Digit Classification

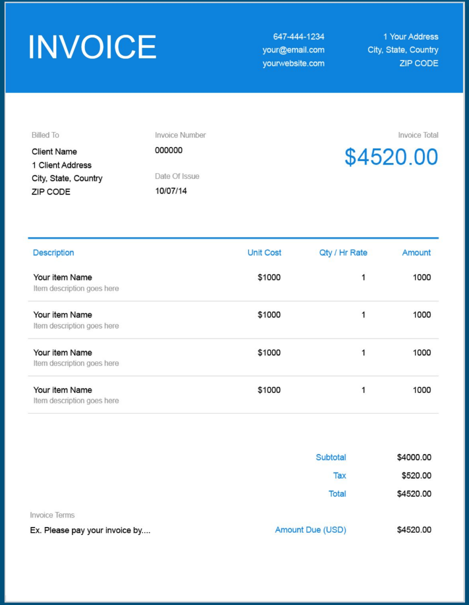
for Receipts and Invoices

Xingliang Shu

Outline

Business Problem

- Account Payable & Account Receivable
- Supply Chain Management



INVOICE

647-444-1234
your@email.com
yourwebsite.com

1 Your Address
City, State, Country
ZIP CODE

Billed To
Client Name
1 Client Address
City, State, Country
ZIP CODE

Invoice Number
000000

Date Of Issue
10/07/14

Invoice Total
$4520.00

Description	Unit Cost	Qty / Hr Rate	Amount
Your item Name Item description goes here	$1000	1	1000
Your item Name Item description goes here	$1000	1	1000
Your item Name Item description goes here	$1000	1	1000
Your item Name Item description goes here	$1000	1	1000

Subtotal	$4000.00
Tax	$520.00
Total	$4520.00

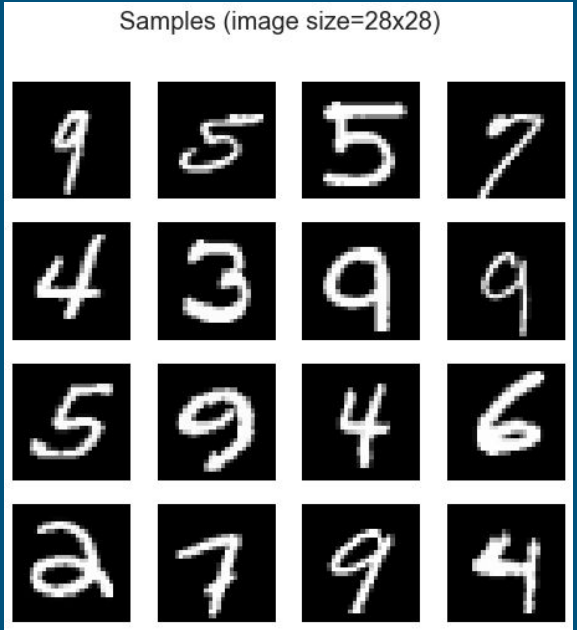
Invoice Terms
Ex. Please pay your invoice by....

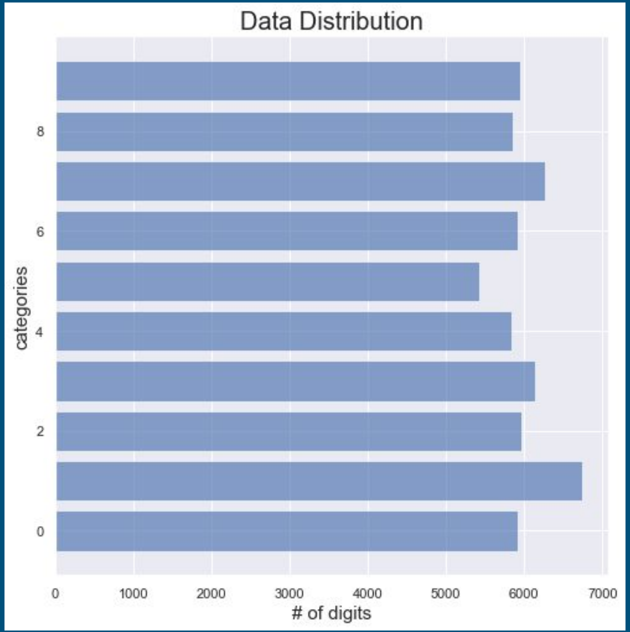
Amount Due (USD) $4520.00

Source from https://nanonets.com/blog/receipt-ocr/

Techniques to Classify Digits

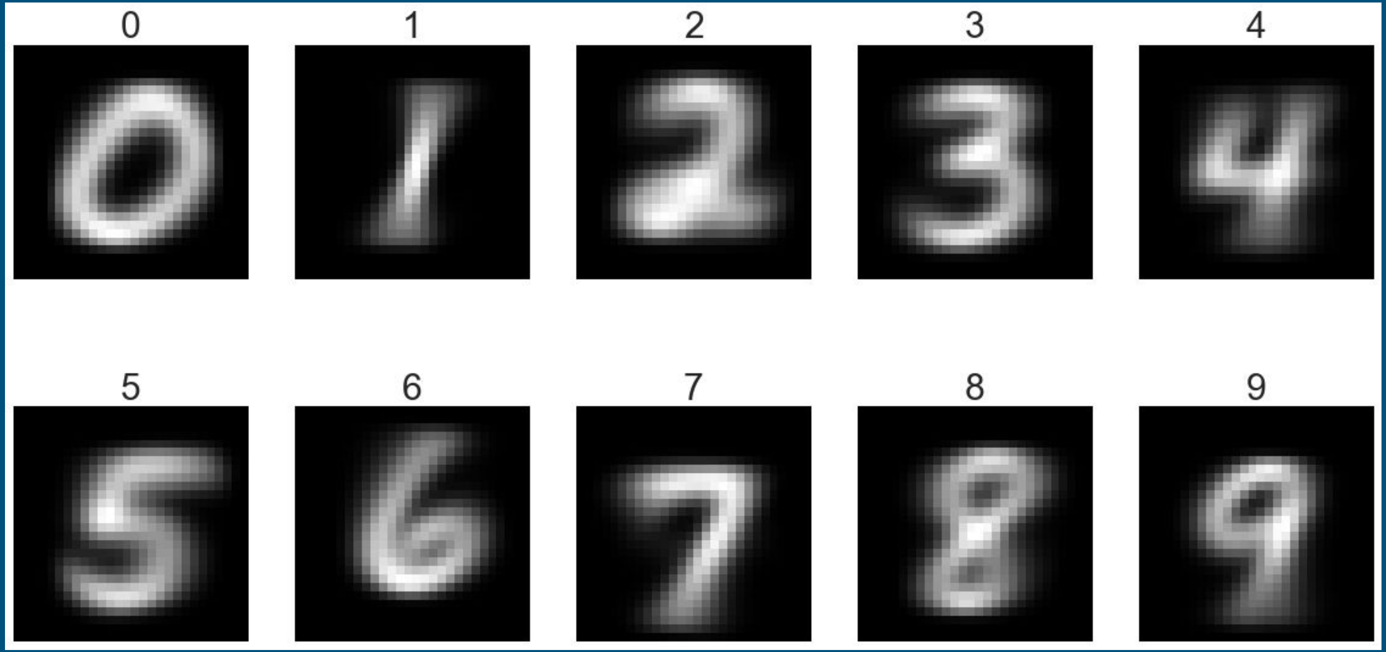
Dataset



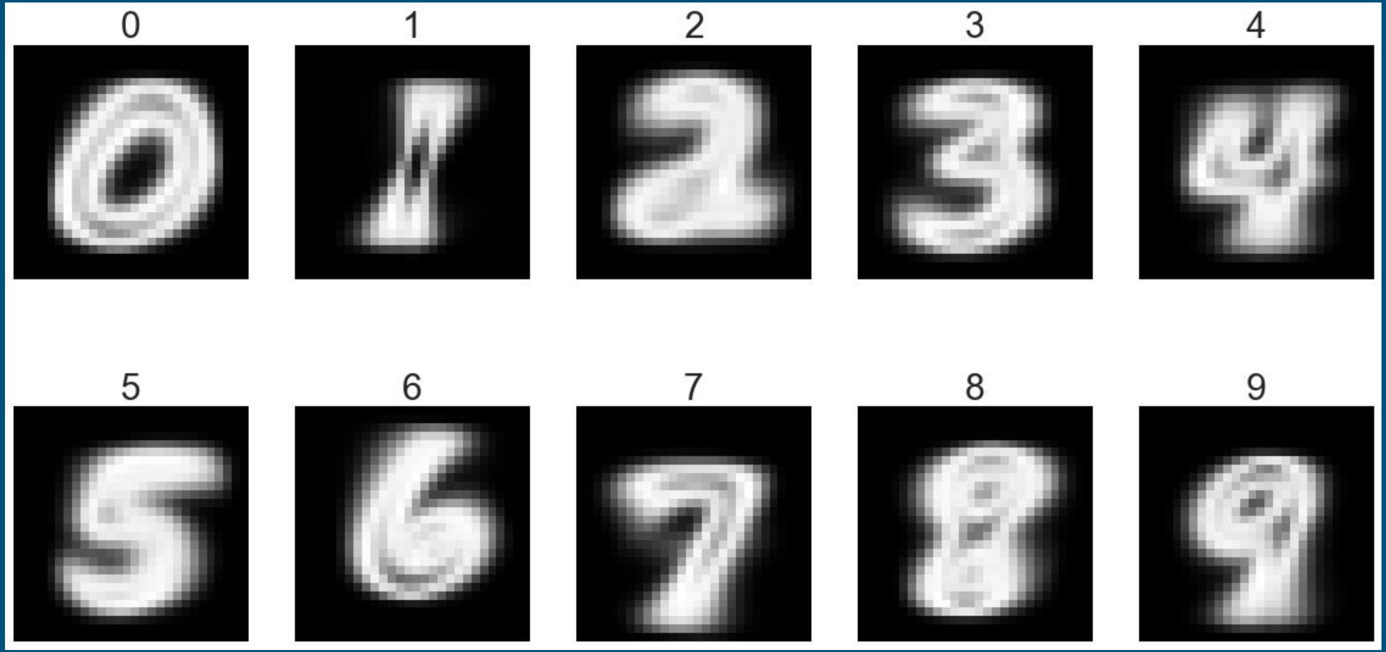


- 10 categories
- Training: 60k
- Testing: 10k
- Metrice: accuracy

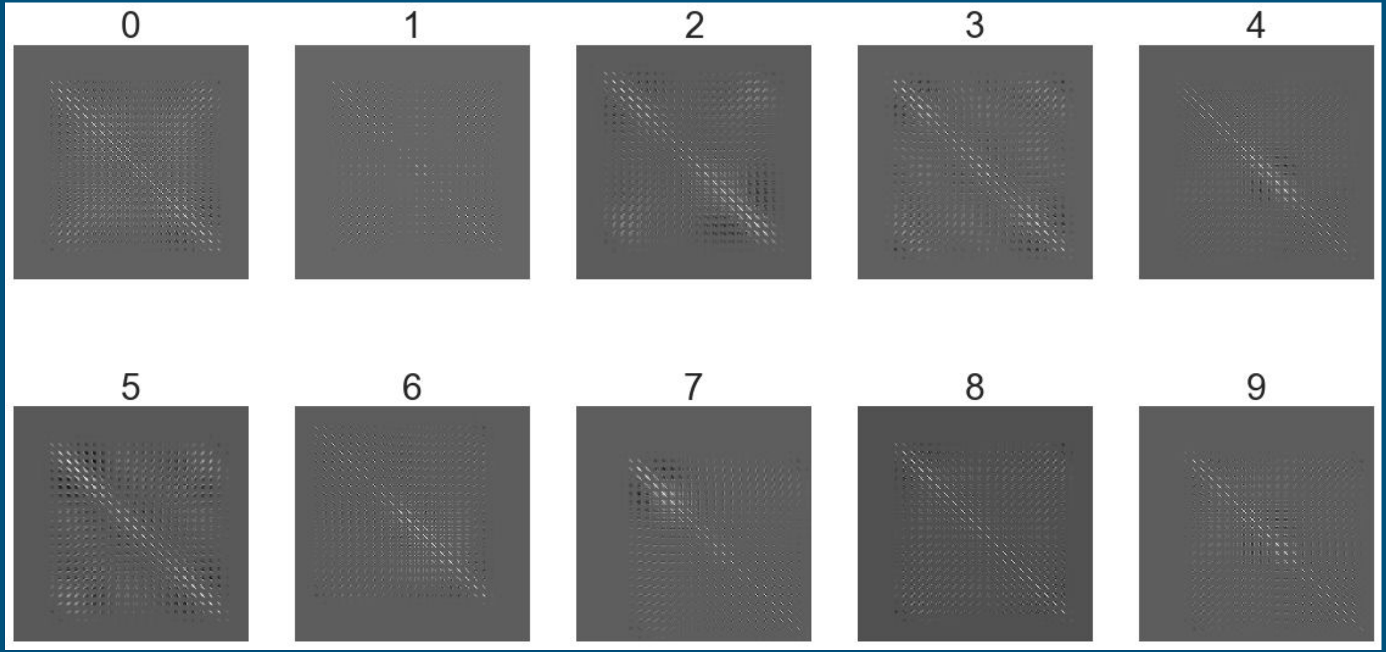
Data Visualization (Means 2D)



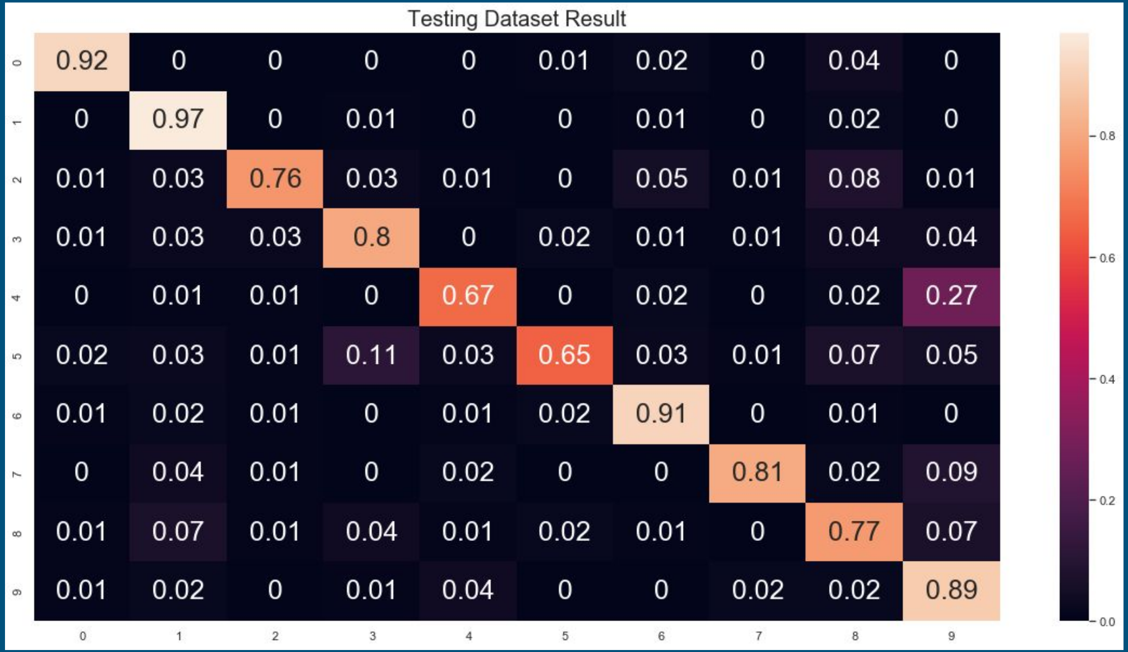
Data Visualization (Variances 2D)



Data Visualization (Covariance Matrix)

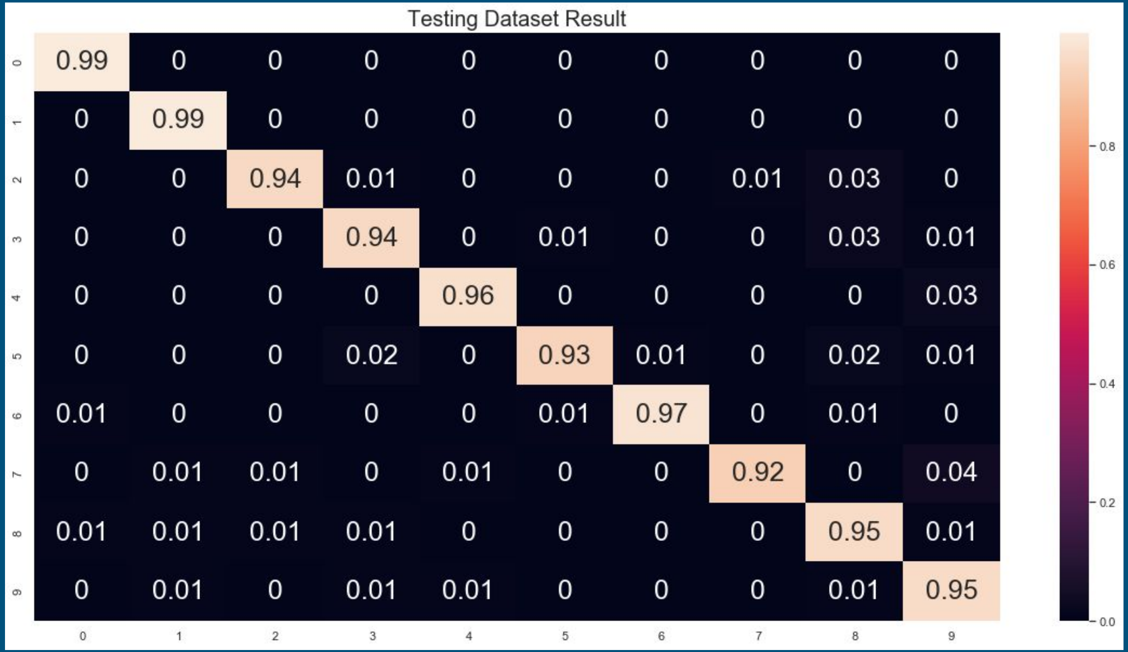


Multivariate Gaussian NB Version 1



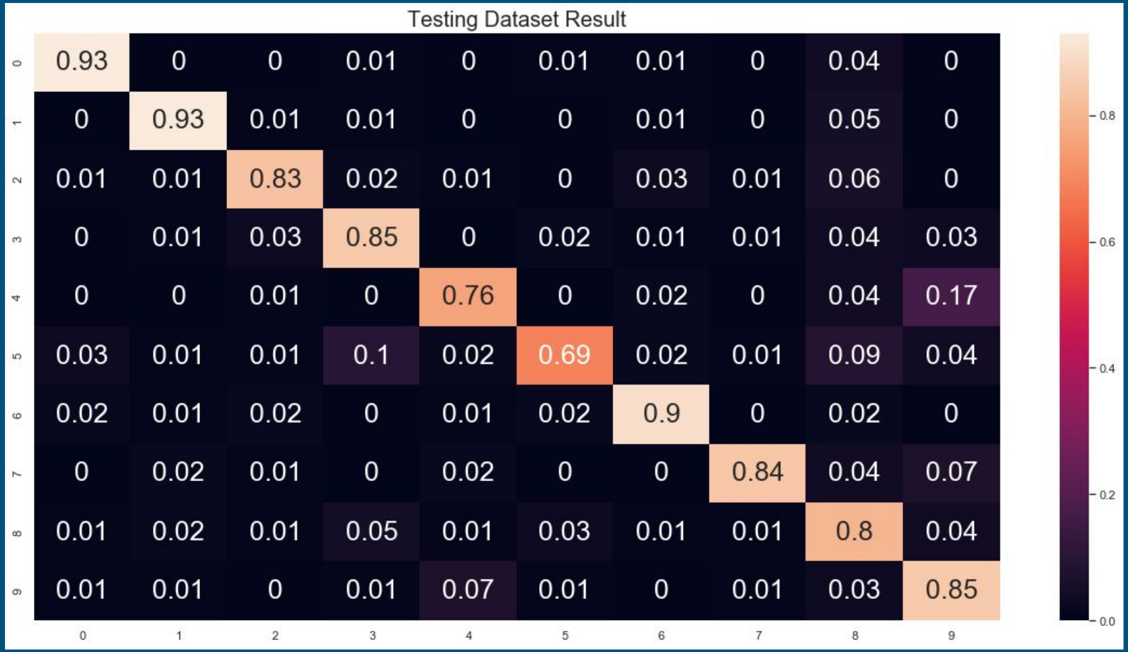
- Parameters
  - Mean
  - Variance
- 4 ⇒ 9
- 5 ⇒ 3

Multivariate Gaussian NB Version 2



- Parameters
  - Mean
  - Covariance matrix

Binomial NB



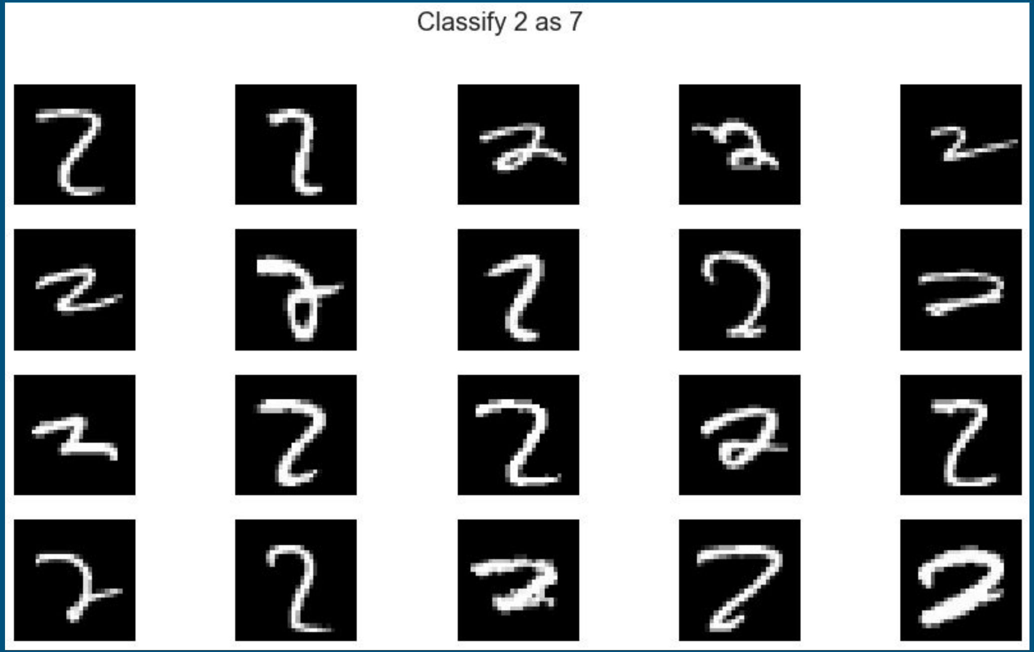
- Parameters
  - Frequencies of 1
  - Frequencies of 0

Comparison Table

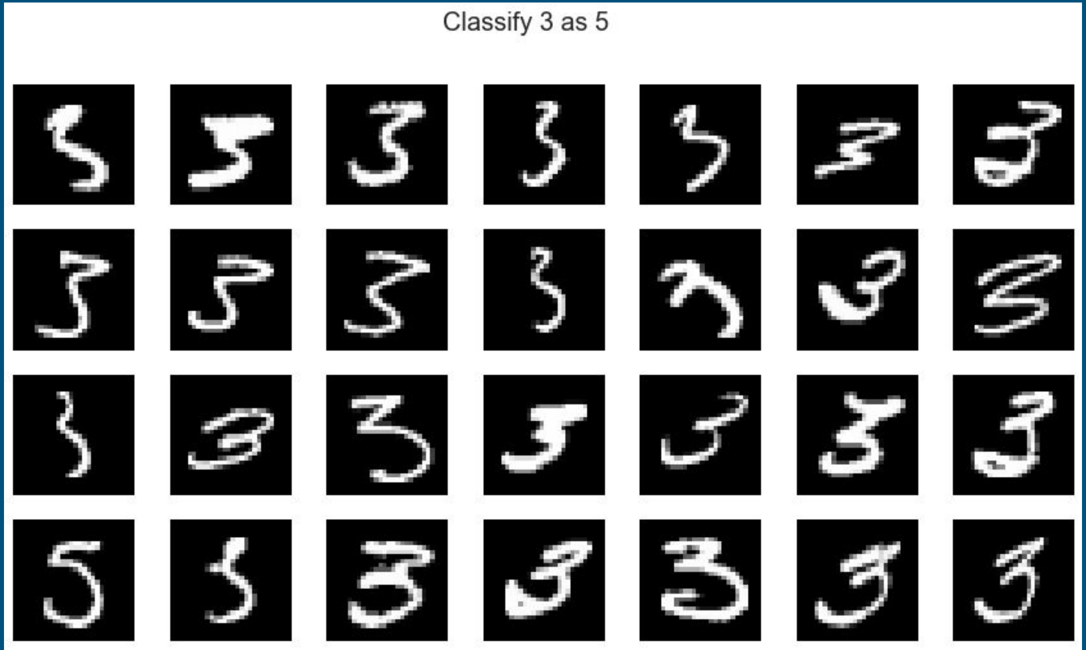
Model	**Train acc**	**Val acc**	**Test acc**
MVGNB 1	80.4%	80.4%	81.7%
BNB	82.7%	82.7%	83.8%
MVGNB 2	**95.9%**	**95.3%**	**95.4%**

- Best model: MVGNB 2

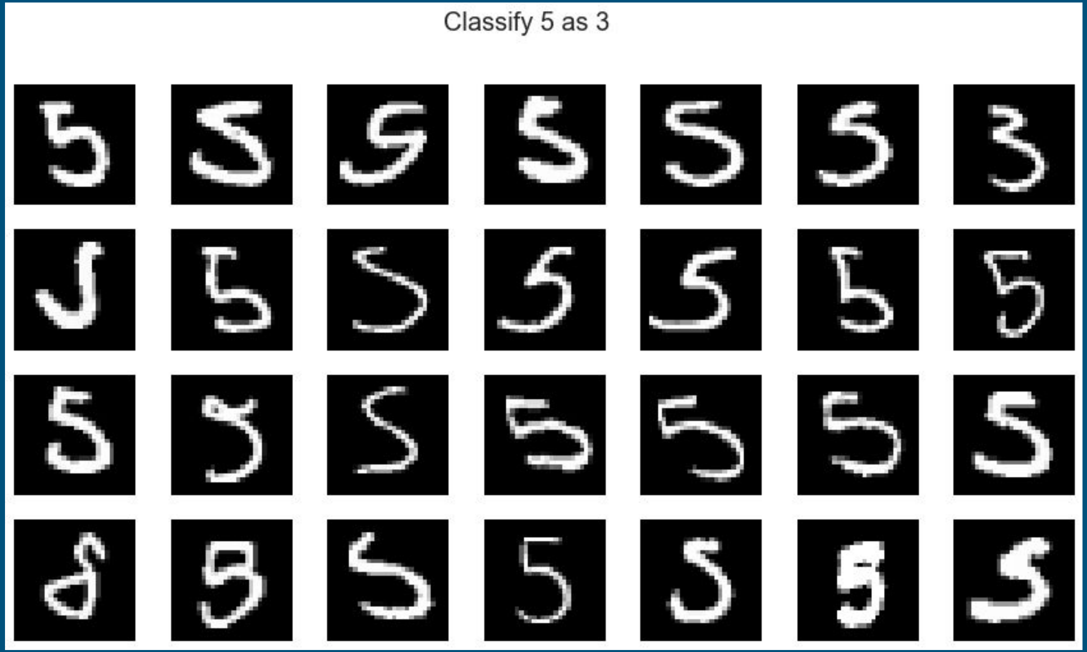
Misclassified Data ($2 \Rightarrow 7$)



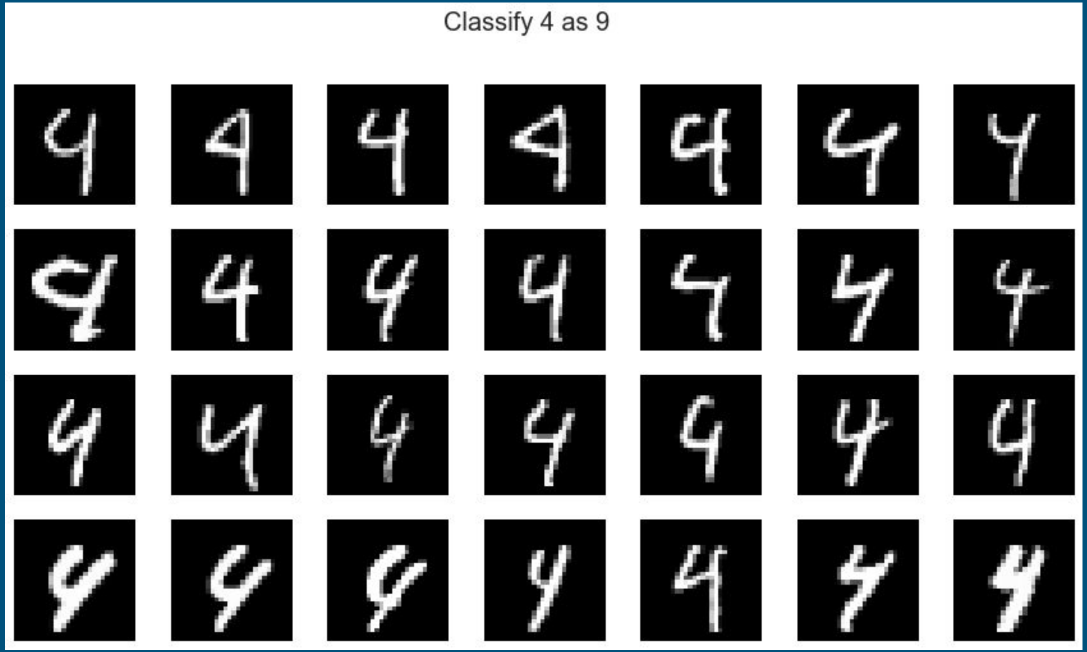
Misclassified Data ($3 \Rightarrow 5$)



Misclassified Data ($5 \Rightarrow 3$)



Misclassified Data ($4 \Rightarrow 9$)



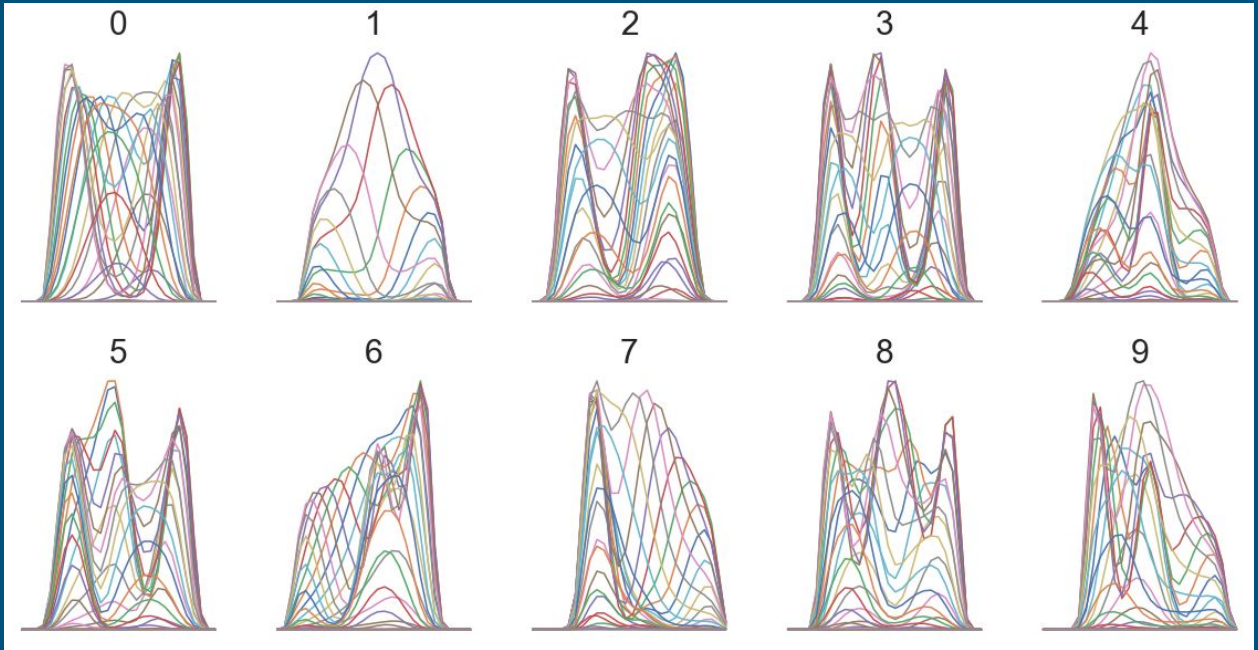
Summary

- Usage of digit classifier
- Insights of parameters
- Best: MVGNB 2
- Misclassification
- Next
  - Digitize receipts
  - Study receipts
  - Advanced model
  - Automate digital process

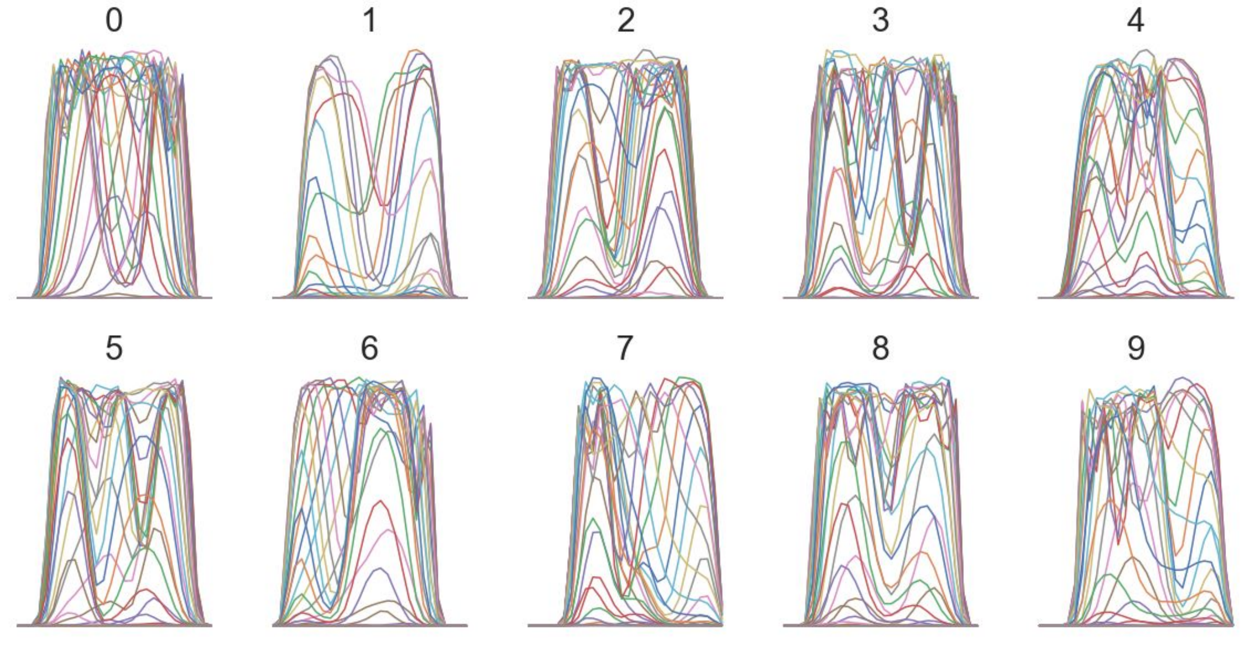
Q&A

Appendix: for Technicians

Data Visualization (Means 3D)



Data Visualization (Variances 3D)



Algorithm

- **What it does: given a sample predict its category.**
- **$P(y|X) \propto \text{argmax}\{P(X|y)P(y)\}$** respect to y
- **X** represents a sample with **F** features, **F = [f1, f2, f3, f4, fF]**
- **y** represents a category.
- **P(y)** is the prior.
- Choose a model for **P(X|y)**: Gaussian, Binomial, etc
- For each category **k**:
  1. Calculate its **P(y)** where **P(y)=(#of samples in k)/(entire dataset)**
  2. Obtain **parameters** based on the selected model.
     a. If it's Gaussian, then (μ and σ^2) or (μ **and** Σ).
     b. If it's Binomial, then the **frequencies of ones** and **zeros**.
     c. Etc.

Multivariate Gaussian Version 1

- How to predict?
  - Given a sample: X
  - X = [x1, x2, x3, …, xi, …]
  - $gi(xi) = (2*pi*\sigma^2)^{-1/2}exp(-0.5*(xi-\mu i)^2/\sigma^2)$
  - P_k = ∏gi * prior_k
  - P = [P_0, P_1, … P_k …, P_9]
  - argmax(P)

Multivariate Gaussian Version 2

- How to predict?
  - Given a sample: X
  - X = [x1, x2, x3, …, xi, …]
  - For each category k
  - g_k(X) = det(∑_k)$^{-1/2}$(2*pi*)$^{-D/2}$exp(-0.5*(X-μ_k)^{T}∑_k(X-μ_k))
  - P_k = g(X) * prior_k
  - P = [P_0, P_1, … P_k …, P_9]
  - argmax(P)

Binomial

- Learned parameters: frequencies of 1s and 0s
- p denotes as the probability of 1
- P(y|X) = p^X(1-p)^(1-X)
- How to predict?
  - Given a sample: X
  - X = [0, 1, 1, 0, 1, … xi …, 1]
  - P_k = p^X(1-p)^(1-X)*prior_k
  - P = [P_0, P_1, … P_k …, P_9]
  - argmax(P)