KING KHALID UNIVERSITY
COLLEGE OF COMPUTER SCIENCE

CLOUD-BASED QUANTUM COMPUTING TOOL FOR ADVANCED ANALYSIS OF BLOOD SAMPLE USING QUANTUM MACHINE LEARNING

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ABSTRACT

This project proposes the development of a cloud-based quantum computing tool focused on blood sample analysis, specifically DNA classification, drug detection, and allergies identification. By integrating quantum machine learning techniques, the project aims to enhance diagnostic accuracy in the medical field.

The tool will use a hybrid approach, combining classical machine learning algorithms with quantum algorithms, to take advantage of quantum computing's inherent strengths. It will be built on a secure and scalable cloud infrastructure, ensuring efficient processing of large datasets and providing seamless access for healthcare professionals and researchers.

The first objective is to create quantum algorithms capable of accurately classifying DNA sequences. This will assist in identifying specific DNA sequences associated with genetic disorders or disease susceptibility.

The second objective is to develop quantum algorithms for substance detection in blood samples. The tool aims to predict the presence of specific substances, enhancing the accuracy and sensitivity of drug detection, which is crucial in forensic analysis and substance abuse treatment.

The third objective involves using quantum machine learning to identify allergies by analyzing blood samples. This will improve the accuracy and efficiency of allergy diagnosis.

The project will utilize quantum programming languages and frameworks and leverage scalable quantum computing resources to ensure efficient execution of the algorithms.

Performance evaluation will involve extensive testing and validation with diverse datasets, including real blood samples. Comparative analysis with classical machine learning methods and existing diagnostic techniques will assess the tool's accuracy, efficiency, and practical potential.

In conclusion, this project aims to create a cloud-based quantum computing tool that integrates quantum machine learning for advanced blood sample analysis, revolutionizing personalized medicine by offering more precise and efficient diagnostic capabilities. It contributes to the ongoing efforts to leverage quantum computing for healthcare applications, potentially advancing medical diagnostics and treatment.

Acknowledgment

We extend our sincere gratitude to all those who have contributed to the completion of this project.

First and foremost, we would like to express our heartfelt appreciation to our supervisor, Mohammed AlShehri, for his unwavering guidance, support, and mentorship throughout the duration of this research endeavour. His expertise, encouragement, and constructive feedback have been invaluable in shaping the direction and quality of our work.

We are deeply thankful to the faculty members of the Department of Computer Science for their encouragement, assistance, and scholarly insights, which have enriched our understanding and facilitated the progress of this project.

We also wish to acknowledge the collaborative efforts and contributions of our fellow classmates and colleagues, whose constructive discussions and diverse perspectives have been instrumental in advancing our research.

We gratefully acknowledge the support and assistance provided by the staff members of King Khalid University, whose dedication ensured access to essential resources and facilities crucial for the successful completion of this project.

Lastly, we extend our heartfelt thanks to our families and friends for their unwavering encouragement, understanding, and support throughout this journey. Their love and encouragement have been a constant source of strength and motivation.

CHAPTER 1: INTRODUCTION

1.1. Problem Statement:

The overarching issue under investigation is the imperative for improved methodologies in the analysis of blood samples. Traditional methods for blood sample analysis possess inherent limitations, prompting the exploration of quantum computing and quantum machine learning as a means to enhance the precision and efficiency of this process.

1.2. Research Questions and Hypotheses:

- Research Question/Hypothesis 1: Is it possible to develop and deploy a cloud-based quantum computing tool capable of processing and analysing blood sample data with greater efficiency and accuracy than classical computing methods?

- Research Question/Hypothesis 2: Can the integration of quantum machine learning algorithms with the quantum computing tool significantly enhance the capacity to detect and categorise various health-related parameters within blood samples, including biomarkers and disease indicators?

- Research Question/Hypothesis 3: What is the scalability and practicality of a cloud-based quantum computing tool for blood sample analysis, and can it be effectively deployed within the healthcare sector.

1.3. Research Objectives and Experiments:

- Research Objective/Experiment 1: To develop and implement a cloud-based quantum computing tool tailored to the precise processing and analysis of blood sample data. This entails the establishment of quantum computing infrastructure, data integration, and the development of requisite algorithms.

- Research Objective/Experiment 2: To apply quantum machine learning algorithms within the quantum computing tool to scrutinise blood sample data, discern patterns, and identify correlations among various health-related parameters, including biomarkers and disease markers.

- Research Objective/Experiment 3: To assess the scalability and operational viability of the cloud-based quantum computing tool through rigorous performance evaluations and usability assessments in real-world healthcare or research environments.

1.4. Alignment of Objectives with Hypotheses:

- The achievement of Research Objective 1 is instrumental in addressing Hypothesis 1 by furnishing the essential tool for quantum-based blood sample analysis, thereby potentially offering swifter diagnoses and more precise medical decision-making.

- Research Objective 2 corresponds directly with Hypothesis 2 by demonstrating the effectiveness of quantum machine learning algorithms in augmenting the analytical capabilities of blood sample analysis, with the potential for more accurate disease detection and personalised healthcare.

The attainment of Research Objective 3 aligns with Hypothesis 3 by elucidating the tool's scalability and practical utility for adoption within healthcare settings, thereby potentially revolutionising the landscape of blood sample analysis and rendering it more accessible.

CHAPTER 2: REVIEW OF LITERATURE.

2.1. OVERVIEW

In this chapter, we illustrate the background information related work of this project, and we discuss already existing work and the specifications of each study.

2.2. background

- Machine Learning:

Machine learning (ML) is a subset of artificial intelligence that focuses on developing algorithms and models that enable computers to learn from data. One powerful aspect is classification, where algorithms can identify patterns and make predictions. For instance, k-nearest neighbours (KNN) and support vector machines (SVM) are examples of classification algorithms, each with its own strengths. Logistic regression and random forest, on the other hand, are used for binary classification and ensemble learning, respectively.

- Quantum Computing:

Quantum computing takes advantage of the principles of quantum mechanics to perform computations at speeds unimaginable with classical computers. Unlike classical bits, which can only be either 0 or 1, quantum bits or qubits can exist in multiple states simultaneously. This allows quantum computers to process vast amounts of information in parallel, potentially revolutionizing fields such as cryptography, optimization, and machine learning.

- Cloud Computing:

Cloud computing is a paradigm that involves delivering computing services, including storage, processing power, and applications, over the internet. It offers scalability, flexibility, and cost-effectiveness. Machine learning models, for instance, can leverage cloud computing resources to train on large datasets without the need for extensive local hardware. Cloud platforms like AWS, Azure, and Google Cloud provide a range of services, from infrastructure to specialized tools for machine learning.

- Blood Sample Analysis:

In the realm of healthcare, analyzing blood samples is a critical aspect of diagnosis and treatment. Machine learning algorithms can be applied to analyze complex patterns within blood samples, aiding in the identification of diseases or anomalies. This could range from classifying blood cell types to predicting the likelihood of certain medical conditions based on biomarkers.

Additionally, advancements in quantum computing could play a role in optimizing complex algorithms used in genomic analysis, allowing for quicker and more accurate assessments of blood samples.

Cloud computing is instrumental in handling the vast amounts of data generated by blood sample analysis. It provides the infrastructure for storing and processing this data securely, facilitating collaboration and accessibility for healthcare professionals.

2.3. Study [1]
Title: Cloud Computing
Authors: Nasser Taleb, elfadel A.Mohammad
Date of publication: January 2020

The study provides a comprehensive overview of cloud computing trends, benefits, challenges, and future prospects for organizations. It focuses on cloud computing, one of the fastest-growing technologies in the computer industry, exploring its advantages, challenges, and employing a mixed research approach, combining quantitative and qualitative information. The technology is described as offering secure data storage and processing power through the internet, with various .characteristics and service models

Cloud computing offers numerous advantages, including processing power, storage, flexibility, scalability, and cost reduction. Startup organizations have benefited by redirecting capital spending into operational expenses. Smaller firms and private individuals are adopting cloud computing, though larger organizations often have .sufficient in-house computing power

Cloud computing also presents challenges such as the need for reliable internet access and concerns about potential service interruptions. Security, privacy, and dependence on service providers are among the main concerns, though .stakeholders anticipate these issues will improve over time

The study highlights emerging trends in cloud computing, including the development of proprietary private cloud networks by large multinational firms, like Coca-Cola and IBM. These trends may lead to more companies outsourcing their IT departments, reducing the need for costly in-house infrastructure. Smaller firms and individuals are .expected to adopt cloud computing as it becomes more user-friendly

Quantum computing is identified as a significant trend in the cloud industry. It is seen as a potential disruptor that could transform the current state of cloud computing and .increase competition among service providers

The review concludes by emphasizing that cloud computing is crucial for businesses, enabling them to store and access data anytime. It predicts that companies will increasingly rely on cloud services for data storage and analytics. The future will likely see organizations becoming more interdependent and requiring reliable cloud computing environments. Internet service providers are expected to improve speed and reduce downtime to support the growing reliance on the cloud. Companies that .do not adapt to these trends may become less competitive

In summary, the study underscores the significance of cloud computing in modern .business and the evolving landscape of technology and services

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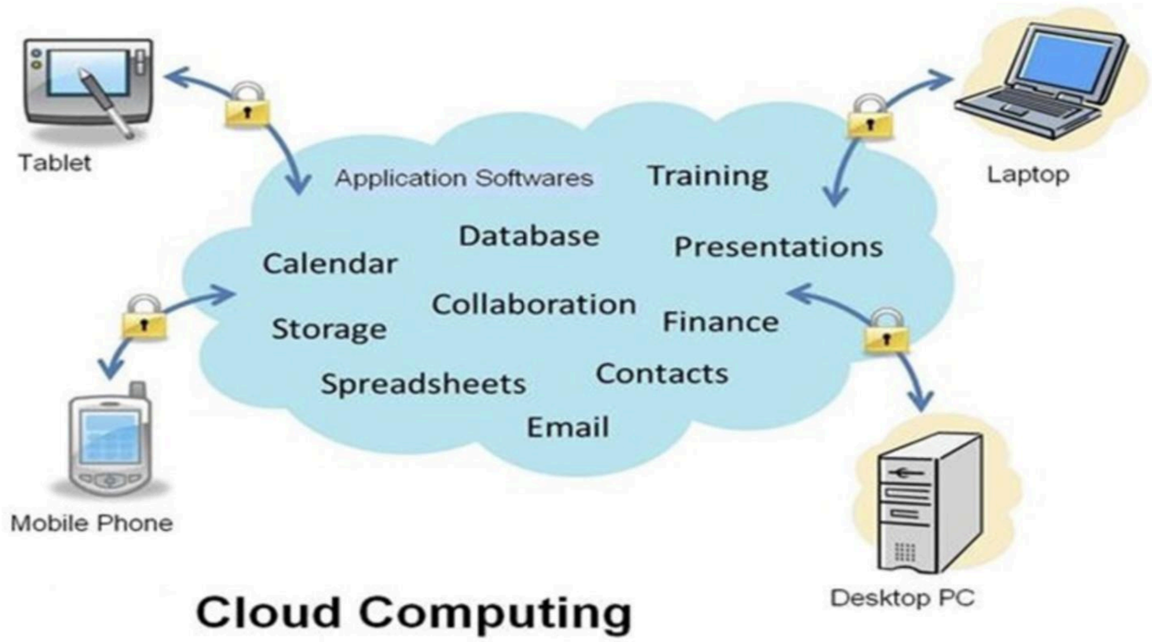


Figure 1: Cloud Computing Applications

2.4. Study [2]
Title: An introduction to quantum machine learning
Authors: Maria Schulda , Ilya Sinayskiya,b and Francesco Petruccionea,b
Date of publication:September 11, 2014

The text underscores the significance of machine learning in computer science, particularly its role in data interpretation, image recognition, and pattern identification. It highlights the growing importance of machine learning in the digital age, with examples like Google's PageRank algorithm. The challenges posed by the vast volume of global data are discussed, along with the potential for quantum computing to optimize classical machine learning algorithms.

Quantum computing is introduced as a solution, leveraging quantum bits (qubits) to process information in parallel. The text acknowledges the difficulties in developing quantum algorithms that surpass classical ones but notes progress in the field. It explores the concept of quantum machine learning, delving into various approaches such as quantum neural networks, quantum pattern recognition algorithms, and adiabatic quantum machine learning.

The paper's focus is to offer a systematic overview of quantum machine learning, primarily in the context of pattern classification methods. It outlines the paper's structure, which presents standard machine learning methods and their quantum counterparts, covering techniques like k-nearest neighbors, support vector machines, k-means clustering, neural networks, decision trees, Bayesian theory, and hidden Markov models.

The conclusion highlights the absence of a comprehensive theory of quantum learning and the need for further research. It emphasizes the potential of quantum machine learning to transform intelligent data processing but acknowledges that the field is still in its early stages of development. The text raises questions about representing classical data in quantum systems and efficiently implementing quantum learning procedures.

2.5. Study [3]

Title: Blood Diseases Detection using Classical Machine Learning Algorithms
Authors: Fahad Kamal Alsheref, Wael Hassan Gomaa
Date of Publication: 2019

The research focuses on the significance of accurate disease diagnosis using quality data and modern technological tools, specifically machine learning and artificial intelligence, to analyze blood parameters that change with age and indicate health status. Machine learning, which teaches computers to learn from data, relies on high-quality data, especially clinical data, for effective medical decision-making. The study introduces various machine learning classifiers, including Naive Bayes, Bayesian network, multilayer perceptron, Logit Boost, Random Forests, Support Vector Machine, K-Nearest Neighbor, Regression Analysis, and Decision Tree.

A new benchmark dataset is presented, comprising 668 patient records, each with 28 blood analysis parameters. This dataset encompasses four main classes representing different blood diseases: Thrombocytopenia, Leukocytosis, Anemia, and a Normal class where all parameters are within the normal range. The research aims to leverage machine learning techniques to accurately detect blood diseases based on this dataset, with an exploration of different classical machine learning algorithms to determine the most suitable algorithm for achieving high prediction accuracy.

2.6. Study [4]

Title: Machine Learning: Algorithms, Real-World Applications and Research Directions.
Author: Iqbal h.sarker
Date of publication: 22 march 2021

This article underscores the significance of machine learning and artificial intelligence (AI) in the context of the Fourth Industrial Revolution (4IR) and emphasizes the wealth of available data in various domains. It discusses how AI and machine learning play an essential role in analyzing data and developing intelligent, automated applications. The article covers different types of machine learning algorithms, such as supervised, unsupervised, semi-supervised, and reinforcement learning, as well as the application of deep learning for large-scale data analysis.

Furthermore, it highlights the practical application of machine learning in various real-world domains, including cybersecurity, smart cities, healthcare, e-commerce, and agriculture. The article also addresses the challenges and potential research directions in the field of machine learning. It notes the growing importance of machine learning in the 4IR and its effectiveness, which is dependent on both the nature of the data and the performance of learning algorithms.
The article classifies machine learning algorithms into different types, such as classification, regression, data clustering, and feature engineering, emphasizing the importance of understanding these principles and their applicability in various real-world applications. Ultimately, the article aims to serve as a reference for academia, industry professionals, and decision-makers across different industries to harness the power of data and enhance intelligent decision-making during the Fourth Industrial Revolution.

2.7 Study [5]

Title: The deep DNA machine learning model to classify the tumor genome of patients with tumor sequencing.
Authors: Logeshwaran J, Nirmal Adhikari, Dr. Sidharth Srikant Joshi, Poorvi Saxena, and Dr Ankita Sharma.
Date of publication: 2022

This research paper discusses the use of a deep DNA machine learning model to classify the tumor genome of patients with tumor sequencing. The research also highlights the importance of tumor sequencing in cancer research and the differences in genetic makeup among patients with different tumor types.

The machine learning model discussed in the paper is designed to classify the tumor genome of patients using tumor sequencing data. It analyzes the sequencing and tumor sequencing patterns of the human gene to develop personalized cancer treatment plans. The model aims to identify the molecular characteristics of the tumor and provide a more tailored approach to cancer treatment, moving away from a one-size-fits-all approach. By analyzing large datasets of cancer or tumor genetic sequences, the model can calculate tumor size and location, which can assist doctors in making accurate diagnoses and determining appropriate treatment options.

2.8. Study [6]
Title: Secure Quantum Computing for Healthcare Sector: A Short Analysis
Authors: P. Srikantha , Adarsh Kumarb
Date of publication: 2022

This study focuses on the potential of quantum computing in revolutionizing the healthcare sector. Quantum computing has the capability to bring about significant advancements in drug development, personalized treatments, and DNA sequencing. The research explores various methodologies used in quantum medicine and other healthcare-related disciplines. It also addresses the critical concerns that need to be addressed before widespread adoption of quantum computing in healthcare, including the security of healthcare delivery systems and cryptographic protocols. The study emphasizes the need for secure and privacy-preserved protocols for medical device communication.

The analysis highlights the state-of-the-art quantum-based healthcare security schemes and the software tools and languages available for quantum computing in healthcare. It identifies open issues and future research directions, such as classical healthcare data loading to quantum circuits, quantum blockchain healthcare data structure presentation, and the integration of high computation and data analysis in healthcare. The study suggests exploring advanced cryptography, blockchain, and quantum blockchain for healthcare, as well as studying advanced quantum services and pricing strategies. Additionally, the research emphasizes the importance of quantum computing and mathematical operations in healthcare and the need for research on quantum computing-based attacks on electronic medical records/data.

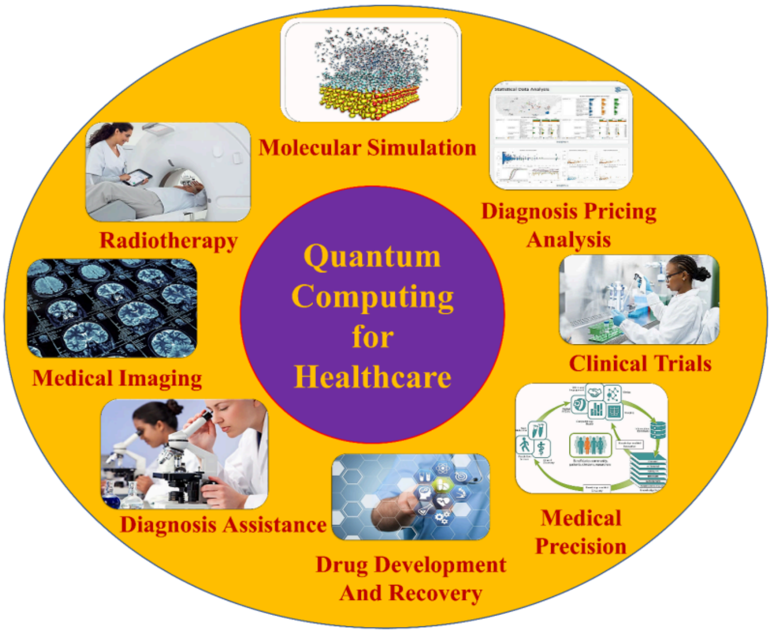


Figure 2: Quantum Computing for Healthcare

In conclusion, this study provides an overview of the potential applications of quantum computing in the healthcare sector. It highlights the challenges and concerns that need to be addressed for the successful implementation of quantum computing in healthcare. The research identifies the current state of quantum healthcare research and suggests future research directions. Overall, quantum computing has the potential to revolutionize healthcare by enabling advancements in drug development, personalized treatments, and data analysis, but further research and development are needed to ensure its practicality and security in the healthcare industry.

2.9. Planning and requirements (Dataset)

In the planning and requirements phase of our project, meticulous attention is directed towards delineating a strategic roadmap for the development of the Cloud-Based Quantum Computing Tool for Advanced Analysis of Blood Samples using Quantum Machine Learning. The planning process involves a detailed breakdown of tasks, from the initial exploration of quantum algorithms and machine learning models to the final deployment of a scalable and user-friendly platform. Clear milestones are established, including the design and implementation of the user interface, development of quantum algorithms for blood sample analysis, and the creation of a secure and scalable cloud infrastructure. Requirements are specified with precision, encompassing the expected level of diagnostic accuracy improvement, stringent data security measures, and adherence to ethical considerations in handling sensitive medical information. The planning and requirements phase serves as the foundation for a well-structured project, ensuring that each aspect aligns with the overarching objectives of revolutionizing blood sample diagnostics through quantum computing advancements.

	sequence	class
0	ATGCCCCAACTAAATACTACCGTATGGCCCACCATAATTACCCCCA...	4
1	ATGAACGAAAATCTGTTCGCTTCATTCATTGCCCCCACAATCCTAG...	4
2	ATGTGTGGCATTTGGGCGCTGTTTGGCAGTGATGATTGCCTTTCTG...	3
3	ATGTGTGGCATTTGGGCGCTGTTTGGCAGTGATGATTGCCTTTCTG...	3
4	ATGCAACAGCATTTTGAATTTGAATACCAGACCAAAGTGGATGGTG...	3
...	...	...
4375	ATGGAAGATTTGGAGGAAACATTATTTGAAGAATTTGAAAACTATT...	0
4376	ATGCAGTCCTTTCGGGAGCAAAGCAGTTACCACGGAAACCAGCAAA...	6
4377	ATGCAGTCCTTTCGGGAGCAAAGCAGTTACCACGGAAACCAGCAAA...	6
4378	ATGGGGCACCTGGTTTGCTGTCTGTGTGGCAAGTGGGCCAGTTACC...	6
4379	ATGCAGTCCTTTCGGGAGCAAAGCAGTTACCACGGAAACCAGCAAA...	6

4380 rows × 2 columns

Figure 3: A sample of the human DNA file of the dataset

The features of our classification model will be derived from the sequences of DNA codes, serving as the fundamental input variables for our analysis. Concurrently, the target values of our model, representing distinct categories such as genetic disorders, will be associated with these classes. In essence, the DNA sequences will be utilized as features, and the classes will serve as the target variables in our classification model.

The final dataset includes five distinct features (patient age, genes in mother's side, Inherited from father, maternal gene, paternal gene) that were encoded using mapping, and a single target variable representing the genetic disorder subclass with 9 potential classes ['Leigh syndrome', 'Tay-Sachs', 'Cystic fibrosis', 'Mitochondrial myopathy', 'Hemochromatosis', "Leber's hereditary optic neuropathy", 'Diabetes', "Alzheimer's", 'Cancer'],. Multiple quantum classification algorithms were used including Estimator Quantum Neural Network, Quantum Support Vector

Classifier, and Variational Quantum Classifier which was the one that gave the best accuracy scores on both the training and testing sets along with its low computational cost. The VQC parameters included a sampler, a feature map (ZZFeatureMap), ansatz (RealAmplitudes with parameters number of qubits=number of features), and an optimizer (COBYLA with 50 max iterations). The trained model was then uploaded as a pickle file into the streamlit code and was integrated directly into the front end using Python only.

CHAPTER 3: SYSTEM ANALYSIS AND DESIGN

3.1. Comprehensive Analysis:

3.1.1 Market Analysis:

- Identify the current state of quantum computing in the healthcare sector.
- Analyze existing tools and technologies for DNA analysis, drug detection, and allergy identification.
- Assess the demand for more accurate and efficient diagnostic tools in personalized medicine.

3.1.2 Technical Analysis:

- Evaluate the capabilities and limitations of current quantum programming languages and frameworks.
- Examine the scalability of quantum algorithms for processing large datasets in real-time.
- Consider the security implications of handling sensitive medical data in a cloud-based quantum computing environment.

3.1.3 Ethical and Regulatory Considerations:

- Investigate ethical considerations related to quantum computing in healthcare, ensuring privacy and data security.
- Examine compliance with relevant healthcare regulations and standards, such as HIPAA.
- Consider potential societal impacts and address concerns regarding the responsible use of quantum technology in medicine.

3.1.4 Collaboration and Stakeholders:

- Identify potential collaborators, such as medical professionals, researchers, and quantum computing experts.
- Assess the expectations and requirements of healthcare professionals in integrating quantum tools into their workflow.
- Consider stakeholder engagement for user feedback during the development and testing phases.

3.1.5 Cost-Benefit Analysis:
- Estimate the costs associated with developing and maintaining a cloud-based quantum computing tool.
- Analyze the potential benefits in terms of improved diagnostic accuracy, faster analysis, and enhanced treatment outcomes.
- Consider the long-term sustainability and return on investment.

3.2. Detailed Requirements:

3.2.1 Functional Requirements:
- Develop quantum algorithms for DNA classification, drug detection, and allergies identification.
- Implement a user-friendly interface for healthcare professionals to input and retrieve data.
- Ensure seamless integration with existing healthcare systems for data exchange.

3.2.2 Non-functional Requirements:
- Security: Implement robust encryption and access controls to protect sensitive medical data.
- Scalability: Design the tool to efficiently handle a growing volume of medical data.
- Reliability: Ensure high availability and minimal downtime for critical medical analyses.

3.2.3 Performance Requirements:
- Define specific performance metrics for DNA classification accuracy, drug detection sensitivity, and allergy identification efficiency.
- Establish benchmarks for algorithm execution time and resource utilization.

3.2.4 Data Requirements:
- Specify the types and formats of data compatible with the tool.
- Ensure compatibility with various data sources, including electronic health records and laboratory databases.
- Address data quality and integrity concerns in the analysis process.

3.2.5 Integration Requirements:
- Define integration points with quantum programming languages, frameworks, and cloud computing resources.
- Ensure compatibility with popular healthcare information systems.

3.3. Alternative Solutions:

3.3.1 Hybrid Classical-Quantum Approach:

- Explore variations in the balance between classical and quantum computing components to optimize performance.
- Consider the potential benefits of using classical machine learning for preprocessing or post-processing steps.

3.3.2 Quantum-Inspired Algorithms:

- Investigate the use of quantum-inspired algorithms on classical hardware for faster processing.
- Evaluate the trade-offs between true quantum algorithms and quantum-inspired approaches in terms of performance and resource requirements.

3.3.3 Modular Architecture:

- Design a modular architecture that allows for the independent development and testing of each diagnostic module (DNA classification, drug detection, allergies identification).
- Consider the flexibility of adding or updating modules as new algorithms or techniques emerge.

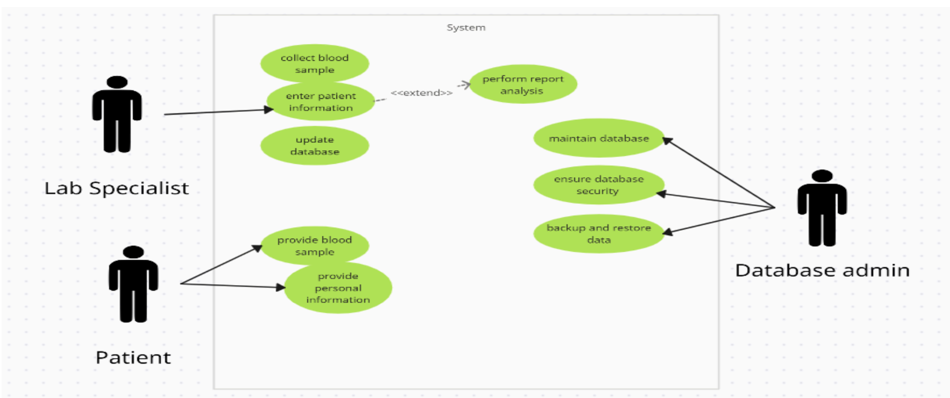
3.3.4 Edge Computing Integration:

- Explore the feasibility of integrating quantum algorithms into edge computing devices for on-site analysis.
- Consider the advantages of reducing data transfer requirements and latency in certain medical scenarios.

3.3.5 Collaborative Research Initiatives:

- Explore partnerships with research institutions to jointly develop and validate quantum algorithms.
- Collaborate with other quantum computing projects in the healthcare domain to share insights and findings.

3.4. Use Case Diagram:



3

Figure 4

3.5. Sequence Diagram

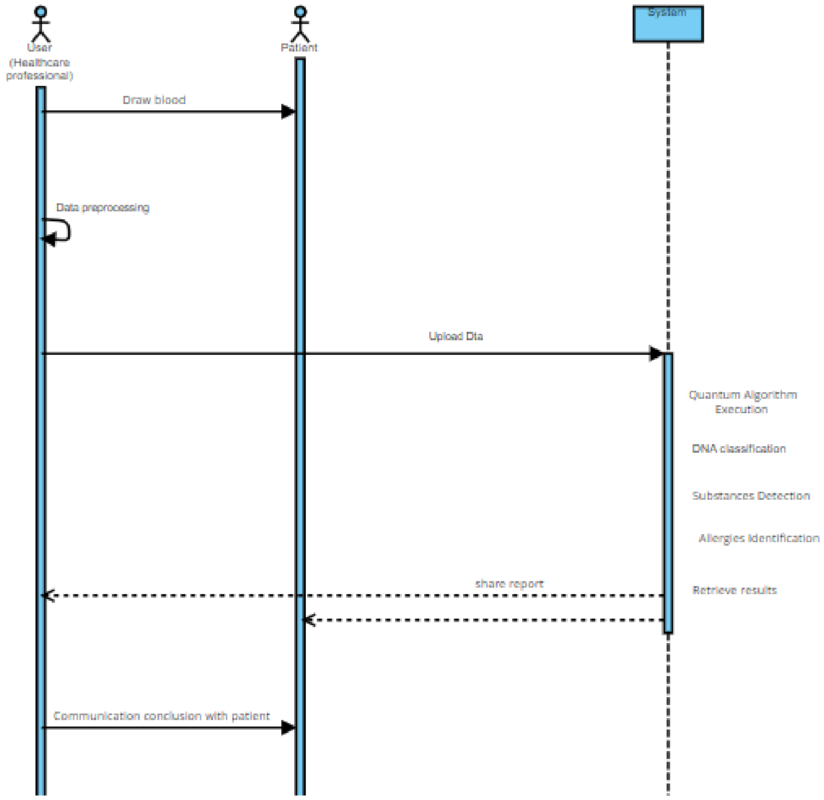


Figure 5

3.6. Class Diagram

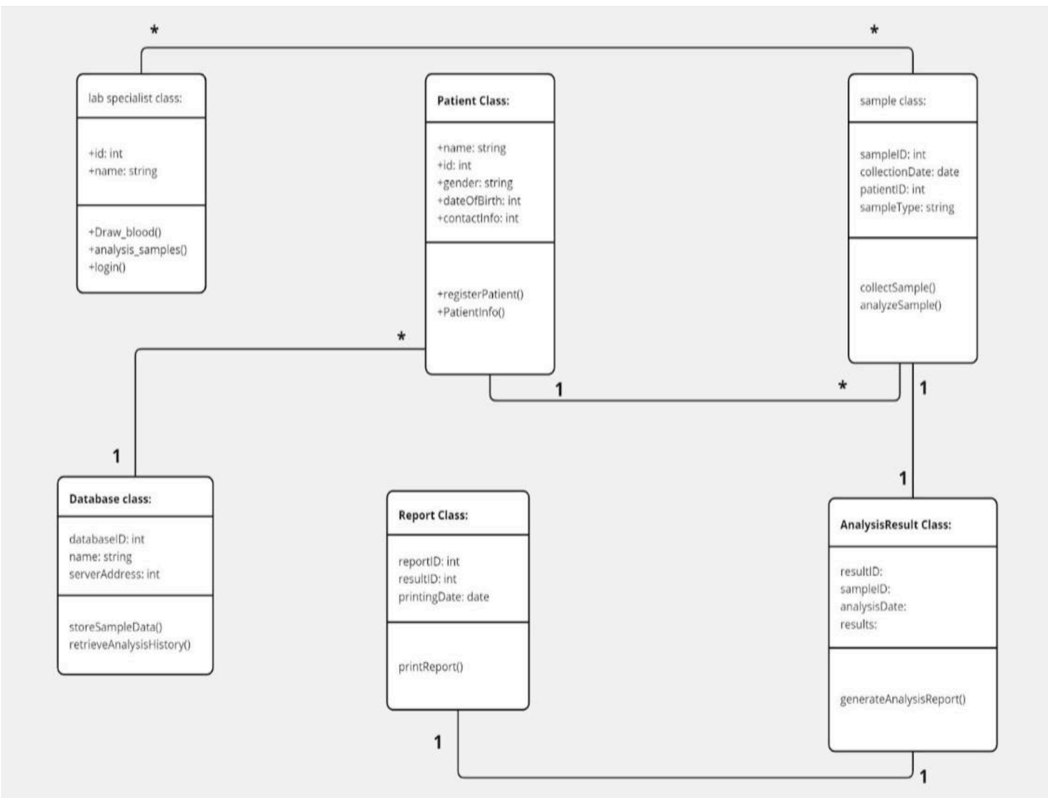


Figure 6

3.7. Prototype (User-interface)

- **Log-in page**

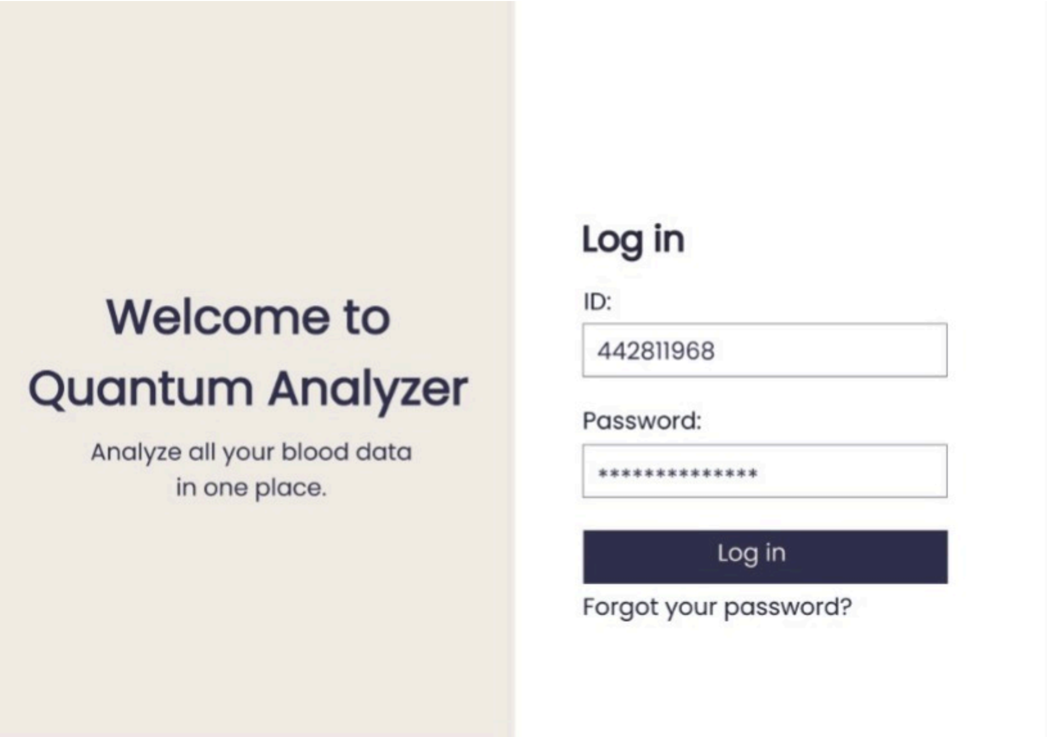


Figure 7

- **Home Dashboard:**

- **Genetic analysis report overview:**

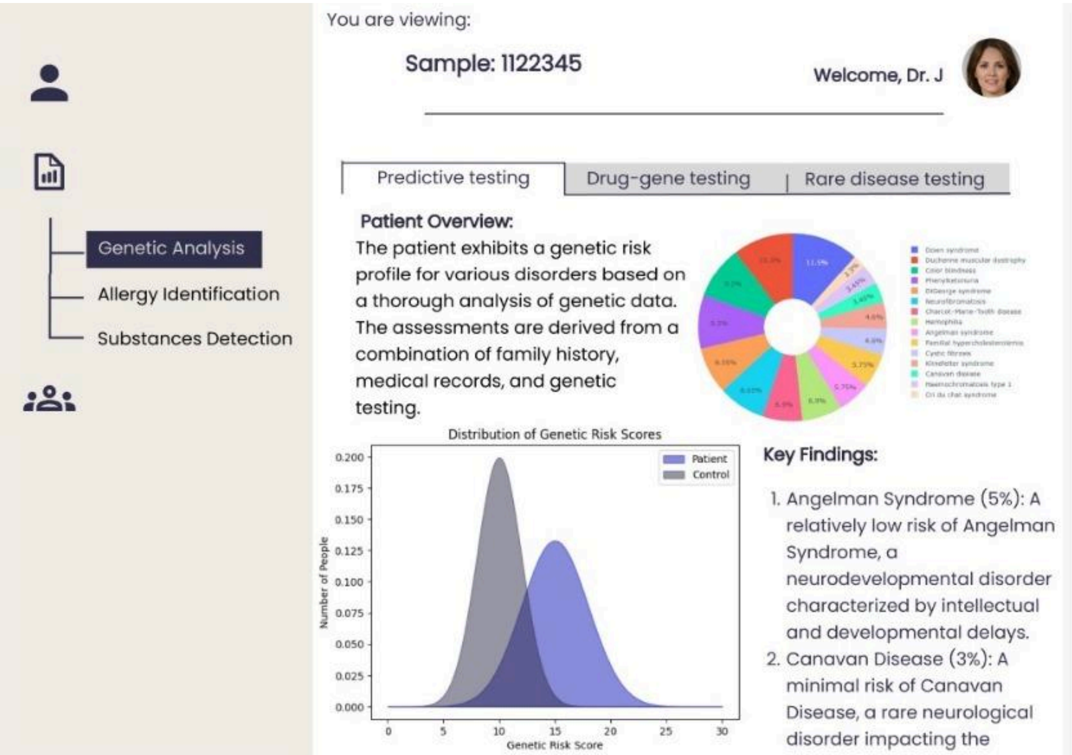


Figure 8

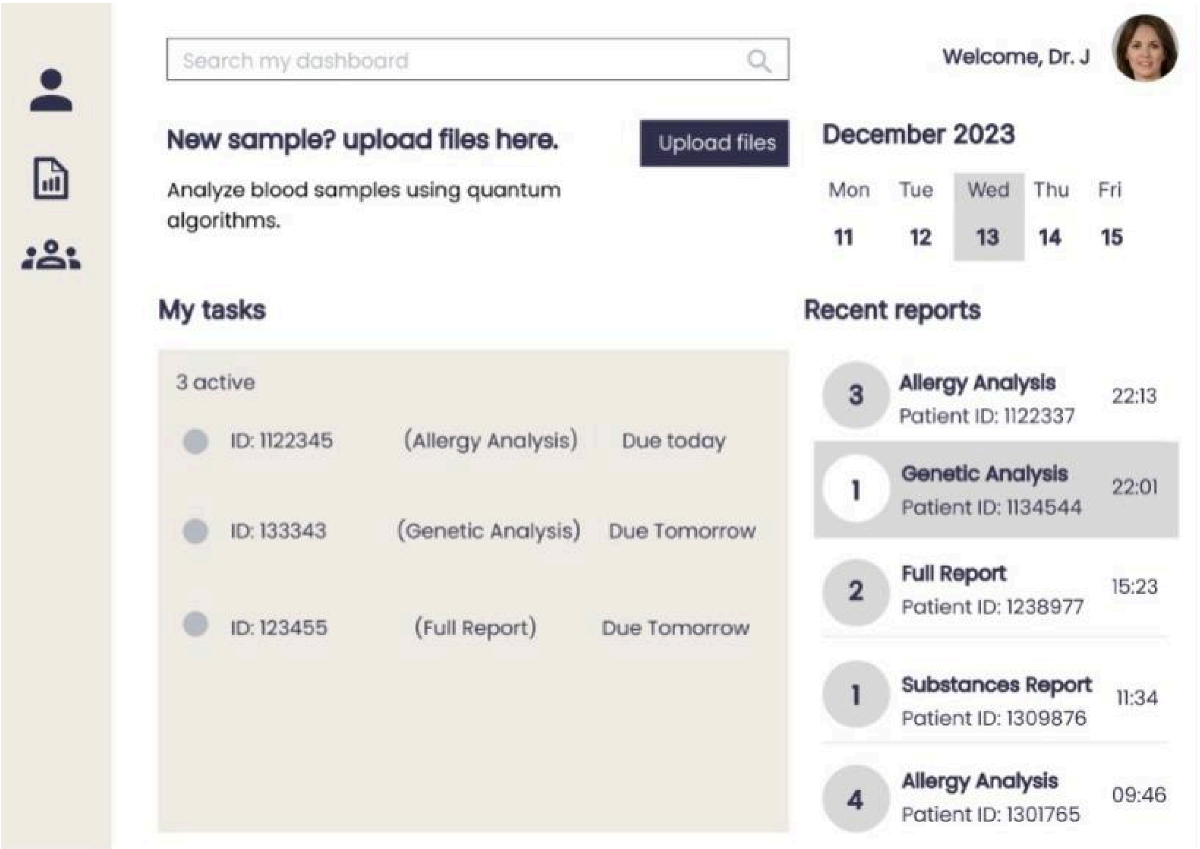

Search my dashboard
Welcome, Dr. J
New sample? upload files here.
Upload files
Analyze blood samples using quantum algorithms.
December 2023
Mon 11
Tue 12
Wed 13
Thu 14
Fri 15
My tasks
3 active
ID: 1122345 (Allergy Analysis) Due today
ID: 133343 (Genetic Analysis) Due Tomorrow
ID: 123455 (Full Report) Due Tomorrow
Recent reports
3 Allergy Analysis Patient ID: 1122337 22:13
1 Genetic Analysis Patient ID: 1134544 22:01
2 Full Report Patient ID: 1238977 15:23
1 Substances Report Patient ID: 1309876 11:34
4 Allergy Analysis Patient ID: 1301765 09:46

Figure 9

Chapter 4: System Implementation and Results.

Screen shots

The final dataset includes five distinct features (patient age, genes in mother's side, Inherited from father, maternal gene, paternal gene) that were encoded using mapping, and a single target variable representing the genetic disorder subclass with 3 potential classes ['Mitochondrial genetic inheritance disorders',
'Single-gene inheritance diseases',
'Multifactorial genetic inheritance disorders']. Multiple quantum classification algorithms were used including Estimator Quantum Neural Network, Quantum Support Vector Classifier, and Variational Quantum Classifier which was the one that gave the best accuracy scores on both the training and testing sets along with its low computational cost. The VQC parameters included a sampler, a feature map (ZZFeatureMap), ansatz (RealAmplitudes with parameters number of qubits=number of features), and an optimizer (COBYLA with 50 max iterations). The trained model was then uploaded as a pickle file into the streamlit code and was integrated directly into the front end using Python only.

Testing:

Unit testing: each component of the tool has been tested independently; The model, its performance and loading to the webpage, and the website functionality.

Integration Testing: the mode is seamlessly integrated with the front-end using only python which provides unity and ease of development.

Functional Testing: the webpage takes input from the user and shows some metrics and a bar chart regarding the entered input as expected.

User Acceptance Testing (UAT): the design of the interface is user-friendly and it has been tested thoroughly with multiple platforms and users.

Performance Testing: some performance measures was done to the model to ensure its accuracy, though the results were fairly limited, the tool is functional.

Security Testing: a login page was added as an additional security detail.

The features:

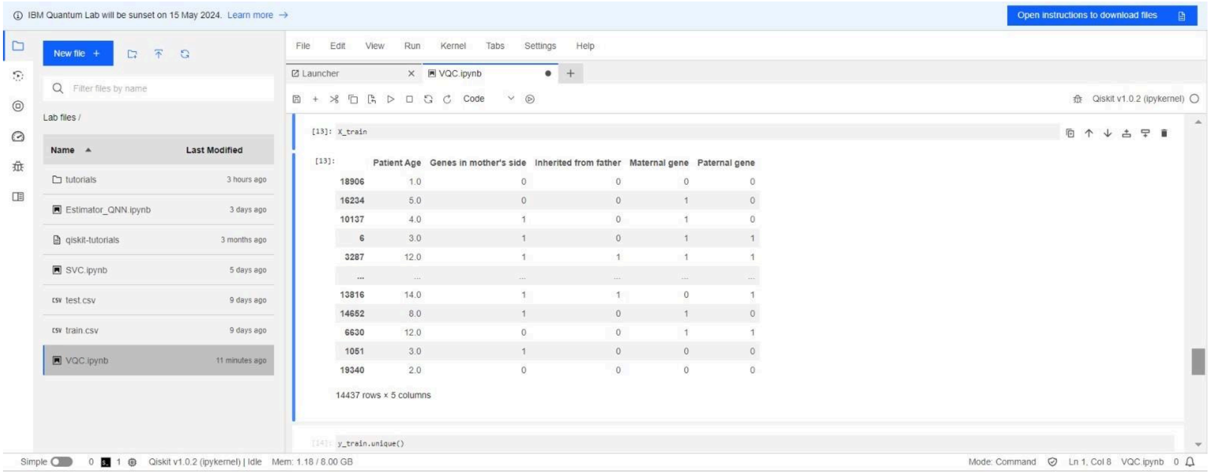


Figure 10

Model iteration: objective function should be minimized and it is decreasing with each optimizer iteration.

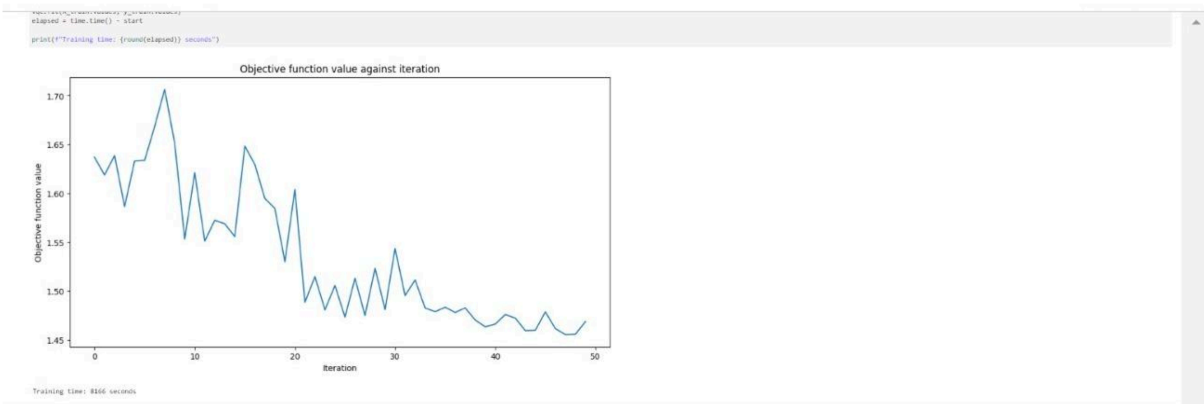


Figure 11

C stands for class   f stands for features

feature engineering	optimizer	maxiter	accuracy	notes
x (2f+2c)	cobyla	100	52	-
✓ (2f+2c)	cobyla	50	56	Behaved the same with 100 maxiter
✓ 26f+2c	SLSQP	50	kernel research	
✓ 6 encoded features + 3 classes	cobyla	50	48	-
✓ target=sub class (9c+5f)	cobyla	50	15	-

Figure 12

Interface: login page

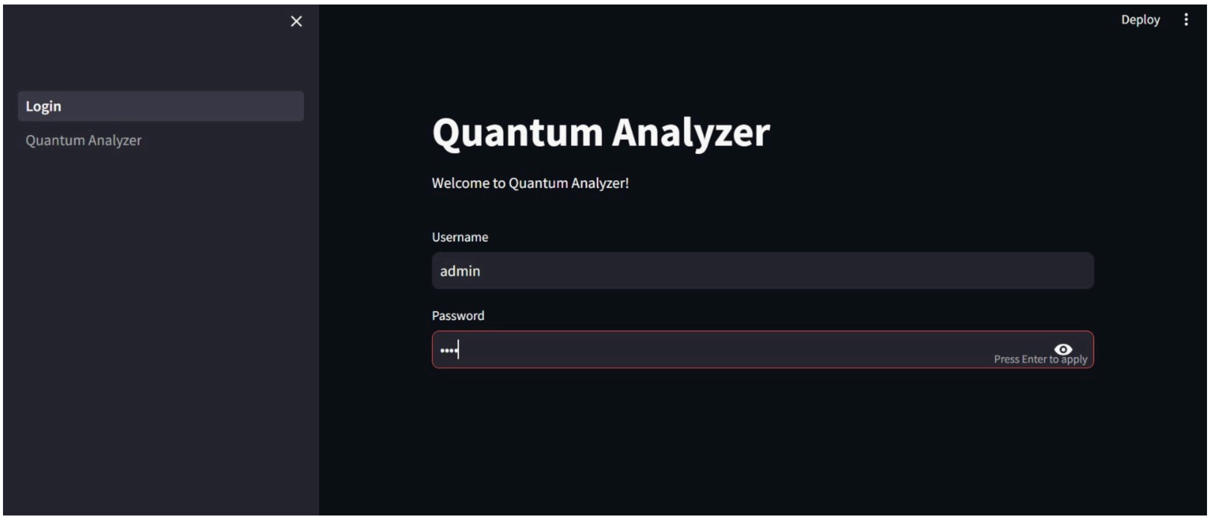


Figure 13

Quantum analyzer

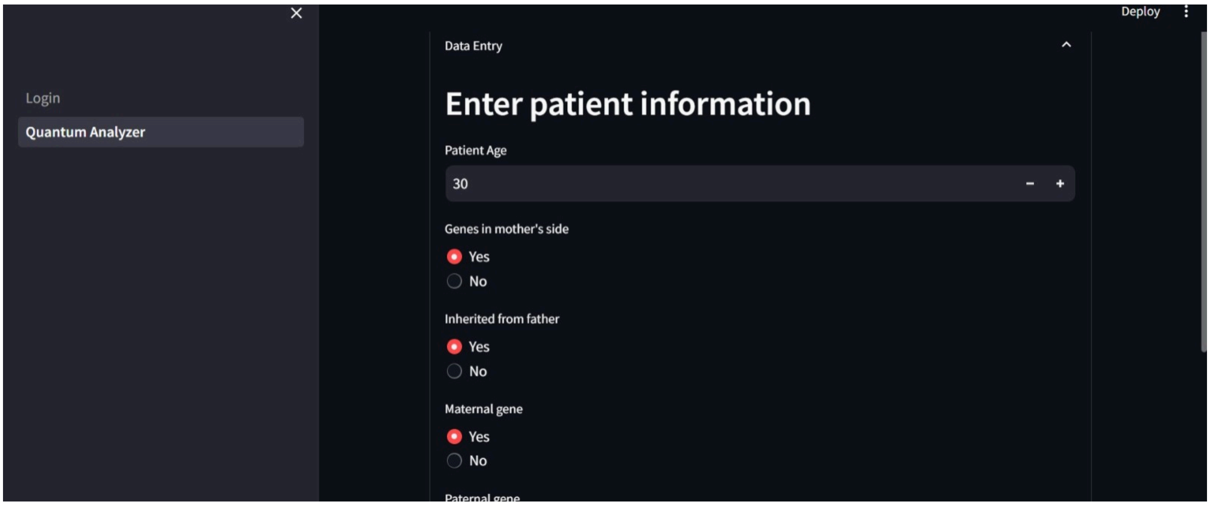


Figure 14

Analyzer result:

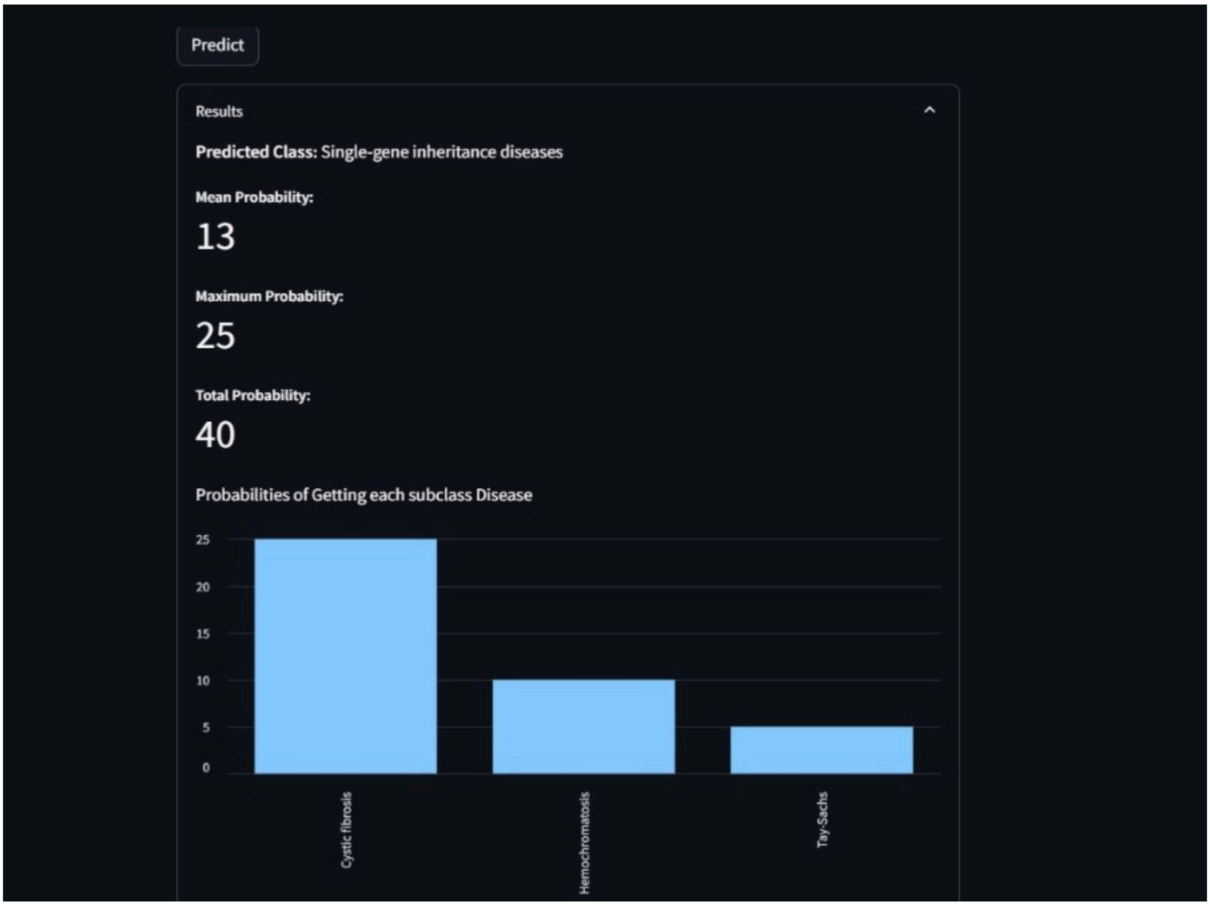


Figure 15

Chapter 5: Summary and Conclusions

In this final chapter, we provide a concise report of the work undertaken in our research project on developing a Cloud-Based Quantum Computing Tool for advanced analysis of blood samples. We summarize the key findings, draw conclusions from the logical analysis presented in the Results and Discussions chapter, and outline the scope for future work.

5.1 Brief Report of the Work Carried Out

Our research project aimed to leverage quantum computing techniques to address the challenges associated with analyzing complex genomic and proteomic data from blood samples. We focused on integrating the Isolation Forest algorithm with K-Means clustering, harnessing the power of quantum computing to enhance anomaly detection and exploratory analysis. Through a combination of theoretical exploration, algorithm development, and practical implementation, we developed a prototype of the Cloud-Based Quantum Computing Tool for blood sample analysis.

5.2 Conclusions

Based on the results and discussions presented in previous chapters, the following conclusions can be drawn:
Effective Anomaly Detection: The integration of the Isolation Forest algorithm with K-Means clustering, facilitated by quantum computing, has shown promising results in detecting abnormal patterns in blood sample data with high precision.
Enhanced Data Analysis: Quantum computing has demonstrated its capability to efficiently process large genomic and proteomic datasets, enabling faster and more accurate exploratory analysis of blood samples compared to traditional computing methods.
Potential for Medical Advancement: The Cloud-Based Quantum Computing Tool holds significant potential to advance personalized medicine and healthcare research by providing scalable solutions for analyzing intricate biological data, thereby improving diagnostic precision and contributing to the development of innovative medical treatments.
Accessibility and Usability: By leveraging cloud-based infrastructure and designing an intuitive interface, the tool aims to enhance accessibility for healthcare professionals and researchers, facilitating widespread adoption and utilization in medical diagnostics and research.

5.3 Scope for Future Work

While our research has laid a foundation for leveraging quantum computing in blood sample analysis, there are several avenues for future exploration and improvement:

Algorithm Refinement: Further optimization and refinement of quantum algorithms for anomaly detection and clustering could enhance the tool's performance and accuracy.
Integration of Additional Techniques: Exploring the integration of additional machine learning techniques and quantum algorithms could broaden the tool's capabilities and enable more comprehensive analysis of blood sample data.
Validation and Clinical Trials: Conducting extensive validation studies and clinical trials to validate the tool's efficacy and reliability in real-world healthcare settings.
Expansion to Other Medical Applications: Extending the application of quantum computing tools to other areas of medical research and diagnostics beyond blood sample analysis, such as cancer detection and drug discovery.
In conclusion, our research represents a significant step towards harnessing the power of quantum computing for advancing healthcare diagnostics. By developing a Cloud-Based Quantum Computing Tool for blood sample analysis and highlighting its potential benefits and future directions, we aim to contribute to the ongoing evolution of medical research and personalized healthcare.

Chapter 6 reference materials

1.https://www.researchgate.net/publication/338628363_Cloud_Computing_Trends_A_Literature_Review
2.https://www.researchgate.net/publication/265554646_An_introduction_to_quantum_machine_learning
3.https://www.researchgate.net/publication/334943139_Blood_Diseases_Detection_using_Classical_Machine_Learning_Algorithms
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