Image Classification

Handwritten Japanese Hiragana Characters

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CS-UY 4563: Introduction to Machine Learning

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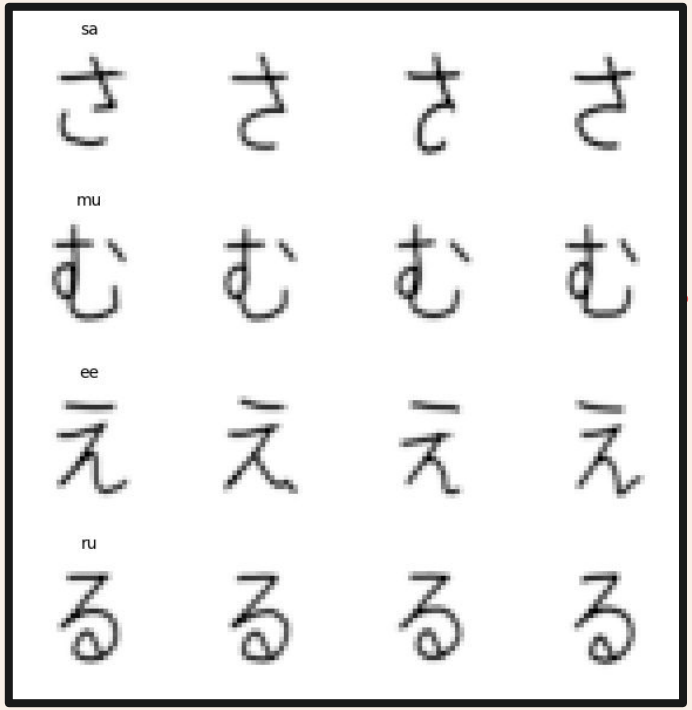
Introduction

Dataset: Handwritten Hiragana Characters
- Raw Images
- 4600 images: 100 per character
- Must classify example into 1 of 46 classes

Preprocessing

- Feature Extraction
  - Pixel intensity statistics
  - Ink count/stroke density
  - Bounding box dimensions and area
  - Center of mass
  - Laplacian variance
- Data distribution
  - 70%: Training
  - 15%: Validation
  - 15%: Testing



Models

Logistic Regression

KNN

Neural Network

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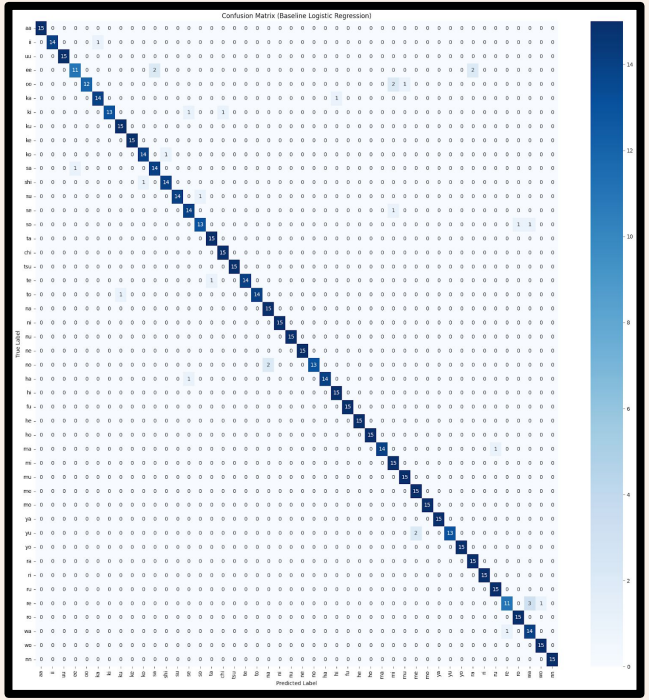
Logistic Regression

- Baseline
  - No regularization

Metric	Score
Training Accuracy	0.9792
Validation Accuracy	0.9551
Validation Precision	0.9580
Validation Recall	0.9551
Validation F1 Score	0.9546



Logistic Regression (cont.)

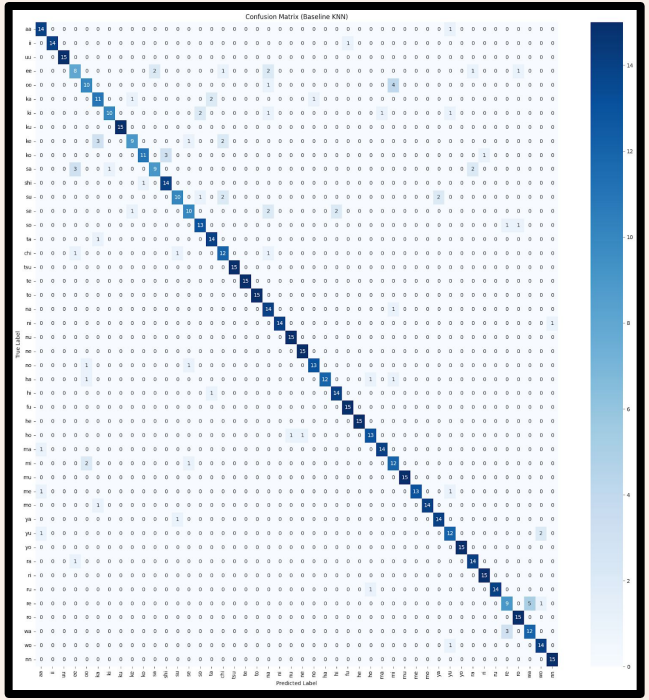
Transformation	C	Train Accuracy	Validation Accuracy	Validation Precision	Validation Recall	Validation F1 Score
None	1000000	0.980124	0.955072	0.958045	0.955072	0.954616

- LogisticRegression()
- Feature Transformation
  - Polynomial Degree Two
  - Polynomial Degree Three
  - K-Means Clustering (k = 8)
- Hyperparameters
  - L2 Regularization
  - C = [1000000, 1.0, 0.1, 0.01, 0.001, 0.0001]

KNN

- Baseline
  - 5 neighbors
  - Weight function: uniform
    - All points in each neighborhood are weighted equally

Metric	Score
Training Accuracy	0.9245
Validation Accuracy	0.8710
Validation Precision	0.8750
Validation Recall	0.8710
Validation F1 Score	0.8693



KNN (cont.)

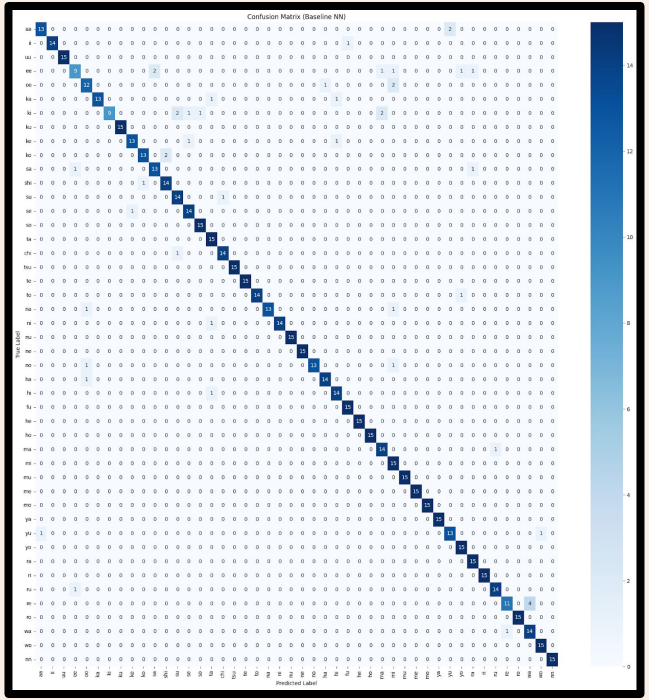
Transformation	Weight Functions	k	Train Accuracy	Validation Accuracy	Validation Precision	Validation Recall	Validation F1 Score
None	distance	10	1	0.882609	0.894165	0.882609	0.8799

- KNeighborsClassifier()
- Feature Transformation
  - Polynomial Degree Two
  - Polynomial Degree Three
  - K-Means Clustering (k = 8)
- Hyperparameters
  - K values = [1, 5, 10]
  - Weight functions
    - Uniform: All points in each neighborhood are weighted equally
    - Distance: Closer neighbors of a point will have a greater influence than neighbors which are further away

Neural Network

- Baseline
  - One hidden layer: 64 neurons
  - Activation function: sigmoid
  - No regularization

Metric	Score
Training Accuracy	0.9531
Validation Accuracy	0.9319
Validation Precision	0.9362
Validation Recall	0.9319
Validation F1 Score	0.9308



Neural Network (cont.)

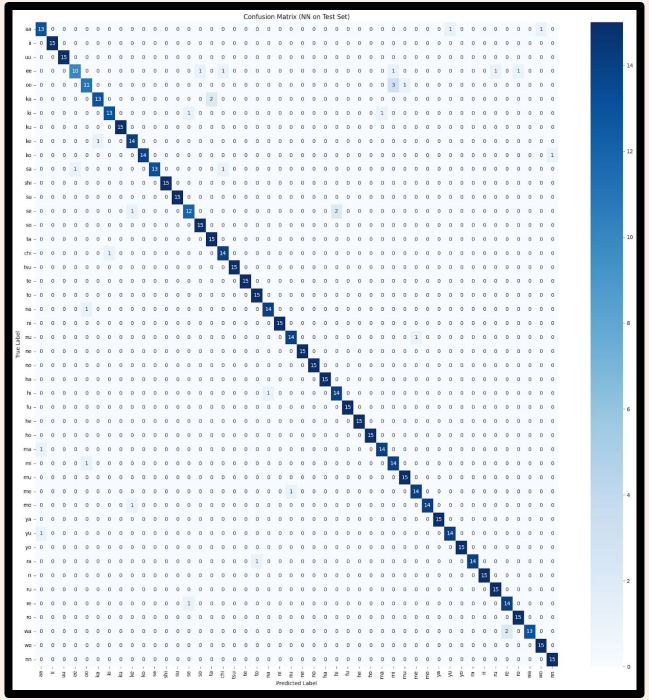
Transformation	Activation Function	Alpha	Train Accuracy	Validation Accuracy	Validation Precision	Validation Recall	Validation F1 Score
Two Layer (64, 32)	Tanh	0.1	0.979814	0.965217	0.96656	0.965217	0.964652

- MLPClassifier()
- Feature Transformation
  - Two Hidden Layers: 64 neurons & 32 neurons
  - Three Hidden Layers: 64 neurons, 64 neurons, & 32 neurons
  - Wide Two Hidden Layers: 128 neurons & 64 neurons
- Hyperparameters
  - Activation functions
    - ReLU
    - Tanh
    - Sigmoid
  - L2 Regularization
    - α = [0.000001, 0.0001, 0.001, 0.01, 0.1, 1.0]

Test Set

- Chosen Model
  - Neural Network
    - Two Layers: 64 neurons & 32 neurons
    - Activation Function: Tanh
    - α: 0.1

Metric	Score
Test Accuracy	0.9493
Test Precision	0.9506
Test Recall	0.9493
Test F1 Score	0.9486

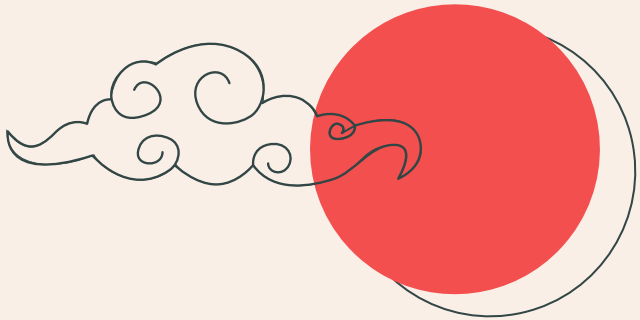


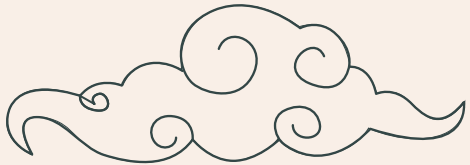
Conclusion

Test Accuracy: 94.93%
Improvements:

- Logistic Regression: PCA → Polynomial Transformation
- KNN: Add Regularization & Higher K Values
- Neural Network: Experiment with wider layers & use larger α `value`

Questions?





Thank you