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Photonics approach to decision making

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Optics and photonics are expected to play crucial roles in artificial intelligence by utilizing the unique physical attributes of photons such as their ultrahigh bandwidth nature, light-matter interactions at the nano-scale, quatum properties, among others. Here we present our research on the physical realization or acceleration of higher-order intelligent functions such as decision making by exploiting photonics. Decision making means to conduct adequate judgements in dynamically changing uncertain environments and is widely utilized in information and communications technology ranging from resource assignments in networks to reinforcement learning in artificial intelligence. The problem of interest is the multi-armed bandit (MAB) problem where the issue is to maximize the total rewards in unknown environments that involve difficult trade-offs known as exploration-exploitation dilemma. We describe the principle of physically solving MAB problems by utilizing the wave–particle duality of single photons in which the probabilistic attributes of single light quanta are employed for exploration. The principle is transformed into ultrafast laser chaos where the chaotically oscillating irregular time series provides ultrafast and scalable decision- making abilities. Its applications to dynamic channel selections in wireless communications and dynamic model selection in reservoir computing will also be demonstrated. In addition, the MAB problem becomes more difficult when multiple players or social aspects are involved because decision conflicts evoke congestions that prevent from maximizing social benefits. We demonstrate that entangled photons perfectly resolve the decision conflicts and ensure equality thanks to quantum attributes of photons. Theoretical backgrounds will also be reviewed including category theoretical modeling and analysis.

Biography

Makoto Naruse received the B.S., M.S., and Ph.D. degrees in Engineering from the University of Tokyo in 1994, 1996, and 1999, respectively. After serving as a Research Associate and Assistant Professor in the University of Toyo from 1999 to 2002, he joined National Institute of Information and Communications Technology, Ministry of Internal Affairs and Communications, Tokyo, in 2002. In 2017, he was an Invited Processor of Univ. Grenoble Alpes, Grenoble, France. Since 2019, he is a Professor in the Department of Information Physics and Computing, Graduate School of Information Science and Technology, The University of Tokyo, Tokyo, Japan.

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