Exercise 06 for MA-INF 2201 Computer Vision WS24/25
29.11.2024
Submission on 08.12.2024

1. **Theory Question** Please submit your solution in a separate file *task1.pdf*.

Prove the following property of k dimensional Gaussian distributions $\text{Norm}_x[\mu, \Sigma]$:
$\int \text{Norm}_x[a, A]\text{Norm}_x[b, B]dx = \text{Norm}_a[b, A + B] \int \text{Norm}_x[\Sigma_*(A^{-1}a + B^{-1}b), \Sigma_*]dx$

where $\Sigma_* = (A^{-1} + B^{-1})^{-1}$
(*5 Points*)

2. **GrabCut with a GMM model** Please submit your solution in a separate file *task2.py*.

In this exercise we want to perform background subtraction for the provided image. The image comes with a rectangular bounding box that contains some skin color pixels (foreground). For this task you are required to implement a Gaussian Mixture Model and the EM algorithm for training. Assume that all covariance matrices are diagonal.

- It is well-known that GMM relies on a good initialization. One strategy is to use K-Means to cluster the data into K clusters, and fit each cluster as a Gaussian distribution. Implement the *kmeans_init* function that partitions data into K gaussians. We assume these K gaussians have equal weights, that is: $\lambda_k = \frac{1}{K}, \forall k \in \{1, 2, \cdots K\}$ and so $\sum_{k=1}^{K} \lambda_k = 1$
  (*3 Points*)
- Implement the EM algorithm to train the GMM.
  (*5 Points*)
- Background Subtraction. Train a GMM with 4 components for the background pixels. Using the thresholding approach from the lecture, set every pixel in the image to zero which is above a threshold τ. Display the resulting image.
  (*2 Points*)

2. **Background subtraction** Please submit your solution in a separate file *task3.py*.

Implement the function updateParam and display the resulting image. Specifically, setting number_of_gaussians to 3, background_thresh to 0.6 and lr to 0.01.

For more details: "Adaptive background mixture models for real-time tracking". Proceedings. 1999 IEEE computer society conference on computer vision and pattern recognition
(*5 Points*)