

I put `time.time()` function between each functions to check how much time is needed for each functions. The result of this is shown in below picture. And I found that two functions take long time. First one is 'findScaleSpaceExtrema' and second one is 'generateDescriptors'. The most slow function in this code is 'generateDescriptors'. There are several ways to speed up this function. First one is changing 'threshold' value in 'findScaleSpaceExtrema' function. When I increase this threshold by modify  $\text{floor}(0.5 * \text{contrast\_threshold} / \text{num\_intervals} * 255)$  to  $\text{floor}(3.0 * \text{contrast\_threshold} / \text{num\_intervals} * 255)$  time reduced more than half. Second way is changing 'window\_width' parameter in 'generateDescriptors' function. Original value of window\_width is 4, but I decrease this one to 1. Then the time needed to complete this code reduced more than half. But when speed increased, the accuracy of this code decreased. By this, I figured that there is trade off between time and accuracy in this matching algorithm.

```
generateBaseImage : 0.0060 sec
computeNumberOfOctaves : 0.0000 sec
generateGaussianKernels : 0.0000 sec
generateGaussianImages : 0.0060 sec
generateDoGImages : 0.0020 sec
findScaleSpaceExtrema : 14.5981 sec
removeDuplicateKeypoints : 0.0030 sec
convertKeypointsToInputImageSize : 0.0010 sec
generateDescriptors : 25.4825 sec
generateBaseImage : 0.0020 sec
computeNumberOfOctaves : 0.0000 sec
generateGaussianKernels : 0.0000 sec
generateGaussianImages : 0.0160 sec
generateDoGImages : 0.0060 sec
findScaleSpaceExtrema : 27.2846 sec
removeDuplicateKeypoints : 0.0040 sec
convertKeypointsToInputImageSize : 0.0020 sec
generateDescriptors : 40.5923 sec
time, sift detection : 108.0146 sec
time, match : 0.0530 sec
```

original

```
generateBaseImage : 0.0070 sec
computeNumberOfOctaves : 0.0000 sec
generateGaussianKernels : 0.0000 sec
generateGaussianImages : 0.0070 sec
generateDoGImages : 0.0030 sec
findScaleSpaceExtrema : 4.9970 sec
removeDuplicateKeypoints : 0.0010 sec
convertKeypointsToInputImageSize : 0.0000 sec
generateDescriptors : 9.8512 sec
generateBaseImage : 0.0030 sec
computeNumberOfOctaves : 0.0000 sec
generateGaussianKernels : 0.0000 sec
generateGaussianImages : 0.0170 sec
generateDoGImages : 0.0070 sec
findScaleSpaceExtrema : 11.0000 sec
removeDuplicateKeypoints : 0.0010 sec
convertKeypointsToInputImageSize : 0.0010 sec
generateDescriptors : 16.1260 sec
time, sift detection : 42.0321 sec
time, match : 0.0060 sec
```

change 'threshold'

```
generateBaseImage : 0.0070 sec
computeNumberOfOctaves : 0.0000 sec
generateGaussianKernels : 0.0000 sec
generateGaussianImages : 0.0070 sec
generateDoGImages : 0.0020 sec
findScaleSpaceExtrema : 15.3068 sec
removeDuplicateKeypoints : 0.0020 sec
convertKeypointsToInputImageSize : 0.0020 sec
generateDescriptors : 4.2500 sec
generateBaseImage : 0.0030 sec
computeNumberOfOctaves : 0.0000 sec
generateGaussianKernels : 0.0000 sec
generateGaussianImages : 0.0170 sec
generateDoGImages : 0.0060 sec
findScaleSpaceExtrema : 27.9363 sec
removeDuplicateKeypoints : 0.0030 sec
convertKeypointsToInputImageSize : 0.0020 sec
generateDescriptors : 6.7786 sec
time, sift detection : 54.3305 sec
time, match : 0.0220 sec
```

change 'window\_width'