QSTH
Quantum Science and Technology
Hackathon

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Prototype Submission

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TEAM NAME and MEMBER DETAILS

AXIS (ID 1567872)

Elena Suraeva, PhD: Team Captain, Quantum Computing Scientist and Mathematician
Olga Okrut: Quantum Computing Researcher and Engineer

THEME: *Compute the mean electrical axis of the heart on IBM quantum hardware. Make the heart axis prediction using the DWave Quantum Annealers.*

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PROBLEM STATEMENT

AXIS Team has developed a mathematical formulation on mapping a human heart to a quantum qubit. The Team uses this model to calculate the heart axis (QRS Axis) on a IBM quantum hardware simulator. The Team also trained an adiabatic linear regression on the heart data that has strong linear pattern such as QRS Axis, QRS duration, and QTc depending on an age.

SOLUTION

- How it helps to solve the problem?

  Representing heart axis as a state vector we convert an information from classical to quantum type. Then prepared data is sent to QML algorithm to create an age-associated model. As a result it is possible to find deviations not related to age.

- What are the impact metrics that one can use to analyze the effect of the solution?

  Comparison to the classical models used in health care. Standard metric used in classical ML.

- Frameworks/Technologies stacks to be used.

  We used IBM quantum simulator and IBM Qiskit SDK. We test our idea on DWave Quantum Annealer and Quantum Annealing Simulators for QML part for which we will use DWave Ocean SDK.

SOLUTION

- Assumptions, constraints, and solution decision points (Reason behind choosing a technology).

  While the gate-based quantum computers are believed to be universal and suitable for a wide range of computational challenges, the current hardware limitations do not allow them to execute large problems. In comparison, Quantum Annealers have more mature hardware allowing them to optimize the cost function of QML models more efficiently.

- How easily can your solution be implemented and how effective will it be?

  Since the quantum technology is in its infant stage, each new problem to solve is a challenge in terms of mapping a problem to quantum circuit and mitigating noise. In health-related problems, one has to pay extreme attention to a wide range of details because one deals with life-dependent data. For the QML part we expect to use less data training reaching the same level of accuracy as in classical ML.

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SOLUTION

- Extent of Scalability/Usability.

  The product can be used among many patients to measure their mean electrical axis of the heart and help doctors in assessing heart diseases. The access to the service will be provided through a user friendly web-based application to make the application easily accessible. On the backend part, all calculations can be submitted to quantum hardware over cloud services.

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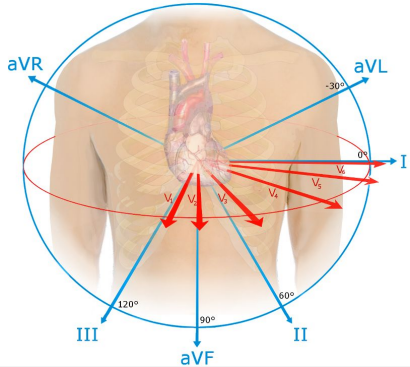
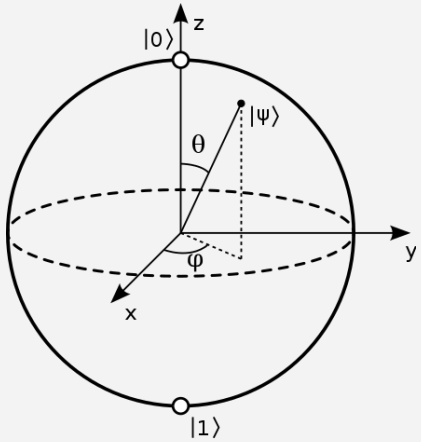
METHODOLOGY

Our approach is to map a human heart to the Qubit (Bloch Sphere) and use transformations to compute the mean electrical axis. We train on the publicly available datasets a QML model to make heart disease predictions.



Spatial orientation of ECG leads @Wikipedia



Bloch sphere @Wikipedia

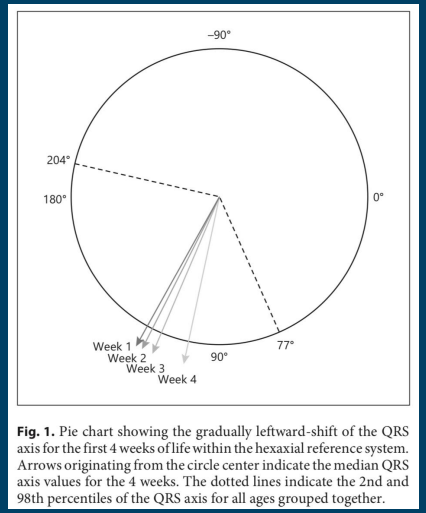
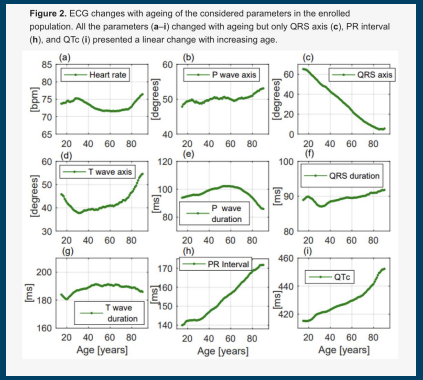


Fig. 1. Pie chart showing the gradually leftward-shift of the QRS axis for the first 4 weeks of life within the hexaxial reference system. Arrows originating from the circle center indicate the median QRS axis values for the 4 weeks. The dotted lines indicate the 2nd and 98th percentiles of the QRS axis for all ages grouped together.

https://doi.org/10.1159/000513526



https://doi.org/10.3390/jcm11133737

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WORKING PROTOTYPE

- *The code implementation is available in the GitHub repo:*

  https://github.com/elenasuraeva/HeartAxis

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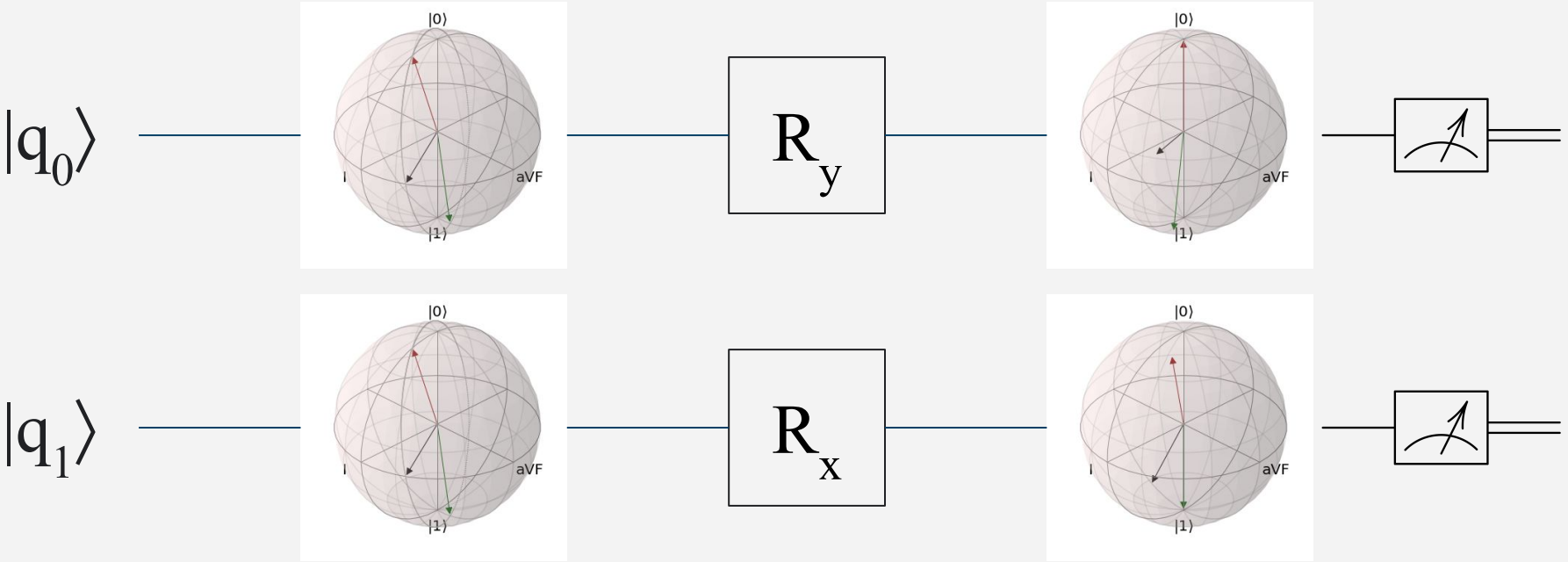
ATTACHMENTS



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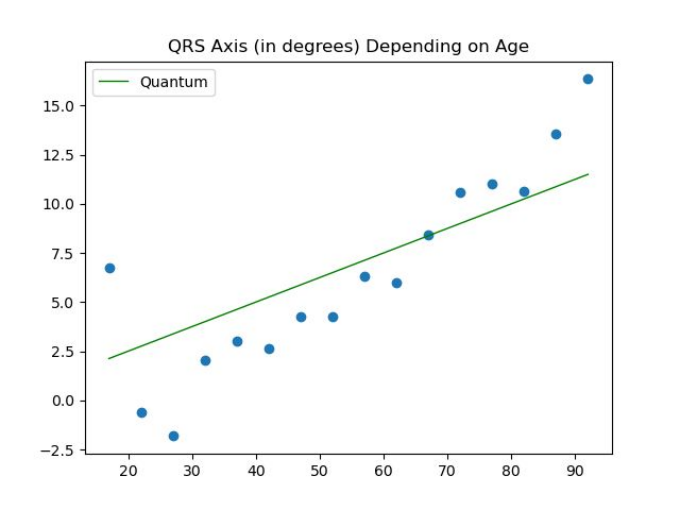
ATTACHMENTS

Adiabatic Linear Regression



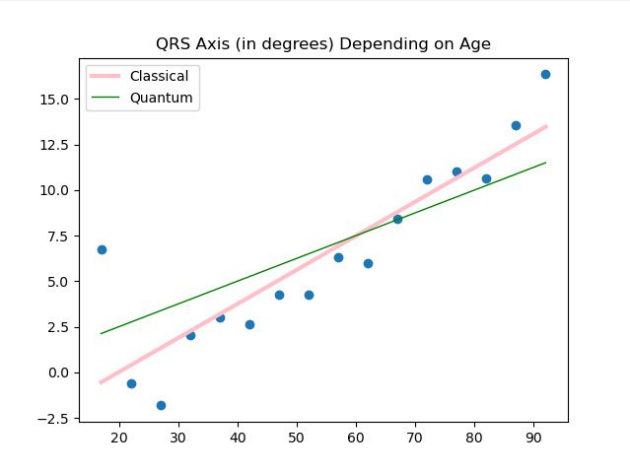
MAE: 29.3.

MSE: 10277.6

RMSE: 101.4

R^2: 0.045

Comparison with Scikit Learn linear Regression



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THANK YOU

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