Recurrent networks

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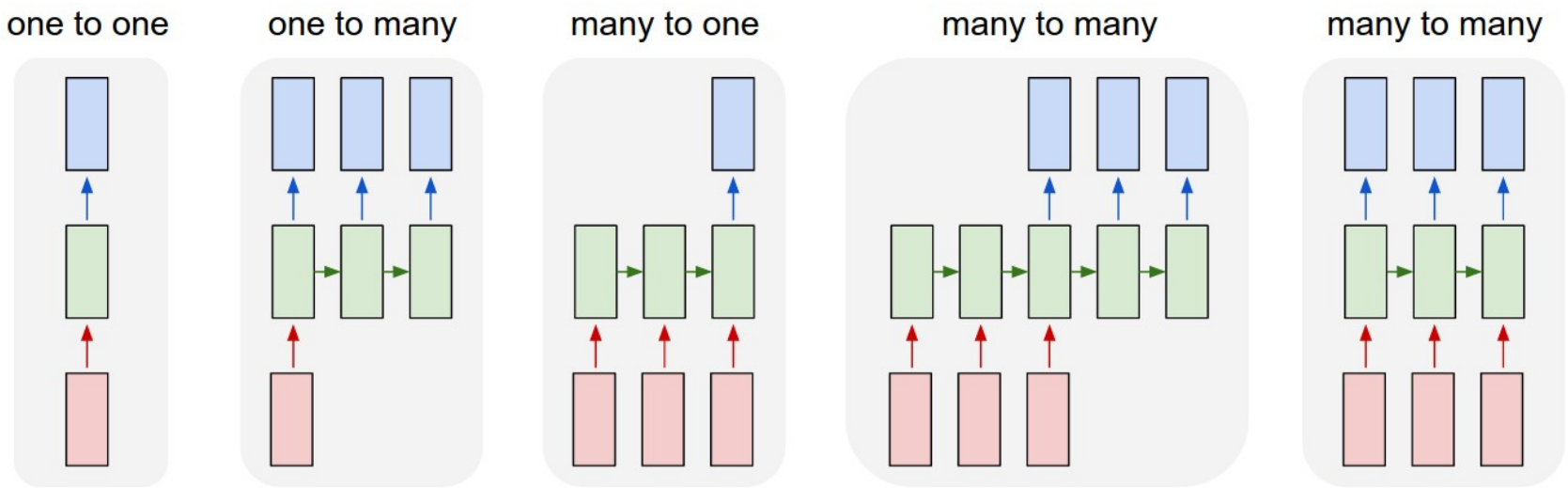
Working with sequences[1]



1. One-to-one: image classification
2. One-to-many: image captioning
3. Many-to-one: sentiment analysis
4. Many-to-many: machine translation
5. Many-to-many: video classification

[1] Karpathy 2015.

Recurrent vs. feedforward networks[2]

- Feedforward networks represent history by **context**, recurrent networks represent history by recurrent network **connections**.
- Feedforward networks have a **fixed** history length, recurrent networks have an **unlimited** history length.
- Feedforward networks compress single words, recurrent networks can compress history (**sequences** of words).
- Recurrent networks can form **short-term memory**.

[2] Mikolov 2010.

Vanishing gradients

"In theory, the time dependency allows [a recurrent network] in each iteration to know about every part of the sequence that came before. However, this time dependency typically causes a **vanishing gradient** problem that results in **long-term** dependencies being **ignored** during training."[3]

Long short-term memory (**LSTM**) networks[4] and gated recurrent units[5] (**GRUs**) are popular solutions to this problem.

[3] Madsen 2019; Pascanu, Mikolov, and Bengio 2013.
[4] Hochreiter and Schmidhuber 1997; Olah 2015.
[5] Cho et al. 2014.

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