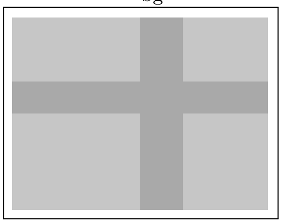
1 Pre-Recorded Tasks

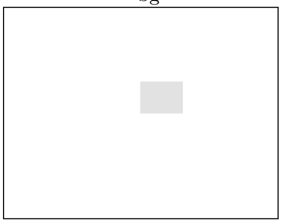
1.1 Bayes Segmentation

In this exercise, we want to investigate a blue screen scenario. We try to segment the image of a person in front of a blue screen. The image was taken in a blue screen studio which is meant for 3-D virtual scenes, and thus, 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 second 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).

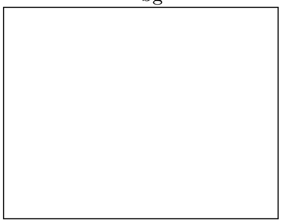
$\mathbf{H}_{\text{bg}}$



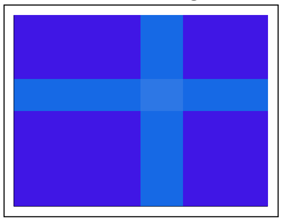
$\mathbf{S}_{\text{bg}}$



$\mathbf{V}_{\text{bg}}$

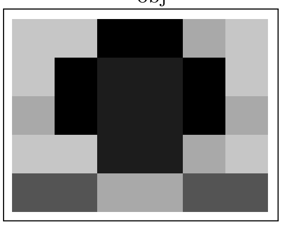


Color Image

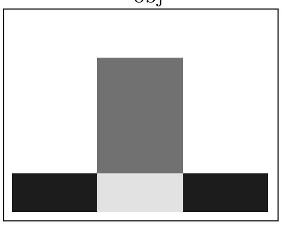


$$\frac{1}{10}\begin{bmatrix} 7 & 7 & 7 & 6 & 7 & 7 \\ 7 & 7 & 7 & 6 & 7 & 7 \\ 6 & 6 & 6 & 6 & 6 & 6 \\ 7 & 7 & 7 & 6 & 7 & 7 \\ 7 & 7 & 7 & 6 & 7 & 7 \\ 7 & 7 & 7 & 6 & 7 & 7 \end{bmatrix} \quad \frac{1}{10}\begin{bmatrix} 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 8 & 9 & 9 \\ 9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

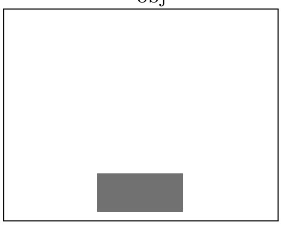
$\mathbf{H}_{\text{obj}}$



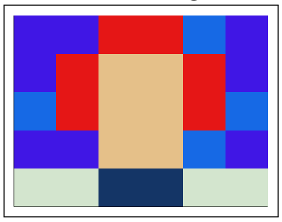
$\mathbf{S}_{\text{obj}}$



$\mathbf{V}_{\text{obj}}$



Color Image



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

The most universal algorithm for classification is the Bayes algorithm. Its decision is based on the probability that a class belongs to a feature vector. To calculate this, the following term has to be maximized: $P(\mathbf{f}|S) \cdot P(S)$.

1. Explain the meaning of $P(\mathbf{f}|S)$ and describe how you would get this information in this specific case for the background area!
2. What is the influence of $P(S)$ and why is this denoted as "a priori information"?
3. How would you choose the probability $P(\mathbf{f}|S)$ in the most common case "object in front of a blue screen" for the class $S =$"object"?
4. How would you change the probability distribution in the case "person"?

5. In the following, we assume that the classes "object" and "background" are equally probable. Additionally, "object" is assumed to be uniformly distributed over all hue and saturation values. Calculate $P(\mathbf{f}|\text{"background"})$ and $P(\mathbf{f}|\text{"object"})$, and segment the last row of the image!

6. Do another segmentation, assuming that only 25% of the image belong to the background!

2 Self-Study Matlab Tasks

2.1 Thresholding

We now want to perform a image segmentation using thresholding, therefore we can use the three implemented MATLAB functions `graythresh()`, `otsuthresh()` and `multithresh()`. What is the difference between the three functions? Load the provided image *circles.png* into your workspace and convert it into a grayscale image. Calculate the thresholds using the three functions mentioned before. Find a reasonable number of thresholds to calculate for the `multithresh()` function. Show the three different masks you obtain in that way.

1 Pre-Recorded Tasks

1.1 Bayes Segmentation

The most universal algorithm for classification is the Bayes algorithm. Its decision is based on the probability that a class belongs to a feature vector. To calculate this, the following term has to be maximized: $P(\mathbf{f}|S)\cdot P(S)$.

1. Explain the meaning of $P(\mathbf{f}|S)$ and describe how you would get this information in this specific case for the background area!

   This term denotes the probability of the occurrence of every possible pattern $\mathbf{f}$ for each class S. In this example, you may take the blue screen only image: It is known a priori that only the class "blue screen" is present. The number of combinations of hue and saturation can be counted in order to generate a probability of the occurrence of each such pattern. The probability of patterns which are nonexistent in the reference image is zero.

2. What is the influence of $P(S)$ and why is this denoted as "a priori information"?

   $P(S)$ denotes the probability that this specific class is chosen when compared to the other classes. In this head-and-shoulder picture, it can be assumed that the background will be visible as often as it is hidden by the person (in contrast to a class which should contain for example earrings). Since this is an information about the *content* of the scene, this must be known before segmentation by external information. (If this was a commercial for a jeweler's shop, the probability for the mentioned class would be much higher than in the image considered here.)

3. How would you choose the probability $P(\mathbf{f}|S)$ in the most common case "object in front of a blue screen" for the class $S =$"object"?

   The probability may be chosen to be uniformly distributed, as nothing is known about the object in front of the blue screen.

4. How would you change the probability distribution in the case "person"?

   The probability of the hue and the saturation of "skin" may be increased, since most often there is a face in the image.

5. In the following, we assume that the classes "object" and "background" are equally probable. Additionally, "object" is assumed to be uniformly distributed over all hue and saturation values. Calculate $P(\mathbf{f}|\text{"background"})$ and $P(\mathbf{f}|\text{"object"})$, and segment the last row of the image!

$$P(\mathbf{f}|\text{"background"}) = \begin{cases} \frac{25}{36} & \text{if } \mathbf{f} = [0.7\ 0.9] \\ \frac{10}{36} & \text{if } \mathbf{f} = [0.6\ 0.9] \\ \frac{1}{36} & \text{if } \mathbf{f} = [0.6\ 0.8] \\ 0 & \text{else} \end{cases}$$

$$P(\mathbf{f}|\text{"object"}) = \frac{1}{10\cdot 10} = \frac{1}{100} \quad \forall\, \mathbf{f}$$

   The segmentation of the last row presents the following result for both hypotheses:

"object"	$\frac{1}{100}\cdot\frac{1}{2}=\frac{1}{200}$	$\frac{1}{200}$	$\frac{1}{200}$	$\frac{1}{200}$	$\frac{1}{200}$	$\frac{1}{200}$
"background"	$0\cdot\frac{1}{2}=0$	0	$\frac{1}{72}$	$\frac{1}{72}$	0	0
"decision"	obj	obj	**bg**	**bg**	obj	obj

6. Do another segmentation, assuming that only 25% of the image belong to the background!

"object"	$\frac{1}{100} \cdot \frac{3}{4} = \frac{3}{400} = 0.0075$	0.0075	0.0075	0.0075	0.0075	0.0075
"background"	$0 \cdot \frac{1}{4} = 0$	0	$\frac{1}{36} \cdot \frac{1}{4} = \frac{1}{144} \approx 0.0069$	0.0069	0	0
"decision"	obj	obj	obj	obj	obj	obj

2 Self-Study Matlab Tasks

2.1 Thresholding

We now want to perform a image segmentation using thresholding, therefore we can use the three implemented MATLAB functions `graythresh()`, `otsuthresh()` and `multithresh()`. What is the difference between the three functions? Load the provided image *circles.png* into your workspace and convert it into a grayscale image. Calculate the thresholds using the three functions mentioned before. Find a reasonable number of thresholds to calculate for the `multithresh()` function. Show the three different masks you obtain in that way.