1. **Binarisation Threshold:**

Feature vectors generated using height, radial, grayscale, density, line and vietoris-rips filtration and persistent entropy vectorization. Data was normalized before classification.

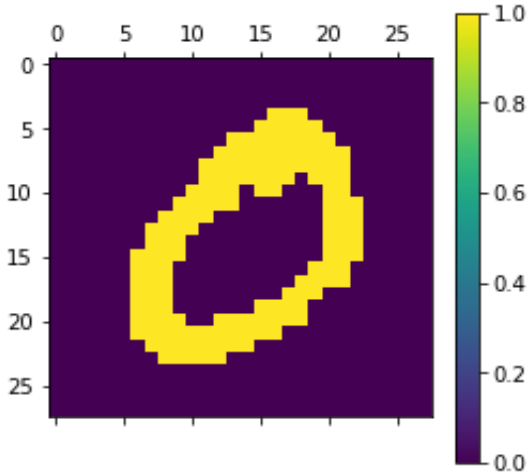
Training data: (50000, 52) and Test data: (10000, 52)

Classifier: Random Forest with number of trees = 1000 and random state = 31415

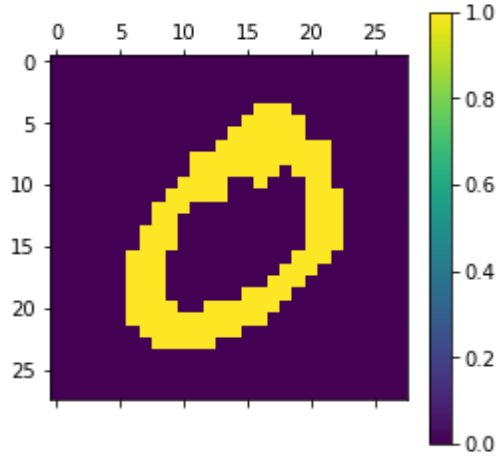
Binarizing threshold	Mismatch	Accuracy
0.5	391	96.09
0.4	385	96.15
0.3	379	96.21
0.2	352	96.48

Images for different threshold:

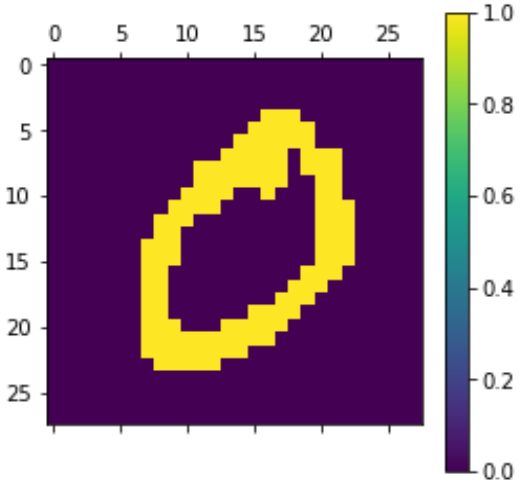
0.2



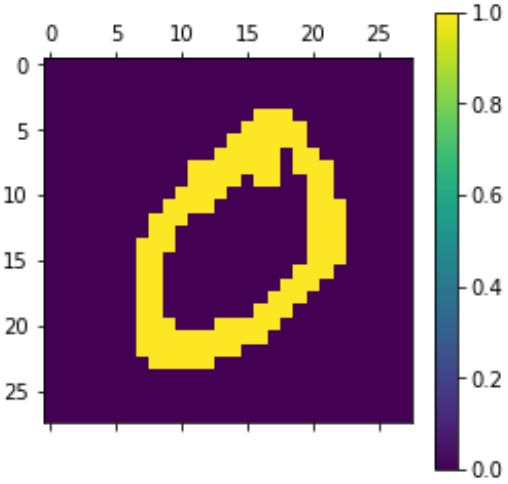
0.3



0.4



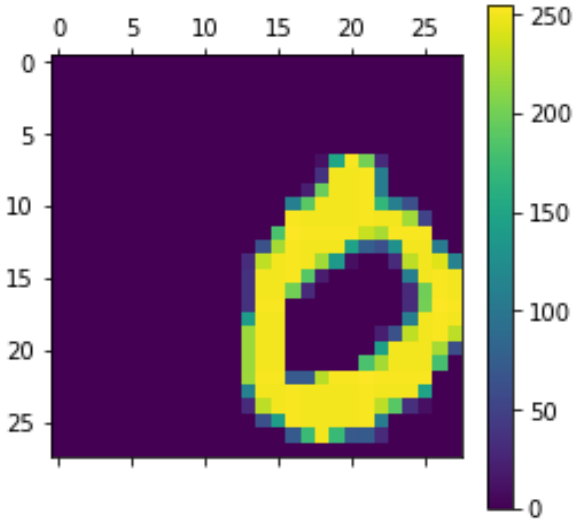
0.5



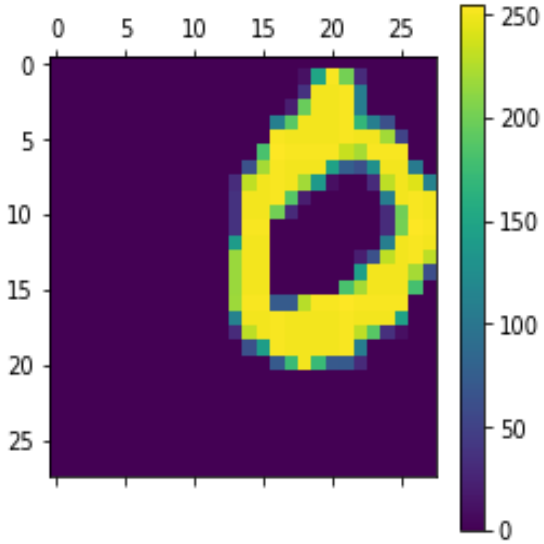
For a binarisation threshold of 0.2 the accuracy of classification with Random Forest Classifier for training with 60,000 images and testing on 10,000 images (without normalization) is **96.4.**

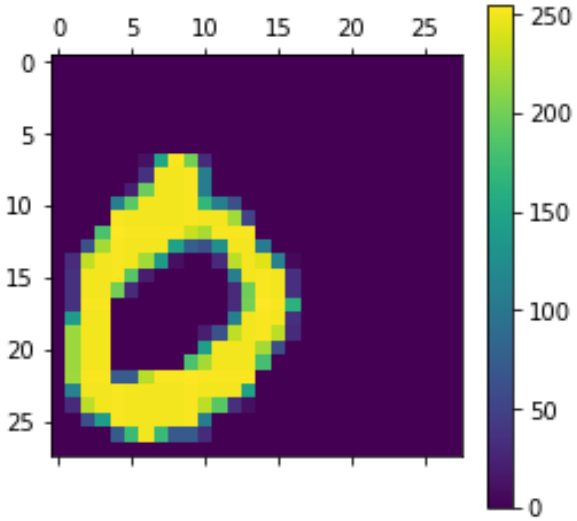
2. Translated Images:

(6,3)

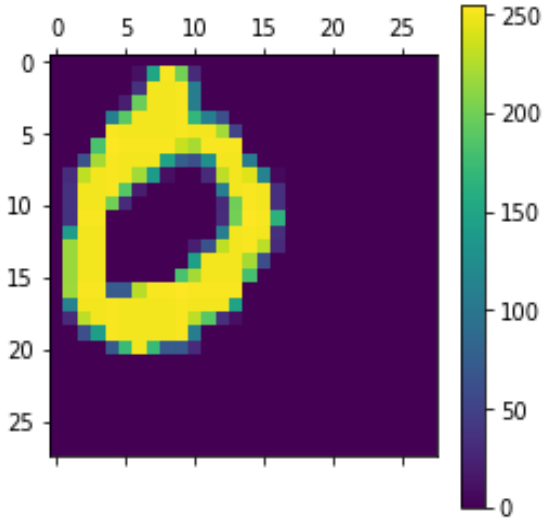


(6, -3)





(-6,3)



(-6,-3)

Feature vectors: Height, Radial, Grayscale, Density, Line and Vietoris-Rips filtrations and persistent entropy vectorisation

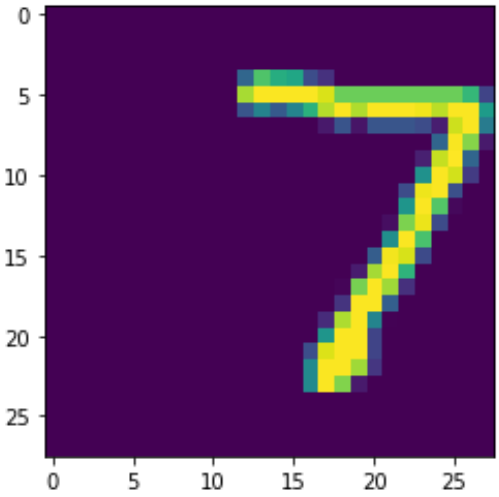
Training: (60000,52) ; No manipulation of images done on training dataset

Test: (3000, 52)

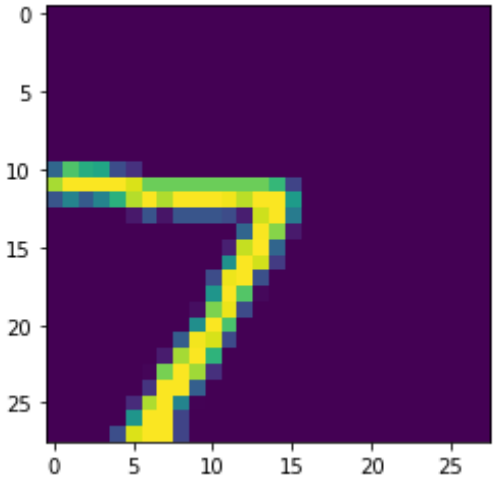
Test	Mismatch (/3000)	Accuracy
No change	135	95.5
Translation: (6,3)	648	78.4
Translation: (6,-3)	633	78.9
Translation: (-6,3)	589	80.36667
Translation: (-6,-3)	577	80.76667

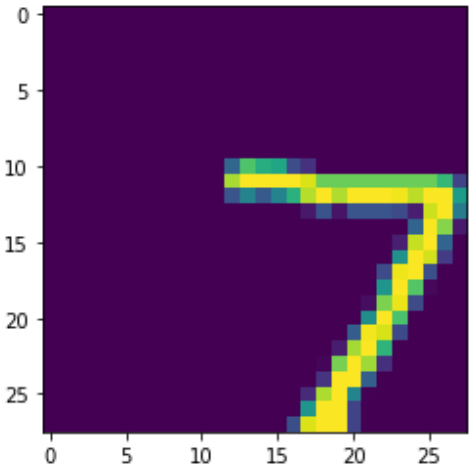
Examples of misclassifications on transforming image:

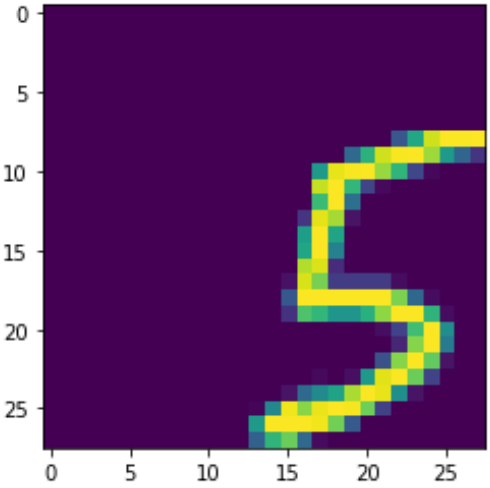
classification : 9



classification: 9



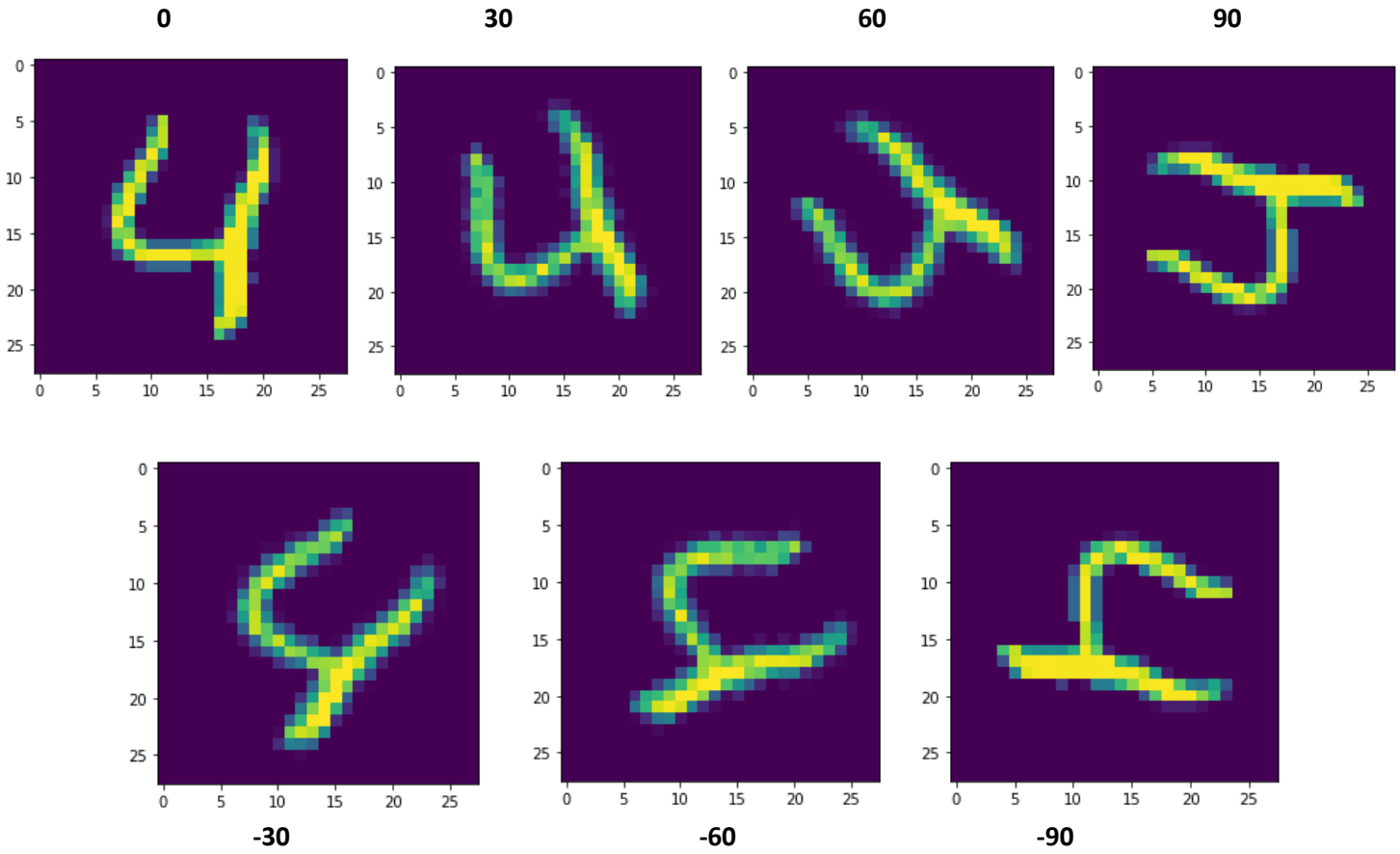




classification: 9

classification: 2

3. Rotated Images:



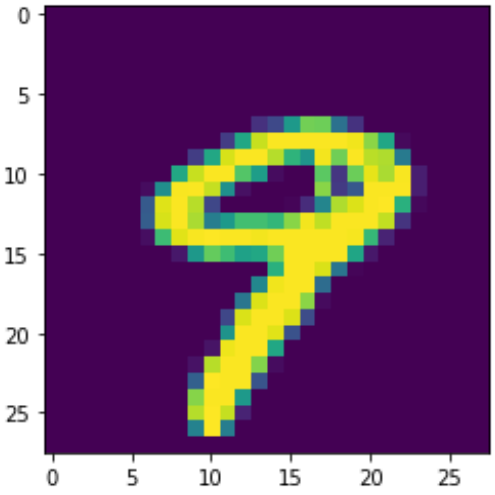
Feature vectors: Height, Radial, Grayscale, Density, Line and Vietoris-Rips filtrations and persistent entropy vectorization.

Training: (60000,52) ; No manipulation of images done on training dataset

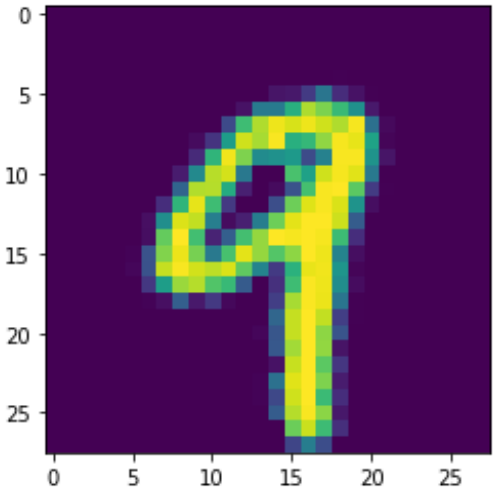
Test: (3000, 52)

Rotation Angle	Mismatch (/3000)	Accuracy
0	135	95.5
30	596	80.13333
60	822	72.6
90	879	70.7
-30	603	79.9
-60	852	71.6
-90	936	68.8

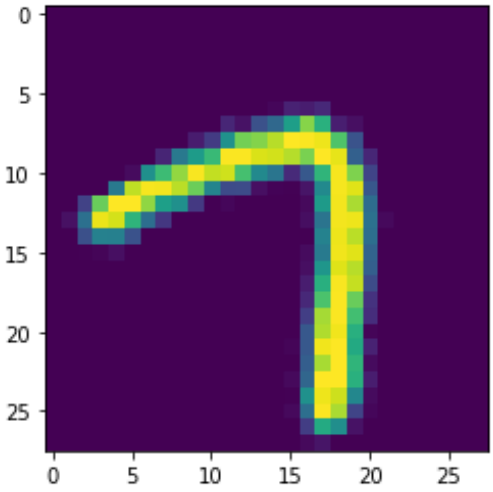
Examples of misclassification on rotation of images:



Angle = 0 ; classification: 9



Angle = 30; classification: 8



Angle = 30 ; classified: 9

4. **<u>Classification using k-NN:</u>**

Train Data: Binarisation threshold = 0.2 ; dim = (60000,52) ; Filtrations: Height, Radial, Grayscale, Density, Line, VR ; Vectorisation: Persistent Entropy. Data was normalized before performing UMAP.

Test: dim = (10000,52)

UMAP was performed on the data to reduce the dimension to 2. The accuracy of k-NN classification with k = 5 is **90.82**.

5. **<u>Persistent Landscapes:</u>**

Train Data: Binarisation threshold = 0.2 ; dim = (60000,50) ; Filtrations: Height, Radial, Grayscale, Density,Line ; Vectorisation: Persistent Landscape

Test: dim = (10000,50). Accuracy of classification using Random Forest Classifier with 1000 trees : **94.92**.

6. Analysis with different vectorisations

Train Data: Binarisation threshold = 0.2 ; dim = (60000,202) ;

Filtrations: Height, Radial, Grayscale, Density, Line — Vectorisation: Persistent Landscape, Betti Curve, Persistent Entropy, Wasserstein.

Vietoris- Rips — Vectorisation: Persistent Entropy

Test: dim = (10000,202).

Accuracy of classification using Random Forest Classifier with 1000 trees : **97.16**

7. Translated Data

Test	Mismatch (/3000)			Accuracy		
	Combined Scaling	Scaling separately	No scaling	Combined Scaling	Scaling separately	No scaling
No change	101	117	100	96.63333333	96.1	96.6666667
Translation: (6,3)	915	263	910	69.5	91.23333333	69.6666667
Translation: (6,-3)	1081	250	1021	63.96666667	91.66666667	65.9666667
Translation: (-6,3)	1389	309	1377	53.7	89.7	54.1
Translation: (-6,-3)	558	208	526	81.4	93.06666667	82.4666667

8. Rotated Data

Rotation Angle	Mismatch (/3000)			Accuracy		
	Combined Scaling	Scaling separately	No scaling	Combined Scaling	Scaling separately	No scaling
0	101	117	100	96.63333333	96.1	96.6666667
30	633	635	476	78.9	78.83333333	84.1333333
60	1701	1715	1832	43.3	42.83333333	38.9333333
90	2078	2068	2421	30.73333333	31.06666667	19.3
-30	529	534	597	82.36666667	82.2	80.1
-60	1593	1612	1865	46.9	46.26666667	37.8333333
-90	2072	2061	2505	30.93333333	31.3	16.5