

# Bayesian Probabilities

## What was the original intention for the approach (if any)?

Thomas Bayes came up with an approach for calculating the probability an event occurred by the number of times the event has occurred in the past. [1] This was published posthumously by his friend, Richard Price in the *Philosophical Transactions of the Royal Society of London*. [2] It was initially presented to “give a clear account of the strength of analogical or inductive reasoning; concerning, which at present, we seem to know little more than that it does sometimes in fact convince us, and at other times not.” This provided the converse solution to De Moivre's Laws of Chance which stated if there were a large number of trials of an event, the proportion number of times it should happen to the number of times it should fail should differ by less than “by small assigned limits from the proportion of its failing a single trial.” The original intention of Bayes was “to confirm the argument taken from final causes for the existence of the Deity” although it was recognized by Bayes that the approach could be used for all probabilities.

## Is it being used in that way or some other way?

Bayesian probabilities are typically used for partial belief rather than a frequency of occurrence. One example of using it as a partial belief system is Los Alamos where it is used to determine intake of radioactive material [3]. Spam filters, such as SurfRight's Caretaker Antispam use a Bayesian library to detect spam and avoid false positives. [4] For speech recognition, Variational Bayesian (VB) trained models work better than the Maximum Likelihood approach and it “can also be used to select the proper model complexity in respect to the training data, without using auxiliary data.” [5]

## What types of problems is the approach most suited to handle?

Bayesian probabilities are best suited for problems with a lot of data related to the problem at hand; the more data the better.

## What types of problems is the approach not suited to handle?

Bayesian probabilities can't determine if no solution exists. It may come up with coincidental conclusion. This was true when looking at Air freshness with the help of SOM (Self-Organizing Map) maps. One evident conclusion was "high value for variable Ergonomics appears only with low value for Air freshness, but careful analysis showed that this was just an effect of vector quantization." [6]

Also, people can fake out Bayesian algorithms, in the case of spam and Bayesian probability spam filters. As noted on SurfRight's page, some spammers send a legitimate looking message with an image containing the spam text. If the filter only looks at the text and continues to get these types of messages, it will start treating legitimate messages as spam. [4] In a nutshell, Bayesian probabilities are only as good as the data it's given, the observations it recognizes, and the hypotheses it knows. Even with good data, if it isn't programmed to recognize observations it wasn't previously programmed to be aware of, it may miss an evident connection between repeating patterns of that observation.

## How successful has the approach been in solving problems?

“At Los Alamos [National Laboratory], Bayesian inference is being used to help determine whether individuals have experienced an intake of radioactive material... The Bayesian approach is not only more accurate, it is more informative. Because we can explicitly calculate the ratio of the likelihood of the competing hypotheses, it is possible to make statements such as, 'The chance that an intake occurred is 37%'. This is much more useful than simply reporting that a measurement result was above or below an arbitrary decision level.” [3] “Search giant Google and Autonomy, a company that sells information retrieval tools, both employ Bayesian principles to provide likely (but technically never exact) results to data searches.” [7]

## How are uncertainty values derived?

Uncertainty values can be derived by how often they occur in the real world. If you want to determine how often it will rain in May, you can count the number of days. If you are determining the cause of a car crash, you can consider road conditions, whether one of the drivers were tired or intoxicated, speed, how sharp the turn was (if there was one), and other factors. You can grab all the information from past occurrences and determine the uncertainty values (or guesses) and then run the data through the model. The probabilities will self-correct after you run through the data from past occurrences of car crashes (see the next question).

## Can the approach be used in conjunction with learning?

Yes. “Bayesian models are self-correcting, meaning that when data changes, so do the results.”[7] This means that even if the people who set up the probability numbers made wild guesses, running data through the system will produce more accurate probabilities and future data will also adjust the results. This may result in the system coming up with conclusions the designers never considered.

## References:

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