04

Certainly, here's a description of the procedure and the main logic for the provided code without including the actual code:

- **Procedure**:
  - **Input**:
    - An image represented as a NumPy array (`img`) is provided.
    - The image may be in color or grayscale format.

  - **Main Logic**:
    - Convert the input image to grayscale:
      - Utilize `np.mean()` function to compute the mean along the last axis (axis=-1) of the image array.
      - Cast the result to unsigned 8-bit integer type (`np.uint8`) using `.astype(np.uint8)`.

    - Crop the image to make it square:
      - Determine the dimensions of the square by finding the minimum of the height and width of the grayscale image.
      - Calculate the cropping parameters to remove excess pixels and center the square within the image.
      - Crop the image using NumPy array slicing to extract the square region.

    - Process the cropped grayscale image:
      - Copy the cropped image data to a new variable (`boundary_img`) for further processing.

    - Define a function to find the center point and create an image:
      - The function `find_center_point()` takes an image and a radius as input.
      - It calculates the center point of the image and creates a new image with zeros around this center.
      - This function is designed to black out the center area of the image.

    - Display the modified image:
      - Utilize `plt.imshow()` function to display the modified image returned by `find_center_point()`.
      - Convert the image from BGR to RGB color space using `cv2.cvtColor()` to ensure proper visualization.

  - **Output**:
    - Display the modified image with the center area blacked out.

By following this procedure and implementing the described main logic, the input image can be processed to crop it into a square shape and then modify it by blacking out the center area.

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05, 6,7,8

Here's a description of the procedures for image addition, subtraction, and logical AND/OR operations, along with their main logic and the functions involved:

- **Image Addition**:

  - **Procedure**:
    - Take two input images of the same size.
    - Add corresponding pixel values of the two images to create a new image.
    - Ensure that the pixel values remain within the valid range (0 to 255 for uint8 images).

  - **Main Logic**:
    - Utilize NumPy's array addition operation (`np.add()` or simply `+`) to add corresponding pixel values of the two images.
    - Optionally, you can use OpenCV's `cv2.add()` function for image addition, which automatically handles overflow.

- **Image Subtraction**:
  - **Procedure**:
    - Take two input images of the same size.
    - Subtract corresponding pixel values of one image from the other to create a new image.
    - Ensure that the resulting pixel values remain within the valid range (0 to 255 for uint8 images).

  - **Main Logic**:
    - Employ NumPy's array subtraction operation (`np.subtract()` or `-`) to subtract corresponding pixel values of one image from the other.
    - Alternatively, you can use OpenCV's `cv2.subtract()` function for image subtraction, which handles overflow similarly to addition.

- **Logical AND Operation**:
  - **Procedure**:
    - Take two input binary images (images with pixel values either 0 or 255).
    - Perform a logical AND operation between the corresponding pixel values of the two images to create a new binary image.

  - **Main Logic**:
    - Use NumPy's logical AND operation (`np.logical_and()`) to perform element-wise logical AND between the pixel values of the two images.
    - Ensure that both input images are properly thresholded to binary format before applying the logical AND operation.

- **Logical OR Operation**:
  - **Procedure**:
    - Take two input binary images (images with pixel values either 0 or 255).
    - Perform a logical OR operation between the corresponding pixel values of the two images to create a new binary image.

  - **Main Logic**:
    - Employ NumPy's logical OR operation (`np.logical_or()`) to perform element-wise logical OR between the pixel values of the two images.
    - Ensure that both input images are properly thresholded to binary format before applying the logical OR operation.

By following these procedures and implementing the described main logic using the mentioned functions (such as NumPy's array operations or OpenCV's functions), you can perform image addition, subtraction, and logical operations effectively in Python.

==========

09 & 10

Sure, here's a compact description of the procedure and main logic for histogram calculation and histogram equalization without including the actual code:

- **Histogram Calculation**:
  - **Procedure**:
    - Convert the input image to grayscale using the provided `gray_image()` function.
    - Compute the histogram of the grayscale image to analyze the distribution of pixel intensities.
    - Calculate the frequency of occurrence of each pixel intensity value within the image.

  - **Main Logic**:
    - Utilize the `histogram()` function to generate the histogram of the grayscale image.
    - Iterate through each pixel of the image and increment the corresponding bin in the histogram array based on the pixel intensity.
    - Normalize the histogram to obtain the probability density function (PDF) using the `pdf()` function.

  - **Output**:
    - Display the histogram to visualize the distribution of pixel intensities within the image.
    - The histogram provides insights into the overall contrast and brightness of the image.

- **Histogram Equalization**:
  - **Procedure**:
    - Calculate the cumulative distribution function (CDF) from the PDF obtained in the histogram calculation step.
    - Use the CDF to perform histogram equalization, which redistributes the pixel intensities to achieve a more balanced histogram.
    - Apply the equalization transformation to the original grayscale image to enhance its contrast.

  - **Main Logic**:
    - Generate the CDF using the `cdf()` function, which accumulates the probabilities of each intensity level.
    - Perform histogram equalization by mapping the pixel intensities of the original image to new values using the CDF.
    - The `hist_equalization()` function applies the equalization transformation to the histogram to spread out the pixel intensities more uniformly.

  - **Output**:
    - Display the original grayscale image alongside its histogram and the equalized image with its corresponding histogram.
    - Histogram equalization enhances the image's contrast by redistributing the pixel intensities.

By following these procedures and implementing the described main logic using the provided functions, you can effectively calculate the histogram of an image and perform histogram equalization to enhance its contrast.

11

Certainly! Here's a concise description of the procedure and main logic for sharpening an image without including the actual code:

- **Sharpening an Image**:
  - **Procedure**:
    - Define a sharpening kernel, such as the provided `sharp_kernel`, which enhances edges in the image.
    - Convolve the image with the sharpening kernel to emphasize edges and fine details.
    - Ensure the pixel values remain within the valid range (0 to 255 for uint8 images) by clipping them.

  - **Main Logic**:
    - Create an empty array (`sharp_img`) to store the sharpened image.
    - Iterate over the pixels of the original image (excluding the border pixels to prevent out-of-bounds access).
    - For each pixel, apply the sharpening kernel by performing element-wise multiplication with the corresponding neighborhood in the original image.
    - Sum up the results to obtain the sharpened pixel value for that location in the output image.
    - Clip the resulting pixel values to ensure they are within the valid range for image representation (0 to 255).

  - **Output**:
    - Display the original grayscale image alongside the sharpened image.
    - The sharpened image will have enhanced edges and fine details, making it appear crisper and more defined.

By following this procedure and implementing the described main logic using the provided kernel and image, you can effectively sharpen an image to enhance its visual quality.

==========

12

Certainly! Here's a concise description of the procedure and main logic for image filtering without including the actual code:

- **Image Filtering**:
  - **Procedure**:

- Define a filter kernel (also known as a convolution kernel or mask) to specify the desired filtering operation.
- Convolve the filter kernel with the input image to perform the filtering operation.
- The result is a new image where each pixel is computed based on the neighboring pixels according to the filter kernel.

- **Main Logic**:
- Choose a filter kernel appropriate for the desired image processing task, such as blurring, sharpening, edge detection, etc.
- Convolve the input image with the chosen filter kernel using convolution operations.
- For each pixel in the input image, apply the filter kernel by performing element-wise multiplication with the corresponding neighborhood in the image.
- Sum up the results to obtain the filtered pixel value for that location in the output image.
- Ensure the pixel values remain within the valid range (0 to 255 for uint8 images) by clipping them if necessary.

- **Common Functions**:
- `cv2.filter2D()`: Used in OpenCV for applying arbitrary kernels to images using convolution.
- `scipy.ndimage.convolve()`: Available in SciPy for performing convolution operations on multi-dimensional arrays.
- `skimage.filters`: Provides various filtering functions like Gaussian blur, median filtering, etc., for different image processing tasks.

- **Output**:
- Display the original input image alongside the filtered image to observe the effects of the filtering operation.
- The filtered image will exhibit characteristics determined by the chosen filter kernel, such as smoothed/blurred edges, enhanced/sharpened features, or highlighted edges.

By following this procedure and implementing the described main logic using appropriate functions and filter kernels, you can effectively perform image filtering to achieve various image processing goals.

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13

Sure, here's a description of the procedure and main logic for adjusting contrast in an image without including the actual code:

- **Adjusting Contrast in an Image**:
- **Procedure**:
- Convert the input image to grayscale using the provided `np.mean()` function.
- Define parameters to adjust the contrast, such as reference points (`r1`, `r2`) and corresponding target points (`s1`, `s2`).
- Apply contrast adjustment transformation to the grayscale image to enhance or reduce the contrast.

- **Main Logic**:
  - Compute the grayscale image by taking the mean along the last axis of the input image array and casting it to unsigned 8-bit integer type (`np.uint8`).
  - Optionally, define reference and target points (`r1`, `r2`, `s1`, `s2`) manually or through some automated process.
  - Compute scaling factors (`a`, `b`, `c`) to map pixel intensities from the original range to the target range.
  - Iterate over each pixel in the grayscale image:
    - Apply piecewise linear transformation to adjust the contrast based on the specified reference and target points.
    - Calculate the new pixel intensity value using the corresponding scaling factors for different intensity ranges.
    - Ensure the pixel values remain within the valid range (0 to 255 for uint8 images) by clipping them.

- **Output**:
  - Display the original grayscale image alongside the contrast-adjusted image to visualize the effect of contrast enhancement or reduction.
  - The contrast-adjusted image will exhibit changes in brightness and intensity levels according to the specified reference and target points.

By following this procedure and implementing the described main logic using the provided functions, you can effectively adjust the contrast of an image to improve its visual appearance.

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14

Certainly! Here's a concise description of the procedure and main logic for erosion and dilation operations without including the actual code:

- **Erosion Operation**:
  - **Procedure**:
    - Define a structuring element (kernel) to specify the erosion operation's neighborhood.
    - Apply the erosion operation to the input image to shrink or erode the boundaries of foreground objects.

  - **Main Logic**:
    - Iterate over each pixel in the input image.
    - For each pixel, compute the minimum value within the neighborhood defined by the kernel.
    - Assign the minimum value to the corresponding pixel in the output image.
    - The output image will have foreground regions eroded or reduced based on the kernel size and shape.

  - **Functions**:

  - `erosion(img, kernel)`: Performs erosion operation on the input image using the specified kernel.
  - The erosion function calculates the minimum value within the neighborhood defined by the kernel and assigns it to the output image.

- **Dilation Operation**:
 - **Procedure**:
  - Define a structuring element (kernel) to specify the dilation operation's neighborhood.
  - Apply the dilation operation to the input image to expand or dilate the boundaries of foreground objects.

 - **Main Logic**:
  - Iterate over each pixel in the input image.
  - For each pixel, compute the maximum value within the neighborhood defined by the kernel.
  - Assign the maximum value to the corresponding pixel in the output image.
  - The output image will have foreground regions expanded or dilated based on the kernel size and shape.

 - **Functions**:
  - `dilation(img, kernel)`: Performs dilation operation on the input image using the specified kernel.
  - The dilation function calculates the maximum value within the neighborhood defined by the kernel and assigns it to the output image.

By following this procedure and implementing the described main logic using the provided functions, you can effectively perform erosion and dilation operations on images for morphological image processing tasks.

Of course! Here's a succinct description of the procedure and main logic for performing opening and closing operations on an image without including the actual code:

- **Opening Operation**:
 - **Procedure**:
  - Define a structuring element (kernel) to specify the opening operation's neighborhood.
  - Apply the opening operation to the input image to remove small objects and smooth the boundaries of larger objects.

 - **Main Logic**:
  - Perform erosion followed by dilation on the input image using the specified kernel.
  - The erosion operation shrinks or erodes the boundaries of foreground objects, removing small details and noise.
  - The dilation operation then expands or dilates the remaining regions, smoothing the boundaries of larger objects while preserving their shapes.

 - **Functions**:
  - `opening(img, kernel)`: Applies opening operation on the input image using the specified kernel.

  - The opening function first performs erosion and then dilation on the input image using the provided kernel.

- **Closing Operation**:
  - **Procedure**:
    - Define a structuring element (kernel) to specify the closing operation's neighborhood.
    - Apply the closing operation to the input image to fill small gaps and holes in foreground objects and smoothen the boundaries.

  - **Main Logic**:
    - Perform dilation followed by erosion on the input image using the specified kernel.
    - The dilation operation expands or dilates the foreground regions, filling in small gaps and holes in objects.
    - The erosion operation then shrinks or erodes the remaining regions, smoothing the boundaries of objects while preserving their shapes.

  - **Functions**:
    - `closing(img, kernel)`: Applies closing operation on the input image using the specified kernel.
    - The closing function first performs dilation and then erosion on the input image using the provided kernel.

By following this procedure and implementing the described main logic using the provided functions, you can effectively perform opening and closing operations on images for morphological image processing tasks.