CSE 565 HW 2 REPORT

244201001033 AKCAN ERCAN

Contents

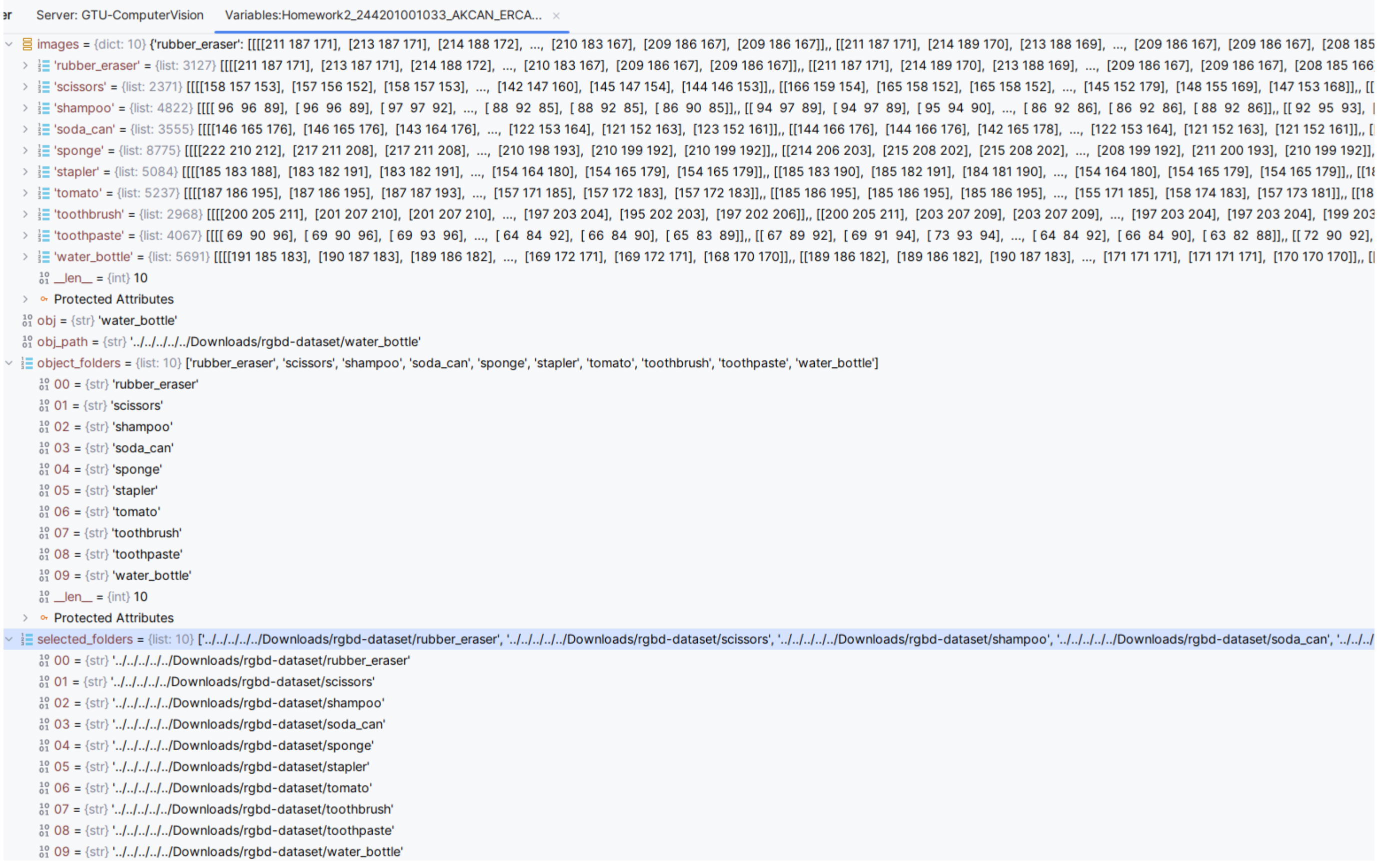
➢ The list of selected object

I selected last 10 objects in rgbd-dataset; rubber_eraser, scissors, shampoo, soda_can, sponge, stapler, tomato, toothbrush, toothpaste, water_bottle.

There are **182,851** items, totally **675.7 MB.**

I saw bunch of sub-folder in each main folder. All sub-folder has three main picture;

- for example tomato object has 8 sub-folder;
    - *tomato_1, tomato_2, tomato_3, tomato_4, tomato_5, tomato_6, tomato_7, tomato_8*
- And tomato_1 has 3 main file;
    - *tomato_1_1_1_crop.png, tomato_1_1_1_depthcrop.png, tomato_1_1_1_loc.txt*
- As you can see, actually we need ..._crop.png, so I selected all pictures where includes name with ***_crop.png*** with sub-folder and main folder. The final folder and images;
- The sum of trained object, I mean sum of *_crop.png* files are **45,697** images.

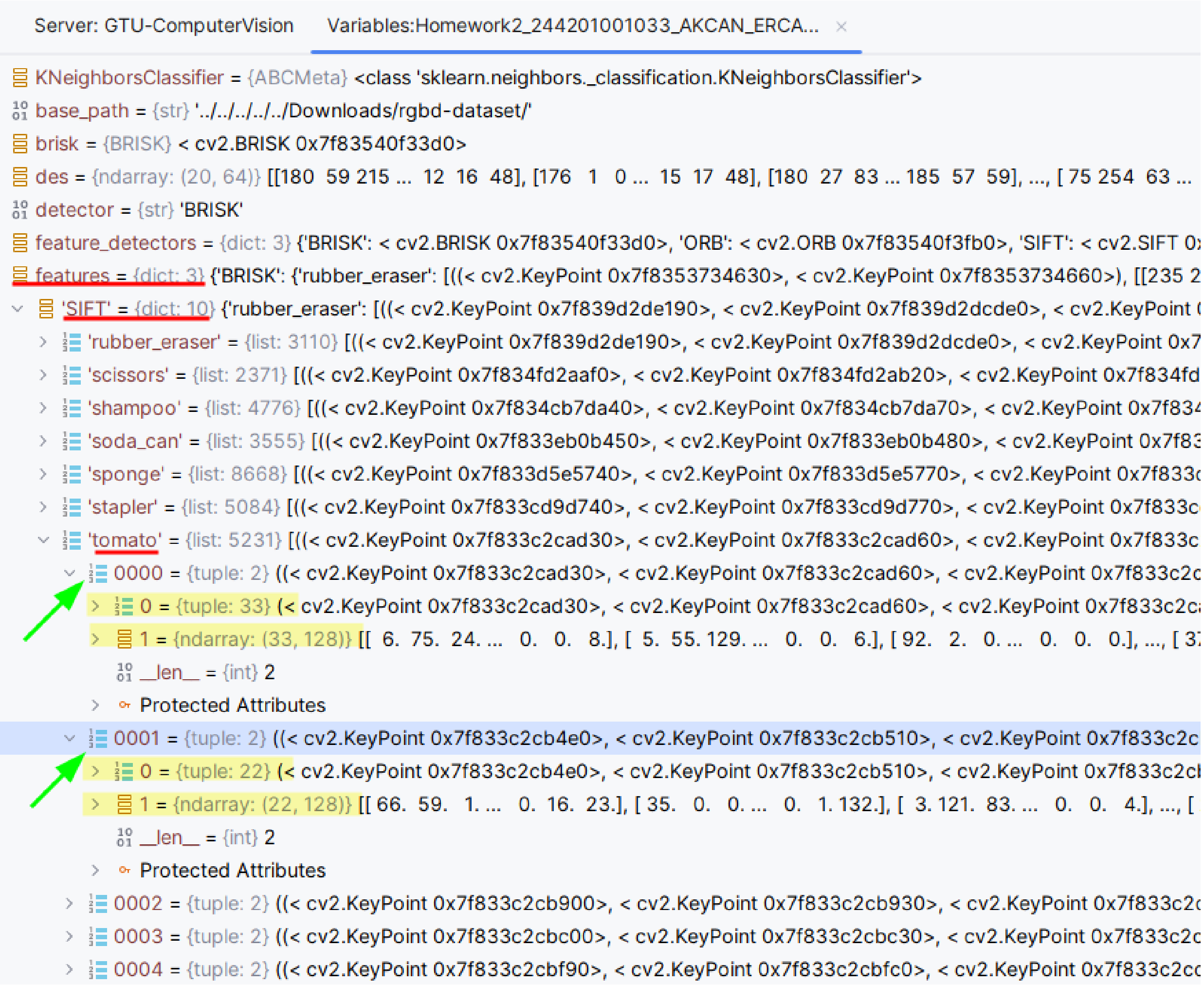


```
er    Server: GTU-ComputerVision    Variables:Homework2_244201001033_AKCAN_ERCA... ×
⌄ images = {dict: 10} {'rubber_eraser': [[[[211 187 171],  [213 187 171],  [214 188 172],  ...,  [210 183 167],  [209 186 167],  [209 186 167]],, [[211 187 171],  [214 189 170],  [213 188 169],  ...,  [209 186 167],  [209 186 167],  [208 185
  > 'rubber_eraser' = {list: 3127} [[[[211 187 171],  [213 187 171],  [214 188 172],  ...,  [210 183 167],  [209 186 167],  [209 186 167]],, [[211 187 171],  [214 189 170],  [213 188 169],  ...,  [209 186 167],  [209 186 167],  [208 185 166
  > 'scissors' = {list: 2371} [[[[158 157 153],  [157 156 152],  [158 157 153],  ...,  [142 147 160],  [145 147 154],  [144 146 153]],, [[166 159 154],  [165 158 152],  [165 158 152],  ...,  [145 152 179],  [148 155 169],  [147 153 168]],, [[
  > 'shampoo' = {list: 4822} [[[[ 96  96  89],  [ 96  96  89],  [ 97  97  92],  ...,  [ 88  92  85],  [ 88  92  85],  [ 86  90  85]],, [[ 94  97  89],  [ 94  97  89],  [ 95  94  90],  ...,  [ 86  92  86],  [ 86  92  86],  [ 88  92  86]],, [[ 92  95  93],  [
  > 'soda_can' = {list: 3555} [[[[146 165 176],  [146 165 176],  [143 164 176],  ...,  [122 153 164],  [121 152 163],  [123 152 161]],, [[144 166 176],  [144 166 176],  [142 165 178],  ...,  [122 153 164],  [121 152 163],  [121 152 161]],, [
  > 'sponge' = {list: 8775} [[[[222 210 212],  [217 211 208],  [217 211 208],  ...,  [210 198 193],  [210 199 192],  [210 199 192]],, [[214 206 203],  [215 208 202],  [215 208 202],  ...,  [208 199 192],  [211 200 193],  [210 199 192]],
  > 'stapler' = {list: 5084} [[[[185 183 188],  [183 182 191],  [183 182 191],  ...,  [154 164 180],  [154 165 179],  [154 165 179]],, [[185 183 190],  [185 182 191],  [184 181 190],  ...,  [154 164 180],  [154 165 179],  [154 165 179]],, [[18
  > 'tomato' = {list: 5237} [[[[187 186 195],  [187 186 195],  [187 187 193],  ...,  [157 171 185],  [157 172 183],  [157 172 183]],, [[185 186 195],  [185 186 195],  [185 186 195],  ...,  [155 171 185],  [158 174 183],  [157 173 181]],, [[18
  > 'toothbrush' = {list: 2968} [[[[200 205 211],  [201 207 210],  [201 207 210],  ...,  [197 203 204],  [195 202 203],  [197 202 206]],, [[200 205 211],  [203 207 209],  [203 207 209],  ...,  [197 203 204],  [197 203 204],  [199 203
  > 'toothpaste' = {list: 4067} [[[[ 69  90  96],  [ 69  90  96],  [ 69  93  96],  ...,  [ 64  84  92],  [ 66  84  90],  [ 65  83  89]],, [[ 67  89  92],  [ 69  91  94],  [ 73  93  94],  ...,  [ 64  84  92],  [ 66  84  90],  [ 63  82  88]],, [[ 72  90  92],
  > 'water_bottle' = {list: 5691} [[[[191 185 183],  [190 187 183],  [189 186 182],  ...,  [169 172 171],  [169 172 171],  [168 170 170]],, [[189 186 182],  [189 186 182],  [190 187 183],  ...,  [171 171 171],  [171 171 171],  [170 170 170]],, [[
    __len__ = {int} 10
  > Protected Attributes
  obj = {str} 'water_bottle'
  obj_path = {str} '../../../../../Downloads/rgbd-dataset/water_bottle'
⌄ object_folders = {list: 10} ['rubber_eraser', 'scissors', 'shampoo', 'soda_can', 'sponge', 'stapler', 'tomato', 'toothbrush', 'toothpaste', 'water_bottle']
    00 = {str} 'rubber_eraser'
    01 = {str} 'scissors'
    02 = {str} 'shampoo'
    03 = {str} 'soda_can'
    04 = {str} 'sponge'
    05 = {str} 'stapler'
    06 = {str} 'tomato'
    07 = {str} 'toothbrush'
    08 = {str} 'toothpaste'
    09 = {str} 'water_bottle'
    __len__ = {int} 10
  > Protected Attributes
⌄ selected_folders = {list: 10} ['../../../../../Downloads/rgbd-dataset/rubber_eraser', '../../../../../Downloads/rgbd-dataset/scissors', '../../../../../Downloads/rgbd-dataset/shampoo', '../../../../../Downloads/rgbd-dataset/soda_can', '../../../
    00 = {str} '../../../../../Downloads/rgbd-dataset/rubber_eraser'
    01 = {str} '../../../../../Downloads/rgbd-dataset/scissors'
    02 = {str} '../../../../../Downloads/rgbd-dataset/shampoo'
    03 = {str} '../../../../../Downloads/rgbd-dataset/soda_can'
    04 = {str} '../../../../../Downloads/rgbd-dataset/sponge'
    05 = {str} '../../../../../Downloads/rgbd-dataset/stapler'
    06 = {str} '../../../../../Downloads/rgbd-dataset/tomato'
    07 = {str} '../../../../../Downloads/rgbd-dataset/toothbrush'
    08 = {str} '../../../../../Downloads/rgbd-dataset/toothpaste'
    09 = {str} '../../../../../Downloads/rgbd-dataset/water_bottle'
```

- I selected 3 different feature detector (descriptor): ***SIFT***, ***ORB*** and ***BRISK***

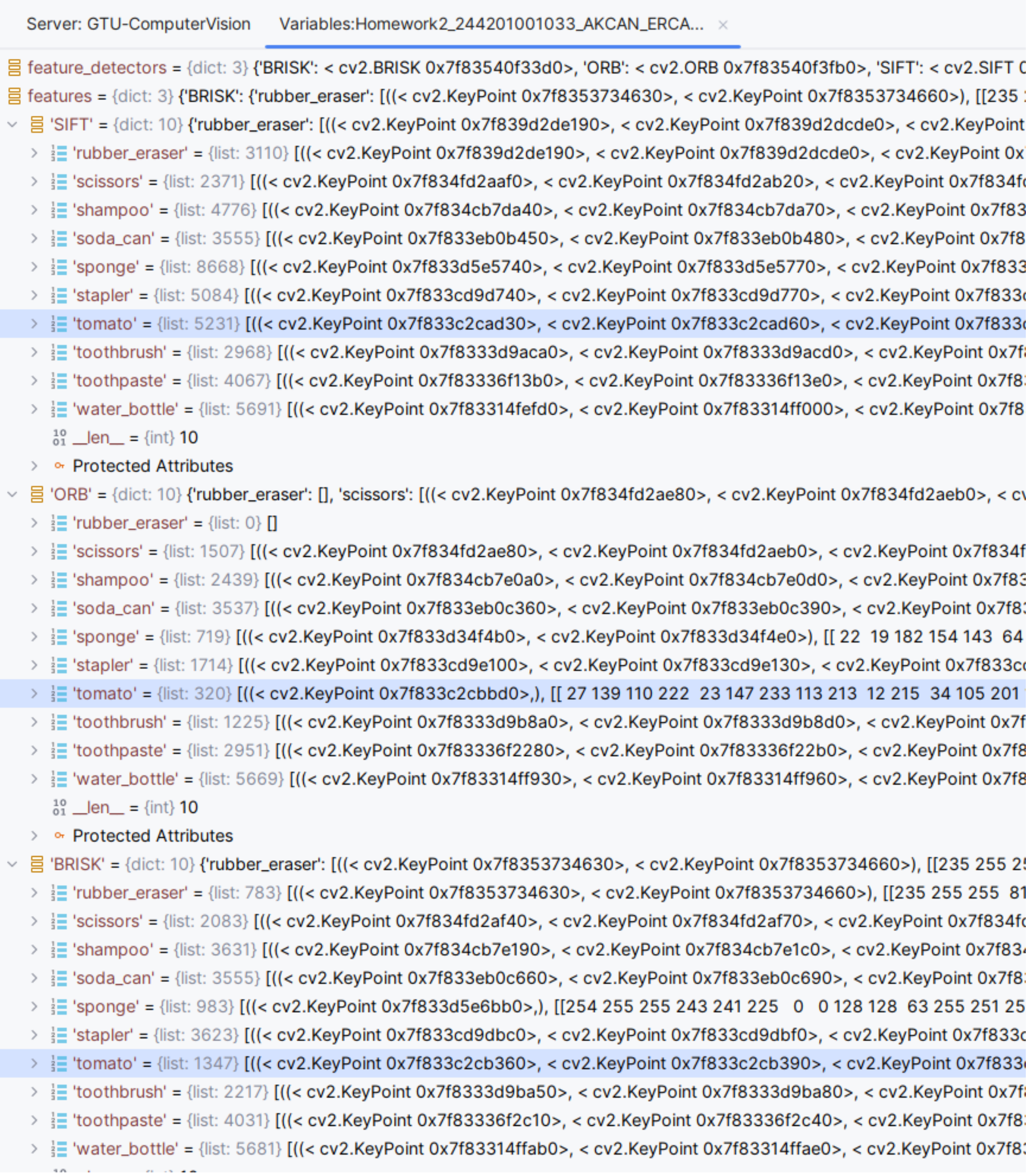
➢ The features detected on the objects

- When I try to show features detected on the objects, I got an error. Actually, features have two element; List {cv2.KeyPoint} and ndarray : { 33, 228}. I found these features for 3 detectors. In that place I will show detected features in PyCharm IDE. As you can see, each features have different KeyPoint in List (actually tupple) and different dimension of ndarray. It is impossible for me to show all the features anyway, because there are so many features.


Server: GTU-ComputerVision
Variables:Homework2_244201001033_AKCAN_ERCA...

```
KNeighborsClassifier = {ABCMeta} <class 'sklearn.neighbors._classification.KNeighborsClassifier'>
base_path = {str} '../../../../../Downloads/rgbd-dataset/'
brisk = {BRISK} < cv2.BRISK 0x7f83540f33d0>
des = {ndarray: (20, 64)} [[180  59 215 ...  12  16  48], [176   1   0 ...  15  17  48], [180  27  83 ... 185  57  59], ..., [ 75 254  63 ...
detector = {str} 'BRISK'
feature_detectors = {dict: 3} {'BRISK': < cv2.BRISK 0x7f83540f33d0>, 'ORB': < cv2.ORB 0x7f83540f3fb0>, 'SIFT': < cv2.SIFT 0x
features = {dict: 3} {'BRISK': {'rubber_eraser': [((< cv2.KeyPoint 0x7f8353734630>, < cv2.KeyPoint 0x7f8353734660>), [[235 2
  'SIFT' = {dict: 10} {'rubber_eraser': [((< cv2.KeyPoint 0x7f839d2de190>, < cv2.KeyPoint 0x7f839d2dcde0>, < cv2.KeyPoint
    'rubber_eraser' = {list: 3110} [((< cv2.KeyPoint 0x7f839d2de190>, < cv2.KeyPoint 0x7f839d2dcde0>, < cv2.KeyPoint 0x7
    'scissors' = {list: 2371} [((< cv2.KeyPoint 0x7f834fd2aaf0>, < cv2.KeyPoint 0x7f834fd2ab20>, < cv2.KeyPoint 0x7f834fd
    'shampoo' = {list: 4776} [((< cv2.KeyPoint 0x7f834cb7da40>, < cv2.KeyPoint 0x7f834cb7da70>, < cv2.KeyPoint 0x7f834
    'soda_can' = {list: 3555} [((< cv2.KeyPoint 0x7f833eb0b450>, < cv2.KeyPoint 0x7f833eb0b480>, < cv2.KeyPoint 0x7f83
    'sponge' = {list: 8668} [((< cv2.KeyPoint 0x7f833d5e5740>, < cv2.KeyPoint 0x7f833d5e5770>, < cv2.KeyPoint 0x7f833
    'stapler' = {list: 5084} [((< cv2.KeyPoint 0x7f833cd9d740>, < cv2.KeyPoint 0x7f833cd9d770>, < cv2.KeyPoint 0x7f833c
    'tomato' = {list: 5231} [((< cv2.KeyPoint 0x7f833c2cad30>, < cv2.KeyPoint 0x7f833c2cad60>, < cv2.KeyPoint 0x7f833c
      0000 = {tuple: 2} ((< cv2.KeyPoint 0x7f833c2cad30>, < cv2.KeyPoint 0x7f833c2cad60>, < cv2.KeyPoint 0x7f833c2c
        0 = {tuple: 33} (< cv2.KeyPoint 0x7f833c2cad30>, < cv2.KeyPoint 0x7f833c2cad60>, < cv2.KeyPoint 0x7f833c2c
        1 = {ndarray: (33, 128)} [[  6.  75.  24. ...   0.   0.   8.], [  5.  55. 129. ...   0.   0.   6.], [ 92.   2.   0. ...   0.   0.   0.], ..., [ 3
        __len__ = {int} 2
        Protected Attributes
      0001 = {tuple: 2} ((< cv2.KeyPoint 0x7f833c2cb4e0>, < cv2.KeyPoint 0x7f833c2cb510>, < cv2.KeyPoint 0x7f833c2c
        0 = {tuple: 22} (< cv2.KeyPoint 0x7f833c2cb4e0>, < cv2.KeyPoint 0x7f833c2cb510>, < cv2.KeyPoint 0x7f833c2c
        1 = {ndarray: (22, 128)} [[ 66.  59.   1. ...   0.  16.  23.], [ 35.   0.   0. ...   0.   1. 132.], [  3. 121.  83. ...   0.   0.   4.], ..., [
        __len__ = {int} 2
        Protected Attributes
      0002 = {tuple: 2} ((< cv2.KeyPoint 0x7f833c2cb900>, < cv2.KeyPoint 0x7f833c2cb930>, < cv2.KeyPoint 0x7f833c2c
      0003 = {tuple: 2} ((< cv2.KeyPoint 0x7f833c2cbc00>, < cv2.KeyPoint 0x7f833c2cbc30>, < cv2.KeyPoint 0x7f833c2c
      0004 = {tuple: 2} ((< cv2.KeyPoint 0x7f833c2cbf90>, < cv2.KeyPoint 0x7f833c2cbfc0>, < cv2.KeyPoint 0x7f833c2c
```

- We also understand here that each descriptor didn’t captured the same number of features. I mean; the sift descriptor described **5231** features for tomato object while the orb descriptor described **320** features object and brisk descriptor described **1347** features for tomato object.

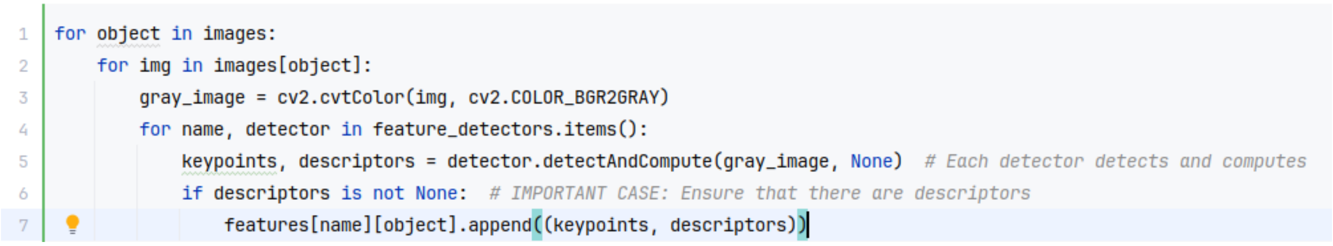


Server: GTU-ComputerVision
Variables:Homework2_244201001033_AKCAN_ERCA...
×
Protected Attributes
Protected Attributes

```
feature_detectors = {dict: 3} {'BRISK': < cv2.BRISK 0x7f83540f33d0>, 'ORB': < cv2.ORB 0x7f83540f3fb0>, 'SIFT': < cv2.SIFT 0
features = {dict: 3} {'BRISK': {'rubber_eraser': [((< cv2.KeyPoint 0x7f8353734630>, < cv2.KeyPoint 0x7f8353734660>), [[235 2
  'SIFT' = {dict: 10} {'rubber_eraser': [((< cv2.KeyPoint 0x7f839d2de190>, < cv2.KeyPoint 0x7f839d2dcde0>, < cv2.KeyPoint
    'rubber_eraser' = {list: 3110} [((< cv2.KeyPoint 0x7f839d2de190>, < cv2.KeyPoint 0x7f839d2dcde0>, < cv2.KeyPoint 0x
    'scissors' = {list: 2371} [((< cv2.KeyPoint 0x7f834fd2aaf0>, < cv2.KeyPoint 0x7f834fd2ab20>, < cv2.KeyPoint 0x7f834f
    'shampoo' = {list: 4776} [((< cv2.KeyPoint 0x7f834cb7da40>, < cv2.KeyPoint 0x7f834cb7da70>, < cv2.KeyPoint 0x7f83
    'soda_can' = {list: 3555} [((< cv2.KeyPoint 0x7f833eb0b450>, < cv2.KeyPoint 0x7f833eb0b480>, < cv2.KeyPoint 0x7f8
    'sponge' = {list: 8668} [((< cv2.KeyPoint 0x7f833d5e5740>, < cv2.KeyPoint 0x7f833d5e5770>, < cv2.KeyPoint 0x7f833
    'stapler' = {list: 5084} [((< cv2.KeyPoint 0x7f833cd9d740>, < cv2.KeyPoint 0x7f833cd9d770>, < cv2.KeyPoint 0x7f833
    'tomato' = {list: 5231} [((< cv2.KeyPoint 0x7f833c2cad30>, < cv2.KeyPoint 0x7f833c2cad60>, < cv2.KeyPoint 0x7f833
    'toothbrush' = {list: 2968} [((< cv2.KeyPoint 0x7f8333d9aca0>, < cv2.KeyPoint 0x7f8333d9acd0>, < cv2.KeyPoint 0x7f
    'toothpaste' = {list: 4067} [((< cv2.KeyPoint 0x7f83336f13b0>, < cv2.KeyPoint 0x7f83336f13e0>, < cv2.KeyPoint 0x7f8
    'water_bottle' = {list: 5691} [((< cv2.KeyPoint 0x7f83314fefd0>, < cv2.KeyPoint 0x7f83314ff000>, < cv2.KeyPoint 0x7f8
    __len__ = {int} 10
    Protected Attributes
  'ORB' = {dict: 10} {'rubber_eraser': [], 'scissors': [((< cv2.KeyPoint 0x7f834fd2ae80>, < cv2.KeyPoint 0x7f834fd2aeb0>, < cv
    'rubber_eraser' = {list: 0} []
    'scissors' = {list: 1507} [((< cv2.KeyPoint 0x7f834fd2ae80>, < cv2.KeyPoint 0x7f834fd2aeb0>, < cv2.KeyPoint 0x7f834f
    'shampoo' = {list: 2439} [((< cv2.KeyPoint 0x7f834cb7e0a0>, < cv2.KeyPoint 0x7f834cb7e0d0>, < cv2.KeyPoint 0x7f83
    'soda_can' = {list: 3537} [((< cv2.KeyPoint 0x7f833eb0c360>, < cv2.KeyPoint 0x7f833eb0c390>, < cv2.KeyPoint 0x7f8
    'sponge' = {list: 719} [((< cv2.KeyPoint 0x7f833d34f4b0>, < cv2.KeyPoint 0x7f833d34f4e0>), [[ 22  19 182 154 143  64
    'stapler' = {list: 1714} [((< cv2.KeyPoint 0x7f833cd9e100>, < cv2.KeyPoint 0x7f833cd9e130>, < cv2.KeyPoint 0x7f833c
    'tomato' = {list: 320} [((< cv2.KeyPoint 0x7f833c2cbbd0>,), [[ 27 139 110 222  23 147 233 113 213  12 215  34 105 201
    'toothbrush' = {list: 1225} [((< cv2.KeyPoint 0x7f8333d9b8a0>, < cv2.KeyPoint 0x7f8333d9b8d0>, < cv2.KeyPoint 0x7f
    'toothpaste' = {list: 2951} [((< cv2.KeyPoint 0x7f83336f2280>, < cv2.KeyPoint 0x7f83336f22b0>, < cv2.KeyPoint 0x7f8
    'water_bottle' = {list: 5669} [((< cv2.KeyPoint 0x7f83314ff930>, < cv2.KeyPoint 0x7f83314ff960>, < cv2.KeyPoint 0x7f8
    __len__ = {int} 10
    Protected Attributes
  'BRISK' = {dict: 10} {'rubber_eraser': [((< cv2.KeyPoint 0x7f8353734630>, < cv2.KeyPoint 0x7f8353734660>), [[235 255 2
    'rubber_eraser' = {list: 783} [((< cv2.KeyPoint 0x7f8353734630>, < cv2.KeyPoint 0x7f8353734660>), [[235 255 255  81
    'scissors' = {list: 2083} [((< cv2.KeyPoint 0x7f834fd2af40>, < cv2.KeyPoint 0x7f834fd2af70>, < cv2.KeyPoint 0x7f834f
    'shampoo' = {list: 3631} [((< cv2.KeyPoint 0x7f834cb7e190>, < cv2.KeyPoint 0x7f834cb7e1c0>, < cv2.KeyPoint 0x7f83
    'soda_can' = {list: 3555} [((< cv2.KeyPoint 0x7f833eb0c660>, < cv2.KeyPoint 0x7f833eb0c690>, < cv2.KeyPoint 0x7f8
    'sponge' = {list: 983} [((< cv2.KeyPoint 0x7f833d5e6bb0>,), [[254 255 255 243 241 225   0   0 128 128  63 255 251 25
    'stapler' = {list: 3623} [((< cv2.KeyPoint 0x7f833cd9dbc0>, < cv2.KeyPoint 0x7f833cd9dbf0>, < cv2.KeyPoint 0x7f833
    'tomato' = {list: 1347} [((< cv2.KeyPoint 0x7f833c2cb360>, < cv2.KeyPoint 0x7f833c2cb390>, < cv2.KeyPoint 0x7f833
    'toothbrush' = {list: 2217} [((< cv2.KeyPoint 0x7f8333d9ba50>, < cv2.KeyPoint 0x7f8333d9ba80>, < cv2.KeyPoint 0x7f
    'toothpaste' = {list: 4031} [((< cv2.KeyPoint 0x7f83336f2c10>, < cv2.KeyPoint 0x7f83336f2c40>, < cv2.KeyPoint 0x7f8
    'water_bottle' = {list: 5681} [((< cv2.KeyPoint 0x7f83314ffab0>, < cv2.KeyPoint 0x7f83314ffae0>, < cv2.KeyPoint 0x7f8
```

- Actually, this operation was effective about our performance. So each descriptor didn’t captured the same number of features, ***Since each detector has its good and bad points, the performance of each detector will be different accordingly.***

- The details of your object recognition algorithm
  - My object recognition algorithm has some steps;
    - Take an image,
    - Convert gray scale,
    - Detect and compute for each detectors: *SIFT, ORB & BRISK*,
    - If detector give description without none,
    - Add features to relevant key: *SIFT, ORB & BRISK*,
    - For loop for all image.



```python
for object in images:
    for img in images[object]:
        gray_image = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
        for name, detector in feature_detectors.items():
            keypoints, descriptors = detector.detectAndCompute(gray_image, None)  # Each detector detects and computes
            if descriptors is not None:  # IMPORTANT CASE: Ensure that there are descriptors
                features[name][object].append((keypoints, descriptors))
```

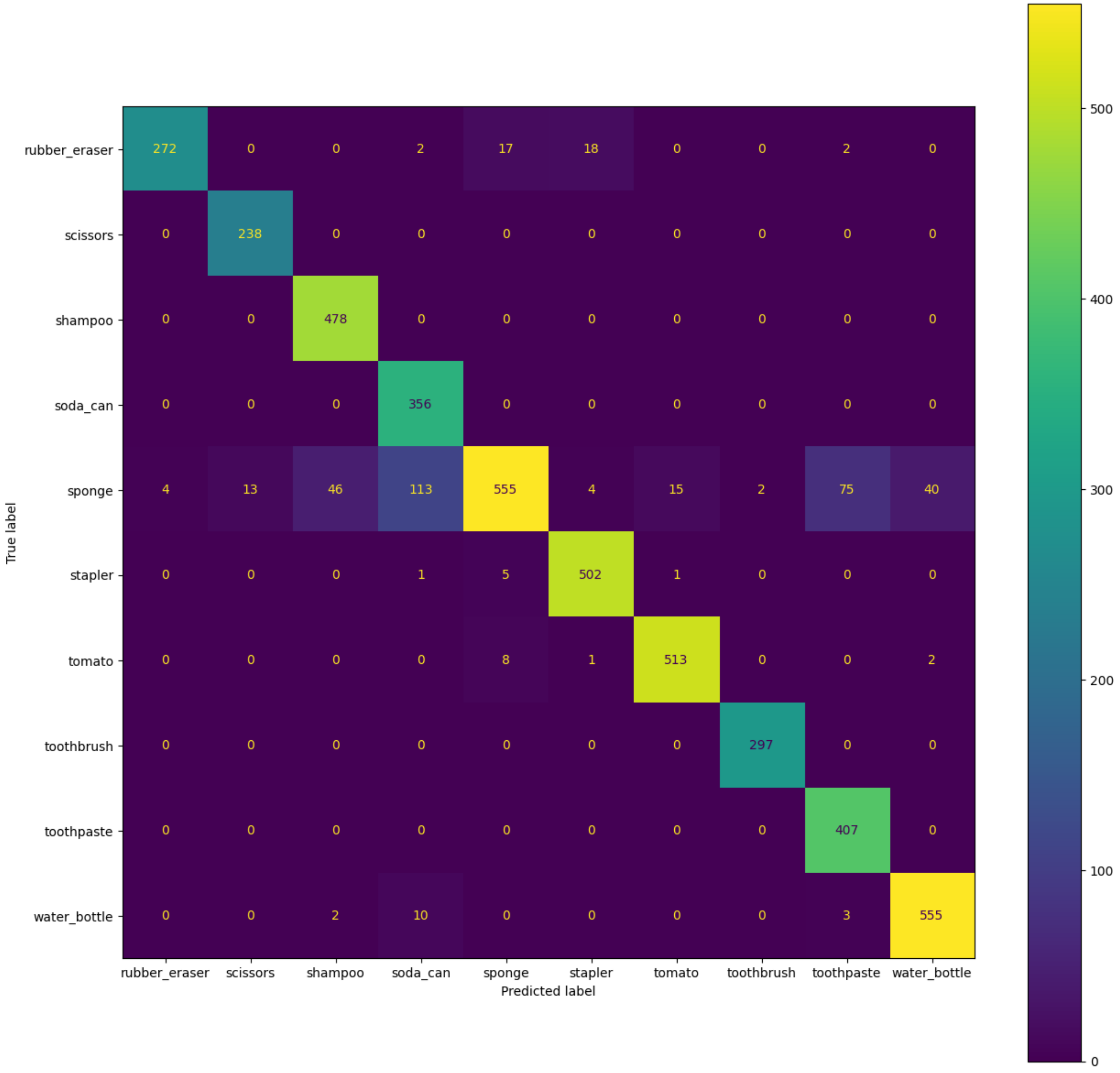
  - The simple steps !

➢ The final confusion matrices

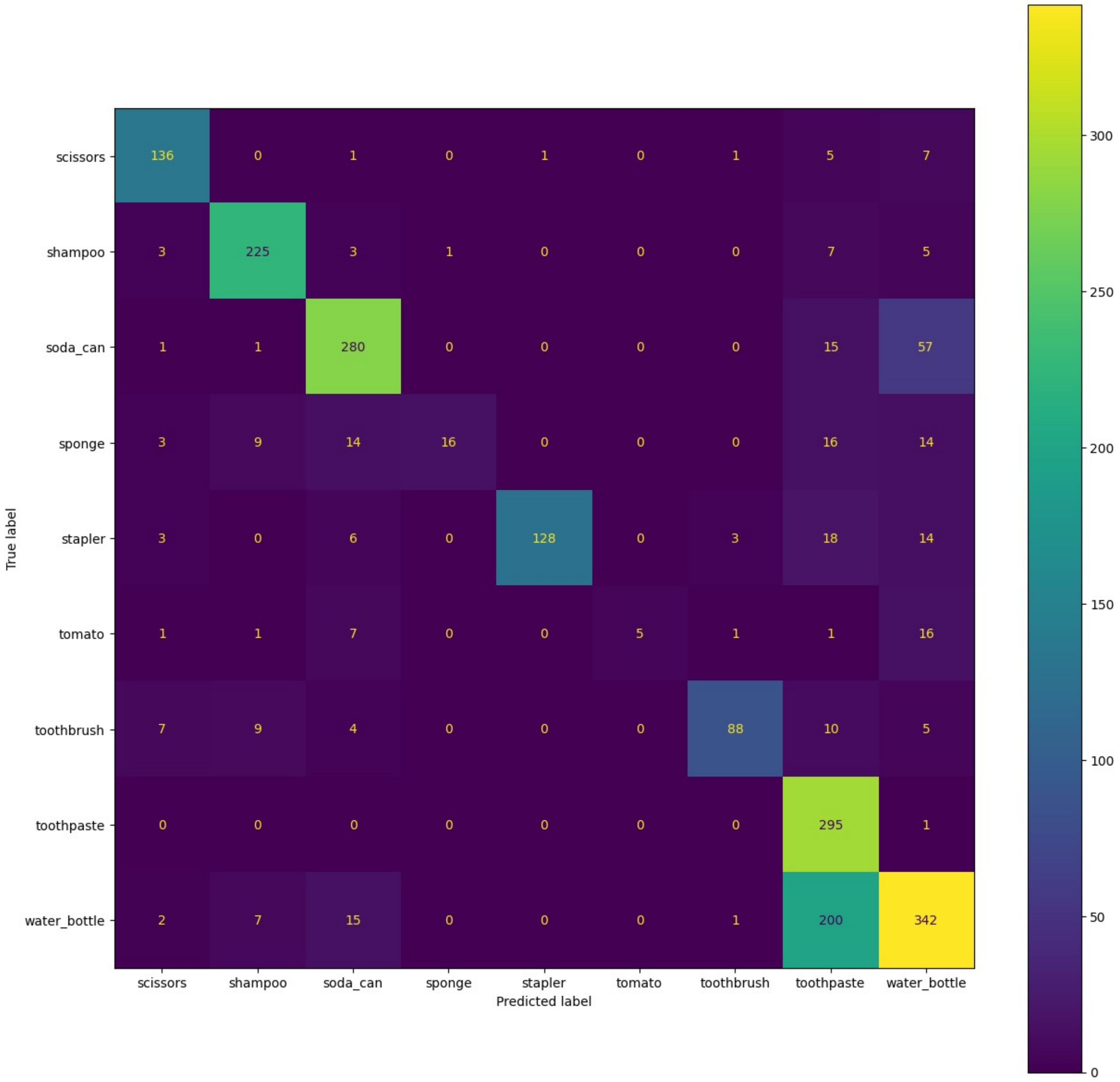
It took approximately **24 minutes** for all the algorithms to run and the results to appear.

There 3 different confusion matrix; ***SIFT, ORB & BRISK***

- ○ Evaluating classifier: **SIFT**, Accuracies: **0.9157340355497038**

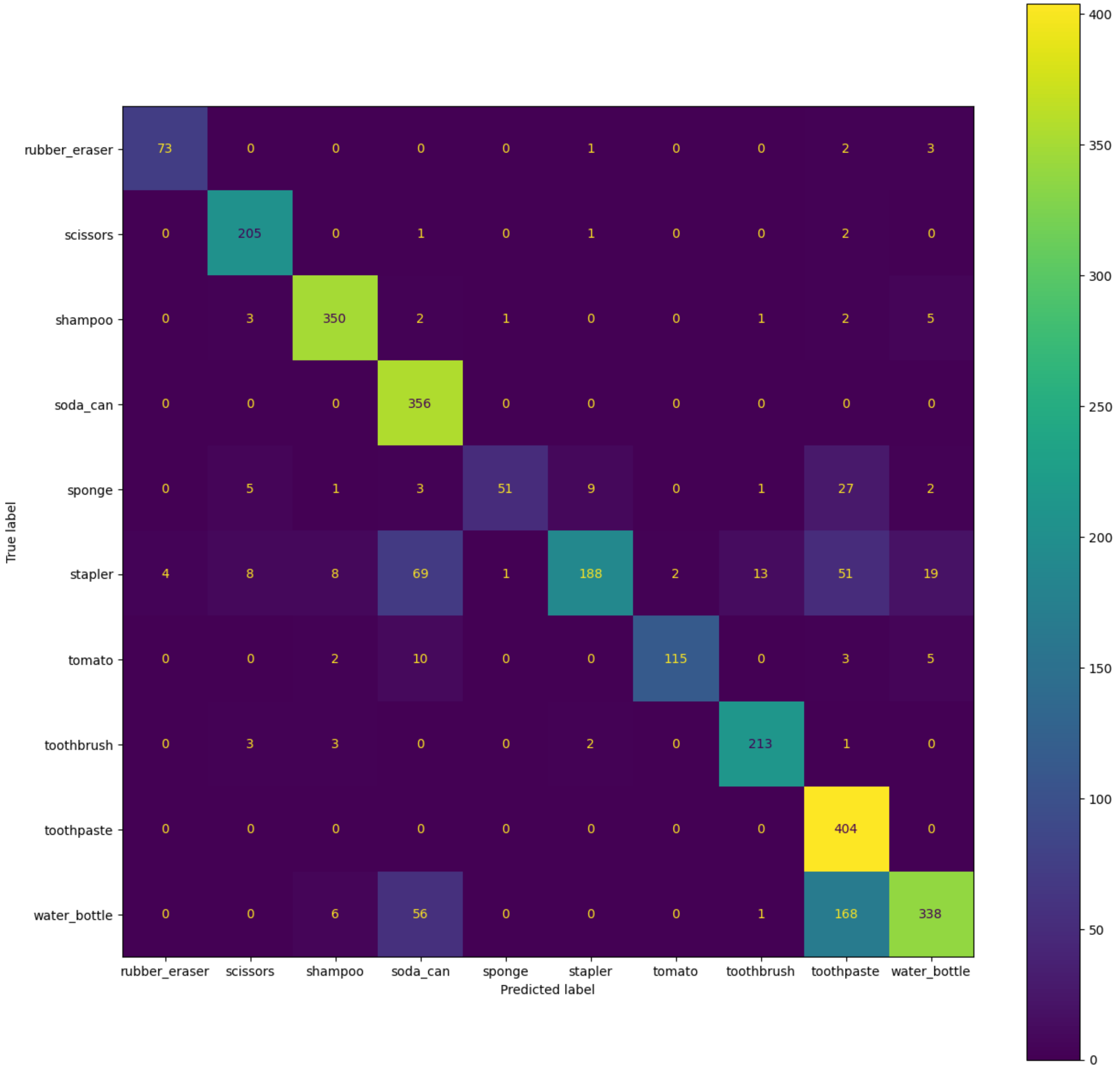


- Evaluating classifier: **ORB**, Accuracies: **0.7533565390353059**



	scissors	shampoo	soda_can	sponge	stapler	tomato	toothbrush	toothpaste	water_bottle
scissors	136	0	1	0	1	0	1	5	7
shampoo	3	225	3	1	0	0	0	7	5
soda_can	1	1	280	0	0	0	0	15	57
sponge	3	9	14	16	0	0	0	16	14
stapler	3	0	6	0	128	0	3	18	14
tomato	1	1	7	0	0	5	1	1	16
toothbrush	7	9	4	0	0	0	88	10	5
toothpaste	0	0	0	0	0	0	0	295	1
water_bottle	2	7	15	0	0	0	1	200	342

- Evaluating classifier: **BRISK**, Accuracies: **0.8189285714285715**



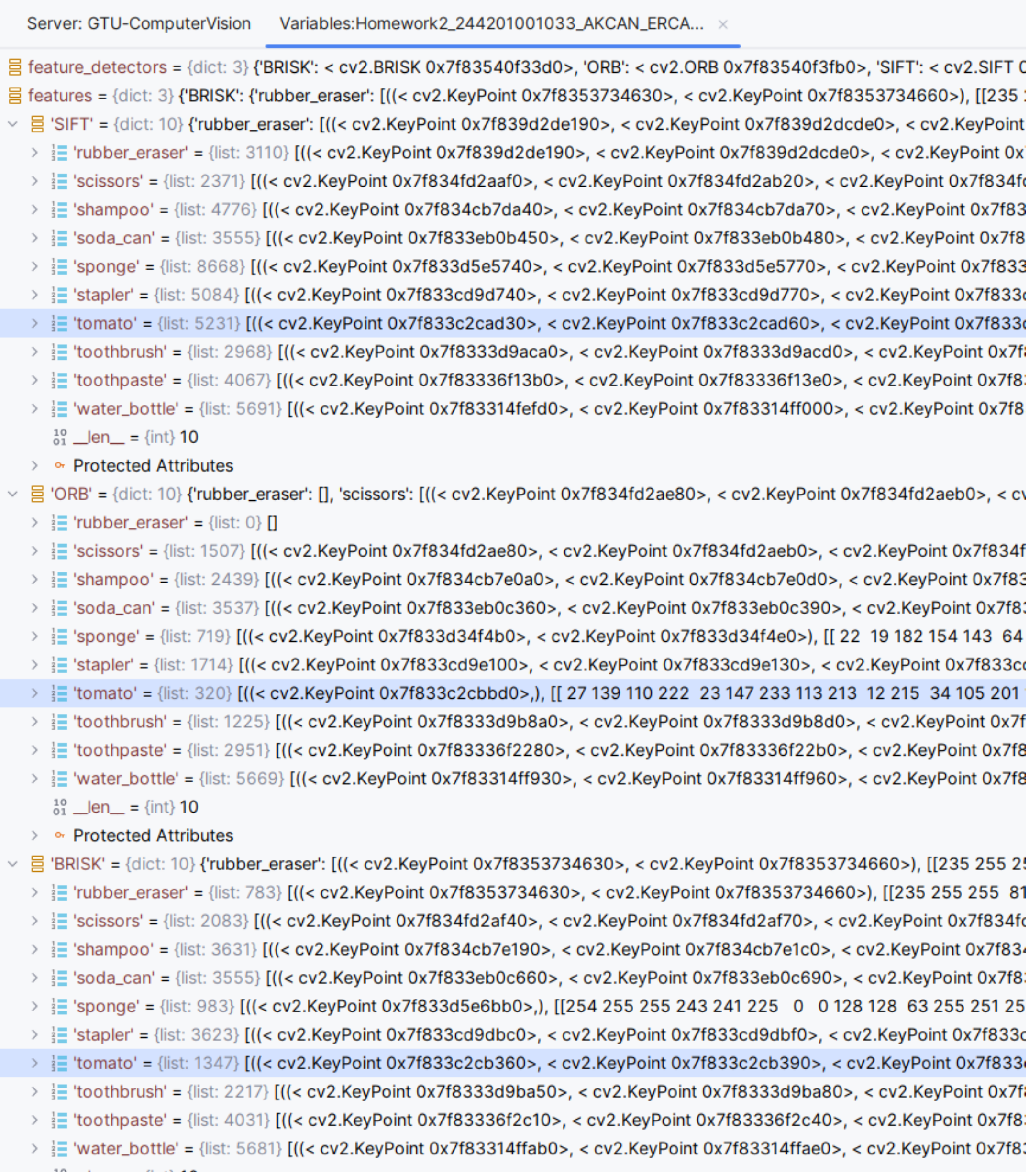
True label \ Predicted label	rubber_eraser	scissors	shampoo	soda_can	sponge	stapler	tomato	toothbrush	toothpaste	water_bottle
rubber_eraser	73	0	0	0	0	1	0	0	2	3
scissors	0	205	0	1	0	1	0	0	2	0
shampoo	0	3	350	2	1	0	0	1	2	5
soda_can	0	0	0	356	0	0	0	0	0	0
sponge	0	5	1	3	51	9	0	1	27	2
stapler	4	8	8	69	1	188	2	13	51	19
tomato	0	0	2	10	0	0	115	0	3	5
toothbrush	0	3	3	0	0	2	0	213	1	0
toothpaste	0	0	0	0	0	0	0	0	404	0
water_bottle	0	0	6	56	0	0	0	1	168	338

➢ Discussion

As we can see, **SIFT** is better for accuracy and failures.

We also discuss above section that each descriptor didn’t captured the same number of features. I mean; the sift descriptor described ***5231*** features for *tomato* object while the orb descriptor described ***320*** features for *tomato* object and brisk descriptor described ***1347*** features for *tomato* object.

These results occur from the methods that each algorithm uses when detecting features. Because if the algorithm cannot detect a feature for each image, it cannot say anything about the image, so the accuracy rate decreases.


Server: GTU-ComputerVision
Variables:Homework2_244201001033_AKCAN_ERCA...

```
feature_detectors = {dict: 3} {'BRISK': < cv2.BRISK 0x7f83540f33d0>, 'ORB': < cv2.ORB 0x7f83540f3fb0>, 'SIFT': < cv2.SIFT
features = {dict: 3} {'BRISK': {'rubber_eraser': [((< cv2.KeyPoint 0x7f8353734630>, < cv2.KeyPoint 0x7f8353734660>), [[235
  'SIFT' = {dict: 10} {'rubber_eraser': [((< cv2.KeyPoint 0x7f839d2de190>, < cv2.KeyPoint 0x7f839d2dcde0>, < cv2.KeyPoint
    'rubber_eraser' = {list: 3110} [((< cv2.KeyPoint 0x7f839d2de190>, < cv2.KeyPoint 0x7f839d2dcde0>, < cv2.KeyPoint 0x
    'scissors' = {list: 2371} [((< cv2.KeyPoint 0x7f834fd2aaf0>, < cv2.KeyPoint 0x7f834fd2ab20>, < cv2.KeyPoint 0x7f834f
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