COURSE: ECE730/QIC890-T36

COURSE TITLE: **Quantum Machine Learning**

INSTRUCTOR: Prof. Na Young Kim
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Note: Do not use LEARN email to reach the instructor

LECTURES: 11-12 Lectures, Fridays 2:30-5:20 pm (9/6/2023 - 12/05/2023)

DESCRIPTION

The course introduces basic classical and quantum machine learning algorithms for solving real-life problems. Classical machine learning algorithms are programmed using Sci-Kit Learn and/or PyTorch/TensorFlow based on python. The elements of quantum circuits (qubits, single-qubit gates, two-qubit gates, and quantum operators) are introduced. A quantum programming language (one of three options: Qiskit, Pennylane, or #q) is used to implement quantum machine learning algorithms. Then, hybrid classical and quantum algorithms are studied and programmed using quantum simulators and/or real quantum computers through a cloud service such as IBM Q experience or Amazon Braket.

COURSE OBJECTIVE

The course is developed for students to

- Learn some basic classical machine learning algorithms;
- Learn quantum versions of classical machine learning algorithms;
- Program these algorithms in classical and quantum machine learning algorithms;
- Apply these techniques to a simple real-life problem as a term project.

Expected Background: Python programming, Some familiarity with basic quantum information processing and basic quantum circuit models, Introduction to classical machine learning

(Tentative) SYLLABUS

1. **PART 1: Basic Foundation of Classical and Quantum Programming Interfaces** (3 weeks)
   a. Overview of Classical and Quantum machine learning
   b. Classical Machine Learning Programming
      i. Sci-Kit Learn
      ii. PyTorch/TensorFlow
   c. Quantum Machine Learning Programming
      i. Quantum Circuit Elements
      ii. Qiskit: Quantum Programming Language
      iii. IBM Q

2. **PART 2: Classical and Quantum-Inspired Machine Learning Algorithms** (6 weeks)
   a. Linear Algebra Subroutines
      i. Fourier transform (FT): Classical Fast FT and Quantum FT
   b. Supervised machine learning algorithms
      i. Support Vector Machines: Classical and Quantum
   c. Unsupervised machine learning algorithms
      i. Principal component analysis: Classical and Quantum

3. **PART 3: Hybrid Classical-Quantum Machine Learning Algorithms** (2 weeks)

a. Quantum Approximate Optimization Algorithm
    i. MAX-Cut problem
b. Variational Quantum Eigensolver Algorithm
    i. H_2 molecule

TEXTBOOK

None required. Article handouts provided and lecture slides will supplement course lectures.

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RESOURCES

Qiskit tutorials for quantum machine learning: https://qiskit.org/learn/course/machine-learning-course/

Sci-Kit user guides for classical machine learning: https://scikit-learn.org/stable/user_guide.html

GRADE DISTRIBUTION

Assignments: 30%
Term Presentation: 20%
Final: 50%

COURSE WEBSITE

The course homepage is on LEARN, where the course syllabus, lecture notes, and assignments are uploaded. Any important updates will be announced as well.

(Tentative) **GRADE DISTRIBUTION**

- 3 **Assignments:** 30%

  Late Policy

  $S(t) = S(0)*(10-t)*0.1$ if $t < t_s$ or $S(t) = 0$ if $t > t_s$,
  where $t = 0$ is the due date, t is the turn-in date, and t_s is the feedback posting date.

  An exception to this policy can be made in special circumstances by contacting the instructor in advance.
  Note that any evidence violating the Honor code (e.g. plagiarism, copying and etc.) will yield $S(t) = 0$ regardless of t.

- **Mid-term Presentation**: 20%
    - **Mid-term Presentation 10/31/2022** 10%
    - **Mid-term Report (Due: 10/31/2022)**: 10%

- **Final: 50%**
    - **Final Oral Presentation 12/06/2022:** 25%
    - **Final Term Paper (Due: 12/13/2022):** 25%

UW POLICY 71-STUDENT DISCIPLINE

https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-71

We honor this policy throughout the course.