Dean&Francis
ISSN 2959-6149

“Belief Updating under Uncertainty: Probabilistic Epistemology and Its Limitations”

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Abstract:

Probabilistic epistemology, especially the Bayesian model, provides a dynamically updated framework for the construction of knowledge under uncertainty. Starting from the shortcomings of the traditional view of knowledge, this paper analyzes how probabilistic theory can cope with uncertainty by adjusting the strength of beliefs, so as to gradually approach the truth. Bayesian epistemology has shown its unique application potential in the fields of science, medicine and economic forecasting. Especially, Bayesian epistemology can enhance rational belief in dynamic environment through the update mechanism of conditional probability. Although Bayesian epistemology has many advantages, it has obvious limitations in its application to non-empirical fields such as ethics and metaphysics. This paper also explores the importance of Bayesianism in knowledge construction and compares it with other epistemological models such as evidentialism and dependability. This paper argues that although Bayesianism provides flexible instrumental support for knowledge construction, it still has great limitations in dealing with fuzzy and non-quantitative knowledge and ethical decision-making, which limits its application to broader epistemological problems. At the same time, it is pointed out that probabilistic epistemology can be combined with other methods to expand its application scope.

Keywords: Bayesianism; Probabilistic epistemology; Evidence evaluation; Non-quantitative knowledge

1. Introduction

In traditional epistemology, knowledge is often viewed as justified true belief, emphasizing certainty and logical proof. However, this view faces challenges in dynamic, uncertain contexts, such as scientific research and medical diagnosis, where absolute certainty is rarely achievable. Probabilistic episte-

ISSN 2959-6149

mology, especially Bayesianism, offers an alternative by enabling belief updating in response to new evidence, allowing knowledge to approach the truth gradually. This study aims to examine Bayesianism's role in knowledge construction under uncertainty, assessing its strengths and limitations compared to other epistemological models, and exploring its potential expansion into broader, non-quantitative domains.

2. Theoretical Background of Probabilistic Epistemology

2.1 Challenges to Traditional Knowledge View

The traditional view of knowledge usually pursues certainty of knowledge, for example, the classic Plato's definition of a triadic, which is presented in his Theattetus. The core content is that knowledge should be "true" belief and argument; that is, knowledge must be true, and its rationality can be supported by logical argument. That is, "Knowledge is proven true belief."[1]

In this view, knowledge should be a complete grasp of truth and, therefore, subject to rigorous logical proof. Based on this definition, knowledge must satisfy three conditions: first, it must be true; Second, the subject has a belief in it; Third, this belief must be supported by soundproof. This "deterministic view of knowledge" is central to Western philosophy. And this rigor of knowledge is further accentuated in skepticism. Descartes put forward "method doubt" and used it as a tool to question all knowledge that could not be rigorously proved, and he tried to find out the unquestionable truth from it and use it as the foundation of all knowledge [2]. However, such a reliable basis is difficult to find in complex practical problems, especially when facing problems with incomplete information; it is difficult to produce effects.

Therefore, the view of traditional knowledge theory is facing more and more doubts in philosophy. The emergence of probabilistic epistemology provides a new perspective for dealing with uncertain knowledge. The theory acknowledges the uncertainty in the process of knowledge acquisition and argues that knowledge can be a belief gradually established under conditional evidence. Belief strength can be constantly adjusted according to new evidence so that the belief can gradually approach the truth in a dynamic environment.

As Popper emphasized in his revision of evidentialism, the growth of scientific knowledge does not lie in the pursuit of absolute proof, but in the gradual approach to truth in the process of constant refutation and falsification[3]. In this perspective, probabilistic epistemology is suitable for constantly updating the belief strength in the belief defect, so that the belief gradually tends to be rational and rational in the dynamic environment. For example, in scientific research, although experimental data cannot provide absolutely sure conclusions, through repeated trials and model revision, researchers can gradually increase the support for the theory, thus making it closer to the truth [4].

At the same time, many viewpoints also provide support for probabilistic epistemology. For example, Peirse's pragmatic thought believes that the value of knowledge does not lie in the absolute truth but in whether it can play a role in actual operation. Under this notion, probability updating helps people to continuously adjust their beliefs in actual decisions to make them closer to valid judgments. Probabilitarism is also considered a powerful challenge to the traditional view of knowledge because it allows knowledge to be constantly equipped in a dynamic and uncertain environment.

2.2 The Rise of Probabilistic Theory and the Position of Bayesianism

In the 20th century, probabilistic theory gradually developed as a new knowledge framework to deal with uncertainty and has been widely used especially in the philosophy of science and decision theory.

Among the specific branches of probabilitism, Bayesianism occupies an important position due to its conditional probability model. Bayesianism uses Bayesian theorem: Prob(H /E) =Prob(E/H)*Prob(H)/Prob(E), combines the prior probability P(H) of new evidence E and hypothesis H, and obtains the posterior probability P(H|E), that is, the updated belief under the influence of evidence E. According to Bayesianism, belief strength should be updated according to the possibility of new evidence, so that belief becomes a dynamic probability distribution[5]. This approach applies to several fields, such as scientific research, medical diagnosis, and economic forecasting, as it allows beliefs to be adjusted to the latest data, thus continuously approaching a correct understanding of the phenomenon.

There are two main branches of Bayesianism: subjective Bayesianism and objective Bayesianism. Subjective Bayesianism considers prior probabilities as the expression of individual beliefs and allows individuals to choose prior distributions based on their own experience or preferences, so it is suitable for fields that emphasize individual judgment. It reflects the relative and personal nature of knowledge, which is especially advantageous in areas with high uncertainty, such as market analysis or clinical trials.

In contrast, objective Bayesianism is devoted to limiting the subjectivity of the prior, emphasizing the selection of

objective priors through reasonable rules, to improve the commonality and consistency of beliefs. For example, the "maximum entropy principle" proposed by E.T. Jaynes advocates that when there is not enough information, the prior with the least informative hypothesis should be chosen so as to reduce bias and bias. This approach is fundamental in scientific research as it attempts to provide a more objective standard of knowledge assessment that contributes to a widely shared knowledge base [6].

The two branches of Bayesianism show different emphases in the view of knowledge: subjective Bayesianism is more inclined to the individualization of knowledge, allowing beliefs to accumulate gradually according to personal experience; Objective Bayesianism, on the other hand, pursues the construction of widely accepted public knowledge under uncertainty. The former shows flexibility in the field of individual decision-making, while the latter has high applicability in public policy and scientific research. Different branches of Bayesianism reflect how probabilistic epistemology achieves the diversity of knowledge construction in situations of uncertainty.

3. Philosophical Controversy and Criticism

3.1 Subjectivity Problem

One of the great philosophical controversies of Bayesianism is its reliance on beliefs, which gives the Bayesian approach a remarkable subjectivity.Subjective Bayesianism emphasizes that the prior distribution in the belief updating process should be determined by the individual's belief and experience, which makes the initial belief of each person may be greatly different.However, this approach also raises philosophical puzzles about "reasonable priors": how to choose a prior distribution that reflects one's beliefs without being overly subjective during the belief updating process?For this reason, the philosophers Kosmos and Hawkes proposed the principle of Bayesian rationality, trying to find a balance between subjectivity and objectivity.They argue that a "reasonable prior" should be based on an objective analysis of the situation, rather than relying solely on individual subjective judgments.For example, applying the maximum entropy principle reduces bias because it selects the least informative prior, limiting the influence of subjective factors [7].

However, even so, the "reasonable prior" may still lead to conflicting posterior conclusions in different contexts. Assuming that we use the same prior distribution to evaluate two situations with different background information, even under similar condition s of evidence, it is possible to produce vastly different posterior conclusions because of the individualized features of the prior.This contradiction shows that prior selection is difficult to ensure consistency in different contexts, and it cannot eliminate the difference in results caused by subjectivity. The issue of Bayesianism subjectivity not only affects the objectivity of belief updates, but also poses a methodological challenge to the applicability of Bayesian models. Therefore, it remains an open question under which conditions the chosen prior distribution is considered "reasonable".

3.2 The Relationship between Probability and Knowledge

Bayesianism regards knowledge as a process of adjustment of belief strength. So, it is reasonable that knowledge from this perspective is equated with quantifying beliefs through changes in probability values. But there are also philosophers who point out that an increase in the strength of beliefs does not necessarily equate to an increase in knowledge. For example, classical knowledge theory requires that knowledge is not only a credible belief, but also must have "corroboration" or "proof", which means that a change in the strength of belief is not sufficient as a sufficient condition for the growth of knowledge strength.

The Gettier problem is a further challenge to the standard of "true belief + proof" in classical knowledge theory. Gettier argues that even if someone has a strong belief in a proposition and the proposition is true, that belief may still not be knowledge. For example, suppose a detective is extremely suspicious of a suspect and constantly increases the strength of his belief that the suspect is guilty through Bayesian belief updating. But if that conclusion is based entirely on misleading evidence, then in this case an increase in belief strength does not imply an increase in knowledge. This case shows that in the Bayesian framework, the increase in the strength of a belief may only reflect the subjective rationality of the belief but does not necessarily mean that the belief is consistent with the objective truth.

Therefore, the "increase in belief strength" achieved by Bayesianism on probability changes cannot satisfy the knowledge requirements of the classical knowledge view. Although probability update provides a process of enhancing the rationality of belief, it cannot completely satisfy the strict condition of "true belief + corroboration" in the classical view of knowledge. This limitation makes Bayesianism still insufficient in the sense of knowledge construction: it is good at quantifying belief adjustment under uncertainty, but it cannot fully fill the demand for "truth" or "reliability" in knowledge theory.

ISSN 2959-6149

4. Belief Updating and Evidence Evaluation

4.1 The Connection between Knowledge Increment and Bayesian Update

"In the framework of Bayesianism, knowledge increment is achieved through the dynamic updating of belief strength. With the arrival of new evidence, the Bayesian theorem adjusts the prior belief according to the conditional probability so that the strength of the belief is gradually increasing and approaching 'knowledge.' However, whether this belief enhancement process of Bayesian updating really constitutes knowledge increment still needs further analysis.

Traditional proof-ism holds that knowledge increment must rely on sound proofs; that is, knowledge growth lies in obtaining an unchallengeable proof base. For example, in mathematical reasoning, new knowledge increments come from accumulating logical proofs. However, the update of Bayesianism is mainly based on probabilistic adjustment of evidence and beliefs, which means that its knowledge increment process may lack absolute probability. Even though the belief strength increases continuously in the Bayesian model, the increase reflects more the "subjective rationality" of the belief, rather than the "certainty" or "absolute reliability" required by the classical view of knowledge. For example, in medical diagnosis, doctors constantly update their beliefs about a disease based on patient symptoms and test results. However, although belief strength increases and enhances the physician's judgment of the patient's condition, the diagnosis remains probabilistic. This case shows that the incremental knowledge acquisition of Bayesian update is difficult to achieve the full 'proof' nature. Therefore, although the Bayesian model provides a certain mode of knowledge increment, its knowledge increment is more inclined to a dynamic and asymptotic process and cannot realize the requirement of knowledge certainty in the provertivism."

4.2 Complexity of Evidence Evaluation

"Bayesianism emphasizes the reasonable distribution of evidence weight in evidence evaluation, and belief update needs to rely on the importance and reliability of different evidence sources. However, in complex situations, evidence evaluation is often not a single, deterministic process but involves inconsistency or ambiguity of evidence. For example, in a decision-making process, evidence from multiple sources may conflict with each other or give different interpretations of the same event. In this context, Bayesian update may encounter challenges that are difficult to adapt.

Jeffrey conditionalization is a belief revision method suitable for such complex situations. Unlike traditional Bayesian conditionalization, Jeffrey conditionalization allows us to perform belief adjustment when the evidence itself has uncertainty or dispersive weights. For example, in psychological experiments, researchers may obtain contradictory partial results. Jeffrey conditionalization can allocate beliefs according to the relative weight of each set of evidence so that belief updating can maintain flexibility in uncertain situations. However, even Jeffrey conditionalization is still difficult to deal with completely opposing evidence, because the Bayesian model does not provide an effective criterion to weigh the evidence precedence in this case.

In addition, when there are conflicts among multiple evidence sources, how to select the best evidence has become a big problem. The Bayesian approach does not provide an explicit mechanism to determine which evidence has more weight or credibility among conflicting evidence. For example, in climate prediction, different research institutions may provide completely different climate models, and the Bayesian method can only update according to the priority of each model, so it is difficult to determine which model is more representative. Thus, the limitations of Bayesianism in the face of complex evidence integration suggest that it may need to be combined with other evidence evaluation models to ensure effectiveness in complex situations."

5. Comparison between Bayesianism and Other Epistemological Models

5.1 Bayesianism and Evidentialism

Evidentialism claims that the rationality of beliefs should be entirely dependent on objective evidence and rejects the role of subjective factors in knowledge construction. The evidentialist believes that knowledge should be universal, that is, different individuals should come to the same conclusion when faced with the same evidence. In order to ensure this consistency, evidentialism insists on the objectivity of beliefs and holds that reasonable beliefs can only be formed based on public and independent evidence. The philosophical foundation of this view lies in the public and universal nature of knowledge-knowledge should be shared by all rational individuals, independent of individual subjective biases. This claim is further strengthened by an evidentialist argument by Alvin Goldman [8]. He argues that consistency in knowledge assessment is essential, and that objective evidence provides us

with a uniform standard, thus avoiding cognitive biases due to individual differences in beliefs. For example, in scientific research, regardless of the background or experience of individual researchers, when faced with the same experimental results, their conclusions should converge to ensure the fairness and objectivity of knowledge.

In contrast, Bayesianism allows individuals to set prior probabilities based on their own beliefs and experiences, so that the belief updating process can be adjusted according to the individual's initial state. This subjectivity of Bayesianism increases the flexibility of belief adjustment but is therefore criticized by evidentialism for possibly introducing individual bias and weakening the objectivity of knowledge. For example, in legal reasoning, evidentialism requires juries to reach a verdict based on all the objective evidence presented, and does not allow for setting priors based on individual preferences or intuitions; however, the Bayesian prior choice may lead jurors to draw different conclusions on the same evidence due to different subjective views. In response to this criticism, proponents of Bayesianism argue that even if the starting point carries a subjective component, the Bayesian updating process can bring individual beliefs close to objective facts by gradually introducing new evidence. This gradual belief adjustment mechanism makes Bayesianism maintain some rationality and adaptability. Bayesians believe that the bias of individual beliefs will be gradually corrected as new evidence is continuously incorporated. Therefore, although Bayesianism does not require that all people must arrive at the same initial belief in the face of the same evidence, the final belief will converge in the long-term update process, so as to maintain the rationality of knowledge.

5.2 Bayesianism and Dependability

Dependability theory holds that the rationality of knowledge depends on the reliability of the external source of belief, and the reliability of this source does not depend on the subjective intention of the individual. The rationality of Bayesian model depends on the continuous input of new evidence, so it can meet partial reliability requirements in the process of knowledge growth. Bayesian beliefs achieve reliability indirectly through the dynamic process of external data. For example, in a dependability framework, if one observes temperature readings through a reliable instrument such as an accurate thermometer, then this belief is considered reasonable because it relies on an external reliable source of knowledge.

Dependability argues that knowledge acquisition must be based on such reliable sources independent of individual beliefs, rather than through subjective judgments. In contrast, Bayesianism allows the belief updating process to be implemented through subjective prior Settings. Individuals can choose different prior probabilities according to their own experience or belief, which may lead to insufficient reliability of knowledge in the view of reliabilitism. Reliabilists question the Bayesian setting of subjective priors because it does not necessarily depend on external objective conditions but is based on the internal state of the individual. For example, in medical diagnosis, doctors may set the prior probability of the disease based on different experiences, which affects the reliability of the diagnosis results. In the view of reliabilitism, the lack of external validation of such subjective belief sources may cause knowledge to lose its due reliability.

Bayesianism responds that although the starting point has a subjective component, the Bayesian updating process can gradually make the belief consistent with the external facts by continuously introducing new evidence, thereby indirectly achieving the reliability of the belief. For example, in weather forecasting, meteorologists can set an initial forecast prior based on previous meteorological data, but as new meteorological observations are added, the forecast model is constantly adjusted to approximate the real weather conditions. This constantly adjusted belief updating process enhances the external consistency of beliefs in the long run. According to Bayesianism, this dynamic consistency process between belief and external data can satisfy the reliability requirement to some extent, even if its starting point contains subjectivity.

6. Philosophical Applications and Limitations of Bayesianism

6.1 Limitations of Bayesianism in Fuzzy Concepts and Non-quantitative Knowledge

Bayesian model performs well in quantitative processing, but its effectiveness is very limited when dealing with fuzzy concepts and non-quantitative knowledge. Bayesianism assumes that beliefs and evidence can be quantified as exact probability distributions, but in many practical situations, knowledge is not always quantifiable. For example, problems such as moral ideas, social norms, and aesthetic evaluation are often highly ambiguous and polysemy, which are difficult to describe by simple probability distributions. In ethics, vague concepts such as "justice" or "goodness" are difficult to define with quantitative criteria, and Bayesian models are difficult to provide a clear analytical framework on such issues.To cope with the problem of fuzziness, fuzzy logic and possibility theory offer potential complementary approaches. Fuzzy

ISSN 2959-6149

logic introduces the concept of fuzzy set, so that beliefs or concepts can have fuzzy boundaries, and it is suitable for situations with strong polysemy. For example, fuzzy logic can describe various degrees between "good" or "bad" in social judgments without having to rely on a single probability numerical value[9]. Possibility theory, on the other hand, allows for flexible adjustment of beliefs in the absence of precise probabilistic information, which is especially helpful for those scenarios with extremely high uncertainty.

Despite the limitations of Bayesianism in dealing with fuzzy knowledge, it may be considered to combine it with models such as fuzzy logic to improve its adaptability to non-quantitative knowledge. Although Bayesianism can be extended to deal with fuzzy concepts and non-quantitative knowledge to a certain extent, it still needs the assistance of other logical methods to solve the fuzziness problem.

7. Conclusion

This paper explores the advantages of probabilistic epistemology, in particular Bayesianism, as a knowledge framework for coping with uncertainty, in updating beliefs and knowledge construction. Probabilistic theory successfully challenges the traditional view of knowledge to a certain extent, and provides a theoretical basis for the acquisition of knowledge under uncertain conditions by dynamically updating belief through Bayesian theorem. However, although Bayesian model has outstanding performance in scientific research, medical diagnosis and economic forecasting, its ability to deal with ambiguous concepts and polysemy knowledge in non-empirical fields such as ethics and metaphysics is still insufficient.

Bayesianism has triggered a fierce philosophical debate on the rationality of prior beliefs, which not only brings about the problem of consistency of belief updates, but also raises questions about the rationality of beliefs and the availability of knowledge. This paper also compares Bayesianism with other epistemological models such as evidentialism and soundness, revealing the limitations of Bayesian models in complex decision making and evidence conflict handling, while pointing out the balance between questioning and truthiness in the application of tools.

In general, as a representative of probabilistic epistemology, Bayesianism provides a unique perspective in dealing with dynamic and uncertain knowledge, but it still needs to be combined with other logical methods (such as fuzzy logic and possibility theory) to compensate for its deficiency in the application of non-quantitative knowledge. Future research could further explore the integration of Bayesianism with other epistemological approaches to the broader challenge of knowledge construction.

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