Experimental Data

This document contains the complete experimental datasets used in the quantum pattern analysis research. The data includes concept extractions from quantum computing frameworks, pattern matching results, and pattern definitions from the PlanQK Pattern Atlas.

Overview

The experimental data consists of: - **Framework Concept Extractions**: Complete datasets of quantum concepts extracted from Classiq, PennyLane, and Qiskit frameworks - **Pattern Matching Results**: Analysis of how concepts match with known quantum patterns - **Pattern Atlas Data**: Complete set of quantum patterns from the PlanQK Pattern Atlas

All datasets are provided in their entirety to ensure reproducibility and enable further analysis.

Classiq Quantum Concepts

The complete dataset of quantum concepts extracted from the Classiq framework.

File: `classiq_quantum_concepts.csv` **Total Concepts**: 65

Row	name
1	.classiq.open_library.functions.amplitude_amplification.amplitude_amplification

Row	name
2	.classiq.open_library.functions.amplitude_amplification.exact_amplitude_amplification
3	.classiq.open_library.functions.amplitude_estimation.amplitude_estimation
4	.classiq.open_library.functions.discrete_sine_cosine_transform.qct_qst_type1

Row	name
5	.classiq.open_library.functions.discrete_sine_cosine_transform.qct_qst_type2
6	.classiq.open_library.functions.discrete_sine_cosine_transform.qct_type2
7	.classiq.open_library.functions.discrete_sine_cosine_transform.qst_type2
8	.classiq.open_library.functions.grover.phase_oracle
9	.classiq.open_library.functions.grover.reflect_about_zero
10	.classiq.open_library.functions.grover.grover_diffuser
11	.classiq.open_library.functions.grover.grover_operator
Row	name

Row	name
12	.classiq.open_library.functions.grover.grover_search
13	.classiq.open_library.functions.hea.full_hea
14	.classiq.open_library.functions.lcu.lcu
15	.classiq.open_library.functions.lcu.lcu_pauli

Row	name
16	.classiq.open_library.functions.linear_pauli_rotation.linear_pauli_rotations
17	.classiq.open_library.functions.lookup_table.span_lookup_table
18	.classiq.open_library.functions.modular_exponentiation.qft_space_add_const
19	.classiq.open_library.functions.modular_exponentiation.cc_modular_add

Row	name
20	.classiq.open_library.functions.modular_exponentiation.c_modular_multiply
21	.classiq.open_library.functions.modular_exponentiation.multiswap
22	.classiq.open_library.functions.modular_exponentiation.inplace_c_modular_multiply

Row	name
23	.classiq.open_library.functions.modular_exponentiation.modular_add_qft_space
24	.classiq.open_library.functions.modular_exponentiation.modular_multiply
25	.classiq.open_library.functions.modular_exponentiation.inplace_modular_multiply
26	.classiq.open_library.functions.modular_exponentiation.modular_exp

Row	name
27	.classiq.open_library.functions.qaoa_penalty.qaoa_mixer_layer
28	.classiq.open_library.functions.qaoa_penalty.qaoa_cost_layer
29	.classiq.open_library.functions.qaoa_penalty.qaoa_layer
30	.classiq.open_library.functions.qaoa_penalty.qaoa_init
31	.classiq.open_library.functions.qaoa_penalty.qaoa_penalty
32	.classiq.open_library.functions.qft_functions.qft_no_swap
33	.classiq.open_library.functions.qft_functions.qft

Row	name
34	.classiq.open_library.functions.qpe.qpe_flexible
35	.classiq.open_library.functions.qpe.qpe

Row	name
36	.classiq.open_library.functions.qsvt.qsvt_step
37	.classiq.open_library.functions.qsvt.qsvt
38	.classiq.open_library.functions.qsvt.projector_controlled_phase
39	.classiq.open_library.functions.qsvt.qsvt_inversion

Row	name
40	.classiq.open_library.functions.qsvt.projector_controlled_double_phase
41	.classiq.open_library.functions.qsvt.qsvt_lcu_step
42	.classiq.open_library.functions.qsvt.qsvt_lcu

Row	name
43	.classiq.open_library.functions.qsvt.gqsp
44	.classiq.open_library.functions.state_preparation.prepare_uniform_trimmed_state
45	.classiq.open_library.functions.state_preparation.prepare_uniform_interval_state

Row	name
46	.classiq.open_library.functions.state_preparation.prepare_ghz_state
47	.classiq.open_library.functions.state_preparation.prepare_exponential_state
48	.classiq.open_library.functions.state_preparation.prepare_bell_state
49	.classiq.open_library.functions.state_preparation.inplace_prepare_int
50	.classiq.open_library.functions.state_preparation.prepare_int

Row	name
51	.classiq.open_library.functions.state_preparation.inplace_prepare_complex_amplitudes
52	.classiq.open_library.functions.state_preparation.prepare_complex_amplitudes
53	.classiq.open_library.functions.state_preparation.prepare_dicke_state_unary_input
54	.classiq.open_library.functions.state_preparation.prepare_dicke_state
55	.classiq.open_library.functions.state_preparation.prepare_basis_state

Row	name
56	.classiq.open_library.functions.state_preparation.prepare_linear_amplitudes
57	.classiq.open_library.functions.state_preparation.inplace_prepare_sparse_amplitudes
58	.classiq.open_library.functions.state_preparation.prepare_sparse_amplitudes
59	.classiq.open_library.functions.swap_test.swap_test

Row	name
60	.classiq.open_library.functions.utility_functions.apply_to_all
61	.classiq.open_library.functions.utility_functions.hadamard_transform
62	.classiq.open_library.functions.utility_functions.modular_increment
63	.classiq.open_library.functions.variational.encode_in_angle
64	.classiq.open_library.functions.variational.encode_on_bloch
65	.classiq.qmod.builtins.functions.exponentiation.suzuki_trotter

PennyLane Quantum Concepts

The complete dataset of quantum concepts extracted from the PennyLane framework.

Row	name
1	.pennylane.pennylane.templates.embeddings.amplitude.AmplitudeEmbedding
2	.pennylane.pennylane.templates.embeddings.angle.AngleEmbedding
3	.pennylane.pennylane.templates.embeddings.basis.BasisEmbedding
4	.pennylane.pennylane.templates.embeddings.displacement.DisplacementEmbedding
5	.pennylane.pennylane.templates.embeddings.iqp.IQPEmbedding
6	.pennylane.pennylane.templates.embeddings.qaoaembedding.QAOAEmbedding
7	.pennylane.pennylane.templates.embeddings.squeezing.SqueezingEmbedding
8	.pennylane.pennylane.templates.layers.basic_entangler.BasicEntanglerLayers
9	.pennylane.pennylane.templates.layers.cv_neural_net.CVNeuralNetLayers

Row	name
10	.pennylane.pennylane.templates.layers.gate_fabric.GateFabric
11	.pennylane.pennylane.templates.layers.particle_conserving_u1.ParticleConservingU1
12	.pennylane.pennylane.templates.layers.particle_conserving_u2.ParticleConservingU2
13	.pennylane.pennylane.templates.layers.random.RandomLayers
14	.pennylane.pennylane.templates.layers.simplified_two_design.SimplifiedTwoDesign
15	.pennylane.pennylane.templates.layers.strongly_entangling.StronglyEntanglingLayers

Row	name
16	.pennylane.pennylane.templates.state_preparations.arbitrary_state_preparation.Arbitrary
17	.pennylane.pennylane.templates.state_preparations.basis_qutrit.QutritBasisStatePrepara
18	.pennylane.pennylane.templates.state_preparations.cosine_window.CosineWindow
19	.pennylane.pennylane.templates.state_preparations.mottonen.MottonenStatePreparatio
20	.pennylane.pennylane.templates.state_preparations.qrom_state_prep.QROMStatePrepa
21	.pennylane.pennylane.templates.state_preparations.state_prep_mps.MPSPrep
22	.pennylane.pennylane.templates.state_preparations.superposition.Superposition
23	.pennylane.pennylane.templates.subroutines.amplitude_amplification.AmplitudeAmplific
24	.pennylane.pennylane.templates.subroutines.aqft.AQFT
25	.pennylane.pennylane.templates.subroutines.arbitrary_unitary.ArbitraryUnitary
26	.pennylane.pennylane.templates.subroutines.arithmetic.adder.Adder
27	.pennylane.pennylane.templates.subroutines.arithmetic.mod_exp.ModExp

Row	name
28	.pennylane.pennylane.templates.subroutines.arithmetic.multiplier.Multiplier
29	.pennylane.pennylane.templates.subroutines.arithmetic.out_adder.OutAdder
30	.pennylane.pennylane.templates.subroutines.arithmetic.out_multiplier.OutMultiplier
31	.pennylane.pennylane.templates.subroutines.arithmetic.out_poly.OutPoly
32	.pennylane.pennylane.templates.subroutines.arithmetic.phase_adder.PhaseAdder
33	.pennylane.pennylane.templates.subroutines.arithmetic.semi_adder.SemiAdder
34	.pennylane.pennylane.templates.subroutines.arithmetic.temporary_and.TemporaryAND
35	.pennylane.pennylane.templates.subroutines.controlled_sequence.ControlledSequence
36	.pennylane.pennylane.templates.subroutines.fable.FABLE
37	.pennylane.pennylane.templates.subroutines.flip_sign.FlipSign
38	.pennylane.pennylane.templates.subroutines.gqsp.GQSP
39	.pennylane.pennylane.templates.subroutines.grover.GroverOperator

Row	name
40	.pennylane.pennylane.templates.subroutines.hilbert_schmidt.HilbertSchmidt
41	.pennylane.pennylane.templates.subroutines.hilbert_schmidt.LocalHilbertSchmidt
42	.pennylane.pennylane.templates.subroutines.interferometer.Interferometer
43	.pennylane.pennylane.templates.subroutines.permute.Permute
44	.pennylane.pennylane.templates.subroutines.prepselprep.PrepSelPrep
45	.pennylane.pennylane.templates.subroutines.qchem.all_singles_doubles.AllSinglesDoub
46	.pennylane.pennylane.templates.subroutines.qchem.basis_rotation.BasisRotation
47	.pennylane.pennylane.templates.subroutines.qchem.fermionic_double_excitation.Fermio
48	.pennylane.pennylane.templates.subroutines.qchem.fermionic_single_excitation.Fermio

Row	name
49	.pennylane.pennylane.templates.subroutines.qchem.kupccgsd.kUpCCGSD
50	.pennylane.pennylane.templates.subroutines.qchem.uccsd.UCCSD
51	.pennylane.pennylane.templates.subroutines.qft.QFT
52	.pennylane.pennylane.templates.subroutines.qmc.QuantumMonteCarlo
53	.pennylane.pennylane.templates.subroutines.qpe.QuantumPhaseEstimation
54	.pennylane.pennylane.templates.subroutines.qrom.QROM
55	.pennylane.pennylane.templates.subroutines.qsvt.QSVT
56	.pennylane.pennylane.templates.subroutines.qubitization.Qubitization
57	.pennylane.pennylane.templates.subroutines.reflection.Reflection
58	.pennylane.pennylane.templates.subroutines.select.Select

Row	name
59	.pennylane.pennylane.templates.subroutines.select_pauli_rot.SelectPauliRot
60	.pennylane.pennylane.templates.subroutines.time_evolution.approx_time_evolution.App
61	.pennylane.pennylane.templates.subroutines.time_evolution.commuting_evolution.Com
62	.pennylane.pennylane.templates.subroutines.time_evolution.qdrift.QDrift
63	.pennylane.pennylane.templates.subroutines.time_evolution.trotter.TrotterProduct
64	.pennylane.pennylane.templates.subroutines.time_evolution.trotter.TrotterizedQfunc
65	.pennylane.pennylane.templates.swapnetworks.ccl2.TwoLocalSwapNetwork
66	.pennylane.pennylane.templates.tensornetworks.mera.MERA

Row	name
67	.pennylane.pennylane.templates.tensornetworks.mps.MPS
68	.pennylane.pennylane.templates.tensornetworks.ttn.TTN

Qiskit Quantum Concepts

The complete dataset of quantum concepts extracted from the Qiskit framework.

File: `qiskit_quantum_concepts.csv` **Total Concepts**: 86

Row	name
1	.qiskit.qiskit.circuit.library.arithmetic.adders.adder.Adder
2	.qiskit.qiskit.circuit.library.arithmetic.adders.adder.HalfAdderGate
3	.qiskit.qiskit.circuit.library.arithmetic.adders.adder.ModularAdderGate

Row	name
4	.qiskit.qiskit.circuit.library.arithmetic.adders.adder.FullAdderGate
5	.qiskit.qiskit.circuit.library.arithmetic.adders.cdkm_ripple_carry_adder.CDKMRippleCarry
6	.qiskit.qiskit.circuit.library.arithmetic.adders.draper_qft_adder.DraperQFTAdder
7	.qiskit.qiskit.circuit.library.arithmetic.adders.vbe_ripple_carry_adder.VBERippleCarryAdd
8	.qiskit.qiskit.circuit.library.arithmetic.exact_reciprocal.ExactReciprocal
9	.qiskit.qiskit.circuit.library.arithmetic.exact_reciprocal.ExactReciprocalGate
10	.qiskit.qiskit.circuit.library.arithmetic.functional_pauli_rotations.FunctionalPauliRotations
11	.qiskit.qiskit.circuit.library.arithmetic.integer_comparator.IntegerComparator
12	.qiskit.qiskit.circuit.library.arithmetic.integer_comparator.IntegerComparatorGate
13	.qiskit.qiskit.circuit.library.arithmetic.linear_amplitude_function.LinearAmplitudeFunction
14	.qiskit.qiskit.circuit.library.arithmetic.linear_pauli_rotations.LinearPauliRotationsGate

Row	name
15	.qiskit.qiskit.circuit.library.arithmetic.multipliers.hrs_cumulative_multiplier.HRSCumulative
16	.qiskit.qiskit.circuit.library.arithmetic.multipliers.multiplier.MultiplierGate
17	.qiskit.qiskit.circuit.library.arithmetic.multipliers.rg_qft_multiplier.RGQFTMultiplier
18	.qiskit.qiskit.circuit.library.arithmetic.piecewise_chebyshev.PiecewiseChebyshevGate
19	.qiskit.qiskit.circuit.library.arithmetic.piecewise_linear_pauli_rotations.PiecewiseLinearPa
20	.qiskit.qiskit.circuit.library.arithmetic.piecewise_polynomial_pauli_rotations.PiecewisePol
21	.qiskit.qiskit.circuit.library.arithmetic.polynomial_pauli_rotations.PolynomialPauliRotation
22	.qiskit.qiskit.circuit.library.arithmetic.polynomial_pauli_rotations.PolynomialPauliRotation
23	.qiskit.qiskit.circuit.library.arithmetic.quadratic_form.QuadraticFormGate
24	.qiskit.qiskit.circuit.library.arithmetic.weighted_adder.WeightedAdder

Row	name
25	.qiskit.qiskit.circuit.library.arithmetic.weighted_adder.WeightedSumGate
26	.qiskit.qiskit.circuit.library.basis_change.qft.QFT
27	.qiskit.qiskit.circuit.library.basis_change.qft.QFTGate
28	.qiskit.qiskit.circuit.library.bit_flip_oracle.BitFlipOracleGate
29	.qiskit.qiskit.circuit.library.blueprintcircuit.BlueprintCircuit
30	.qiskit.qiskit.circuit.library.boolean_logic.inner_product.InnerProductGate
31	.qiskit.qiskit.circuit.library.boolean_logic.quantum_and.AND
32	.qiskit.qiskit.circuit.library.boolean_logic.quantum_and.AndGate
33	.qiskit.qiskit.circuit.library.boolean_logic.quantum_or.OR
34	.qiskit.qiskit.circuit.library.boolean_logic.quantum_xor.BitwiseXorGate
35	.qiskit.qiskit.circuit.library.boolean_logic.quantum_xor.random_bitwise_xor

Row	name
36	.qiskit.qiskit.circuit.library.data_preparation.pauli_feature_map.z_feature_map
37	.qiskit.qiskit.circuit.library.data_preparation.pauli_feature_map.zz_feature_map
38	.qiskit.qiskit.circuit.library.data_preparation.initializer.Initialize
39	.qiskit.qiskit.circuit.library.data_preparation.pauli_feature_map.PauliFeatureMap
40	.qiskit.qiskit.circuit.library.data_preparation.pauli_feature_map.self_product
41	.qiskit.qiskit.circuit.library.data_preparation.state_preparation.StatePreparation
42	.qiskit.qiskit.circuit.library.data_preparation.state_preparation.UniformSuperpositionGate
43	.qiskit.qiskit.circuit.library.fourier_checking.FourierChecking
44	.qiskit.qiskit.circuit.library.generalized_gates.diagonal.Diagonal
45	.qiskit.qiskit.circuit.library.generalized_gates.diagonal.DiagonalGate
46	.qiskit.qiskit.circuit.library.generalized_gates.gms.GMS
47	.qiskit.qiskit.circuit.library.generalized_gates.gms.MSGate
48	.qiskit.qiskit.circuit.library.generalized_gates.gr.GR
49	.qiskit.qiskit.circuit.library.generalized_gates.gr.GRX
50	.qiskit.qiskit.circuit.library.generalized_gates.gr.GRY

Row	name
51	.qiskit.qiskit.circuit.library.generalized_gates.gr.GRZ
52	.qiskit.qiskit.circuit.library.generalized_gates.isometry.Isometry
53	.qiskit.qiskit.circuit.library.generalized_gates.linear_function.LinearFunction
54	.qiskit.qiskit.circuit.library.generalized_gates.mcg_up_to_diagonal.MCGupDiag
55	.qiskit.qiskit.circuit.library.generalized_gates.mcmt.MCMTGate
56	.qiskit.qiskit.circuit.library.generalized_gates.mcmt.MCMTVChain
57	.qiskit.qiskit.circuit.library.generalized_gates.pauli.PauliGate
58	.qiskit.qiskit.circuit.library.generalized_gates.permutation.Permutation
59	.qiskit.qiskit.circuit.library.generalized_gates.permutation.PermutationGate
60	.qiskit.qiskit.circuit.library.generalized_gates.rv.RVGate

Row	name
61	.qiskit.qiskit.circuit.library.generalized_gates.uc.UCGate
62	.qiskit.qiskit.circuit.library.generalized_gates.uc_pauli_rot.UCPauliRotGate
63	.qiskit.qiskit.circuit.library.generalized_gates.ucrz.UCRZGate
64	.qiskit.qiskit.circuit.library.generalized_gates.unitary.UnitaryGate
65	.qiskit.qiskit.circuit.library.graph_state.GraphState
66	.qiskit.qiskit.circuit.library.graph_state.GraphStateGate
67	.qiskit.qiskit.circuit.library.grover_operator.GroverOperator
68	.qiskit.qiskit.circuit.library.hamiltonian_gate.HamiltonianGate
69	.qiskit.qiskit.circuit.library.hidden_linear_function.HiddenLinearFunction
70	.qiskit.qiskit.circuit.library.iqp.IQP
71	.qiskit.qiskit.circuit.library.iqp.random_iqp

Row	name
72	.qiskit.qiskit.circuit.library.n_local.efficient_su2.EfficientSU2
73	.qiskit.qiskit.circuit.library.n_local.evolved_operator_ansatz.hamiltonian_variational_ansa
74	.qiskit.qiskit.circuit.library.n_local.evolved_operator_ansatz.EvolvedOperatorAnsatz
75	.qiskit.qiskit.circuit.library.n_local.excitation_preserving.ExcitationPreserving
76	.qiskit.qiskit.circuit.library.n_local.n_local.NLocal
77	.qiskit.qiskit.circuit.library.n_local.pauli_two_design.PauliTwoDesign
78	.qiskit.qiskit.circuit.library.n_local.qaoa_ansatz.QAOAAnsatz
79	.qiskit.qiskit.circuit.library.n_local.real_amplitudes.RealAmplitudes
80	.qiskit.qiskit.circuit.library.n_local.two_local.TwoLocal
81	.qiskit.qiskit.circuit.library.overlap.UnitaryOverlap
82	.qiskit.qiskit.circuit.library.pauli_evolution.PauliEvolutionGate
83	.qiskit.qiskit.circuit.library.phase_estimation.PhaseEstimation

Row	name
84	.qiskit.qiskit.circuit.library.phase_oracle.PhaseOracle
85	.qiskit.qiskit.circuit.library.phase_oracle.PhaseOracleGate
86	.qiskit.qiskit.circuit.library.quantum_volume.QuantumVolume

Pattern Analysis Results

The following tables contain the complete results of the pattern matching analysis.

Top Matched Quantum Concepts

The most frequently matched quantum concepts across all frameworks and projects.

Total Concepts: 20

Rank	Framework	Concept	Matches
1	Classiq	...hadamard_transform	52
2	Classiq	...qpe	30
3	Classiq	...qpe_flexible	26
4	Classiq	...qft	26
5	Qiskit	...QFT	24
6	Pennylane	...QFT	21
7	Classiq	...qsvt	19
8	Classiq	...apply_to_all	16
9	Classiq	...suzuki_trotter	15

Rank	Framework	Concept	Matches
10	Qiskit	...AND	11
11	Classiq	...phase_oracle	9
12	Pennylane	...QuantumMonteCarlo	9
13	Classiq	...grover_operator	8
14	Qiskit	...z_feature_map	8
15	Classiq	...qft_no_swap	8
16	Qiskit	...zz_feature_map	8
17	Classiq	...amplitude_amplification	7
18	Classiq	...qct_qst_type2	7
19	Classiq	...qsvt_inversion	7
20	Qiskit	...Permutation	7

Match Type Analysis

Distribution of matches by type (name-based, semantic, etc.).

Total Match Types: 2

Row	match_type	count
1	name	373
2	summary	185

Framework Analysis

Distribution of matches by source framework.

Frameworks: 3

Row	framework	count
1	classiq	343
2	qiskit	112
3	pennylane	103

Pattern Frequency Analysis

Frequency of quantum patterns in the analysis.

Total Patterns: 25

Row	pattern	count
1	Basis Change	154
2	Quantum Phase Estimation (QPE)	57
3	Quantum Arithmetic	40
4	Data Encoding	35
5	Quantum Singular Value Transformation	34
6	Circuit Construction Utility	33
7	Oracle	29
8	Amplitude Amplification	25
9	Hamiltonian Simulation	20
10	Initialization	17
11	Quantum Logical Operators	13
12	Variational Quantum Algorithm (VQA)	13
13	Quantum Neural Network (QNN)	11
14	Grover	10

Row	pattern	count
15	Quantum Approximate Optimization Algorithm (QAOA)	10
16	Quantum Amplitude Estimation (QAE)	9
17	Linear Combination of Unitaries	7
18	SWAP Test	6
19	Variational Quantum Eigensolver (VQE)	5
20	Controlled Linear Rotation	5
21	Creating Entanglement	5
22	Quantum Singular Value Transformation (QSVT)	5
23	Phase Shift	4
24	Linear Combination of Unitaries (LCU)	1
25	Quantum Amplitude Estimation	1

Quantum Patterns from PlanQK Pattern Atlas

This section contains the complete dataset of quantum patterns downloaded from the PlanQK Pattern Atlas. These patterns serve as the reference set for pattern matching analysis.

Total Patterns: 59 **Source**: PlanQK Pattern Atlas **File**: `quantum_patterns.json`

Pattern Details

The following table contains all patterns with their metadata:

Row	ID	Name	Alias	Intent
1	1		Quantum Transfer Learning	How to process large data items through quantum neural

Row	ID	Name	Alias	Intent
		Pre-Trained Feature Extractor		networks (QNNs) when the number of available ...
2	2	Variational Parameter Transfer	—	How to obtain a problem-aware parameter initialization for [Variational Quantum Algorithms] (pattern-...
3	3	Chained Optimization	—	How to avoid local optima and improve convergence when optimizing variational parameter values for [...
4	4	Quantum Clustering		How to partition a data set into different clusters based on their similarity utilizing a quantum de...
5	5	Biased Initial State	—	How to utilize efficient approximations in quantum algorithms to improve the solution quality or spe...
6	6	Circuit Cutting	Enter your input for this section here.	How to partition the computation of a quantum circuit into multiple smaller computations fitting the...

Row	ID	Name	Alias	Intent
7	7	Uniform Superposition		Create a uniform superposition of all possible states of a quantum register
8	8	Matrix Encoding	Dynamic Encoding [Schuld and Petruccione 2018]	Represent a matrix as an operation on a quantum computer
9	9	Schmidt Decomposition		Prepare an arbitrary state
10	10	Uncompute	This pattern has also been referred to as Unentangling or Copy-Uncompute.	Remove entanglement that resulted from a previous computation
11	11	Basis Encoding	Enter your input for this section here.	Represent data elements in a quantum computer in order to perform calculations
12	12	Angle Encoding	This pattern has also been referred to as Qubit Encoding (LaRose and Coyle 2020) since each qubit represents a single data point.	"Represent each data point by a separate qubit" [(Weigold et al. 2021)](https://ieeexplore.ieee.org/...
			The resulting encoding of this pattern is not entangled, thus, another alias for this	

Row	ID	Name	Alias	Intent
			pattern is (Tensor) Product Encoding (Leymann and Barzen 2020).	
13	13	Creating Entanglement		Enforce a strong correlation between qubits by entangling them.
14	14	Error Correction	Enter your input for this section here.	How to detect and correct errors occurring during the execution of a quantum circuit?
15	15	Gate Error Mitigation	Enter your input for this section here.	How to reduce the negative impact of noisy gate executions such that the pre-measurement state is cl...
16	16	Quantum Kernel Estimator (QKE)		Use a quantum routine to estimate a kernel for a classical SVM.
17	17	Function Table	Enter your input for this section here.	Compute a function table of a finite Boolean function
18	18	Amplitude Amplification		Increase the probability of finding a solution
19	19	Post-Selective Measurement		Select one branch of a superposition to proceed with

Row	ID	Name	Alias	Intent
20	20	Initialization	This pattern has also been referred to as State Preparation.	Initialize the input of a quantum register, taking into account the prerequisites of the subsequent ...
21	21	Unified Observability	–	How to ensure reproducibility, understandability, and quality when executing hybrid quantum applicat...
22	22	Alternating Operator Ansatz (AOA)		"Approximate the solution of an optimization problem" [(Weigold et al. 2021)] (https://www.springer.c...
23	23	Amplitude Encoding	This encoding has also been referred to as Wavefunction Encoding by (LaRose and Coyle 2020). Every quantum system is described by its wavefunction ψ which also defines the measurement probabilities. By expressing that the wavefunction is used to encode data, it is therefore	Encode data in a compact manner that do not require calculations

Row	ID	Name	Alias	Intent
			implied that amplitudes of the quantum system are used to represent data values.	
24	24	Phase Shift		Distinguish the important aspects of a state in an efficient manner
25	25	Unified Execution	–	How to execute a quantum circuit independently of the heterogeneous quantum cloud offerings and thei...
26	26	Quantum Application Archive	–	How to store, version, and distribute the various heterogeneous artifacts of a hybrid quantum applic...
27	27	Quantum Application Testing	–	How to ensure the correctness of all functionalities of a hybrid quantum application?
28	28	Quantum Hardware Selection	–	How to automatically select a suitable quantum device to execute a given quantum circuit?
29	29			How to train a classifier to assign new

Row	ID	Name	Alias	Intent
		Quantum Classification		data points to one of multiple classes using a quantum devic...
30	30	Quantum Neural Network (QNN)	Not available	How to learn an unknown unitary operator using a quantum device?
31	31	Hadamard Test	Enter your input for this section here.	How to calculate the expectation value of a unitary operator for a given quantum state?
32	32	SWAP Test	Enter your input for this section here.	How to evaluate how similar two given quantum states are to each other?
33	33	Quantum Fourier Transformation	Enter your input for this section here.	How to extract frequencies from a function using a quantum device?
34	34	Ad-hoc Hybrid Code Execution	–	How to execute quantum circuits with classical pre- and post-processing steps with no additional dep...
35	35	Classical-Quantum Interface	–	How can a quantum algorithm implementation be used by developers without quantum

Row	ID	Name	Alias	Intent
				computing knowledge...
36	36	Hybrid Module	–	How can the implementation of a quantum algorithm requiring both classical and quantum computations ...
37	37	Orchestrated Execution	–	How to ensure the control and data flow for quantum applications comprising one or more quantum circ...
38	38	Pre-deployed Execution	–	How to execute quantum circuits with classical pre- and post-processing steps that have custom deplo...
39	39	Mid-Circuit Measurement	Enter your input for this section here.	How to extract partial information from a quantum device while a circuit execution is still running?
40	40	Dynamic Circuit	Enter your input for this section here.	How to modify a quantum computation during runtime based on intermediate information about a part of...

Row	ID	Name	Alias	Intent
41	41	Prioritized Execution	–	How to execute multiple quantum circuits in succession while keeping the queuing time low?
42	42	Quantum Circuit Translator	–	How can a quantum circuit be executed by different quantum computers with different instruction sets...
43	43	Quantum Module	–	How can the implementation of the quantum part of a quantum algorithm be packaged for reuse independ...
44	44	Quantum Module Template	–	How can the implementation of the quantum part of a quantum algorithm be packaged for reuse when som...
45	45	Readout Error Mitigation	Enter your input for this section here.	How to reduce the impact of erroneous measurements such that the measured result is closer to the in...
46	46	Quantum Approximate Optimization		Approximate the solution of an optimization problem

Row	ID	Name	Alias	Intent
		Algorithm (QAOA)		[Weigold et al. 2021] (https://www.springer.com/d...
47	47	Standalone Circuit Execution	–	How to execute standalone quantum circuits that impose no deployment or integration requirements?
48	48	Wire Cut	Enter your input for this section here.	How to interrupt a wire in a quantum circuit classically such that no quantum information is transmi...
49	49	Gate Cut	Enter your input for this section here.	How to partition a multi-qubit gate into independent gates while preserving the computation's result...
50	50	Variational Quantum Eigensolver (VQE)	An alias for this pattern is Quantum Variational Eigensolver (QVE) (Mitarai et al. 2018).	"Approximate the lowest eigenvalue of a matrix" [(Weigold et al. 2021)](https://www.springer.com/de/...
51	51	Warm Start		"Fine-tune an optimization algorithm by warm starting it" [(Weigold et al. 2021)] (https://www.spring...
52	52	Variational Quantum		"Optimize the parameters of a

Row	ID	Name	Alias	Intent
		Algorithm (VQA)		quantum circuit on a classical computer" [(Weigold et al. 2021)] (https...
53	53	Grover		How can you find a specific element (\tilde{x}) within an unsorted database of (N) elements?
54	54	Oracle	This pattern has also been referred to as Black Box.	Re-use a computation of a quantum algorithm without necessarily knowing the implementation.
55	55	Quantum Associative Memory (QuAM)	Enter your input for this section here.	Encode data in a compact manner that do not require calculations
56	56	Quantum-Classic Split	Enter your input for this section here.	Split computational tasks into a quantum part running on a quantum computer and a classical part run...
57	57	Quantum Random Access Memory (QRAM) Encoding	Enter your input for this section here.	"Use a quantum random access memory to access a superposition of data values at once" [(Weigold et a...
58	58	Quantum Phase		

Row	ID	Name	Alias	Intent
		Estimation (QPE)	Phase estimation algorithm (PEA)	Approximate the eigenvalue of a unitary matrix.
59	59	Speedup via Verifying		Achieve a computational speedup on computation when verification of a solution is simple.

References

@online{PlanQK_QuantumPatterns_2024, author = {{PlanQK}}, title = {Quantum Computing Patterns}, year = {2025}, url = {https://patternatlas.planqk.de/pattern-languages/af7780d5-1f97-4536-8da7-4194b093ab1d}, urldate = {2025-09-28} }

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