Northrop Grumman, Quantum AI at the Edge

Prepared by the CU Boulder Northrop Grumman Capstone Team

Team

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- Kirby Linvill - Project Mentor & TA
- Dave Motta - Project Sponsor
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Executive Summary

- Northrop Grumman uses science, technology, and engineering to create and deliver advanced systems, products, and services. The company's problem spaces include full spectrum cyber solutions across land, air, sea, and space.
- Northrop Grumman solves problems in space, aeronautics, defense, and cyberspace to meet the evolving needs of their customers worldwide. Their capabilities include preventing cyber-attacks, securing military communications, as well as providing customers unique and custom solutions.

Opportunities

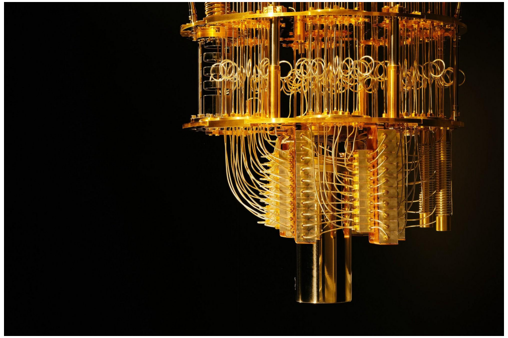
- The capstone is fully research and development orientated. Our project explores the intersection of quantum computing and machine learning deployed to embedded platforms.
    - Current AI solutions require performance improvements in training, and these solutions are being deployed to new domains.
    - Simple classifiers are starting to show promise on quantum processors, and these classifiers are deployable on edge processors for inference.
    - The intersection between machine learning and quantum computing has attracted considerable attention in recent years. This has led to several recently proposed quantum algorithms.

Objective

- Apply quantum AI to train a simple classifier network and then use that network for inference on an emulated embedded platform.
- If the quantum piece does not show improvement over traditional techniques, then traditionally trained modes will be used for inference on the emulator.

Qiskit

XILINX VITIS™



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High Level Requirements

- SVM and MLP classifiers will be trained using OpenCV and/or TensorFlow to establish baselines
- IBM Qiskit and Google Cirq will be used to implement SVM and MLP and compared with the baselines in terms of accuracy
- Models should be run first in simulation and then on IBM and Google quantum processors
- The Quantum classifiers should then be used for inference on a XILINX Vitis emulator to demonstrate similar performance to what we see in training. If the quantum piece fails to show improvement, then traditionally trained models will be used for inference on the emulator

Project Scope

In Scope

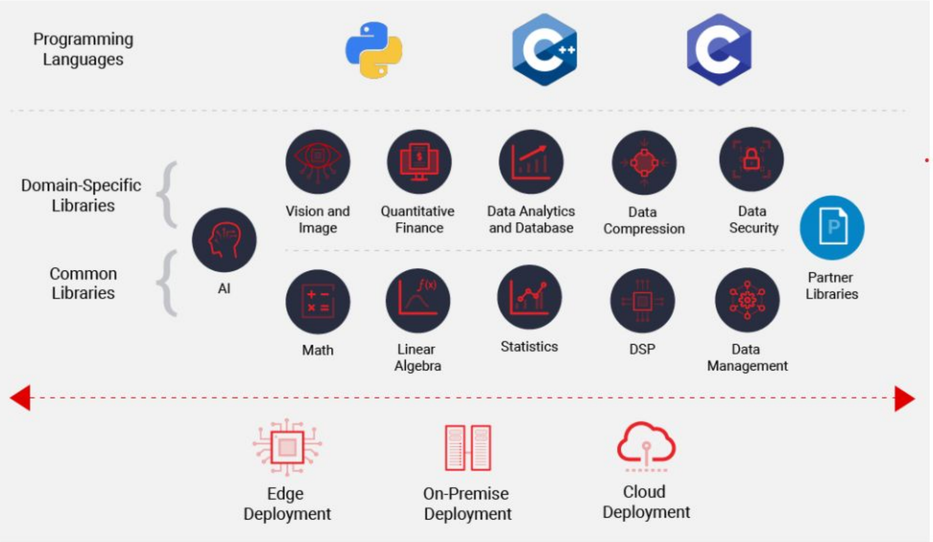
- Translating quantum algorithms to utilize qubits in the Qiskit quantum simulator
- Understanding constraints of embedded and edge computing platforms
- Using traditionally trained models to be used for inference on the emulator

Out of Scope

- Modifications to existing algorithms or creations of new algorithms
- Fundamental research on new quantum algorithmic techniques
- Building novel quantum AI, embedded, and edge computing toolkits

Project Approach

- Establish familiarity with existing quantum technology through research, documentation, and tutorials.
- Test working code on the respective IBM and Google SDK’s and libraries.
- Develop working models for the embedded and edge platforms
- Analyze performance differences between the base technologies, quantum baseline, and embedded and edge platforms.



Assumptions, Risks, and Changes

- There is no guarantee that the quantum component of the project will work
    - Baseline classifiers will be used if that becomes the case
- Any changes to the project scope and requirements will be reviewed by the project sponsor and team.
- All changes to scope and requirement will be documented in the Project Log, along with all issues that arise that put the success of the project at risk.

Project Plan

- Key Deliverables:
  - Project Charter, Project Plan, Requirements Document
  - Solution Design, Solution Construction and Testing
  - Primary deliverables: Baseline SVM and MLP models, Quantum SVM models, emulated embedded models, and an analysis of their performance

Timeline

- Project Charter - October 3, 2021
- Requirements - October 15, 2021
- Project Plan - December 5, 2021
- Project Presentation - December 5, 2021
- High Level Solution Design - January 24, 2022
- Detailed Solution Design - February 25, 2022
- Solution Implementation - March 17, 2022
- Solution Testing - April 13, 2022

Requirements

- Functional Requirements - models should have the ability to be:
  - Trained on a provided data set
  - Evaluated on a separate data set
  - Compared to other models via various metrics
- Non-functional Requirements:
  - Accuracy
  - Flexibility
  - Reliability/Replicability
  - Usability

Questions?

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