FlowNet: Learning Optical Flow with Convolutional Networks

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Outline

Introduction

- What is Optical Flow?

- The pattern of apparent motion of objects, surfaces, and edges in a visual scene caused by the relative motion between an observer and a scene.

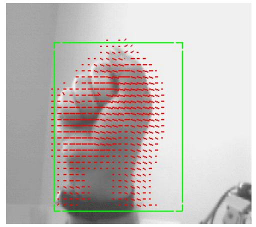
[Video result of this paper]

Where can it be used?

Object Tracking

Face tracking

Robotics



Motivation

- Convolutional neural networks in computer vision problems.

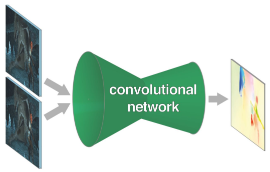
- Main Idea/Method: Train CNN end-to-end to learn predicting optical flow field for a pair of images.

Requirements for Optical Flow

- Estimation needs per-pixel localization.
- Also need to find correspondences between the pair of images.

- It will involve not only learning image feature representations, but also learning to match them at different locations in the two images.

Overview of the Network



- Not sure whether this task could be solved with a standard CNN architecture
- Also developed architecture with a correlation layer that explicitly provides matching capabilities.

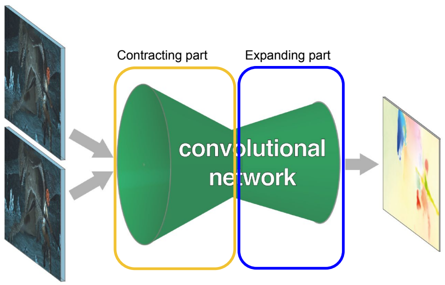
Related work

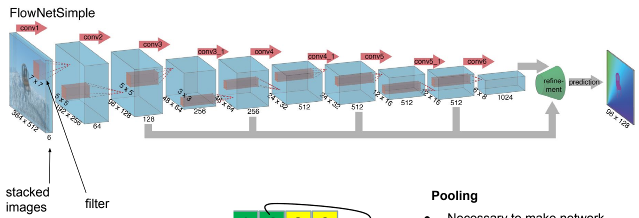
- Horn and Schunck(1981)
- Lucas-Kanade(1981)
- DeepMatching and DeepFlow (2013)
- EpicFlow (2015)
- Sun et al. (2008)

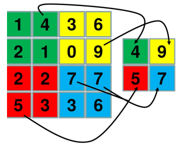
Continued.

- No direct work of predicting optical flow with CNNs.
- Why?

Network Architecture

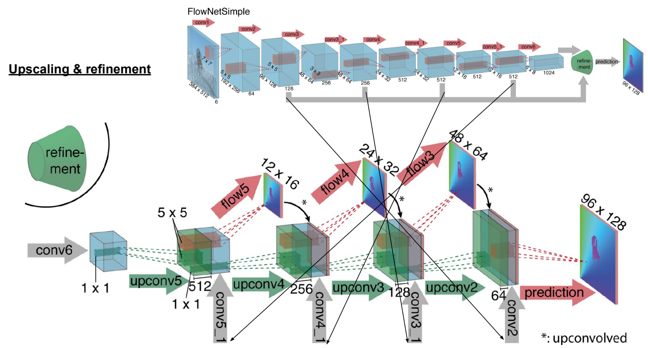


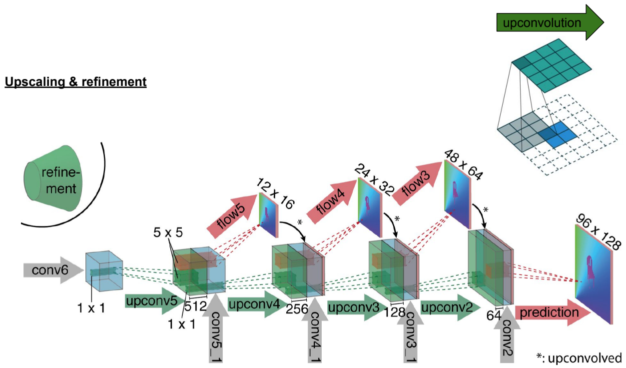


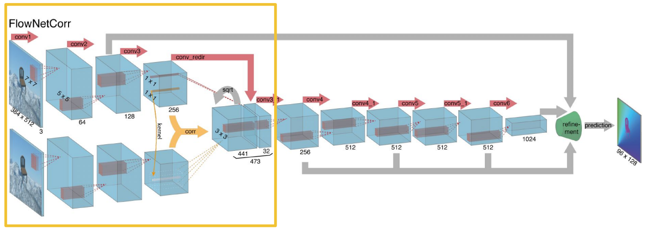


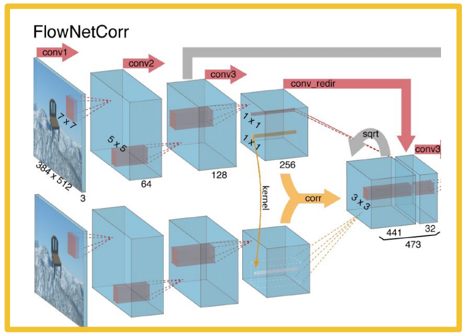
Pooling

- Necessary to make network training computationally feasible
- Problem: reduces resolution
- Solution: refine coarse feature maps



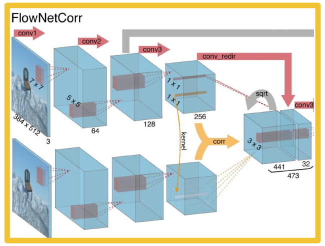






Correlation

$$c(\mathbf{x}_1, \mathbf{x}_2) = \sum_{\mathbf{o} \in [-k,k] \times [-k,k]} \langle \mathbf{f}_1(\mathbf{x}_1 + \mathbf{o}), \mathbf{f}_2(\mathbf{x}_2 + \mathbf{o}) \rangle$$



Dataset

	Frame pairs	Frames with ground truth	Ground truth density per frame
Middlebury	72	8	100%
KITTI	194	194	∽50%
Sintel	1,041	1,041	100%

Dataset

Experiment

Convolution layer : 9

Stride : 2 (Only in six of them)

Nonlinearity : ReLu (After each layer)

Filter sizes: Decreases as we go deeper in network.(7X7 to 3X3)

Training loss: Endpoint error (EPE)

Optimization Method: Adam

Results

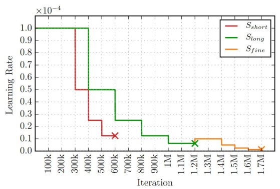
Method	Sintel Clean train	Sintel Clean test	Sintel Final train	Sintel Final test	KITTI train	KITTI test	Middlebury train AEE	Middlebury train AAE	Middlebury test AEE	Middlebury test AAE	Chairs test	Time (sec) CPU	Time (sec) GPU
EpicFlow [30]	2.27	4.12	3.57	6.29	3.47	3.8	0.31	3.24	0.39	3.55	2.94	16	-
DeepFlow [35]	3.19	5.38	4.40	7.21	4.58	5.8	0.21	3.04	0.42	4.22	3.53	17	-
EPPM [3]	-	6.49	-	8.38	-	9.2	-	-	0.33	3.36	-	-	0.2
LDOF [6]	4.19	7.56	6.28	9.12	13.73	12.4	0.45	4.97	0.56	4.55	3.47	65	2.5
FlowNetS	4.50	7.42	5.45	8.43	8.26	-	1.09	13.28	-	-	2.71	-	0.08
FlowNetS+v	3.66	6.45	4.76	7.67	6.50	-	0.33	3.87	-	-	2.86	-	1.05
FlowNetS+ft	(3.66)	6.96	(4.44)	7.76	7.52	9.1	0.98	15.20	-	-	3.04	-	0.08
FlowNetS+ft+v	(2.97)	6.16	(4.07)	7.22	6.07	7.6	0.32	3.84	0.47	4.58	3.03	-	1.05
FlowNetC	4.31	7.28	5.87	8.81	9.35	-	1.15	15.64	-	-	2.19	-	0.15
FlowNetC+v	3.57	6.27	5.25	8.01	7.45	-	0.34	3.92	-	-	2.61	-	1.12
FlowNetC+ft	(3.78)	6.85	(5.28)	8.51	8.79	-	0.93	12.33	-	-	2.27	-	0.15
FlowNetC+ft+v	(3.20)	6.08	(4.83)	7.88	7.31	-	0.33	3.81	0.50	4.52	2.67	-	1.12

Conclusion

- It is possible to train Network to directly predict OpticalFlow
- Even if training set in not real.
- On synthetic Test set : CNNs Outperforms state-of-the -art Methods.

Can we do better? Yes, with FlowNet 2.0

- Realistic training data and improved training schedule
  - More iterations during training
  - More realistic training data only presented during fine tuning
  - First, the network learns basic features, then ones more refined



IF AT FIRST YOU DON'T SUCCEED,
TRY, TRY AND TRY AGAIN (WITH MORE NETWORKS).