RNN: Time-Step Recurrence

Recurrent Neural Networks (RNNs) are designed to process sequential data where order matters, such as text, time series, or signals.

- Core Idea: An RNN maintains a hidden state that carries information from previous time steps to the current one.
- Goal: Learn a hidden state that summarizes past inputs while processing sequences step by step.
- Recurrence equation

$$h_t = \tanh(W_x x_t + W_h h_{t-1} + b)$$

  - x_t: input at time step t
  - h_{t-1}: previous hidden state (memory)
  - W_x: input → hidden weights
  - W_h: hidden → hidden (recurrent) weights
  - h_t: updated hidden state

- Conclusion

RNNs model temporal dependencies, but simple recurrence can suffer from vanishing/exploding gradients for long sequences.