

**ORB descriptor.**

**FAST detector.**

XMIN in the topview: 7.974[m]  
detector with n= 1864 keypoints in 2.09383 ms  
descriptor extraction in 10.6657 ms

XMIN in the topview: 7.913[m]  
detector with n= 1898 keypoints in 1.54543 ms  
descriptor extraction in 6.51079 ms  
TTC Lidar: 12.5156 [sec] TTC Camera: 11.0105 [sec]

XMIN in the topview: 7.849[m]  
detector with n= 1865 keypoints in 1.48532 ms  
descriptor extraction in 6.32721 ms  
TTC Lidar: 12.6142 [sec] TTC Camera: 10.7587 [sec]

XMIN in the topview: 7.793[m]  
detector with n= 1840 keypoints in 1.48938 ms  
descriptor extraction in 6.29417 ms  
TTC Lidar: 14.091 [sec] TTC Camera: 11.4167 [sec]

XMIN in the topview: 7.685[m]  
detector with n= 1867 keypoints in 1.57367 ms  
descriptor extraction in 6.16402 ms  
TTC Lidar: 16.6894 [sec] TTC Camera: 12.8338 [sec]

XMIN in the topview: 7.638[m]  
detector with n= 1876 keypoints in 1.3264 ms  
descriptor extraction in 6.5076 ms  
TTC Lidar: 15.7466 [sec] TTC Camera: 18.5008 [sec]

XMIN in the topview: 7.577[m]  
detector with n= 1843 keypoints in 1.40726 ms  
descriptor extraction in 6.26457 ms  
TTC Lidar: 12.7834 [sec] TTC Camera: 12.9991 [sec]

XMIN in the topview: 7.555[m]  
detector with n= 1829 keypoints in 1.5894 ms  
descriptor extraction in 6.0709 ms  
TTC Lidar: 11.9844 [sec] TTC Camera: 11.6025 [sec]

XMIN in the topview: 7.475[m]  
detector with n= 1843 keypoints in 1.68569 ms  
descriptor extraction in 6.23957 ms  
TTC Lidar: 13.1241 [sec] TTC Camera: 11.1687 [sec]

XMIN in the topview: 7.434[m]  
detector with n= 1818 keypoints in 1.55738 ms  
descriptor extraction in 6.48932 ms  
TTC Lidar: 13.0241 [sec] TTC Camera: 12.1119 [sec]

XMIN in the topview: 7.393[m]  
detector with n= 1879 keypoints in 1.6863 ms  
descriptor extraction in 6.18852 ms  
TTC Lidar: 11.1746 [sec] TTC Camera: 13.3448 [sec]

XMIN in the topview: 7.205[m]  
detector with n= 1849 keypoints in 1.24044 ms  
descriptor extraction in 6.25634 ms  
TTC Lidar: 12.8086 [sec] TTC Camera: 13.788 [sec]

XMIN in the topview: 7.272[m]  
detector with n= 1826 keypoints in 1.81953 ms  
descriptor extraction in 6.87853 ms  
TTC Lidar: 8.95978 [sec] TTC Camera: 10.8955 [sec]

XMIN in the topview: 7.194[m]  
detector with n= 1842 keypoints in 1.56475 ms  
descriptor extraction in 6.20848 ms  
TTC Lidar: 9.96439 [sec] TTC Camera: 12.0411 [sec]

XMIN in the topview: 7.129[m]  
detector with n= 1833 keypoints in 1.44494 ms  
descriptor extraction in 5.97212 ms  
TTC Lidar: 9.59863 [sec] TTC Camera: 10.7303 [sec]

XMIN in the topview: 7.042[m]  
detector with n= 1921 keypoints in 1.43667 ms  
descriptor extraction in 6.31553 ms  
TTC Lidar: 8.52157 [sec] TTC Camera: 11.2058 [sec]

XMIN in the topview: 6.827[m]  
detector with n= 1934 keypoints in 1.47544 ms  
descriptor extraction in 6.50777 ms  
TTC Lidar: 9.51556 [sec] TTC Camera: 11.1948 [sec]

XMIN in the topview: 6.896[m]  
detector with n= 1946 keypoints in 1.4022 ms  
descriptor extraction in 6.03927 ms  
TTC Lidar: 9.61238 [sec] TTC Camera: 7.85414 [sec]

XMIN in the topview: 6.814[m]  
detector with n= 1961 keypoints in 1.24148 ms  
descriptor extraction in 6.51442 ms  
TTC Lidar: 8.3988 [sec] TTC Camera: 10.6099 [sec]

**BRISK descriptor.**

**FAST detector.**

XMIN in the topview: 7.974[m]  
detector with n= 1864 keypoints in 1.6182 ms  
descriptor extraction in 31.5907 ms

XMIN in the topview: 7.913[m]  
detector with n= 1898 keypoints in 1.34608 ms  
descriptor extraction in 20.3647 ms  
TTC Lidar: 12.5156 [sec] TTC Camera: 12.6032 [sec]

XMIN in the topview: 7.849[m]  
detector with n= 1865 keypoints in 1.55043 ms  
descriptor extraction in 19.0118 ms  
TTC Lidar: 12.6142 [sec] TTC Camera: 12.6222 [sec]

XMIN in the topview: 7.793[m]  
detector with n= 1840 keypoints in 1.37819 ms  
descriptor extraction in 18.0928 ms  
TTC Lidar: 14.091 [sec] TTC Camera: 14.4443 [sec]

XMIN in the topview: 7.685[m]  
detector with n= 1867 keypoints in 1.34758 ms  
descriptor extraction in 18.4052 ms  
TTC Lidar: 16.6894 [sec] TTC Camera: 12.6254 [sec]

XMIN in the topview: 7.638[m]  
detector with n= 1876 keypoints in 1.61313 ms  
descriptor extraction in 18.1734 ms  
TTC Lidar: 15.7466 [sec] TTC Camera: 51.4453 [sec]

XMIN in the topview: 7.577[m]  
detector with n= 1843 keypoints in 1.41236 ms  
descriptor extraction in 17.9375 ms  
TTC Lidar: 12.7834 [sec] TTC Camera: 12.435 [sec]

XMIN in the topview: 7.555[m]  
detector with n= 1829 keypoints in 1.30714 ms  
descriptor extraction in 18.2126 ms  
TTC Lidar: 11.9844 [sec] TTC Camera: 25.6779 [sec]

XMIN in the topview: 7.475[m]  
detector with n= 1843 keypoints in 1.36248 ms  
descriptor extraction in 18.1449 ms  
TTC Lidar: 13.1241 [sec] TTC Camera: 11.1209 [sec]

XMIN in the topview: 7.434[m]  
detector with n= 1818 keypoints in 1.61318 ms  
descriptor extraction in 17.9572 ms  
TTC Lidar: 13.0241 [sec] TTC Camera: 12.9066 [sec]

XMIN in the topview: 7.393[m]  
detector with n= 1879 keypoints in 1.69192 ms  
descriptor extraction in 18.3318 ms  
TTC Lidar: 11.1746 [sec] TTC Camera: 12.5274 [sec]

XMIN in the topview: 7.205[m]  
detector with n= 1849 keypoints in 1.38904 ms  
descriptor extraction in 18.2608 ms  
TTC Lidar: 12.8086 [sec] TTC Camera: 14.2506 [sec]

XMIN in the topview: 7.272[m]  
detector with n= 1826 keypoints in 1.60648 ms  
descriptor extraction in 18.5187 ms  
TTC Lidar: 8.95978 [sec] TTC Camera: 11.436 [sec]

XMIN in the topview: 7.194[m]  
detector with n= 1842 keypoints in 1.39651 ms  
descriptor extraction in 18.2077 ms  
TTC Lidar: 9.96439 [sec] TTC Camera: 12.2419 [sec]

XMIN in the topview: 7.129[m]  
detector with n= 1833 keypoints in 1.71567 ms  
descriptor extraction in 18.0516 ms  
TTC Lidar: 9.59863 [sec] TTC Camera: 12.8223 [sec]

XMIN in the topview: 7.042[m]  
detector with n= 1921 keypoints in 1.42825 ms  
descriptor extraction in 18.9663 ms  
TTC Lidar: 8.52157 [sec] TTC Camera: 12.1403 [sec]

XMIN in the topview: 6.827[m]  
detector with n= 1934 keypoints in 1.44956 ms  
descriptor extraction in 19.1218 ms  
TTC Lidar: 9.51556 [sec] TTC Camera: 12.1722 [sec]

XMIN in the topview: 6.896[m]  
detector with n= 1946 keypoints in 1.61012 ms  
descriptor extraction in 19.2192 ms  
TTC Lidar: 9.61238 [sec] TTC Camera: 8.51608 [sec]

XMIN in the topview: 6.814[m]  
detector with n= 1961 keypoints in 1.73011 ms  
descriptor extraction in 19.1516 ms  
TTC Lidar: 8.3988 [sec] TTC Camera: 11.7578 [sec]

**BRISK descriptor.**

**ORB detector.**

XMIN in the topview: 7.974[m]  
detector with n= 500 keypoints in 13.7305 ms  
descriptor extraction in 5.94118 ms

XMIN in the topview: 7.913[m]  
detector with n= 500 keypoints in 10.3235 ms  
descriptor extraction in 5.40033 ms  
TTC Lidar: 12.5156 [sec] TTC Camera: 17.4836 [sec]

XMIN in the topview: 7.849[m]  
detector with n= 500 keypoints in 12.5633 ms  
descriptor extraction in 5.52238 ms  
TTC Lidar: 12.6142 [sec] TTC Camera: 15.5366 [sec]

XMIN in the topview: 7.793[m]  
detector with n= 500 keypoints in 12.049 ms  
descriptor extraction in 5.64216 ms  
TTC Lidar: 14.091 [sec] TTC Camera: 20.7919 [sec]

XMIN in the topview: 7.685[m]  
detector with n= 500 keypoints in 12.4994 ms  
descriptor extraction in 5.50701 ms  
TTC Lidar: 16.6894 [sec] TTC Camera: 21.3012 [sec]

XMIN in the topview: 7.638[m]  
detector with n= 500 keypoints in 12.4203 ms  
descriptor extraction in 5.48572 ms  
TTC Lidar: 15.7466 [sec] TTC Camera: 73.2489 [sec]

XMIN in the topview: 7.577[m]  
detector with n= 500 keypoints in 14.679 ms  
descriptor extraction in 5.65971 ms  
TTC Lidar: 12.7834 [sec] TTC Camera: 12.6176 [sec]

XMIN in the topview: 7.555[m]  
detector with n= 500 keypoints in 14.0637 ms  
descriptor extraction in 5.58931 ms  
TTC Lidar: 11.9844 [sec] TTC Camera: 17.36 [sec]

XMIN in the topview: 7.475[m]  
detector with n= 500 keypoints in 12.5582 ms  
descriptor extraction in 5.57351 ms  
TTC Lidar: 13.1241 [sec] TTC Camera: 11.1 [sec]

XMIN in the topview: 7.434[m]  
detector with n= 500 keypoints in 13.163 ms  
descriptor extraction in 5.48284 ms  
TTC Lidar: 13.0241 [sec] TTC Camera: 11.9786 [sec]

XMIN in the topview: 7.393[m]  
detector with n= 500 keypoints in 13.0196 ms  
descriptor extraction in 5.59202 ms  
TTC Lidar: 11.1746 [sec] TTC Camera: 13.3055 [sec]

XMIN in the topview: 7.205[m]  
detector with n= 500 keypoints in 13.3976 ms  
descriptor extraction in 5.58581 ms  
TTC Lidar: 12.8086 [sec] TTC Camera: 8.49484 [sec]

XMIN in the topview: 7.272[m]  
detector with n= 500 keypoints in 12.445 ms  
descriptor extraction in 5.53198 ms  
TTC Lidar: 8.95978 [sec] TTC Camera: 5416.2 [sec]

XMIN in the topview: 7.194[m]  
detector with n= 500 keypoints in 12.5886 ms  
descriptor extraction in 5.55053 ms  
TTC Lidar: 9.96439 [sec] TTC Camera: 8.33753 [sec]

XMIN in the topview: 7.129[m]  
detector with n= 500 keypoints in 12.0804 ms  
descriptor extraction in 5.44086 ms  
TTC Lidar: 9.59863 [sec] TTC Camera: 9.26013 [sec]

XMIN in the topview: 7.042[m]  
detector with n= 500 keypoints in 12.4895 ms  
descriptor extraction in 5.68913 ms  
TTC Lidar: 8.52157 [sec] TTC Camera: 9.65484 [sec]

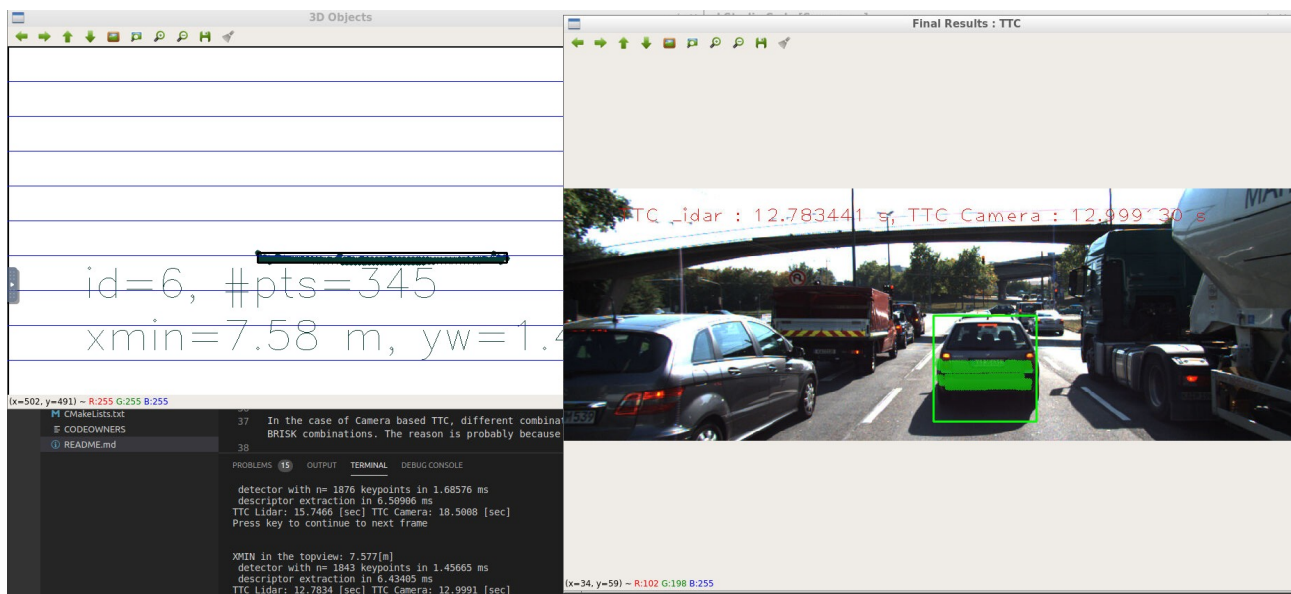
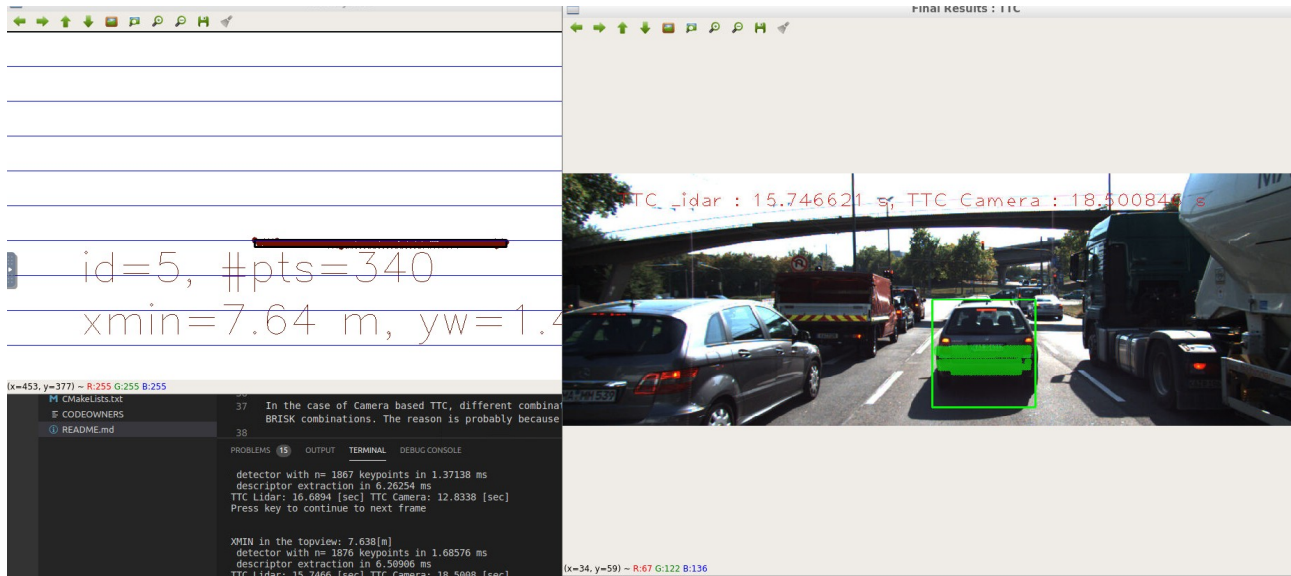
XMIN in the topview: 6.827[m]  
detector with n= 500 keypoints in 12.7562 ms  
descriptor extraction in 6.06212 ms  
TTC Lidar: 9.51556 [sec] TTC Camera: 9.37082 [sec]

XMIN in the topview: 6.896[m]  
detector with n= 500 keypoints in 12.8298 ms  
descriptor extraction in 5.76421 ms  
TTC Lidar: 9.61238 [sec] TTC Camera: 14.3156 [sec]

XMIN in the topview: 6.814[m]  
detector with n= 500 keypoints in 12.6516 ms  
descriptor extraction in 6.58875 ms  
TTC Lidar: 8.3988 [sec] TTC Camera: 18.6402 [sec]

## Manual computation based on the xMin

The results shown that the TTC computation based on the median distance to the vehicle (TTC results above and shown in the right figures) is more robust than the minimum distance (TTC results below and x minimum distance shown in the left figures).



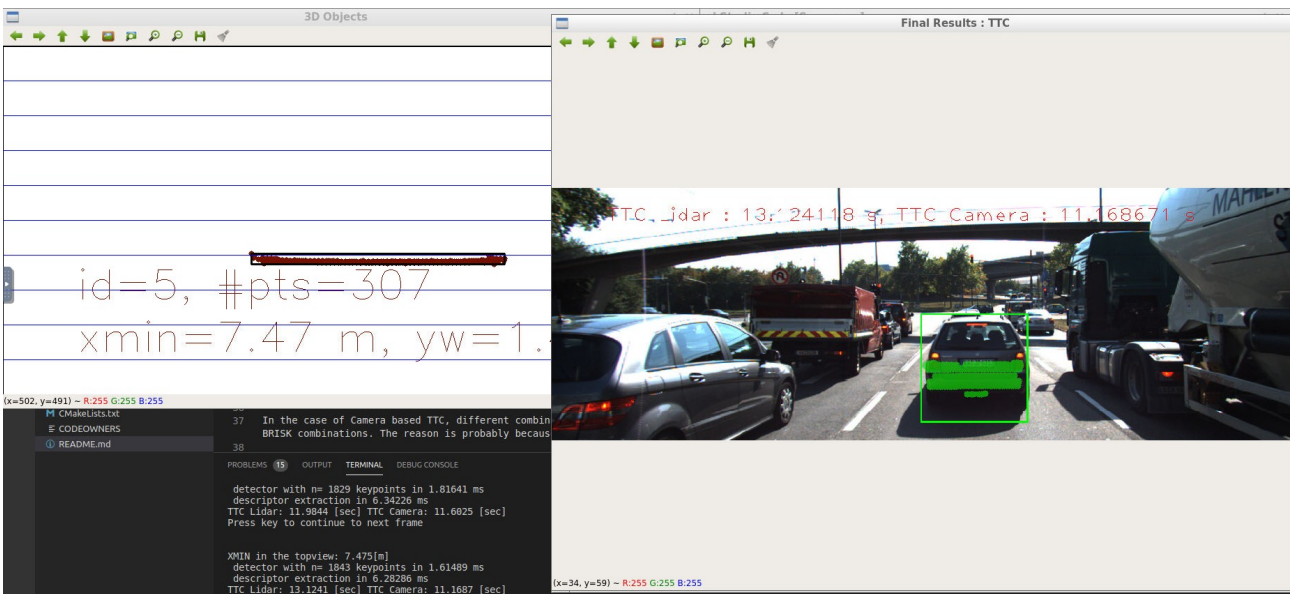
$$TTC = xMinCurr * dT / (xMinPrev - xMinCurr);$$

$$TTC = 7.58 * 0.1 / (7.64 - 7.58) = 12.63 \text{ sec}$$



$$TTC = xMinCurr * dT / (xMinPrev - xMinCurr);$$

$$TTC = 7.55 * 0.1 / ( 7.58 - 7.55 ) = 25.16 \text{ sec}$$



$$TTC = xMinCurr * dT / (xMinPrev - xMinCurr);$$

$$TTC = 7.47 * 0.1 / ( 7.55 - 7.47 ) = 9.33 \text{ sec}$$