Object Segmentation Using Core Image Processing

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***Abstract*—this project presents object segmentation using image processing techniques by applying them to the given COIL-20 dataset.the main objective of this one is to segment objects from grayscale images without using any machine learning methods.as given in the pipeline we first use gaussian blur for noise removal,and for edge detection we use canny and sobel,from the observed results canny's edge detection was better than sobel. their comparisons is also shown in the results,so canny produced better segmentation results.morpholigcal operations look further more to enhance object boundaries,the final step contour-based masking isolates objects from their background even if it is in different orientation as given in the dataset.the final results show the classical image processing techniques can perform well on object segmentation in limited grayscale datasets.**

***Index Terms*—Object segmentation, COIL-20 dataset, Canny edge detection, Sobel operator, Morphological operations, Contour extraction, Image processing**

I. Introduction

The main contributions of this work are as follows: The main contributions of this work are as follows:

- Nowadays images have been widely used from sharing data,or in fields like medicine and robotics.But if the data is in large numbers reviewing each image is not practical,for this reason we have image processing techniques which consumes comparatively less amount of time to extract useful information from them.
- the image processing methods are as follows starting from filtering,edge detection ,thresholding,and morphological operations are executed.in this project we have focused in traditional image processing techniques without machine learning and deep learning.the COIL-20 dataset is used for evaluation.it consists of grayscale images and the dataset includes images from different orientations,so it becomes suitable for testing edge based and intensity based segmentation methods.
- from the proposed pipeline,the first step begins with preprocessing.to do this gaussian filter is applied while preserving important structural details.
- after this edge detection is performed both using sobel and canny operators.the sobel operator calculates images gradients to detect edges,but sometimes it produces noisy images ,but canny edge detector is much more efficient as it follows multiple steps and it produces more accurate boundaries.A lot of researches shows how canny edge detector is better than sobel.
- Next comes the morphological operations such as erosion,dilation opening and closing.this helps improve object boundaries.Contour extraction is used to detect connected object regions,this creates a clean object mask which is helpful to separate object from the background.The above process shows the segmentation process which combines noise reduction,edge detection,morphological operation,contour extraction,and finally object mask.
- this approach shows that classical image processing techniques when applied on controlled dataset can produce reliable results.

II. Literature Survey

classical segmentation is a image processing technique which partitions image into separate or distinct region depending on low level pixel features like intensity,color etc.there are different techniques like edge-based,region-based and thresholding.

there are several operators like sobel which is a straightforward, gradient-based method for detecting edges in images whereas operator like canny is designed to be with high accuracy and noise resistant.

Several researchers have done this using both sobel and canny and have compared them explaining why canny is better than sobel in many ways.for example J.Siswantoro used sobel operator and k-means clustering for automatic image segmentation shows that sobel predicts edge well in grayscale images but generally canny works well under noisy conditions [1].A research paper on" Comparison of Canny edge detector with Sobel and Prewitt edge detector" using different image formats shows Canny produces more complete edges than sobel across different image formats which was done by Mamta Joshi,Ashutosh Vyas in 2014 [2].

In comparative studies, Kurniastuti (2025) demonstrated that traditional edge detectors combined with morphological closing and adaptive thresholding produce superior segmentation results compared to only using Sobel or Canny methods, especially in biomedical imaging tasks."Improved Edge Detection using Morphological Operation to Segmentation of Fingernail Images"P.Singh and R.sharma,they have mentioned that The results clearly show that the improved method, using adaptive thresholding and morphological closing, provides superior segmentation performance [3].

By this findings,the proposed pipeline applies noise removal techniques does edge detection using canny and sobel,followed by morphological refinement and contour-based object masking on COIL-20 images to achieve accurate results for object segmentation.

III. Methodology

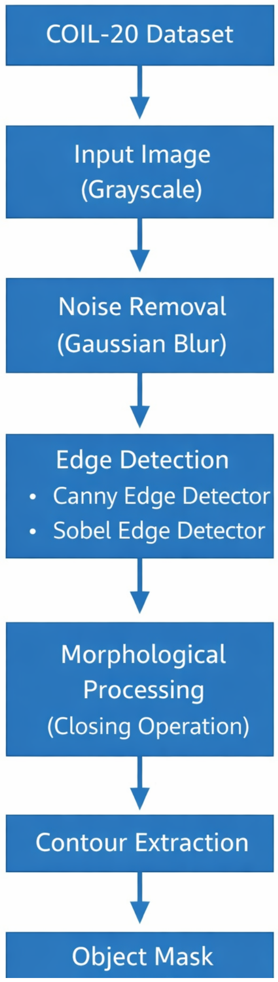

Fig. 1. Proposed Architecture Diagram

A. Dataset Organization

The experiments conducted in this study were based on the COIL-20 dataset. This dataset contains grayscale images of twenty objects captured from different orientations. Each object is imaged at regular angular intervals over a full 360-degree rotation, resulting in seventy-two images per object. The background in all images are mostly dark, which makes the dataset suitable for evaluating classical object segmentation techniques.

segmentation performance was assessed qualitatively through visual inspection of generated masks and bounding regions. This decision aligns with the objective of studying the behavior of filtering, thresholding, edge detection, and morphological transformations in controlled grayscale conditions.

All images were loaded in grayscale mode to maintain consistency with the original dataset structure.

For easy experimentation, a structured loop-based loading mechanism was implemented. This allowed sequential processing of each object category and ensured reproducibility. The dataset was not split into training and testing subsets, as the task does not involve learning-based classification. Instead, segmentation behavior was analyzed across multiple object views to observe robustness under rotation.

All outputsin a pipeline, including blurred images, edge maps, morphologically processed images, contour overlays, and final masks, were stored in separate output directories. This organization enabled stage-wise comparison and helped in analyzing the contribution of each processing step. By preserving the intermediate results, it was possible to systematically compare Sobel-based segmentation, Canny-based segmentation, and adaptive threshold-based segmentation under identical conditions.

This structured dataset organization ensured clarity, reproducibility, and efficient experimentation while maintaining the integrity of the original data.

B. Pre-processing and Input Construction

Pre-processing plays a main role in classical object segmentation. eventhough the COIL-20 images are clean and taken under controlled lighting, there were minor intensity variations and edge discontinuities which can affect contour extraction because of this a multi-stage pre-processing pipeline was designed to improve segmentation results.

The first stage involved was noise reduction. Gaussian smoothing was applied to each image in the dataset. A fixed kernel size was selected after verified observation to balance smoothing and edge preservation. Excessive smoothing was avoided, as it may blur object boundaries and reduce edge sharpness. The selected Gaussian filter reduced high-frequency noise while retaining meaningful structural information.

In parallel experiments, median filtering was also tested to observe its effect on potential impulse noise but as the dataset does not contain significant salt-and-pepper artifacts, Gaussian filtering was found to be sufficient and computationally efficient.

After noise reduction, edge detection was also performed. Two gradient-based methods were done: Sobel operator and Canny edge detector. The Sobel operator computes first-order derivatives along horizontal and vertical directions, producing gradient magnitude maps. Although Sobel effectively highlights edge transitions, the resulting edges were often thicker and required additional refinement compared to canny.

The Canny edge detector was also applied due to its multi-stage approach, which includes gradient calculation, non-maximum suppression, and hysteresis thresholding. The dual-threshold mechanism allowed stronger control over edge connectivity. it was observed Canny produced thinner and more continuous boundaries compared to Sobel due to this it was primarily used in the final segmentation pipeline, while Sobel results were retained for comparative analysis.

In addition to gradient-based segmentation, adaptive thresholding was explored as an alternative approach. Unlike global thresholding, which applies a single threshold value across the entire image, adaptive thresholding computes local thresholds based on neighborhood statistics. This approach is particularly useful when illumination varies spatially. Although COIL-20 images exhibit relatively uniform lighting, adaptive thresholding provided an additional segmentation pathway for evaluation.

After edge detection or thresholding, morphological operations were applied to refine the binary representations. Raw edge maps often contain small discontinuities . To address this, morphological closing was performed using a predefined structuring element. Closing combines dilation followed by erosion, effectively bridging small gaps in object boundaries while preserving overall shape integrity. The size of the structuring element was chosen carefully to avoid excessive merging of nearby regions.

when a coherent binary representation was obtained, contour extraction was performed. Only external contours were retrieved to isolate the primary object boundary. In cases where multiple contours were detected, the contour with the largest area was selected under the assumption that the object occupies the dominant region of the image. This assumption holds for the dataset used, as each image contains a single centered object.

From the selected contour, a binary object mask was generated by filling the enclosed region. This mask served as the final segmentation output. Additionally, bounding rectangles were computed to visualize object localization. These bounding boxes were overlaid on the original grayscale images for qualitative assessment.

Throughout the pre-processing pipeline, parameters such as Gaussian kernel size, Canny thresholds, and morphological kernel dimensions were kept consistent across all experiments. This ensured fairness in comparison and prevented parameter overfitting to specific object instances.

The complete input construction process transformed raw grayscale images into refined binary masks representing segmented objects. By systematically integrating filtering, edge detection, thresholding, and morphology, the pipeline achieved reliable object isolation without relying on machine learning models. This shows the effectiveness of carefully designed classical image processing techniques for structured grayscale datasets.

IV. Results and Discussion

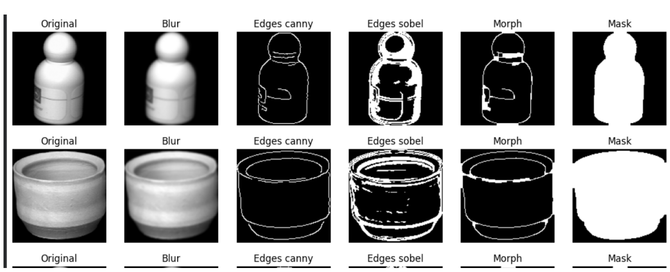

Fig. 2. Object Segmentation Output

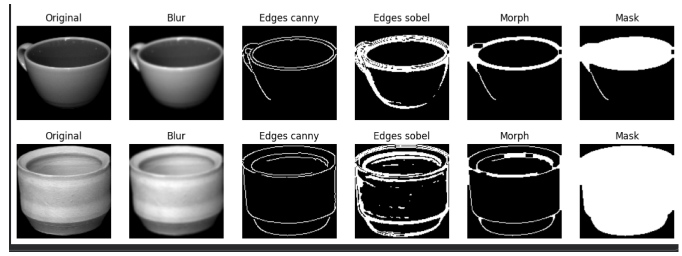

Fig. 3. Object Segmentation Output

the above pictures shows 4 samples it shows the flow from original to blur and then detecting edges by canny and sobel and then shows images from morph and mask.the results shows that canny detects edges more accurately than sobel,because sobel sometimes produces noisy or broken edges.as shown in the pipeline morphology is applied this applies erosion and dilation which makes the edges more sharp by reducing noise.in this process we have contour based masking,this technique efficiently separates the object from its background which creates clean object masks.So overall ,this pipeline works efficiently for the COIL-20 dataset provided. **Link to GitHub repository:https://github.com/Sreya889/pixel2intelligence** from the above link the segmented objects can be viewed along with the code.

V. Conclusion

the pipeline shows classic image processing techniques,which includes noise removal,edge detection,morphology,contour based masking,comparing canny and sobel ,it has been seen canny produces more accurate edges which have been shown with images in the results.the last two steps,morphological operations and contour based masking are important to refine the edges and get more accurate segmented objects,this pipeline is suitable simple method for object segmentation without using any machine learning and this is suitable for small sized datasets like COIL-20.Future work it can be explored for color images ,adaptive thresholding etc.

GitHub repository link: https://github.com/Sreya889/pixel2intelligence

References

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