Recurrent Neural Networks

Introduction and overview of the latest advances and trends in the field

Roberto Souza
Assistant Professor
Electrical and Computer Engineering
Schulich School of Engineering

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Outline

- Learning Goals
- Motivation
- Recurrent Neural Networks (RNNs)
  - Basic architecture
  - Long short-term memory (LSTM)
  - Gated Recurrent Unit
- Summary

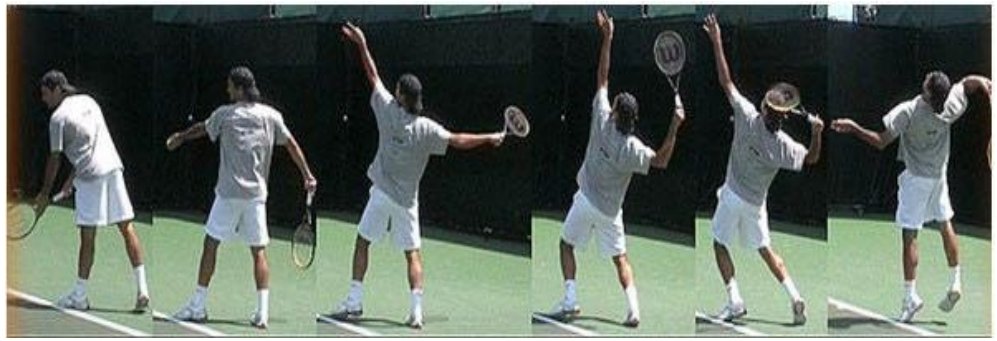
Learning Goals

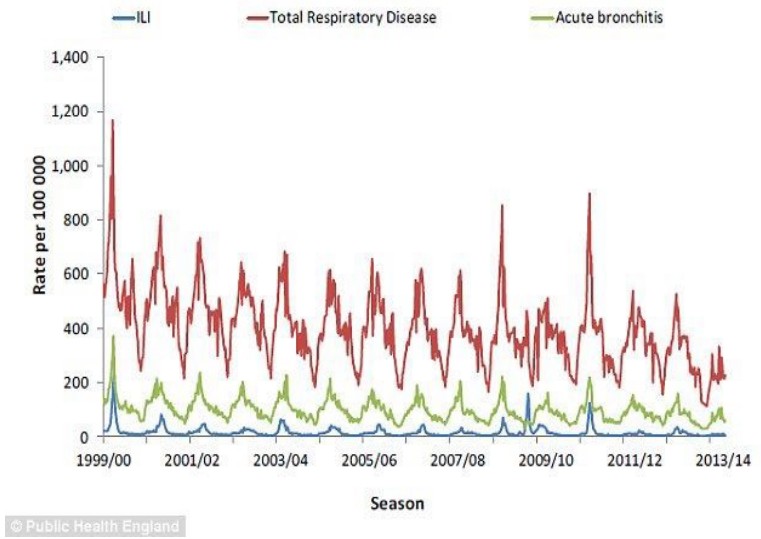
- Learn the intuition behind RNNs
- Get familiar with the most common types of RNNs (LSTM, GRU)

Motivation - Data is often sequential in nature

Steph Curry releases the ball and as it moves you know it is going to be 3 points to Golden State…

Motivation - Data is often sequential in nature





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Introduction

- Building models of sequential data is important: automatic speech recognition, machine translation, natural language, …

- Recurrent nets (RNN) are a simple and general framework for this type of tasks

Introduction

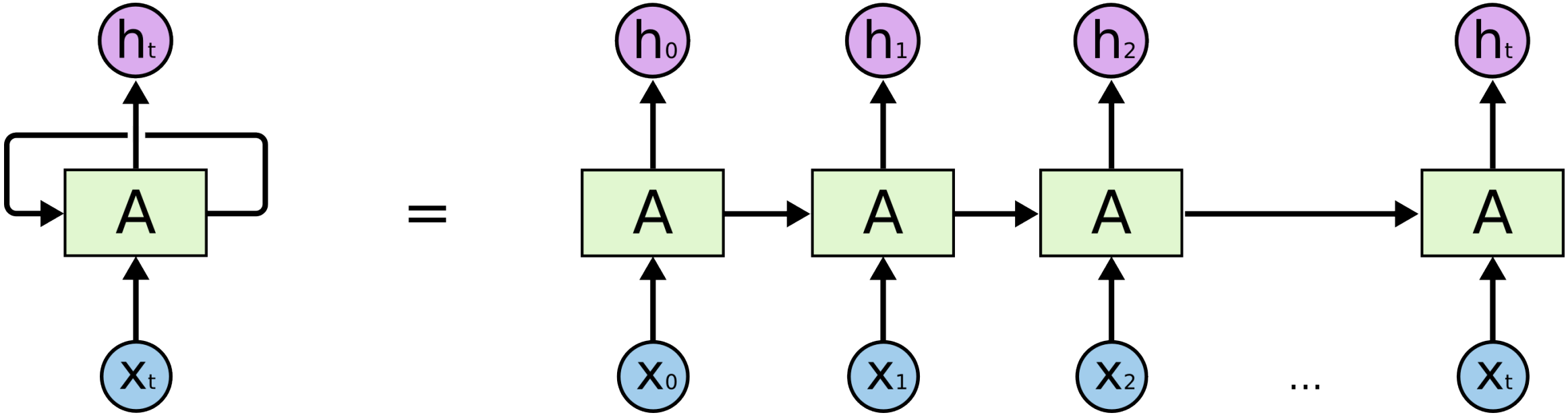
A B C A B C A B _

- What symbol comes next?
- What is its probability?

Yesterday it was Sunday, so today it must be _

- How to predict the next word?
- What is this good for?

Simple RNN



Major shortcomings

- Handling of complex non-linear interactions
- Difficulties using BPTT to capture long-term dependencies exploding gradients
- Vanishing gradients

Training: Backpropagation through time (BPTT)

- How to train the recurrent nets?
- The output value does depend on the state of the hidden layer, which depends on all previous states of the hidden layer (and thus, all previous inputs)
- Recurrent net can be seen as a (very deep) feedforward net with shared weights

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Vanishing gradients

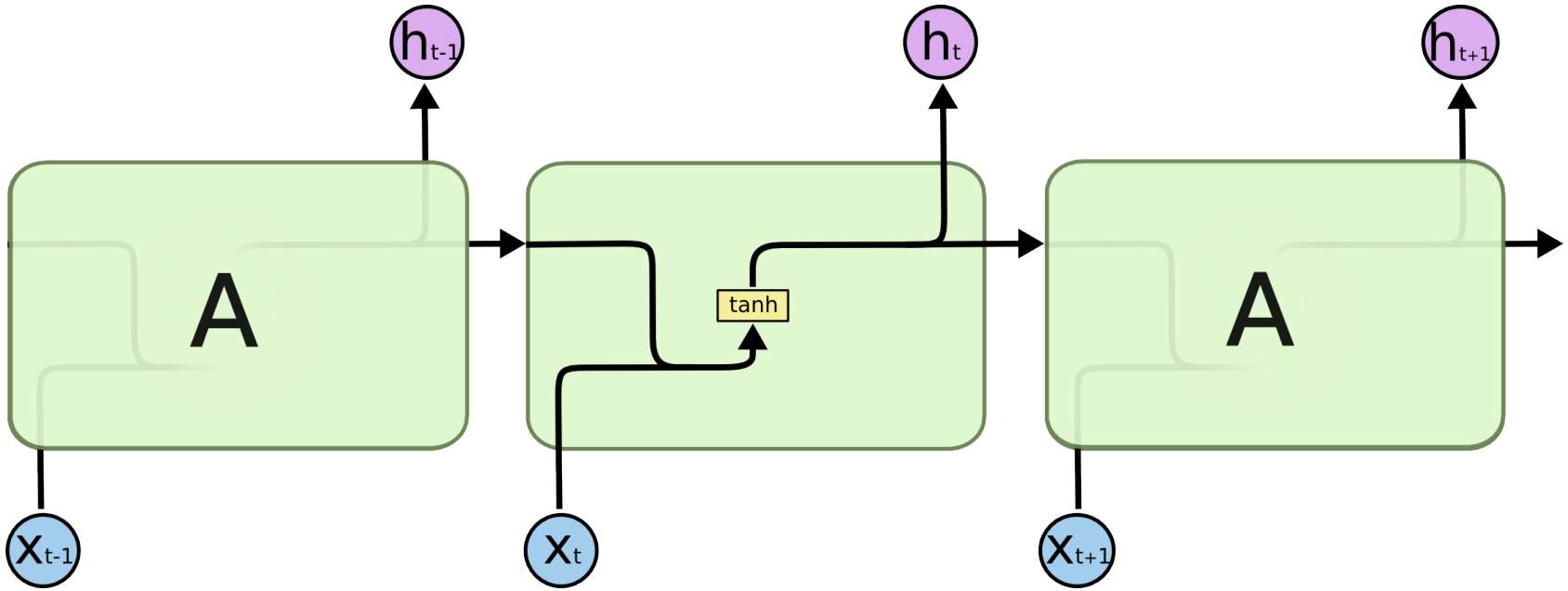
- As we propagate the gradients back in time, usually their magnitude quickly decreases: this is called “vanishing gradient problem”

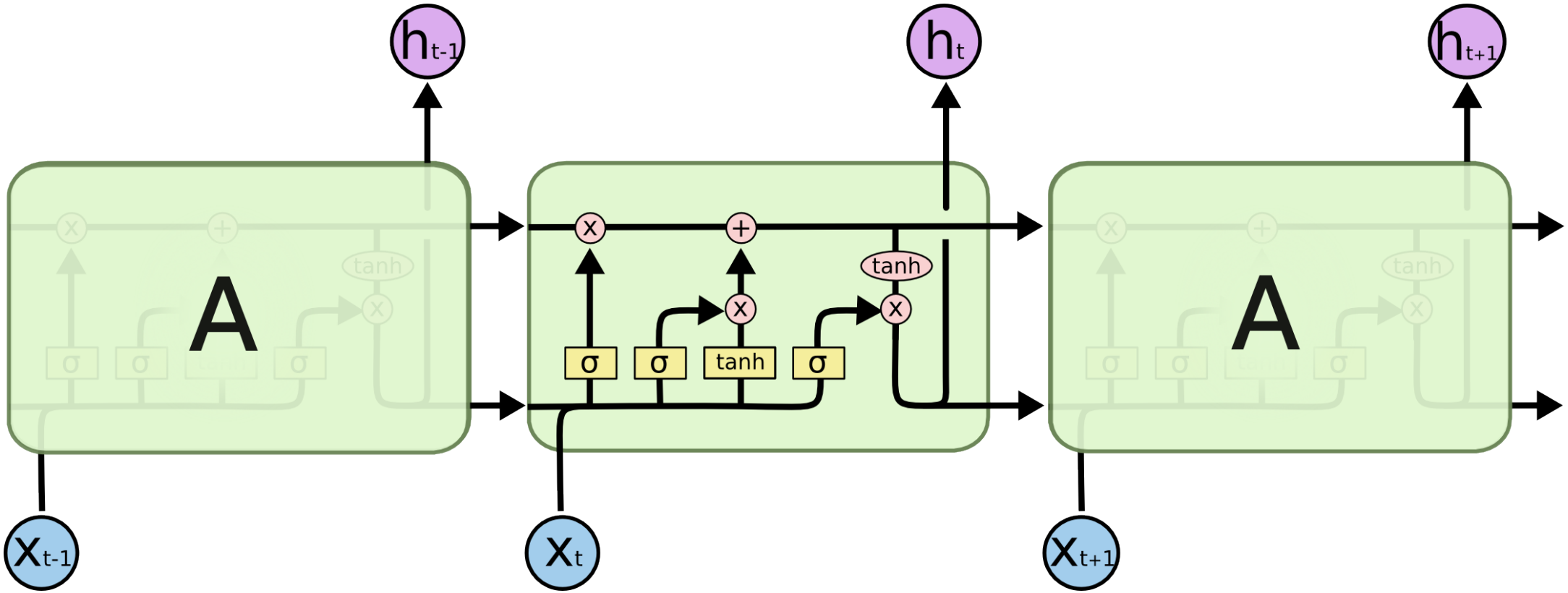
- In practice this means that learning long term dependencies in data is difficult for simple RNN architecture

- Special RNN architectures address this problem:
  - *Exponential trace memory* (Jordan 1987, Mozer 1989)
  - *Long Short-term Memory* (Hochreiter & Schmidhuber, 1997))
  - will be described in the second part of this lecture

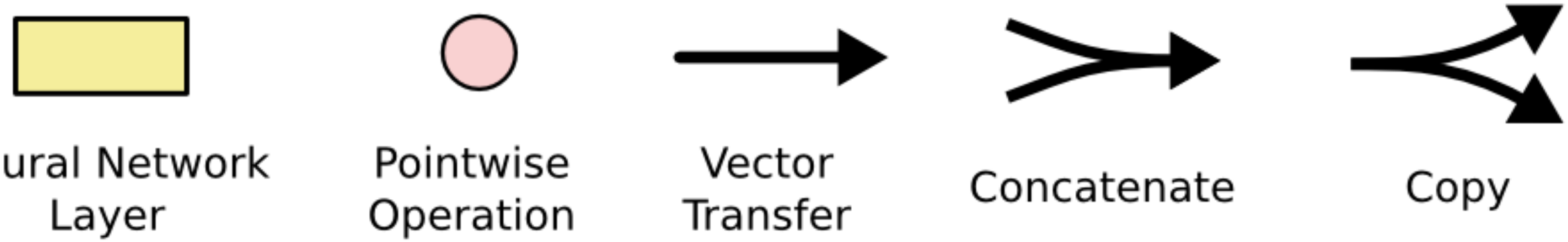
Exploding gradients

- Sometimes, the gradients start to increase exponentially during backpropagation through the recurrent weights
- Happens rarely, but the effect can be catastrophic: huge gradients will lead to big change of weights, and thus destroy what has been learned so far
- One of the main reasons why RNNs were supposed to be unstable
- Simple solution (first published in RNNLM toolkit in 2010): clip or normalize values of the gradients to avoid huge changes of weights





Summary



Thank you!