

Table 2. Different hyperparameters value optimized using grid search cross-validation for SNNc features in Table 2. Hyperparameter tuning was conducted using a grid search cross-validation approach to determine the optimal values for various SVM kernels and ML classifiers.

Data	Model	Hyperparameter(s)	Estimates/Values
SNN {1, 2}	Linear (Lin)	Regularization parameter (C)	1
	Radial Basis Function (RBF)	Regularization parameter (C), and Kernel coefficient (γ)	1, 1
	Decision Tree (DT)	Tree depth	1
	Random Forest (RF)	Forest depth	1
	MLP	Hidden nodes, Iterations, Activation function, Solver	10, 500, ReLU, Adam
SNN {1, 3}	Linear (Lin)	Regularization parameter (C)	1
	Radial Basis Function (RBF)	Regularization parameter (C), and Kernel coefficient (γ)	1, 1
	Decision Tree (DT)	Tree depth	4
	Random Forest (RF)	Forest depth	1
	MLP	Hidden nodes, Iterations, Activation function, Solver	10, 500, ReLU, Adam
SNN {2, 3}	Linear (Lin)	Regularization parameter (C)	5
	Radial Basis Function (RBF)	Regularization parameter (C), and Kernel coefficient (γ)	5, 1
	Decision Tree (DT)	Tree depth	2
	Random Forest (RF)	Forest depth	4
	MLP	Hidden nodes, Iterations, Activation function, Solver	10, 500, ReLU, Adam

Table 3. Different hyperparameters value optimized using grid search cross-validation for CSP features in Table 3. Hyperparameter tuning was conducted using a grid search cross-validation approach to determine the optimal values for various SVM kernels and ML classifiers.

Data	Model	Hyperparameter(s)	Estimates/Values
CSP {1, 2}	Linear (Lin)	Regularization parameter (C)	2
	Radial Basis Function (RBF)	Regularization parameter (C), and Kernel coefficient (γ)	2, 1
	Decision Tree (DT)	Tree depth	3
	Random Forest (RF)	Forest depth	2
	MLP	Hidden nodes, Iterations, Activation function, Solver	10, 500, ReLU, Adam

CSP {1, 3}	Linear (Lin)	Regularization parameter (C)	1
	Radial Basis Function (RBF)	Regularization parameter (C), and Kernel coefficient (γ)	1, 0.1
	Decision Tree (DT)	Tree depth	1
	Random Forest (RF)	Forest depth	1
	MLP	Hidden nodes, Iterations, Activation function, Solver	10, 500, ReLU, Adam
CSP {2, 3}	Linear (Lin)	Regularization parameter (C)	2
	Radial Basis Function (RBF)	Regularization parameter (C), and Kernel coefficient (γ)	2, 1
	Decision Tree (DT)	Tree depth	1
	Random Forest (RF)	Forest depth	1
	MLP	Hidden nodes, Iterations, Activation function, Solver	10, 500, ReLU, Adam

Table 3. IBM Brisbane QPU details including processor type, version, basis gates, and different error rates.

Processor	Version	CLOPS	Basis Gates	2Q Error (Best)	Median ECR Error	Median Readout Error
Eagle r3	1.1.40	30K	ECR, ID, RZ, SX, X	3.34e-3	7.561e-3	1.370e-2