Assignment 1
Machine Learning in Robotics

Atussa Koushan - 03713848

June 2019

1 Estimating velocity motion model of a mobile robot through linear regression

In this exercise linear regression is used to learn the input, output mapping of a mobile robot where the inputs are velocity v and angular velocity w and the output is the pose x, y and θ. Furthermore, k-fold cross validation with $k = 5$ is used to avoid over fitting of the data.

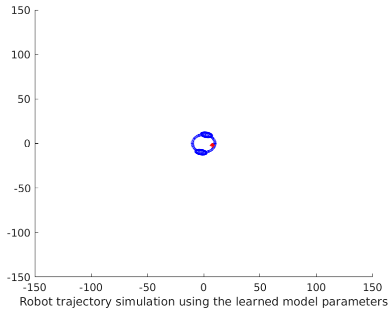
The polynomial of the mapping is varied from 1 to 6. p_1 is the polynomial order used to estimate the position (x, y) and p_2 is the polynomial order used to estimate the orientation θ.

a) The optimal polynomial orders were found to be $\mathbf{p_1 = 4}$ and $\mathbf{p_2 = 1}$.

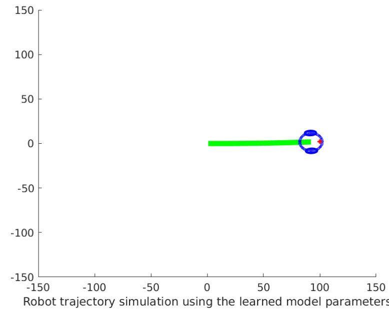
b) Learned parameter values are shown in table 1 where a_1 and a_2 contain the parameters for the position estimation and a_3 contains the parameters for the orientation estimation.

a_1	a_2	a_3
0.0025	-0.0043	0.0008
0.9198	-0.0010	-0.0003
-0.0029	0.0014	0.9987
-0.0007	0.4680	0.0003
-0.0010	0.0006	
0.0014	-0.0025	
0.0025	-0.0010	
0.0001	1.9246	
-0.0003	-0.0017	
6.693e-05	-0.0007	
1.306e-05	-7.8462	
-0.0043	0.0035	
-4.517e-05	8.716e-06	

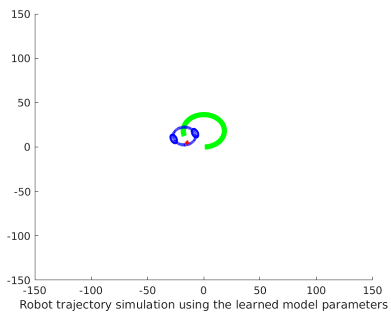
Table 1: Learned parameters for input, output mapping



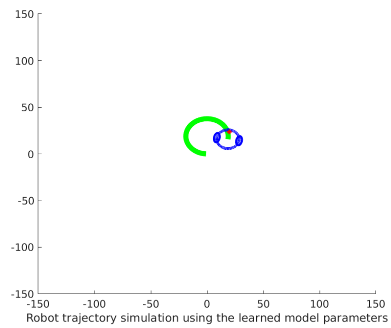
(a) $(v, w) = (0, 0.05)$



(b) $(v, w) = (1, 0)$



(c) $(v, w) = (1, 0.05)$



(d) $(v, w) = (-1, -0.05)$

Figure 1: Simulated robot trajectories based on learned dynamics

c) Figure 1 shows a visualization of the learned dynamics for four different combinations of velocity and angular velocity.

2 Handwritten digits classification using Bayesian classifier

The goal of this exercise is to classify handwritten digits (0-9) using a Bayesian classifier. Since the dimension of an image is quite big, the data is projected onto a smaller dimension using PCA before it is classified.

Dimensions between 1 and 60 are tested, whereas $\mathbf{d} = \mathbf{48}$ results in the lowest classification error on the test set. The corresponding classification error is $\mathbf{3.62}$. The corresponding confusion matrix is shown in figure 2.

A plot of the classification errors when varying d from 1 to 60 is shown in figure 3. From this figure it can be seen that the error is converging already at $d \approx 30$.

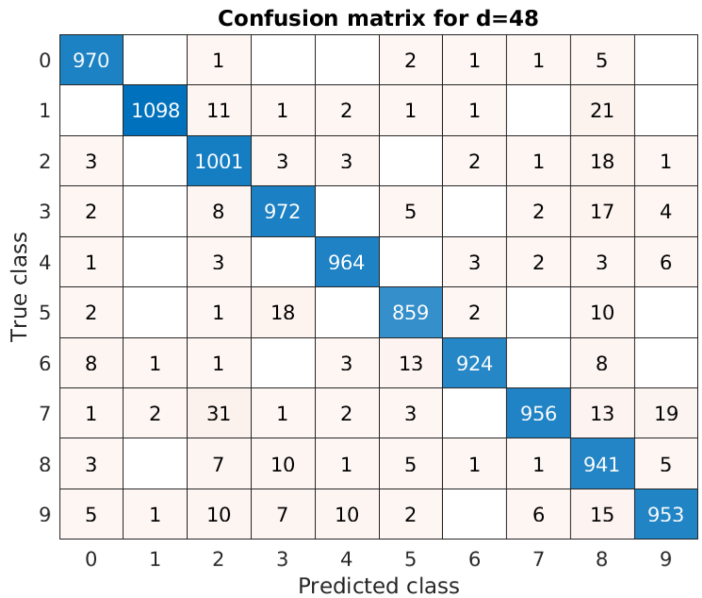


Figure 2: Confusion matrix for optimal d

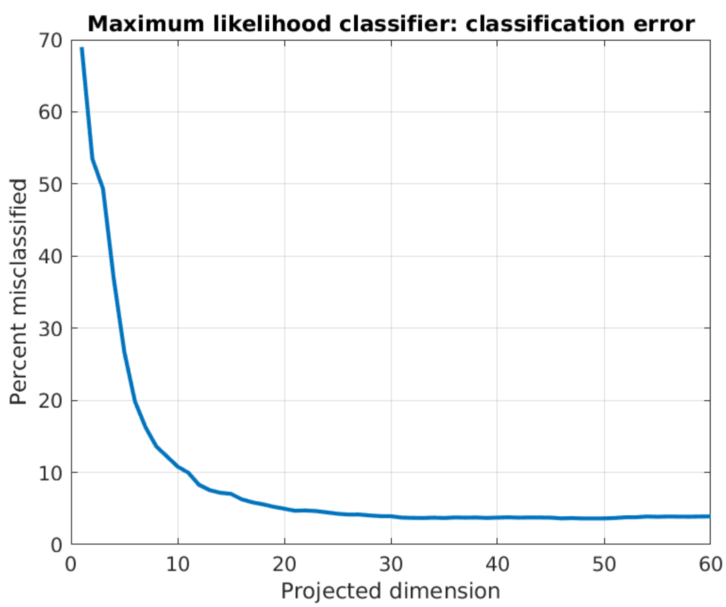
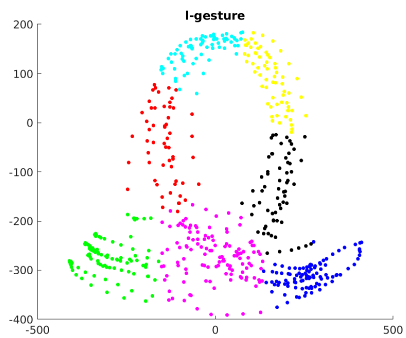
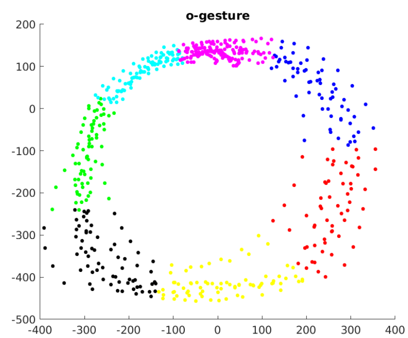


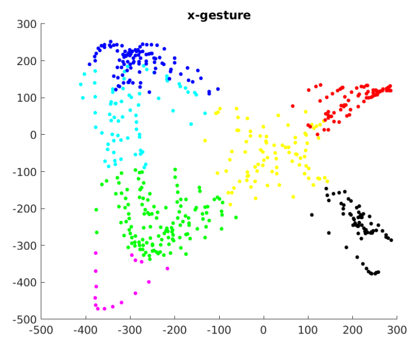
Figure 3: Plot of classification errors corresponding dimension d



(a)



(b)



(c)

Figure 4: Results of k-means algorithm clustering

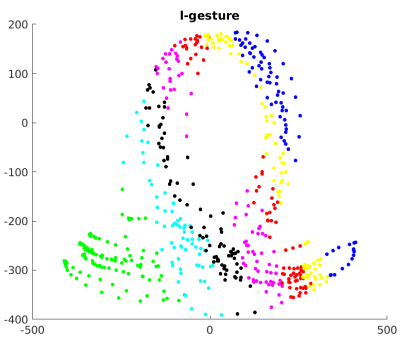
3 Human motion clustering

In this exercise motion data from a human is clustered into 7 clusters/classes using two different unsupervised clustering algorithms.

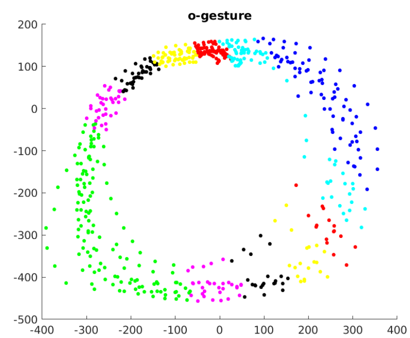
a) The results of the classification of the three gestures using the k-means algorithm are shown in figures 4a-4c.

b) The results of the classification of the three gestures using the non-uniform binary split algorithm are shown in figures 5a-5c.

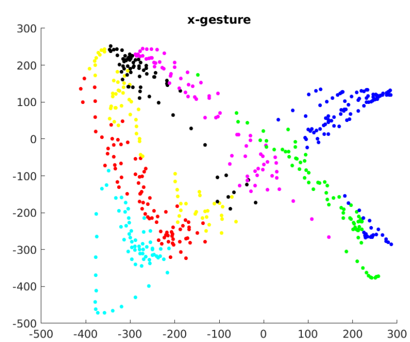
From these results it is clear that the k-means algorithm clusters the data more logically in this scenario as the clusters actually follow the given motions.



(a)



(b)



(c)

Figure 5: Results of non-uniform binary split algorithm clustering