Efficient Coarse-to-Fine PatchMatch for Large Displacement Optical Flow

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CVPR 2016

Contributions

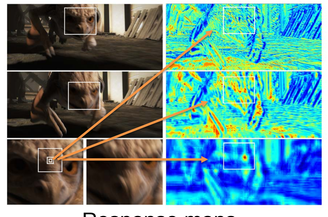
A simple but effective matching method that:

- introduces a pyramid structure into NNF (Nearest Neighbor Field) algorithms
- yields state-of-the-art optical flow results after interpolation

Demo available:

Motivations

- NNF algorithms are often too noisy for optical flow
- Matching correspondences of larger patches are often more discriminative
- Optical flow is naturally smooth

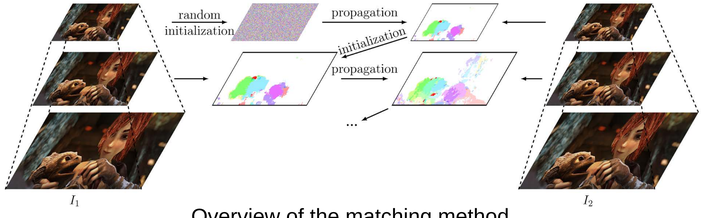


Response maps
of patches with different size

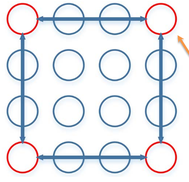
Main Ideas

- Introduce a coarse-to-fine scheme into NNF algorithms
- Use the matching of larger patches as guidance
- Perform the matching for uniform distributed seeds on image grid rather than every pixel of the image

Coarse-to-Fine PatchMatch



Overview of the matching method

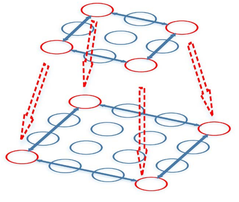


① PatchMatch on Grid Structure:

- Generate ***seeds*** on image grid
- *Neighborhood propagation + random search*
- Controllable accuracy by different grid spacing
- Highly efficient

② Propagation between Adjacent Levels:

- Just multiply the scaling factor of the pyramid
- Constrain the search radius within a small range
- Enjoy a built-in smoothing effect **V.S.** noisy results in single-scale PatchMatch
- Can recover the matching of small structures which is vanished on higher levels



Example coarse-to-fine matching results

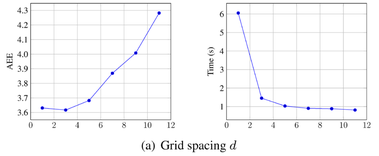
Experimental results:

Comparison with other matching

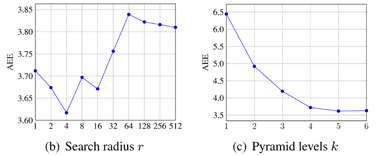
Method	#	Density	Precision	AEE	Time
SIFT-NN	1K	0.175	0.581	29.835	0.5s
KPM	**446K**	**1.000**	0.595	6.961	**0.4s**
DeepMatching	5K	0.892	0.945	3.774	15s
CPM	40K	0.886	**0.975**	**3.617**	1.3s

"#": the average number of matches

Parameter sensitivity



(a) Grid spacing d



(b) Search radius r (c) Pyramid levels k

Comparison to the state of the art

- MPI-SIntel:

	Method	AEE All	AEE Noc	AEE Occ	Time
Clean Set	**CPM-Flow**	**3.557**	1.189	**22.889**	4.3s
	DiscreteFlow	3.567	1.108	23.626	~180s
	FlowFields	3.748	**1.056**	25.700	18s
	EpicFlow	4.115	1.360	26.595	16.4s
	PH-Flow	4.388	1.714	26.202	~800s
	DeepFlow	5.377	1.771	34.751	19s
	PCALayers	5.730	2.455	32.468	**3.2s**
Final Set	FlowFields	**5.810**	**2.621**	31.799	18s
	CPM-Flow	5.960	2.990	**30.177**	**4.3s**
	DiscreteFlow	6.077	2.937	31.685	~180s
	EpicFlow	6.285	3.060	32.564	16.4s
	TF+OFM	6.727	3.388	33.929	~400s
	Classic+NLP	8.291	4.287	40.925	~800s
	MDPFlow2	8.445	4.150	43.430	~700s

- KITTI:

Method	Out Noc3	Out All3	AEE Noc	AEE All	Time
PH-Flow	**5.76%**	**10.57%**	**1.3**	**2.9**	800s
FlowFields	5.77%	14.01%	1.4	3.5	23s
CPM-Flow	5.79%	13.70%	**1.3**	3.2	**4.2s**
NLTGV-SC	5.93%	11.96%	1.6	3.8	16s
DiscreteFlow	6.23%	16.63%	**1.3**	3.6	180s
DeepFlow	7.22%	17.79%	1.5	5.8	17s
EpicFlow	7.88%	17.08%	1.5	3.8	15s
TF+OFM	10.22%	18.46%	2.0	5.0	350s