QuantA&M

Samuel Bieberich - QuantA&M Pres.

What is our mission?

The mission of QuantA&M is to connect students with the resources they need to learn more about the development, implementation, and application of quantum computing technology.

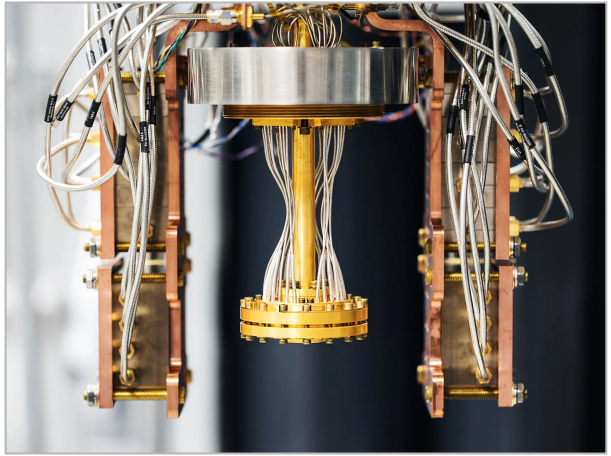
The organization also hopes to bring a new generation of inquisitive students to the forefront of quantum computing innovation as we enter a society which uses quantum computing as a mainstream method of solving complex problems.

Why?

At QuantA&M, we want every one of our members to use their experience in the student organization to increase their chances of success in applying for internships or other related experiences in the field of quantum computing.

Because quantum computing is a small, but growing field, there are limited opportunities at the moment, meaning only those with good resumes will be accepted to the most enviable positions.

This is why we encourage our members to take part in an individual or group project, sponsored by QuantA&M, which they may use on their resumes or for future reference with applications in the field.

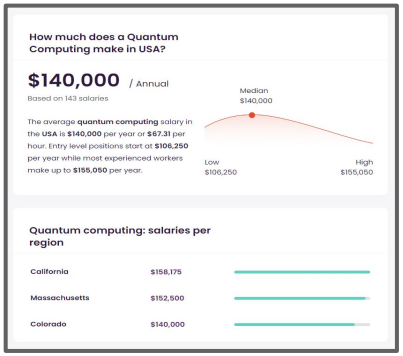


Who?

- Founded Dec. 2022 by David Tanase, Mac Morrison, and Sam Bieberich
- Supported by faculty advisor Dr. James Cai:
  - Associate Professor, Veterinary Medicine & Biomedical Sciences
  - Affiliated Faculty, Electrical & Computer Engineering
  - https://cailab-tamu.github.io/
- Inspired by the lack of infrastructure A&M boasts in the field of Quantum Computing compared to other Universities
  - tu Quantum Collective - 600 members
  - Q-Munity (HS) - 12,000 members

"Our research lies at the interface of human genetics, computational statistics, and data science. Current research focuses on understanding diverse behaviors of cells using machine learning, network theory, and quantum computation."

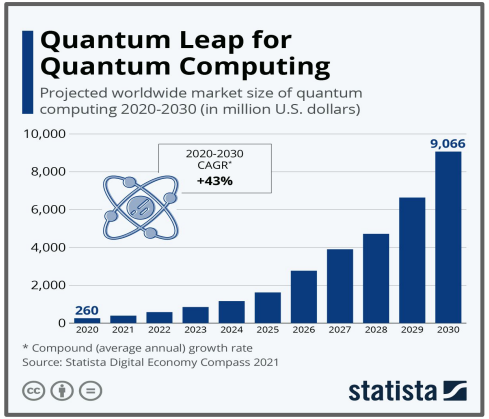
Why should I care?

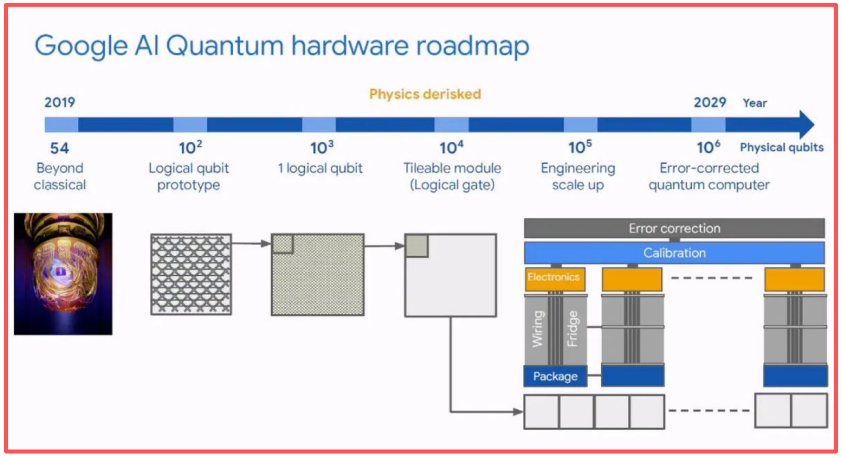


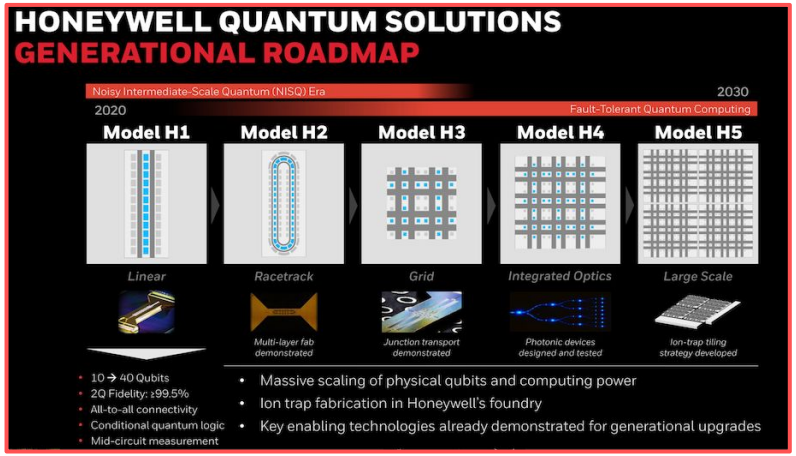
EMPLOYER	JOB TITLE	BASE SALARY	LOCATION	SUBMIT DATE	START DATE
IBM CORPORATION	QUANTUM COMPUTING APPLICATIONS RESEARCHER	250,000	SAN FRANCISCO, CA	02/26/2019	03/12/2019
JPMORGAN CHASE & CO	QUANTUM COMPUTING SCIENTIST	150,000	NEW YORK, NY	03/11/2019	09/10/2019
IBM CORPORATION	QUANTUM COMPUTING APPLICATIONS RESEARCHER	145,000	SAN JOSE, CA	03/26/2019	09/04/2019
RIGETTI & CO INC	QUANTUM ENGINEER	140,000	BERKELEY, CA	03/13/2019	09/09/2019
ALIBABA GROUP (US) INC	QUANTUM RESEARCH SCIENTIST	138,000	BELLEVUE, WA	03/11/2019	09/07/2019
IBM CORPORATION	QUANTUM SOLUTIONS DEVELOPER	125,445	YORKTOWN HEIGHTS, NY	03/20/2019	09/19/2019
PSIQUANTUM CORP	QUANTUM ARCHITECT	123,261	PALO ALTO, CA	03/12/2019	09/10/2019
PSIQUANTUM CORP	QUANTUM ARCHITECT	123,261	PALO ALTO, CA	03/12/2019	09/10/2019
RAYTHEON BBN TECHNOLOGIES CORP	QUANTUM COMPUTING THEORIST	121,555	CAMBRIDGE, MA	03/08/2019	08/08/2019
IBM CORPORATION	QUANTUM SOLUTIONS DEVELOPER	120,000	YORKTOWN HEIGHTS, NY	02/04/2019	08/06/2019

	MSc(grad)	POST DOC (2 years)	1-2 years (industry)	2-3 years (industry)	3-4 years (industry)	5+ years +
Quantum Algorithm Scientist	$90k +	$115k - $145k	$130k - $150k	$155k - $180k	$190k - $225k	$250k +
Quantum Hardware Engineer	$80k +	$95k - $125k	$115k - $130k	$125k - $160k	$160k - $180k	$200k +
Quantum Software Engineer	$90k +	$115k - $145k	$130k - $150k	$155k - $180k	$190k - $225k	$250k +
Optomechanical Engineer	$85k +	$110k - $125k	$125k - $140k	$145k - $155k	$160k - $180k	$200k +
Superconducting Circuit Designer	$90k +	$110k - $125k	$125k - $140k	$145k - $155k	$160k - $180k	$200k +
Business Development	$75k +	$90k - $110k	$105k - $115k	$120k - $135k	$140k - $155k	$175k +

For more information or to discusss career opportunities contact Connor@quantum-futures.com







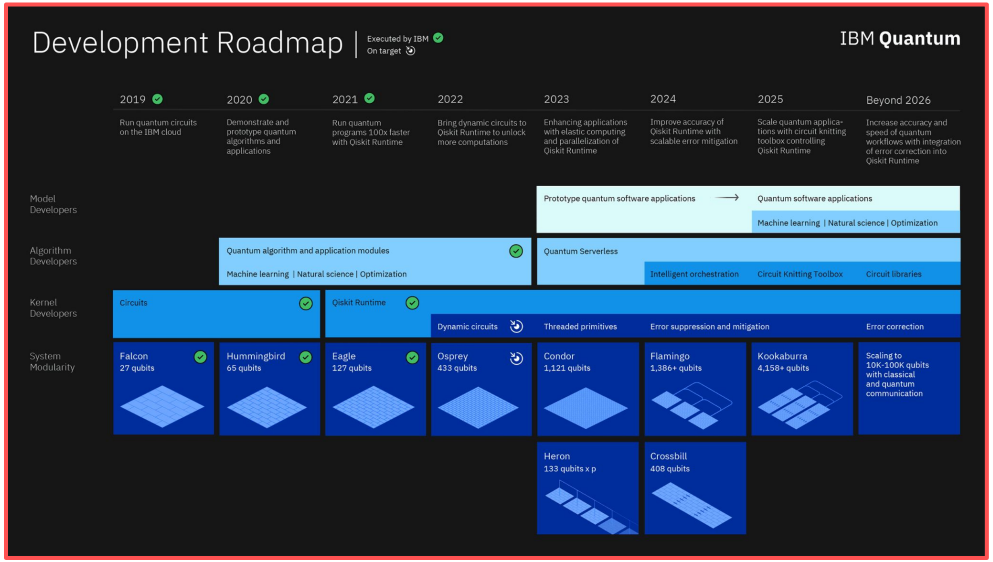
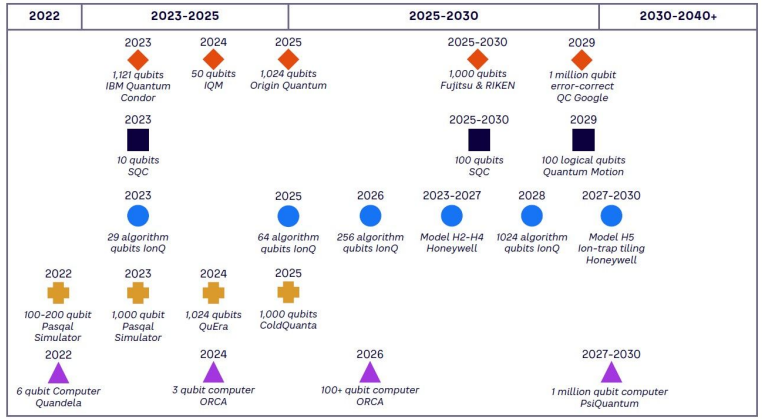
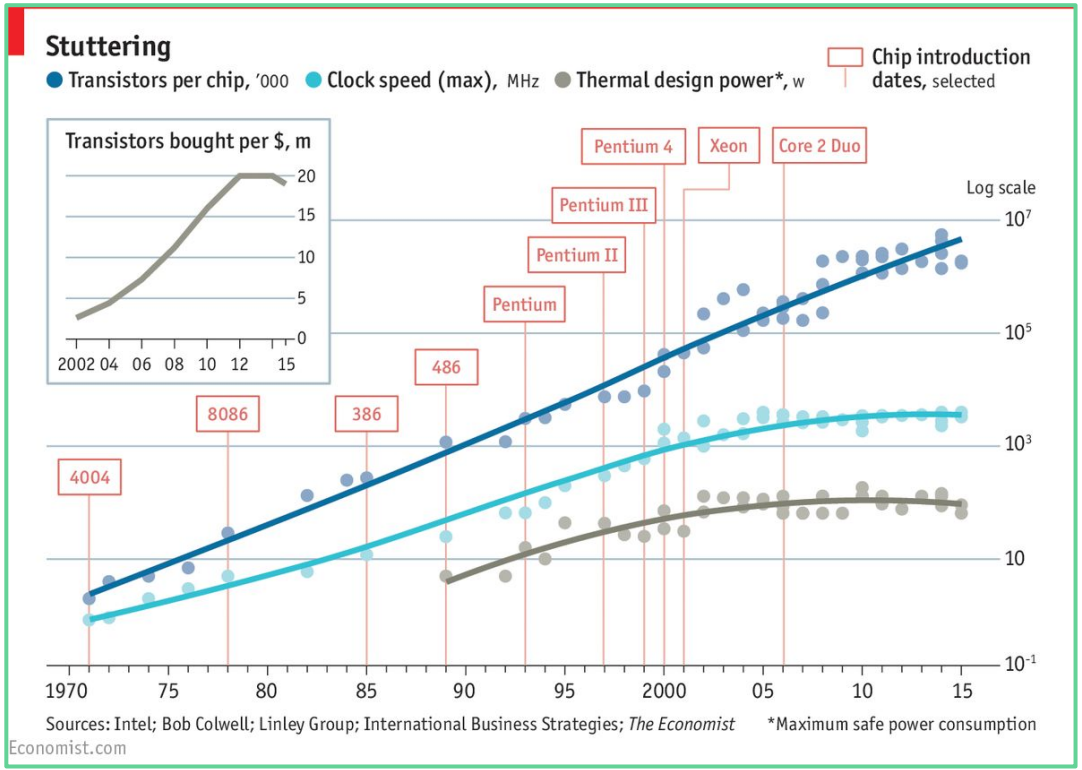


Figure 2. Quantum computing prototypes announced on vendor roadmaps



Source: Arthur D. Little, Olivier Ezratty

Moore's Law


Stuttering
Transistors per chip, '000
Clock speed (max), MHz
Thermal design power*, w
Chip introduction dates, selected
Transistors bought per $, m
20
15
10
5
0
2002 04 06 08 10 12 15
Pentium 4
Xeon
Core 2 Duo
Pentium III
Pentium II
Pentium
486
386
8086
4004
Log scale
10^7
10^5
10^3
10
10^{-1}
1970 75 80 85 90 95 2000 05 10 15
Sources: Intel; Bob Colwell; Linley Group; International Business Strategies; *The Economist*
*Maximum safe power consumption
Economist.com


THE END IS
NIGH

What do we do?

Three Pillars

This semester we will have three main opportunities:

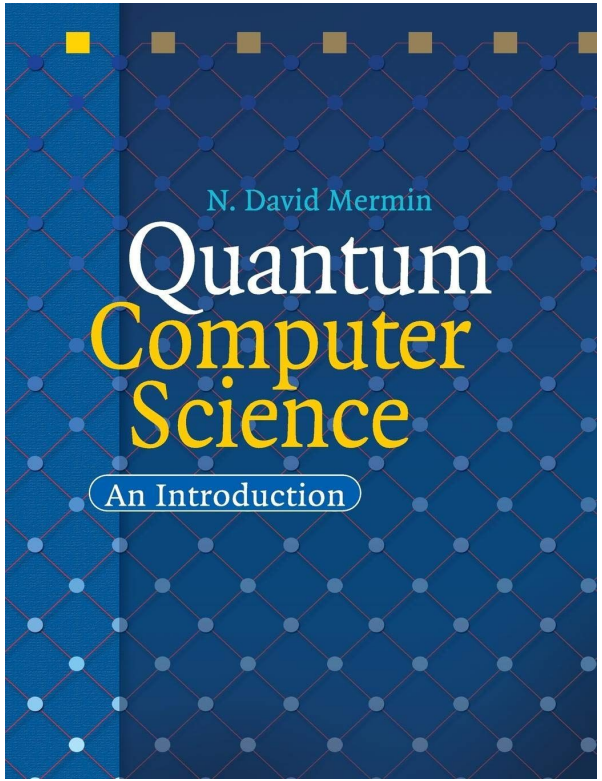
1. Quantum Book Club
2. Quantum Projects
3. Quantum Speaker Events

You can attend any or all of these if you want to! The book club meetings are bi-weekly, project meetings will likely be monthly, and speaker events monthly (variable)

Quantum Book Club

Last academic year we covered the Qiskit Textbook, an online book covering the IBM Qiskit framework and superconducting quantum computing.

This year, we will be going over Quantum Computer Science: An Introduction, by David Mermin. Arjun will be leading it, and it will be taking place on Thursdays from 7-8.



Quantum Projects

- While many organizations at Texas A&M may be **competitive** with projects, we hope to be **collaborative**
- This semester is admittedly a test-run, but we hope that projects can be started soon so that we may lobby to enter the greater undergraduate quantum network
- It isn't easy to start a project, but it can make a huge difference in job applications. Nobody has to work alone, and for now there are no due dates or real responsibilities, but we hope that students will take this as an opportunity to learn more about quantum computing in a helpful, like-minded environment

The vision

- Spend the first semester this year meeting monthly to determine projects and options for deliverables
- Spend the second semester performing testing and determining a medium with which to present results
  - Undergraduate research journal?
  - Website posting?
  - ArXiv?

Project 1: Quantum Specifications

IBM Quantum Infrastructure and Data

Name	Qubits	QV	CLOPS	Status	Total pending jobs	Processor type	Plan	Features
ibmq_toronto	27	32	1.8K	Online	826	Falcon r4	premium	
ibmq_quito	5	16	2.5K	Online	37	Falcon r4T	open	
ibmq_mumbai	27	128	1.8K	Online	457	Falcon r5.10	premium	OpenQASM 3
ibmq_montreal	27	128	2K	Online	28	Falcon r4	premium	
ibmq_manila	5	32	2.8K	Online	61	Falcon r5.11L	open	OpenQASM 3
ibmq_lima	5	8	2.7K	Online	33	Falcon r4T	open	
ibmq_kolkata	27	128	2K	Online	689	Falcon r5.11	premium	OpenQASM 3
ibmq_jakarta	7	16	2.4K	Online	461	Falcon r5.11H	premium	OpenQASM 3
ibmq_guadalupe	16	32	2.4K	Online	94	Falcon r4P	premium	
ibmq_belem	5	16	2.5K	Online	32	Falcon r4T	open	

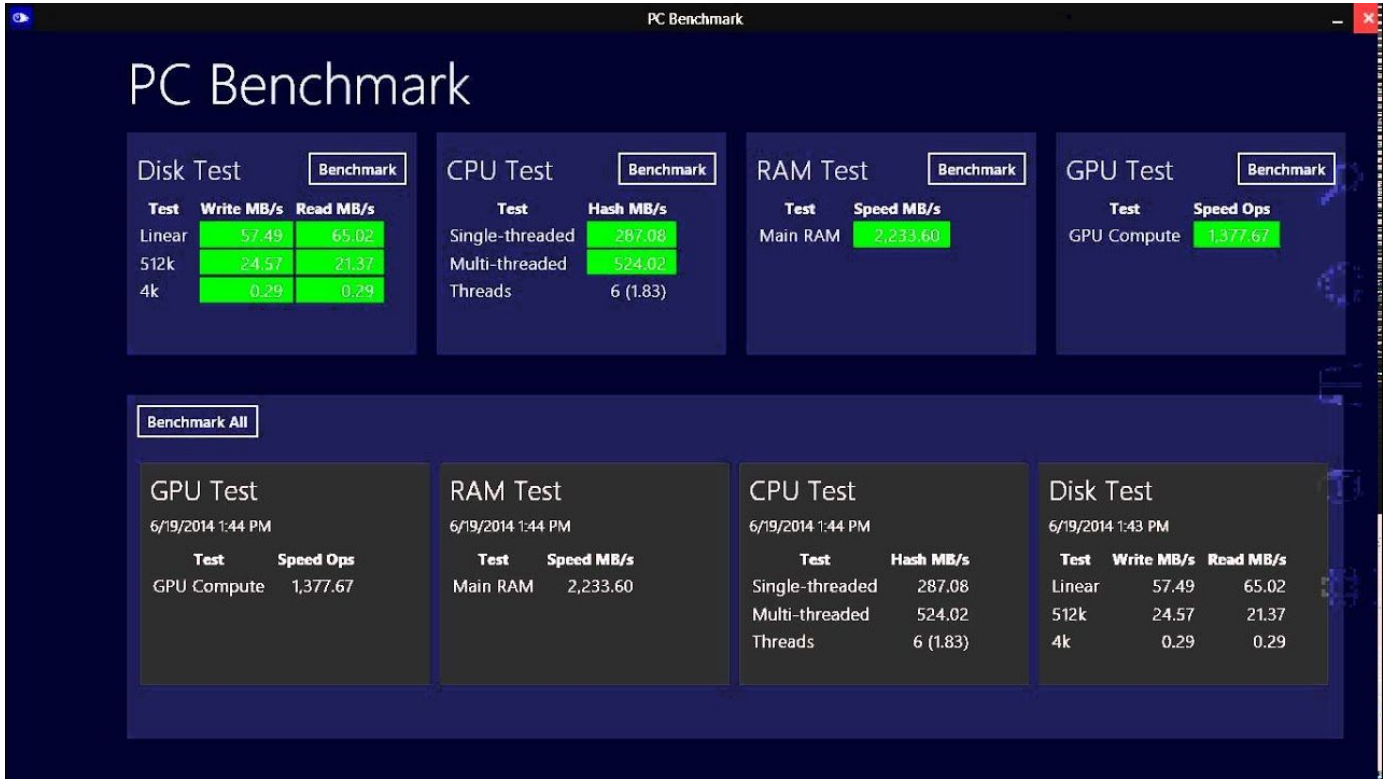
Items per page: 10 | 1-10 of 24 items | 1 of 3 pages

Project 1

IBM has a lot of different computers, and because they are the most transparent about the specs of their devices, it would be easiest to run tests on their computers or design guides that help understand the various hardware and software components of the computer.

There are a lot of different ways to measure how good a QC is, like a classical computer.

Project 1


PC Benchmark
PC Benchmark
Disk Test
Benchmark
Test Write MB/s Read MB/s
Linear 57.49 65.02
512k 24.57 21.37
4k 0.29 0.29
CPU Test
Benchmark
Test Hash MB/s
Single-threaded 287.08
Multi-threaded 524.02
Threads 6 (1.83)
RAM Test
Benchmark
Test Speed MB/s
Main RAM 2,233.60
GPU Test
Benchmark
Test Speed Ops
GPU Compute 1,377.67
Benchmark All
GPU Test
6/19/2014 1:44 PM
Test Speed Ops
GPU Compute 1,377.67
RAM Test
6/19/2014 1:44 PM
Test Speed MB/s
Main RAM 2,233.60
CPU Test
6/19/2014 1:44 PM
Test Hash MB/s
Single-threaded 287.08
Multi-threaded 524.02
Threads 6 (1.83)
Disk Test
6/19/2014 1:43 PM
Test Write MB/s Read MB/s
Linear 57.49 65.02
512k 24.57 21.37
4k 0.29 0.29

Name	Description	IC×10⁹	CPI	Tc (ns)	Exec time	Ref time	SPECratio
perl	Interpreted string processing	2,118	0.75	0.40	637	9,777	15.3
bzip2	Block-sorting compression	2,389	0.85	0.40	817	9,650	11.8
gcc	GNU C Compiler	1,050	1.72	0.47	24	8,050	11.1
mcf	Combinatorial optimization	336	10.00	0.40	1,345	9,120	6.8
go	Go game (AI)	1,658	1.09	0.40	721	10,490	14.6
hmmer	Search gene sequence	2,783	0.80	0.40	890	9,330	10.5
sjeng	Chess game (AI)	2,176	0.96	0.48	37	12,100	14.5
libquantum	Quantum computer simulation	1,623	1.61	0.40	1,047	20,720	19.8
h264avc	Video compression	3,102	0.80	0.40	993	22,130	22.3
omnetpp	Discrete event simulation	587	2.94	0.40	690	6,250	9.1
astar	Games/path finding	1,082	1.79	0.40	773	7,020	9.1

Benchmarking

IBM has been the main leader in QC for many years, and in terms of software it still is with Python libraries like Qiskit.

However, Honeywell (Air conditioners, barcode scanners, and aerospace ‘cuz why not) split a few years ago and a company Quantinuum was born. Quantinuum uses a different kind of qubit in their computers which is much more coherent (lasts longer before failure) than IBM’s. Thus, even though Quantinuum has less qubits, it has much stronger computers:

Architecture Differences

Theoretical example numbers:

Quantinuum: factor of 10 qubits

IBM: factor of 100 qubits

Quantinuum: factor of 1 sec coherence

IBM: factor of 10^-4 sec coherence

Calculation for the efficiency of a QC when performing alg. :

Qubits * coherence

IBM = 100 * 0.00001 = 0.001

Quantinuum = 10 * 1 = 10

This has resulted in Quantinuum taking some of IBM's market share!

QV

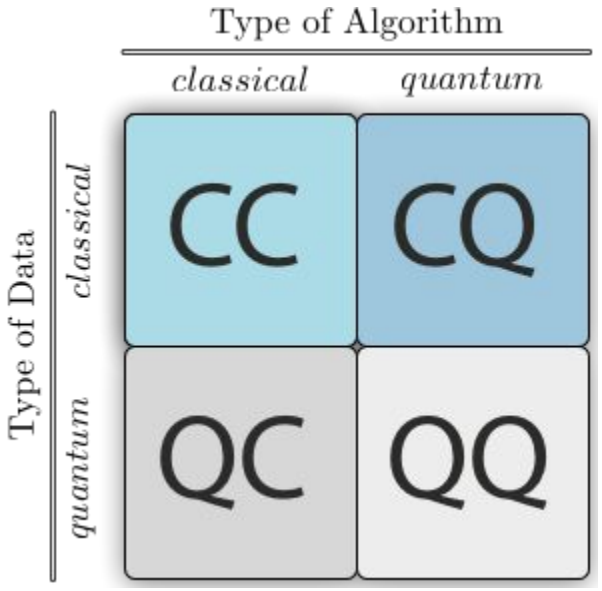
Quantum Volume is one of the benchmark tests to see how good a quantum computer is (like how many instances of Doom it can run, but for non-juveniles)

Date	Quantum volume[a]	Manufacturer	Notes
2020, January	2^5 = 32	IBM	"Raleigh" (28 qubits)[13]
2020, June	2^6 = 64	Honeywell	6 qubits[14]
2020, August	2^6 = 64	IBM	Falcon r4 "Montreal" (27 qubits)[15]
2020, November	2^7 = 128	Honeywell	"System Model H1" (10 qubits)[16]
2020, December	2^7 = 128	IBM	Falcon r4 "Montreal" (27 qubits)[17]
2021, March	2^9 = 512	Honeywell	"System Model H1" (10 qubits)[18]
2021, July	2^{10} = 1024	Honeywell	"Honeywell System H1" (10 qubits) [19]
2021, December	2^{11} = 2048	Quantinuum (previously Honeywell)	"Quantinuum System Model H1-2" (12 qubits) [20]
2022, April	2^8 = 256	IBM	Falcon r10 "Prague" (27 qubits) [21]
2022, April	2^{12} = 4096	Quantinuum (previously Honeywell)	"Quantinuum System Model H1-2" (12 qubits) [22]
2022, May	2^9 = 512	IBM	Falcon r10 "Prague" (27 qubits) [23]
2022, September	2^{13} = 8192	Quantinuum (previously Honeywell)	"Quantinuum System Model H1-1" (20 qubits)[24]
2023, February	2^7 = 128	Alpine Quantum Technologies	"Compact Ion-Trap Quantum Computing Demonstrator" (24 qubits) [25]
2023, February	2^{15} = 32,768	Quantinuum (previously Honeywell)	"Quantinuum System Model H1-1" (20 qubits) [26]
2023, May	2^{16} = 65,536	Quantinuum (previously Honeywell)	"Quantinuum System Model H2" (32 qubits) [1]

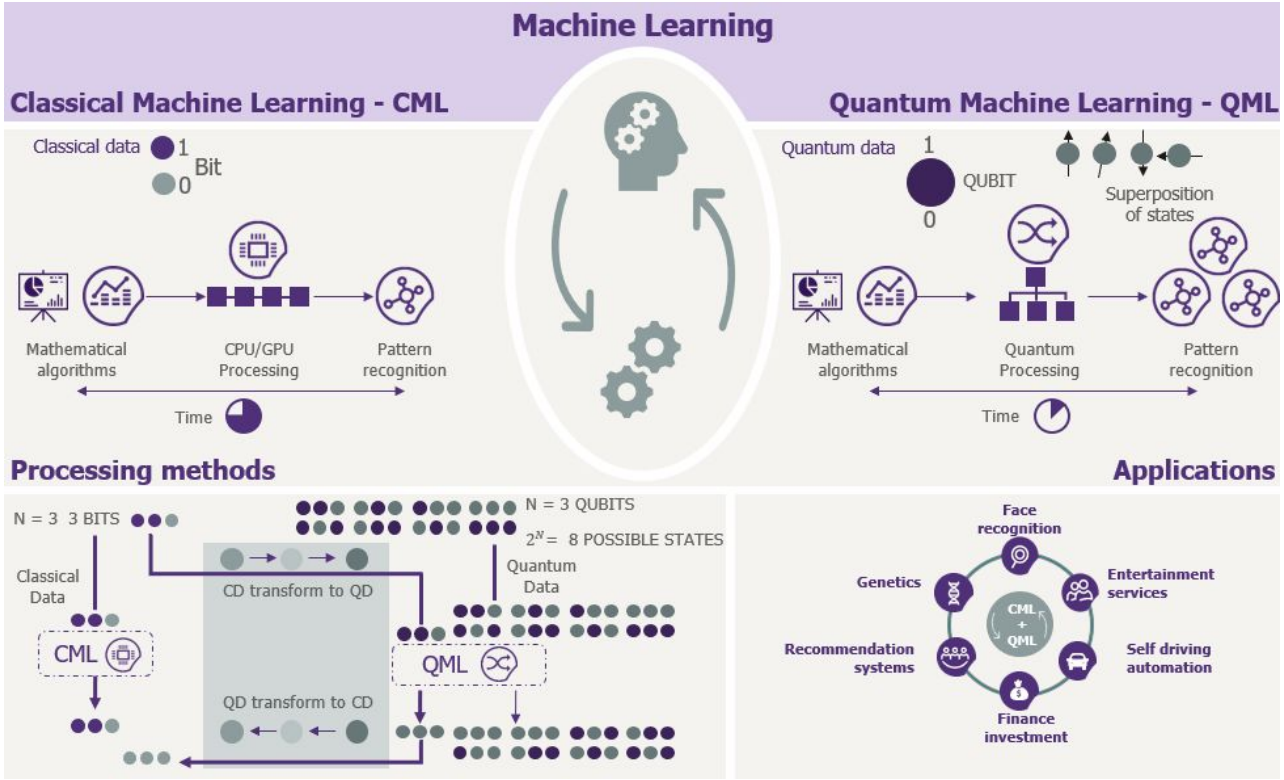
Project 2: Quantum Machine Learning

Project 2

Quantum Computers can help optimize the process of machine learning

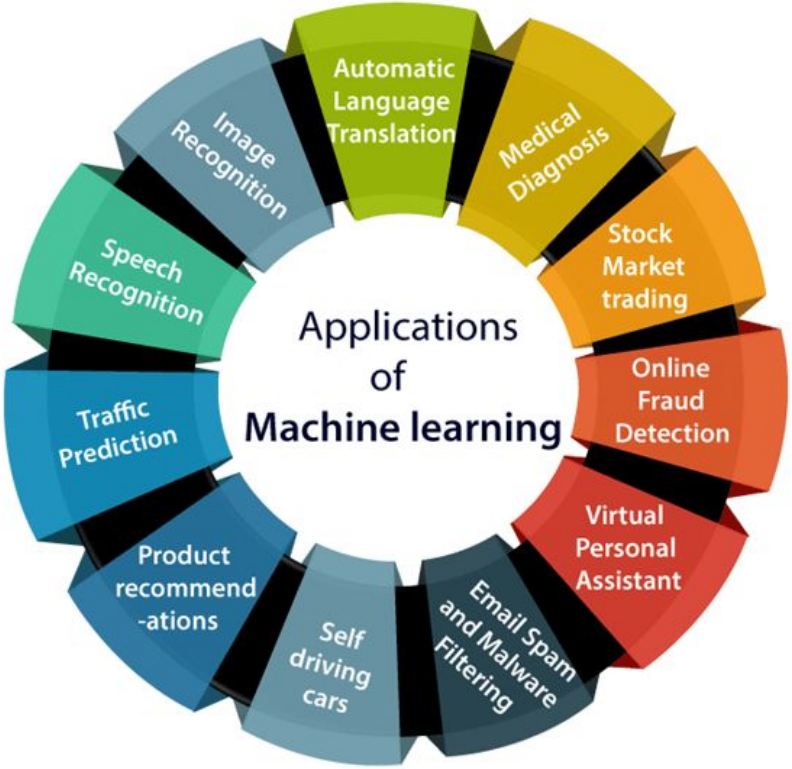


Project 2


Machine Learning
Classical Machine Learning - CML
Classical data
1
0
Bit
Mathematical algorithms
CPU/GPU Processing
Pattern recognition
Time
Quantum Machine Learning - QML
Quantum data
1
0
QUBIT
Superposition of states
Mathematical algorithms
Quantum Processing
Pattern recognition
Time
Processing methods
N = 3 3 BITS
Classical Data
CML
CD transform to QD
QD transform to CD
N = 3 QUBITS
2^N = 8 POSSIBLE STATES
Quantum Data
QML
Applications
Face recognition
Genetics
Entertainment services
CML + QML
Recommendation systems
Self driving automation
Finance investment

Project 2

This project may be best suited for math or physics majors who want to stray from the focus on hardware and see the relevance of modern quantum computers in ML. ML is used in many applications online that we often encounter, including the Google search engine and Chat GPT.



Project #: Make your own!

Project

If you have another idea for a project, contact either Sam, Akshat, or one of the graduate mentors to seek support!

That being said, if you want to solo your own project without any help/team, we would be happy to promote your project online and at SQUID conference when completed anyways!

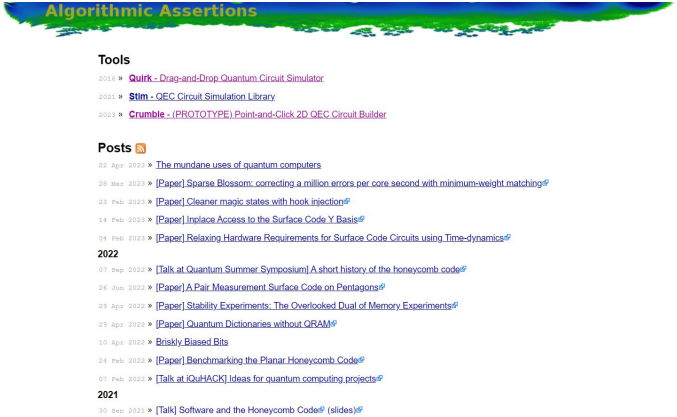
Presenting your Projects

Projects as an art

These projects are supposed to be very open-ended, so if you have ideas besides those on the next pages, feel free to try them out!

We want to make the process as streamlined as possible, so just check with your project mentor and they will help brainstorm ways you can present your work at the end of the academic year (Spring 2024).

Ideas



Blog

Ex: Craig Gidney's https://algassert.com/

Ex: Scott Aaronson's https://scottaaronson.blog/

GitHub

Medium

Hosted on **QuantA&M website** (GH pages)

- Very common in science & academia, could very well be the *easiest* choice as well

Ideas

Publishable research paper

Tushar's GPT paper - https://drive.google.com/file/d/1cK8XUmHm6yp_gYrGcezFZQ3bhs6mOpV1/view?usp=sharing

(Also in the Discord, pinned in #general)

Sam's internship paper - pending release

Hosted on QuantA&M website, Medium, Personal/Team website (GH, other), LinkedIn, SQUID

- Best opportunity to prepare for SQUID and bolster your resume

Ideas

Programming Project + write up

https://medium.com/qiskit/learn-quantum-computing-with-these-seven-projects-7478d90d125a

https://medium.com/@michal.stechly/solving-the-traveling-salesman-problem-using-quantum-computer-bb00438de223

https://medium.com/mit-6-s089-intro-to-quantum-computing/quantum-approximate-optimization-algorithms-on-the-traveling-salesman-problem-703b8aee6624

- Best for CS majors

Ideas

Quantum Grad / News

https://www.quantumgrad.com/contribute

https://quantumzeitgeist.com/author/quantum-evangelist/

Third-party sites

- QuantumGrad
- QuantumZeitgeist
- Qmunity

- Also a very reputable source, looks good on resume. Less focused on research than others, more room for blogging voice

Ideas

Other

1. YouTube channel/videos
2. Social Media news postings
3. Online guide for high school students (or younger)
4. Pamphlet promoting the project for professors
5. Etc.

Shoutout to the people who shared these ideas!

Ok now what

Who’s the point of contact

Project 1 (Quantum specs): Sam Bieberich

Project 2 (QML): Wei-Chih Huang or Sam

Other project ideas: Sam or Arjun on Discord

Book Club: Arjun

Speaker Events: Sam

Starting point

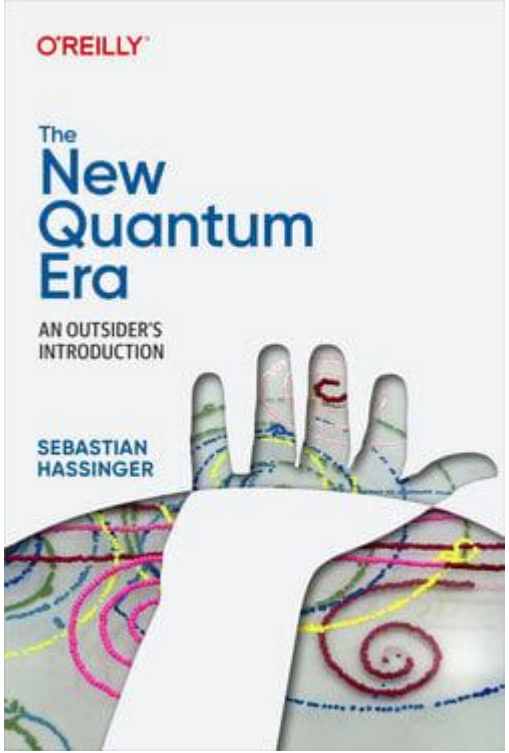
https://github.com/desireevl/awesome-quantum-computing

This resource, shared by Wei-Chih (one of our graduate mentors) is a very comprehensive list of quantum computing resources. If you want to get access to the link, it is pinned in #quantum-projects

Another random opportunity

The author of a book about the history of quantum computing reached out to me and is interested in speaking to QuantA&M!

This book is accessible on the TAMU library website via O'Reilly, and I highly recommend it, as he will be taking a Q&A (event probably in mid-October).



Thanks for giving us a shot!

- Discord
  - Main source of information for now

    (website being fixed)
- Newsletter
  - Publishing announcements and dates of events
  - Posted weekly in the Discord, and sent via email

Upcoming Event:

- Sep. 19 First Book Club meeting (7-8 pm approx.), location pending
  - How to access the book and starting from the bottom