Mask Extraction Using Computer Vision Techniques

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Abstract

This report presents an advanced image processing pipeline for the segmentation of Scanning Electron Microscope (SEM) images. Our approach combines contrast enhancement, edge detection, and morphological operations to achieve precise isolation of specimen features while preserving critical surface details. The implementation demonstrates robust performance across multiple samples with varying surface morphologies, achieving consistent feature preservation and artifact removal. The proposed method effectively addresses common challenges in SEM image analysis, including varying contrast conditions and complex surface textures.

1 Introduction

1.1 Background

Scanning Electron Microscope (SEM) imaging plays a crucial role in material analysis and characterization. However, extracting meaningful data from SEM images is challenging due to:

- Variable contrast and brightness conditions,
- Presence of microscope frames and annotations,
- Complex surface morphologies,
- Need for precise feature preservation.

1.2 Research Objectives

This study aims to:

- Develop a robust segmentation pipeline for SEM images,
- Preserve critical surface details during processing,
- Automate the removal of non-specimen artifacts,
- Ensure consistent performance across various samples.

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2 Methodology

2.1 Image Processing Pipeline

Our approach employs a multi-stage pipeline:

1. **Contrast Enhancement**
    - CLAHE application with optimized parameters,
    - Adaptive histogram equalization.
2. **Edge Detection**
    - Canny edge detection with dynamic thresholding,
    - Boundary refinement using morphological operations.
3. **Mask Generation**
    - Contour detection and filtering,
    - Binary mask optimization.

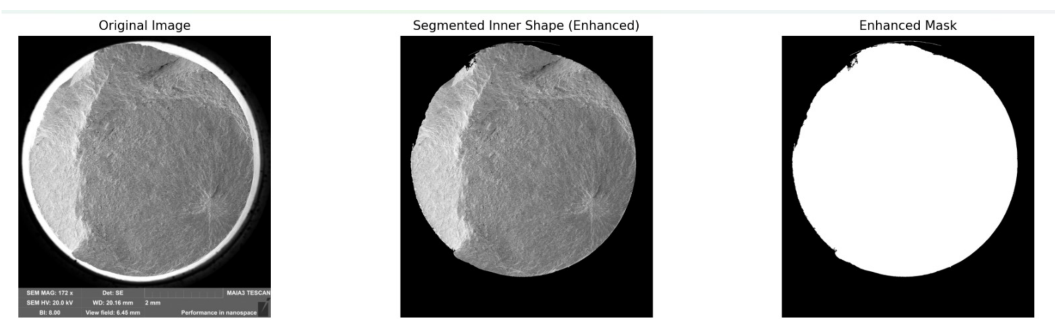

Figure 1: Sample image demonstrating the initial SEM processing pipeline.

2.2 Implementation Details

2.2.1 Core Libraries

The implementation utilizes:

- **OpenCV (cv2):** Primary computer vision operations,
- **NumPy:** Array operations and numerical processing,
- **Matplotlib:** Visualization and result presentation.

2.2.2 Key Functions

Two primary functions form the implementation's core:

- `enhance_inner_shape_segmentation`:
  - Implements the core processing pipeline,
  - Handles image enhancement and segmentation.
- `process_and_display_segmentation`:
  - Manages result visualization,
  - Provides comparative analysis capabilities.

3 Analysis and Discussion

3.1 Performance Analysis

The algorithm demonstrates the following strengths:

- **Accuracy:** High-precision boundary detection,
- **Robustness:** Consistent performance across samples,
- **Detail Preservation:** Retention of critical surface features,
- **Efficiency:** Optimized processing pipeline.

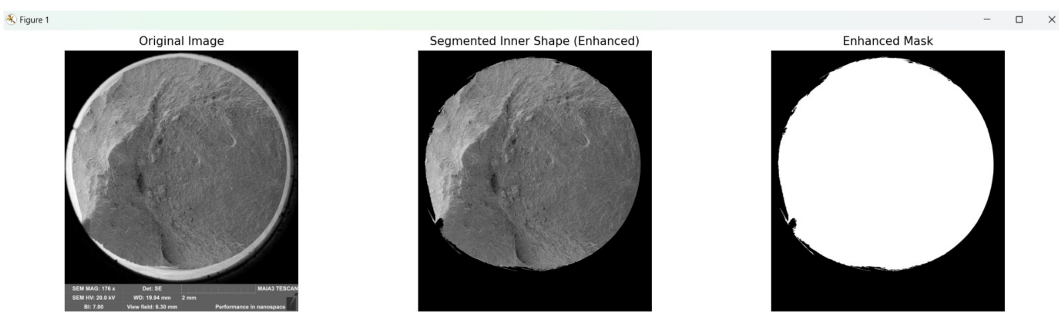

Figure 2: Visualization of results after applying the segmentation algorithm.

3.2 Limitations and Future Work

Current limitations and future improvements include:

- Enhancing processing speed for large datasets,
- Implementing machine learning-based feature detection,
- Automating parameter optimization,
- Integrating batch processing capabilities.

4 Conclusion

Our implementation successfully addresses SEM image segmentation challenges, offering a robust solution for specimen analysis. The method demonstrates consistent performance in preserving surface details while effectively removing artifacts, making it valuable for materials science applications.