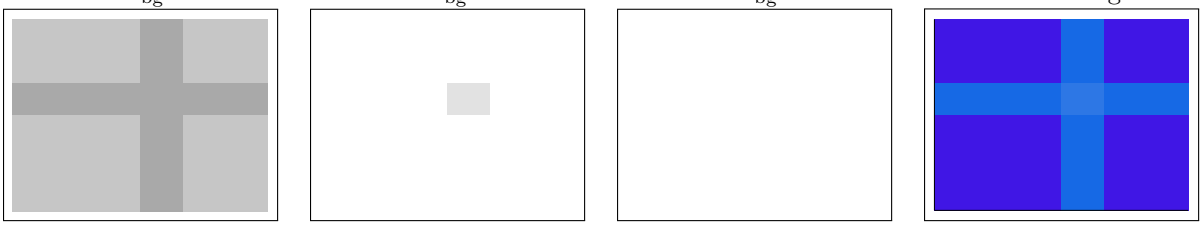
1 Pre-Recorded Tasks

1.1 Segmentation via Clustering

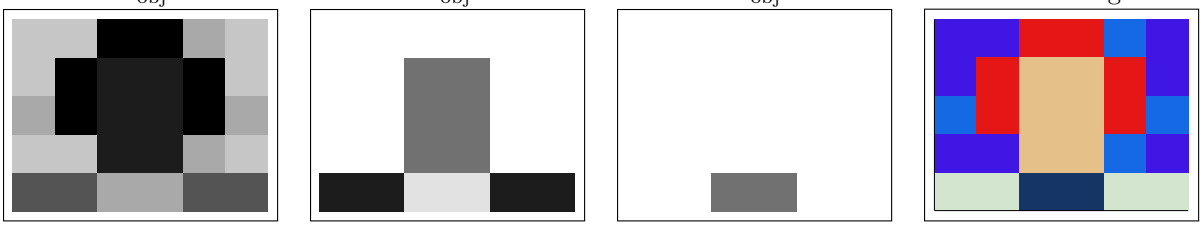
In this exercise, we investigate the same blue screen scenario as in the last exercise. Again we try to segment the image of a person in front of a blue screen. The image was taken in the same blue screen studio for 3-D virtual scenes as in the last exercise. The background contains two different types of blue in order to allow the system to retrieve the position information in three dimensions. Besides the image of the person ("the object"), there is also an image that only shows the background of the blue screen studio. This image is used to extract the information of the color blue. Moreover, it is assumed that there was enough light on the object surface so that the luminance signal is not important for the segmentation when utilizing the HSV color space. The HSV color space coefficients are quantized with 10 levels (not uniformly distributed).

$\mathbf{H}_{\text{bg}}$ | $\mathbf{S}_{\text{bg}}$ | $\mathbf{V}_{\text{bg}}$ | Color Image



$$\frac{1}{10}\begin{bmatrix} 7 & 7 & 7 & 6 & 7 & 7 \\ 7 & 7 & 7 & 6 & 7 & 7 \\ 6 & 6 & 6 & 6 & 6 & 6 \\ 7 & 7 & 7 & 6 & 7 & 7 \\ 7 & 7 & 7 & 6 & 7 & 7 \\ 7 & 7 & 7 & 6 & 7 & 7 \end{bmatrix} \quad \frac{1}{10}\begin{bmatrix} 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 8 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 \end{bmatrix} \quad \frac{1}{10}\begin{bmatrix} 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 \end{bmatrix}$$

$\mathbf{H}_{\text{obj}}$ | $\mathbf{S}_{\text{obj}}$ | $\mathbf{V}_{\text{obj}}$ | Color Image



$$\frac{1}{10}\begin{bmatrix} 7 & 7 & 0 & 0 & 6 & 7 \\ 7 & 0 & 1 & 1 & 0 & 7 \\ 6 & 0 & 1 & 1 & 0 & 6 \\ 7 & 7 & 1 & 1 & 6 & 7 \\ 3 & 3 & 6 & 6 & 3 & 3 \end{bmatrix} \quad \frac{1}{10}\begin{bmatrix} 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 4 & 4 & 9 & 9 \\ 9 & 9 & 4 & 4 & 9 & 9 \\ 9 & 9 & 4 & 4 & 9 & 9 \\ 1 & 1 & 8 & 8 & 1 & 1 \end{bmatrix} \quad \frac{1}{10}\begin{bmatrix} 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 4 & 4 & 9 & 9 \end{bmatrix}$$

1. As a first step, describe how the segmentation process would be affected if the illumination was too low!
2. In a first, very easy attempt, only the saturation value shall be used for segmentation. The thresholding algorithm shall be applied:
   (a) Specify a reasonable threshold value!
   (b) Conduct the segmentation!
   (c) What is the drawback of this algorithm?

3. Now, we would like to use two features: hue and saturation. Therefore, a cluster-based analysis is needed.
   (a) What is the general disadvantage of all cluster-based segmentation algorithms?
   (b) Plot a diagram with the x-axis denoting the hue and the y-axis denoting the saturation, and mark those points where the image contains value pairs. Additionally, write down the number of occurrences for each value pair!
   (c) How many classes would you assign to this image?
   (d) How must the cluster centroid locations be chosen in order to segment the blue screen background from the person?
4. Alternatively, k-means clustering shall be used now. In this algorithm, the number of clusters is fixed and the cluster centroids are calculated.
   (a) Does the iterative algorithm of the k-means clustering always ensure that each cluster gets the same number of pixels?
   (b) Would you choose this algorithm for the problem described here?

2 Self-Study Matlab Tasks

2.1 K-Means Clustering

We now want to use the image `colors.png`.

1. How many different colors does it have?
2. For k-means clustering, we want to use the RGB color space and employ the R and G components only. Define 4 color centroids by randomly selecting R and G values for each centroid.
3. Perform a segmentation based on the previous color centroids. For each pixel, you need to find the closest centroid. Calculate the Euclidean distance between the color value of the current pixel and each centroid. The result is a segmentation image with the same width and height as the original image. Display the first segmentation with the help of `imagesc()` and `colorbar`!
4. Calculate the new cluster centroids based on the previous segmentation. For all pixels of a class, calculate the average color value. This yields the new cluster centroids.
5. Finally, perform multiple k-means iterations. Where does it converge to?

1 Pre-Recorded Tasks

1.1 Segmentation via Clustering

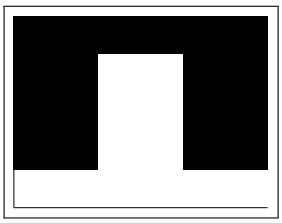
1. As a first step, describe how the segmentation process would be affected if the illumination was too low!

   Dark colors become more and more colorless, in fact, black would be indistinguishable based on hue and saturation.

2. In a first, very easy attempt, only the saturation value shall be used for segmentation. The thresholding algorithm shall be applied:

   (a) Specify a reasonable threshold value!
   All values $x[m,n] \leq 8$ belong to the object.

   (b) Conduct the segmentation!

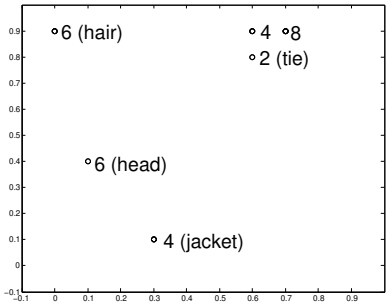


   (c) What is the drawback of this algorithm?
   Saturated red areas (hair) are also masked out.

3. Now, we would like to use two features: hue and saturation. Therefore, a cluster-based analysis is needed.

   (a) What is the general disadvantage of all cluster-based segmentation algorithms?
   The spatial neighborhood of the pixels is not taken into account.

   (b) Plot a diagram with the x-axis denoting the hue and the y-axis denoting the saturation, and mark those points where the image contains value pairs. Additionally, write down the number of occurrences for each value pair!



   (c) How many classes would you assign to this image?
   4

   (d) How must the cluster centroid locations be chosen in order to segment the blue screen background from the person?
   Choose the centroid of the first cluster in the middle of the blue screen values. The second one must be placed very closely to the first one but shifted a little bit towards the center of the diagram. This ensures that, according to the nearest neighbor classification, all points belonging to the object are associated with it.

4. Alternatively, k-means clustering shall be used now. In this algorithm, the number of clusters is fixed and the cluster centroids are calculated.

   (a) Does the iterative algorithm of the k-means clustering always ensure that each cluster gets the same number of pixels?

   No, since the decision whether a pixel belongs to the object or not is made based on the nearest neighbor algorithm.

   (b) Would you choose this algorithm for the problem described here?

   No, because for the segmentation of the blue screen and the object with 2 clusters, some parts of the object would be associated with the background.

2 Self-Study Matlab Tasks

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