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Text Document Enhancement with Image Processing

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Project Vision & Purpose

• Text documents may consist of a noisy background that are difficult for computers and people to interpret:
  - Stains
  - Eraser Marks
  - Fold Creases
  - Salt and Pepper Noise
• Significant real-world benefits include:
  - Restoring old, distorted, and/or historical documents.
  - Increasing text visibility, which is especially advantageous for visually impaired individuals
  - Useful for researching ideal preprocessing techniques for all kinds of noise.

Project Algorithm

- Allow the user to select an image preprocessing technique
  - Practical options currently include Otsu's, binary, and adaptive thresholding, opening/closing morphology, and bilateral filtering
- Obtain an image (preferably a text document)
- Calculate the grayscale version of the image
- Perform the user-selected preprocessing technique with the OpenCV library on Python and display the resulting binary image.
  - Dynamically update the image based on additional user-input
- Allow the user to extract text via Tesseract.

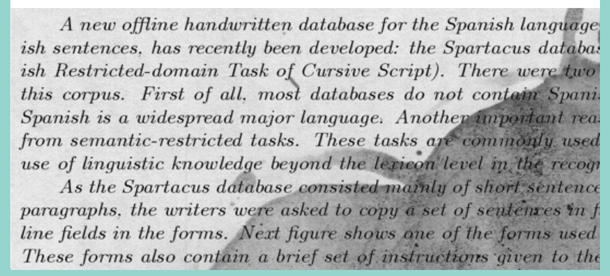


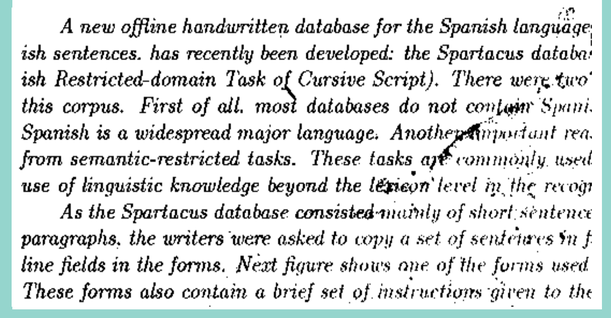
Image Preprocessing Techniques

- Thresholding
  - Otsu's Thresholding
    - Automatically calculates an optimal threshold value that separates the foreground from the background
  - Binary Thresholding
    - Allows the user to manually input a threshold value.
    - Convenient because Otsu's method could worsen the noise.
  - Adaptive Thresholding
    - Divides an image into regions and calculates thresholds for each region.
    - Computed by either taking the mean of the region or through a weighted sum, and then subtracted by a constant
- Mathematical Morphology
  - Opening
    - Dilate and then erode image regions
    - Useful to remove small objects, lines, and bridges
  - Closing
    - Erode and then dilate image regions
    - Helps with eliminating holes and filling gaps
- Filtering
  - Median Filtering
    - For every pixel, set that pixel to the median value based on a certain size of neighboring pixels
    - Preserves edges
  - Gaussian Blur
    - Same idea as median filtering, except instead of the median, it's a weighted sum
  - Bilateral Filtering
    - Considers neighboring pixels and their intensity differences.
    - Results in only nearby and similar pixels being blurred
    - Reduces "salt-and-pepper" noise

Determining The Best Method

- There is no "one-size-fits-all" solution for enhancing text documents.
  - However, there are algorithms that find the best image that a computer understands.
- A "text extraction accuracy" is calculated through the "Levenshtein Distance" algorithm
  - Calculates the distance required to go from one list of characters to another.
    - Ex: Going from "You are sitting" to "You are a kitten" requires two words to be modified.
  - The accuracy is calculated as ((max_cost - calculated_cost) / max_cost) * 100
  - Useful for when there is a noisy and clean version of the same image.

- Most effective preprocessing methods to remove specific types of noise:
  - Stains -> Adaptive thresholding
  - Eraser marks -> Otsu's or binary thresholding
  - Fold creases -> Otsu's or binary thresholding
  - Salt and pepper noise -> Bilateral filtering



Where Do We Go From Here?

- Custom-made image preprocessing algorithms could be created based on which ones were the most successful
  - Additional real-world applications include training machine learning algorithms, medical imaging, object detection/recognition
- The Levenshtein distance will help in determining the best preprocessing technique, as well as the best parameters when given a noisy image
- Advantageous features to add to software that utilizes binary images, like PDF scanning apps.

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