Extracting and manipulating lighting through intrinsic image decomposition

Pierre-Yves Laffont
Postdoctoral researcher at ETH Zürich (Switzerland) with Markus Gross, since March 2014

Visiting the BeingThere Centre at NTU Singapore since June 2014
Postdoctoral researcher at **Brown University** (USA)
  - with James Hays, 2012 – 2014 (16 months)

PhD from **INRIA Sophia-Antipolis** (France)
  - with George Drettakis & Adrien Bousseau, 2009 – 2012
  - visiting student researcher at MIT and UC Berkeley (USA)
The appearance of a scene changes with many factors:

- Viewpoint
- Lighting
- Time of day
- Season
- Weather
- Material/geometry changes (e.g. aging)

CRACOW 4 seasons timelapse
by Piotr Wancerz - www.timelapsemmedia.pl
Exploring and Editing Scene Appearance
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- What can those appearance variations teach us about the scene?
  ⇒ image analysis / scene understanding
Exploring and Editing Scene Appearance

- What can those appearance variations teach us about the scene?
  \[\implies\text{image analysis / scene understanding}\]

- Can we manipulate scene appearance and synthesize new images?
  \[\implies\text{image editing / example-based transfer}\]
Understand and edit outdoor scene appearance with transient attributes

SIGGRAPH 2014

Synthesize novel views
EGSR 2011

Transfer weathering effects
TOG 2011

Extract and manipulate lighting with intrinsic images
SIGGRAPH Asia 2012
TVCG 2013
TOG 2015
ICCV 2015

more “autumn” more “winter”
more “warm” more “moist”
Extract and manipulate lighting with intrinsic images

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SIGGRAPH 2014
Motivation: Lighting matters
Motivation: Relighting for telepresence

Life-size 3D transparent displays in Zurich and Singapore
Motivation: Relighting for telepresence

Participant and his virtual representation

[Maimone13]
Extracting and manipulating lighting through intrinsic image decomposition
Intrinsic images

- Decompose input image [Barrow-Tenenbaum78] into reflectance and illumination layers

\[ I = R \times S \]
Intrinsic images

- Decompose input image into reflectance and illumination layers

\[ I = R \times S \]

[Barrow-Tenenbaum 78]

Per-pixel per-channel multiplication
Decomposition example

Input

Reflectance

Illumination

[Laflont13]
Ill-posed problem

\[ I = R \ast S \]

Radiance
3 known values

Reflectance
3 unknowns

Illumination
3 unknowns

⇒ need to constrain the decomposition
Automatically from a single image

- Analyze local variations [Land71, Horn86, Tappen05]
- Incorporate global constraints [Shen08, Gehler11, Shen11]
- Fine tune with crowdsourced database [Bell14]
With user interaction

- Propagate user scribbles [Bousseau09, Shen11]
- Refine automatic results with scribbles [Bonneel14]

Input image  User scribbles  Reflectance  Illumination
From multiple views

- Use extra information to constrain decomposition
- Reconstruct sparse geometry
  - Structure from motion
    [Snavely06]
  - Multi view stereo
    [Furukawa09]
From multiple views

- From photocollections with varying lighting  

Input images  Reflectance  Illumination
From multiple views

- From photocollections with varying lighting [Laffont12]
From multiple views

- From multiple views with constant lighting [Laffont13]

Outdoor photographs

Reflectance  Sun illumination  Sky illumination  Indirect illumination
From multiple views

- From multiple views with constant lighting  
  [Laffont13]

Edited reflectance  Virtual object insertion  Sunset relighting
From multiple views

- From multiple views with constant lighting  
  \[\text{[Laffont13]}\]
- Relighting with moving shadows  
  \[\text{[Duchêne15]}\]

(a) Input image  
(b) Relighting +30 minutes

(c) Reflectance  
(d) Shading
From *timelapse* sequences

- Fixed viewpoint, varying lighting  
  [Weiss01, Matsushita04]  
  [Sunkavalli08, Hauagge13]
Intrinsic decomposition of image sequences from local temporal variations

Pierre-Yves Laffont, Jean-Charles Bazin
ICCV 2015
Intrinsic images from a timelapse

- Input: Timelapse with N frames
- Output: 1 reflectance image, N illumination images

\[ I = R \times S \]

- Radiance: 3*N known values
- Reflectance: 3 unknowns
- Illumination: 3*N unknowns
Intrinsic images from a timelapse

Reflectance

Shading images
Locally smooth illumination

- In flat regions with no cast shadows, the illumination $S$ is constant
Locally smooth illumination

Locally adaptive smoothing weights
Results: Madrid sequence

Input

Illumination

Reflectance
Results: City sequence

Illumination

Input

Reflectance
Evaluation: St Basil synthetic benchmark
Conclusion

- Automatically decompose timelapse sequences into reflectance and illumination sequences
- Enforces smooth illumination locally based on the observations
- Synthetic benchmark for evaluation

https://graphics.ethz.ch/~plaffont/research/intrinsicTimelapse
Laffont P.Y. and Bazin J.C. Intrinsic decomposition of image sequences from local temporal variations. To be presented at IEEE International Conference on Computer Vision (ICCV 2015), Santiago.

