

## Unfolding Graphs:

→ Recurrent Neural Network is formalized as an unfolded computational graph. It refers to the process of "unrolling" or "unfolding" the computations of a recurrent model across time steps to better understand or implement its behaviour.

### What is Unfolding:-

→ Recurrent Neural Network (RNNs) are designed to process sequential data, where the output at each time step depends on the current input and the state from the previous time step.

→ Conceptually, RNNs can be thought of as a computational graph that repeats itself over multiple time steps. This repeated structure is represented as a loop in the computational graph.

→ Unfolding the graph means expanding this loop into a series of nodes, each representing the computations for a single time step. This makes the sequential nature of the RNN explicit.



Why unfold the graph:-

1) Visualization and Understanding:-

- Unfolding helps visualize how the RNN process data over time.
- Each time step has its own set of computations, which becomes clear when unfolded.

2) Backpropagation Through time (BPTT):-

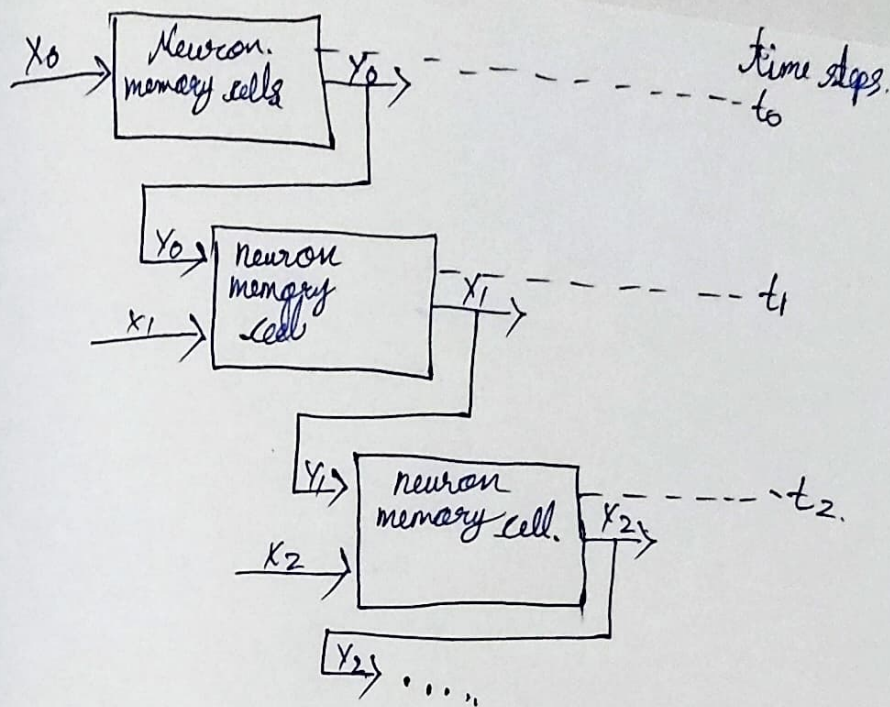
• Unfolding is essential for training RNNs. To compute gradients and update the model's weights, the BPTT algorithm unfolds the RNN across all time steps to calculate the gradients.

• Errors propagate backward from the last time step to the first, traversing the unfolded graph.

3) Implementation in Frameworks:-

• In deep learning framework like TensorFlow or PyTorch, the unrolled structure is how computations are carried out step-by-step during forward & backward passes.





Unfolding represents this loop as a sequence of nodes like:-

$$(x_1, h_0) \rightarrow h_1 \rightarrow y_1(x_2, h_1) \rightarrow h_2 \rightarrow y_2(x_3, h_2) \rightarrow h_3 \rightarrow y_3$$

### Key Takeaways:

- Unfolding a graph makes the temporal sequence of computations explicit.
- It is crucial for training recurrent models using gradient-based methods.
- While the actual implementation might use loops or recursion for efficiency, conceptually, unfolding provides clarity on the sequential operations of RNNs.