CRITERIA	IMPLEMENTATION
MP.1 Data Buffer Optimization	**vector<DataFrame>::iterator it;** **frame.cameraImg = imgGray;** **if(dataBuffer.size()>=dataBufferSize)** **{** **it = dataBuffer.begin();** **dataBuffer.erase(it);** **}** **dataBuffer.push_back(frame);**

Keypoints

CRITERIA	IMPLEMENTATION
MP.2 Keypoint Detection	In "matching2D.hpp" replaced ShiTomasi of the function declaration **void detKeypointsShiTomasi(std::vector<cv::KeyPoint> &keypoints, cv::Mat &img, bool bVis=false);** **by** Harris, Fast, Brisk, Orb, Akaze, and Sift and implemented corresponding function in "**matching2D.cpp"** with **cv::Ptr<cv::FeatureDetector> detector** **detector->detect(img,keypoints);(**for Fast, Brisk, Orb, Akaze, and Sift)

MP.3 Keypoint Removal	Erasing all keypoints outside the given Rect structure, considers only the keypoints very near to the preceding vehicle, for matching with the next frame
	cv::Rect vehicleRect(535, 180, 180, 150);
	if (bFocusOnVehicle)
	{
	for(auto it=keypoints.begin();it!=keypoints.end();++it)
	{
	if(vehicleRect.contains((*it).pt))
	continue;
	else
	{
	keypoints.erase(it);
	- -it;//compensate for erasing an entry
	}
	}
	}

Descriptors

CRITERIA	IMPLEMENTATION
MP.4 Keypoint Descriptors	BRIEF, ORB, FREAK, AKAZE and SIFT added to matchDescriptors function in matching2D_Student.cpp.
MP.5 Descriptor Matching	Implemented FLANN being selected by **string matcherType = "MAT_FLANN";** .
MP.6 Descriptor Distance Ratio	For KNN for each keypoint 2 best matches selected , and the corresponding keypoint selected only if their distance ratio less than 0.8.

Performance

CRITERIA	IMPLEMENTATION
MP.7 Performance Evaluation 1	Counted the number of keypoints on the preceding vehicle for all 10 images and take note of the distribution of their neighborhood size. Did this for all the detectors as tabulated in **Table MP.7**(page3/5).
MP.8 Performance Evaluation 2	Counted the number of matched keypoints for all 10 images using all possible combinations of detectors and descriptors as tabulated in **table MP.8**(page4/5). (In the matching step, the BF approach is used with the descriptor distance ratio set to 0.8) **Note1:-norm type of cv::BFMatcher, set to cv::NORM_L2 for SIFT descriptor and cv::NORM_HAMMING for all other descriptors.** **Note2:-AKAZE descriptor only used with AKAZE detector.**
MP.9 Performance Evaluation 3	Thw time it takes for keypoint detection and descriptor extraction and TOP3 detector / descriptor combinations recommended as tabulated in **Table MP.9.** (page5/5).

Table MP.7

SL.NO	DETECTOR	KEYPOINT COUNT IN PRECEDING VEHICLE IMAGE										NEIGHBOURHOOD DISTRIBUTION NOTES
		1	2	3	4	5	6	7	8	9	10	
1	SHITOMASI	50	52	55	54	48	51	55	57	43	43	sensitive to intensity variation due to numbers on number plate(points have highest frequency distribution)
2	HARRIS	11	9	10	13	14	14	12	18	15	20	distributed at transition of bright and dark, larger numbers at curved reflective surfaces, almost none for shadowed areas
3	FAST	44	40	51	59	51	52	50	55	48	44	keypoints crowded on edges
4	BRISK	55	60	62	60	60	60	60	60	60	60	keypoints with different scales indistinguishably crowded at edges.
5	ORB	30	26	30	30	30	30	30	35	30	29	keypoints with different scales centered on points of intensity transition
6	AKAZE	30	33	45	41	41	32	32	30	34	37	keypoints with different scales lined along edges,shadowed regions almost left out.
7	SIFT	40	40	40	40	36	36	37	37	42	40	optimum keypoints with different scales, maintainining consistency frame after frame , many small radii key points on number plate.

Table MP.8

DETECTOR	DESCRIPTOR	MATCHED KEYPOINTS IN THE RECTANGLE AROUND PRECEDING VEHICLE FOR IMAGES-								
		1&2	2&3	3&4	4&5	5&6	6&7	7&8	8&9	9&10
SHITOMASI	BRISK	95	88	80	90	82	79	85	86	82
	BRIEF	115	111	104	101	102	102	100	109	100
	ORB	106	102	99	102	103	97	98	104	97
	FREAK	86	90	86	88	86	80	81	86	85
	AKAZE	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SIFT	112	109	104	103	99	101	96	106	98
HARRIS	BRISK	11	9	10	11	16	14	12	21	17
	BRIEF	12	12	14	17	17	16	12	20	21
	ORB	11	11	14	17	19	19	13	21	20
	FREAK	11	9	13	14	13	18	10	17	18
	AKAZE	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SIFT	14	11	16	19	22	22	13	24	22
FAST	BRISK	80	91	85	94	71	83	92	86	94
	BRIEF	88	102	88	102	94	98	112	107	92
	ORB	96	102	87	94	87	100	101	96	99
	FREAK	64	80	65	79	61	76	83	77	82
	AKAZE	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SIFT	118	123	110	119	114	119	123	117	103
BRISK	BRISK	138	144	133	144	139	155	137	150	158
	BRIEF	138	166	129	141	148	155	158	161	148
	ORB	94	107	88	97	85	114	112	114	122
	FREAK	114	121	113	118	103	129	135	129	131
	AKAZE	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SIFT	182	193	169	183	171	195	194	176	183
ORB	BRISK	60	65	65	76	72	83	83	73	72
	BRIEF	37	38	37	53	42	64	58	62	59
	ORB	40	57	49	54	57	68	71	62	72
	FREAK	39	33	37	40	33	40	41	39	44
	AKAZE	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SIFT	67	79	78	79	82	82	95	95	94
AKAZE	BRISK	137	125	129	129	131	132	142	146	144
	BRIEF	141	134	131	130	134	146	150	148	152
	ORB	131	129	127	117	130	131	137	135	145
	FREAK	126	129	127	121	122	133	144	147	138
	AKAZE	138	138	133	127	129	146	147	151	150
	SIFT	134	134	130	136	137	147	147	154	151
SIFT	BRISK	57	63	58	61	55	52	54	63	73
	BRIEF	63	72	64	66	52	57	72	67	84
	ORB	Showing Insufficient Memory, during runtime.								
	FREAK	65	72	64	66	59	59	64	65	79
	AKAZE	NA	NA	NA	NA	NA	NA	NA	NA	NA
	SIFT	82	81	85	93	90	81	82	102	104

Table MP.9
(Each of the following entries for detector and descriptor obtained by averaging over 10 observations)

DETECTORS ARRANGED FROM FASTEST TO SLOWEST			TOP 3 FASTEST DETECTOR-DESCRIPTOR COMBINATIONS	
SL.NO	DETECTOR	DETECTION TIME,ms		
1	FAST	1		
2	ORB	8	COMBINATION	NET TIME(ms)
3	SHITOMASI	17		
4	HARRIS	19	*FAST DETECTOR +ORB/BRIEFDESCRIPTOR*	*2*
5	AKAZE	81		
6	SIFT	130		
7	BRISK	375		
DESCRIPTORS ARRANGED FROM FASTEST TO SLOWEST			*FAST DETECTOR + BRISK DESCRIPTOR*	*3*
SL.NO	DESCRIPTOR	DESCRIPTOR EXTRACTION TIME, ms		
1,2	BRIEF & ORB	1		
3	BRISK	2	*FAST DETECTOR + SIFT DESCRIPTOR*	*20*
4	SIFT	19		
5	FREAK	39		
6	AKAZE	71		