

A Nonparametric Statistical Approach for Stereo Correspondence*

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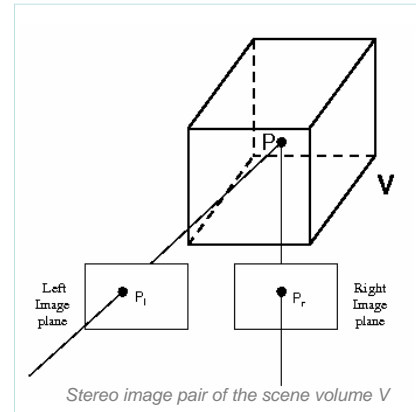
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The level of significance can be used as a quality metric of the solution which makes it possible

- ✓ to compare the solutions obtained using different optimization methods, and
- ✓ to set intuitive thresholds on the acceptance criteria.

We mainly use the permutation test in stereo correspondence problem to bring the results of different optimization processes into the same comparable base.

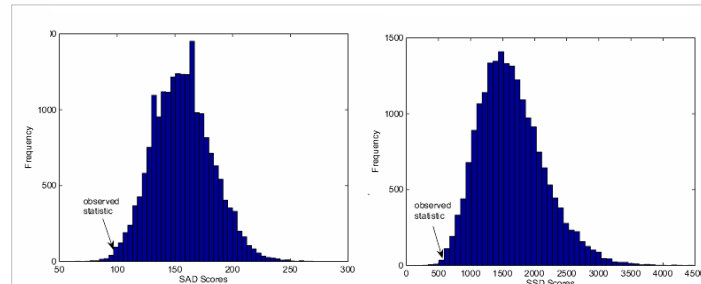
Stereo correspondence problem: finding the corresponding points in the left and right images. Once the correspondences are found, the position of the **real world point P** can be found using simple triangulation.



Similarity measures in dense stereo algorithms:

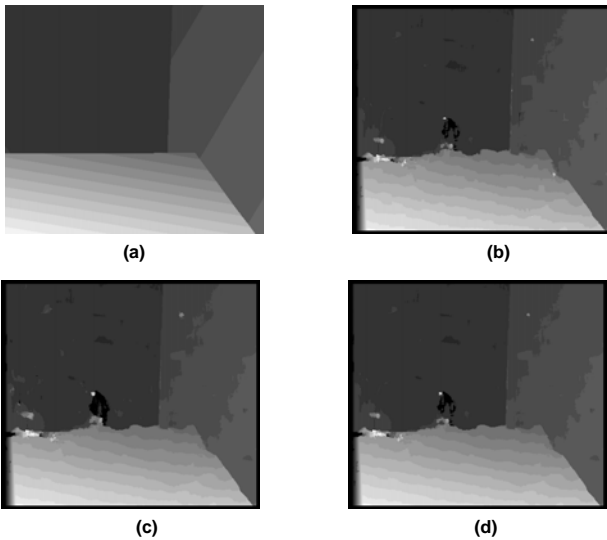
Sum of Squared Differences (SSD)
$$\sum_{u,v} (I_1(u, v) - I_2(u + d, v))^2$$

Sum of Absolute Differences (SAD)
$$\sum_{u,v} |I_1(u, v) - I_2(u + d, v)|$$



Reference distribution of the SSD and SAD optimization functions. Location of the observed statistics on distributions produces p-values. We can compare and combine solutions by using these p-values.

- ✓ The **permutation test** is a type of statistical significance test.
- ✓ Distribution of the observation are generated by using all permutations of data.
- ✓ Reference distribution is used to asses the significance of observed statistic.
- ✓ **It is trivial to combine two different optimization method's results by choosing the statistically more meaningful solution.**



(a) Ground truth disparity map for the bull image, (b) Depth map obtained by SAD function, number of error pixel is 41816, (c) Depth map obtained by SSD function, number of error pixel is 41199, (d) Depth map obtained by SAD+SSD function using our combination approach, number of error pixel is 40476.

Percentage correction of SAD is 23%, percentage correction of SSD is 12%.

The introduced idea actually work very well and it can be used to improve the optimization results from different sources.

Image	Window Size	# of incorrect matches by SAD	# of incorrect matches by SSD	# of incorrect matches by SAD+SSD	# of pixels correct by SAD	# of pixels correct by SAD, incorrect by SSD	# of correct d in SSD	# of corrected in SAD	percentage of corrected in SSD	percentage of corrected in SAD
barn1	7	32682	32056	31628	2952	2326	428	1054	8%	20%
barn1	9	32296	32450	31538	2386	2540	912	758	19%	15%
barn1	11	32744	33334	32176	2110	2700	1158	568	24%	12%
barn2	7	45682	43874	43968	4856	3048	-94	1714	-1%	22%
barn2	9	43518	42408	42288	3863	2753	120	1230	2%	19%
barn2	11	43067	42165	42092	3429	2527	73	975	1%	16%
bull	7	44596	41948	42101	5332	2684	-153	2495	-2%	31%
bull	9	42217	40403	40120	4279	2465	283	2097	4%	31%
bull	11	41553	40300	39830	3696	2443	470	1723	8%	28%
cones	9	105961	104038	102805	5158	3235	1233	3156	15%	38%
cones	11	105009	104234	102666	4486	3711	1568	2343	19%	29%
cones	13	104292	105293	103643	3469	4470	1650	649	21%	8%
map	5	19259	19437	19169	1734	1556	268	90	8%	3%
map	7	17814	17727	17583	1314	1401	144	231	5%	9%
map	9	17720	17371	17375	1003	1352	-4	345	0%	15%
poster	9	47696	45885	45798	4233	2422	87	1898	1%	29%
poster	11	46263	44865	44506	3912	2534	359	1757	6%	27%
poster	13	45635	44786	43967	3544	2695	819	1668	13%	27%
sawtooth	7	42609	42920	42228	2509	2820	692	381	13%	7%
sawtooth	9	42741	43751	42596	1904	2914	1155	145	24%	3%
sawtooth	11	43866	45209	43863	1771	3114	1346	3	28%	0%
teddy	7	87204	85502	84749	5415	3713	753	2455	8%	27%
teddy	9	86839	85802	84332	5269	4232	1470	2507	15%	26%
teddy	11	87330	86833	84788	5095	4648	2045	2542	21%	26%
venus	9	39816	39518	39039	3955	3657	479	777	6%	10%
venus	11	38243	38654	37882	3099	3510	772	361	12%	5%
venus	13	38191	39241	38006	2466	3516	1235	185	21%	3%
Average Error		50920.11	50370.52	49656.89						
								Average Correction	11%	18%

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