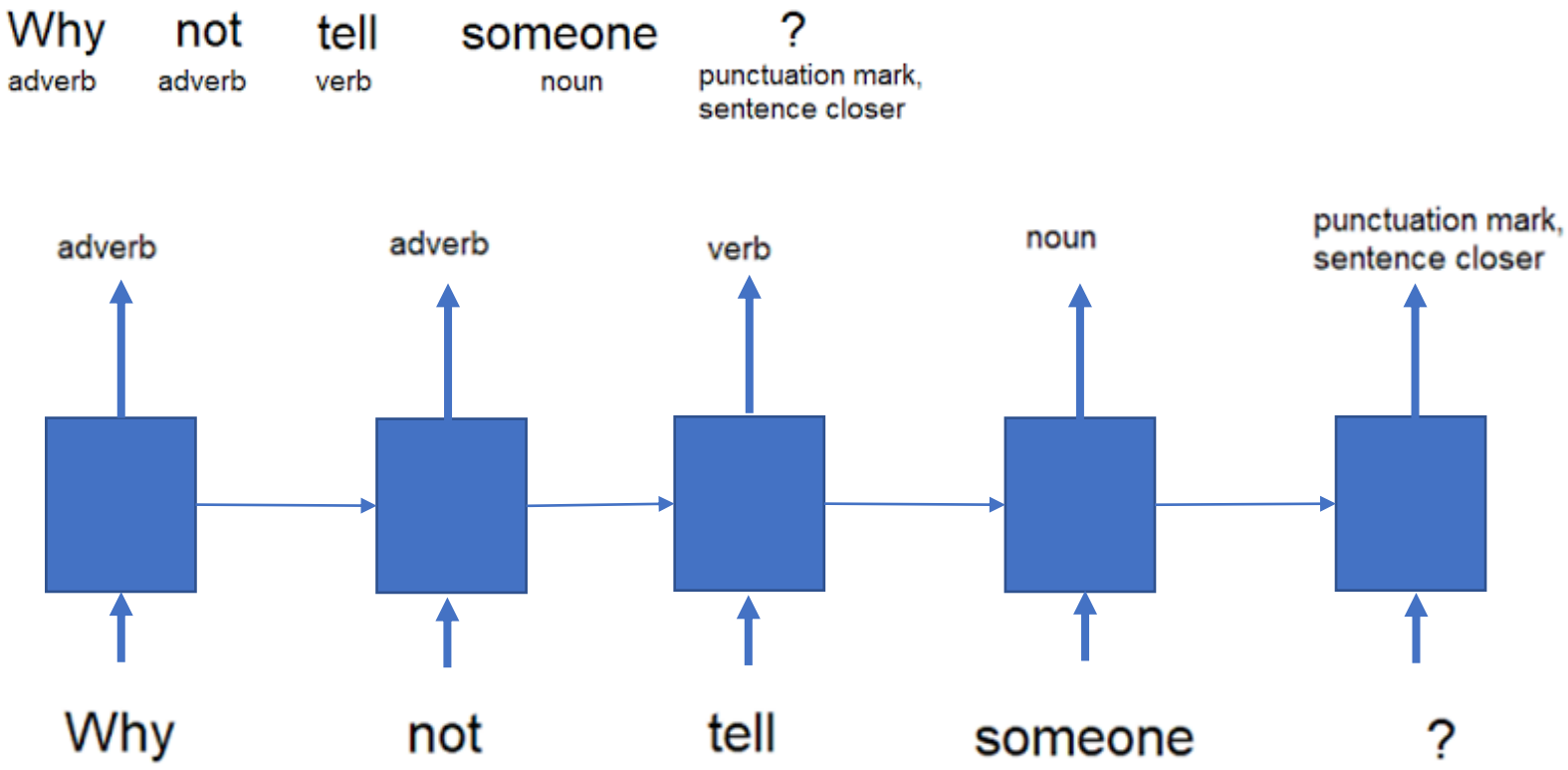




The output vector $h^t$ represents the input sequence till time t.

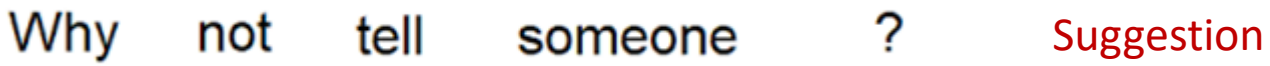
# Different forms of RNN : Many-to Many

| Why | not | tell | someone | ? |
| --- | --- | --- | --- | --- |
| adverb | adverb | verb | noun | punctuation mark, sentence closer |

# Different forms of RNN: Many-to Many

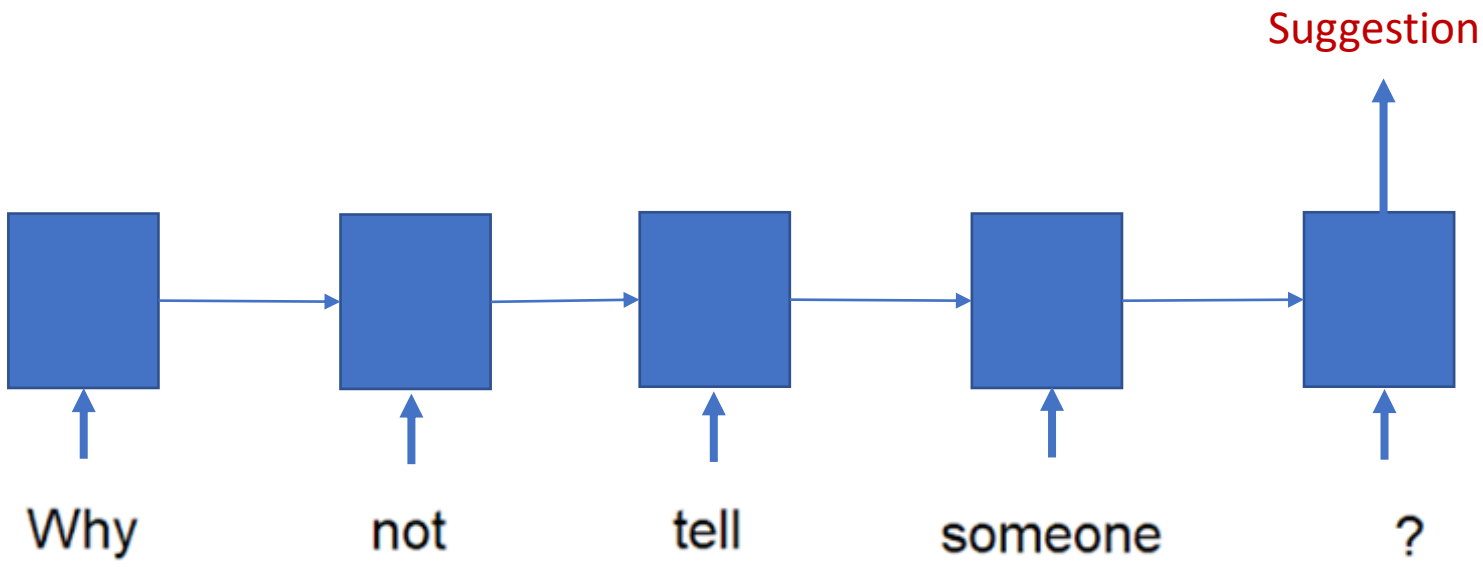


# Different forms of RNN: Many-to-One

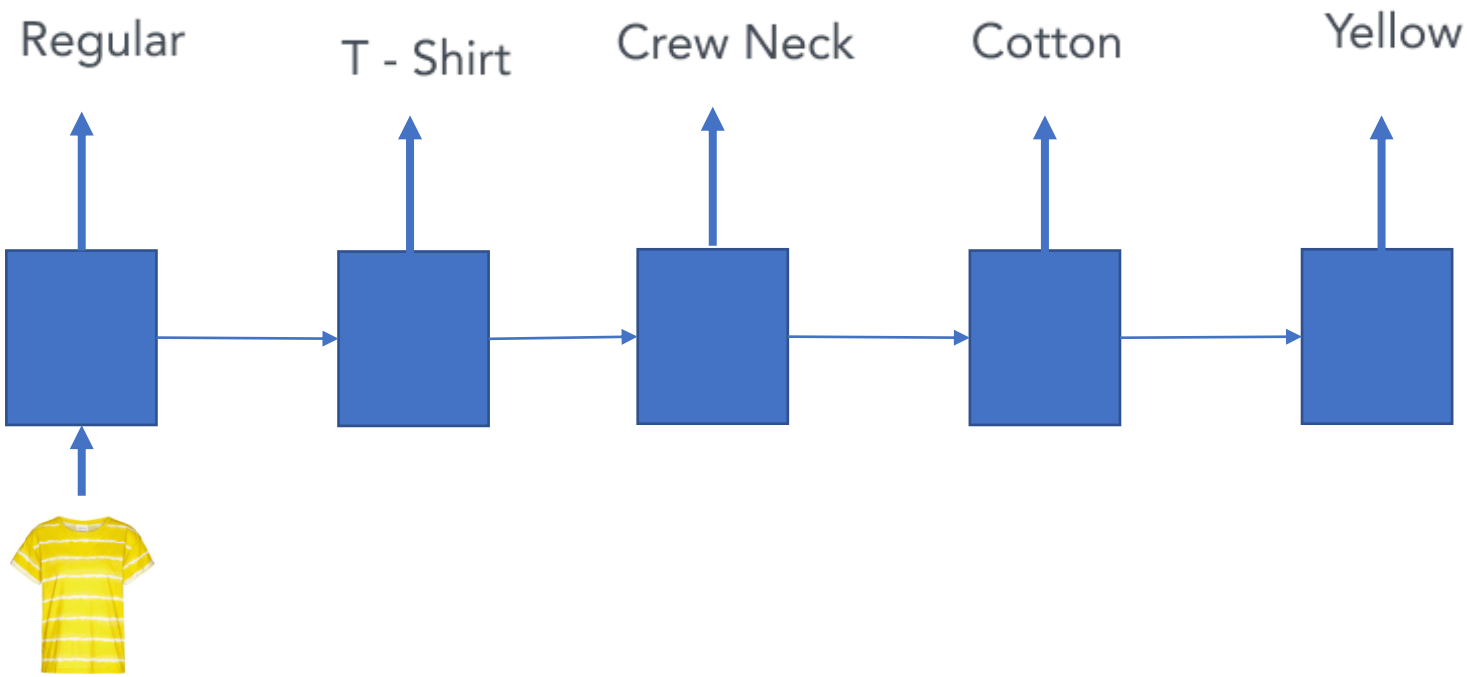


# Different forms of RNN: Many-to-One

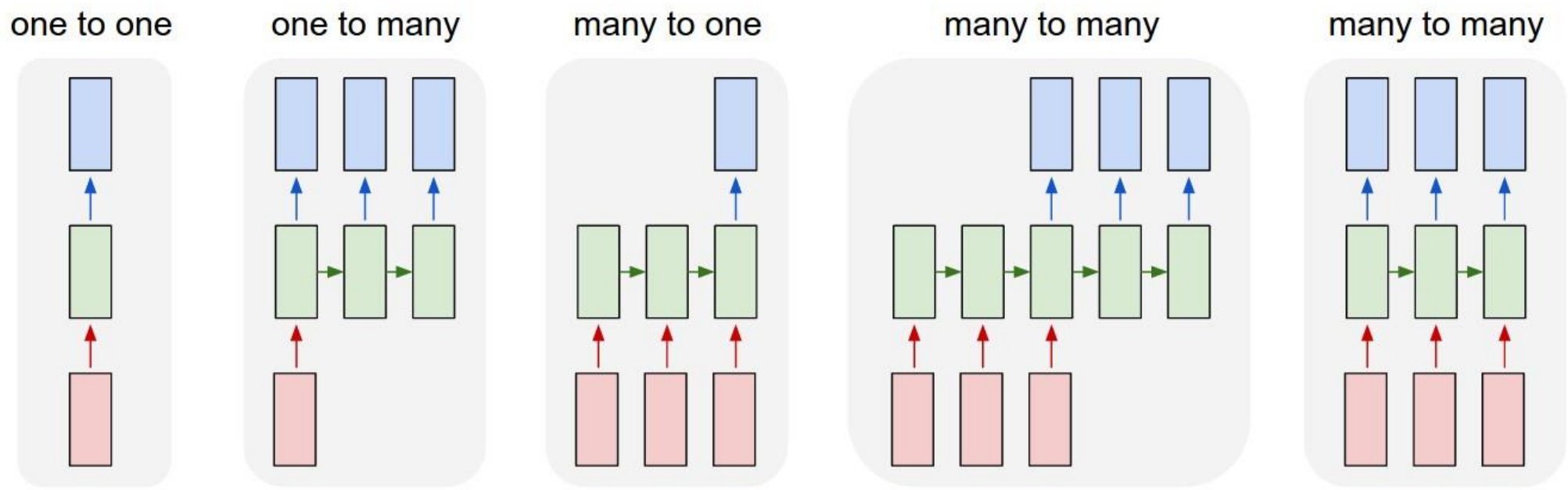
Why not tell someone ? Suggestion



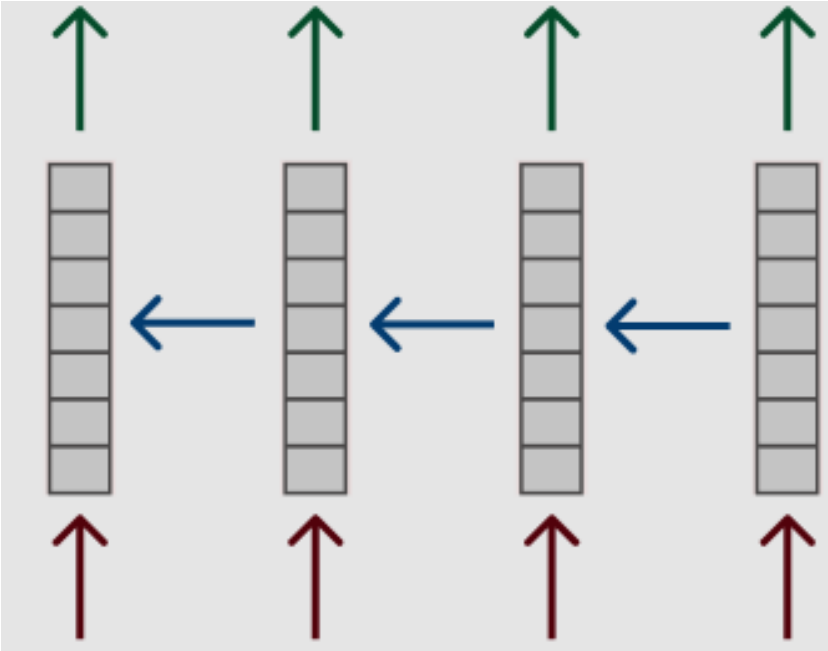
# Different forms of RNN: One-to-Many



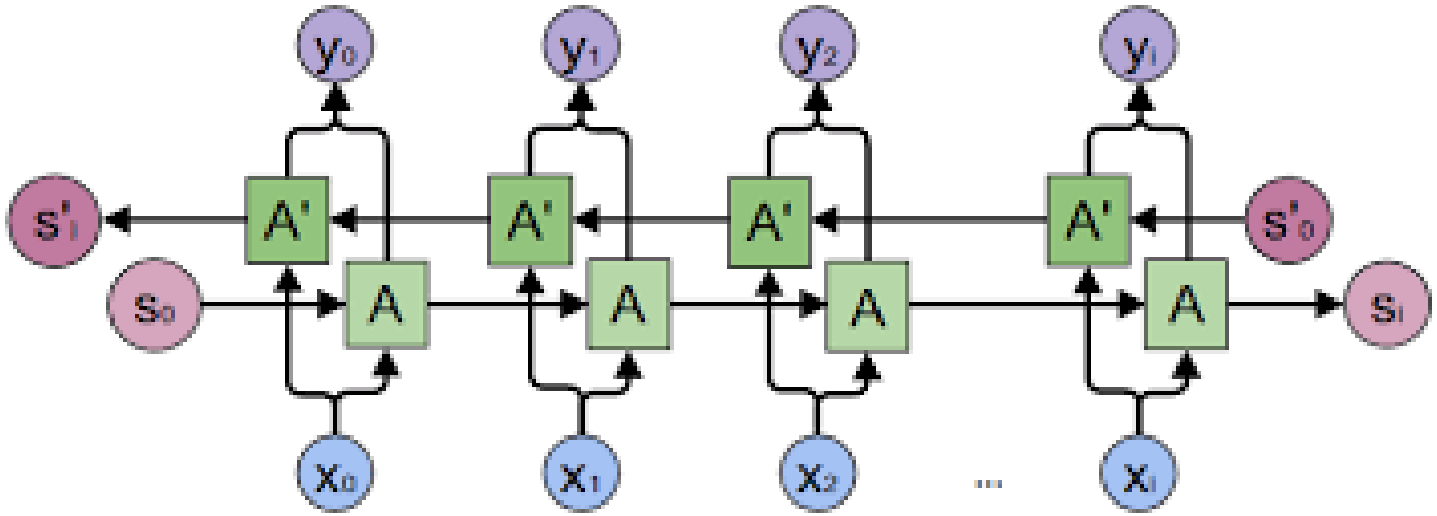
# Types of RNN



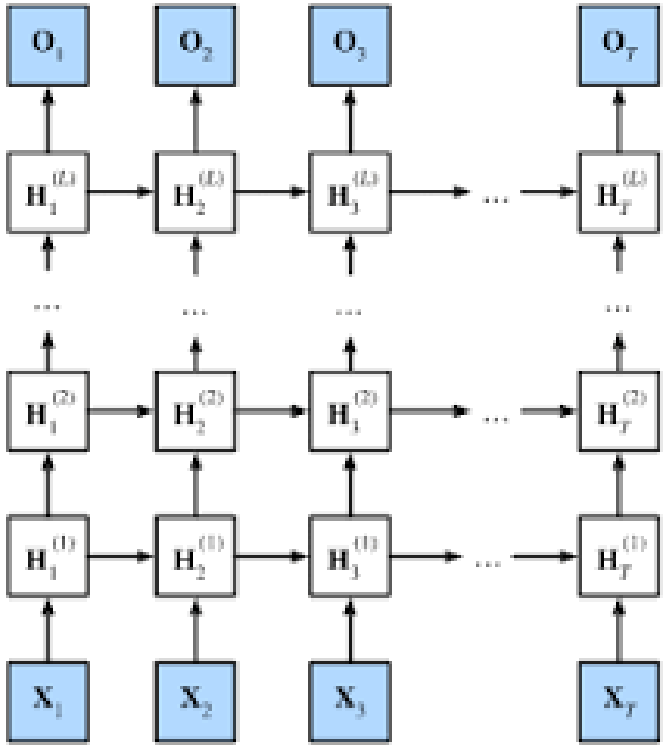
# It can be backward.



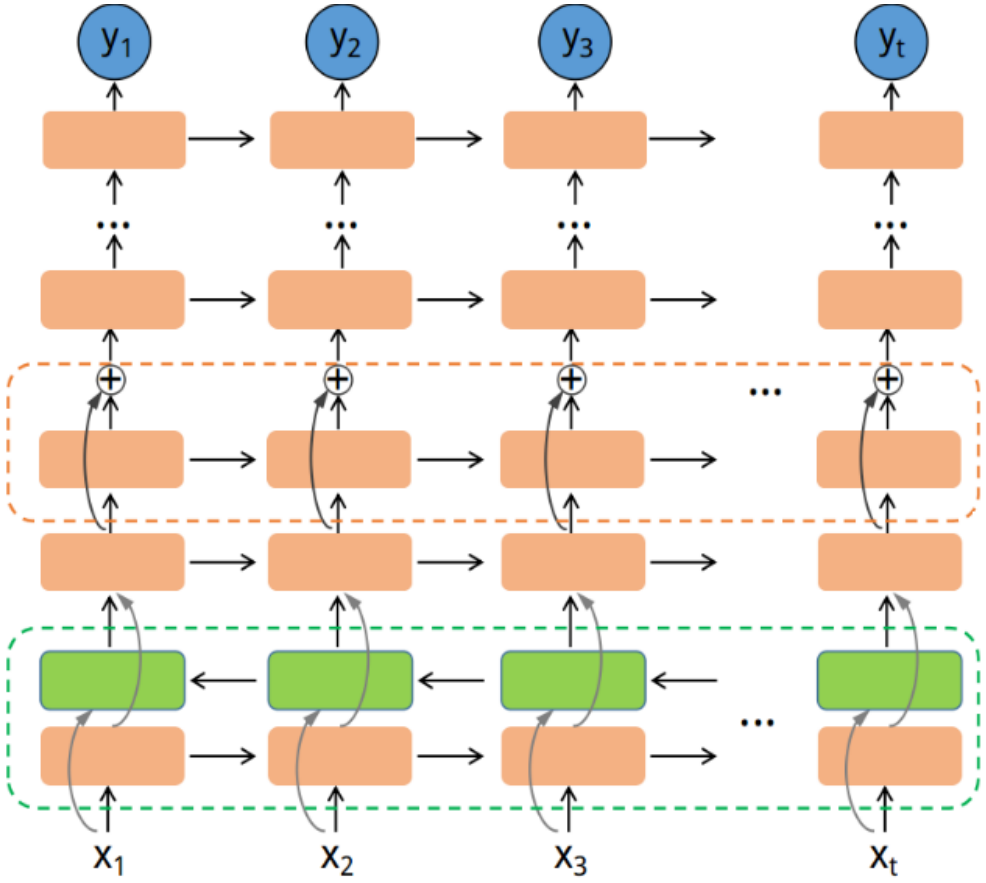
# It can be bidirectional



# It can be multi-layer (deep) RNN



# It can be hybrid RNN



# Summary

- RNN considers sequential context.
- RNN can be used for wide ranges of applications.
- The directions, the connections and the layers can be manipulated based on the need of the underlying problem