Microsoft Research Cambridge

SIGGRAPH2004

GrabCut

Interactive Foreground Extraction using Iterated Graph Cuts

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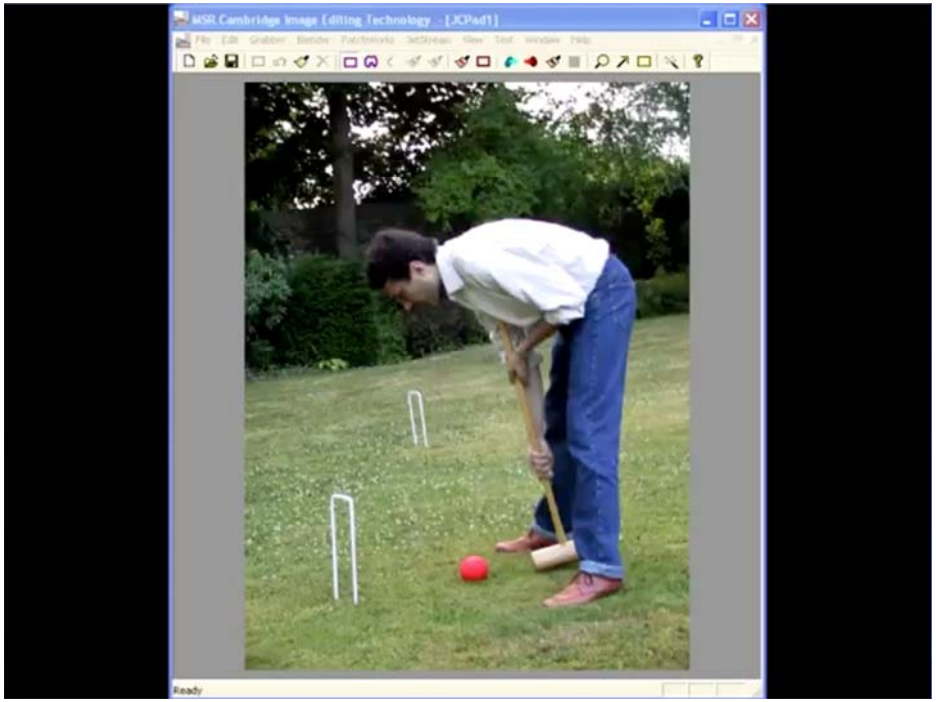
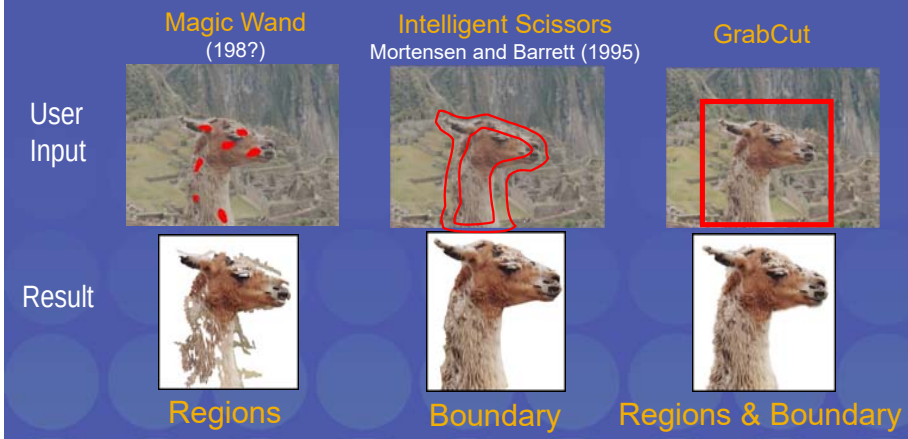
Photomontage



Problem

Fast &
Accurate ?

What GrabCut does

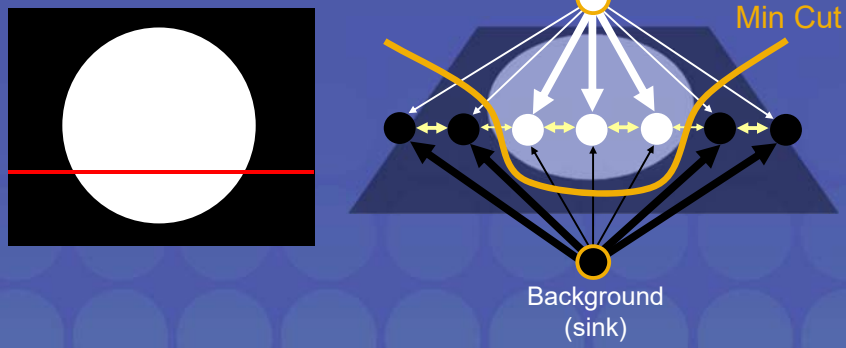


Framework

- **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

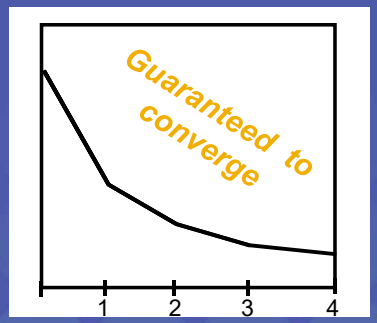
User Initialisation

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

K-means for learning colour distributions

Graph cuts to infer the segmentation

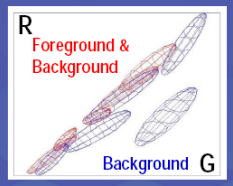
Iterated Graph Cuts



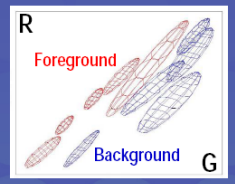
Result

Energy after each Iteration

Colour Model



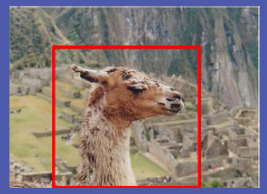
Iterated graph cut



Gaussian Mixture Model (typically 5-8 components)

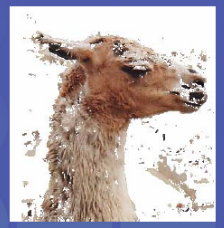
$$E_{Col}(\Theta, \mathbf{S}, \mathbf{x}) = \sum_{\mathbf{n}} \mathbf{D}(\mathbf{S_n}, \Theta, \mathbf{x_n})$$

Coherence Model



An object is a coherent set of pixels:

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



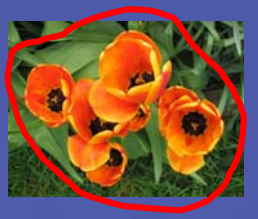
$\lambda = 0$

$\lambda = 50$

$\lambda = 1000$

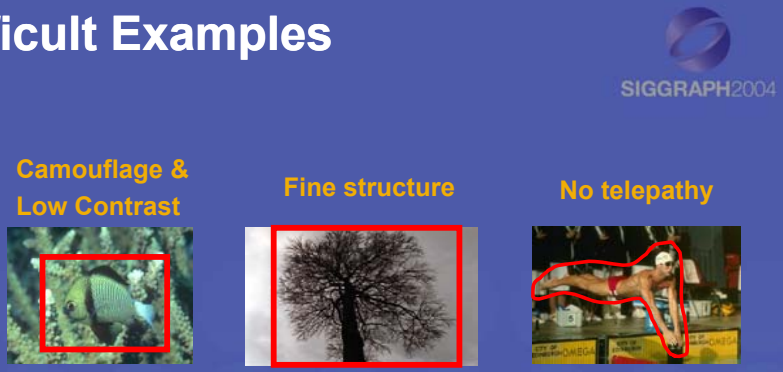
Blake et al. (2004): Learn Θ, λ jointly

Moderately straightforward examples

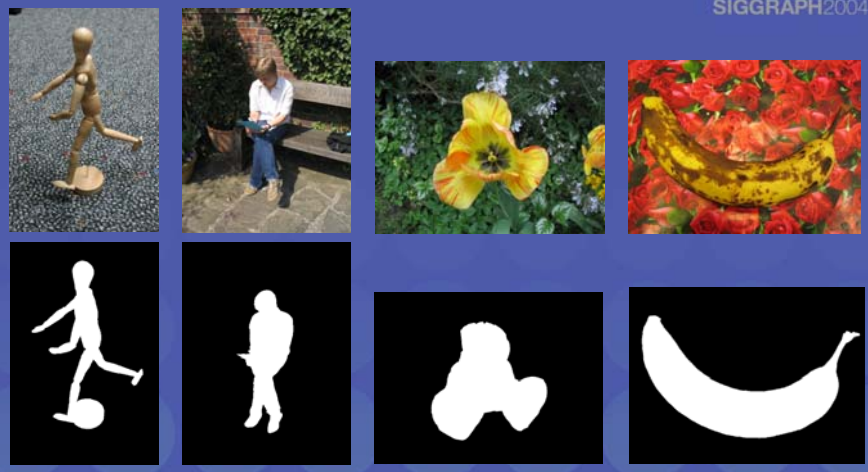


… GrabCut completes automatically

Difficult Examples

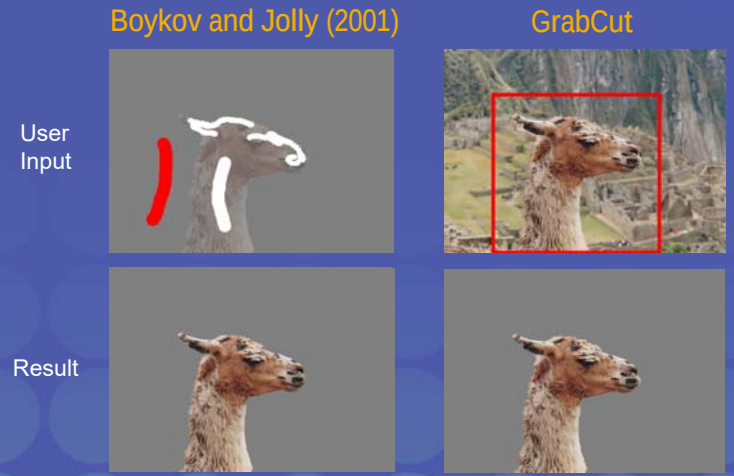


Evaluation – Labelled Database

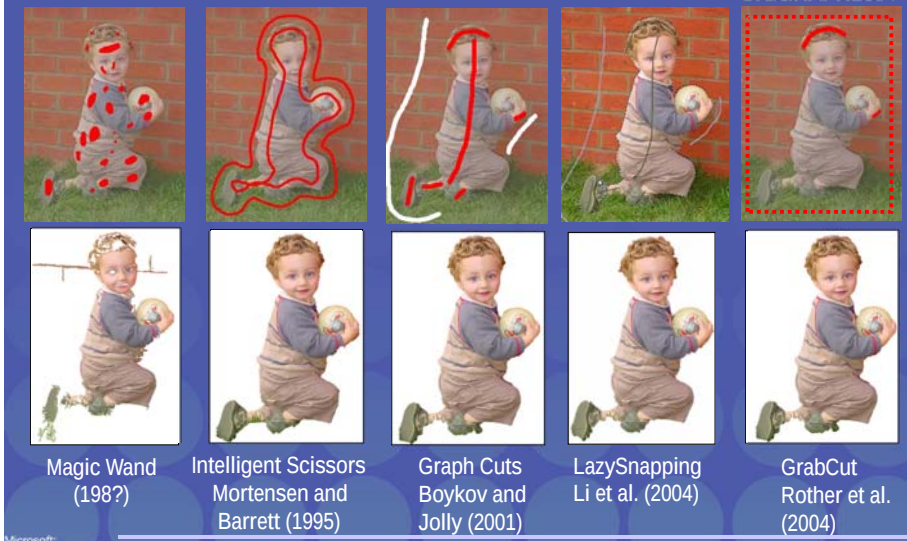


Available online: http://research.microsoft.com/vision/cambridge/segmentation/

Comparison



Summary



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%

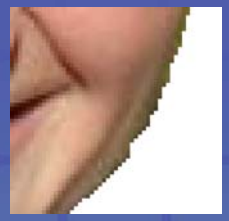
- Error rate - modestly increase
- User Interactions - considerable reduced

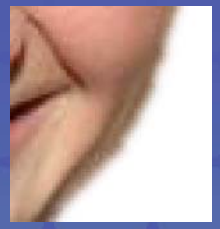
Comparison

	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



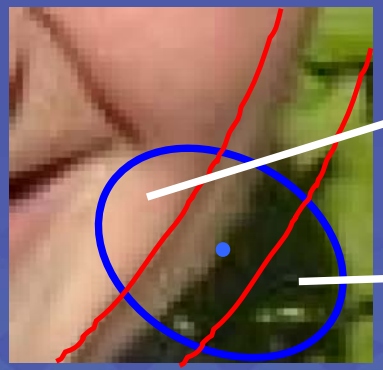


Hard Segmentation

Automatic Trimap

Soft Segmentation

Natural Image Matting



Mean Colour Foreground

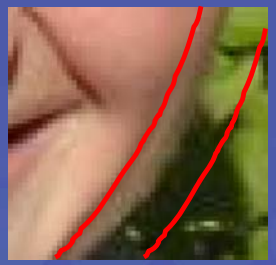
Mean Colour Background

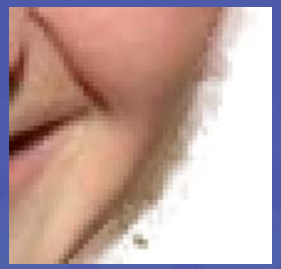
Solve

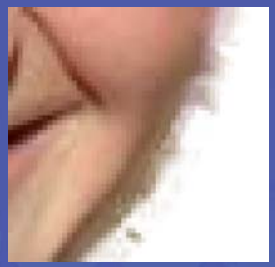
Ruzon and Tomasi (2000): Alpha estimation in natural images

Comparison

With no regularisation over alpha







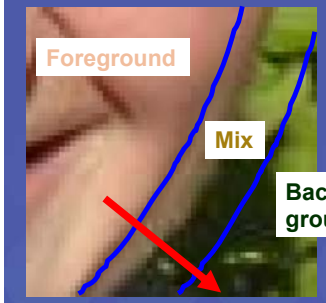
Input

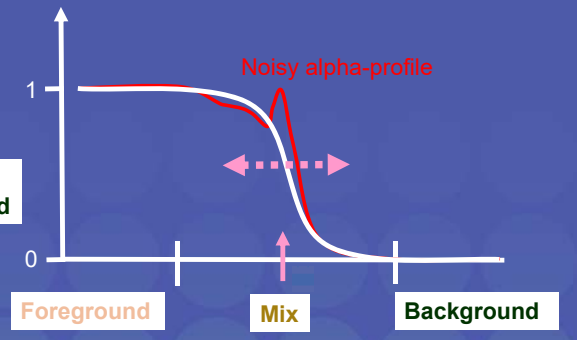
Bayes Matting
Chuang et. al. (2001)

Knockout 2
Photoshop Plug-In

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

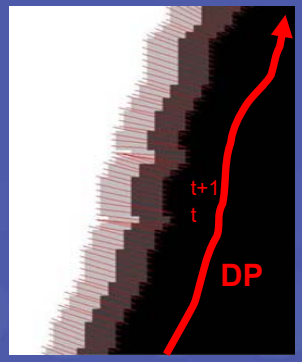
Border Matting

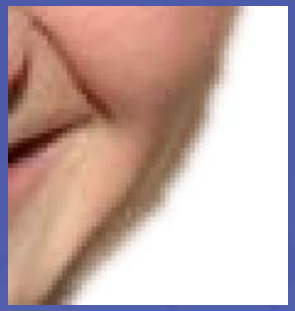




Fit a smooth alpha-profile with parameters

Dynamic Programming





Result using DP Border Matting

Noisy alpha-profile

Regularisation

Results