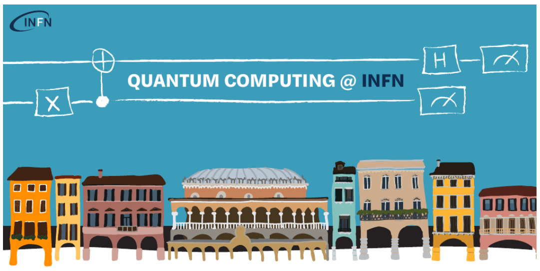

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Quantum Fuzzy Logic

Wednesday, 30 October 2024 12:00 (20 minutes)

Quantum Fuzzy Logic integrates two distinct mathematical frameworks—quantum computing and fuzzy logic—both of which fundamentally deal with uncertainty and imprecision. Quantum mechanics inherently involves uncertainty through its stochasticity, while fuzzy logic addresses vagueness in reasoning and decision-making processes, allowing for degrees of truth rather than binary true/false values. The proposed abstract explores the synergy between these fields, particularly the potential for quantum computing to enhance fuzzy logic systems, and conversely, how classical fuzzy logic can contribute to advancements in quantum computing.

On the one hand, quantum computing, with its ability to process information in superposed states, provides an innovative platform for the development of fuzzy rule-based control systems. Indeed, this well-known classical controller suffers when the number of input variables in the systems increases, because of the related exponential number of rules to be computed. To address this issue, an innovative quantum fuzzy inference engine capable of firing fuzzy rules exponentially faster than the classical counterpart was recently proposed [1]. Its applicability has been proved thanks to the implementation of quantum control systems in scenarios like particle accelerators [2] or smart cities [3].

Conversely, classical fuzzy logic can also play a critical role in improving quantum computing. Fuzzy logic algorithms, designed to operate effectively in uncertain and imprecise environments, could offer solutions to some of the challenges in quantum computing, such as noise suppression and mitigation [4]. The proposed abstract presents an application of the Fuzzy C-means algorithm exploited to mitigate error on an actual superconductive quantum device [5].

Overall, Quantum Fuzzy Logic is this innovative bidirectional research line that offers a new perspective both for quantum computing and fuzzy logic. This bidirectionality, not only fosters innovation in both domains but also creates a feedback loop where advancements in one field continuously drive progress in the other, opening new pathways for the development of advanced computational systems.

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[2] G. Acampora, M. Grossi, M. Schenk and R. Schiattarella, "Quantum Fuzzy Inference Engine for Particle Accelerator Control," in IEEE Transactions on Quantum Engineering, vol. 5, pp. 1-13, 2024, Art no. 3101013, doi:10.1109/TQE.2024.3374251.

[3] G. Acampora, R. Schiattarella and A. Vitiello, "Using Quantum Fuzzy Inference Engines in Smart Cities," 2024 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), Yokohama, Japan, 2024, pp. 1-8, doi: 10.1109/FUZZ-IEEE60900.2024.10611863.

[4] G. Acampora and A. Vitiello, "Error Mitigation in Quantum Measurement through Fuzzy C-Means Clustering," 2021 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), Luxembourg, Luxembourg, 2021, pp. 1-6, doi: 10.1109/FUZZ45933.2021.9494538.

[5] H. G. Ahmad, R. Schiattarella, P. Mastrovito, A. Chiatto, A. Levochkina, M. Esposito, D. Montemurro, G. P. Pepe, A. Bruno, F. Tafuri, A. Vitiello, G. Acampora, D. Massarotti, Mitigating Errors on Superconducting Quantum Processors Through Fuzzy Clustering. Adv Quantum Technol. 2024, 7, 2300400. https://doi.org/10.1002/qute.202300400

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