

# Hidden Markov Model (HMM)

## Problem Statement

Consider a Hidden Markov Model (HMM) with the following parameters:

- **Hidden States:**  $S_1, S_2$
- **Observations:**  $O_1, O_2$
- **Initial State Probabilities:**

$$P(S_1) = 0.6, \quad P(S_2) = 0.4$$

- **Transition Probabilities:**

$$\begin{aligned} P(S_1 \rightarrow S_1) &= 0.7, & P(S_1 \rightarrow S_2) &= 0.3 \\ P(S_2 \rightarrow S_1) &= 0.4, & P(S_2 \rightarrow S_2) &= 0.6 \end{aligned}$$

- **Emission Probabilities:**

$$\begin{aligned} P(O_1|S_1) &= 0.5, & P(O_2|S_1) &= 0.5 \\ P(O_1|S_2) &= 0.1, & P(O_2|S_2) &= 0.9 \end{aligned}$$

## Question 1: Forward Algorithm Calculation

Given the observation sequence  $O = (O_1, O_2)$ , compute the probability of observing this sequence using the **Forward Algorithm**. Specifically, compute:

$$P(O|\lambda) = \sum_{S_t} P(O, S_t | \lambda)$$

where  $\lambda$  represents the model parameters.

## Question 2: Viterbi Algorithm Calculation

Given the same observation sequence  $O = (O_1, O_2)$ , determine the most probable hidden state sequence using the **Viterbi Algorithm**, i.e., find:

$$S^* = \arg \max_S P(S|O, \lambda)$$

where  $S^*$  is the most likely sequence of hidden states.