

# Place Recognition / Deep Learning

## 1 Numerical Exercises

1. Consider the clustering of the following points in  $\mathbb{R}^2$  using the  $k$ -means clustering, where  $k = 2$ .

$x_1$	0	0
$x_2$	0	1
$x_3$	-1	2
$x_4$	2	0
$x_5$	3	0
$x_6$	4	-1

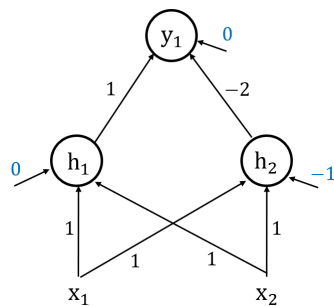
Table 1: Datapoints

- (a) In a first step, compute the squared distance matrix  $D_{ij} = \text{dist}_{eucl.}(\mu_i, x_j)^2$  between the datapoints  $x_j$  and the initial cluster centers  $\mu_i$ . Assume that the first and last datapoint are the initial centers.
  - (b) Based on the distance matrix  $D_{ij}$ , perform one iteration (cluster assignment and center update) of the  $k$ -mean clustering algorithm.
2. Consider the following query image with the set of visual words  $Q$  and the image vocabulary  $V$ . Using the image retrieval method presented in the lecture, construct the voting array and state which image ( $A, B, C$  or  $D$ ) is the closest to the query image.

$$Q = \{1, 2, 3, 4\}$$

$$V = \{1 = \{A, B\}, 2 = \{A, B, C\}, 3 = \{C\}, 4 = \{A, B, C, D\}\}$$

3. Consider the following MLP with the black numbers above the edges representing the weights and the blue numbers above the arrows the biases. All activations are ReLU function, i.e.,  $f(x) = \max(0, x)$ . Compute the hidden activations  $h_1$  and  $h_2$  and output  $y_1$  for the following inputs to the network.



- (a)  $x_1 = 0$  and  $x_2 = 0$
- (b)  $x_1 = 1$  and  $x_2 = 0$
- (c)  $x_1 = 0$  and  $x_2 = 1$
- (d)  $x_1 = 1$  and  $x_2 = 1$
- (e) For the above binary inputs, what function does this MLP approximate?