Quantum neural networks

Academic Year: (2023 / 2024) **Review date: 14/04/2023 16:10:49**

Department assigned to the subject: Signal and Communications Theory Department

Coordinating teacher: VAZQUEZ VILAR, GONZALO

Type: Electives ECTS Credits : 3.0

Year : 2 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Students are expected to have sufficient background in calculus, linear algebra, programming, and quantum computing.

OBJECTIVES

This course introduces the fundamental concepts of neural networks and the backpropagation algorithm. We shall explore how this architecture can be applied in the design and automatic learning of quantum circuits for certain tasks. We will present extensions of classical to quantum neural networks and analyze their performance for classical and quantum learning problems.

Students attending this course will:
- Understand the theoretical basis and the most common architectures of neural networks.
- Study the different architectures of hybrid-quantum models and quantum neural networks.
- Know and use automatic differentiation software packages for training quantum learning models.
- Apply a quantum neural network for simple learning tasks with classical and quantum training data.

DESCRIPTION OF CONTENTS: PROGRAMME

Unit 1. Introduction to neural networks
1.1. Perceptron, layers, and backpropagation algorithm
1.2. Deep architectures and methods for correlated data

Unit 2. Classical-quantum hybrid models
2.1. Parametric quantum circuits
2.2. Training datasets and loss functions
2.3. Learning quantum algorithms

Unit 3. Quantum neural networks (QNN)
3.1. Quantum models of a perceptron
3.2. QNN for classical learning tasks
3.3. Quantum learning tasks

LEARNING ACTIVITIES AND METHODOLOGY

- Theoretical sessions presenting the fundamentals of neural networks and backpropagation.
- Practical sessions on automatic differentiation software packages for model training.
- Practical labs implementing and training classical-quantum hybrid models and QNNs.
- Tutorial sessions.
- Student individual and team work.

ASSESSMENT SYSTEM

% end-of-term-examination/test:	0
% of continuous assessment (assigments, laboratory, practicals…):	100

- Homework and/or quizzes: 50%
- Lab projects: 50%

% end-of-term-examination/test:	0
% of continuous assessment (assigments, laboratory, practicals…):	100

The course evaluation will be based on a continuous assessment of the student work. To this end, homework deliverables and/or quizzes will contribute to the 50% of the final grade and reports of the practical assignments will sum up the remaining 50%.
The evaluation in the extra-ordinary evaluation call will consist of one single exam covering both theoretical questions and practical problems.

ADDITIONAL BIBLIOGRAPHY

- M. Schuld, F. Petruccione Supervised Learning with Quantum Computers, Springer Cham, 2018