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Recurrent Neural Networks (RNNs)

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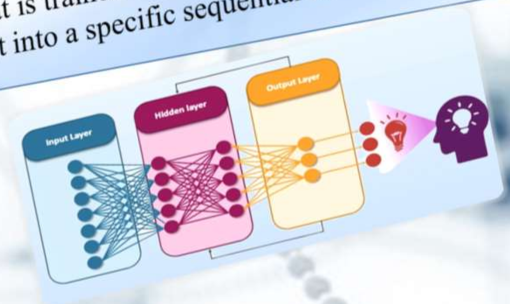
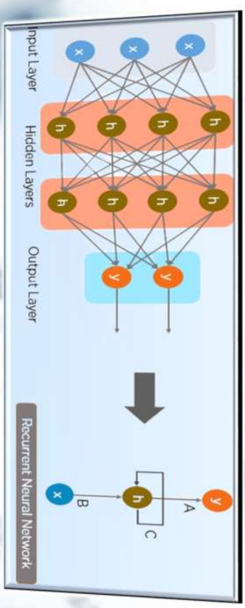
Recurrent Neural Network (RNN):

A recurrent neural network (RNN) is a deep learning model that is trained to process and convert a sequential data input into a specific sequential data output.



Architecture of Recurrent Neural Network (RNN):

The RNN takes an input vector X and the network generates an output vector y by scanning the data sequentially from left to right, with each time step updating the hidden state and producing an output. It shares the same parameters across all time steps.



Mathematical Equations:

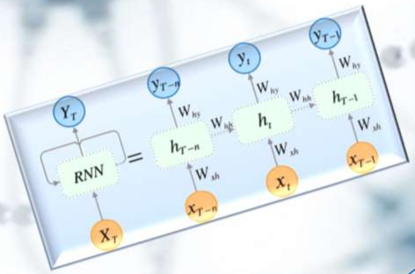
Hidden State Update:

$$h_t = tanh(a)$$

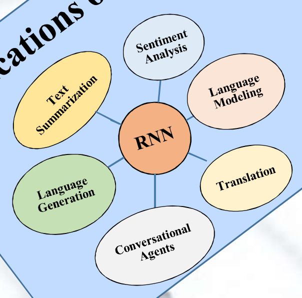
$$\therefore a = W_{hx}x_t + W_{hh}h_{t-1} + b_h$$

Output Calculation:

$$y_t = softmax(W_{hy}h_t + b_y)$$



Applications of RNNs:



Advantages of RNNs:

Temporal Dependencies: Ideal for tasks where context and order matter, like language processing.

Memory: Maintain a hidden state to utilize past inputs for current predictions.

Versatility: Applicable to speech recognition, language translation, sentiment analysis, etc.

Sequential Data Handling: Process sequences of varying lengths flexibly.

Complex Pattern Recognition: Capture long-term dependencies and complex patterns in data.

Conclusion:

Recurrent Neural Networks (RNNs) are powerful for processing sequential data and capturing temporal dependencies, with applications in NLP, time series, and audio processing. Advancements like GRUs, LSTMs, and Transformer models enhance their capabilities, driving innovation in complex sequence-related problems and expanding possibilities in machine learning.

Reference:

Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep Learning*. MIT Press.Hochreiter, S., & Schmidhuber, J. (1997).