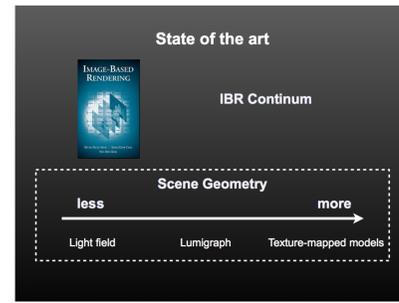
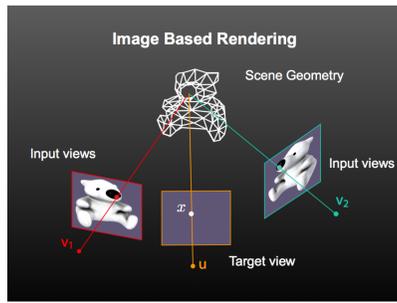
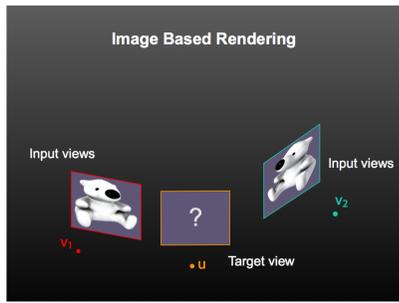


Image-Based Rendering

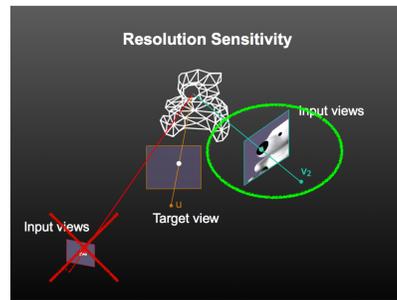
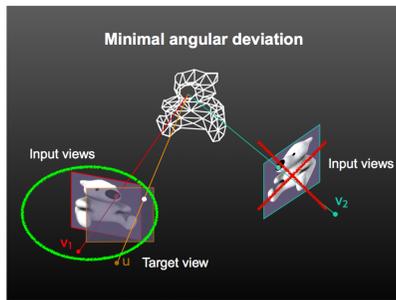


State of the art

Unstructured Lumigraph Rendering
C. Buehler et al. - SIGGRAPH 2001

8 Desirable Properties

- Use of geometric proxies
- Unstructured input
- Minimal angular deviation
- Epipole consistency
- Equivalent ray consistency
- Resolution sensitivity
- Continuity
- Real-time



State of the art

Method	Formal deduction Physics-Based Parameters	Resolution sensitivity	Minimal angular deviation
Buehler et al. SIGGRAPH 2001 <i>Unstructured Lumigraph Rendering</i>	✗	✓	✓
Kaita Takahashi ECCV 2010 <i>Theory of Optimal View Interpolation with Depth Inaccuracy</i>	✓	✗	✓
Wanner and Goldluecke ECCV 2012 <i>Spatial and Angular Variational Super-resolution of 4D Light Fields</i>	✓	✓	✗
Our method CVPR 2014	✓	✓	✓

Previous and Proposed Generative Model

Bayesian Approach: Inverse Problem

Scene Geometry

Perfect image $\tilde{v}_i(x) = (u \circ \tau_i)(x)$

Observed image $v_i(x) = \tilde{v}_i(x) + e_s(x)$

Sensor noise

Gaussian distribution

Least squares minimisation problem

Bayesian Approach: Inverse Problem

Scene Geometry

*Spatial and Angular Variational
Super-resolution of 4D Light Fields*
S. Wanner and B. Goldluecke ECCV 2012

$v_i(x) = \tilde{v}_i(x) + e_s(x)$

Physics based
Resolution sensitivity
Minimal angular deviation

Bayesian Approach: Proposed Method

Depth distribution

Observed image

Sensor noise

Perfect image

Geometric Noise

Support of the projected Gaussian depends on the angular deviation

Deduced weights

$$\det D\tau_i^{-1} \sigma_{z_i}^2 \left(\frac{\partial(u \circ \tau_i)}{\partial z_i} \right)^{2d-1}$$

- ✓ Minimal angular deviation
- ✓ Physics based
- ✓ Resolution sensitivity

Weighting factor depends on

- ✓ correspondence confidence
- ✓ image content (color gradient along epipolar line)

Equations

Notation

Target image: $u : \Gamma \rightarrow \mathbb{R}$ (or \mathbb{R}^3)

Input images: $v_i : \Omega_i \rightarrow \mathbb{R}$ (or \mathbb{R}^3)

Backwards warp: $\tau_i : \Omega_i \rightarrow \Gamma$

Binary occlusion mask: $m_i : \Omega_i \rightarrow \{0, 1\}$

Visibility set: $V_i \subset \Omega_i \mid m_i = 1$

Forward warp: $\beta_i : \tau_i(V_i) \rightarrow \Omega_i \mid \beta_i \circ \tau_i = Id$

Maximum a Posteriori energy

$$E(u) = E_{\text{data}}(u) + \lambda E_{\text{prior}}(u)$$

$$E_{\text{data}}(u) = \sum_{i=1}^n \frac{1}{2} \int_{\Omega_i} \omega_i(u) m_i(b * (u \circ \tau_i) - v_i)^2 dx,$$

with $\omega_i(u) = (\sigma_s^2 + \sigma_{g_i}^2)^{-1}$

$$E_{\text{prior}}(u) = \int_{\Gamma} |Du|$$

Relation between image error on geometric error

$$\sigma_{g_i} = \sigma_{z_i} \left| b * \frac{\partial(u \circ \tau_i)}{\partial z_i} \right| = \sigma_{z_i} \left| b * \left((\nabla u \circ \tau_i) \cdot \frac{\partial \tau_i}{\partial z_i} \right) \right|$$

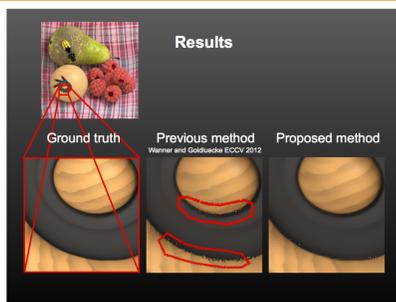
Minimization with a re-weighted iterative method

- Use estimate \tilde{u} of u and consider $\omega_i(\tilde{u})$ constant during iteration: the simplified energy is convex.
 - Minimize simplified energy using FISTA.
 - Update weights with current solution and iterate.
- First iteration: $\tilde{u} = \frac{1}{n} \sum v_i \circ \beta_i$

Code available at

<http://sourceforge.net/projects/cocolib/>

Example for Intuition



Numerical and Visual Results

	HCI light fields, raytraced		HCI light fields, gantry		Stanford light fields, gantry			
	<i>still life</i>	<i>buddha</i>	<i>maria</i>	<i>couple</i>	<i>truck</i>	<i>gum nuts</i>	<i>tarot</i>	
Estimated disparity								
Wanner et al. ECCV 2012	30.13	58	42.84	17	40.06	53	26.55	226
Proposed	30.45	55	42.37	18	40.10	53	28.50	178
Planar disparity								
Wanner et al. ECCV 2012	21.28	430	34.28	74	31.65	144	20.07	725
Proposed	22.24	380	37.51	44	34.38	99	22.88	457
Super-resolution								
Wanner et al. ECCV 2012	24.93	230	34.50	122	35.18	129	25.54	287
Proposed	25.12	228	34.44	123	35.20	129	25.34	289

Top: Numerical results for synthetic and real-world light fields. We compare our method to Wanner et al. ECCV 2012 work with respect to same-resolution view synthesis for estimated disparity and a flat plane proxy, as well as super-resolved view synthesis. For each light field, the first value is the PSNR (bigger is better), the second value is DSSIM in units of 10^{-4} (smaller is better). The better value is highlighted in bold.

Right: Visual comparison of novel views obtained for different light fields. From top to bottom, the rows present closeups of the ground truth images, the results obtained by Wanner et al. ECCV 2012 work, and our results. CD stands for computed disparity, PD for planar disparity and SR for super-resolution. The results obtained by the proposed method are visibly sharper, in particular along color edges.

