**The Surprising Brittleness of Hidden Markov Model to Time Dependent Omitting Processes**

This study investigates the inherent limitations of Hidden Markov Models (HMMs) when subjected to time-dependent omitting processes. Despite the wide application of HMMs in analysing sequential data, our research reveals a critical vulnerability: the model's performance significantly deteriorates in the absence of consecutive observational data. Through a series of experiments utilizing synthetic data, we examined the impact of various omission processes on the ability of standard HMM algorithms to accurately reconstruct transition matrices.

Our findings demonstrate that both Expectation Maximization and Gibbs Sampling algorithms fail to accurately infer the underlying model structure under conditions of non-consecutive data observations. The implications of these results underscore a pressing need for the development of new HMM algorithms capable of handling non-consecutive observation scenarios, promising significant advancements in fields reliant on accurate time-series analysis. Our research sets a new direction for future investigations into enhancing HMM resilience against data omission, with potential applications across a broad spectrum of scientific inquiries.

