Deep Fundamental Matrix Estimation without Correspondences

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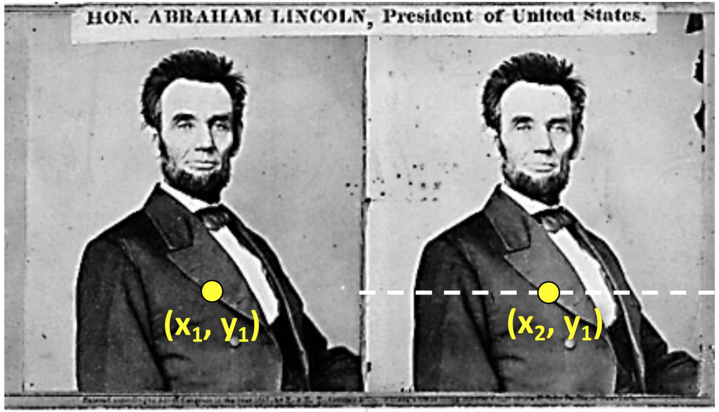
Depth Estimation

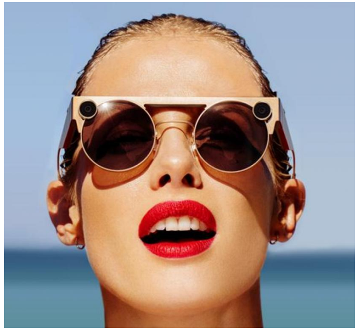
Depth estimation is crucial in many applications such Augmented Reality

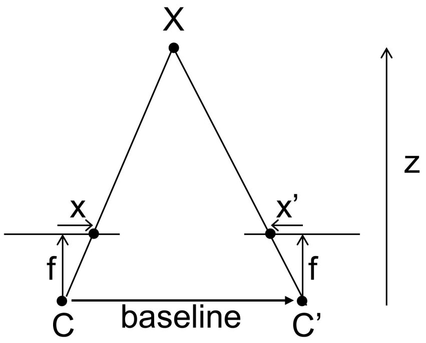
Depth from Disparity



epipolar lines

x_2 - x_1 = the *disparity* of pixel (x_1, y_1)





$$disparity = x - x' = \frac{baseline * f}{z}$$

Deep Fundamental Matrix Estimation without Correspondences; Poursaeed et al.; ECCV 2018

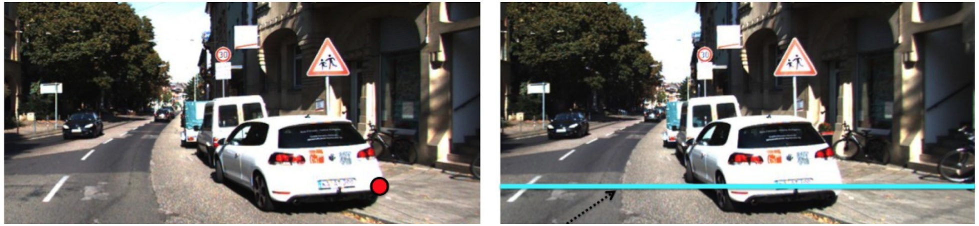
Fundamental Matrix

Describes the geometric relation that relates two stereo images

Homogeneous rank-2 matrix with seven degrees of freedom

Useful for:

- Estimating disparity and depth
- Rectifying stereo images
- Structure from Motion



Deep Fundamental Matrix Estimation without Correspondences; Poursaeed et al.; ECCV 2018

Fundamental Matrix

$$\mathbf{F} = \mathbf{K}_2^{-T}\mathbf{R}\,[\mathbf{t}]_\times\,\mathbf{K}_1^{-1}$$

$$\mathbf{t}_\times = \begin{bmatrix} 0 & -t_z & t_y \\ t_z & 0 & -t_x \\ -t_y & t_x & 0 \end{bmatrix}$$

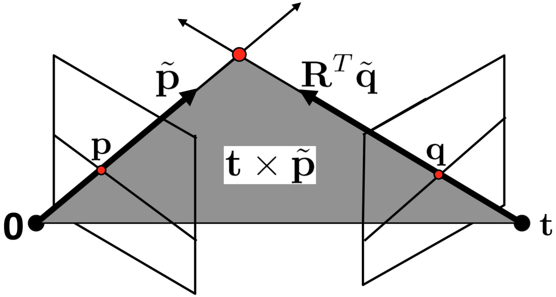
$$\mathbf{R} = \mathbf{R_x}(r_x)\mathbf{R_y}(r_y)\mathbf{R_z}(r_z)$$

$$\mathbf{K} = \begin{bmatrix} -f & s & c_x \\ 0 & -\alpha f & c_y \\ 0 & 0 & 1 \end{bmatrix}$$

$(c_x, c_y)^T$ is the principal point of the camera

f_i is the focal length of camera

$\mathbf{R}$ and $[\mathbf{t}]_\times$ are the relative camera rotation and translation respectively



- Epipolar Constraint: $q^T\mathbf{F}p = 0$

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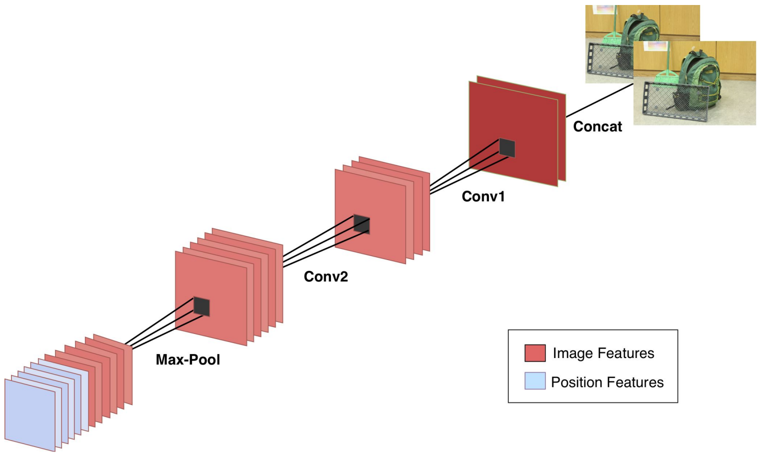
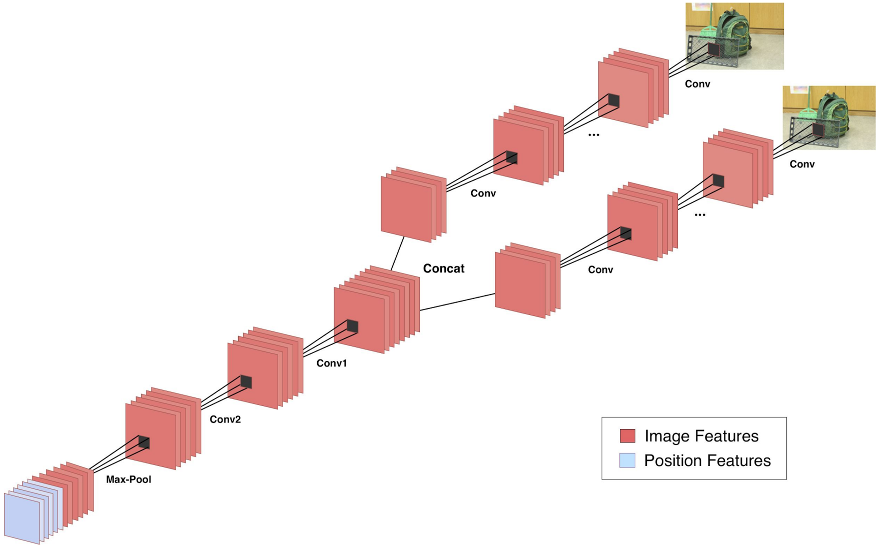
Feature Extraction

Single-Stream Architecture



Siamese Architecture



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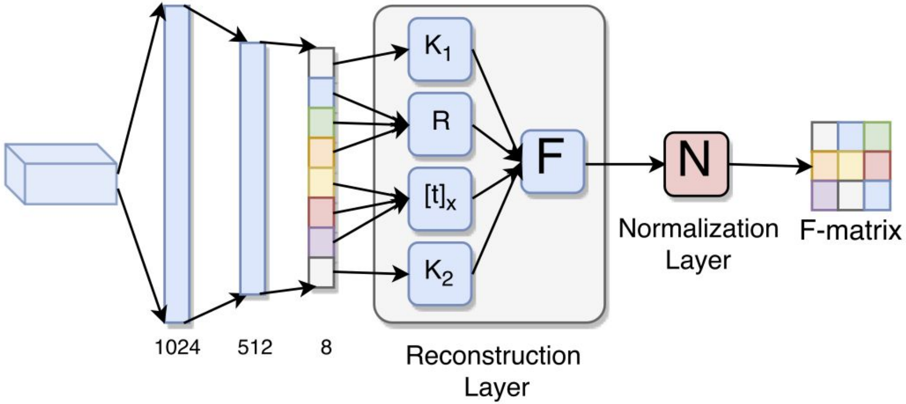
Regression

Reconstruction Layer: A differentiable layer to reconstruct the F-matrix based on predicted camera parameters.



$$\mathbf{F} = \mathbf{K}_2^{-T}\mathbf{R}\,[\mathbf{t}]_\times\,\mathbf{K}_1^{-1}$$

Epipolar Parametrization: Parametrizing the F-matrix based on the first two rows and two coefficients to linearly combine them to obtain the third row $\mathbf{f}_3 = \alpha\mathbf{f}_1 + \beta\mathbf{f}_2$

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Results on KITTI dataset

$$\mathcal{M}_{EPI-ABS}(\mathbf{F}, p, q) = \sum_i |q_i^T \mathbf{F} p_i| \qquad \mathcal{M}_{EPI-SQR}(\mathbf{F}, p, q) = \sum_i (q_i^T \mathbf{F} p_i)^2$$

	Siamese Network			Single-stream Network		
Normalization	Models	EPI-ABS	EPI-SQR	Models	EPI-ABS	EPI-SQR
ETR-Norm	Base	3.77	27.16	Base	4.43	34.34
	POS	4.05	21.90	POS	2.47	9.79
	EPI	0.52	0.28	EPI	1.00	0.99
	EPI + POS	0.88	1.02	EPI + POS	1.00	1.00
	REC	0.56	0.45	REC	0.99	0.99
	REC + POS	0.97	0.98	REC + POS	1.00	0.99
	7-point	1.91	152.83	7-point	1.91	152.83
	LeMedS	1.09	25.50	LeMedS	1.09	25.50
	RANSAC	0.60	3.85	RANSAC	0.60	3.85
	Ground-truth	0.05	0.004	Ground-truth	0.05	0.004

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Results on KITTI dataset

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	Siamese Network			Single-stream Network		
Normalization	Models	EPI-ABS	EPI-SQR	Models	EPI-ABS	EPI-SQR
FBN-Norm	Base	1.44	2.58	Base	2.45	9.99
	POS	1.97	5.66	POS	2.78	8.55
	EPI	0.07	0.01	EPI	0.91	0.91
	EPI + POS	0.06	0.005	EPI + POS	0.67	0.58
	REC	0.92	1.11	REC	0.78	1.24
	REC + POS	0.43	0.44	REC + POS	0.87	0.81
	7-point	1.06	11.7	7-point	1.06	11.7
	LeMedS	0.39	0.68	LeMedS	0.39	0.68
	RANSAC	0.27	0.21	RANSAC	0.27	0.21
	Ground-truth	0.05	0.004	Ground-truth	0.05	0.004

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