

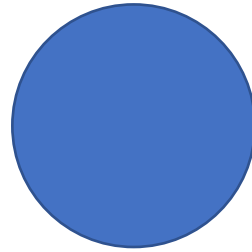
sequence modeling



midjourney bot (2023)

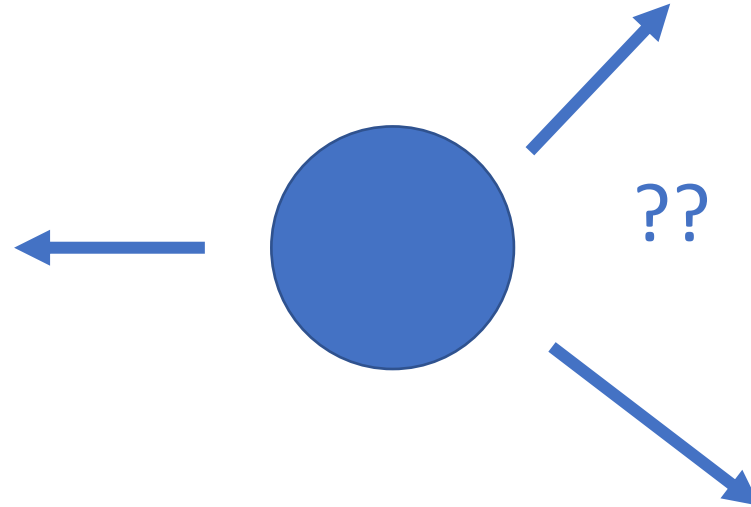
sequence modeling

Where does the ball go next?



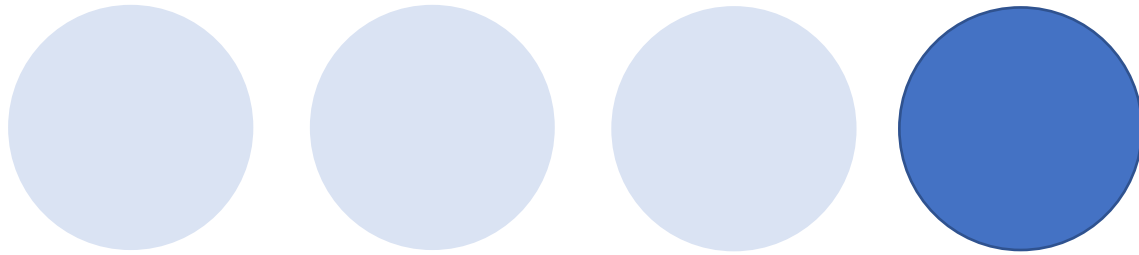
sequence modeling

Where does the ball go next?



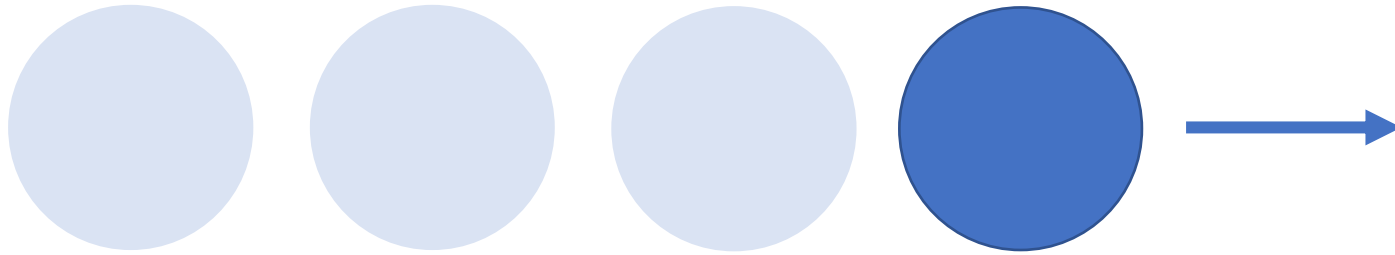
sequence modeling

Where does the ball go next?



sequence modeling

Where does the ball go next?



sequence modeling

text

video streams

audio streams

genomics, transcriptomics, proteomics

stock markets

weather, climate

electrocardiogram

...

Facebook's Turbulent 10 Years on the Stock Market

Stock price of Facebook/Meta since the company's IPO on May 18, 2012



Source: Yahoo! Finance



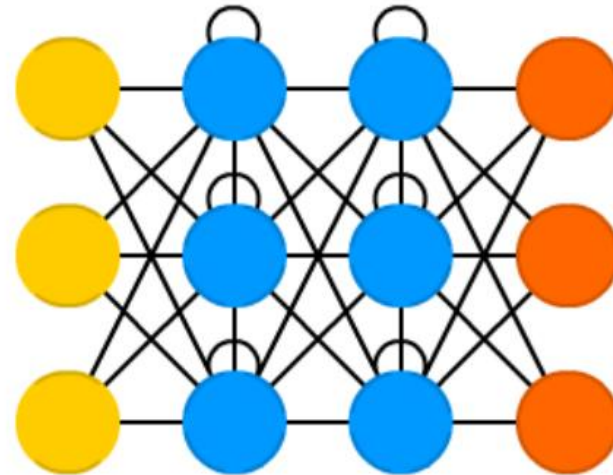
statista

sequence modeling

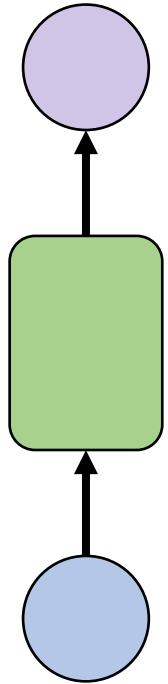
Sequences can have variable length, which makes it hard to represent them as fixed length feature vectors.

The **recurrent neural network** module is designed to tackle this issue.

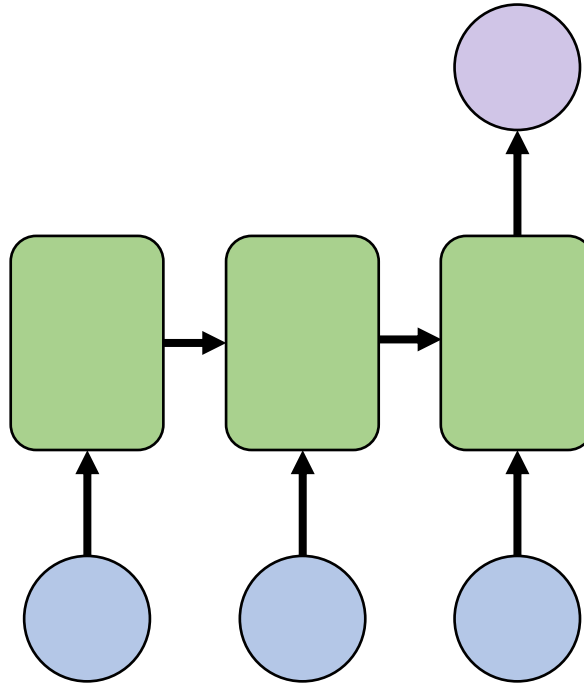
Recurrent Neural Network (RNN)



sequence modeling



one to one



many to one

sentiment classification

protein function prediction

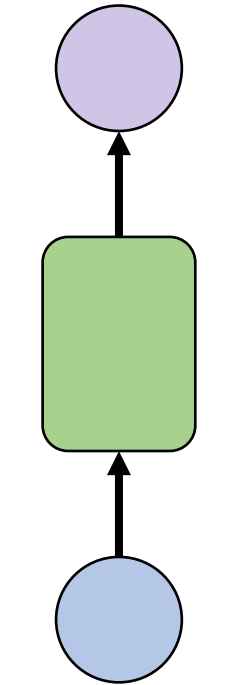
stock market price prediction

gene expression prediction

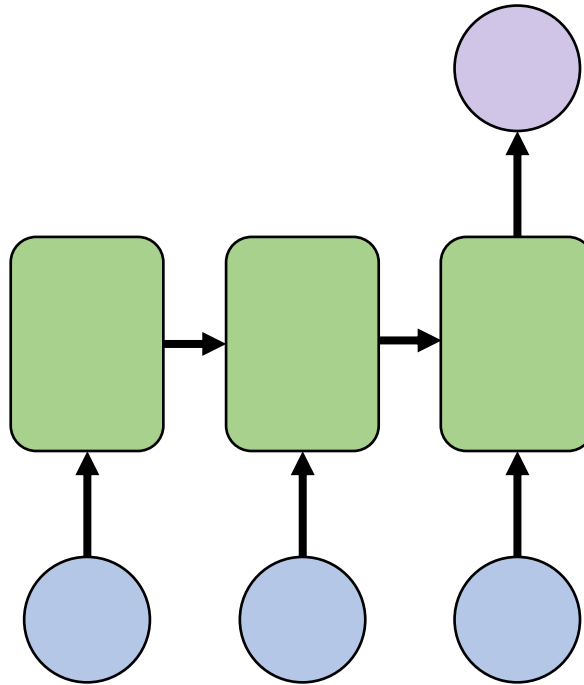
video topic classification

...

sequence modeling



one to one

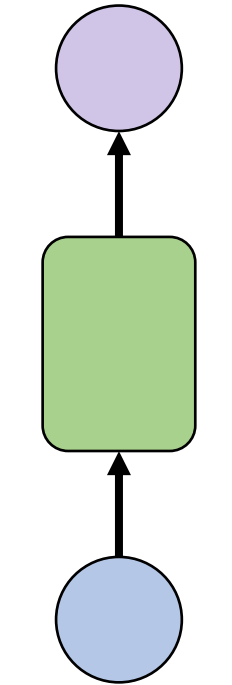


many to one

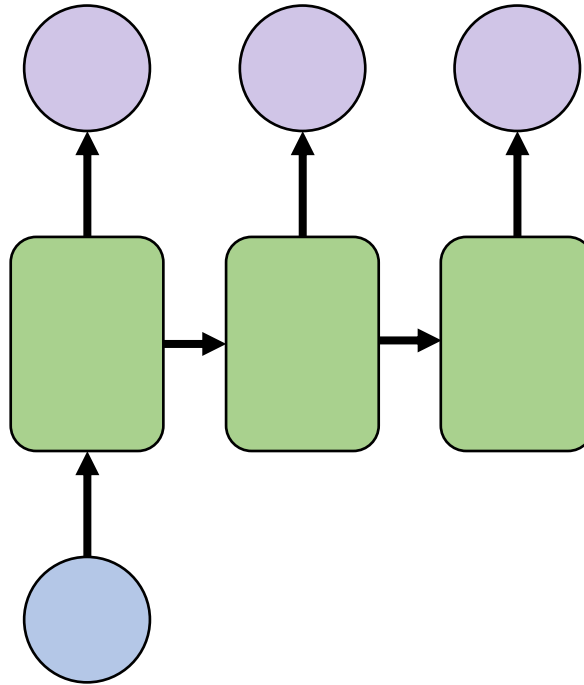


A classroom with students discussing the future of AI in healthcare, photorealistic.

sequence modeling



one to one

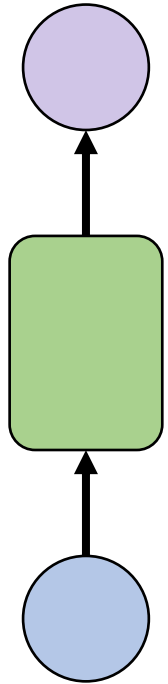


one to many

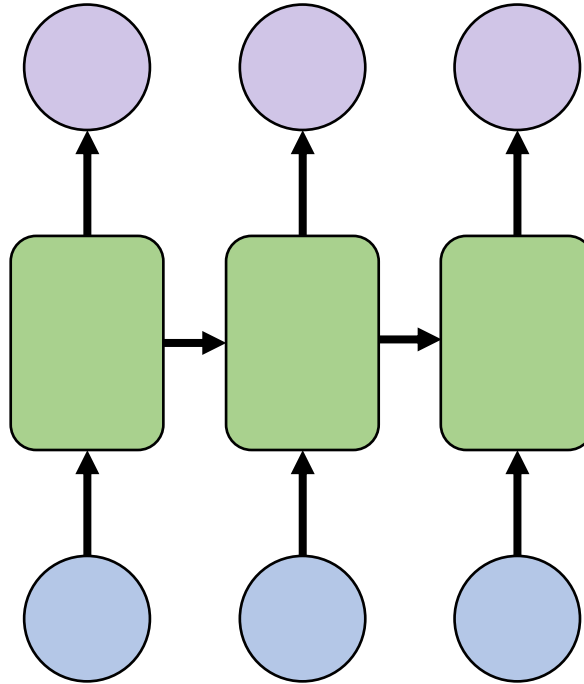
A baseball player throwing a ball.



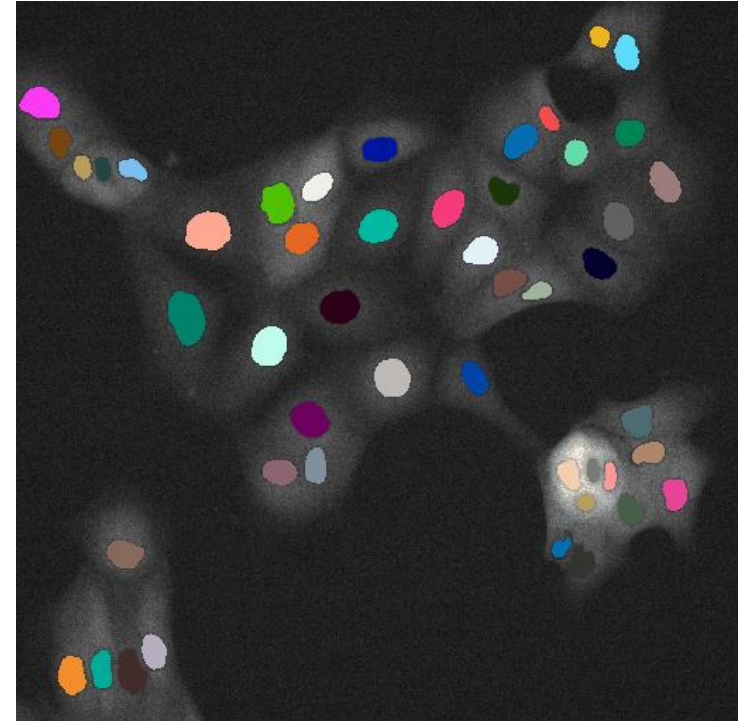
sequence modeling



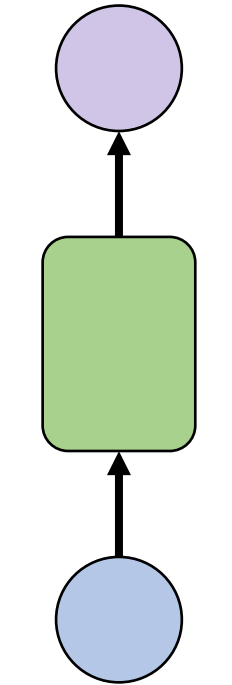
one to one



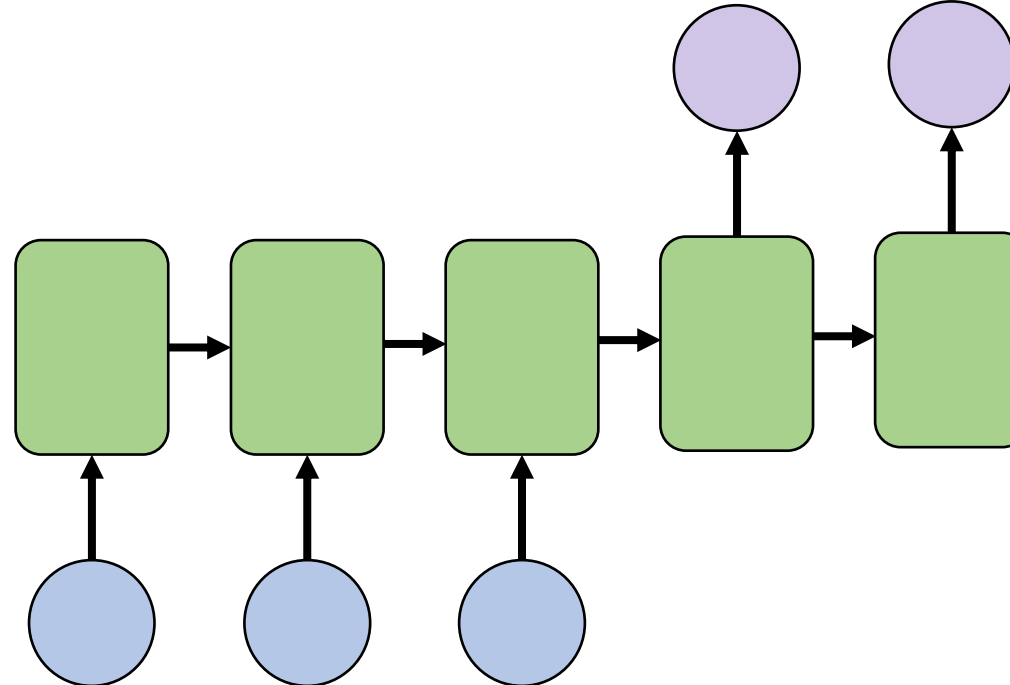
many to many



sequence modeling



one to one



many to many

text translation

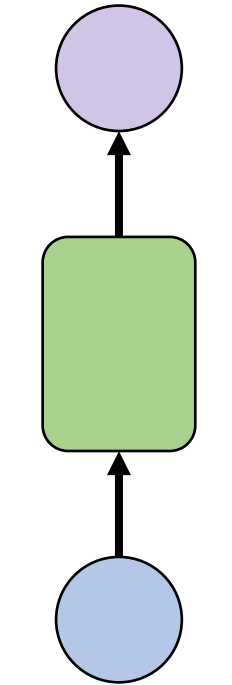
protein secondary structure
prediction

MS/MS spectrum prediction

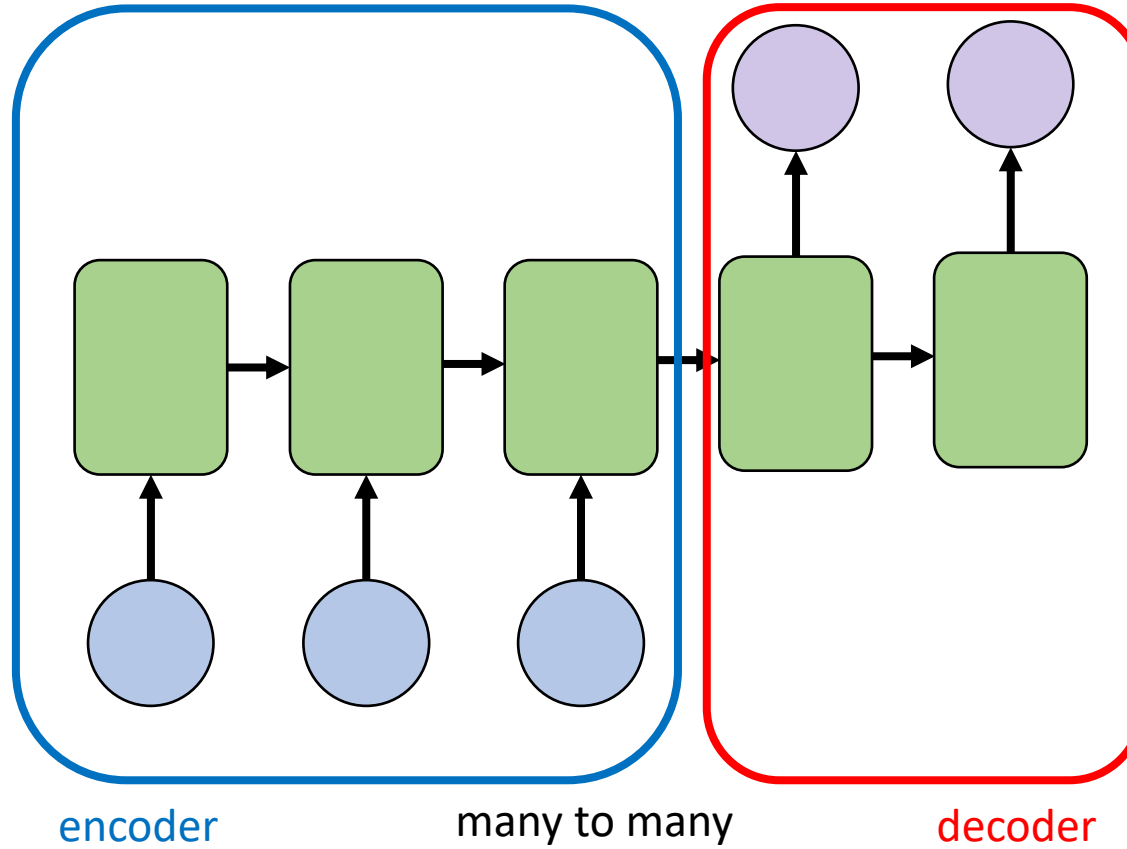
peptide identification

...

sequence modeling



one to one



text translation

protein secondary structure
prediction

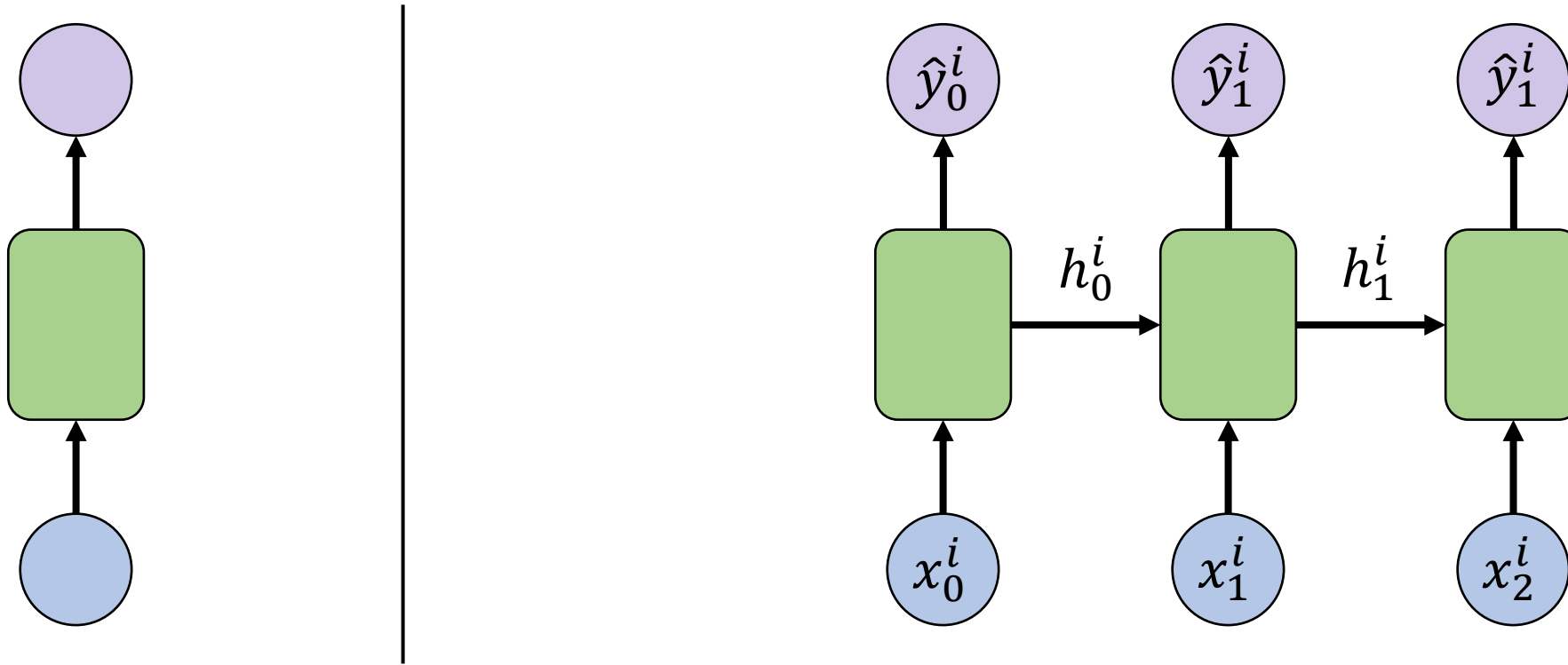
MS/MS spectrum prediction

peptide identification

...

recurrent neural network (RNN)

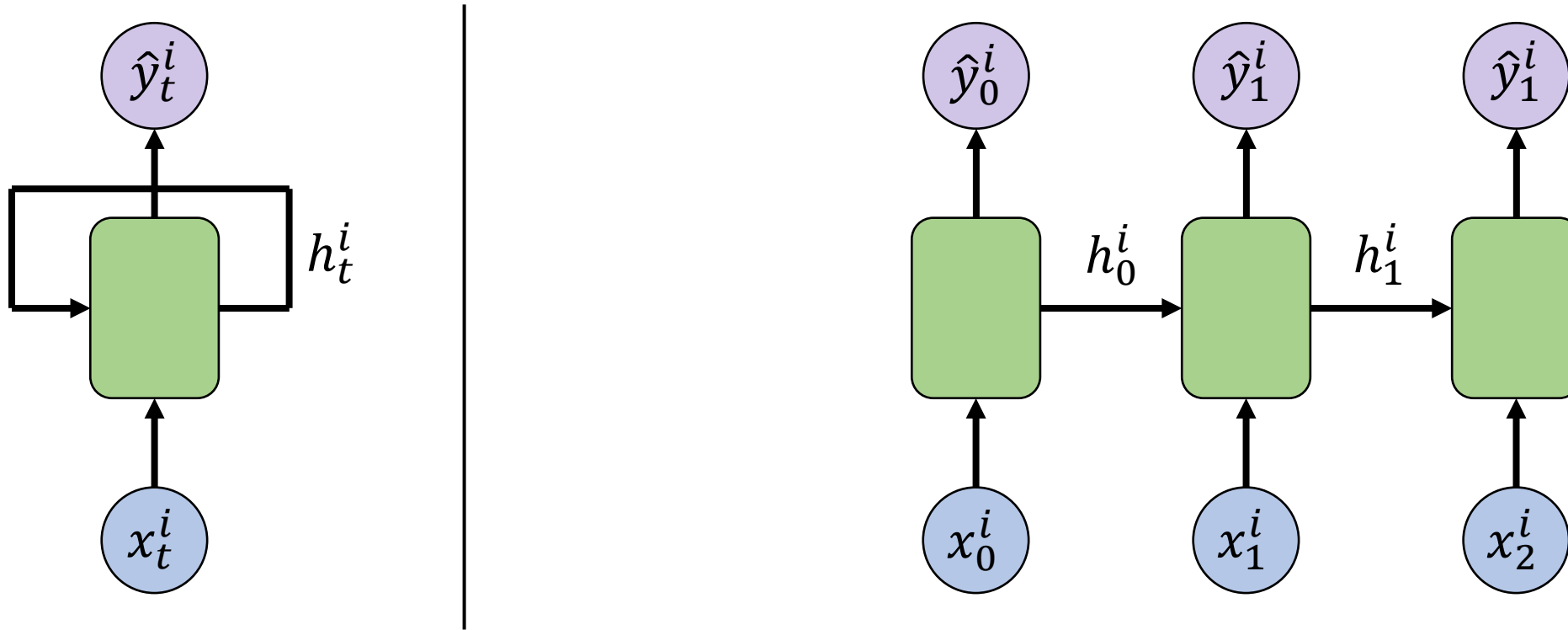
It is important to realize that the model parameters of the RNN are the same in each time-step, i.e. the green part in the diagram is always the same.



recurrent neural network (RNN)

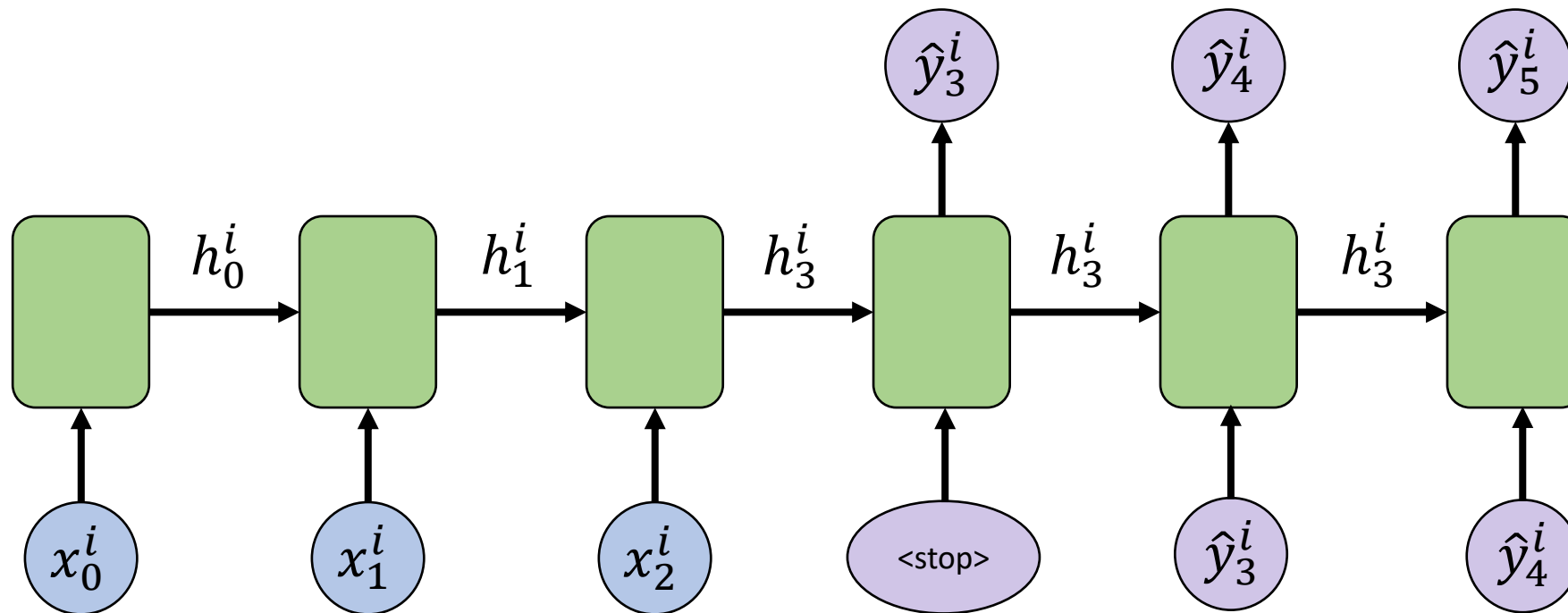
It is important to realize that the model parameters of the RNN are the same in each time-step, i.e. the green part in the diagram is always the same.

So, we can also represent the RNN as shown on the left.



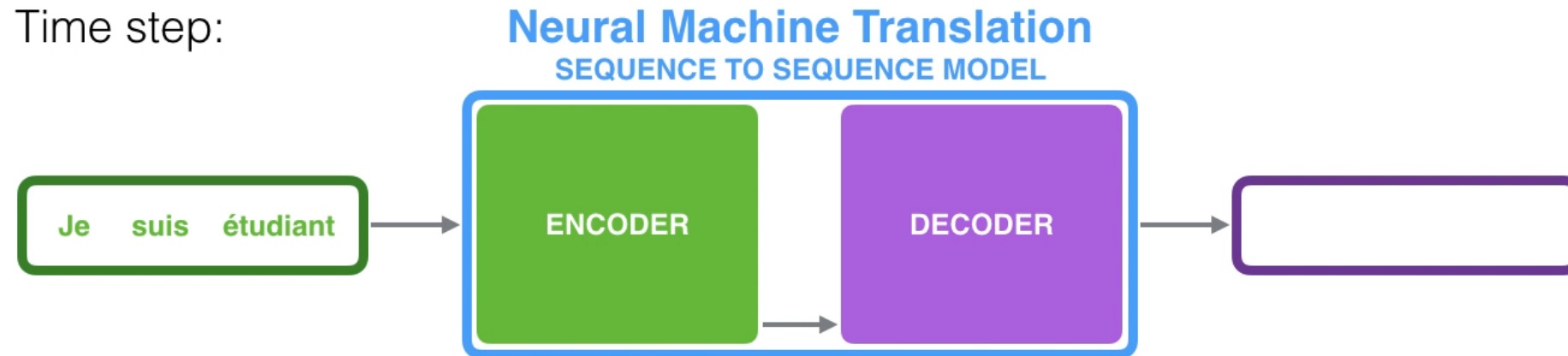
RNN encoding - decoding

A general case of an RNN is many to many with an encoder encoding the input sequence into a hidden state vector (h_3^i in the diagram below) and then applying the decoder to decode the hidden state vector into the output sequence.



RNN encoding - decoding

Folded this looks like this.

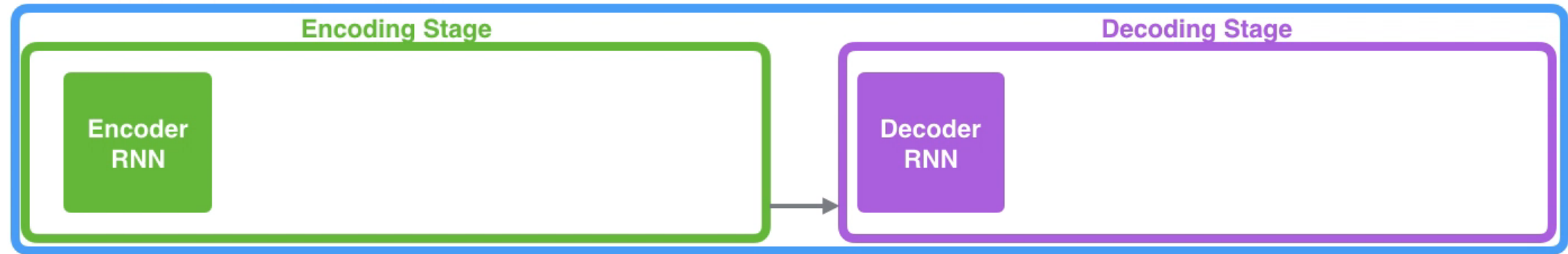


RNN encoding - decoding

Unfolded this looks like this.

Neural Machine Translation

SEQUENCE TO SEQUENCE MODEL



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suis

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This creates a bottleneck in which all information in the input sequence needs to be encoded into the final hidden state vector.

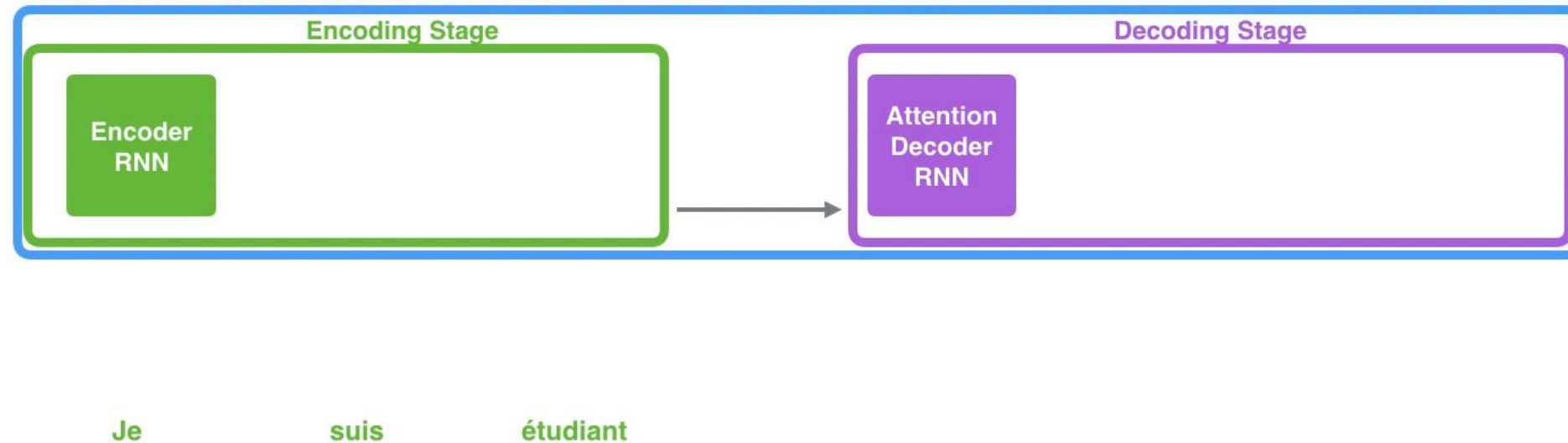
This puts limitations to the length of the input sequence.

RNN encoding - decoding

One way to solve this issue is to use a hidden state vectors to decode.

Neural Machine Translation

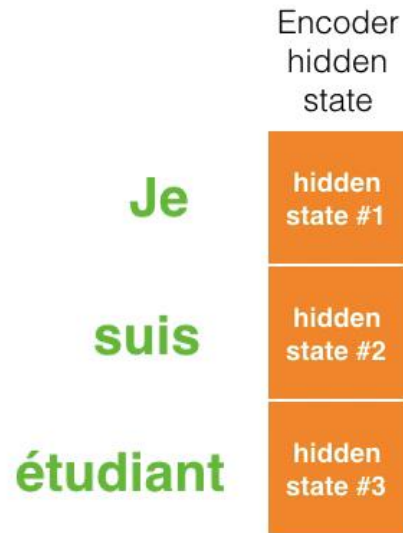
SEQUENCE TO SEQUENCE MODEL WITH ATTENTION



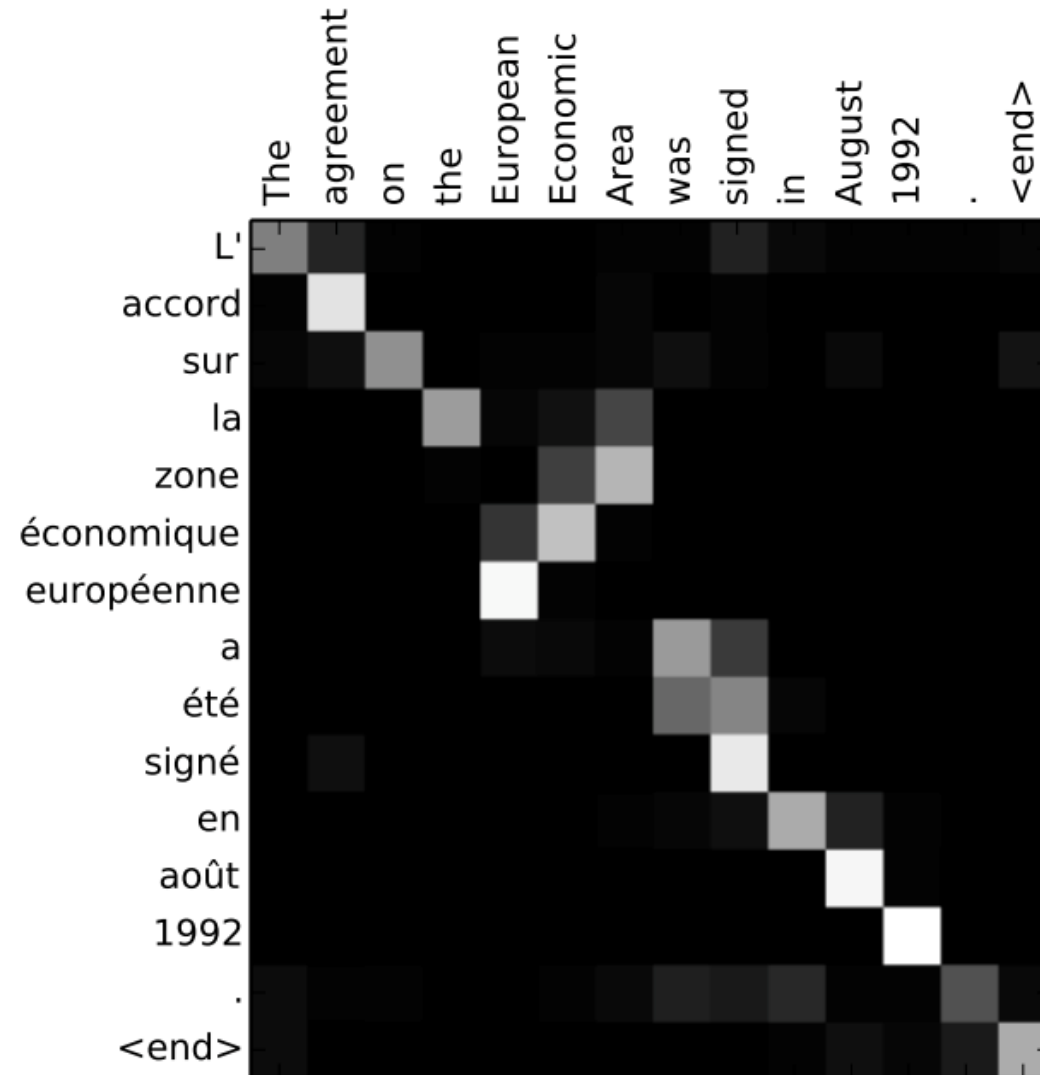
But this can create an information overflow during decoding.

learning to pay attention

This issue can be solved by adding an **attention layer**. This is again a specialized architecture with model parameters that learns to pay more or less attention to the specific hidden state vectors during each time-step in the decoding.



learning to pay attention



attention is all you need

The transformer architecture is the current state of the art (I think...).

