SNS COLLEGE OF TECHNOLOGY

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Coimbatore-35

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECT303-ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

III YEAR/ V SEMESTER

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UNIT 5 – DEEP LEARNING

5.3 Bidirectional RNN

Bidirectional RNN

Need for bi directionality

- In speech recognition, the correct interpretation of the current sound may depend on the next few phonemes because of coarticulation and the next few words because of linguistic dependencies
- Also true of handwriting recognition

Bidirectional RNN

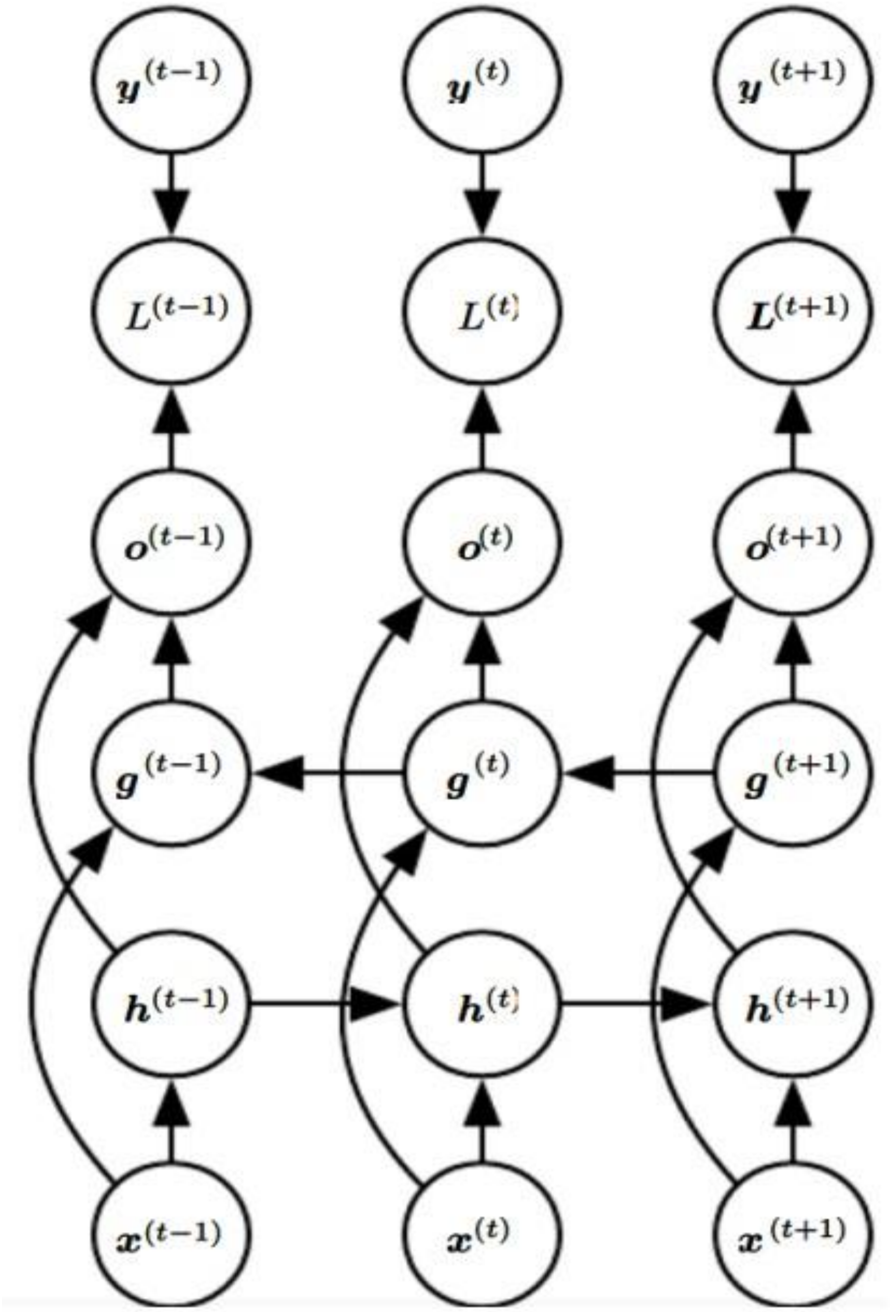
A birectional RNN

- Combine an RNN that moves forward through time from the start of the sequence
- Another RNN that moves backward through time beginning from the end of the sequence
- A bidirectional RNN consists of two RNNs which are stacked on the top of each other.
- The one that processes the input in its original order and the one that processes the reversed input sequence.
- The output is then computed based on the hidden state of both RNNs.

Bidirectional RNN

Typical bidirectional RNN

Maps input sequences $\boldsymbol{x}$ to target sequences $\boldsymbol{y}$ with loss $L(\mathrm{t})$ at each step t



$\boldsymbol{h}$ recurrence propagates to the right

$\boldsymbol{g}$ recurrence propagates to the left.

This allows output units $\boldsymbol{o(t)}$ to compute a representation that depends

both the past and the future

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Bidirectional RNN

Bidirectional recurrent neural networks (**BRNN**) connect two hidden layers of opposite directions to the same output.

With this form of generative deep learning, the output layer can get information from past (backwards) and future (forward) states simultaneously.

Invented in 1997 by Schuster and Paliwal, BRNNs were introduced **to increase the amount of input information available to the network**.

For example, ***multilayer perceptron (MLPs) and time delay neural network (TDNNs)*** have limitations on the input data flexibility, as they require their input data to be fixed.

Standard recurrent neural network (RNNs) also have restrictions as the future input information cannot be reached from the current state.

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On the contrary, BRNNs do not require their input data to be fixed. And future input information is reachable from the current state.

BRNN are especially useful when the context of the input is needed.

For example, in handwriting recognition, the performance can be enhanced by knowledge of the letters located before and after the current letter.

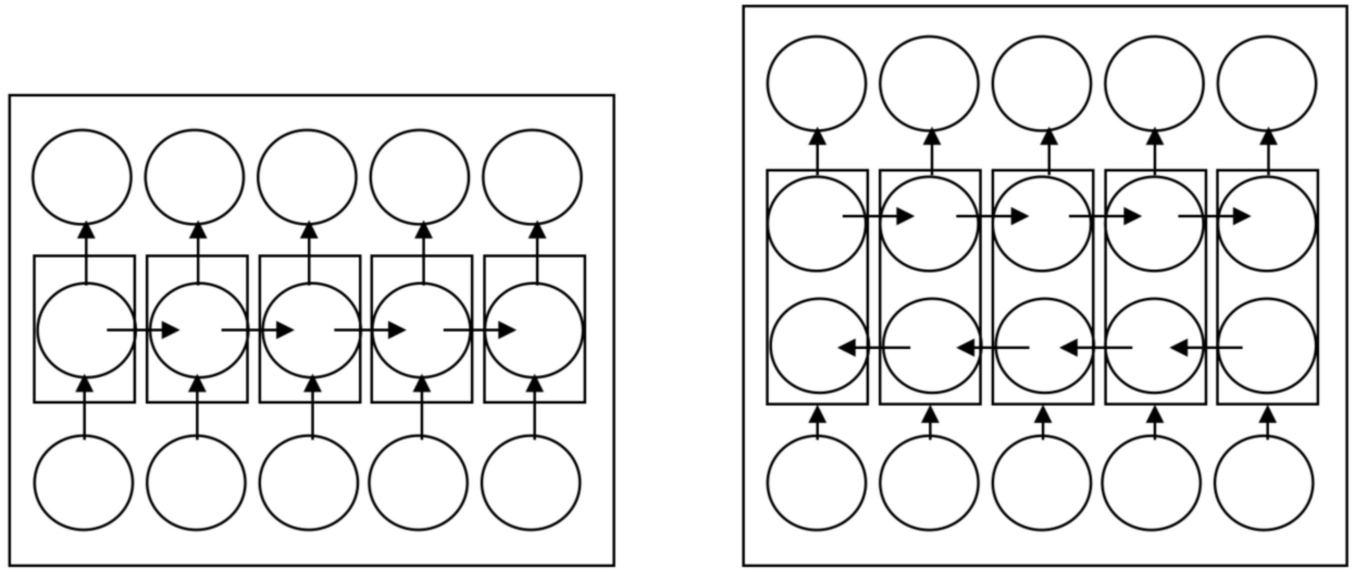
Bidirectional RNN

The principle of BRNN is to split the neurons of a regular RNN into two directions, one for positive time direction (forward states), and another for negative time direction (backward states).

Those two states' output are not connected to inputs of the opposite direction states.

The general structure of RNN and BRNN can be depicted in the diagram.

By using two time directions, input information from the past and future of the current time frame can be used unlike standard RNN which requires the delays for including future information.



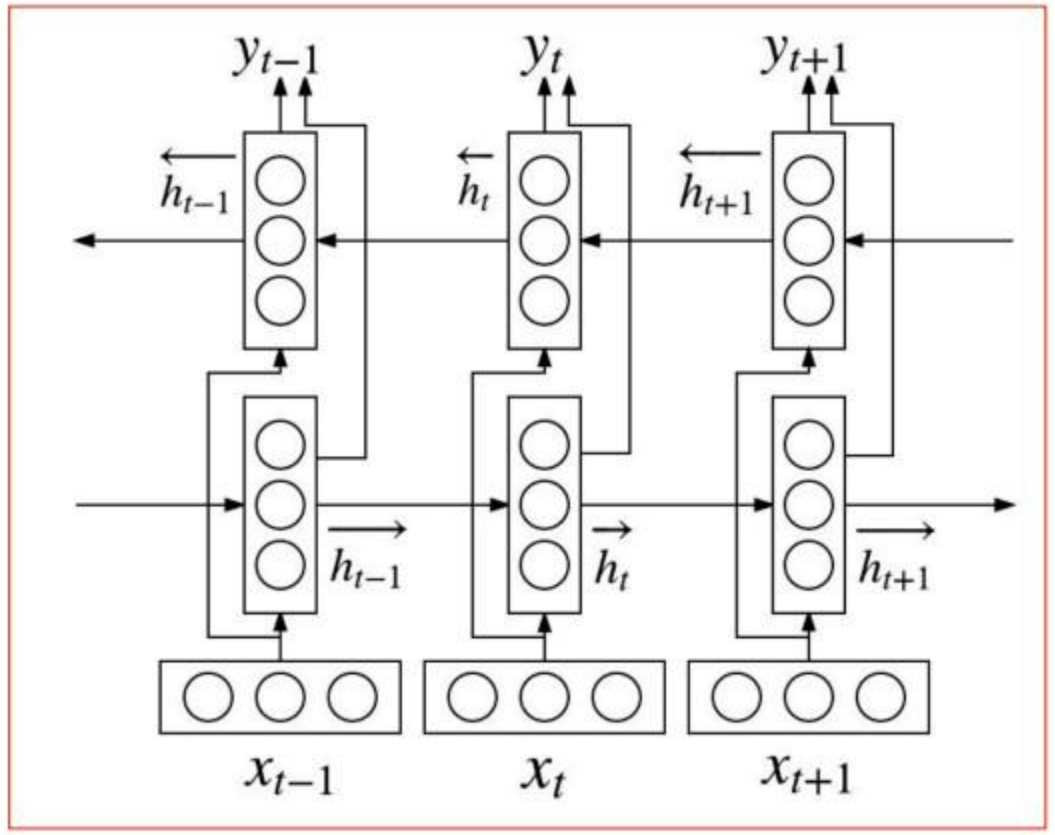
(a) (b)

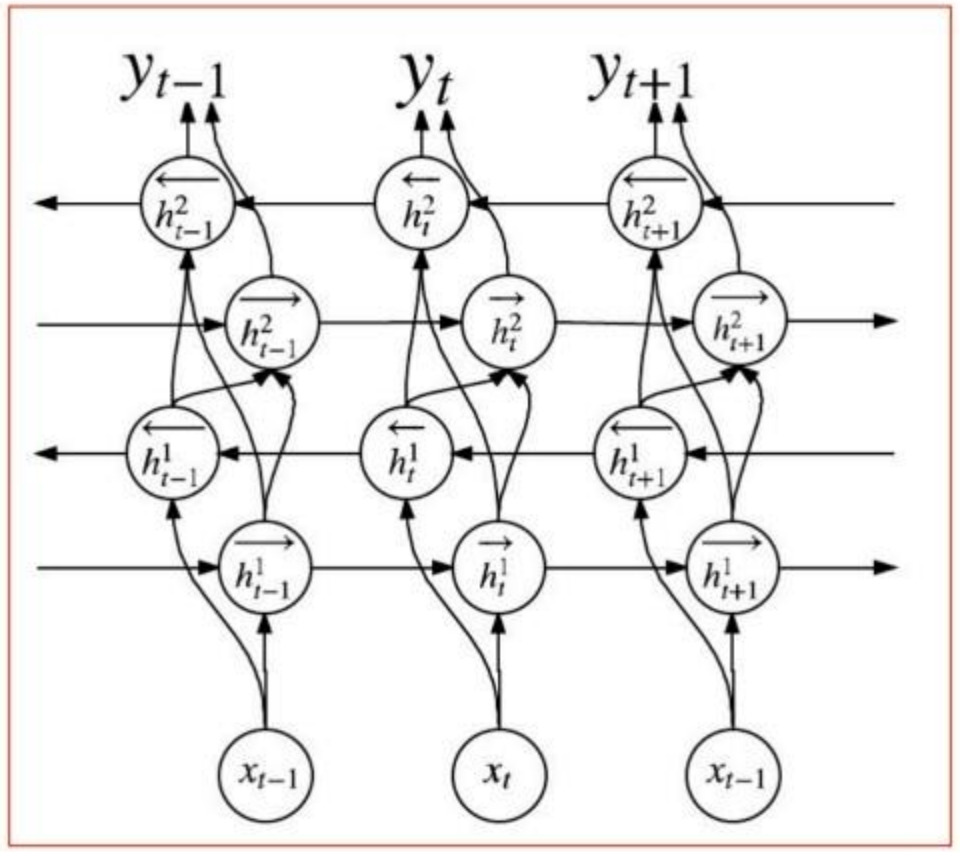
Structure overview

(a) unidirectional RNN
(b) bidirectional RNN

Bidirectional RNN

Parameters of a Bidirectional RNN





Deep Bidirectional RNN has multiple layers per time step

Bidirectional RNN

Training

BRNNs can be trained using similar algorithms to RNNs, because the two directional neurons do not have any interactions.

However, when back-propagation through time is applied, additional processes are needed because updating input and output layers cannot be done at once.

General procedures for training are as follows:

1. For forward pass, forward states and backward states are passed first, then output neurons are passed.
2. For backward pass, output neurons are passed first, then forward states and backward states are passed next.
3. After forward and backward passes are done, the weights are updated.

Bidirectional RNN

Applications of BRNN include :

1. Speech Recognition (Combined with Long short-term memory)
2. Translation
3. Handwritten Recognition
4. Protein Structure Prediction
5. Part-of-speech tagging
6. Dependency Parsing
7. Entity Extraction