Project Work Plan

Project Overview: Distance-Focused Deformation Analysis of Letter Shapes

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Project Overview: This project focuses on representing English letters as geometric shapes, applying controlled, structure-dependent deformations, and analyzing shape distance metrics to determine if they effectively reflect perceptual similarity.
By comparing intra-letter and inter-letter distances, we quantitatively evaluate the effectiveness of the distance metric.

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Course: Advanced topics in image processing
Project title: Controlled Deformation and Distance Analysis of English Letter Shapes
Milestones: 3
Programming Language: Python

Milestone 1
Letter Representation & Dataset Preparation

Due Date: 18.12
Objectives:

- Define a computational representation for a selected subset of English letters (e.g., A, B, C, D).
- Implement a Letter Shape Class supporting:
    a. Raster Image Representation (Binary Mask).
    b. Normalization pipeline: Centering to the origin and scaling to a fixed reference size/resolution.
- Generate the normalized base shapes for the selected letters, ensuring high-quality.
- Implement basic visualization tools to display the letter shapes.

Deliverables:

- Source code for the Letter Shape Class and the normalization functions.
- Visualizations of the normalized base letter shapes.
- Justification of the chosen raster representation (explaining why it was chosen over a vector approach).
- Initial plotted figures showing each base letter shape.

Comments:

- This milestone focuses on preparing the fundamental data structure (normalized letter masks) for the deformation and distance analysis experiment.

Milestone 2
Deformation Operator Design & Distance Metric Implementation

Due Date: 31.12
Objectives:

- Define and implement a single, generic Deformation Operator T(t) that acts on the binary mask, reflecting structure-dependent change (e.g., based on Morphological Operations applied to the mask).
- Generate a set of discrete deformation levels for each selected letter (e.g., t=1, 2, …, Tmax steps).
- Define and enforce a deformation Limit Tmax for each letter, where deformation ceases when the letter loses its visual identity (e.g., when a hole closes or a line disappears).

- Implement a Distance Metric between the binary masks, such as the Pixel-wise Euclidean L2 distance or Jaccard/Dice Similarity Coefficient (primary).
- Compute and store distances for three categories:
    - Original vs. Deformed.
    - Original vs. Other Original Letters
    - Deformed vs. Other Deformed Letters.

<u>Deliverables:</u>

- Code for the generic deformation operator.
- Distance metric implementation.
- Visualization of several deformation levels (minimal, mid-range, and the limit Tmax).
- Preliminary graph(s) showing deformation level vs. distance for each letter.

<u>Comments:</u>

- This milestone focuses on the core experimental design. We define a single, consistent deformation operator whose effect is analyzed across different letter structures. Critically, we introduce and test a Maximum Deformation Limit to ensure the preservation of letter identity and implement the raster-based distance metric for evaluation.

Milestone 3
Distance Metric Analysis & Cross-Letter Comparison

<u>Due Date:</u> 07.01
<u>Objectives:</u>

- Analyze and visualize the distance metric behavior: Graph: Deformation level T (x-axis) vs. Raster Distance Metric (y-axis) for each letter. Side-by-side visualization of the deformation progression up to Tmax.
- Validate the Core Research Hypothesis: Conduct a quantitative comparison of Intra-letter distances (A0,At) versus Inter-letter distances (A0,B0).
- Analytical Study and Interpretation: Investigate whether the distance metric aligns with the perceived deformation. Visualize the relationship between all shapes using a Distance Matrix (Heatmap) or dimensionality reduction (e.g., PCA) to show clustering.
- Prepare a Comprehensive Final Report.

<u>Deliverables:</u>

- Final graphs and visualizations quantifying the core hypothesis validation.
- Comprehensive Comparative Analysis of Intra-letter vs. Inter-letter results.
- Final Report describing: Motivation, Methodology (Raster Representation), Deformation Operator Design, Distance Metric, Validation Results, and Conclusions.

- Final demo code.

Comments:

- This final milestone focuses on the rigorous analysis and validation of the distance metric's performance. The final report will explicitly address the core research question, providing quantitative data that validates or challenges the metric's ability to distinguish between controlled structural change (deformation) and change of identity (switching letters).