Digits Recognizer

Group 2
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The Handwritten Digits

They are originally from the MNIST database.

- 60000 training data
- 10000 test data

Now, it is a competition on the Kaggle.

- 42000 training data
- 28000 test data

Information

- Images contain 28×28 pixels.
- There are 784 independent variables.
- The response labels the real values of images.

Table: Frequency of Digits

digit	0	1	2	3	4
freq.	4132	4684	4177	4351	4072
digit	5	6	7	8	9
freq.	3795	4137	4401	4063	4188

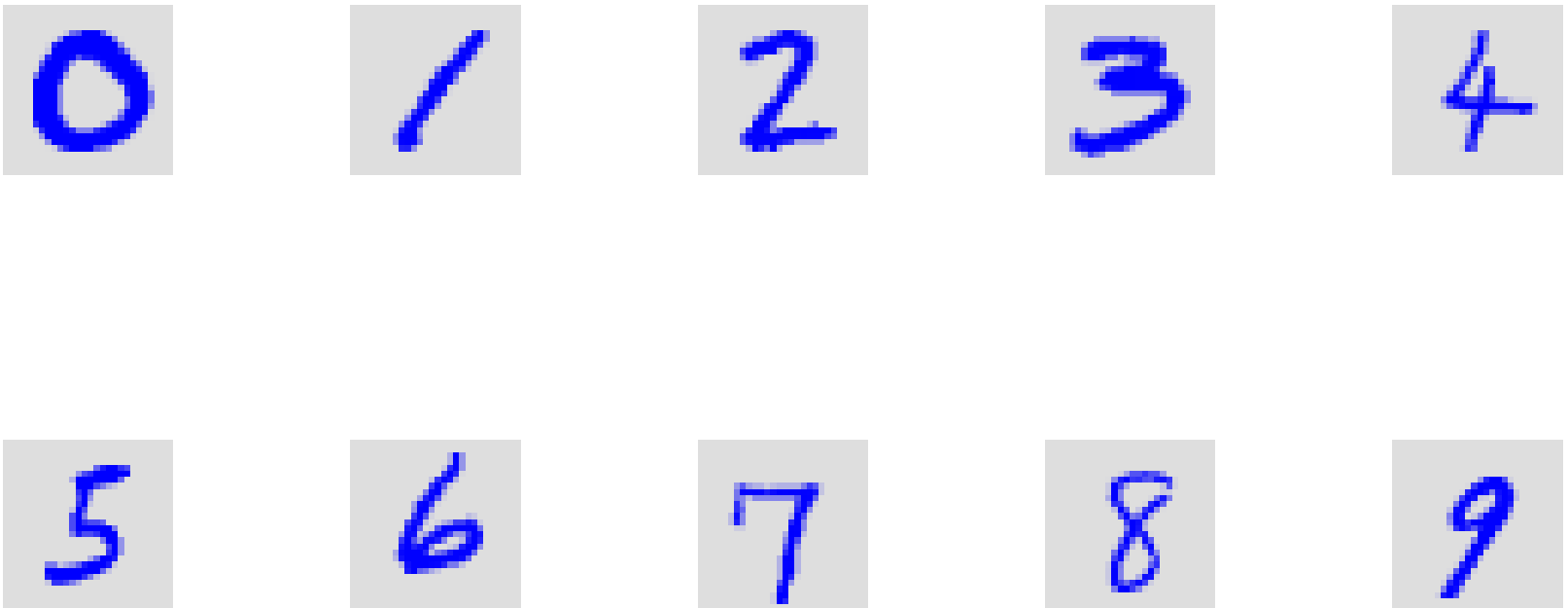
Representation

The function, f transfers an observation with 784 variables into an 28×28 image matrix.

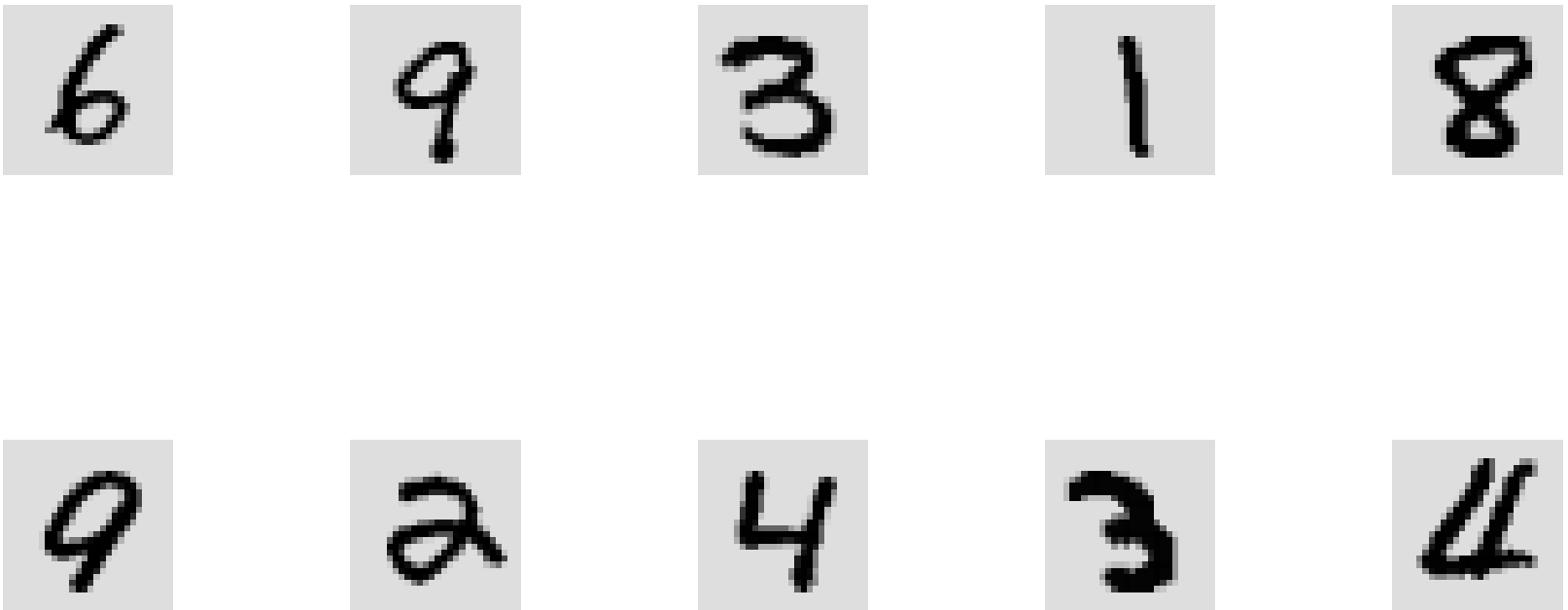
$$f : \mathbb{R}^{784} \rightarrow M_{28 \times 28}$$

$$M = \begin{bmatrix} \text{pixel}_{000} & \text{pixel}_{001} & \cdots & \text{pixel}_{027} \\ \text{pixel}_{028} & \text{pixel}_{029} & \cdots & \text{pixel}_{055} \\ \vdots & \vdots & \ddots & \vdots \\ \text{pixel}_{756} & \text{pixel}_{757} & \cdots & \text{pixel}_{783} \end{bmatrix}_{28 \times 28}$$

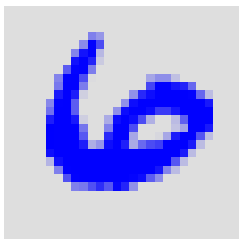
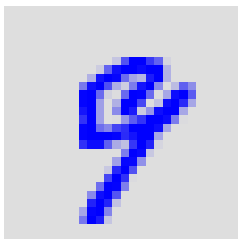
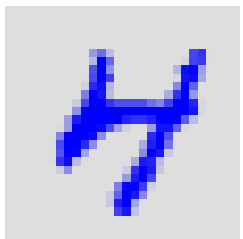
Images from the Training Data



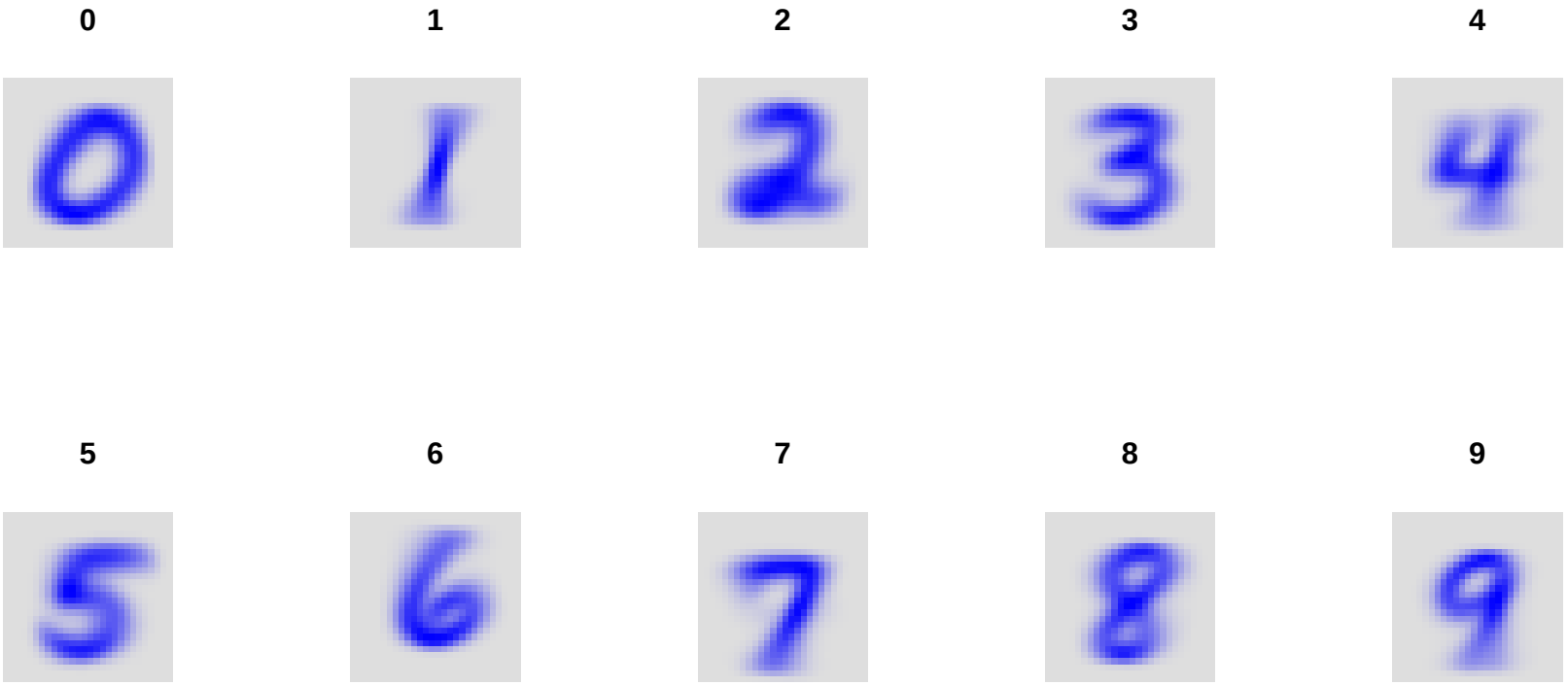
Images from the Test Data



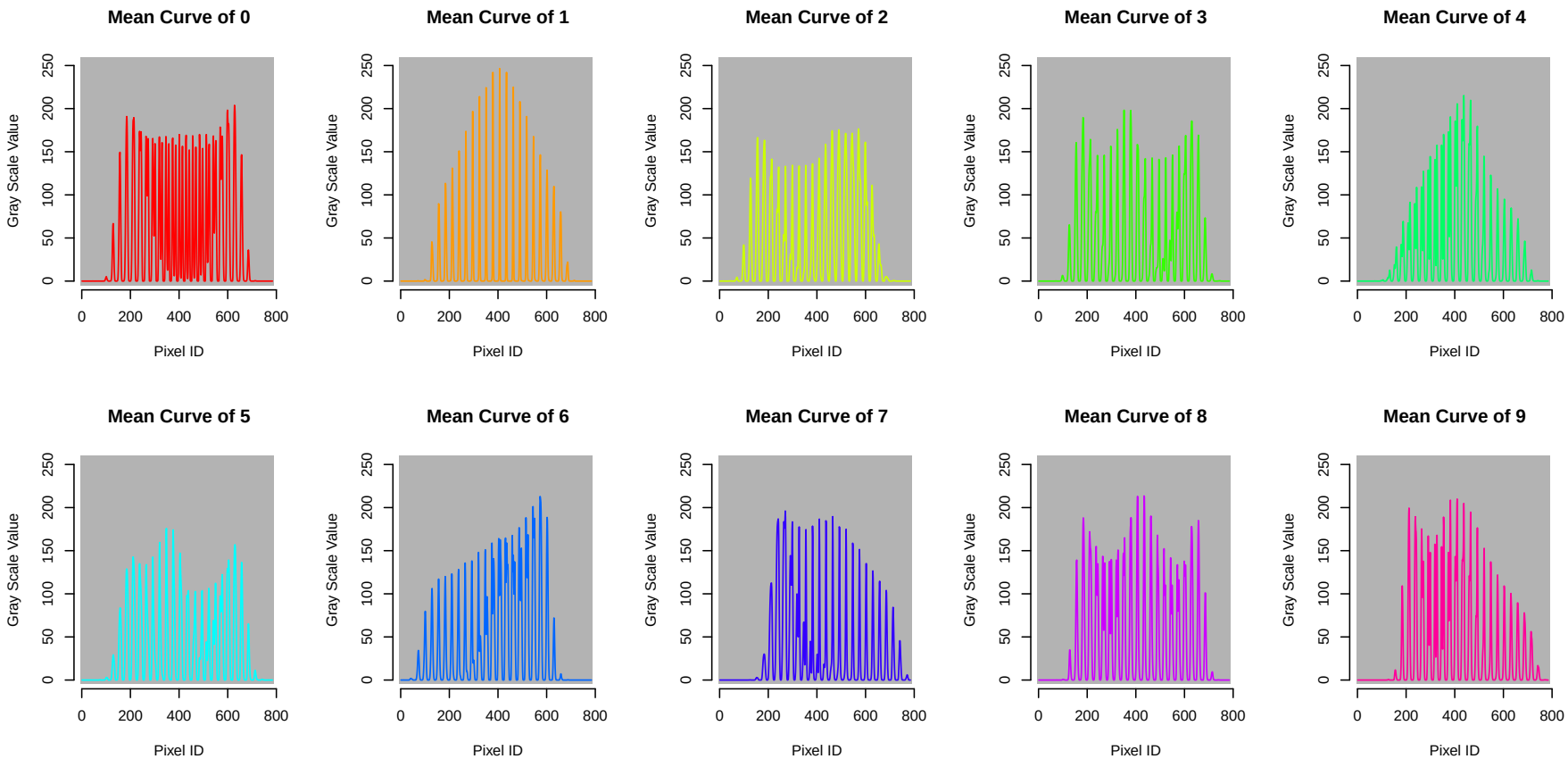
Some Naked-eyed Unrecognizable Images

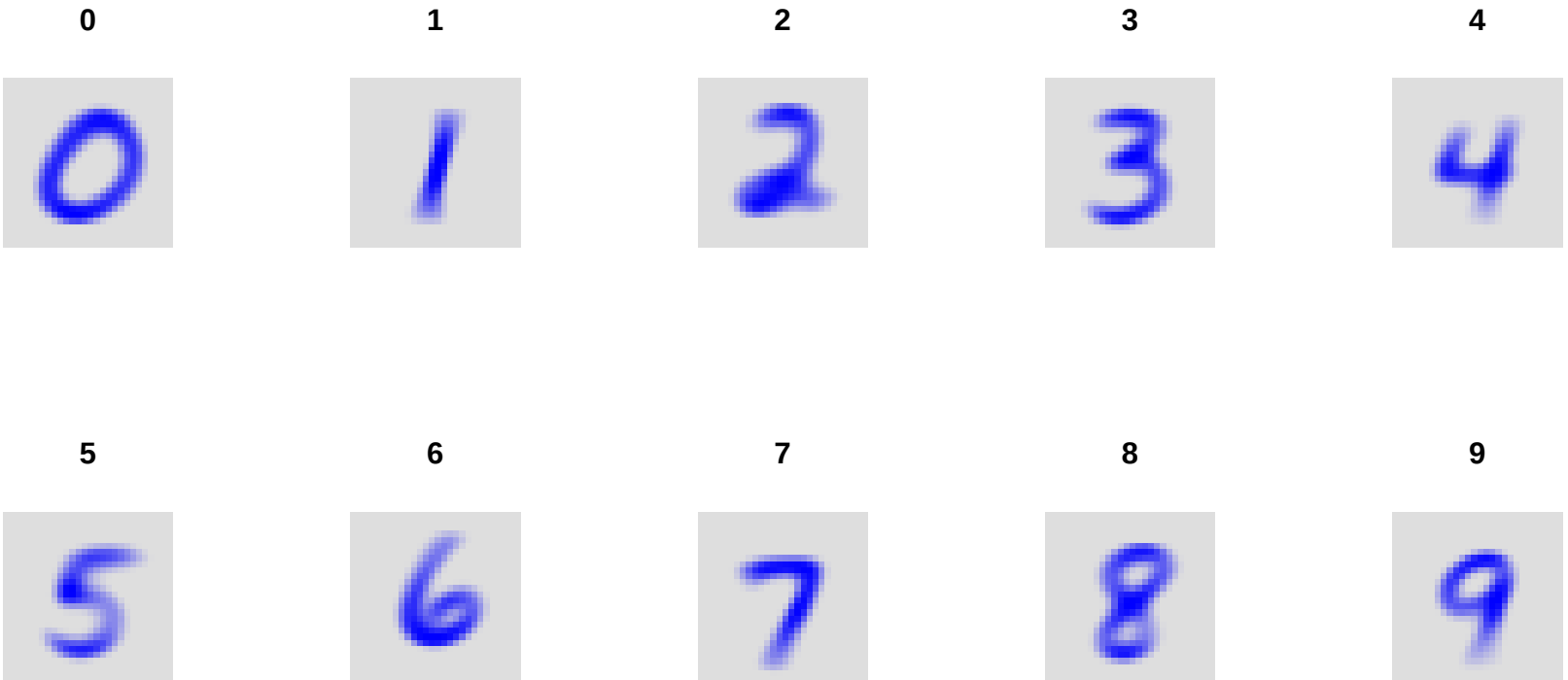
The Mean Images of the Different Digits



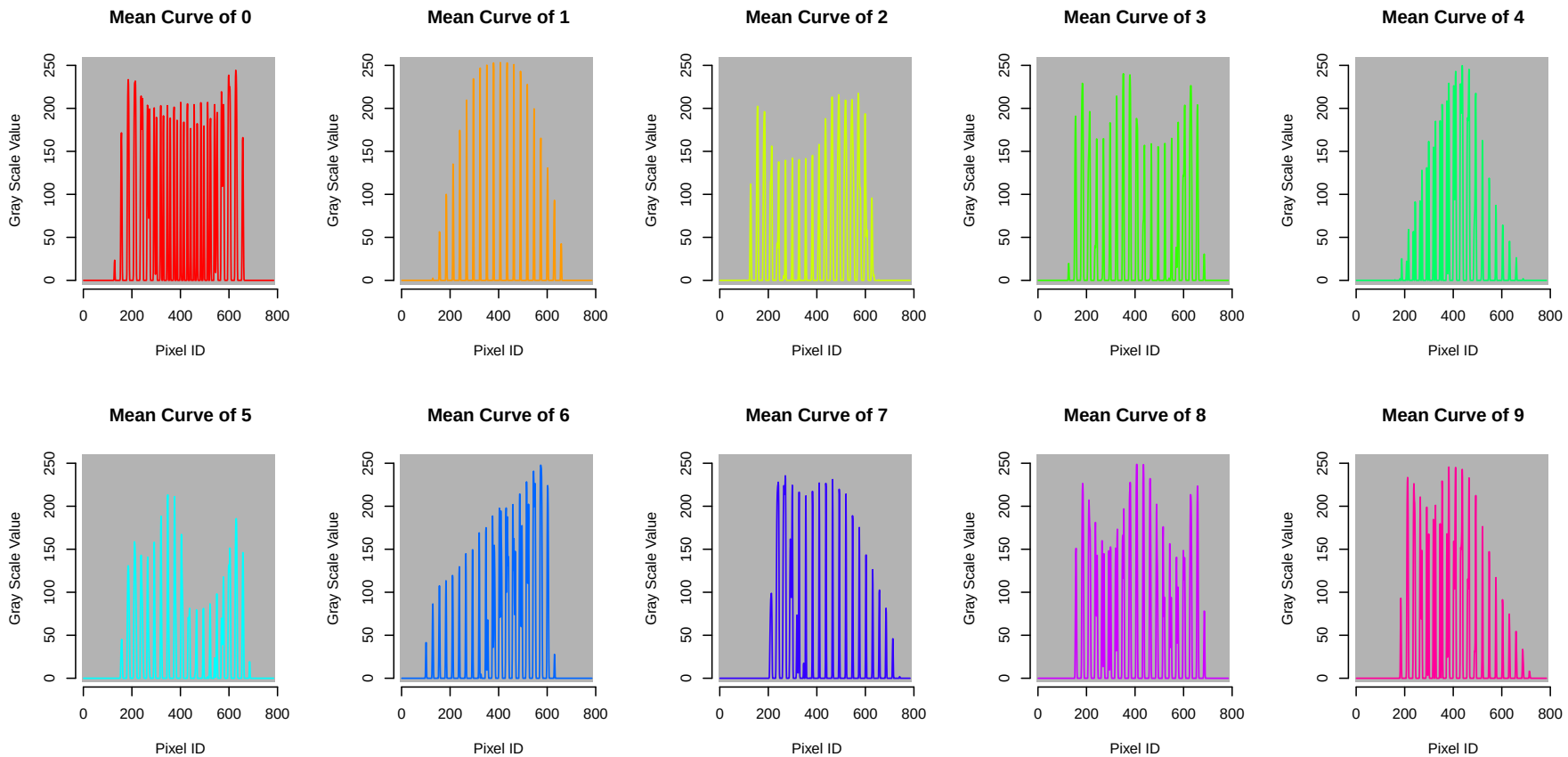
The Mean Curves of the Different Digits



The 20% Trimmed Mean Images of the Different Digits



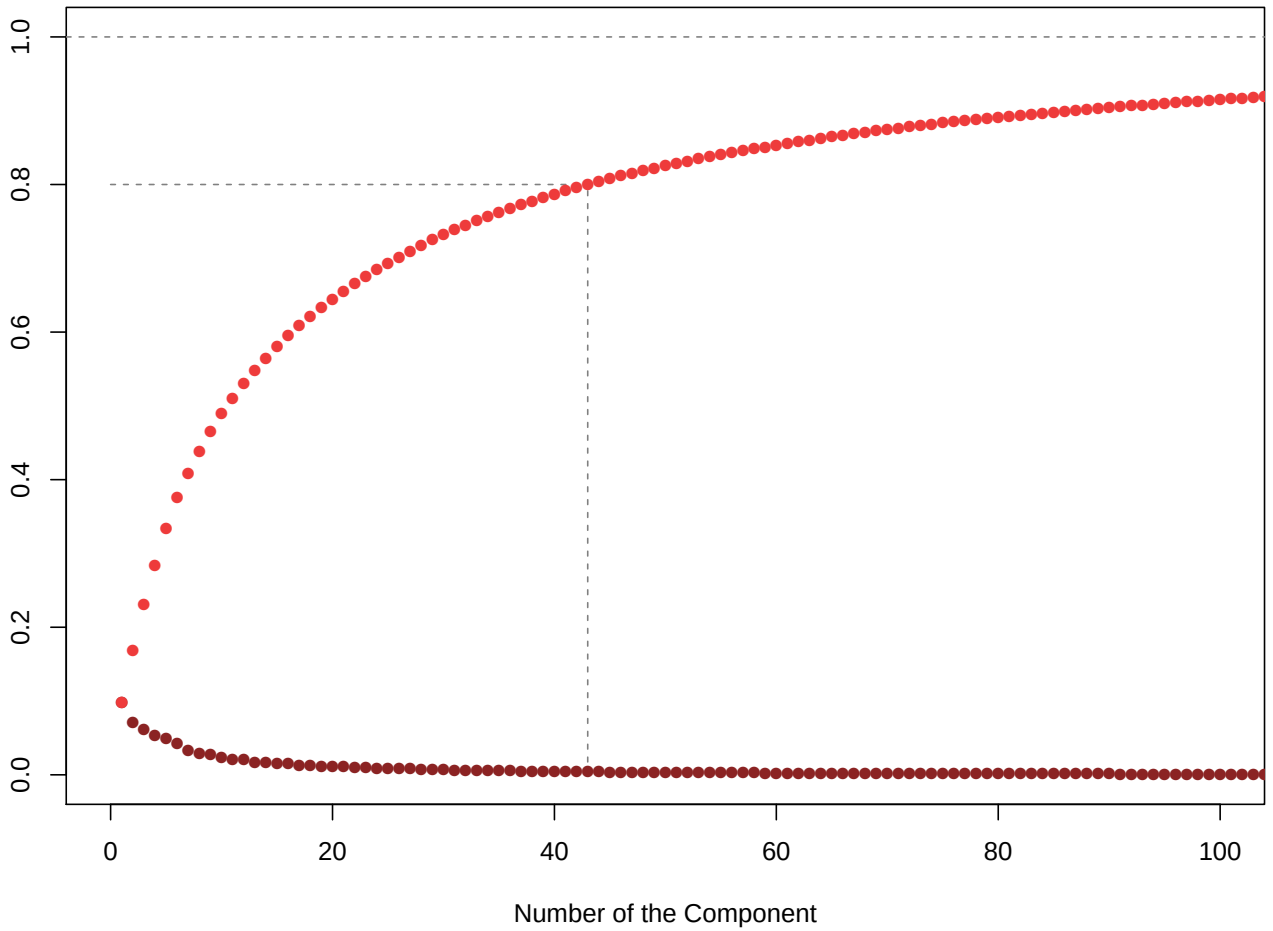
The 20% Trimmed Mean Curves of the Different Digits



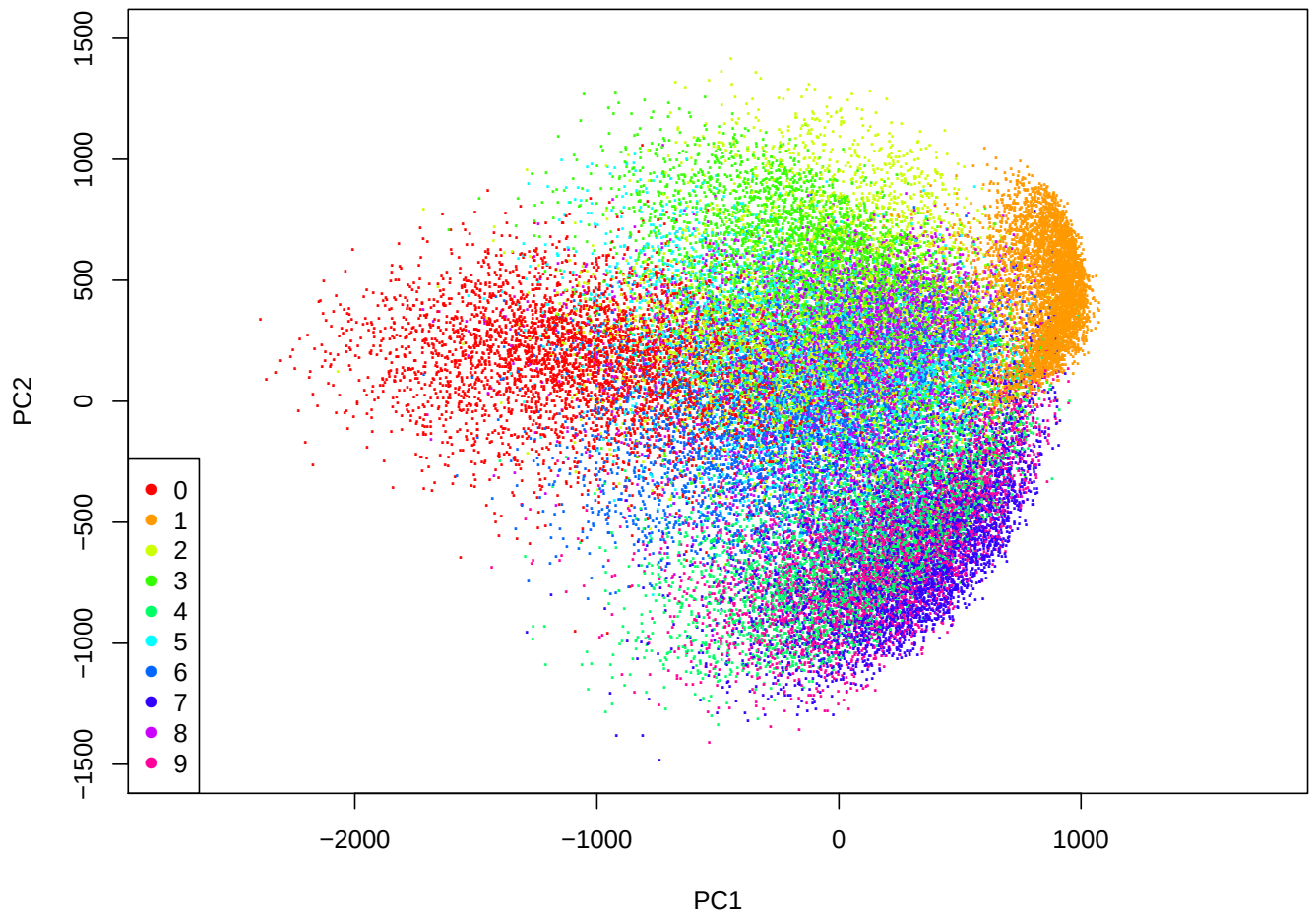
Coefficients for the Principal Component

	PC1	PC2	$\cdots$	PC43	$\cdots$	PC784
$pixel_0$	0.000	0.000	$\cdots$	0.000	$\cdots$	0.000
$pixel_1$	0.000	0.000	$\cdots$	0.000	$\cdots$	-0.072
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\ddots$	$\vdots$
$pixel_{462}$	0.075	-0.013	$\cdots$	0.059	$\cdots$	0.000
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\ddots$	$\vdots$
$pixel_{783}$	0.000	0.000	$\cdots$	0.000	$\cdots$	0.000
Variance	5.149	3.781	$\cdots$	0.221	$\cdots$	0.000
Cumulative Ratio of Total Variance	0.098	0.169	$\cdots$	0.800	$\cdots$	1.000

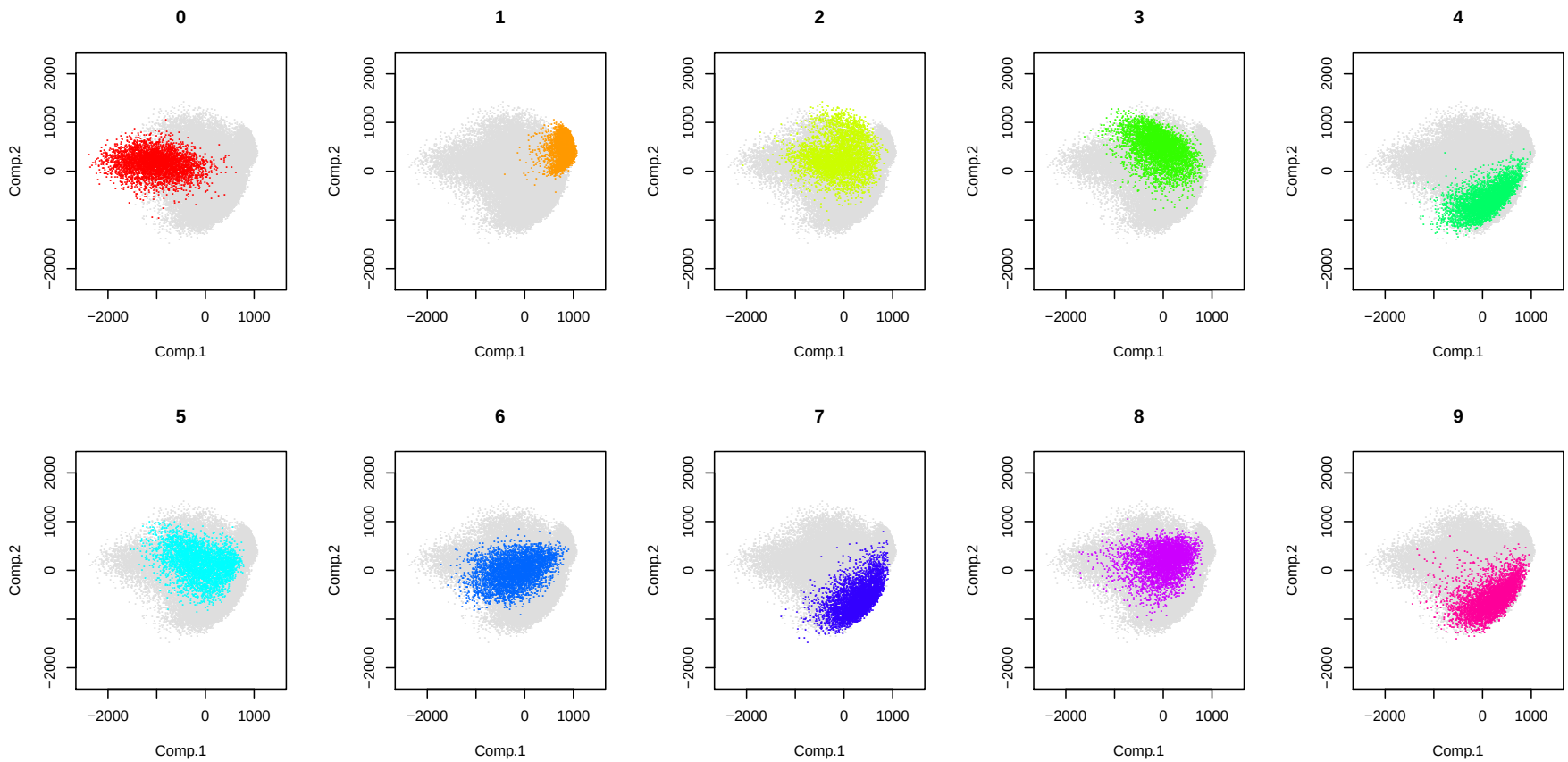
Cumulative Ratio of Total Variance



Scatter Plot for the First Two Components



Separated Scatter Plot for the First Two Components



Models

- One-Versus-All Logistic Regression
- PC One-Versus-All Logistic Regression
- K-Nearst Neighbors Classifier (KNN)
- Random Forest
- Support Vector Machine (SVM)
- Convolutional Neural Network (CNN)

Example

- `http://myselph.de/neuralNet.html`
- Neural Network Model
- Trained with Matlab and Displayed in JavaScript
- 3 msec
- 1.92% error rate

Plans

Plan A Calculate on JavaScript (Less Time Complexity)

Plan B Front-End + LAMP + R (More Time Complexity)

Plan C Front-End + PHP + Cloudinary + R

Thank you for listening.