Basic elements and problems of probability theory

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Abstract

After a brief review of ontic and epistemic descriptions, and of subjective, logical and statistical interpretations of probability, we summarize the traditional axiomatization of calculus of probability in terms of Boolean algebras and its set-theoretical realization in terms of Kolmogorov probability spaces. Since the axioms of mathematical probability theory say nothing about the conceptual meaning of " randomness " one considers probability as property of the generating conditions of a process so that one can relate randomness with predictability (or retrodictability). In the measure-theoretical codification of stochastic processes genuine chance processes can be defined rigorously as so-called regular processes which do not allow a long-term prediction. We stress that stochastic processes are equivalence classes of individual point functions so that they do not refer to individual processes but only to an ensemble of statistically equivalent individual processes. Less popular but conceptually more important than statistical descriptions are individual descriptions which refer to individual chaotic processes. First, we review the individual description based on the generalized harmonic analysis by Norbert Wiener. It allows the definition of individual purely chaotic processes which can be interpreted as trajectories of regular statistical stochastic processes. Another individual description refers to algorithmic procedures which connect the intrinsic randomness of a finite sequence with the complexity of the shortest program necessary to produce the sequence. Finally, we ask why there can be laws of chance. We argue that random events fulfill the laws of chance if and only if they can be reduced to (possibly hidden) deterministic events. This mathematical result may elucidate the fact that not all nonpredictable events can be grasped by the methods of mathematical probability theory.

Keywords:	Ontic description. Epistemic description. Randomness. Regular stochastic processes. Individual description of trajectories. Predictability. Retrodictability. Hidden determinism.
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