CMSC 591
Quantum- and Quantum-inspired Machine Learning
Syllabus

Catalog listing:	CMSC 591, section C51 (CRN: 44551)
Course Level:	Graduate
Prerequisites:	Graduate standing or permission of instructor
Instructor:	Tomasz Arodz
Office:	E4252
Phone:	804 827 3989
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Classroom:	online (zoom)
Class website:	Canvas
Office Hours:	MW 3:15pm-4:15pm (online)

1.0 – Overview (Catalog Course Description, pending approval):

Semester course; 3 lecture hours. 3 credits. Prerequisites: graduate standing or permission of instructor. Introduction to quantum information processing: qubit, quantum gates, quantum measurement, quantum speedup. Introduction to machine learning algorithms: models, loss, optimization. Quantum procedures for machine learning: data input and output, algebra, search, gradient descent. Quantum optimization for convex models, quantum variational neural networks. Quantum-inspired algorithms: dequantization, compact representations, tensor networks.

2.0 – Course Structure:

Lecture hours/week –	3
Lab hours/week –	0

3.0 – Course Goals

Upon successful completion of this course, the student will be able to:
• understand the differences between classical and quantum computing, and the benefits and limitations of quantum computing,
• understand the mathematical foundations of quantum computing, and the notation used in describing quantum algorithms,
• understand how quantum algorithms for training machine learning models work,
• understand how quantum approaches can inspire classical machine learning.

4.0 – Major Topics Covered:

- Classical versus quantum computation: benefits and limitations of quantum computing
- Introduction to machine learning: models, loss function, optimization. Overview of how quantum algorithms can improve machine learning.
- Linear algebra for quantum computing: complex numbers, Hilbert space, tensor product space, unitary and self-adjoint operators; Dirac notation
- Qubit, quantum gates and circuits, quantum oracles
- Quantum measurement, quantum parallelism and its limitations
- Basic quantum algorithms for machine learning: Grover's search algorithm, HHL algorithm, quantum gradient descent
- Quantum machine learning: convex models, neural networks
- Quantum-inspired machine learning algorithms: dequantization, compact representations, tensor networks

5.0 – Textbook(s):

Introductory chapters from Ian Goodfellow, Yoshua Bengio, and Aaron Courville. *"Deep Learning"*. Introductory chapters from Isaac Chuang and Michael Nielsen. *"Quantum Computation and Quantum Information"*. Review and research articles.

6.0 – Class schedule:

- Lecture: M/W 2:00 pm - 3:15 pm (online)
- Lab: None

7.0 – Evaluation:

Category	**% weight of final grade**
Homework coding assignments (python)	75
Test	25

Late submissions: 10% penalty per day, up to 5 days.

Final grade:
A [90% - 100%],
B [80% - 90%),
C [70% - 80%),
D [60% - 70%),
F [0% - 60%)

Students should visit http://go.vcu.edu/syllabus and review all syllabus statement information. The full university syllabus statement includes information on safety, registration, the VCU Honor Code, student conduct, withdrawal and more.