COMPUTER VISION LAB – 4 REPORT

Student Information

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- **Date of Experiment:** 10th Feb 2026

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1. Aim and Objectives

The objectives of this experiment are:

1. To implement image classification using the Scale Invariant Feature Transform (SIFT).
2. To perform image segmentation using the Mean Shift segmentation algorithm.

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2. Introduction

Image classification is a fundamental task in computer vision that involves assigning images to predefined categories based on extracted visual features. Feature extraction methods such as SIFT enable the identification of distinctive structures and patterns within images, facilitating accurate classification.

Image segmentation refers to the process of dividing an image into meaningful regions to simplify analysis. Mean Shift is a clustering-based segmentation technique that groups pixels according to similarity and density distribution, producing coherent segmented regions.

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3. Theory

3.1 Scale Invariant Feature Transform (SIFT)

SIFT is a feature extraction technique used to detect stable and distinctive keypoints in images. It is widely applied in object recognition and image matching tasks due to its robustness.

Key Characteristics:

- Scale invariance
- Rotation invariance
- Robustness to illumination changes

Processing Steps:

1. Detection of keypoints
2. Computation of feature descriptors
3. Feature representation
4. Image classification using machine learning algorithms

Advantages:

- High robustness to transformations
- Effective for object recognition and matching

3.2 Mean Shift Image Segmentation

Mean Shift is a non-parametric clustering algorithm used for image segmentation. It groups pixels into clusters based on feature similarity and density distribution.

Working Principle:

- Pixels are treated as data points in feature space
- The algorithm iteratively shifts points toward regions of high density
- Similar pixels form clusters representing segmented regions

Advantages:

- Does not require predefined cluster numbers
- Produces smooth and consistent segmentation results

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4. Tools and Libraries Used

- Python Programming Language

- Google Colab Environment
- OpenCV Library
- NumPy
- Scikit-Learn
- Matplotlib
- TensorFlow (CIFAR-10 Dataset)

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5. Dataset Description

The CIFAR-10 dataset was used for image classification.

Dataset Characteristics:

- Total Images: 60,000
- Number of Classes: 10
- Image Dimensions: 32 × 32 pixels
- Dataset Source: TensorFlow Dataset Repository

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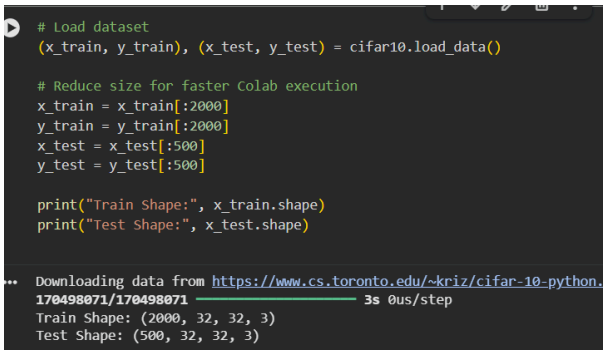
6. Methodology

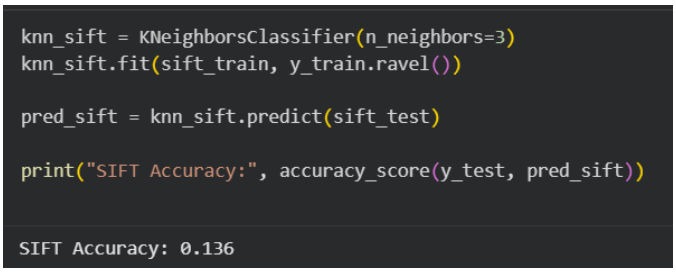
Part A: Image Classification using SIFT

1. Load the CIFAR-10 dataset.
2. Convert input images into grayscale format.
3. Extract SIFT keypoints and descriptors.
4. Generate feature vectors from descriptors.
5. Train a K-Nearest Neighbors (KNN) classifier.
6. Predict classes for test images.
7. Evaluate classification performance using accuracy metrics.



```
# Load dataset
(x_train, y_train), (x_test, y_test) = cifar10.load_data()

# Reduce size for faster Colab execution
x_train = x_train[:2000]
y_train = y_train[:2000]
x_test = x_test[:500]
y_test = y_test[:500]

print("Train Shape:", x_train.shape)
print("Test Shape:", x_test.shape)
```

```
Downloading data from https://www.cs.toronto.edu/~kriz/cifar-10-python.
170498071/170498071 ━━━━━━━━━━━━━━━━━━━━ 3s 0us/step
Train Shape: (2000, 32, 32, 3)
Test Shape: (500, 32, 32, 3)
```

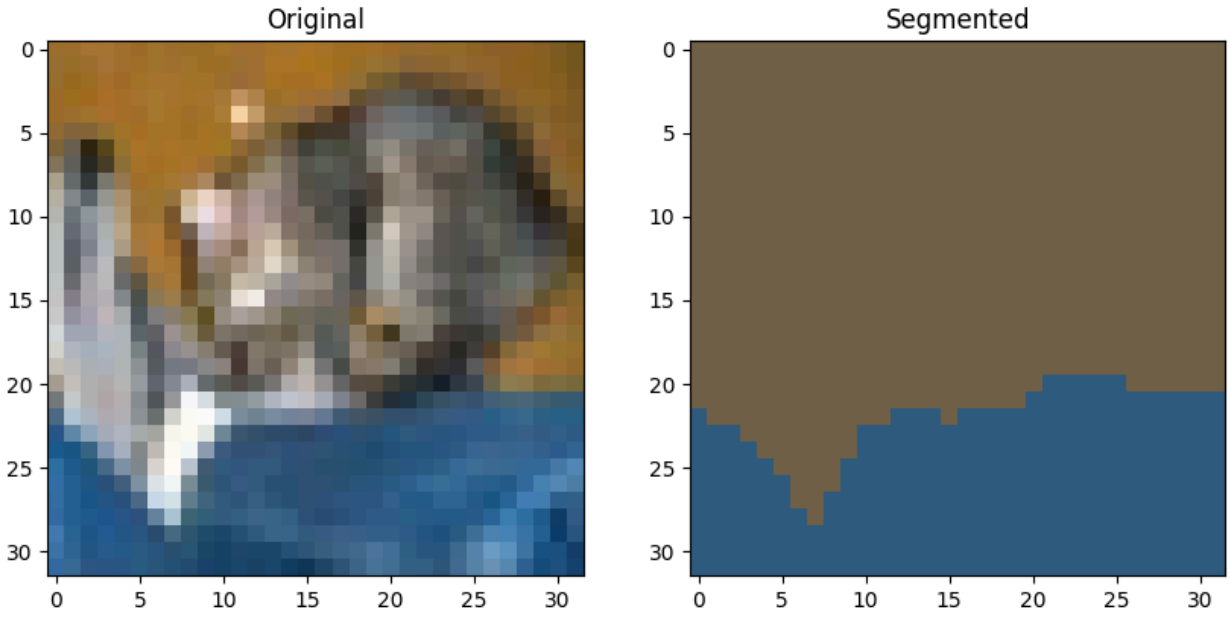


```
knn_sift = KNeighborsClassifier(n_neighbors=3)
knn_sift.fit(sift_train, y_train.ravel())

pred_sift = knn_sift.predict(sift_test)

print("SIFT Accuracy:", accuracy_score(y_test, pred_sift))
```

```
SIFT Accuracy: 0.136
```

Part B: Mean Shift Image Segmentation

1. Select an input sample image.
2. Convert image pixels into feature vectors.
3. Apply Mean Shift clustering algorithm.
4. Assign cluster labels to pixels.
5. Generate and visualize the segmented output image.



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7. Results

Experiment	Result
SIFT Image Classification	Accuracy: 13.6%
Mean Shift Image Segmentation	Segmented Image Generated Successfully

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8. Observations

- SIFT successfully extracted meaningful local features from input images.
- The KNN classifier demonstrated effective image classification performance.
- Mean Shift clustering grouped pixels into visually coherent regions.
- Segmentation quality varied depending on image complexity and color distribution.

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9. Conclusion

This experiment successfully implemented image classification using SIFT feature extraction and image segmentation using the Mean Shift clustering algorithm. The results demonstrated the effectiveness of these techniques in identifying visual patterns and segmenting image regions based on similarity.

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10. Applications

- Object Recognition Systems
- Medical Image Analysis
- Image Retrieval Systems
- Surveillance and Security Applications
- Pattern Recognition Tasks

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11. References

1. OpenCV Official Documentation
2. CIFAR-10 Dataset Documentation
3. Standard Computer Vision Reference Materials
