Bayesian Modelling in Cognitive Processes

Generated by LectureMate

February 21, 2025

1 Introduction

In this lecture, we explore Bayesian modelling, a framework that integrates symbolic and sub-symbolic aspects of cognitive processes. We will discuss the foundational concepts of Bayesian modelling, including posteriors, priors, and Bayes' rule, and provide examples to illustrate these concepts.

2 Overview of Computational Models

We begin by reviewing various computational models of cognitive processes introduced in the course:

- **Rule-based models**: These models generate outputs based on a set of rules and a lexicon, such as generating past tense forms.
- **Neural network models**: These models generalize outputs from input patterns using powerful learning algorithms and large datasets.

3 Bayesian Modelling

Bayesian modelling has gained popularity in cognitive modelling over the past 10-15 years. It combines rules and probabilities, allowing for a more nuanced understanding of cognitive processes.

3.1 Key Concepts

- **Prior**: The initial belief about a hypothesis before observing any evidence.
- **Posterior**: The updated belief about a hypothesis after observing evidence.
- **Likelihood**: The probability of observing the evidence given that the hypothesis is true.

3.2 Bayes' Rule

Bayes' rule is the central formula in Bayesian modelling, expressed mathematically as:

$$P(H|D) = \frac{P(D|H) \cdot P(H)}{P(D)}$$

where:

- $P(H|D)$ is the posterior probability.
- $P(D|H)$ is the likelihood.
- $P(H)$ is the prior probability.
- $P(D)$ is the probability of the evidence.

3.3 Bayesian Update

The process of updating beliefs based on new evidence is known as Bayesian update. This is crucial for modelling learning, as it reflects how individuals adjust their beliefs in light of new information.

4 Examples

4.1 Reference Resolution

We illustrate Bayesian modelling through a reference resolution example. Consider a scenario where a speaker refers to one of three smileys. Initially, all smileys are equally likely (prior). Upon hearing a word (evidence), the probabilities are updated based on the likelihood of the word corresponding to each smiley.

4.2 Decision Making Example

In a decision-making scenario, two individuals, Peter and John, are trying to determine the type of day at a hot spring based on the people they observe coming out. The hypothesis space includes:

- Women only
- Men only
- Mixed day

Using Bayes' rule, they can update their beliefs about the type of day based on the observed evidence.

5 Conclusion

Bayesian modelling provides a robust framework for understanding cognitive processes by allowing for the integration of prior knowledge and new evidence. In future lectures, we will apply these concepts to word learning and decision-making biases.