Course guide
230986 - QUAI - Practicals in Quantum Computing and Artificial Intelligence

Last modified: 11/04/2025

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications.

Degree: MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).
MASTER'S DEGREE IN CYBERSECURITY (Syllabus 2020). (Optional subject).

Academic year: 2025 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: JOSE ANTONIO LAZARO VILLA

Others:

REQUIREMENTS

Basic background on engineering or science

TEACHING METHODOLOGY

Classes in English.
- Laboratory Practices.
- Group work.
- Individual work.
- Oral presentations.

LEARNING OBJECTIVES OF THE SUBJECT

Both quantum computing and artificial intelligence are game changers. With classical computers, artificial intelligence creates functional applications, but it is limited by the computational capabilities of classical computers. Quantum computing is expected to aid artificial intelligence in making significant advances. IBM Quantum leads the world in quantum computing, with IBM having the largest quantum computing fleet in the world, whereas AI is widely acknowledged to be led by several players as Google, IBM, and Microsoft. On the one hand, Google Quantum AI is pushing the boundaries of quantum computing by developing hardware and software tools that go beyond classical capabilities. Meanwhile, IBM is one of the companies developing robust quantum safe technology and services for the near future. Microsoft is working to deliver quantum at scale by engineering a unique, stable qubit and bringing a full-stack, fault-tolerant quantum machine as Microsoft Azure Quantum including the pursuit of fault-tolerant topological qubits that scale towards a general-purpose quantum computer.

QUAI focuses on providing a Hands-on Quantum Computing and Artificial Intelligence by laboratory practice introducing the main programming tools.

STUDY LOAD

Type	Hours	Percentage
Hours small group	24,0	32.00
Self study	51,0	68.00

Total learning time: 75 h

CONTENTS

Introduction

Description:
- Subject introduction
- Introduction to Quantum Computing:
• Why quantum computing?
• Quantum states entangled stated and quantum computing
• Example of quantum algorithm for searching in data bases.

Full-or-part-time: 25h
Laboratory classes: 8h
Self study : 17h

Quantum Machine Learning

Description:
- Training parametrized quantum circuits
- Supervised quantum learning
- Unsupervised quantum learning

Full-or-part-time: 25h
Laboratory classes: 8h
Self study : 17h

Hybrid-quantum-classical algorithms and advanced topics

Description:
- Near-term Hybrid-quantum-classical algorithms requiring smaller quantum computers
- Variational algorithms
- TensorFlow Quantum
- Advanced topics

Full-or-part-time: 25h
Laboratory classes: 8h
Self study : 17h

GRADING SYSTEM

The final grade for the course will be obtained from the continuous assessment grade, work proposed by the professors throughout the course and laboratory practices, and a final project.
Laboratory Practices: 75%
Final project: 25%

BIBLIOGRAPHY

Basic:
- Durmus, Murat. Quantum computing and artificial intelligence: the perfect match?. Independently published, 2023. ISBN 9798464587502.
- Wichert, A. Principles of quantum artificial intelligence: quantum problem solving and machine learning [on line]. Second edition. Singapore; Hackensack, NJ: World Scientific Publishing Co. Pte. Ltd., 2020 [Consultation: 07/07/2023]. Available on: https://www.worldscientific.com/worldscibooks/10.1142/11938#t=toc. ISBN 9789811224317.
- Pattanayak, S. Quantum machine learning with Python: using Cirq from Google research and IBM Qiskit [on line]. Apress L. P., 2021 [Consultation: 07/07/2023]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=6516150. ISBN 9781484265222.
- Swan, M.; Dos Santos, R.P.; Witte, F. Quantum computing: physics, blockchains, and deep learning smart networks [on line]. London: World Scientific Publishing Europe Ltd., 2020 [Consultation: 07/07/2023]. Available on: https://www.worldscientific.com/worldscibooks/10.1142/q0243#t=toc. ISBN 9781786348210.

Complementary:
- Raj, Pethuru; Kumar; Kumar Dubey, Abhishek Ashutosh ... [et alk.]. Quantum Computing and Artificial Intelligence: Training Machine and Deep Learning Algorithms on Quantum Computers [on line]. 2023. Berlin, Boston: Walter De Gruyter, 2023 [Consultation: 07/11/2023]. Available on: https://www-degruyter-com.recursos.biblioteca.upc.edu/document/doi/10.1515/9783110791402/html#contents. ISBN 9783110791402.
- Glisic, S.G.; Lorenzo, B. Artificial intelligence and quantum computing for advanced wireless networks [on line]. Hoboken, New Jersey: Wiley, 2022 [Consultation: 07/07/2023]. Available on: https://onlinelibrary.wiley.com/doi/book/10.1002/9781119790327. ISBN 9781119790327.
- Girasa, R.; Scalabrini, G.J. Regulation of innovative technologies: blockchain, artificial intelligence and quantum computing [on line]. Cham, Switzerland: Springer, 2022 [Consultation: 07/07/2023]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=7018976. ISBN 9783031038693.
- Norlén, H. Quantum computing in practice with Qiskit and IBM quantum experience: practical recipes for quantum computer coding at the gate and algorithm level with Python [on line]. 2020. Birmingham, UK ; Mumbai: Packt Publishing, 2020 [Consultation: 07/07/2023]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=6408333. ISBN 9781838821036.
- Bernhardt, C. Quantum computing for everyone [on line]. Cambridge: The MIT Press, 2019 [Consultation: 07/07/2023]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=5719673. ISBN 9780262039253.
- Kaiser, S.C.; Granade, C.E. Learn quantum computing with Python and Q#: a hands-on approach [on line]. 2021. Shelter Island, NY: Manning Publications, 2021 [Consultation: 07/07/2023]. Available on: https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=6665869. ISBN 9781638350903.
- Swan, M.; Dos Santos, R.P.; Lebedev, M.; Witte, F. Quantum computing for the brain [on line]. London: World Scientific Publishing Europe Ltd., 2022 [Consultation: 07/07/2023]. Available on: https://www.worldscientific.com/worldscibooks/10.1142/q0313#t=toc. ISBN 9781800610620.

RESOURCES

Other resources:
Tutorial material on basic topics about the contents of the subject will be offered to those students who may request or need it