Human-centered Assistive Robotics Technische Universität München Prof. Dr.-Ing. Dongheui Lee	**MACHINE LEARNING IN ROBOTICS** Assignment 1

Exercise 3: *Human motion clustering*

Background

Learning by Demonstration (LbD) is a powerful tool widely used in robotics for acquiring new skills for robots. LbD has the advantage of learning new skills directly from demonstrations, this makes possible to avoid tedious hand programming of new tasks. Moreover, by the means of learning algorithm, the skill can be represented in a compact form reducing the amount of data to store.

LbD works in two steps. Firstly, an expert provides some demonstrations of a task to execute. There are two main ways to collect these demonstrations. The user can directly drive the robot from an initial configuration to the desired one (kinaesthetic teaching). Or, the user can execute the task several times while some sensors track its motion and collect data. Secondly, the demonstrations are encoded using machine learning algorithms. Gaussian Mixture Models (GMM) and Hidden Markov Models (HMM) have been widely used to encode robot's skills from demonstrations and to retrieve the desired trajectory.

The set of parameters needed by GMM or HMM is usually learned using an iterative optimization technique, the so-called Expectation Maximization algorithm. The results of the Expectation Maximization algorithm are on the initial guess of the parameters. Typically, unsupervised clustering algorithms are use to determine the initial parameters.

Task

In this exercise you have to implement in Matlab two unsupervised clustering algorithms, namely the K-means (without using the *kmeans* Matlab function) and the Non-Uniform Binary Split Algorithm. These algorithms will be used to cluster the data in *gesture_dataset.mat*. After loading this file you will get three $60 \times 10 \times 3$ matrices, called *gesture_l*, *gesture_o* and *gesture_x* respectively. Each matrix contains 10 repetitions of the same gesture. Each gesture consists of 60 3D positions (x, y and z) of the user's right hand. The dataset is shown in Figure 1.

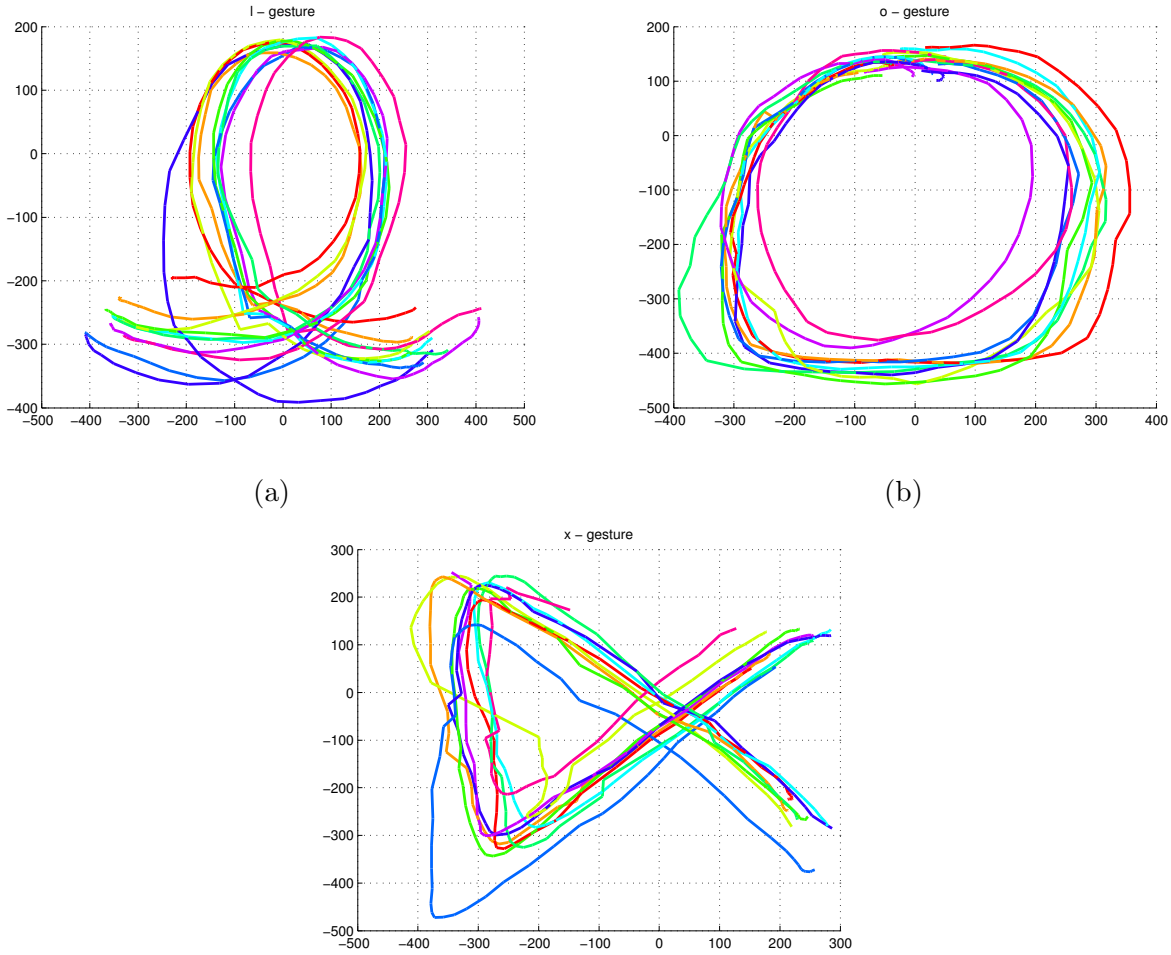
a) Classify each one of the 60 points in every trajectory in the dataset. Classify the points using the K-means ($k = 7$) algorithm, choosing the euclidean distance as distortion function. The initial cluster centers are provided into the *gesture_dataset.mat* as three 7×3 matrices (*init_cluster_l*, *init_cluster_o* and *init_cluster_x*). Run the algorithm until the decrement of the total distortion function is less than 10^{-6}.

b) Classify the dataset points using the Non-Uniform Binary Split algorithm ($k = 7$) using the same split vector $\mathbf{v} = [0.08,\ 0.05,\ 0.02]^T$ for each iteration.

For both algorithms, provide Matlab files and six figures (three for each question) in which the points belonging to different clusters are drawn with different colours. Use the mapping between clusters and colours provided in Table 1.

cluster	1	2	3	4	5	6	7
colour	blue	black	red	green	magenta	yellow	cyan

Table 1: Mapping between clusters and colours



(a) (b)

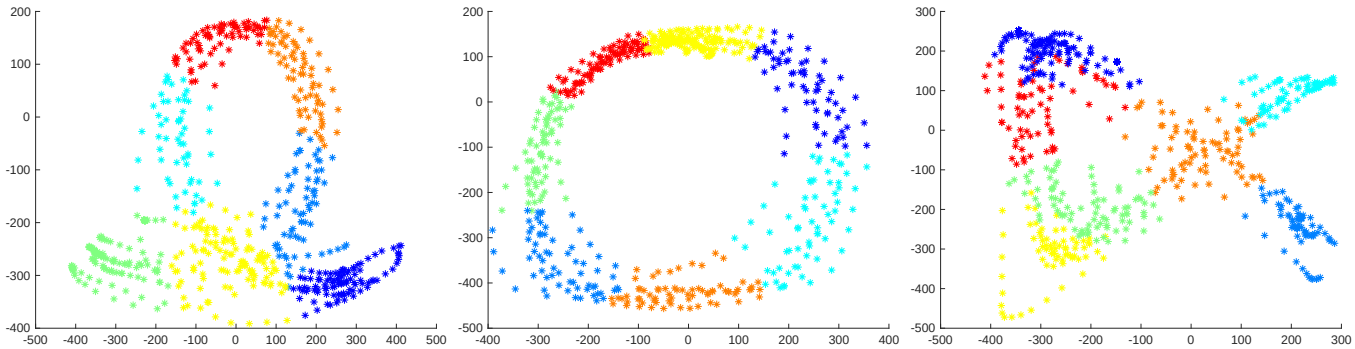
(c)

Figure 1: 2D plots of the datasets in Exercise 3

Solution 3: *Human motion clustering*

Keep in mind that the provided code is just one possible implementation and other implementations might exist.

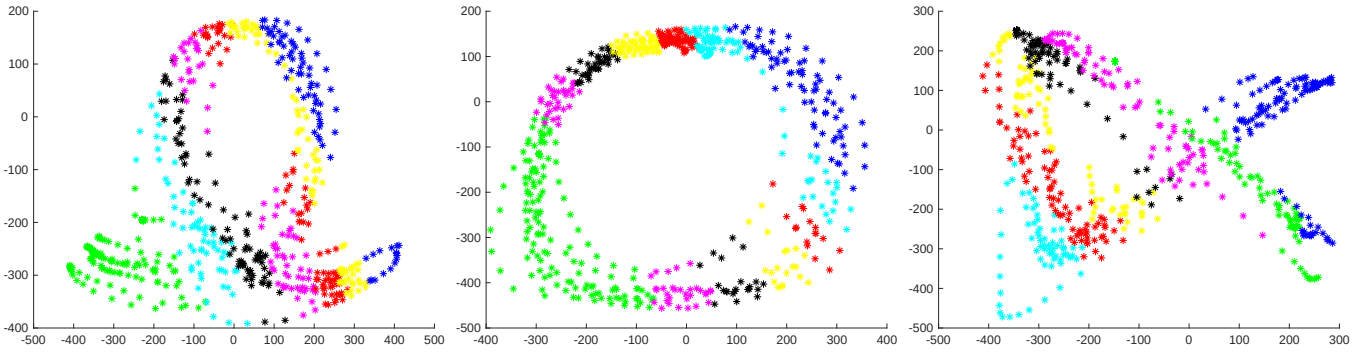
a) Please check the accompanying code file `Exercise3_kmeans.m` and the plots in Fig.2.



(a) Gesture l (b) Gesture o (c) Gesture x

Figure 2

b) Please check the accompanying code file `Exercise3_nubs.m` and the plots in Fig.3.



(a) Gesture l (b) Gesture o (c) Gesture x

Figure 3