

# Machine Learning for Robotics: Assignment 1

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# Chapter 1

## Assignment 1

### 1.1 Exercise 1

#### 1.1.1 Model parameters and complexity

Crossvalidation was done for  $k = 2$  and  $k = 3$ . The complexity resulting is shown in table ?? . The resulting model parameters are shown in 1.1 and 1.2.

$k$	$p_1$	$p_2$
2	5	3
5	4	1

Table 1.1: p values for optimization over k-fold

$$A_{k=2} = \begin{pmatrix} 0.0022 & -0.0027 & -0.0006 \\ 0.9217 & -0.0014 & -0.0002 \\ 0.0066 & -0.0115 & 0.9997 \\ -0.0016 & 0.473 & 0.0008 \\ -0.001 & 0.0002 & 0.0001 \\ 0.0025 & -0.0083 & 0.0018 \\ 0.0023 & 0.0001 & -0.0001 \\ 0 & 0 & 0 \\ -0.013 & 0.0164 & -0.0006 \\ 0.0001 & -0.001 & 0 \\ 0 & 0 & 0 \\ -0.0045 & 0.0043 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0.0026 & -0.0038 & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad (1.1)$$

$$A_{k=5} = \begin{pmatrix} 0.0025 & -0.0043 & 0.0008 \\ 0.9198 & -0.001 & -0.0003 \\ -0.0029 & 0.0014 & 0.9987 \\ -0.0007 & 0.468 & 0.0003 \\ -0.001 & 0.0006 & 0 \\ 0.0014 & -0.0025 & 0 \\ 0.0025 & -0.001 & 0 \\ 0.0001 & 0 & 0 \\ -0.0003 & -0.0017 & 0 \\ 0.0001 & -0.0007 & 0 \\ 0 & 0 & 0 \\ -0.0043 & 0.0035 & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad (1.2)$$

### 1.1.2 Robot simulations

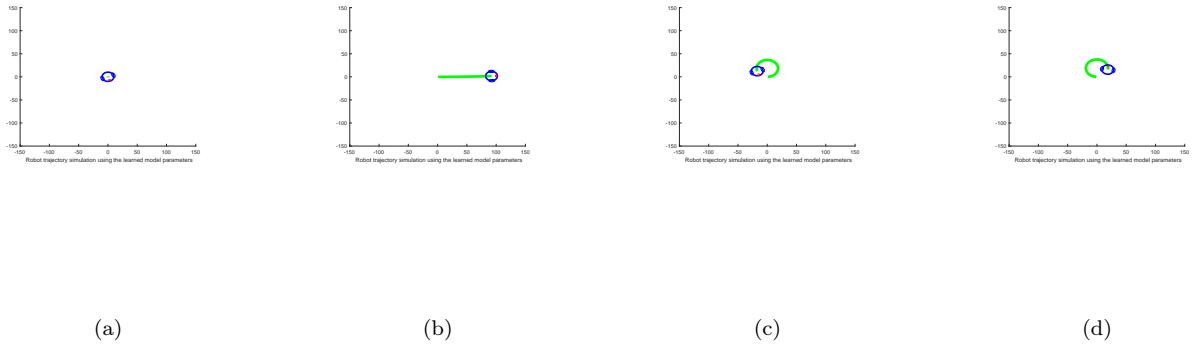


Figure 1.1: Simulated robot with learned parameters 1.2 for the control inputs  
a)  $v = 0$ ,  $w = 0.05$ , b)  $v = 1$ ,  $w = 0$ , c)  $v = 1$ ,  $w = 0.05$  and d)  $v = -1$ ,  
 $w = -0.05$

## 1.2 Exercise 2

The error decreases very fast with growing  $d$ . The lowest error is at  $d = 48$ . It is possible to use smaller  $d$  values, since it doesn't fall a lot after approximately 30. The classification error at  $d = 48$  is 3,62%.

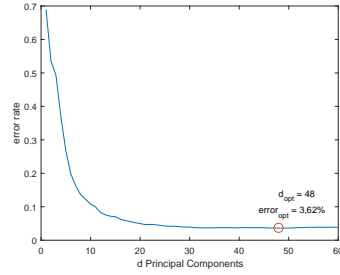


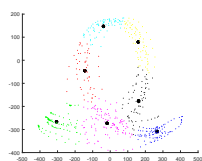
Figure 1.2: classification error with  $d$  principle components used for classification

Matrix 1.3 shows the confusion matrix of if the classification at  $d = 48$ .

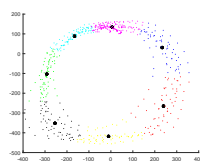
$$\begin{pmatrix} 970 & 0 & 1 & 0 & 0 & 2 & 1 & 1 & 5 & 0 \\ 0 & 1098 & 11 & 1 & 2 & 1 & 1 & 0 & 21 & 0 \\ 3 & 0 & 1001 & 3 & 3 & 0 & 2 & 1 & 18 & 1 \\ 2 & 0 & 8 & 972 & 0 & 5 & 0 & 2 & 17 & 4 \\ 1 & 0 & 3 & 0 & 964 & 0 & 3 & 2 & 3 & 6 \\ 2 & 0 & 1 & 18 & 0 & 859 & 2 & 0 & 10 & 0 \\ 8 & 1 & 1 & 0 & 3 & 13 & 924 & 0 & 8 & 0 \\ 1 & 2 & 31 & 1 & 2 & 3 & 0 & 956 & 13 & 19 \\ 3 & 0 & 7 & 10 & 1 & 5 & 1 & 1 & 941 & 5 \\ 5 & 1 & 10 & 7 & 10 & 2 & 0 & 6 & 15 & 953 \end{pmatrix} \quad (1.3)$$

## 1.3 Exercise 3

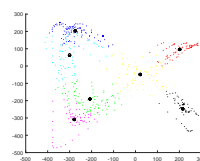
### 1.3.1 k-means



(a)

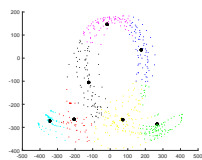


(b)

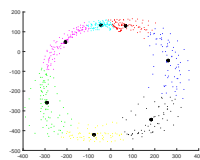


(c)

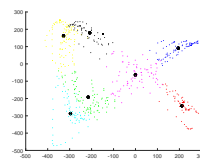
### 1.3.2 non uniform binary split



(a)



(b)



(c)