

# An introduction to Recurrent Neural Networks

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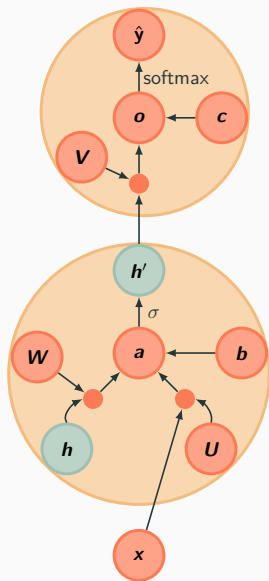
October 12, 2017

**IME-USP:** Institute of Mathematics and Statistics, University of São Paulo

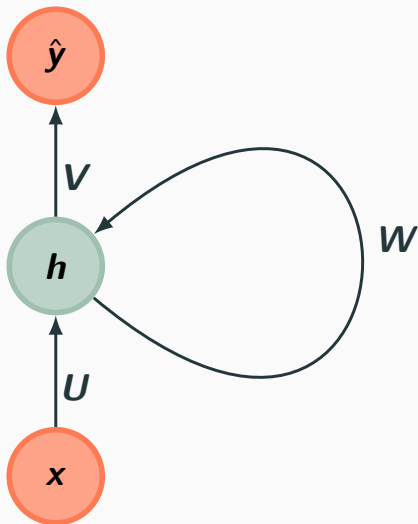
**RNN**

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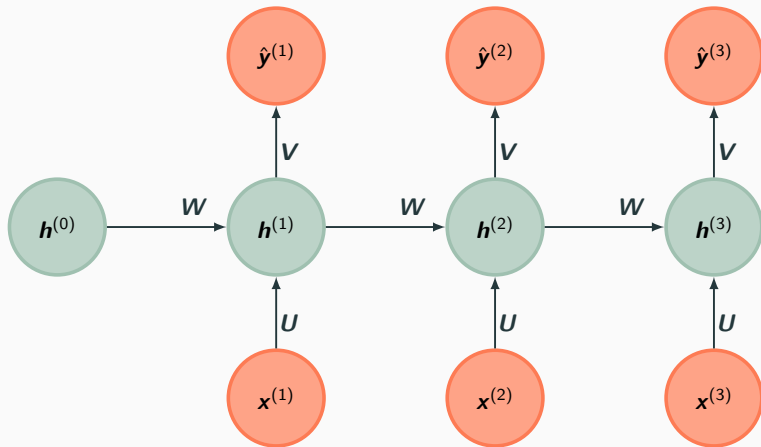
# RNN as a graph



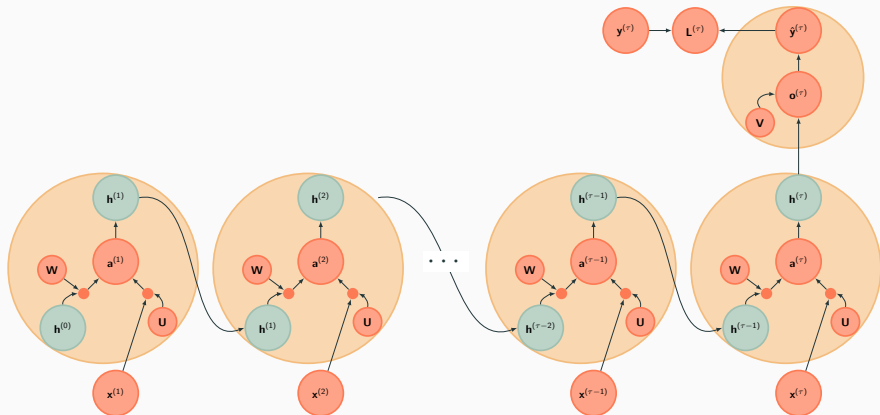
## RNN as a graph



# Unfolding the graph



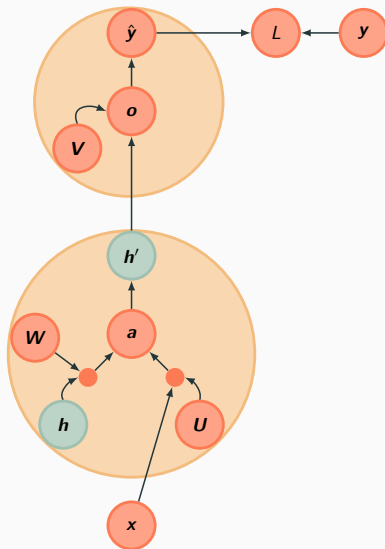
# RNN time unfolding



# BackPropagation

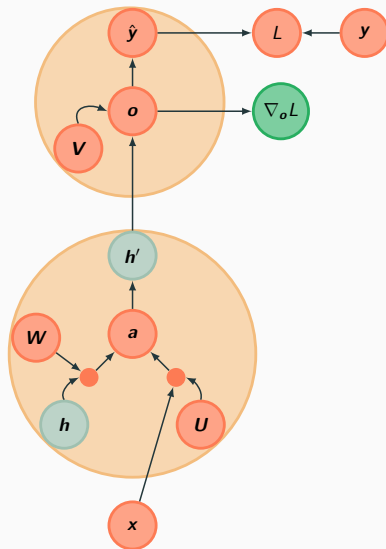
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## Chain rule: RNN graph

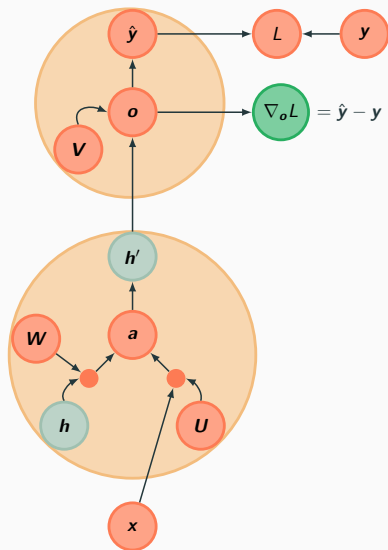




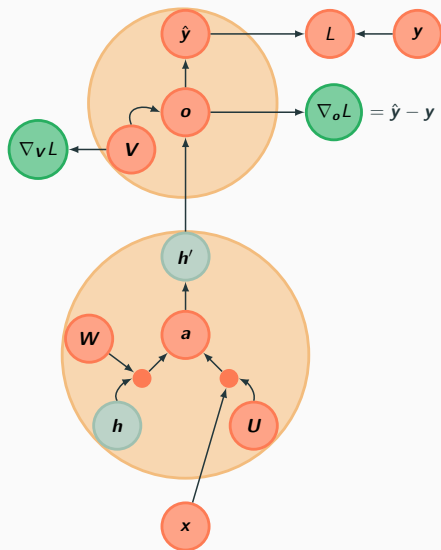
## Chain rule: RNN graph



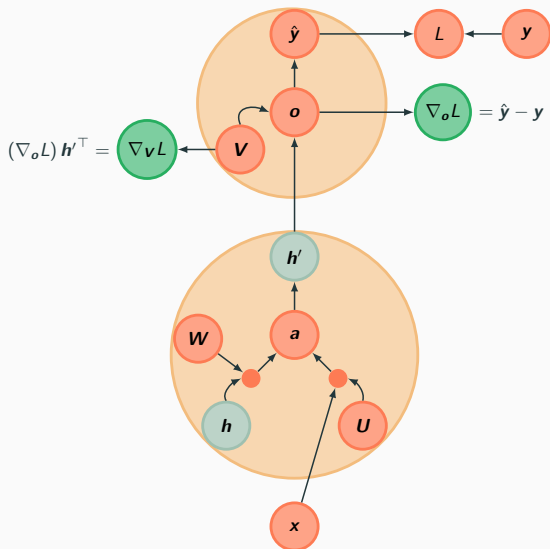
## Chain rule: RNN graph



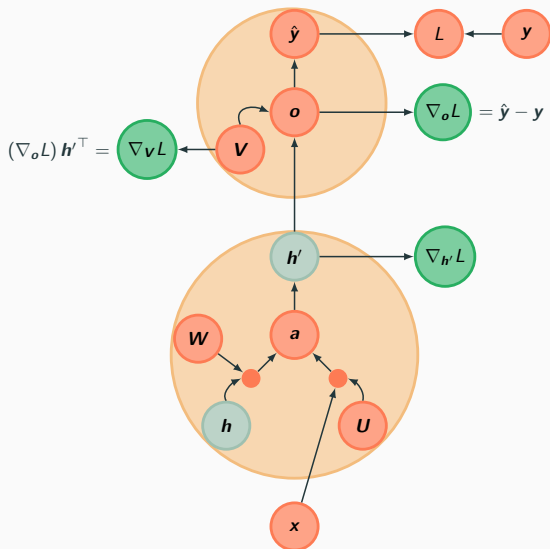
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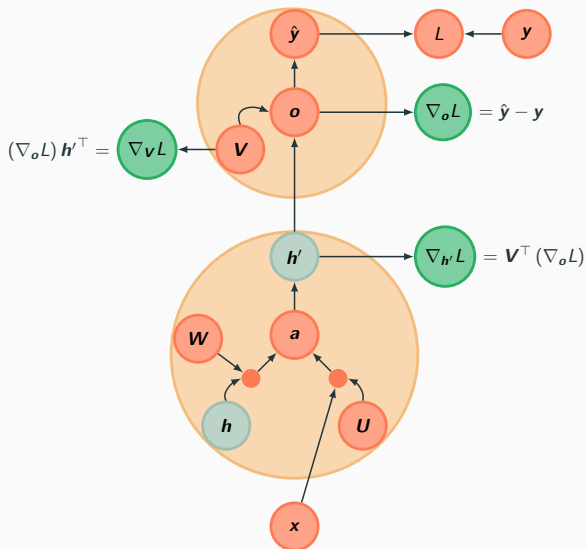
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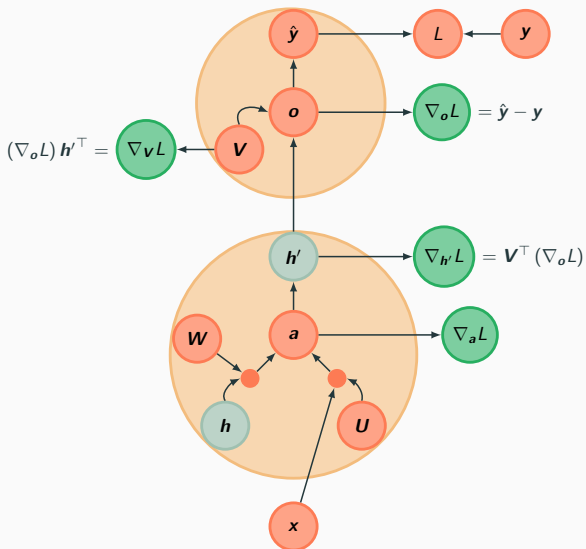
## Chain rule: RNN graph



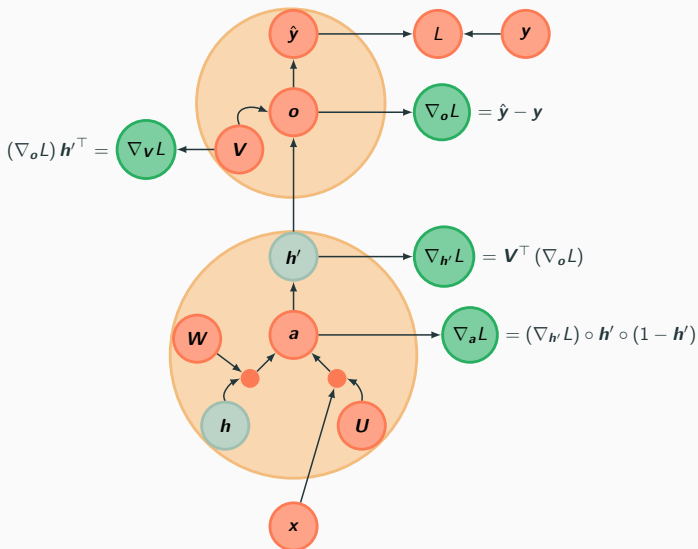
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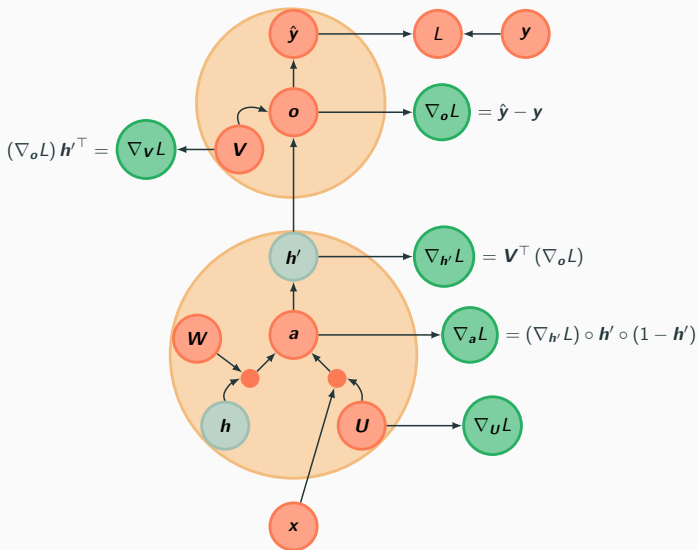


## Chain rule: RNN graph

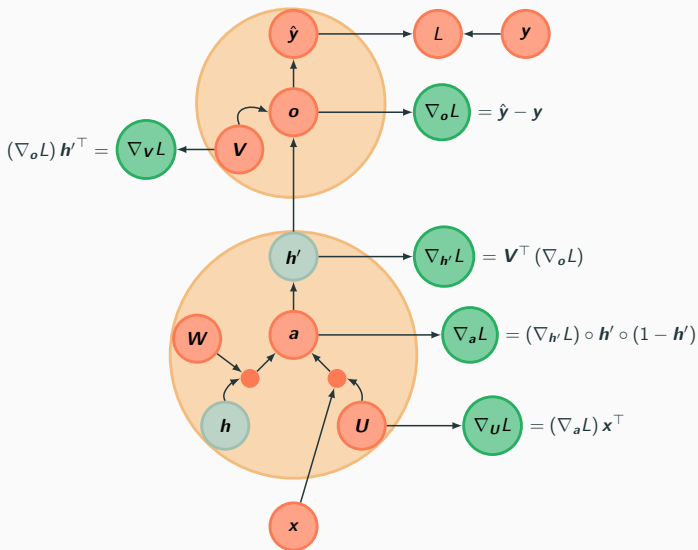




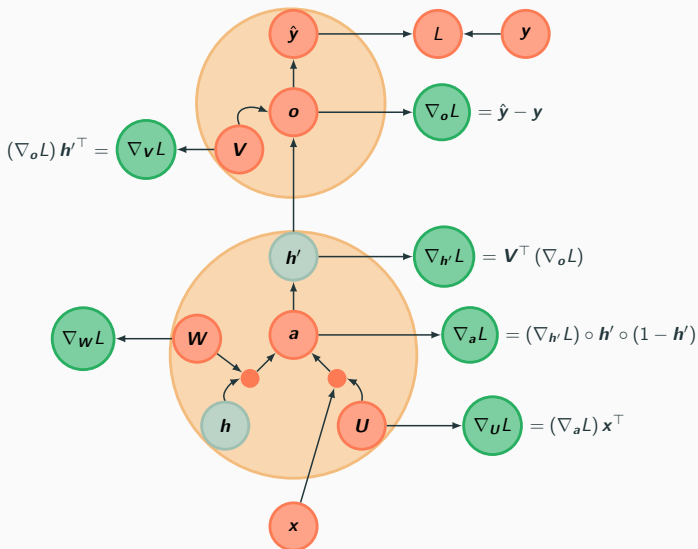
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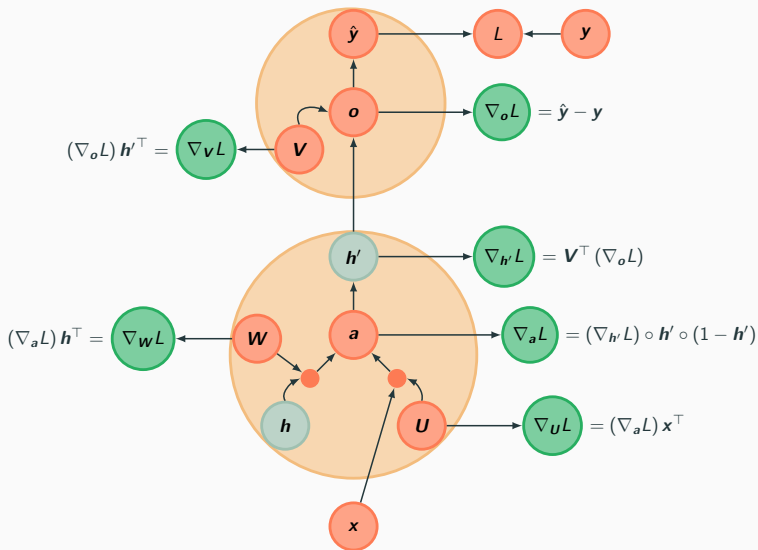
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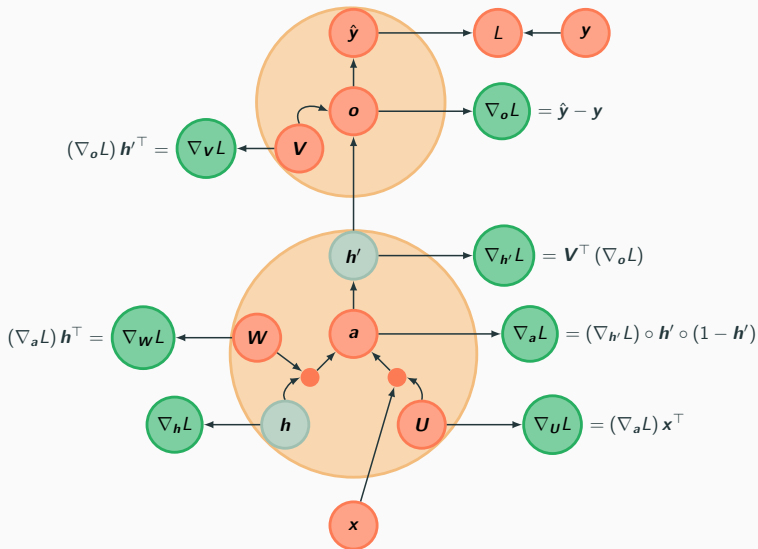
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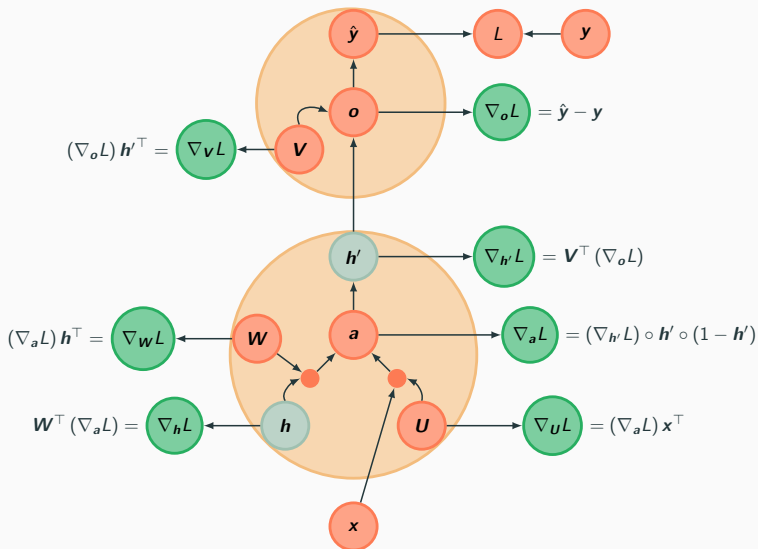
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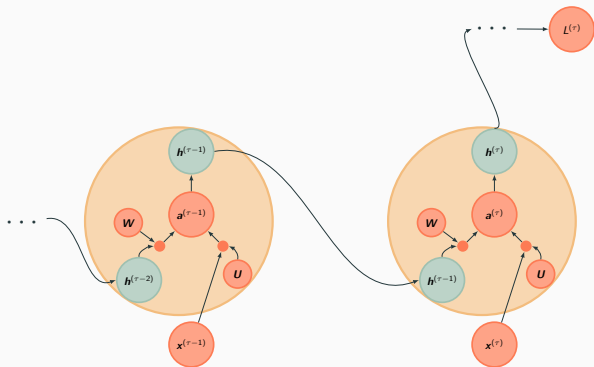
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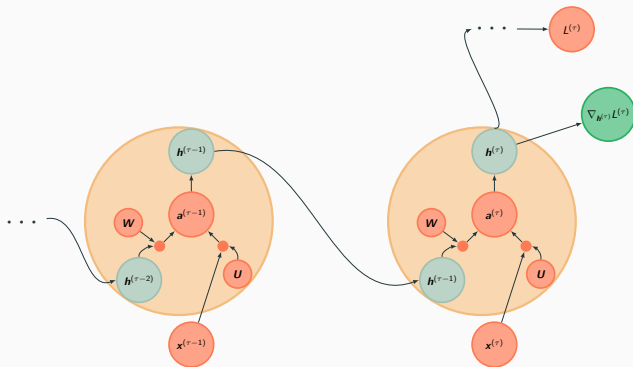
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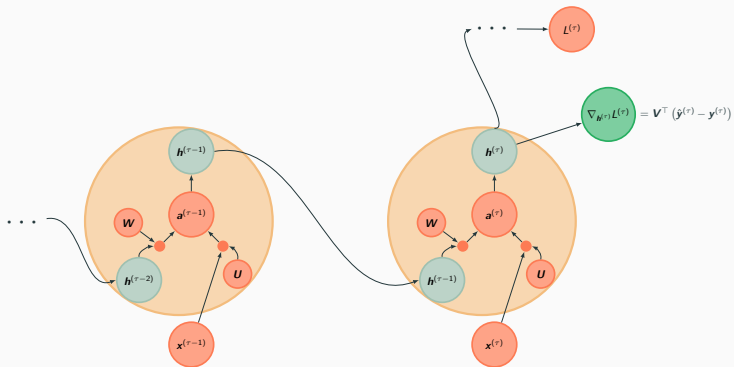


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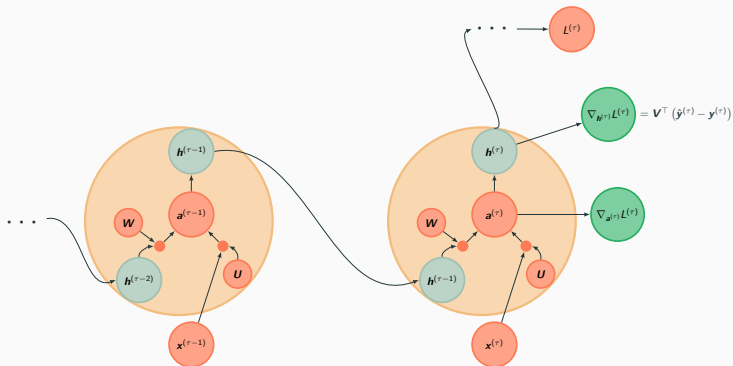




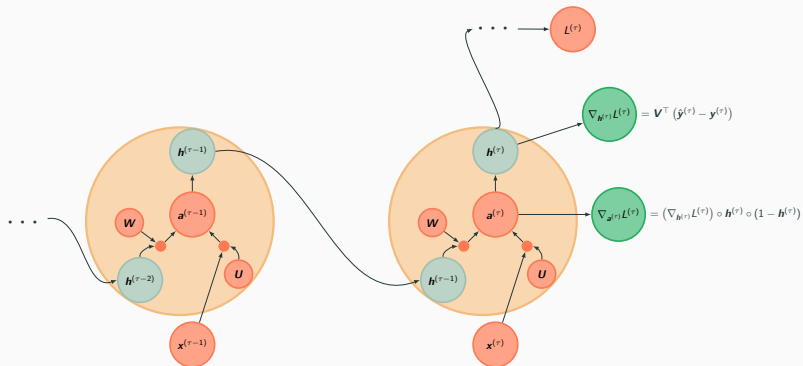
## Chain rule: RNN graph



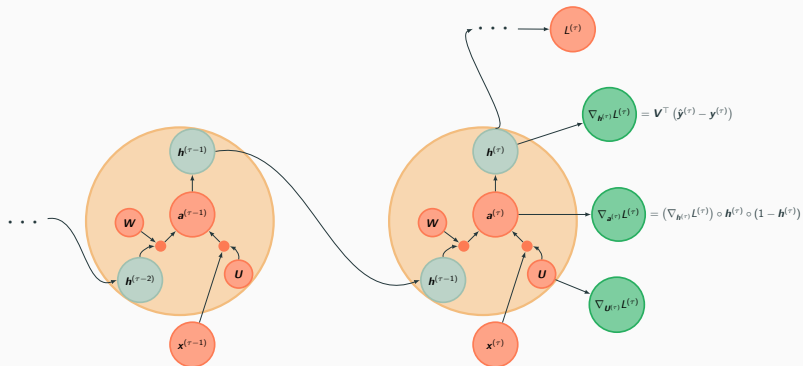
# Chain rule: RNN graph



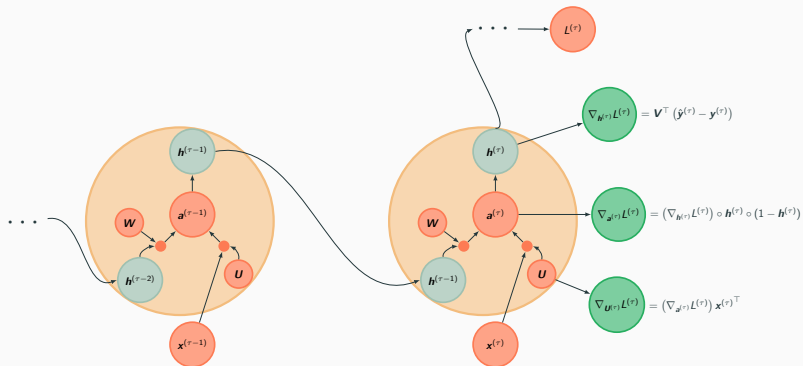
# Chain rule: RNN graph



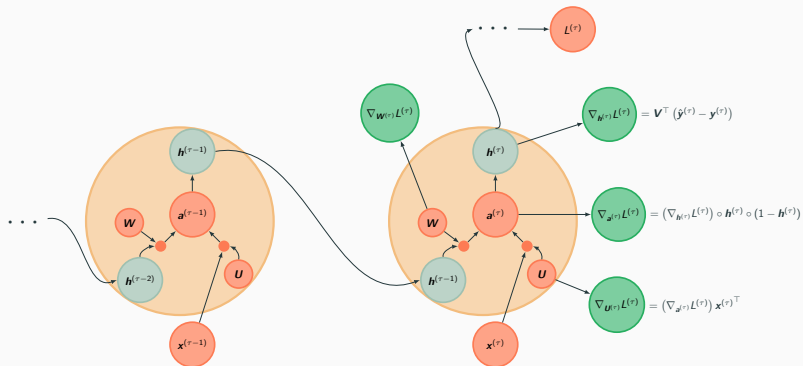
# Chain rule: RNN graph



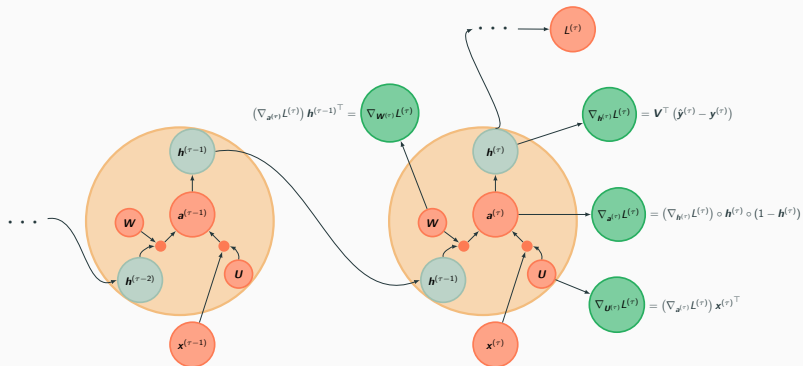
# Chain rule: RNN graph



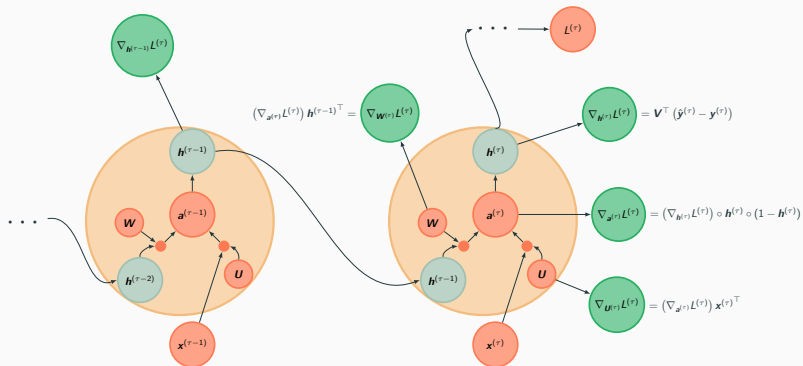
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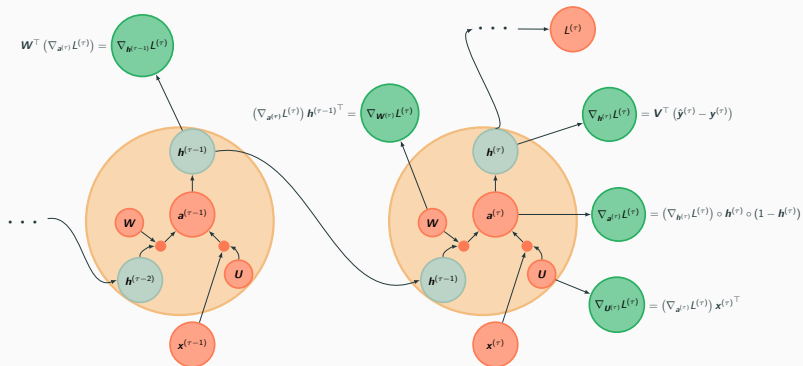


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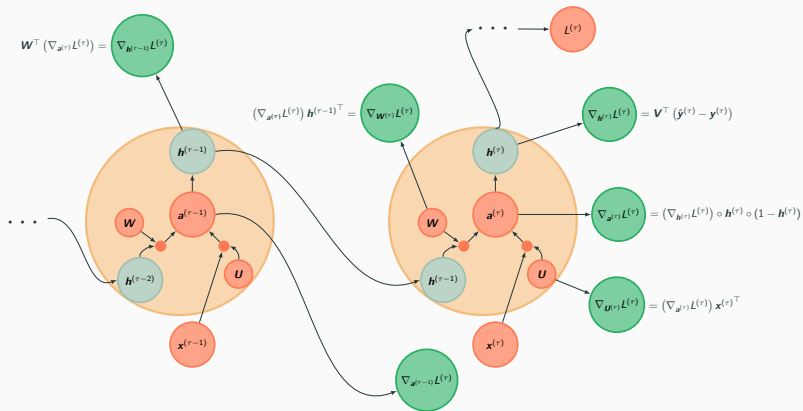




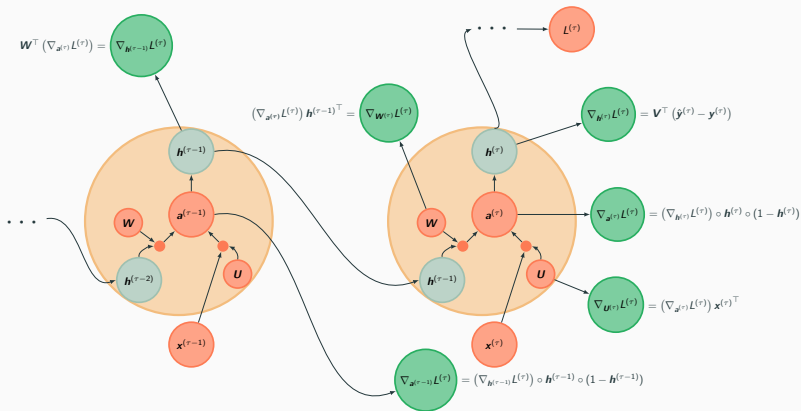
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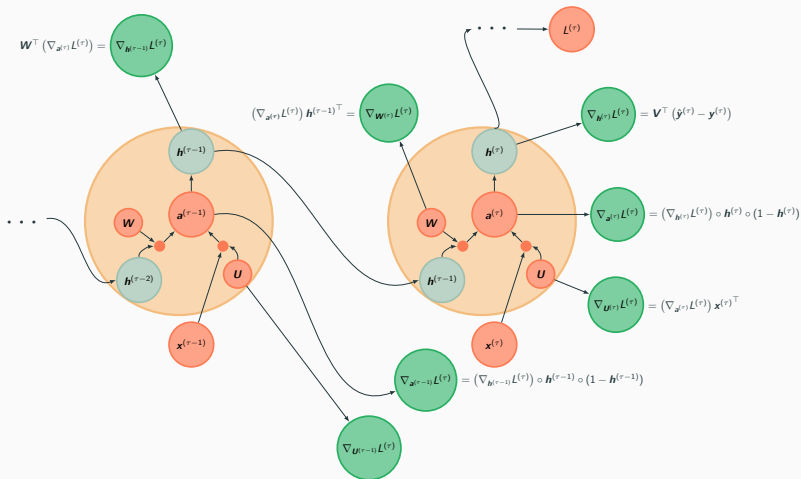
# Chain rule: RNN graph



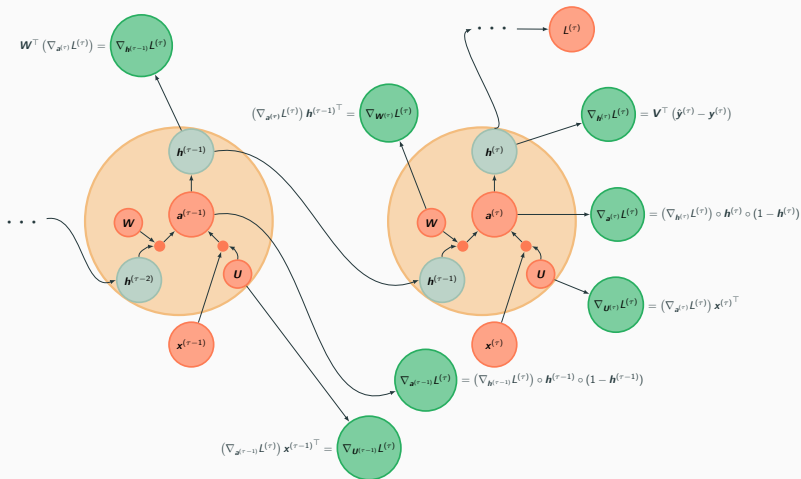
# Chain rule: RNN graph



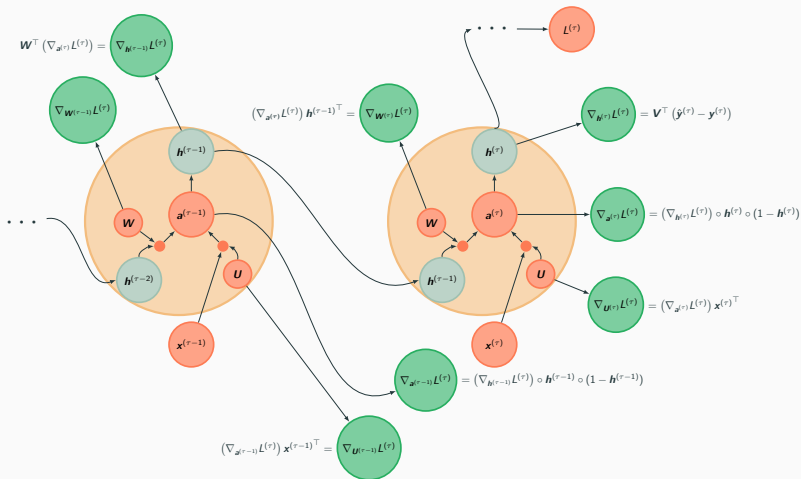
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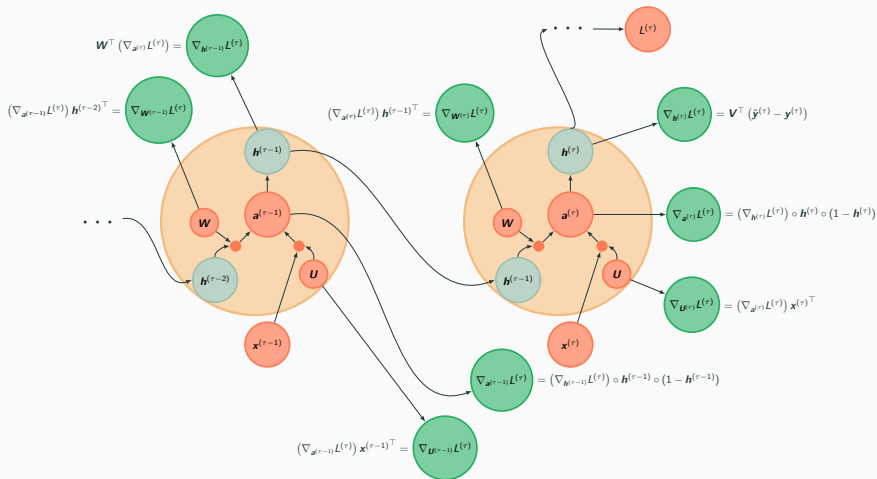
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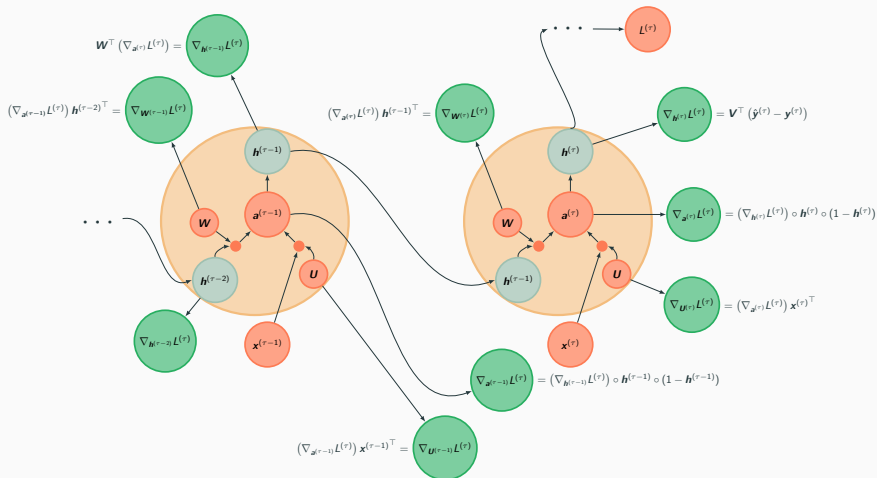
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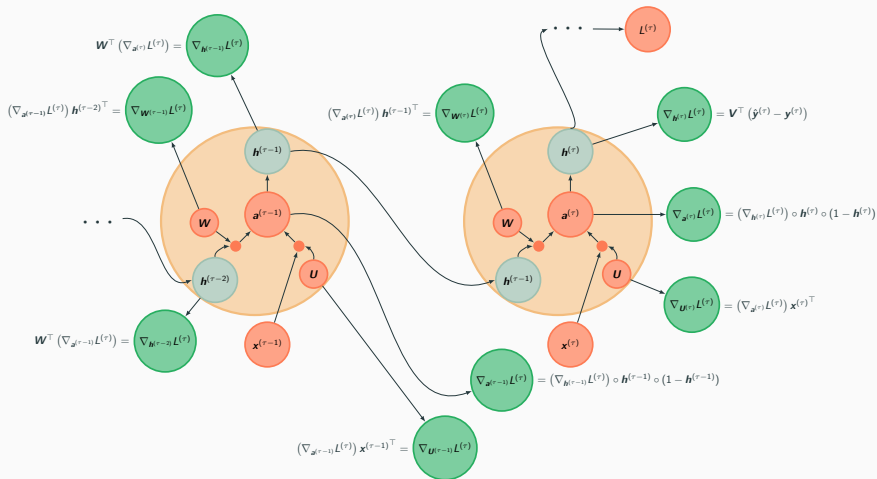


# Chain rule: RNN graph





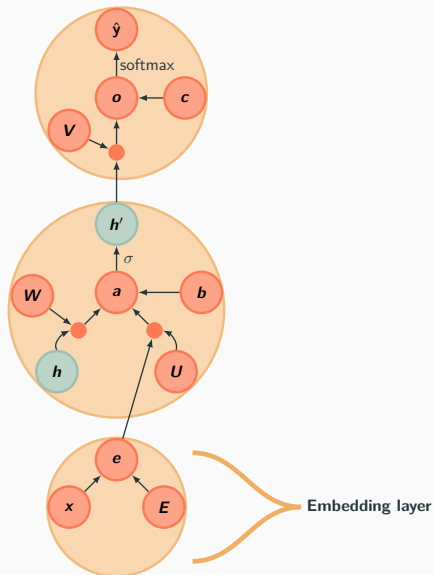
# Chain rule: RNN graph



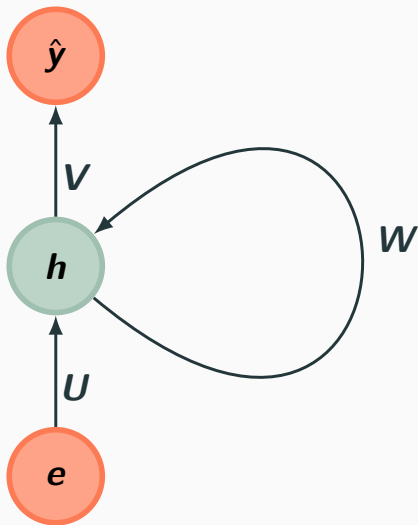
# Language model

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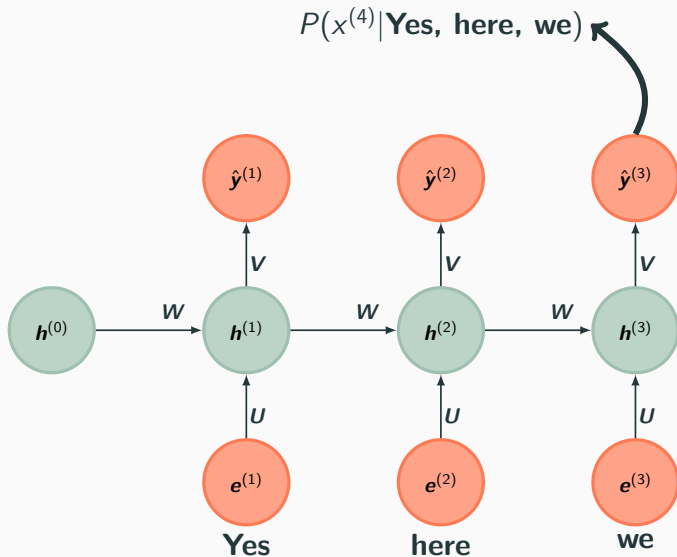
# The language model: graph



## The language model: graph



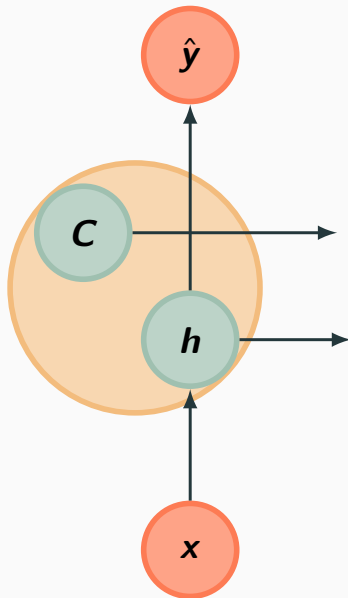
# The Language model: unfolding example



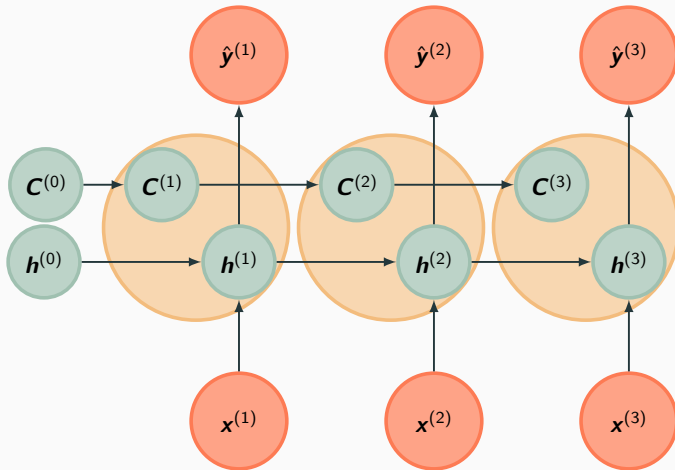
# LSTM

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# LSTM

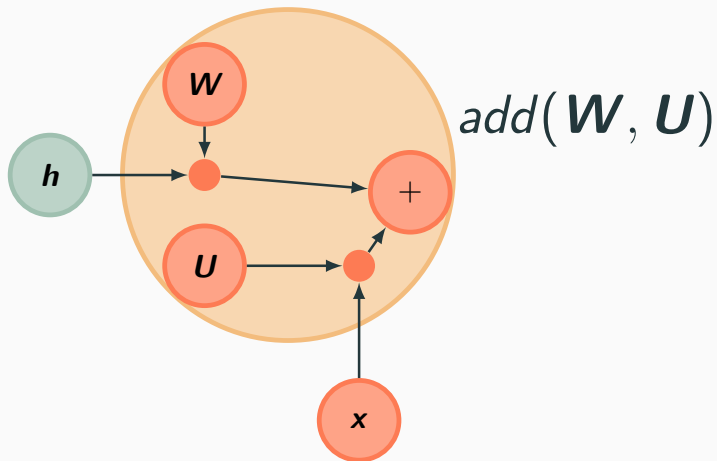


## LSTM: unfolded model

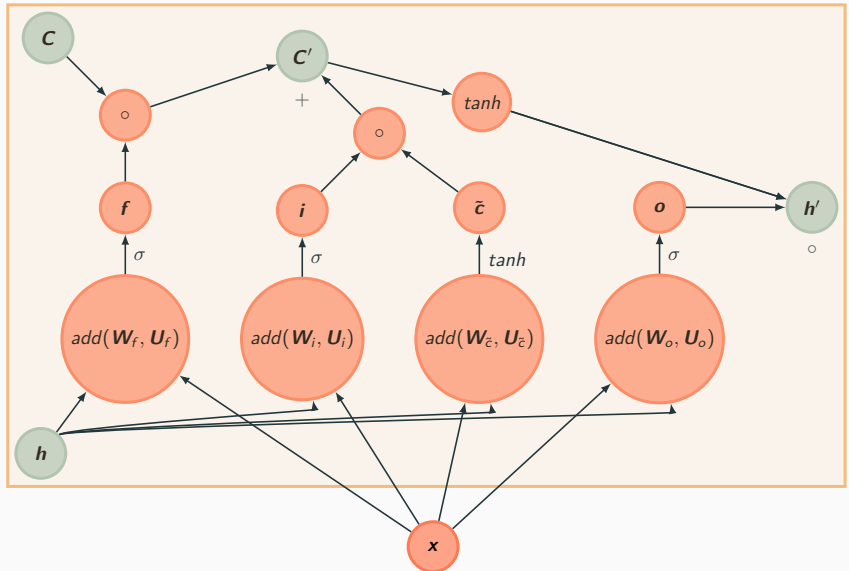




# Simplification



# LSTM: recurrence





I. Goodfellow, Y. Bengio, and A. Courville.

***Deep Learning.***

MIT Press, 2017.