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COG 356

Markov Investigation

Abstract: This paper was written in an attempt to catalog the Markov Process, from its origins, history, implementation, and benefits versus disadvantages.

The Markov Process, or Markov Chain, was developed in 1913 by Russian probability theorist A. A. Markov. Unique among other probability models at the time, it did not predict probability from a stateless origin, but instead calculated based off of a previous state. Importantly, it is based only off of the most recent state, not any state before that. Markov's work began in an attempt to refute a peer. Markov sought to show a crucial rule regarding the law of large numbers, defined as "which says that if you keep flipping an unbiased coin, the proportion of heads will approach 1/2 as the number of flips goes to infinity" (Hayes). Some assume this law implies that the event occurring must be independent in order to match the rule. Markov's process proved that wrong. He first began with a simple model with two states, but his true proof came in 1913, where he applied his stochastic process to a beloved poem, determining the probability of whether the next letter would be a vowel or consonant. His development of the processes led to its implementation in many prediction models.

Markov processes have a tremendous amount of real-world applications. They are used to model everything from stock market events, social statistics, and cruise control missile systems (Tweedie). Markov processes can also be used for more theoretical applications, like game theory and computational thought experiments (Maltby). Biologists use the Markov process to determine the flow of electricity within cells (Dempster). These processes benefit from a Markov process in their analysis because these events, as well as many more, can have probability derived from their current state while ignoring their previous ones. This simple but profound power allows the Markov Process to be used anywhere data analytics takes place.

Markov Processes are pivotal in many algorithms that are integral to data science (Tyagi). They are commonplace and ubiquitous in many parts of analytics, statistics, and probability. Their strength lies in modeling stochastic events, and as such, some have argued that Markov processes are limited by three assumptions (Ma). The probability must apply to all participants in a system generated by a Markov process, the transition probabilities are constant over a period of time, or take place within a short enough time that it does not matter, and finally the states of the process must be independent over time, and their probabilities must not change with the continuation of time. With these assumptions either in place or not relevant to the specific event being modeled, Markov processes can be wielded to tremendous effect. It is not a perfect methodology, however. Markov processes can take large amounts of computational power when the assumptions are not met, such as time-dependent outcomes (Billard). The strengths and weaknesses of a Markov process must be considered before its application to a specific model, but in the event that those assumptions are met and a Markov process can be used, it is among the best modeling tools for the relevant stochastic events.

Works Cited

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