Master Internship/Stage de Fin d'Études 2023/2024

"Resource-Efficient Distributed Quantum Detection"

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Location: The student will be working at the COMELEC Department of Telecom Paris.

Related Fields: Information theory, Quantum information theory, Detection theory

Project Description: Quantum sensing technologies are currently pushing their way into the market. Quantum sensing allows to detect changes at the microscopic level of quantum states and thus single atoms or photons, whereas traditional classical sensing systems can only observe changes induced by large sets of atoms/photons, and as such have lower precision. While fundamental limits *non-distributed* quantum detection systems have been derived under various assumptions [1], distributed systems remain almost unstudied. The sole exceptions are the recent works [2, 3].

In this project our goal will be to improve resource-efficiency of the distributed quantum detection systems in [2, 3]. In particular, we shall allow for variable-length coding in the communication protocols and our goal will be to reduce the required average communication rate (which proportionally relates to the required communication bandwidth) while preserving the achieved detection performance. In particular, we shall be interested in determining the fundamental limits of the maximum rate-reduction that is possible under variable-length coding compared to fixed-length coding. We have related results for the classical case [4, 5], and expect that similarly intuitive and clear expressions for the rate-reduction are possible in the quantum setup. Finally, besides reductions in bandwidth will also consider other reductions of other resources like power consumption.

Expected Skills: The candidate is expected to have good analytic skills and solid backgrounds in probability, information theory, and algebra. Knowledge in quantum information theory is a plus but not absolutely required. The project is of fundamental and theoretical nature, but also involves also a small part on programming.

References

[1] F. Hiai and D. Petz, "The proper formula for relative entropy and its asymptotics in quantum probability," *Communications in mathematical physics*, vol. 143, pp. 99–114, 1991.

[2] H.-C. Cheng, N. Datta, and C. Rouzé, "Strong converse bounds in quantum network information theory: distributed hypothesis testing and source coding," 2019. [Online]. Available: https://arxiv.org/abs/1905.00873

[3] H.-C. Cheng, N. Datta, and C. Rouzé, "Strong converse bounds in quantum network information theory," *IEEE Transactions on Information Theory*, vol. 67, no. 4, pp. 2269–2292, 2021.

[4] S. Salehkalaibar and M. Wigger, "Distributed hypothesis testing with variable-length coding," *IEEE Journal on Selected Areas in Information Theory*, vol. 1, no. 3, pp. 681–694, 2020.

[5] M. Hamad, M. Wigger, and M. Sarkiss, "Multi-hop network with multiple decision centers under expected-rate constraints," *IEEE Transactions on Information Theory*, 2023.