Error-tolerant Image Compositing

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naïve compositing


Poisson compositing


our result

Objectives

Seamless compositing

- Robust to inaccurate selection
- Output Quality
    - Limit color bleeding
- Time-Performance
    - Efficient method

Related Work: Poisson Compositing

Pasting gradients instead of pixels

Pérez 03, Georgiev 06, …

Poisson Compositing Result

Pros:

- Blends seamlessly
- Linear computation

Cons:

- Bleeding visible
- Foreground to background bleeding

Related Work: L_1 Norm

Introduced in shape from shading

Reddy 09

L_1 Norm Result

Pros:

- Reduced bleeding

Cons:

- Nonlinear

  - *Computationally intensive*

Related Work: Moving Boundaries

Move the boundaries to avoid bleeding

Jia 06

Changing boundaries

Pros:

- Avoids bleeding

Cons:

- We don't want boundaries to change
- Changed composition

Contributions

- Conceal bleeding in textured areas
- Better gradient field at boundary
- Efficient linear scheme

Overview

➡ **Problem Description**

- **Hiding Residuals with Visual Masking**
- **Generating a low-curl boundary**
- **Results and Comparisons**

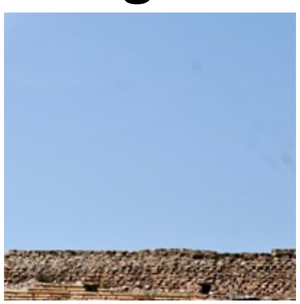
Algorithm Overview

Foreground

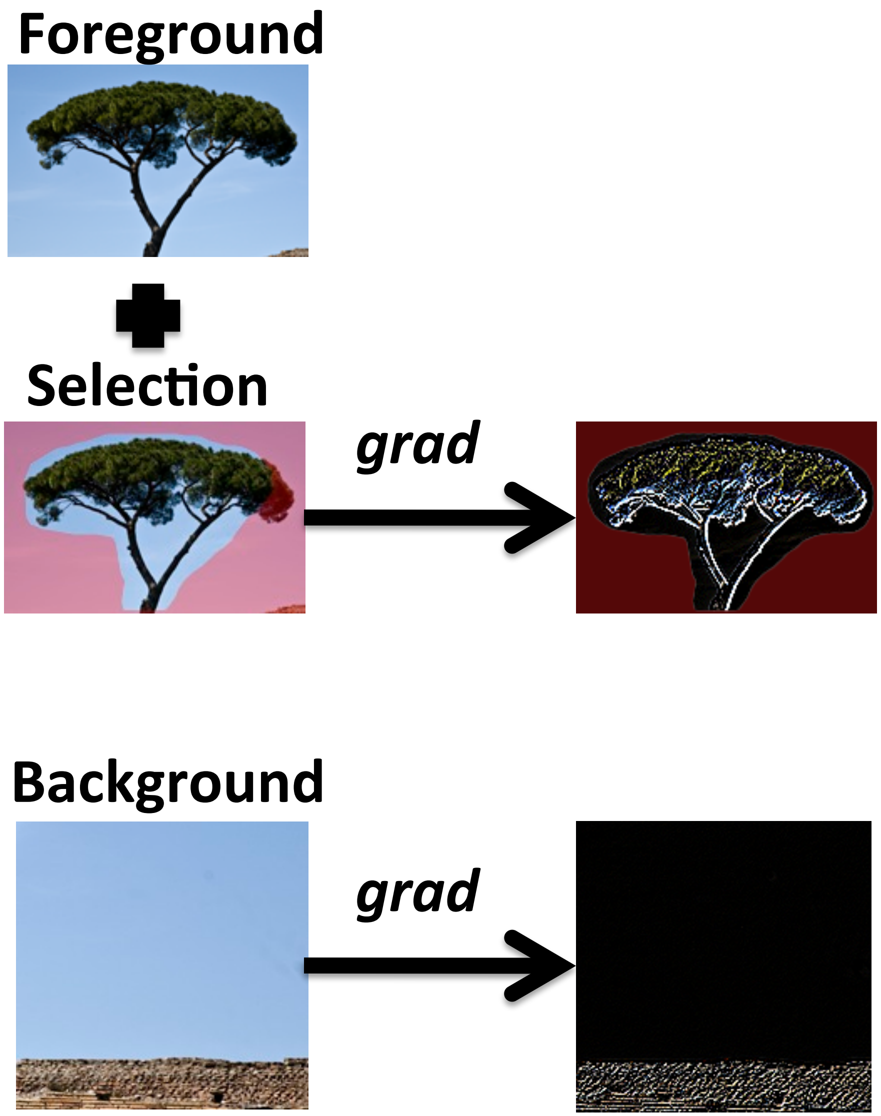
+

Selection

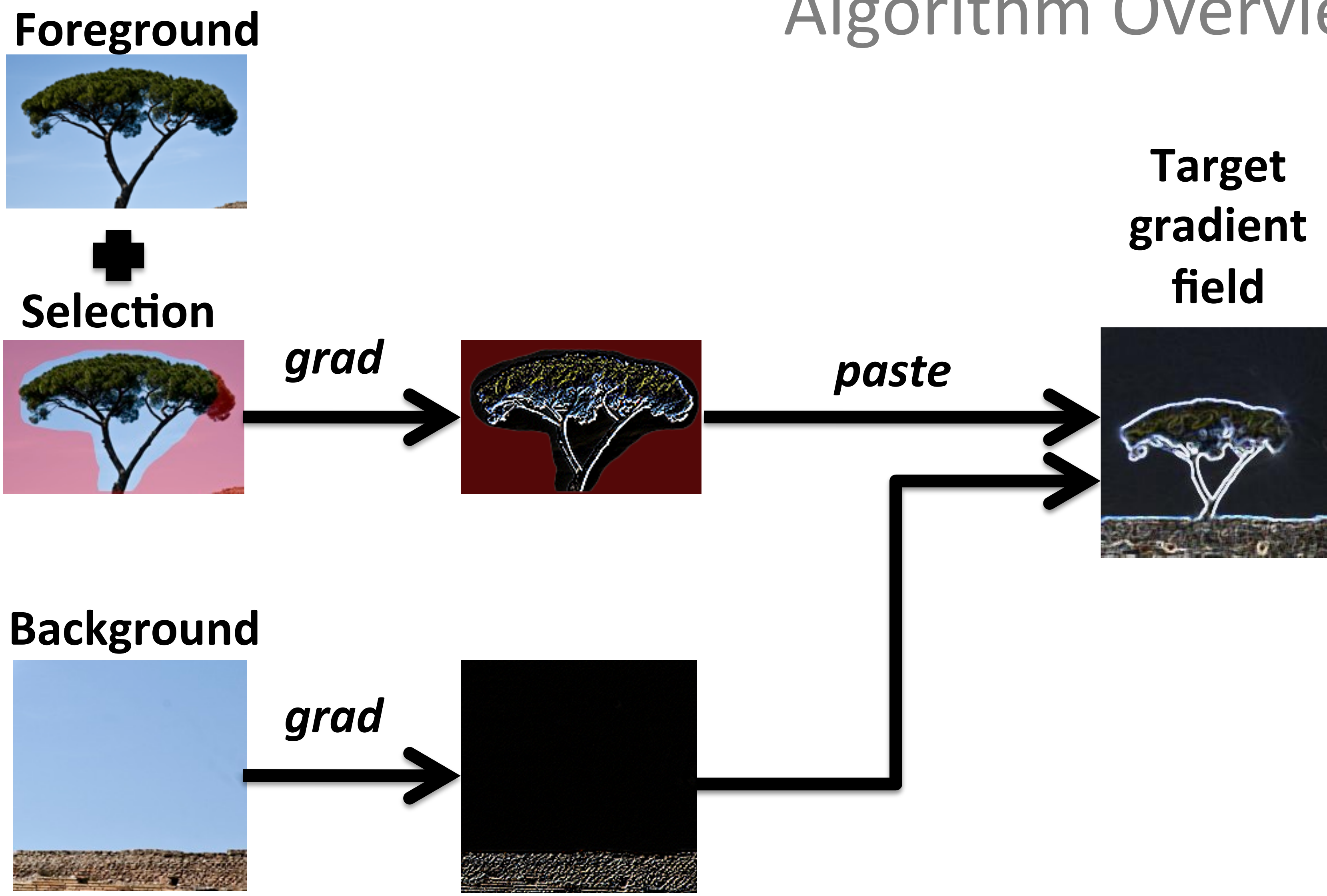
Background



Algorithm Overview



Algorithm Overview



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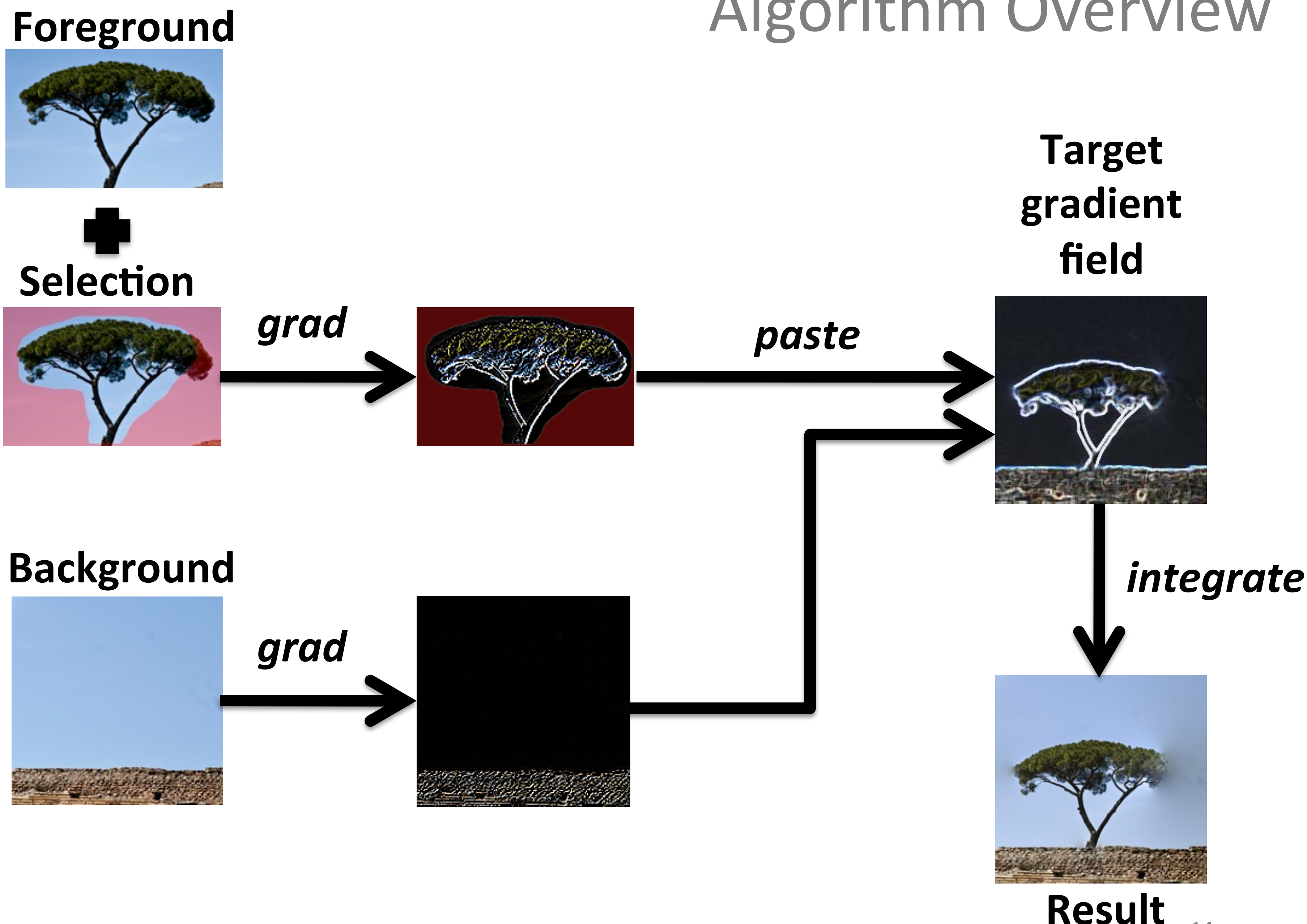

Standard Approach: Poisson compositing

We seek image I with gradients close to target $\mathbf{v}$.

target gradient field

$$\mathbf{V} = \begin{cases} \nabla Foreground & within\ selection \\ \nabla Background & out\ of\ selection \\ \dfrac{\nabla Foreground + \nabla Background}{2} & boundary\ of\ selection \end{cases}$$

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Least-squares: $$\int \|\nabla I - \mathbf{v}\|^2$$

output gradient field

Our Approach

We seek image I with gradients close to target $\mathbf{v}$.

target gradient field

$$\mathbf{V} = \begin{cases} \nabla \textit{Foreground} & \textit{within selection} \\ \nabla \textit{Background} & \textit{out of selection} \\ \text{value that minimizes curl} & \textit{boundary of selection} \end{cases}$$

Weighted least-square: $$\int W_{\mathrm{P}} \left\| \nabla I - \mathbf{v} \right\|^2$$

weight

output gradient field

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- Problem Statement
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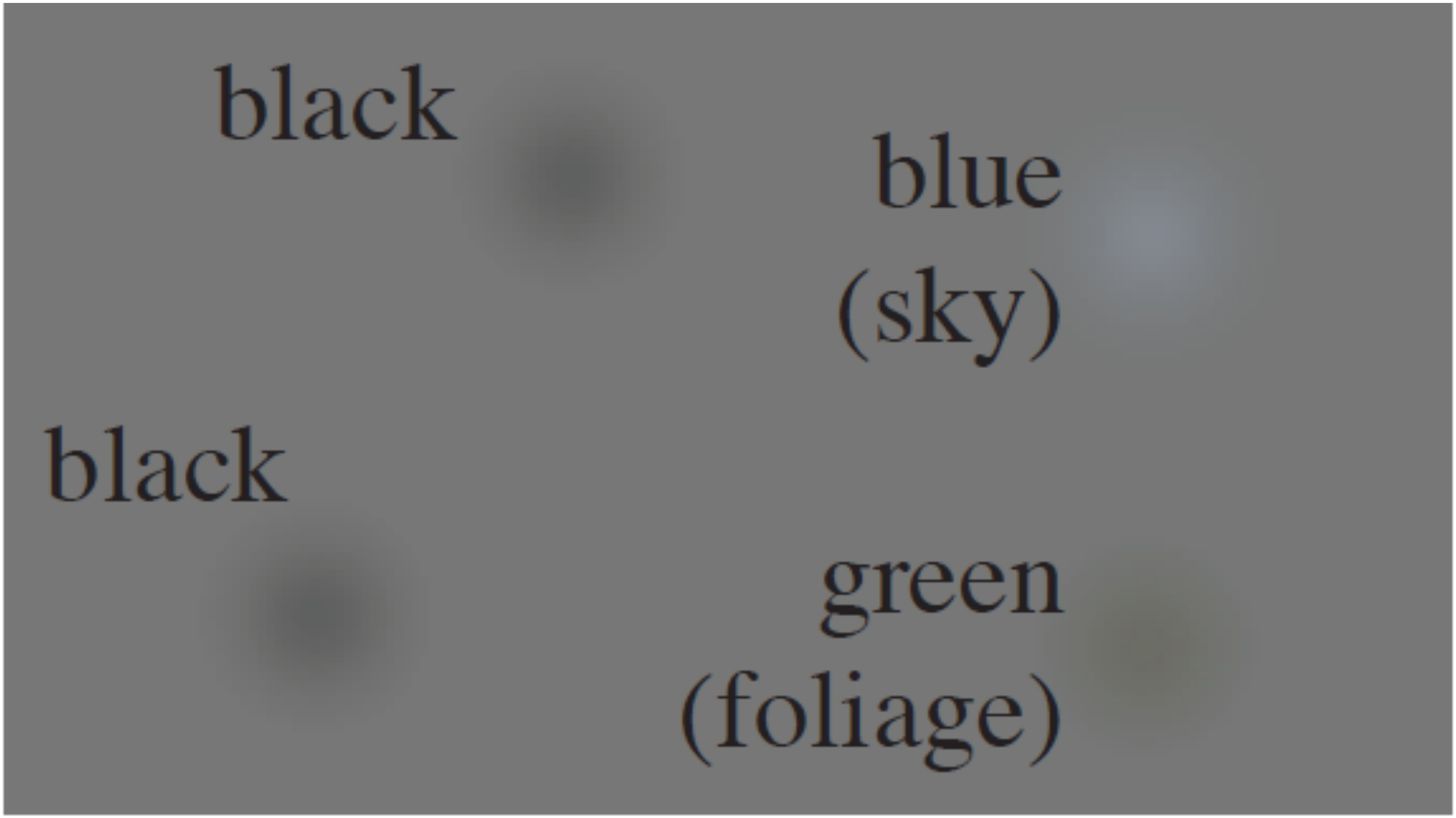
Our Strategy

- Use the weights to locate integration residuals where they are less visible
- Exploit perceptual effect: **visual masking**
  - – human perception affected by texture.

Visual Masking Demo

Can you spot all the dots?

Visual Masking Demo



Texture hides low-frequency content

Visual Masking Demo

Can you spot all the dots?

Design of the Weights

$$\int W_{\mathrm{P}} \left\| \nabla I - \mathbf{v} \right\|^2$$

smooth region:
needs high weight
to prevent bleeding

textured regions:
low weight is ok
because bleeding
less visible

weights (white is high)

Estimating the Amount of Texture

RGB gradient field

↑

$$T_{\sigma_1,\sigma_2}(\mathbf{g}) = \frac{G_{\sigma_1} \otimes \|\mathbf{g}\|}{G_{\sigma_2} \otimes \|\mathbf{g}\|}\, n(\|\mathbf{g}\|)$$

$$\sigma_1 < \sigma_2$$

Estimating the Amount of Texture

Small Gaussian convolution

RGB gradient field

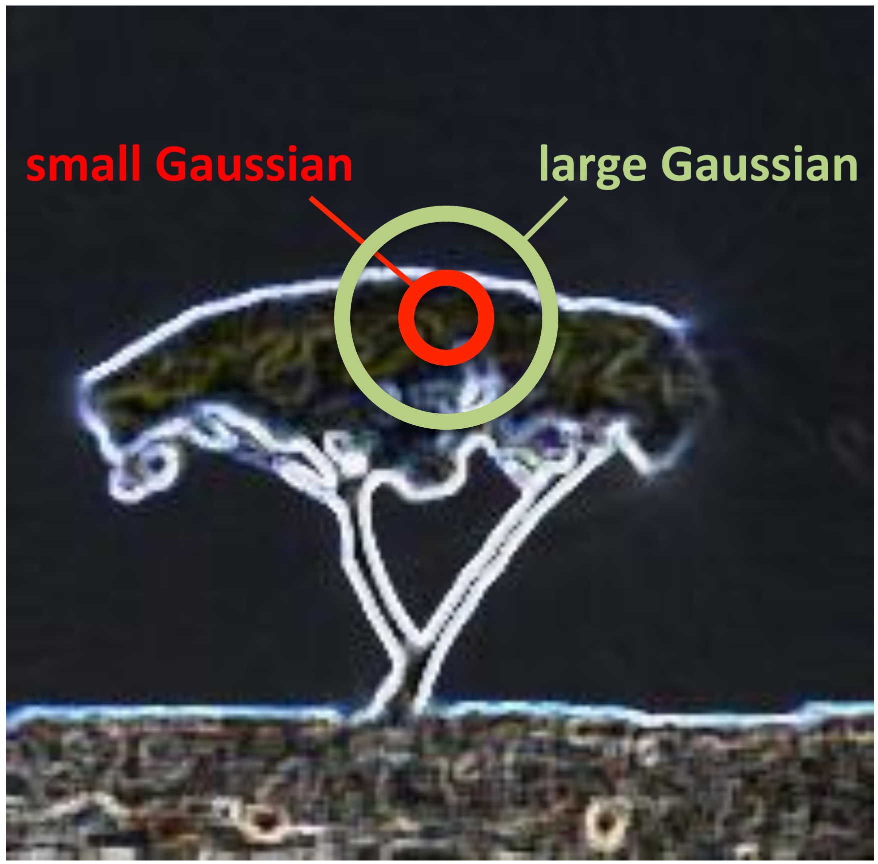
Noise controlling function

$$T_{\sigma_1,\sigma_2}(\mathbf{g}) = \frac{G_{\sigma_1} \otimes \|\mathbf{g}\|}{G_{\sigma_2} \otimes \|\mathbf{g}\|} n(\|\mathbf{g}\|)$$

Large Gaussian convolution

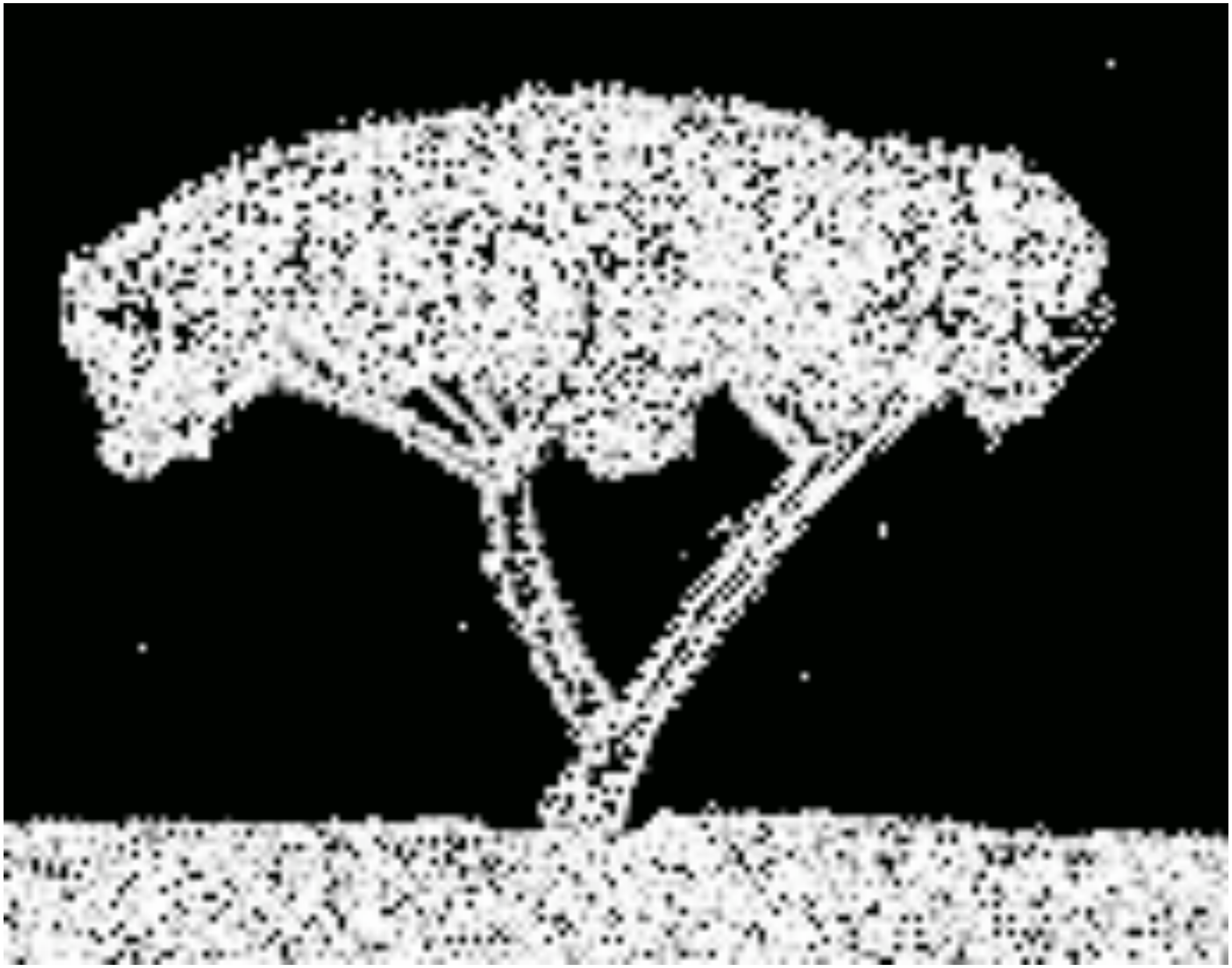
Estimating the Amount of Texture

$$T_{\sigma_1,\sigma_2}(\mathbf{g}) = \frac{G_{\sigma_1} \otimes \|\mathbf{g}\|}{G_{\sigma_2} \otimes \|\mathbf{g}\|} n(\|\mathbf{g}\|)$$



gradient field $\mathbf{g}$

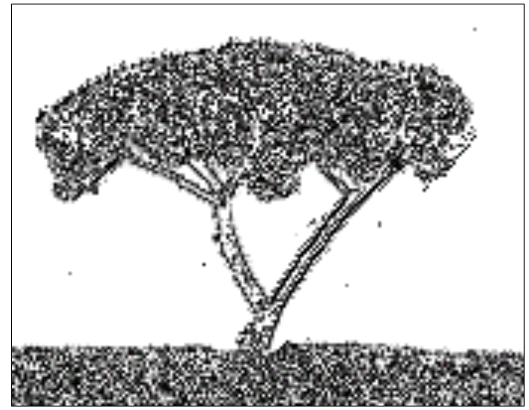
Estimating the Amount of Texture



Texture Map Output (white indicates more texture)

Weight Formula

$$W_{\mathrm{P}} = 1 - T(\mathbf{v})$$



Weight output

- $\mathbf{v}$ depends only on foreground and background
  - does not depend on the unknown I
  - weights are constant in the optimization
- our energy is a **classical least-squares optimization**

$$\int W_{\mathrm{P}} \left\|\nabla I - \mathbf{v}\right\|^2$$

Hiding Residuals with Visual Masking

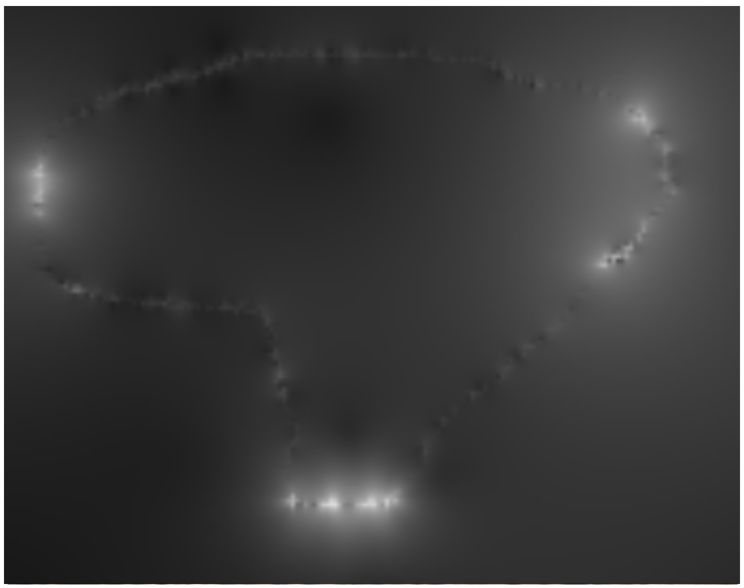
Bleeding only in textured areas

Poisson compositing

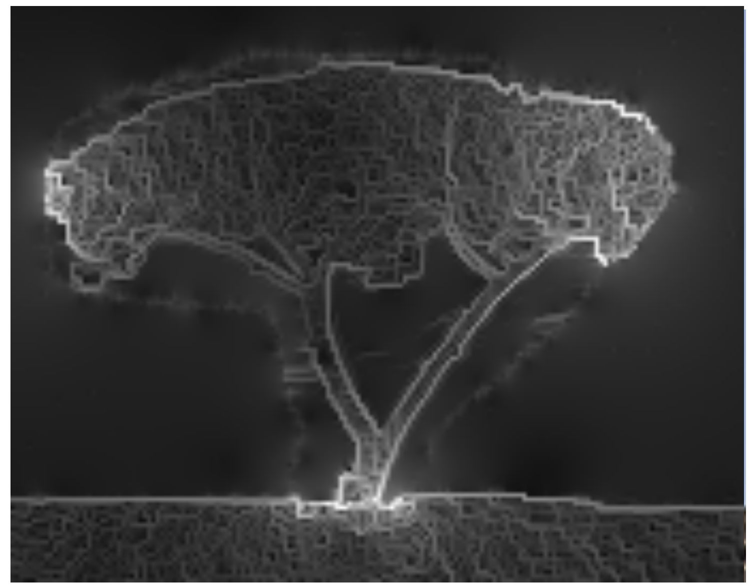
With texture weights

Hiding Residuals with Visual Masking

Residuals $\|\nabla I - \mathbf{v}\|^2$



Poisson compositing



With texture weights

Hiding Residuals with Visual Masking

Reduced bleeding but not fully

Poisson compositing

With texture weights

Overview

- Problem Statement
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- ➡ **Generating a low-curl boundary**
- **Results and Comparisons**

Boundary Problems

- Target field **v** integrable iff curl(**v**)=0
- Only boundary has non-zero curl
  - Consequence of target field construction (see paper)

curl using
standard strategy

- Our strategy: **reducing the curl**

Naïve Approach

- Minimize $\int_{\beta} [\mathrm{curl}\,(\mathbf{v})]^2$

- Unfortunately, the result is not seamless:

output of naïve approach

close-up

Our Approach: Least Squares Trade-off

- Unknowns: target field $\mathbf{v}$ along boundary
- Weights depend on texture (detail in paper)

zero curl weight seamless compositing

$$\int_\beta \left([\mathrm{curl}\,(\mathbf{v})]^2 + W_\beta \left[\mathbf{v} - \frac{1}{2}(\nabla B + \nabla F)\right]^2 \right)$$

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Results and Comparisons

Copy-and-paste

Results and Comparisons

Poisson Reconstruction : Pérez 03, Georgiev 06, …

Results and Comparisons

Maximum Gradient : Pérez 03

Results and Comparisons

Diffusion : Agrawal 06

Results and Comparisons

Lalonde 07

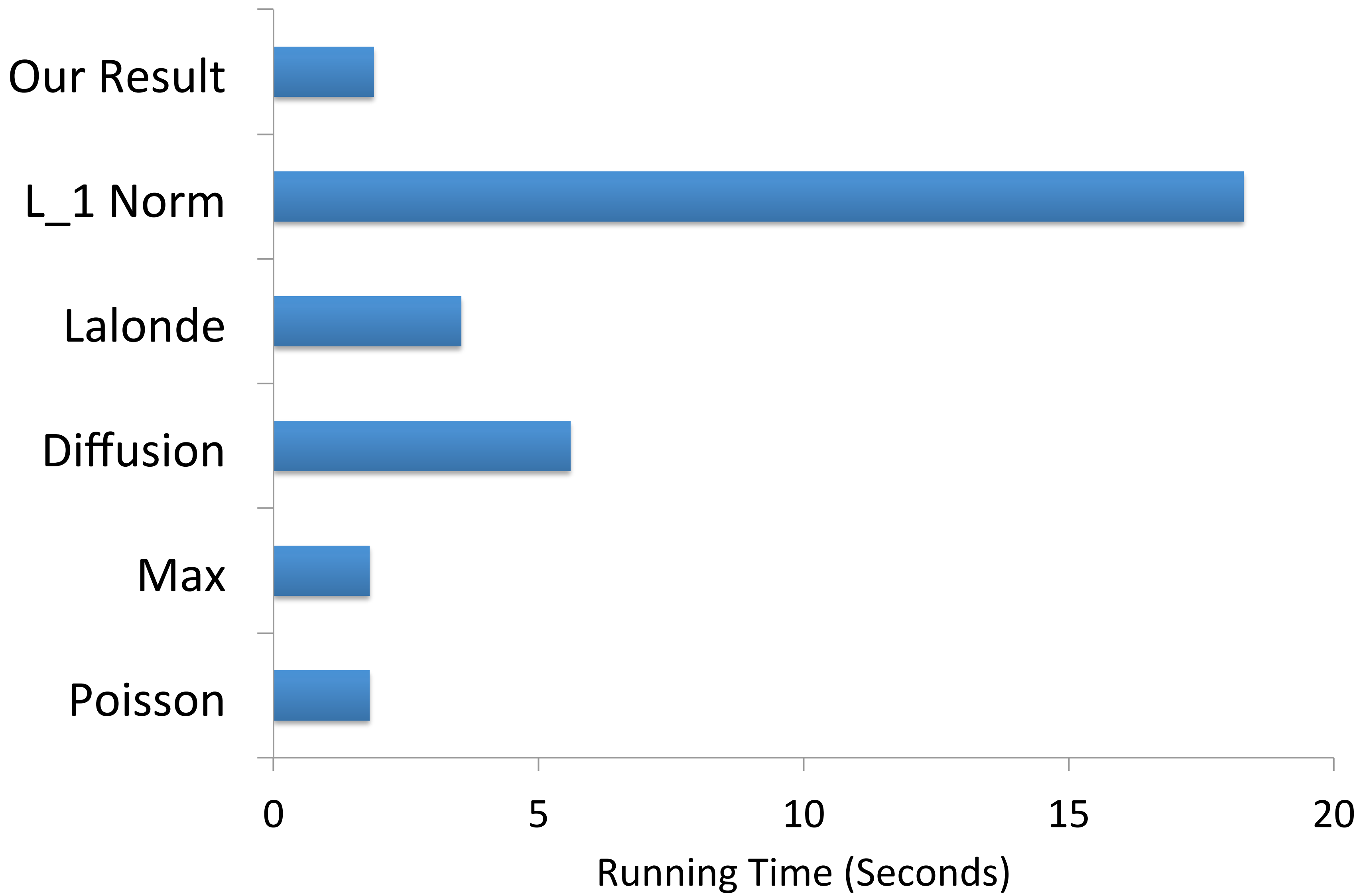
Results and Comparisons

L_1 Norm : Reddy 09

Results and Comparisons

Our Result

Results and Comparisons



Results and Comparisons

Poisson

Results and Comparisons

Our Result

Results and Comparisons

Poisson

Results and Comparisons

Our Result

Discussion

- Several parameters

  - all examples use the same parameters

- Discoloration may happen

  - happens in all gradient based operators

- Our model of visual masking is simple

  - good for performance

  - more complex model could be used

Conclusion

- Robust compositing using visual masking
- Better gradient field at boundary
- Efficient linear scheme


Poisson Reconstruction


Our Result

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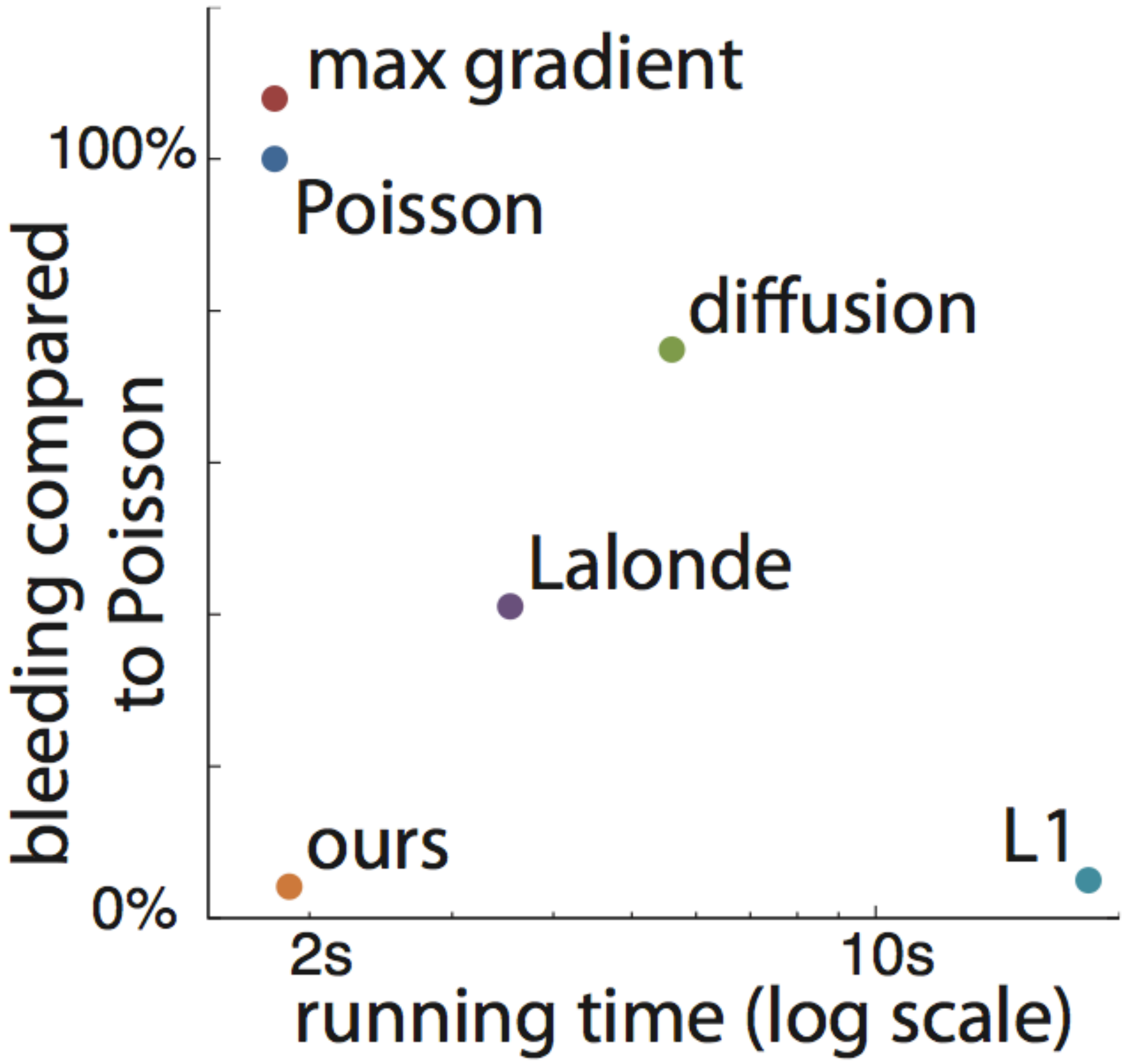
Poisson Reconstruction

Our Result

Results and Comparisons



Results and Comparisons

Poisson

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