S1. The influenza datasets used in this study can be found at the following link:

S2. Table: The division of amino acid groups based on physicochemical properties and amino acid indices.

Attributes	Group 1	Group 2	Group 3
Hydrophobicity	Polar Q, E, R, K, D, N	Neutral G,P, H, A, S, T, Y	Hydrophobic C, V, F, L, I, M, W
Polarizability	0-1.08 S, D, G, A, T	0.128-0.186 C, Q, I, P, N, V, E, L	0.219- 0.409 Y, M, K, R, H, F, W
Normalized Van der Waals	0-2.78 S, C, G, A, T, P, D	2.95-4.0 E, Q, N, V, I, L	4.0-8.1 K, F, M, H, R, Y, W
Polarity	4.9-6.2 W, C, L, I, F, M, V, Y	8.0-9.2 T, G, P, A, S	10.4-13.0 K, N, H, Q, R, E, D
Solvent Accessibility	Buried A, I, F, C, G, L, V, W	Exposed R, K, Q, E, N, D	Intermediate M, S, P, T, H, Y
Secondary Structure	Helix E, A, L, M, Q, K, R, H	Strand V, I, Y, C, W, F, T	Coil G, N, P, S, D
Charge	Positive K, R	Neutral A, N, C, Q, G, H, I, L, M, F, P, S, T, W, Y, V	Negative D, E

S3. The parameter setting for traditional machine learning classifiers.

Logistic Regression: penalty='L2', tol =0.0001, c=1.0, intercept_scaling=1, class_weight=None, max_iter=100

K-nearest neighbor: n_neighbors=5, weights='uniform', algorithm='auto', leaf_size=30, p=2, metric='minkowski', metric_params=None, n_jobs=None

Support vector machinne: C=1.0, kernel='rbf', degree=3, gamma='scale', coef0=0.0, shrinking=True, probability=False, tol=0.001, cache_size=200, class_weight=None, verbose=False, max_iter=-1, decision_function_shape='ovr', break_ties=False,

Naïve bayes: alpha=1.0, binarize=0.0, fit_prior=True, class_prior=None

S4. Table: Performance on different values of hyperparameters α and β on testing data for virulence prediction with ResNet-50*.

β (α=1)	Testing data				
	Accuracy	Precision	Recall	F-score	AUC
0	0.745	0.824	0.836	0.83	0.512
0.1	0.745	0.824	0.836	0.83	0.515
0.2	0.745	0.824	0.836	0.83	0.524
0.3	0.745	0.824	0.836	0.83	0.528
0.4	0.745	0.824	0.836	0.83	0.528
0.5	0.745	0.824	0.836	0.83	0.527
0.6	0.745	0.824	0.836	0.83	0.529
0.7	0.745	0.824	0.836	0.83	0.529
0.8	0.735	0.822	0.822	0.822	0.53
0.9	0.745	0.824	0.836	0.83	0.528
1	0.693	0.693	0.693	0.693	0.693
2	0.735	0.822	0.822	0.822	0.544
3	0.735	0.822	0.822	0.822	0.55

β (α=1)	Testing data				
	Accuracy	Precision	Recall	F-score	AUC
0	0.755	0.818	0.863	0.84	0.608
0.1	0.765	0.838	0.849	0.844	0.464
0.2	0.786	0.842	0.877	0.859	0.561
0.3	0.745	0.808	0.863	0.834	0.531
0.4	0.653	0.831	0.671	0.742	0.506
0.5	0.755	0.836	0.836	0.836	0.61
0.6	0.724	0.838	0.781	0.809	0.582
0.7	0.745	0.824	0.836	0.83	0.615
0.8	0.704	0.789	0.822	0.805	0.597
0.9	0.765	0.821	0.877	0.848	0.649
1	0.745	0.824	0.836	0.83	0.693
2	0.714	0.8	0.822	0.811	0.58
3	0.724	0.838	0.781	0.809	0.664