Microsoft Research Cambridge

SIGGRAPH2004

GrabCut

Interactive Foreground Extraction using Iterated Graph Cuts

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Photomontage

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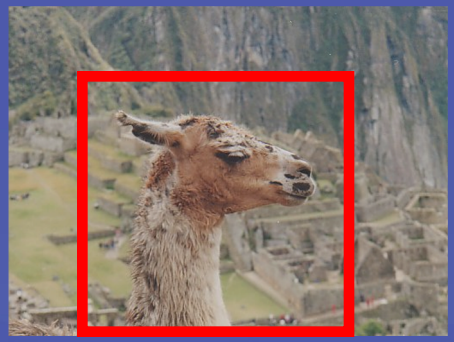
MSR Cambridge Image Editing Technology - [JCPad1]
File Edit Grabber Blender Patchworks JetStream View Test Window Help
Ready

Problem

Fast &
Accurate ?

What GrabCut does

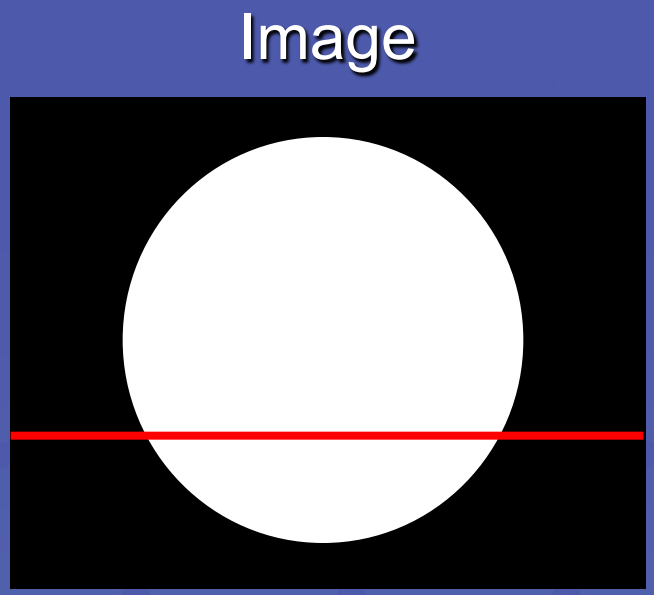
	Magic Wand (198?)	Intelligent Scissors Mortensen and Barrett (1995)	GrabCut
User Input			
Result			
	Regions	Boundary	Regions & Boundary

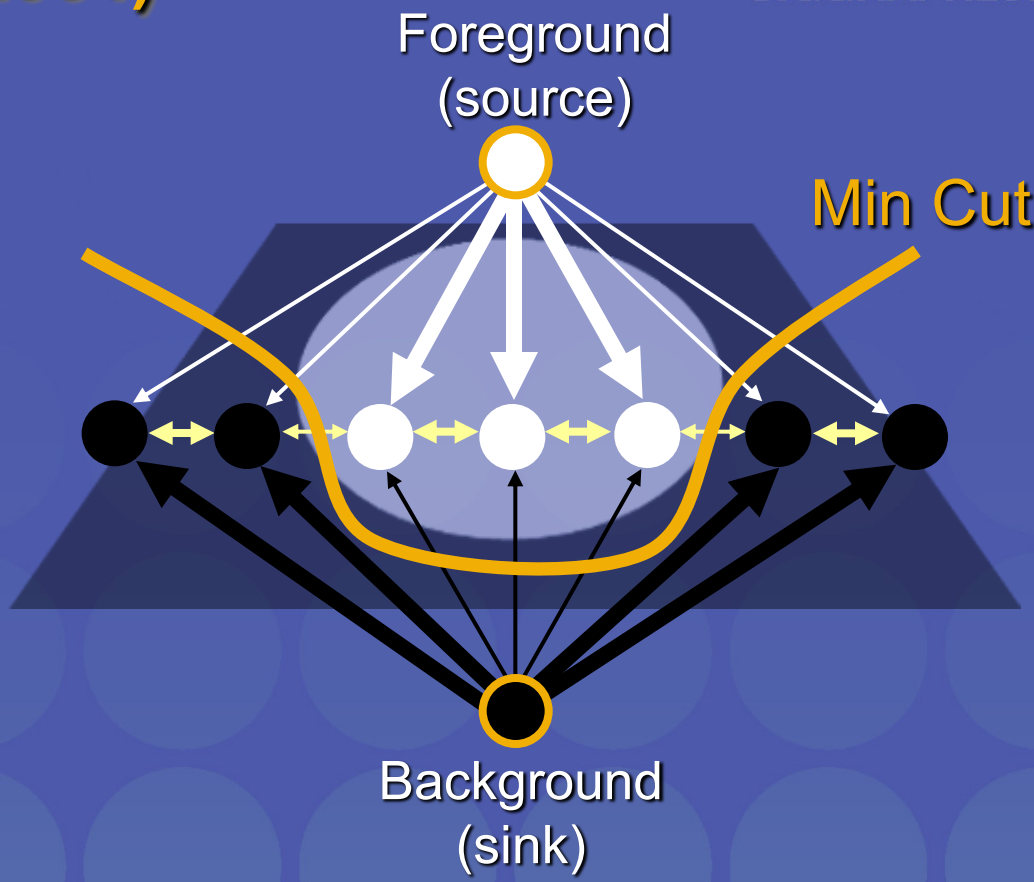
Framework

- **Input**: Image $\mathbf{x} \in \{\mathbf{R}, \mathbf{G}, \mathbf{B}\}^{\mathbf{n}}$
- **Output**: Segmentation $\mathbf{S} \in \{\mathbf{0}, \mathbf{1}\}^{\mathbf{n}}$
- **Parameters:** Colour $\boldsymbol{\Theta}$,Coherence λ
- **Energy:** $E(\boldsymbol{\Theta}, \mathbf{S}, \mathbf{x}, \lambda) = E_{Col} + E_{Coh}$
- **Optimization:** $\arg\min_{\mathbf{S}, \boldsymbol{\Theta}} E(\mathbf{S}, \boldsymbol{\Theta}, \mathbf{x}, \lambda)$

Graph Cuts

Boykov and Jolly (2001)





Cut: separating source and sink; Energy: collection of edges

Min Cut: Global minimal enegry in polynomial time

Iterated Graph Cut

User Initialisation

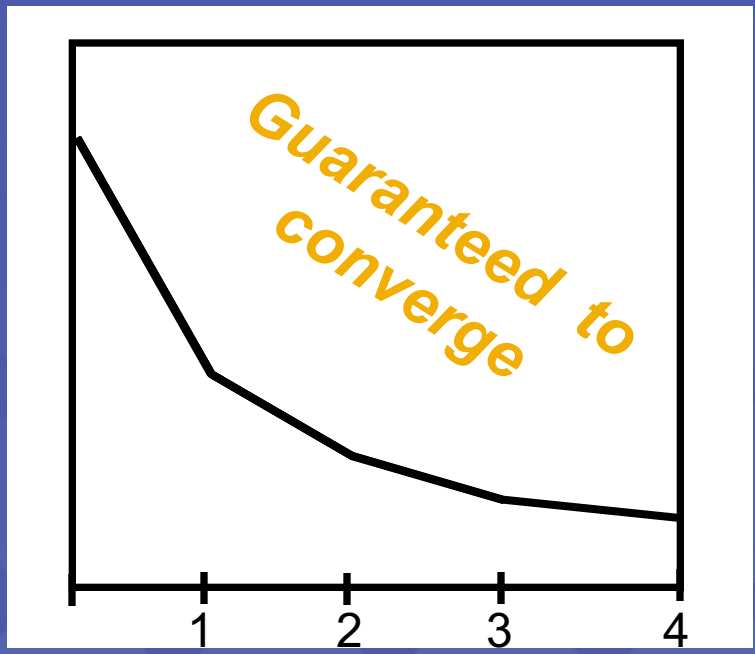
$$\arg\min_{\Theta} E(\mathbf{S}, \Theta, \mathbf{x}, \lambda)$$

$$\arg\min_{\mathbf{S}} E(\mathbf{S}, \Theta, \mathbf{x}, \lambda)$$

K-means for learning colour distributions

Graph cuts to infer the segmentation

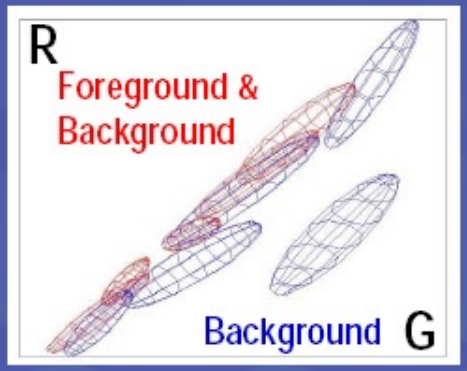
Iterated Graph Cuts



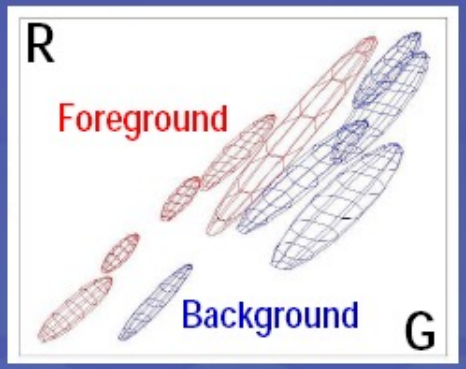
Result

Energy after each Iteration

Colour Model



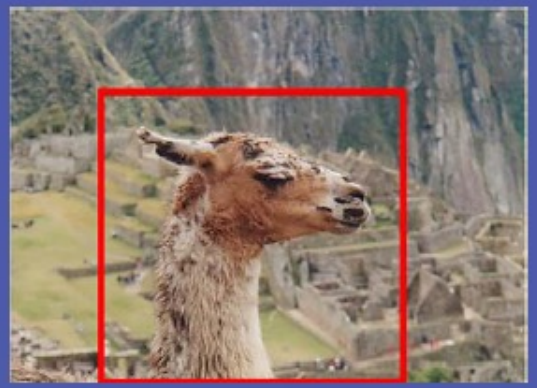
Iterated graph cut



Gaussian Mixture Model (typically 5-8 components)

$$E_{Col}(\Theta, \mathbf{S}, \mathbf{x}) = \sum_{\mathbf{n}} \mathbf{D}(\mathbf{S_n}, \Theta, \mathbf{x_n})$$

Coherence Model



An object is a coherent set of pixels:

$$E_{coh}(\mathbf{S}, \mathbf{x}, \lambda) =$$

$$\lambda \sum_{i,j \text{ adj.}} (S_i \neq S_j)\ exp\{-\frac{1}{2\sigma^2}||x_i - x_j||^2\}$$

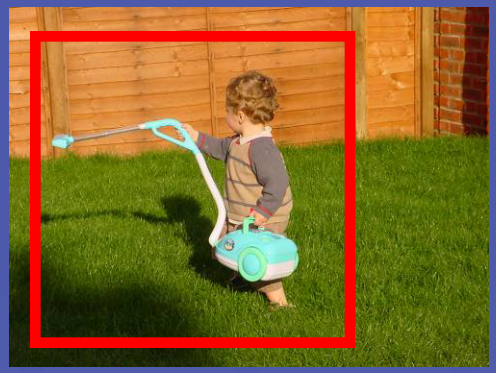
$\lambda = 0$

$\lambda = 50$

$\lambda = 1000$

Blake et al. (2004): Learn Θ, λ jointly

Moderately straightforward examples






… GrabCut completes automatically

Difficult Examples

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Camouflage & Low Contrast

Fine structure

No telepathy

Initial Rectangle

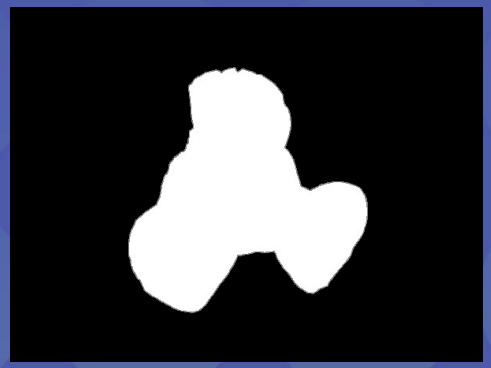
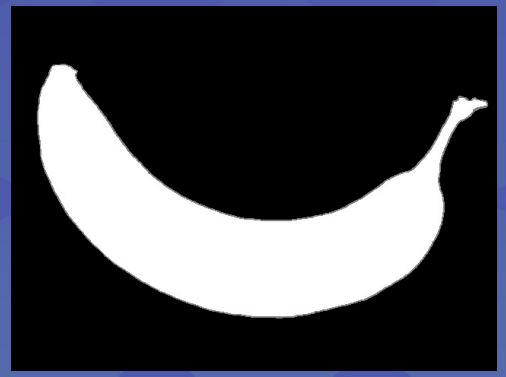
Initial Result

Evaluation – Labelled Database







Available online: http://research.microsoft.com/vision/cambridge/segmentation/

Comparison

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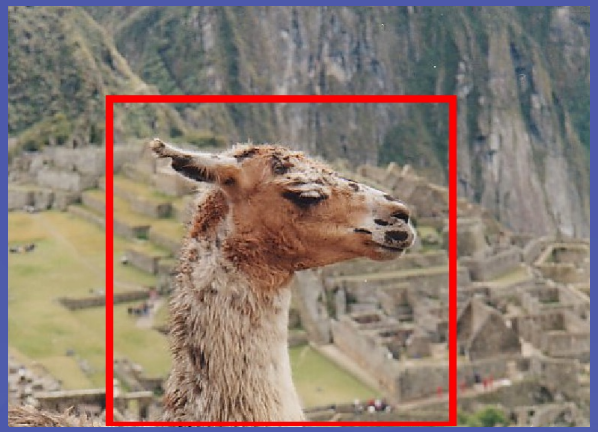
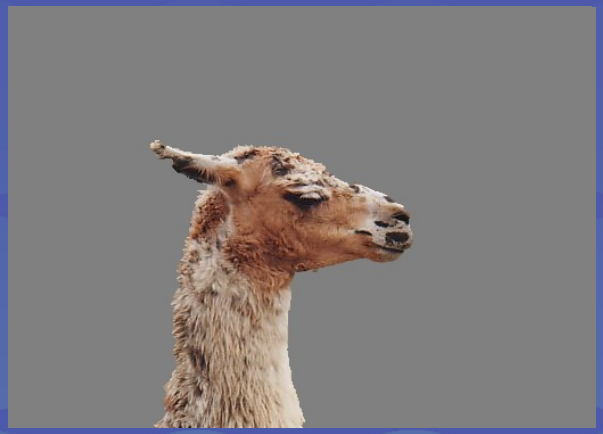
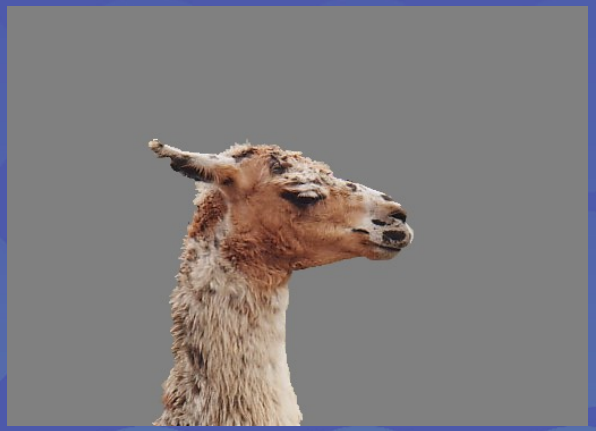
	Boykov and Jolly (2001)	GrabCut
User Input		
Result		
	Error Rate: 0.72%	Error Rate: 0.72%

Summary

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Magic Wand (198?)

Intelligent Scissors Mortensen and Barrett (1995)

Graph Cuts Boykov and Jolly (2001)

LazySnapping Li et al. (2004)

GrabCut Rother et al. (2004)

Conclusions

- GrabCut – powerful interactive extraction tool
- Iterated Graph Cut based on colour and contrast
- Regularized alpha matting by Dynamic Programming

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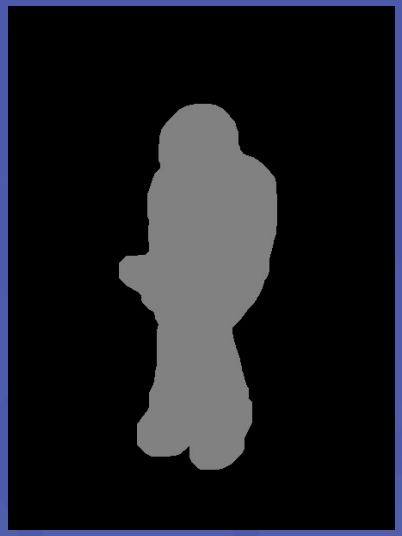
Comparison

Input Image

Ground Truth

Trimap
Boykov and Jolly

Error Rate: 1.36%



Bimap
GrabCut

Error Rate: 2.13%

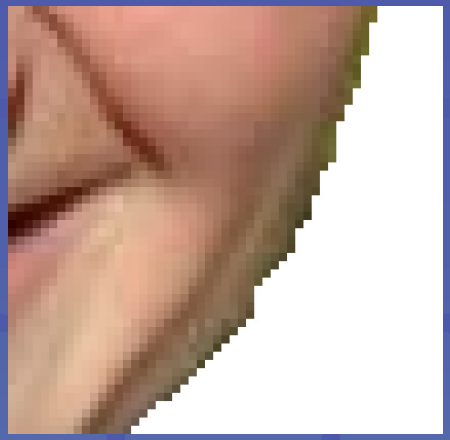
- Error rate - modestly increase
- User Interactions - considerable reduced

Comparison

	LazySnapping	GrabCut
Smart Initialisation		Rectangle or Lasso
Editing	Boykov-Jolly Brushing (global) Boundary editing (local)	Boykov-Jolly Brushing (global) Boundary editing (local)
Speed	Interactive, due to segmentation into regions	Interactive, due to multiple image resolution
Pre-processing (Image loading)	Segmentation into regions	

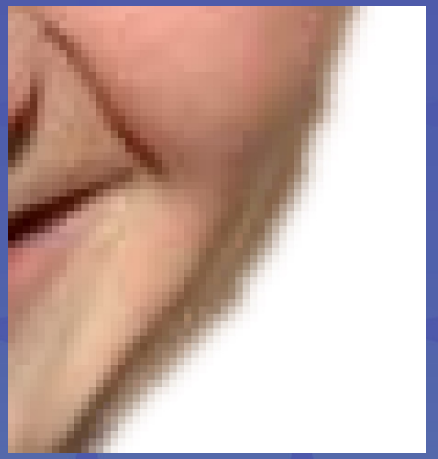
Li et al. (2004), LazySnapping

Border Matting



Hard Segmentation

Automatic Trimap



Soft Segmentation

Natural Image Matting

Mean Colour
Foreground

Mean Colour
Background

Solve

Ruzon and Tomasi (2000): Alpha estimation in natural images

Comparison

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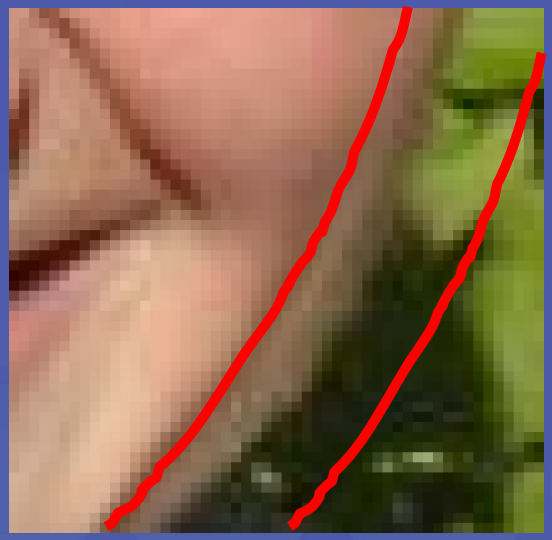
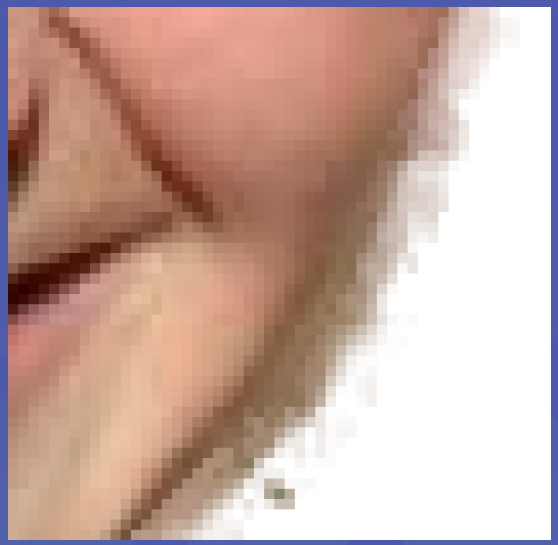
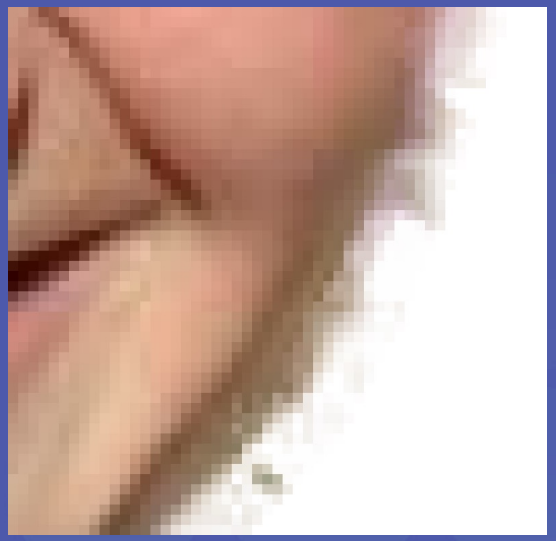
With no regularisation over alpha



Input



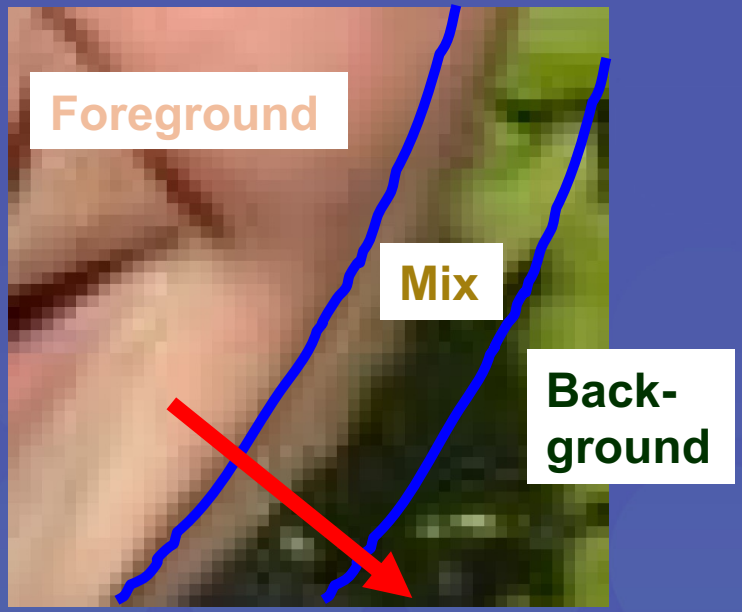
Bayes Matting
Chuang et. al. (2001)

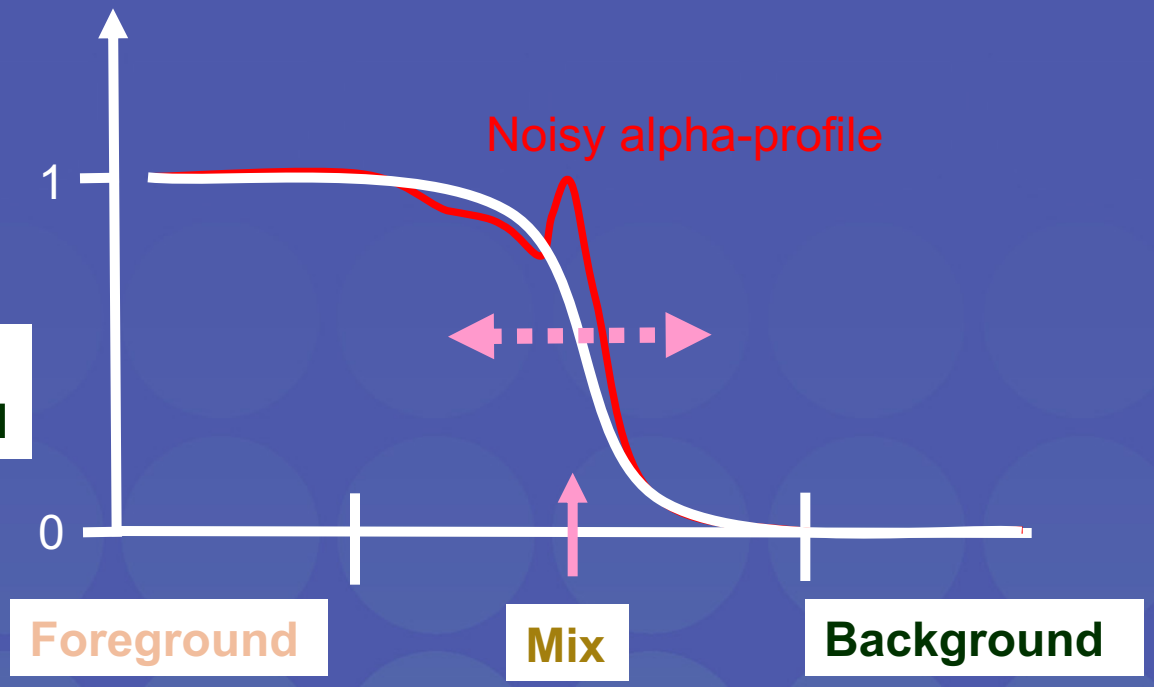


Knockout 2
Photoshop Plug-In

Shum et. al. (2004): Coherence matting in “Pop-up light fields”

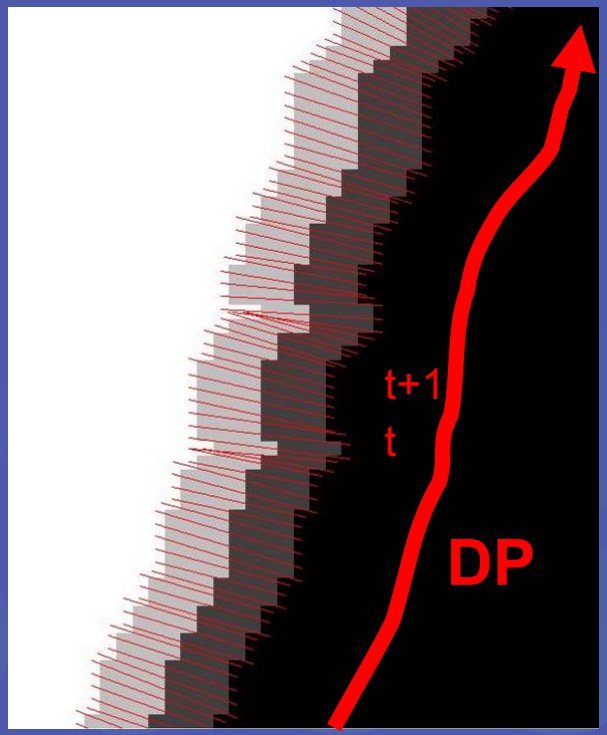
Border Matting

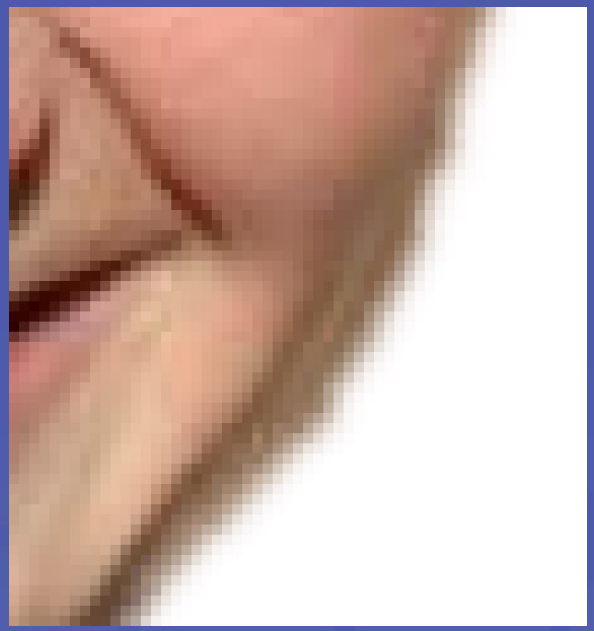




Fit a smooth alpha-profile with parameters

Dynamic Programming





Result using DP Border Matting

Noisy alpha-profile

Regularisation

Results