AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

i-CREDIT HOURS ENGINEERING PROGRAMS

JIGSAW PUZZLE IMAGE PREPROCESSING

Phase 1

Submitted by:

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1. Objective

The goal of Milestone 1 is to **prepare all puzzle piece images** (2×2, 4×4, 8×8) for later assembly in Milestone 2.
This includes:

- enhancing edges,
- reducing noise,
- producing clean binary masks,
- and ensuring the images are ready for contour extraction and edge matching.

Only **classical computer vision** (OpenCV + NumPy) is used, as required.

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2. Preprocessing Pipeline Overview

We implemented a **robust, multi-step classical CV pipeline** that works across all puzzle folders.

Pipeline Steps:

1. **Grayscale Conversion**
   Simplifies the image and prepares it for intensity-based processing.
2. **Noise Reduction (Three Blurs)**
   - **Gaussian blur** removes general noise.
   - **Median blur** reduces salt-and-pepper noise.
   - **Bilateral filter** smooths textures while **preserving edges**, which is important for puzzle contours.
3. **Histogram Equalization**
   Improves contrast and makes edges more visible, especially in tiles with uneven lighting.

4. **Adaptive Thresholding**
   Separates foreground (puzzle piece) from background.

Adaptive thresholding performs better than Otsu because it handles local lighting changes between tiles.

5. **Morphological Cleaning**
   Morphological opening removes small noise regions and closes gaps, giving cleaner shapes.
6. **Contour Extraction & Mask Creation**
   - Extracts outer contours of each puzzle tile.
   - Produces a **binary mask** (white piece on black background).
     This mask will be used in Milestone 2 for contour-based edge matching.

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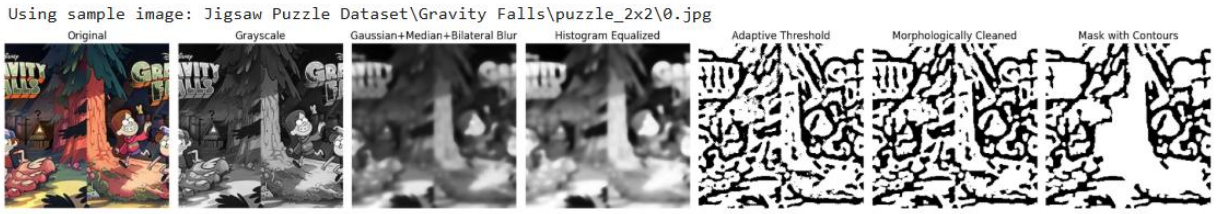
3. Visual Examples

You MUST include at least **2 sets of images**:

A. Full Pipeline Example

Include a 7-stage image grid showing:

- Original → Grayscale → Blurs → Equalized → Threshold → Cleaned → Mask



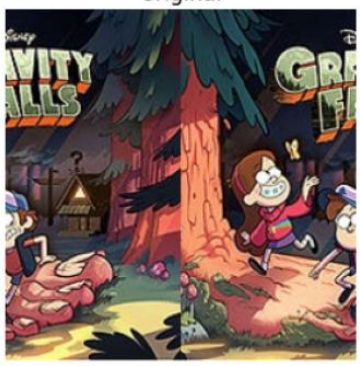
B. Before/After/Masks for Each Puzzle Folder

Include 1 sample per folder:

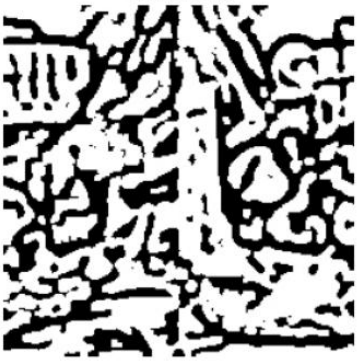
- Original
- Enhanced
- Mask

puzzle_2x2 - 0.jpg

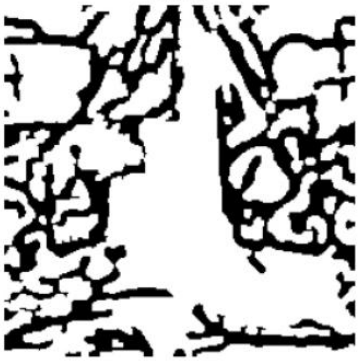
Original



Enhanced



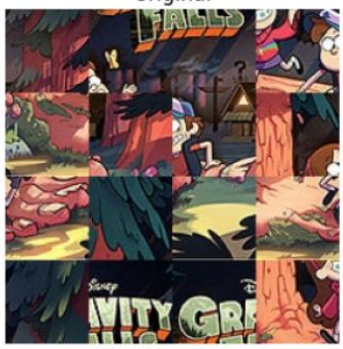
Mask



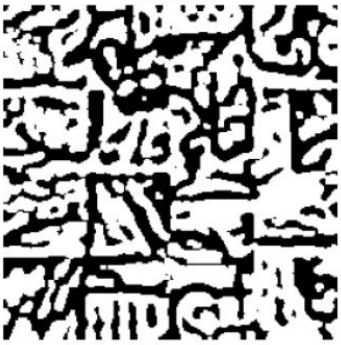
=== Previewing folder: puzzle_4x4 ===

puzzle_4x4 - 0.jpg

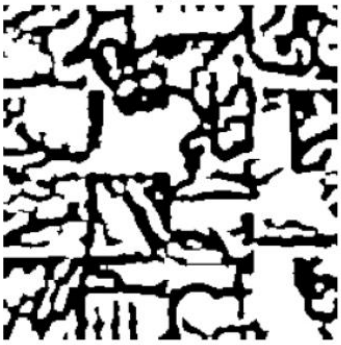
Original



Enhanced

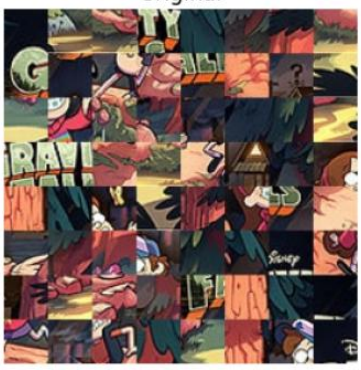


Mask

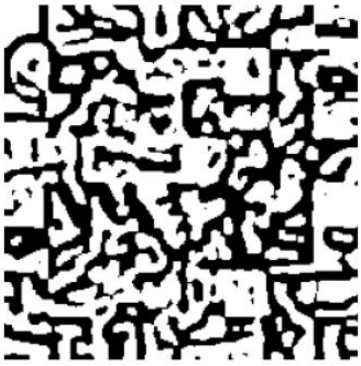


puzzle_8x8 - 0.jpg

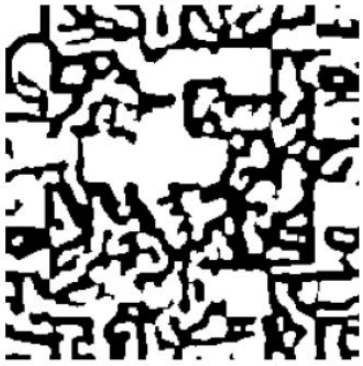
Original



Enhanced



Mask



4. Observations & Failure Cases

- Some tiles had slight shadows or different brightness, but adaptive threshold + histogram equalization handled them well.
- Very small noise spots appeared after thresholding; morphological opening removed them.
- Bilateral filtering helped preserve puzzle edge shapes without blurring them.

Overall, the pipeline performed consistently across all puzzle folders.

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5. Conclusion

In Milestone 1, we successfully created a complete image preprocessing pipeline using classical computer vision methods. The pipeline enhances edges, reduces noise, and produces clean masks for all puzzle configurations (2×2, 4×4, 8×8). These outputs prepare the dataset for the contour and edge-matching steps required in Milestone 2.