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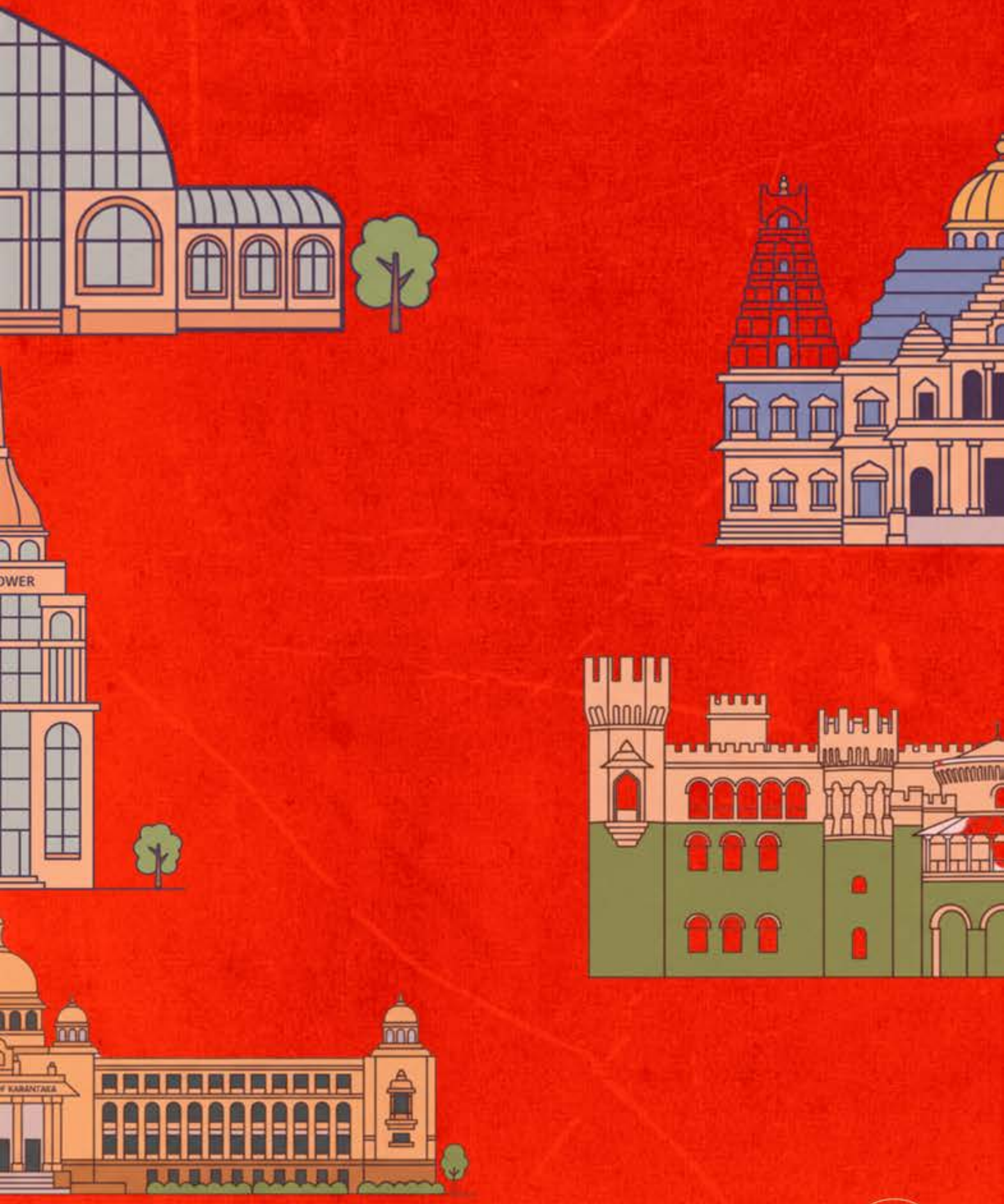

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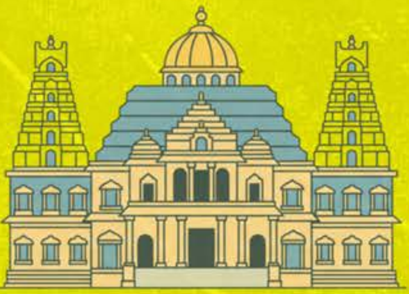


Editors Note

This issue is dedicated to our beautiful state **Karnataka**. Some science, some history and a dash of notable academic work from Param sponsored **research paperathon** conducted in PES university. Paraminions dabbled in sketching for **Inktober** featured in this issue along with a write up on the **Phonetics of Kannada language** makes this issue a mixed bag.

Kannada Nudi

Phonetics of Kannada

Kannada doesn't just sound good, **it feels good.** It rolls out in a clear, rounded rhythm that is steady, uncluttered, and **instantly recognisable.**

With over **44 million native speakers** and 12.9 million others who have happily adopted it, it is no surprise that the Government of India declared it a **Classical Language** in 2008. We Kannadigas always knew it, and now the world does too.

Kannada is quiet a marvel. It uses **retroflex consonants** - those effortless tongue curl sounds we make without getting our tongues stuck.

It has **geminate consonants** which means, holding a sound for even a tiny extra moment changes the meaning completely.

For example **"sadhya"**(meaning **present**) and **"saadhya"**(meaning **possible**), two different words created by minutest elongation of the vowel **'a'**.

Phonetically, the language rests on about **37 distinct sounds**, which explains why it feels so clean, precise, and mathematical.

The **flavour of Kannada** shifts beautifully as you travel across Karnataka. **Mysuru Kannada** is gentle and flowing. **Dharwad Kannada** has its own swag. **Mangaluru Kannada** hits you with crispiness.

Gulbarga Kannada carries its own unique spice. And **Bengaluru Kannada** is a lively blend of old city charm, modern slang, and every influence the city has welcomed over the years.

There may be many dialects, but they still feel unmistakably Kannada, carrying the same warmth, and familiar pulse that make every Kannadiga feel at home.

Even the script has its history. The soft curves and flowing shapes come from a practical past. In earlier times, people wrote on **palm leaves**, and **straight strokes would scratch or tear them.**

So the letters **slowly got rounder and smoother** to glide easily across the surface. Over centuries, those curves settled into the elegant writing style we know today.

Kannada has been around since the **5th century AD**, making it older than English and French.

Every word in Kannada **ends with a vowel,** making the language musical.

If your name doesn't end with a **vowel**, Kannadigas will **add one for you**. Shankar becomes Shankara, Raj becomes Raja and Mahesh becomes Mahesha.

Kannada is very straight-forward. No silent letters, no surprises. You **read it exactly the way you write it**, which is why the script is called one of the most scientific and phonetic in the world.

Ferdinand Kittel, a German Indologist wrote one of the earliest Kannada–English dictionaries, and some Kannada phrases have been **used in ancient Greek plays.**

Masal Dose

There are Dosas and there is the **OG MasalDose** that is unique to Karnataka! There have been Dosa wars on who makes the best Dosas based on textures, colours, size and even the chutneys and Sambars that are mere sidekicks!

The one and only MasalDose from Karnataka wins hands down! That's what all the passionate fans feel anyway!

So what's the history of this particular savory pancake? It has now crossed oceans and continents, donning various Avatars, stuffed with a variety of fillings and doused in butter/ghee, served **in streets, hotels and Michelin starred restaurants all over the world.**

As we all know, necessity is the mother of all inventions and the most popular version of this most favorite dish was invented on the same principle!

The story of this once humble dish originated in Madras, now Chennai, in the early 20th century.

Krishna Rao of the Woodlands fame came to Chennai from Udupi to make a living and in the iconic restaurant **Udupi krishna Vilas** he built, added the spicy potato filling to make the dish more satiating and fulfilling.

Udupi cooks, their cuisine and the popular **Udupi hotels predominantly vegetarian have found no match even after centuries.** They are masters in innovating and redefining dishes.

They used potato to give volume to the otherwise light and flaky dosa

as potatoes were economical and easily available and most importantly had the most endearing quality of assimilating without overpowering.

The addition of the potato filling and a side of Sambar along with the chutney made this dish complete in a way.

The art or we can call it science is in the fermentation and the heat treatment of the batter that is ground to the right consistency,

poured to perfection, doused in oil, butter or ghee on a cast iron girdle, heated to the exact temperature for the Dosa to become one golden red, crispy wonder!

The standard surface, texture, temperature and fermentation

affects the final outcome and taste that guarantees insane loyalty taken very seriously in the foodie circles so much so that Bangalore airport houses an iconic franchise of decades old Masaldose outlet so travellers can dive into iconic bliss before they dive into its legendary traffic.

Each region has added a unique twist to this delectable dish **with different chutneys smeared inside** and different additions to the humble potato filling..

As people migrated to different countries, they took their culinary skills and cravings with them and now

MasalDose is one of the most popular south indian dishes found all over the world!

Erstwhile Madras, now Chennai can take the geographical credit for the MasalDose but the credit for

innovating it sits firmly on the shoulders of the brilliant cooks of Udupi, Karnataka

and there's nothing more to it!

The **MasalaDose** has certainly evolved after a journey through history, culture, and flavor. From its simple origins to its global fame, it stays a dish that is associated with

ecstacy with every crispy bite.

Inktober
at param

Inktober is an annual, month-long art challenge where artists create a drawing every day in October, focusing on ink. Created by artist **Jake Parker** in 2009.

This year, a few of our folks at Param decided to try out Inktober together and we even had an exhibiton for it!

Vinod Gowda

Inktober 2025 forced me **out of my comfort zone,** exploring subjects like women and children under one style, that I never thought I'd attempt, and unlocking a creative confidence I didn't know I had.

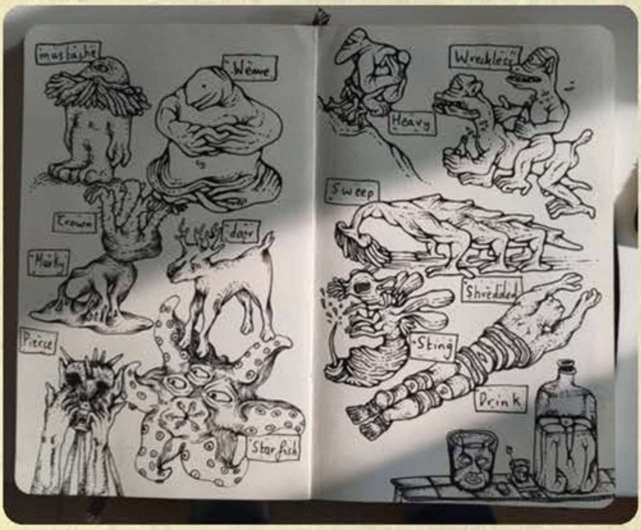
This year was extra special: we **came together as a group**, and learning from everyone was the highlight.

The biggest lesson? Inktober isn't about winners—**it's about finishers.**

Jaden GT

For this year's Inktober, I decided to **stick to my forte** and embrace it. I love drawing organic forms and **creatures**, largely inspired by my love for ecosystems. Trying to be precise with my linework and concepts

I did all the drawings in my trusty **sketchbook**, that I keep on hand all the time. Many camped into a single page.



I had a lot of fun and am happy with how it turned out.

Raghavendra Hegde

31 days, 31 heads.

Every thought, every vision, every reflection begins here. **The head is the canvas of my imagination** and Inktober was my journey through its endless shapes.

" Everything reflects first in the head — my 31 Inktober drawings are proof of that."

- Raghavendra Hegde

Utkarsh

I loved the Param Inktober challenge ! It revived my childhood **passion for magic** and pushed my creativity.

For each prompt, I interpreted it through magic and drew the artwork in **one continuous pen stroke**.

Planning beforehand and committing to a single take gave the pieces a unique, beautiful style.

Bhavana

My aim was to draw the **first thing that comes** to mind and within **5 minutes**, which was quite a challenge for a perfectionist mind.

But it worked out for me.

I found more **creativity in myself** than I expected, and even discovered that I had my own style of drawing which I had never noticed before.

Sajal

As Inktober has no medium now but originally it was a game of consistency and learing.

Each inktober I try to pick one software and try to do art with that. This inktober I picked up my favorite software blender in oder to achieve a certain artstyle.

I may not be able to complete whole 30 days by whatever I have completed had gave me alot of learing. I will continue this practice **throughout my life.**

Sushma

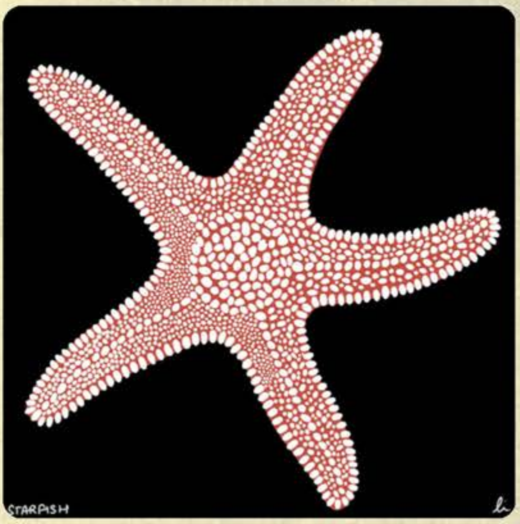
Watching so many ideas and viewpoints come alive on one page has **felt almost magical**.

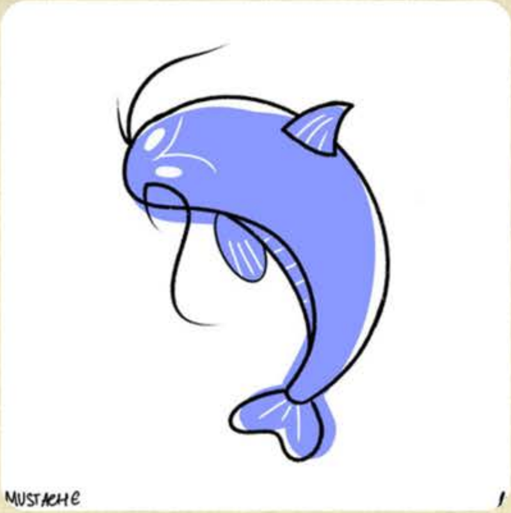
I didn't complete all 30 days, but this drawing became my favourite. One of the most exciting parts of the journey was **presenting all drawings in an exhibition** .

My first time showcasing my art on a platform and sharing different perspectives. It was a little nerve-racking, but incredibly rewarding to see people connect with the art and engage with the stories behind it"

Leha

Inktober ended up being a nice little **creative reset** for me. I didn't do the whole month, but the few prompts I did were soo fun, and it felt good to just sit and draw without overthinking.





Honestly, **seeing everyone else's work** every day was super inspiring. It kept the whole thing feeling exciting even on the days I didn't draw.

Sumedha

Personally, Inktober has always been an intriguing yet intimidating experience.

This year, I gravitated back & forth from sketches and small clay sculptures, doing whatever felt familiar and spontaneous.

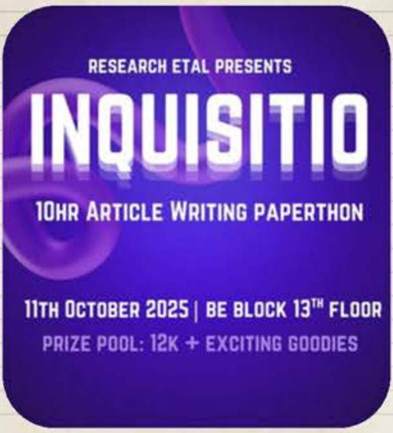
The goal of Inktober was not just to complete 30 drawings, and show off ones skill, but to **build a discipline of repeated practice**.

Through this wonderful undertaking, we nurtured a loving **community of artists here at Param**, which will continue to grow!

Inquisito Paper-thon - I

Param sponsored Inquisito, **a 10 hour article writing paperathon** for the students of PES university.

Our magazine will **feature six shortlisted papers,** one every month.



FEATURED PAPER

QuantumLeap: Integrating Quantum Computing backends with Mainstream Machine Learning Frameworks (e.g., TensorFlow, PyTorch) for seamless Hybrid Model Training.

by P Saanvi, Moksha S, N Lakshanyaa and Vishwas V

QuantumLeap: Integrating Quantum Computing backends with Mainstream Machine Learning Frameworks (e.g., TensorFlow, PyTorch) for seamless Hybrid Model Training

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Abstract - While Hybrid Quantum-Classical (HQC) models represent the most pragmatic path forward in the Noisy Intermediate-Scale Quantum (NISQ) era, their adoption is critically hampered by the integration gap with mainstream machine learning frameworks. Developers face significant hurdles in workflow latency, usability, and the complex challenge of gradient computation for quantum circuits. To resolve these issues, we propose QuantumLeap: a high-level, open-source package designed to provide a seamless training for HQC models within TensorFlow and PyTorch. This package will abstract away the backend complexities of quantum hardware and simulators, presenting the Parameterized Quantum Circuit (PQC) as a native, plug-and-play layer for classical deep learning architectures. This paper serves as the foundational design document for the QuantumLeap package. We present its architectural blueprint, hybrid data flow and how it automates quantum-aware gradient computation via methods like the parameter-shift rule. Furthermore, we analyse the core optimization challenges, such as barren plateaus and shot noise. By delivering a tangible software solution, we aim to democratize Quantum Machine Learning (QML) and empower the vast ML community to build and experiment with HQC models efficiently.

Index Terms – Hybrid Quantum Classical Model, Pennylane, Quantum Machine Learning, TensorFlow quantum

INTRODUCTION

There is a major integration gap between Quantum Computing and mainstream Machine Learning. Classical ML/Deep Learning is now hitting computational limits with exponentially complex data. Integration reduces the barrier of usability.

As the number of features (dimensions) in the data increases, the amount of data needed for the model to generalize accurately grows exponentially. This significantly increases computational complexity, time and the risk of overfitting. Classical Models are highly sensitive to the quality of the training data. This require the data to be clean, accurate and representative. Classical models struggle performing well with limited data or noisy, incomplete, biased data. While some classical models like linear regression and decision trees are interpretable, more powerful ensemble methods can become "black-box" models making it difficult to understand and explain their decisions.

I. Introduction to Quantum Computing (QC):

QC is a new computing paradigm that harnesses the laws of quantum mechanics like superposition, entanglement and interference to process information. Quantum computers use qubits which can exist in a superposition of both states (0 or 1) simultaneously.[1],[2] For some hard problems, QC algorithms offer an exponential speedup. QML aims to apply this exponential power to the field of machine learning, which is increasingly bottlenecked by the sheer size and complexity of the modern datasets. Hybrid Quantum Classical (HQC) model combines the data-handling and optimization power of classical ML with the unique feature-processing capabilities of quantum circuits.[3] HQC offloads the resource intensive, iterative optimization process to the classical computer and minimizes required circuit depth on the QPU. This reduces the accumulation of noise and errors inherent to NISQ devices.

II. State-of-the-Art in Classical ML Frameworks

PyTorch/TensorFlow frameworks are the de facto standards for ML development. Their automatic differentiation capabilities, GPU acceleration support, and massive developer communities make them the ideal platforms for accelerating QML adoption. PyTorch is widely dominant in AI research and academia, while TensorFlow retains strong foothold in industry production and deployment.[4],[5],[6]. Due to this dominance, any emerging QML solution or library like PennyLane, TensorFlow Quantum must provide a seamless interface with at least one. This integration is crucial for QML to leverage their establishment user base, ecosystem and hardware acceleration capabilities. [5]

The current state of QML faces three hurdles. Firstly, Workflow gaps and Latency arise from the core classical-quantum data exchange. Secondly, there are significant barrier in usability and abstraction. Early QML demanded a deep understanding of quantum physics. Thirdly, Differentiation for training presents a challenge. The quantum computation's gradient cannot use standard classical backpropagation.

RESEARCH OVERVIEW

Current research in HQC ML is advancing, underscoring the field's dynamism. Foundational work by Muhammad Jawad Khan, Kamila Zaman have focused on benchmarking and performance analysis of leading frameworks, including PennyLane, TensorFlow Quantum, and Qiskit, with a specific emphasis on their hybrid integration capabilities. [15] Researchers like Azadeh Alavi and her team are exploring more theoretical perspectives, investigating HQC models through the lens of geometric and manifold learning to develop novel pipelines for applications in healthcare and structural monitoring.[16] Complementing these efforts, various research groups have demonstrated the practical utility of HQC models in domains such as generative chemistry, drug design, and combinatorial optimization, leveraging the very frameworks analyzed by Khan's group to achieve tangible results.

Theoretical Feasibility of Quantum Teleportation in the Presence of Quantum Oscillations Under Intrinsic Decoherence achieved a key breakthrough where quantum teleportation was achieved over existing fiber-optic networks, overcoming decoherence to enable scalable, robust quantum communication. The technique used was by transferring states via entanglement and classical communication. [13] A Quantum Circuit Born Machine Approach to Quantum Kolmogorov Arnold Networks had key breakthroughs where models trained without the pre-trained QCBM-encoded spline basis quickly plateau during training. The technique used was Autograd ADAM based learning.[14]

QUANTUM FRAMEWORKS

I. Frameworks & integration techniques: tensorflow quantum and pennylane

TensorFlow Quantum builds on TensorFlow framework by adding quantum capabilities. It introduces new quantum data types and uses the Google Cirq library to design parameterized quantum circuits. [7] Quantum Circuits can be inserted as layers directly into TensorFlow models, allowing classical and quantum components to be trained together end-to-end. This seamless embedding turns quantum circuits into trainable building blocks.

PennyLane is designed to be backend-agnostic, working with both TensorFlow and PyTorch. By defining "quantum nodes" (QNodes), PennyLane wraps quantum circuits so they can be treated just like a classical neural network. This modular design supports a variety of quantum devices and simulators, making it flexible for exploring different quantum hardware. [6], [7]

The central idea in both frameworks is the use of parameterized quantum circuits, where circuit gates depend on tunable parameters. To use classical data, encoding strategies like angle encoding translate inputs into quantum states. Both TFQ and PennyLane support differentiable pipelines—meaning the whole hybrid model, including quantum parameters, can be optimized using gradient descent. This is enabled by techniques such as the parameter-shift rule, which allows gradients to flow through quantum circuits just like in classical neural nets.[8]

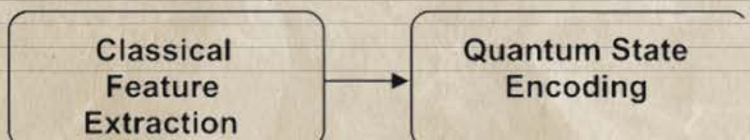
TensorFlow Quantum and PennyLane handle hybrid calculations by combining the results from both classical backpropagation and the quantum gradient method into a single, unified gradient vector. [5] PennyLane encapsulates quantum circuits into quantum nodes (QNodes), which are differentiable functions that return expectation values. The gradients of these quantum circuits are computed using the parameter-shift rule, a specialized quantum gradient technique. When interfaced with TensorFlow, these QNodes behave like standard differentiable TensorFlow functions. TensorFlow's automatic differentiation system captures gradients from classical components via backpropagation and from quantum nodes through quantum-specific gradient methods, integrating both into one gradient vector. This unified gradient allows end-to-end training of hybrid models where classical and quantum components are optimized simultaneously using classical optimizers, enabling efficient hybrid quantum-classical machine learning. [4], [5],[7].

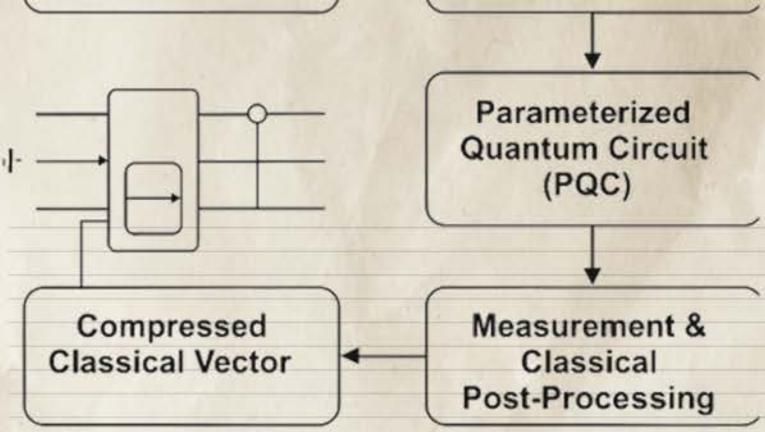
HYBRID ARCHITECTURE

1. Hybrid model design, training, and optimization

The hybrid quantum-classical model involves data flow between classical and quantum processing units. This architecture can be deconstructed into several sequential stages, beginning with classical feature extraction. Conventional deep learning layers (Convolutions, recurrent layers), process high-dimensional input data to extract a salient, low-dimensional feature representation, reducing the computational burden on the quantum processor. This compressed classical vector serves as the input for the quantum state encoding stage, where classical information is mapped onto the quantum state of a qubit register (angle encoding or amplitude encoding). [1] The encoded state is processed by a Parameterized Quantum Circuit (PQC), the core quantum computational block. The final stage involves measurement and classical post-processing, where the quantum register is measured to yield classical expectation values, collapsing the quantum state into probabilistic classical data, which is processed into subsequent fully connected layers for post-processing, interpretation and further analysis. [2]

This multi-stage process reflects a common design pattern found in contemporary QML research, forming the basis for many modern hybrid algorithms (Shenson Joseph et al., 2024) [3]

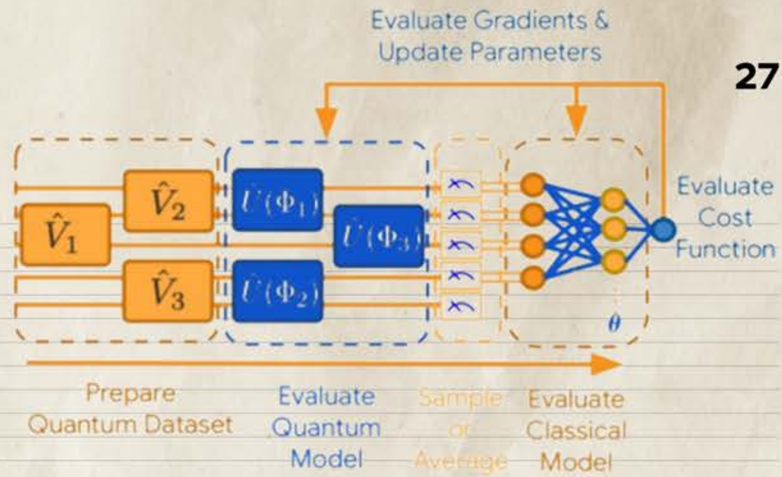




II. Training Methodologies and Gradient Computation

The training of a hybrid model constitutes a joint optimization problem over both its classical and quantum parameters. The objective is to minimize a classically-defined cost function $C(\theta,\phi)$, through an iterative process structurally analogous to classical deep learning. Each training iteration proceeds through four distinct stages. The first is the forward pass execution, where an input sample is processed by initial classical layers parameterized by to yield an intermediate feature vector. This vector is then encoded into an initial quantum state, which is evolved by the Parameterized Quantum Circuit (PQC), a unitary operator, to the final state. A quantum observable is measured with respect to this state to produce a classical expectation value, which is then passed through any subsequent classical layers to produce the final model output, [3]

In the second stage, loss function evaluation, the model's prediction is compared to the true label using a standard loss function to compute the scalar error. The third and most critical stage is the backward pass and hybrid gradient computation. Here, gradients for the classical parameters are computed using the standard backpropagation algorithm. However, gradients for the quantum parameters require specialized, quantum-aware differentiation methods. The two predominant techniques are the Parameter-Shift Rule (PSR), an analytical method that is computationally intensive but viable on hardware, and the Adjoint Differentiation method, an efficient state-based simulation technique. Integration frameworks like TensorFlow Quantum and PennyLane seamlessly handle this hybrid calculation, combining the results from both classical backpropagation and the quantum gradient method into a single, unified gradient vector.[4], [5] Finally, in the parameter update stage, a classical optimizer receives this unified gradient vector and performs its standard update step based on its internal logic and learning rate. This process is repeated until the model's performance on a validation dataset converges. A quantum dataset is a collection of data that fundamentally describes quantum systems and their evolution. Unlike classical datasets, quantum datasets contain features, known as quantum data, which are inherently quantum mechanical.



Abstract pipeline for inference and training of a hybrid discriminative model in TFQ. Here ϕ represents the quantum model parameters, and θ represesnts the classical model parameters

III. Challenges in Hybrid Model Optimization

Barren Plateau Phenomena

For certain classes of PQCs, variance of the gradient [8] of the cost function with respect to the parameters vanishes exponentially with the number of qubits with the training landscape becoming almost flat. The hybrid model guides users toward more trainable models by offering smart initialization strategies and pre-vetted, shallow PQC architectures, while also supporting gradient-free optimizers as a fallback.

Shot Noise

It is the inherent statistical error that arises from needing to run a quantum circuit many times ("Shots") to estimate its output. This introduces fluctuation in the model's gradients, which misleads the training optimizer. The framework manages shot noise by employing an adaptive shot scheduling mechanism that balances speed and precision, and by integrating noise-aware optimizers that handle stochastic gradients effectively [9]

Hardware and Qubit Limitations

Practical implementation of hybrid models is constrained due to physical limitations of current Noisy Intermediate-Scale Quantum (NISQ) hardware (Low Qubit Count, restricted qubit connectivity, gate infidelity and decoherence). It abstracts these limitations by using a hardware-aware transpiler to manage qubit connectivity and providing automated error mitigation techniques to counteract the effects of decoherence and gate infidelity, making the user's code effectively hardware-agnostic.
To ground these proposed solutions in current practice, our analysis is informed by a review of several open-source hybrid models hosted on platforms like GitHub.[9]

OUTLOOK AND FUTURE DIRECTIONS:

I.Challenges and Limitations:

NISQ quantum computers face specific challenges such as decoherence, gate imperfections, and readout errors that limit the reliability of quantum computations. To combat high error rates, methods like Quantum Error Correction (QEC) are required. However, QEC schemes are computationally expensive, requiring many physical qubits to create a single logical qubit. Current hardware hasn't yet reached the threshold for truly fault-tolerant, large-scale systems. Many qubit architectures require extremely specialized and complex environments, such as dilution refrigerators that cool the system to near absolute zero (0.015K). [9],[10] The structure of quantum circuits varies during iterative processes like variational quantum algorithms. However, embedding these variable structures statically inside TensorFlow's computational graph is difficult. Changes in the quantum circuit require rebuilding the TensorFlow graph, which is inefficient. Quantum processing units (QPU) operate very fast on quantum states, but there is relatively high latency in communication between the classical CPU and the QPU. Batching and managing these interactions efficiently is challenging for performance.

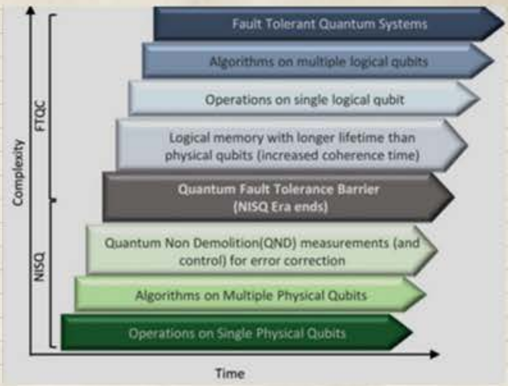
II. Application

In Materials Science and Drug Discovery, quantum computers can precisely simulate complex molecular interactions, accelerating the development of novel drugs and tailored materials. In Finance and general Optimization, quantum algorithms are poised to enhance portfolio management and solve intractable logistics problems. The field of Cryptography counters with quantum key distribution (QKD) to ensure Cybersecurity. Future research efforts to advance Quantum Error Correction Codes (QECCs) from theoretical constructs to practical components of NISQ-ready cryptographic systems must prioritize three areas. The development of lightweight surface code variants with minimal qubit connectivity and the creation of HQC decoders to significantly reduce computational overhead. Hardware Integration necessitates a co-design approach where QECCs are adapted to the specific topological constraints of existing NISQ architectures, while simultaneously driving improvements in gate and readout fidelities to meet the necessary error thresholds.

III. References

IV. Trends

Research moving from purely theoretical QML algorithms to practical implementation and hardware-aware optimization of hybrid models (NISQ-to-Hybrid shift). Large tech companies (Google, IBM, Microsoft, Amazon/AWS) are actively developing integrated quantum software stacks (e.g., TensorFlow Quantum, PennyLane, Qiskit, Amazon Braket) to create a path to "quantum advantage" for enterprise applications. [12]



Quantum Information Processing Development Stages highlighting NISQ and FTQC era phases

CONCLUSION

In essence, QuantumLeap aims to translate the abstract promise of QML into a concrete, understandable, and actionable engineering discipline by integrating QML into packages that the developer can use with TFQ.

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