

Parallelize 2D Optical Flow Estimation Algorithm on Video

Progress Report

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DeepFlow algorithm

- ❖ For a pair of consecutive images, deepflow algorithm minimizes a non-convex and non-linear energy function: downsampling first, fixed point iterations then and **iterative method** to solve linear equations.
- ❖ Iterative methods, such as Gauss-Seidel, Jacobi method, have a lot of matrix operations in every iteration, and that's where we can apply parallelism and optimizations.
- ❖ Existing codes use SOR to solve linear equations iteratively.

- ❖ SOR part takes over 78% of total running time.
- ❖ The time complexity of this algorithm is $O(Mn^3)$

Each sample counts as 0.01 seconds.

	%	cumulative	self		self	total	
time	seconds	seconds	calls	ms/call	ms/call	name	
78.38	20.29	20.29	335	60.58	61.50	sor_coupl	
8.15	22.40	2.11	335	6.30	6.30	compute_dat	
4.29	23.51	1.11	132	8.41	8.41	color_image	
2.01	24.03	0.52	335	1.55	2.29	compute_sm	
1.20	24.34	0.31	335	0.93	0.93	calculate_co	
1.12	24.63	0.29	1565	0.19	0.19	convolve_v	
0.97	24.88	0.25	1364	0.18	0.18	convolve_h	
0.77	25.08	0.20	132	1.52	1.52	image_resize	
0.73	25.27	0.19	67	2.84	2.84	image_warp	
0.62	25.43	0.16	670	0.24	0.24	sub_laplacia	
0.58	25.58	0.15	132	1.14	1.14	color_image	
0.31	25.66	0.08	132	0.61	0.61	image_resize	
0.27	25.73	0.07	67	1.04	362.21	compute_or	
0.23	25.79	0.06	67	0.90	4.80	get_derivativ	
0.19	25.84	0.05	67	0.75	0.75	descflow_res	
0.08	25.86	0.02	67	0.30	0.67	compute_smd	
0.08	25.88	0.02	1	20.00	25.57	compute_des	

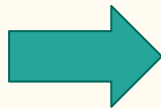
Parallel Computing Structure

- ❖ **Big Data:** divide video into pairs of 2 consecutive images:

- MapReduce: Task Level

- ❖ **Big Compute:** in solving linear systems part, instead of SOR (Successive over-relaxation), we apply other solvers (Jacobi, RedBlack SOR), where data dependency is less:

- OpenMP+MPI: Loop Level
- OpenACC: Loop Level



- ❖ We partition video into multiple pairs of images and run deepflow algorithm on all of them: **Data Parallelism**

- ❖ We do operations on matrices, and operation on each element is independent within each iteration: **Function Parallelism**

Parallel Model: Multiple Program - Multiple Data

Overheads, expected speed-up, future improvements

❖ Overheads

- Communications
 - MapReduce: network latency
 - MPI
- Synchronization
 - OpenACC
 - OpenMP+MPI

❖ Speed-up: for a pair of 720p images, on 2-core CPU,

- 12s using Jacobi with OpenMP
- 18s using SOR optimized for serial
- 24s without any optimization
- Expected near-linear speed-up
- Strong scaling (total problem size fixed)

❖ Next steps

- apply MapReduce to process video
- Try MPI
- replace Jacobi with RedBlack SOR to achieve better convergence