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# Bayesian Kernel Methods:
## Applications in Medical Diagnosis Decision-Making Processes (A Case Study)

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## ABSTRACT

In the healthcare industry, sources look after different customers with diverse diseases and complications. Thus, at the source, a great amount of data in all aspects like status of the patients, behaviour of the diseases, etc. are collected, and now it becomes the job of the practitioner at source to use the available data for diagnosing the diseases accurately and then prescribe the relevant treatment. Machine learning techniques are useful to deal with large datasets, with an aim to produce meaningful information from the raw information for the purpose of decision making. The inharmonious behavior of the data is the motivation behind the development of new tools and demonstrates the available information to some meaningful information for decision making. As per the literature, healthcare of patients can be analyzed through machine learning tools, and henceforth, in the article, a Bayesian kernel method for medical decision-making problems has been discussed, which suits the purpose of researchers in the enhancement of their research in the domain of medical decision making.

## KEYWORDS

Bayesian Inference, Bayesian Kernel, Bayesian Network Structure, Kernel Mean, Kernels, Medical Decision, Non-Parametric Bayesian Kernel Method

## INTRODUCTION

Many people all around the world die due to error in healthcare systems. In healthcare industry, several strategies have been proposed by various professionals like IT adoption, collaboration among various disciplines etc. to design medical decision support systems, which help clinicians for medical decision making. From the last three decades, the applications of Bayesian approaches have grown at an exponential pace, but research in this domain has developed very slowly in first one hand half decade. The major reason for that is to generate Bayesian networks for practical and analytical purposes are quite difficult. Therefore, generating Bayesian networks was a challenge for researchers and this made inaccessible to vast community of scientist for their applicability. Now, Bayesian and its native forms are generated by the help of computers, which address the vast community of researchers to became a tool and have wings spread over many disciplines such as computer science, logic, information theory, probability theory, statistics, machine learning etc. and can be utilized in almost all the disciplines for the purpose of application. Bayesian based models are mainly used to answer the queries for the variables, their relationship to compute the evidence for the variables in complex situations and are considered as graphical probabilistic models. Decisions making under the state of

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uncertainty are the typical most problems in medical decision making and Bayesian kernel methods are very promising in tackling such situations problems and becomes more rational as compared to the conventional models, the assumptions made are more obvious and thus making the decision making easy and defendable. The analytical approach of the theory became a boon for the researchers, which flavoured with machine learning algorithms to grow beyond their domain. The traditional statistical techniques such as regressions have explanatory purposes and have applications in simulation and optimization, epidemiology and social sciences. The foundation of Bayesian approach lies from the rule for updating probabilities, given by Rev. Thomas Bayes (1702-1761) as Bayes' theorem. He addresses both discrete and continuous probability distributions by means of conditional and marginal probabilities. Bayes' theorem is used for the calculation of inverse probability and is based on the apriori and posterior probability measures and provides uncontroversial result in the field of probability but its applications fall under controversy for more than two decades. This chapter is an introduction to the modernized Bayesian approach which leads to algorithms within the frame work of risk minimization and giving us a new insight into kernel algorithms. There are many ways we could take to motivate the readers for using Bayesian kernel methods in medical diagnosis, which is based on the assumption that all the quantities of interest are governed by probability distributions. Optimized results can be obtained in Bayesian theory by evaluating these probabilities together and combines prior knowledge with the observed data and is the sole theory in medical diagnosis which accommodates hypothesis.

## LITERATURE REVIEW

During the clinical examination of a patient, some patient-centric information is recorded such as age, gender, medical history and some parameters related to the disease. Clinicians prefer an interpretable decision support system, based on clinical and pathological indicators. Many researchers used SVM for this purpose, but due to the heterogeneous nature of clinical data, SVM is not easy to implement and the results obtained are not reliable. Therefore, to get better results, kernel methods should be implemented. Schurmann (1996) explained the concepts behind the designing of kernels and its properties. Ghosh (2000) elaborated that the Bayesian approach has been recognized as an promising technique for tackling clinical decision making problems and has the ability to represent uncertain knowledge. He represented Bayesian based mathematical model of heart disease. Spiegelhalter (2000) presented decision theoretic statistical based bayesian methods and its implementation in the assessment of health technology. He claimed that bayesian methods are the best in transforming the problem from initial opinion to final judgement. Scholkopf (2003) described the basic principles of Gaussian processes and their implementation in his chapter on Bayesian Kernel Methods. Sheppard (2005) presented a mathematical approach flavoured with Bayesian theory to measure the level of uncertainty and further utilize the assessment to propose the improved diagnosis. Due to which, one could treat the probability of false detection or missed detection and provide the treatment for false diagnosis. Kadane (2005) discussed the use of Bayesian approach in medical decision making and emphasized on how decision makers consider the subjective concepts of probability and utility functions in his research. Kim (2006) used Bayesian based Gaussian Process classifier kernel method to classify gender among various face images of men and women. The proposed method is efficient over the traditional support vector machines based kernel classifiers and found that they determine hyper parameters on model selection criterion. Van Calster (2007) used Bayesian least square support vector machines method to separate malignant from benign and develop a classifier to predict malignancy in adnexal masses. He used a large dataset collected from the nine databases of different centres and comes out with the better results as compared with the traditional support vector machine method. Broemeling (2007) explained various benefits of employing Bayesian methods in clinical studies and emphasizes that variety of areas where diagnostic medicine is used such as in the estimation of accuracy by sensitivity, positive and negative predictive values of diagnostic measurements. Lukic (2007) also