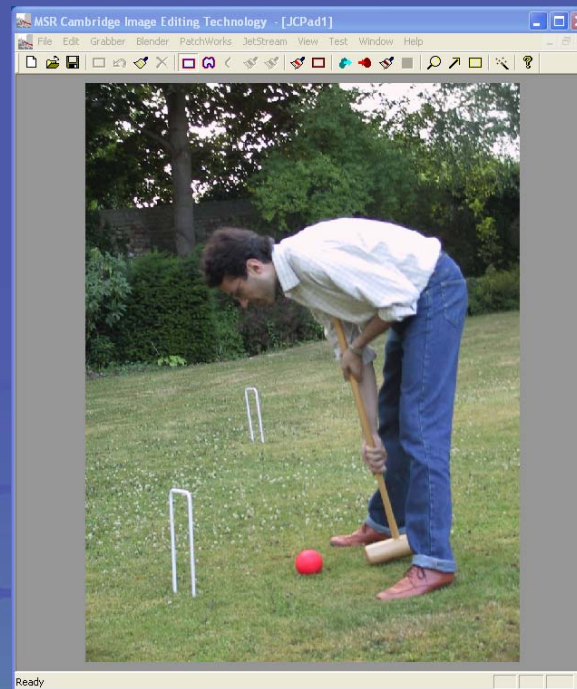


# GrabCut Interactive Foreground Extraction using Iterated Graph Cuts

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video

## Problem



Fast & Accurate ?



## What GrabCut does

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

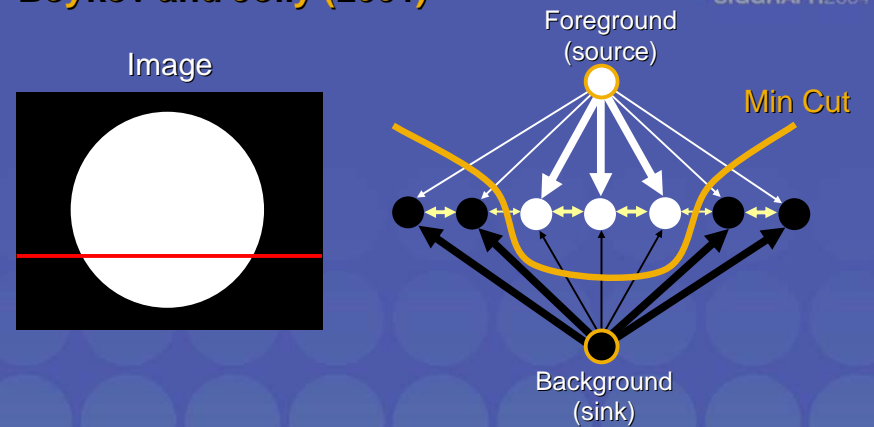
# Framework



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

# Graph Cuts

Boykov and Jolly (2001)



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

**Min Cut:** Global minimal energy in polynomial time

# Iterated Graph Cut



User Initialisation

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

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

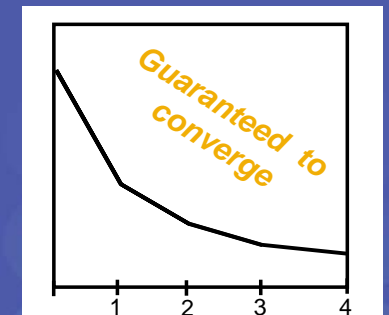
K-means for learning colour distributions

Graph cuts to infer the segmentation

# Iterated Graph Cuts



Result

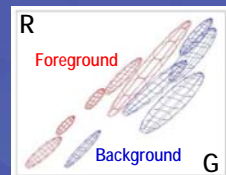
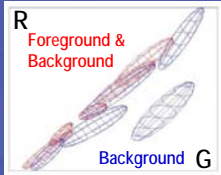


Energy after each Iteration

# Colour Model



Iterated graph cut



Gaussian Mixture Model (typically 5-8 components)

$$E_{Col}(\Theta, \mathbf{s}, \mathbf{x}) = \sum_{\mathbf{n}} D(\mathbf{s}_{\mathbf{n}}, \Theta, \mathbf{x}_{\mathbf{n}})$$

# Coherence Model

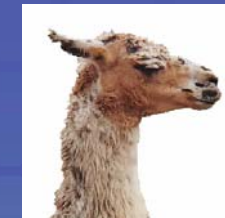


An object is a coherent set of pixels:

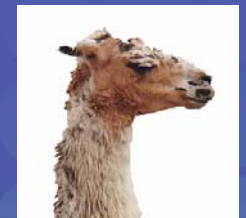
$$E_{coh}(\mathbf{S}, \mathbf{x}, \lambda) = \lambda \sum_{i,j \text{ adj.}} (S_i \neq S_j) \exp\left[-\frac{1}{2\sigma^2} \|\mathbf{x}_i - \mathbf{x}_j\|^2\right]$$



$\lambda = 0$



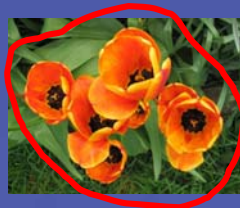
$\lambda = 50$



$\lambda = 1000$

Blake et al. (2004): Learn  $\Theta, \lambda$  jointly

# Moderately straightforward examples



... GrabCut completes automatically

# Difficult Examples

Camouflage & Low Contrast

Initial Rectangle



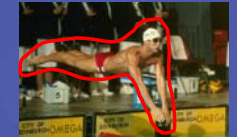
Initial Result



Fine structure

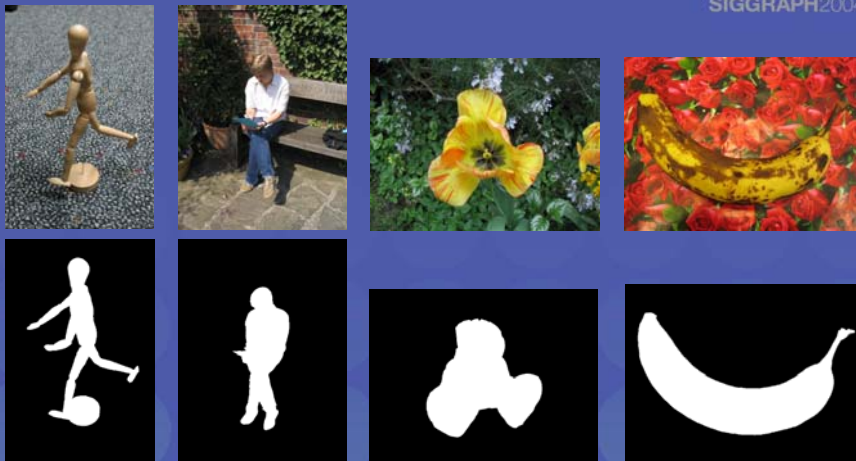


No telepathy





# Evaluation – Labelled Database



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



# Comparison



Boykov and Jolly (2001)

GrabCut

User Input



Result

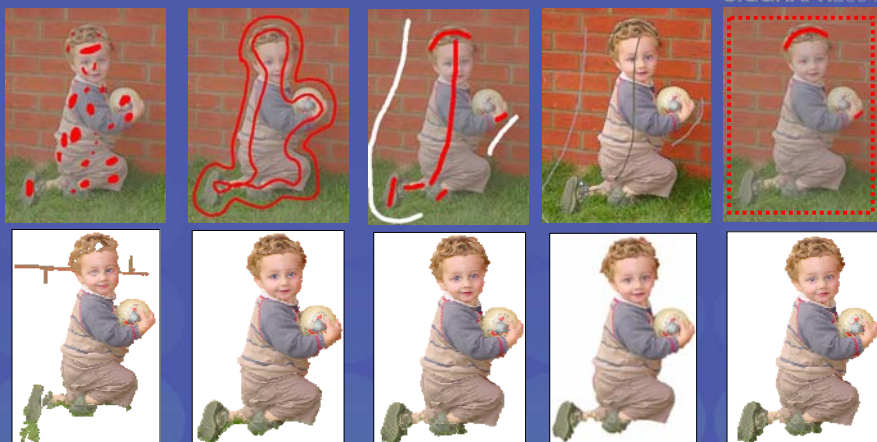


Error Rate: 0.72%

Error Rate: 0.72%



# Summary



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

