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Task 1:
Performing Adaptive Binarization and Cropping of an input image

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Aim of the Task:

The Aim of the task is to perform adaptive binarization and cropping of an input image.

Introduction:

The image binarization is a technique used to convert a grayscale image or a colour image into a binary image (black and white image).The main goal is to separate the image's foreground from its background, typically to highlight certain features or objects in the image or to facilitate further processing such as segmentation or object recognition.
Image Binarization is one of the most fundamental ways to extract useful information from a given image. [1a]
This can be achieved with the help of a process called thresholding. [1c]

Binarization is a fundamental preprocessing step in various computer vision and image analysis applications, particularly in the areas of document analysis, optical character recognition (OCR), and pattern recognition. [1c]

What is Cropping?

To “crop” an image is to remove or adjust the outside edges of an image (typically a photo) to improve framing or composition, draw a viewer’s eye to the subject[1b], or change the size or aspect ratio. In other words, Image cropping is the act of improving an image by removing unnecessary parts.[1b]

Working Steps and Reasoning Process:

To Binarize an input image, First the Input colour image is converted to grey scale image , then the grey scaled image is converted to Binary Image and then the Binarized image is Cropped. The Binarized Image is obtained by a technique called Adaptive Thresholding.

Step 1 : Grey Scaling

What is Grey Scaling of Image ?

Grayscale conversion of an image involves transforming it from a multi-color representation (e.g., RGB) to a single-channel representation, where each pixel's intensity corresponds to its brightness level. Grayscale images lack colour information but retain luminance, making them suitable for various image processing tasks.[1d]

Why Grey Scaling is done?

For simplification of Image, Grayscaled images are simpler than color images, reducing computational complexity and memory requirements for image processing tasks.

To Focus on Luminance of Image, By removing colour distractions, grayscale images emphasize luminance variations, which are often critical for tasks like edge detection, feature extraction, and image segmentation. .[1d]

Step 2 : Adaptive Thresholding

What is Adaptive Thresholding?

Adaptive Thresholding is an technique to determine the correct or optimal threshold value automatically to binarize an Input image.

Steps for Computing the Adaptive Thresholding:[1e]

1. Let T_i be an initial threshold - T_i the initial threshold value is calculated as the average pixels intensity for the input image.

2. Pixels are divided into two groups by using the Initial threshold T_i, and the means of pixel intensities are calculated on both sides of the initial threshold: m0 and m1.

   Calculating the new threshold value is as:

   $$T_{new} = (m0+m1)/2$$

3. If the change in threshold is small, i.e., $|T_i - T_{new}| <=$Epsilon the algorithm is completed, and the selected threshold is T_{new}. Otherwise, the Initial threshold T_i is set to the new threshold T_{new} and the algorithm continues with Step 2.

Step 3 : Image Binarization

What is Binarization?

Binarization is a digital image processing technique used to convert a grayscale image or a colour image into a binary image. The binary image created as a result of binarization contains only two pixel values, typically 0 and 255, where 255 represents the background (usually white) and 0 represents the foreground or the object of interest (usually black). Binarization is a fundamental preprocessing step in various computer vision and image analysis applications, particularly in the areas of document analysis, optical character recognition (OCR), and pattern recognition. [1c]

How Does Binarization Work?

The process of binarization involves the selection of a threshold value, and then converting all pixel values below the threshold to 0 and all pixel values above the threshold to 1. The choice of threshold is critical and can be determined using various methods, including manual selection, global thresholding, or adaptive thresholding. [1c]

One of the use of binarization in image processing is that to prepare images for pattern recognition tasks, such as fingerprint identification, where the focus is on the structure of the object rather than its colour or grayscale intensity.[1c]

Step 3 : Image Cropping

Cropping is the process of selectively removing unwanted portions of an image while retaining the most relevant or visually appealing parts. It is done to improve the composition, focus on the main subject, remove distractions, adjust aspect ratios, and enhance visual appeal. Cropping enables users to tailor images for specific display formats, platforms, or purposes, ensuring optimal presentation and effective communication of visual content. [1d]

Explaining the Program Functionality(What is going in the code):

As explained in the working , each step is defined as functions in the program and it is explained below.(Program File: Final_ProjectSubTask1.pde)

Grey Scale Function:

The function grayscale has a single parameter input image.
An Image “img_G”(dummy image) is created using a ‘createImage’ data type, and pixels are loaded for original image and created image. Then have used a for loop to iterate through the columns (y) and rows(x).Then the index is calculated using the formula x + y * image width.
The RGB components of the image pixels are extracted by there indexes using the predefined keyword red, green, blue. Then the colour image is converted to grey image using the luminosity method by the formula - **0.21 * red channel pixels + 0.72 * green channel pixels + 0.07 * blue channel pixels.** Then the “img_G” pixels are updated and returns the grey scales image.

Adaptive Thresholding Function:

This function has two parameters , an input image and epsilon value, which is given reasonably. Then initial threshold value Ti is calculated using the average intensity of the image.
The iterative thresholding process is then performed inside a do-while loop, indicated by the Boolean variable “done”. Within each iteration, the image pixels are classified into two groups based on their intensity values , if below (group1) and above (group2) the current threshold Ti.The average intensity values (avg1 and avg2) are calculated for each group(group1) and (group2).Then the average of avg1 and avg2 is taken and computed as Tnew. The difference

of the old and new thresholds is compared to the epsilon value. If the difference is less than or equal to epsilon, the iterative process is terminated, and done is set to true. If not the new threshold is taken as Initial threshold and the iteration continues till its less than or equal to the epsilon. Once the final threshold is computed it returns the value , which is used further by binarization function.

Binarization Function :

The function binarization takes two parameters: the grey scaled image and the adaptive threshold value. A new image “img_B” ”(dummy image) is created with the same dimensions as the input image using the createImage function. The function iterates over each pixel in the input image using nested for loops with image width and height. It calculates the brightness value using the brightness function. If the brightness value is less than or equal to the adaptive threshold value, the corresponding pixel in the binarized image (img_B) is set to black (colour0).Otherwise, the pixel is set to white (colour 255).
After processing all pixels, the pixel data for the binarized image is updated using the updatePixels function and returns the binarized image.

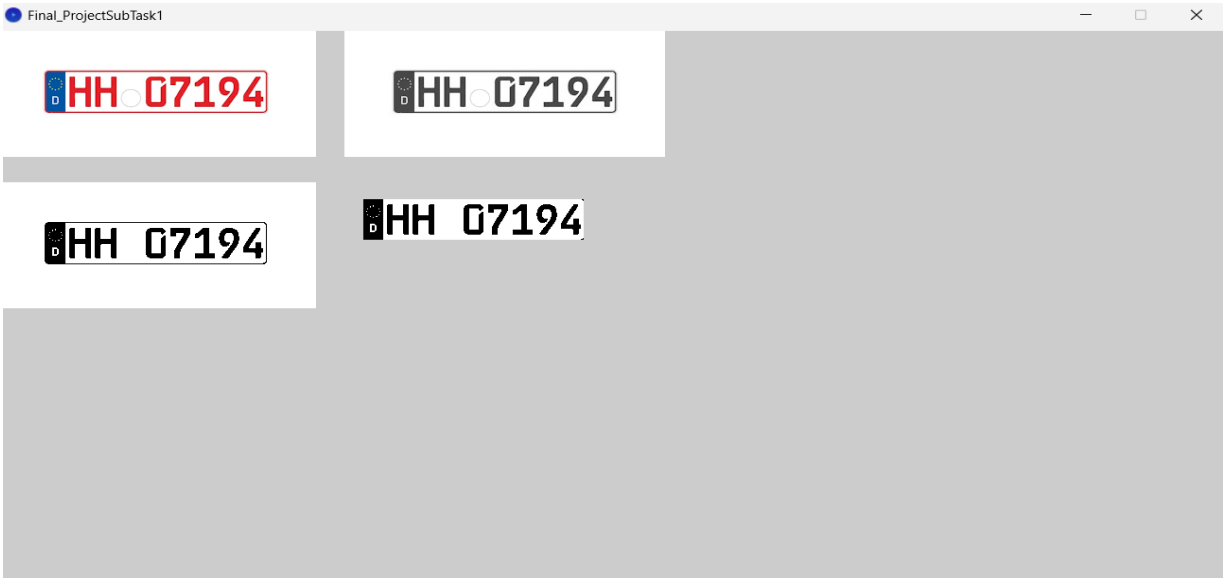
Cropping Function: (Where the Object is Black , and background is white)

The function first loads the pixel data of the binarized image. It initializes variables for the boundaries of the object (top, bottom, left, and right).

Top and Bottom Boundaries: Two nested for loops iterate over the image's rows (y-axis) to find the top and bottom boundaries of the object. It checks each pixel's brightness value using the brightness function. When it encounters a pixel with a brightness value of 0 (object), it marks it as part of the object and stops searching.

Left and Right Boundaries: Similar nested loops iterate over the image's columns (x-axis) within the detected top and bottom boundaries to find the left and right boundaries of the object. When it encounters a pixel with a brightness value of 0 (object), it marks it as part of the object and stops searching.
Once all boundaries are determined, the function uses the get function to extract the portion of the extracted image.

Output Results:



References:

1. **Text Reference :**
a) https://medium.com/@tharindad7/image-binarization-in-a-nutshell-b40b63c0228e

b) https://www.techsmith.com/blog/image-cropping-101-basics/

c) https://deepai.org/machine-learning-glossary-and-terms/binarization#:~:text=Pattern%20Recognition%3A%20Binarization%20is%20used,its%20color%20or%20grayscale%20intensity.

d) https://chat.openai.com/

e) Lecture Notes.

2. **Source Code Reference :**
a) http://gnjatovic.info/imageprocessing/ip.code.snippets.txt
b) Lecture Notes.

3. Image Reference:
a) Original image: https://fuwong.com/wp-content/uploads/2017/08/German-license-plate-101-Europlates-wiki-11.jpg