Single Image Portrait Relighting

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Photography & Recording Allowed
Overview
Overview

light from the back
Overview

light from the back

shadow on the face
Overview

light from the back

shadow on the face

want to add dramatic lighting
Overview

Change the lighting of any portrait after capture using post-processing algorithm

light from the back

shadow on the face

want to add dramatic lighting
Overview
Overview
Overview

Portrait Relighting System
Overview

Portrait Relighting System

another lighting
Overview

Portrait Relighting System

another lighting
Overview

Portrait Relighting System
Overview

Portrait Relighting System
I want to rotate the lighting a little bit.
I want to rotate the lighting a little bit.
Previous work
Previous work

- Light Stage

Previous work

• Light Stage

Previous work

- Light Stage

Previous work

• Light Stage: capture ~100 images and do image-based relighting

Previous work
Previous work

- Deep image-based relighting

Xu, Zexiang, et al. "Deep image-based relighting from optimal sparse samples." SIGGRAPH 2018
Previous work

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Previous work

- Deep image-based relighting

Xu, Zexiang, et al. "Deep image-based relighting from optimal sparse samples." SIGGRAPH 2018
Previous work

- Deep image-based relighting
capture 5 images and do relighting via neural network

Xu, Zexiang, et al. "Deep image-based relighting from optimal sparse samples." SIGGRAPH 2018
Previous work
Previous work

- Portrait lighting transfer

Previous work

• Portrait lighting transfer

Previous work

- Portrait lighting transfer
  transfer lighting from one portrait to another

Previous work
Previous work

- SfSNet

Previous work

- **SfSNet**: deep intrinsic decomposition mostly trained on synthetic faces

Previous work

- SfSNet: deep intrinsic decomposition mostly trained on synthetic faces

Overview
Overview

• Goal: practical relighting on single portrait image
Overview

- Goal: **practical relighting on single portrait image**

- Practical in detail:
  - Robust to the pose and camera view
  - Work well on natural lightings
  - Adapt to high-resolution images
  - Run at interactive rate
Overview

- **Goal:** practical relighting on single portrait image

- Practical in detail:
  - Robust to the pose and camera view
  - Work well on natural lightings
  - Adapt to high-resolution images
  - Run at interactive rate

- **Solution:** Deep Neural Network + Real Face Data.
Method
Method

portrait under lighting A
Method

portrait under lighting A

Portrait Relighting System (Neural Network)
Method

portrait under lighting A

Portrait Relighting System (Neural Network)

lighting B
Method

Portrait Relighting System (Neural Network)

portrait under lighting A

lighting B

portrait under lighting B
Method

Portrait Relighting System (Neural Network)

portrait under lighting A → lighting A

Portrait Relighting System (Neural Network)

portrait under lighting B → lighting B
Method

Portrait Relighting System (Neural Network)

portrait under lighting A

lighting A

lighting B

portrait under lighting B
Method

Portrait Relighting System (Neural Network)

portrait under lighting A → lighting A → lighting B → portrait under lighting B
Method

Portrait Relighting System (Neural Network)

portrait under lighting A

lighting A

lighting B

portrait under lighting B
Method

How can we get the portrait pair for training?

portrait under lighting A

Portait Relighting System (Neural Network)

lighting A

portrait under lighting B

lighting B
Method: Data
Method: Data

Light Stage
Method: Data

Light Stage

One-Light-At-a-Time scans (OLAT)
Method: Data
Method: Data

Method: Data

Method: Data

Method: Data

Method: Data
Method: Data

- OLAT images
- 22 people (18 training, 4 validation), each 3~5 facial expressions
Method: Data

• OLAT images
  • 22 people (18 training, 4 validation), each 3~5 facial expressions
  • Each OLAT captured with 7 cameras in 6 seconds.
Method: Data

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• HDR lighting environments
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  - ~2000 indoor HDR lighting from Laval Dataset
Method: Data

- OLAT images
  - 22 people (18 training, 4 validation), each 3~5 facial expressions
  - Each OLAT captured with 7 cameras in 6 seconds.
- HDR lighting environments
  - ~2000 indoor HDR lighting from Laval Dataset
  - ~1000 outdoor HDR lighting from the web
Method: Data

- OLAT images
  - 22 people (18 training, 4 validation), each 3~5 facial expressions
  - Each OLAT captured with 7 cameras in 6 seconds.
- HDR lighting environments
  - ~2000 indoor HDR lighting from Laval Dataset
  - ~1000 outdoor HDR lighting from the web
- Total: 226,800 portrait and lighting pairs for training
Method: Training
Method: Training

Encoder  Bottleneck  Decoder
Method: Training

- Task 1: Complete relighting
Method: Training

- Task 1: Complete relighting
Method: Training

• Task 1: Complete relighting
Method: Training

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Method: Training

- Task 1: Complete relighting
Method: Training

- Task 1: Complete relighting

![Diagram showing the training process with encoder, bottleneck, and decoder, and the corresponding source and target images and lights.](image-url)
Method: Training
Method: Training

- Task 2: Illumination retargeting
Method: Training

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Method: Training

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Method: Training

• Task 2: Illumination retargeting
Method: Training

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Method: Training

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Method: Training

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Method: Training
Method: Training

- Network structure
- U-Net

Spatial Resolution: 256 x 256

- 128 x 128
- 64 x 64
- 32 x 32
- 16 x 16

- k-dimensional input/label
- k-dimensional activation
- k x k conv layer
- weighted average
- tiling
- concatenation
- loss
Method: Training

- Network structure
- U-Net
Method: Training

- Network structure
- U-Net
- Predict and feed in light at bottleneck

Spatial Resolution:
- Source Image: 256 x 256
- 128 x 128
- 64 x 64
- 32 x 32
- 16 x 16

Output
- True Source Light: 16 x 32 x 3
- 16 x 32 x 1

k-dimensional input/label
- k-dimensional activation
- k x k conv layer
- weighted average
- tiling
- concatenation
- loss
Method: Training

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- U-Net
- Predict and feed in light at bottleneck

Spatial Resolution:
- 256 x 256
- 128 x 128
- 64 x 64
- 32 x 32
- 16 x 16

Source Image:
- k-dimensional input/label
- k-dimensional activation
- k x k conv layer
- weighted average
- tiling

Output Light:
- 16 x 32 x 3
- 16 x 32 x 1

Confidence learning module
Method: Training

- Network structure
  - U-Net
  - Predict and feed in light at bottleneck

Spatial Resolution:
- 256 x 256
- 128 x 128
- 64 x 64
- 32 x 32
- 16 x 16

Source Image
- 64 x 64
- 3
- 128 x 128
- 3
- 256 x 256
- 3
- 512 x 512
- 3

Output Light
- 16 x 32 x 3
- 3
- 256 x 256
- 3
- 512 x 512
- 3

Target Image
- 64 x 64
- 3
- 128 x 128
- 3
- 256 x 256
- 3
- 512 x 512
- 3

Output Light
- 16 x 32 x 3
- 3
- 256 x 256
- 3
- 512 x 512
- 3

Confidence learning module
Method: Training
Method: Training

- Confidence learning
Method: Training

• Confidence learning
Method: Training

- Confidence learning

Several conv layers
Method: Training

- Confidence learning
Method: Training

- Confidence learning
Method: Training

- Confidence learning

Several conv layers

Resolution of the light

Light prediction on each image patch
Method: Training

- Confidence learning
- Predict the confidence of light prediction
Method: Training

- Confidence learning
- Predict the confidence of light prediction
Method: Training

- Confidence learning
  - Predict the confidence of light prediction
  - Allow network to say “I don’t know”
Results: Validation
Results: Validation

➤ Relit images for complete relighting
Results: Validation

- Relit images for complete relighting
Results: Validation

➤ Relit images for complete relighting
Results: Validation

➤ Relit images for complete relighting
Results: Validation

- Relit images for complete relighting
Results: Validation

- Relit images for complete relighting

source image  target image  ours  [Barron & Malik 2015][Sengupta et al. 2018]  [Li et al. 2018]
Results: Validation

➤ Relit images for complete relighting

source image  target image  ours  [Barron & Malik 2015]  [Sengupta et al. 2018]  [Li et al. 2018]
Results: Validation

Complete Relighting

Input
(Lower-left: GT source light)
(Lower-right: predicted source light)
Results: Validation

Complete Relighting

Input
(Lower-left: GT source light)
(Lower-right: predicted source light)
Results: Validation
Results: Validation

➢ Relight images with predicted light as target light
Results: Validation

- Relight images with predicted light as target light

![Diagram of Encoder, Bottleneck, and Decoder with source images and relighted images]
Results: Validation

➤ Relight images with predicted light as target light

Encoder  Bottleneck  Decoder
Results: Validation

Illumination Retargeting

Input

Ground Truth

(Relit by Ground Truth Source Light)
Results: Validation

Illumination Retargeting

Input

Ground Truth

(Relit by Ground Truth Source Light)
Results: Validation
Results: Validation

➤ Comparison with portrait lighting transfer
Results: Validation

➤ Comparison with portrait lighting transfer reference image
Results: Validation

➤ Comparison with portrait lighting transfer
reference image

source image
Results: Validation

➤ Comparison with portrait lighting transfer

source image

Extract light from reference

reference image
Results: Validation

- Comparison with portrait lighting transfer

  reference image

  Extract light from reference

  Apply to source image

  source image
Results: Validation

➤ Comparison with portrait lighting transfer

- Reference image
- Groundtruth
- Ours

Extract light from reference
Apply to source image
Results: Validation

➤ Comparison with portrait lighting transfer

- Extract light from reference
- Apply to source image

reference image | groundtruth | ours

source image

[Shih et al. 2014] [Shu et al. 2018]
Results: Validation
Results: Validation

➤ Evaluation on lighting prediction
Results: Validation

➤ Evaluation on lighting prediction

source image

ground truth
Results: Validation

➤ Evaluation on lighting prediction
Results: Validation

- Evaluation on lighting prediction

- Ground truth

- Ours

- Ours w/o confidence learning

- [Barron & Malik 2015]

- [Sengupta et al. 2018]
Results: Images in the wild
Results: Images in the wild

Input Image

Relit Image
Results: Images in the wild

Input Image

Relit Image
Results: Images in the wild
Results: Images in the wild
Results: Images in the wild
Complete Relighting

Input Image

Relit Image
(Lower-right: input target light)
Results: Images in the wild
Complete Relighting

Input Image

Relit Image
(Lower-right: input target light)
Results: Images in the wild

Illumination Retargeting

Input Image

Relit Image
(Lower-right: predicted source light)
Results: Images in the wild
Illumination Retargeting

Input Image

Relit Image
(Lower-right: predicted source light)
Limitations
Limitations

- Complex shadows
- Specular highlights
- Overexposed pixels
Limitations

- Complex shadows
- Specular highlights
- Overexposed pixels
- Over-smoothing

Input Image

Relit Image
Limitations

- Complex shadows
- Specular highlights
- Overexposed pixels
- Over-smoothing
- Unseen high-saturation color
Conclusion
Conclusion

- Learn the relighting function on portraits using Light Stage data
Conclusion

• Learn the relighting function on portraits using Light Stage data

• Take home message:
Conclusion

• Learn the relighting function on portraits using Light Stage data

• Take home message:

  • For human faces, use real data.
Conclusion

• Learn the relighting function on portraits using Light Stage data

• Take home message:
  • For human faces, use real data.
  • End-to-end training vs assuming models.
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Single Image Portrait Relighting

Also presenting in poster session today at 12:15-1:15.
Single Image Portrait Relighting

input image

generated portraits under new illuminations
Single Image Portrait Relighting

input image

generated portraits under new illuminations