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The Bayes' formula in terms of the multi-optional uncertainty conditional optimality doctrine

The paper theoretically considers the possibility of the multi-optional hybrid functions entropy conditional optimization principle applicability with the purpose of discovering one more substantiated reason for the Mr. Thomas Bayes' Theorem Formula existence, as well as the reasons for the formula optimality.

Introduction. Engineering diagnostics (as an important part of maintenance) predictions influence a lot the decisions made in order to avoid damages and hard consequences of them (such as, for example, unexpected breaks, emergency situations, failures, other tough troubles etc.) acquired or got because of the problems of technical use, of machines as a whole, their parts, mechanisms or just elements, gained, obtained or encountered in operation of, let us say, aeronautical engineering [1, 2] (as well as at any kind of engineering operation when one should take into consideration the issues of safety, reliability, maintenance, risks, maintainability and so on [3-5]).

State of the problem. Safety endeavors, related with risks and reliabilities [3-5], therefore probabilities [6-8], in aeronautical engineering operation generally [1, 2] and in its particular sorts of uncertainties [9], progressive and prospective techniques development [10-18], accompanying the processes of the theories evolutions [19-22], issues of multi-alternativeness and "multi-optionallity" [23-34], have instigated through the decades and will definitely continue to instigate the scientifically grounded research in the fields on knowledge so that to gain a more and more proper theoretical background for some reasonable explanations and substantiations of the observed phenomena.

In this respect, the identified research gap is still the lack of the newly emerged theories (like of the Subjective Entropy Maximum Principle (SEMP)) [9], and for present days being undergone the evolution into the doctrine of multi-optional conditional optimality of special hybrid-optional effectiveness functions uncertainty [10-19]) connections to the having already been developed through centuries well-known concepts (regarding the presented paper objectives it is the diagnostics based upon the Mr. Thomas Bayes' Theorem Formula [6-8]).

Purpose of the paper. The presented paper is aimed at discovering the substantiated reasons for an a-posterior probability of a hypothesis existence and to demonstrate, on such an example, the multi-optional hybrid functions entropy conditional optimization principle applicability.

Problem setting. According to the state of the problem, it is required to find the Mr. Thomas Bayes' Theorem Formula [6-8] following a certain variational principle of multi-optional conditional optimality of special hybrid-optional effectiveness functions uncertainty [10-19], similar to SEMP [9].

Multi-optional concept. One can present the process of random events happenings as a multi-optional problem. Generally speaking it is supposed that occurrence of an event, let us designate it as A, has a possibility to be realized with just one of the set's hypothesis of H_i and only. That is the classical problem setting according to the references of [6-8], as well as which can be found in many study books in multiple of interpretations and with a brilliant collections of numerous examples.

However, for us now, it is important to treat the conditions of the complete group of disjunctive events (hypothesis) of H_i, the probability of which is indicated as a rule as $P(H_i)$, and conditional probability of $P(A|H_i)$ of the event of A occurrence on condition that the hypothesis of H_i has been realized, denoted in the traditional manner as well as that, like multi-optional chances with an optimal, in a certain respect, and objectively existing on some needed to be revealed reason, hybrid multi-optional function of $f[\cdot]$, pertaining with a-posterior probability of the hypothesis of H_i realization on condition that the diagnostic event of A have already taken place, $P(H_i|A)$ stands for the corresponding probability of such case.

The things to be taken into consideration are: 1) "optionality's" or option's (optional) effectiveness of the probability of the events of H_i and A happening in conjunction, i.e. $P(H_i \text{ and } A)$, in a logarithmic style: $\ln[P(H_i)P(A|H_i)]$, allowing a representation of that in a linear combination: $\ln[P(H_i)]+\ln[P(A|H_i)]$; with 2) taking into account the corresponding multi-optional hybrid effectiveness function of $f[\cdot]$, of the a-posterior probability: $f\left[P_{H_i}^{(posterior)}\right]$; and 3) uncertainty of the hybrid-optional effectiveness function of $f\left[P_{H_i}^{(posterior)}\right]$.

The most important here is to understand that there must be some optimality in the framework of the nature things "optionality". The approach similar to seeking after preferences in subjective analysis, SEMP [9], and applied, including, to the hybrid optional optimal distribution densities findings and [10-34], allows implementing the objective functional of the following kind [22, p. 96, (1)]:

$$G_f=-\sum_{i=1}^{n} f\left[P_{H_i}^{(posterior)}\right]\ln\left\{f\left[P_{H_i}^{(posterior)}\right]\right\}+\beta\sum_{i=1}^{n} f\left[P_{H_i}^{(posterior)}\right]\ln\left[P(H_i)P(A|H_i)\right]+$$
$$+\gamma\left[\sum_{i=1}^{n} f\left[P_{H_i}^{(posterior)}\right]-1\right], \qquad (1)$$

where β and γ are the internal structural parameters of the hybrid optional functions $f\left[P_{H_i}^{(posterior)}\right]$ distribution (conditional optimal distribution of the a-posterior probabilities functions with respect to the functions' degree of uncertainty and regarding to the logarithmic values of conjunctive events of H_i and A chances corresponding probabilities) as an uncertain Lagrange multipliers for the options' (optional) effectiveness: $\ln[P(H_i)] + \ln[P(A|H_i)]$ and normalizing condition envisaged with last member of the objective functional, together β and γ are analogous to the parameters characterizing a system's intrinsic hybrid optimal optional behavior [10-34], likewise for the active element's psych [9], SEMP, (endogenous parameter for the functions of the optional effectiveness $\ln[P(H_i)] + \ln[P(A|H_i)]$ and uncertain Lagrange multiplier for the normalizing condition $\sum_{i=1}^{n} f\left[P_{H_i}^{(posterior)}\right] - 1$ respectively).

The necessary condition of functional (1) extremum existence [22, p. 97, (2)]:

$$\frac{\partial G_f}{\partial f\left[P_{H_i}^{(posterior)}\right]} = -\ln f\left[P_{H_i}^{(posterior)}\right] - 1 + \beta \ln[P(H_i)P(A|H_i)] + \gamma = 0\,, \quad (2)$$

yields [22, p. 97, (5)]:

$$f\left[P_{H_i}^{(posterior)}\right] = \frac{[P(H_i)P(A|H_i)]^{\beta}}{\sum_{j=1}^{n}[P(H_j)P(A|H_j)]^{\beta}}\,. \quad (3)$$

Which is, at the parameter of [22, p. 97, (6)]: $\beta = 1$ value, absolutely exactly nothing more than the a-posterior probability of a diagnosis (by Mr. Thomas Bayes' Theorem Formula) [6-8]. That is [22, p. 97, (7)]:

$$f\left[P_{H_i}^{(posterior)}\right]\Big|_{(\beta=1)} \equiv P(H_i|A)\,. \quad (4)$$

The proposed approach (1)-(4) is different from the entirely probabilistic way of Bayes' formulae derivation [6-8].

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