CSE463 Homework 2

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1 Introduction

This report presents the findings of an object recognition task using four different feature detectors: SIFT, ORB, AKAZE, and BRISK. The goal was to classify 10 objects from the RGBD dataset using feature descriptors extracted from images. The results were evaluated using confusion matrices. The entire process takes approximately 10-15 minutes to run.

2 Selected Objects

The following objects were selected for this experiment:

- lime_1
- bowl_4
- lemon_1
- instant_noodles_1
- ball_1
- orange_2
- toothpaste_2
- peach_3
- water_bottle_1
- scissors_3

3 Feature Detection and Extraction

For each object, images were loaded, augmented, and features were extracted using the four detectors. The number of features detected per object for each detector is visualized in Figures 1, 2, and 3.


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Number of features extracted per object by each detector:

Object: lime_1
SIFT: 26823
BRISK: 819

Object: bowl_4
SIFT: 20651
ORB: 16194
AKAZE: 1470
BRISK: 9713

Object: lemon_1
SIFT: 16093
BRISK: 668

Object: instant_noodles_1
SIFT: 489928
ORB: 427932
AKAZE: 96163
BRISK: 476159
```

Figure 1: Number of Features Extracted per Object by Each Detector (Part 1)

```
Object: ball_1
SIFT: 57320
BRISK: 5206

Object: orange_2
SIFT: 21851
BRISK: 166

Object: toothpaste_2
SIFT: 158786
ORB: 70551
AKAZE: 18791
BRISK: 82319

Object: peach_3
SIFT: 31552
ORB: 1452
AKAZE: 723
BRISK: 2773

Object: water_bottle_1
SIFT: 164128
ORB: 53847
AKAZE: 8583
BRISK: 66548
```

Figure 2: Number of Features Extracted per Object by Each Detector (Part 2)

```
Object: scissors_3
SIFT: 35987
ORB: 8463
AKAZE: 2550
BRISK: 8933
```

Figure 3: Number of Features Extracted per Object by Each Detector (Part 3)

4 Object Recognition Algorithm

The object recognition algorithm was implemented as follows:

- **Image Loading and Augmentation**: Images for each object were loaded and augmented by flipping and rotating.

- **Feature Extraction**: Features were extracted using SIFT, ORB, AKAZE, and BRISK detectors.

- **Training and Testing**: Features were used to train a RandomForest-Classifier, which was then tested on a separate test set.

5   Results

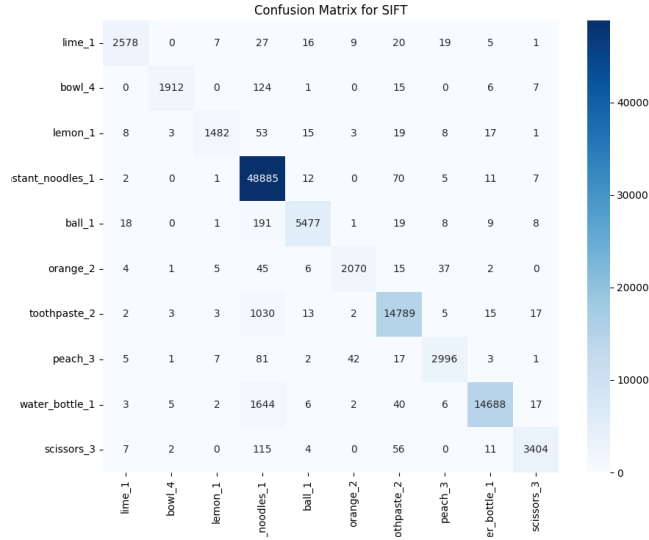The confusion matrices for each detector are shown in Figures 4, 6, 5, and 7.
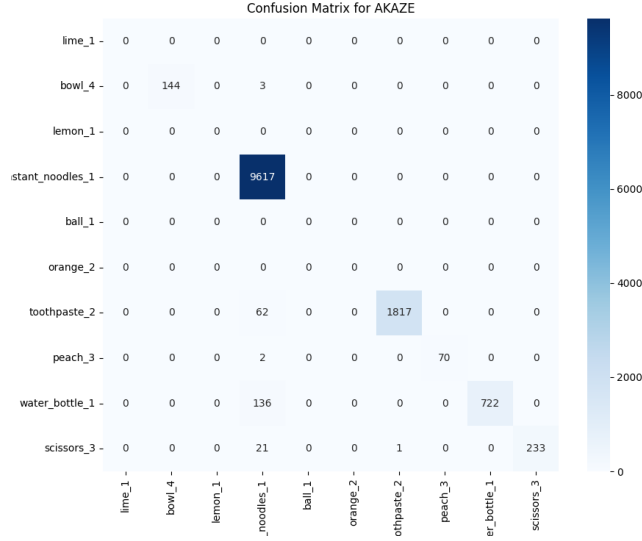

Figure 4: Confusion Matrix for SIFT
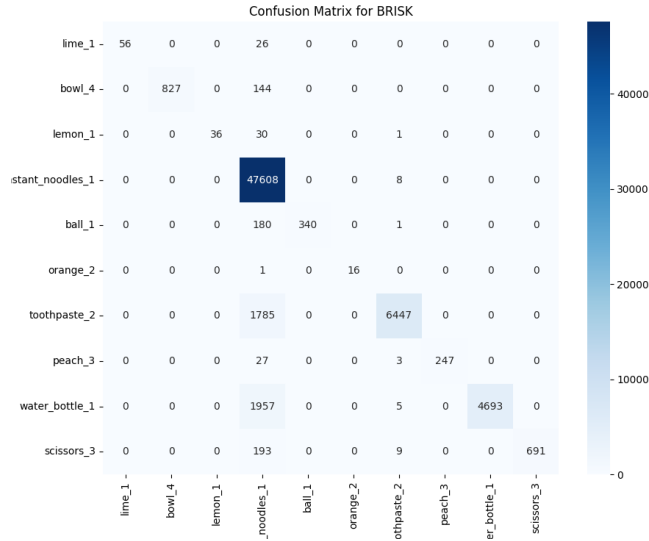
Figure 5: Confusion Matrix for AKAZE
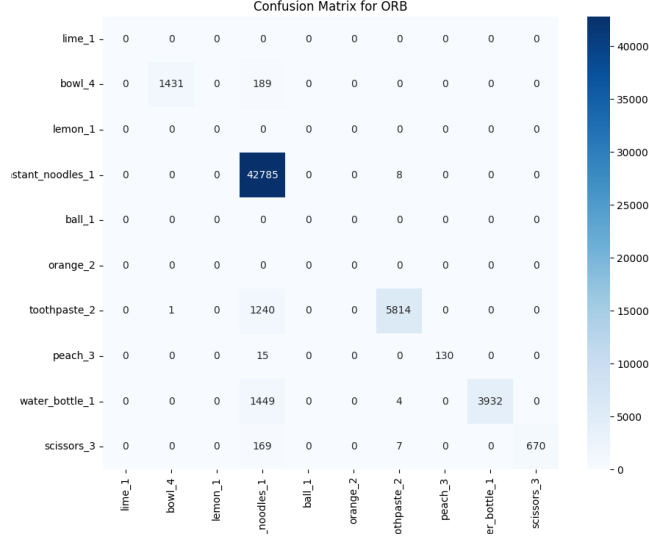

Figure 6: Confusion Matrix for BRISK

Figure 7: Confusion Matrix for ORB

6 Discussion

The results show varying levels of performance for different feature detectors:

- **SIFT**: Provided a high number of features but suffered from overfitting, resulting in misclassifications.

- **ORB**: Performed moderately well but with fewer features compared to SIFT.

- **AKAZE**: Showed a balanced performance with a reasonable number of features and accuracy.

- **BRISK**: Provided the least number of features but maintained decent accuracy.

7 Conclusion

Using four detectors helped in understanding the strengths and weaknesses of each feature detector. The RandomForestClassifier proved to be an effective approach for improving classification performance. Future work can explore additional detectors and advanced fusion techniques to further improve performance.

8 Intermediate Results and Performance Analysis

The intermediate results show the number of features detected per object for each detector (Figures 1, 2, 3). The detailed object recognition algorithm steps have been outlined, and confusion matrices for each detector's performance are provided.

The detectors showed varying accuracy due to differences in feature extraction capabilities:

- **SIFT**: High feature count but prone to overfitting, leading to lower generalization on test data.

- **ORB**: Lower feature count but provided a good balance between accuracy and computational efficiency.

- **AKAZE**: Balanced performance with reasonable feature count and accuracy.

- **BRISK**: Least number of features but maintained acceptable accuracy.