Matting and Compositing

Salvador Dali, Couple with Their Heads Full of Clouds

Many slides from
Kyros Kutulakos, Fredo Durand, Bill Freeman,
Robert Collins, Anat Levin

CSC320: Introduction to Visual Computing
Michael Guerzhoy

Compositing in Movies: Combining background and Foreground

Matting and Compositing in *King Kong (2005)*

Compositing for *Titanic* (1997)

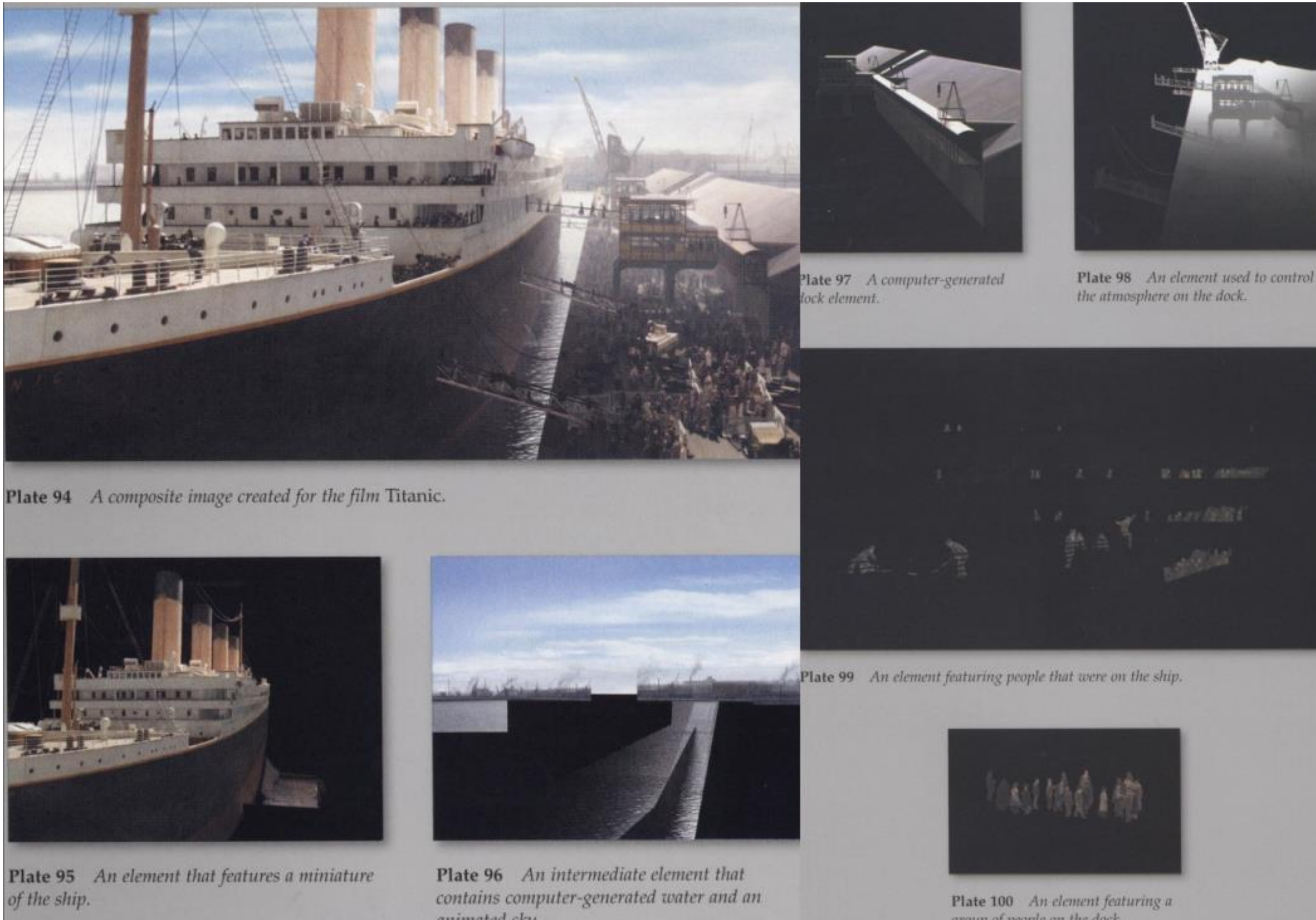


Plate 94 *A composite image created for the film* Titanic.

Plate 95 *An element that features a miniature of the ship.*

Plate 96 *An intermediate element that contains computer-generated water and an animated sky.*

Plate 97 *A computer-generated dock element.*

Plate 98 *An element used to control the atmosphere on the dock.*

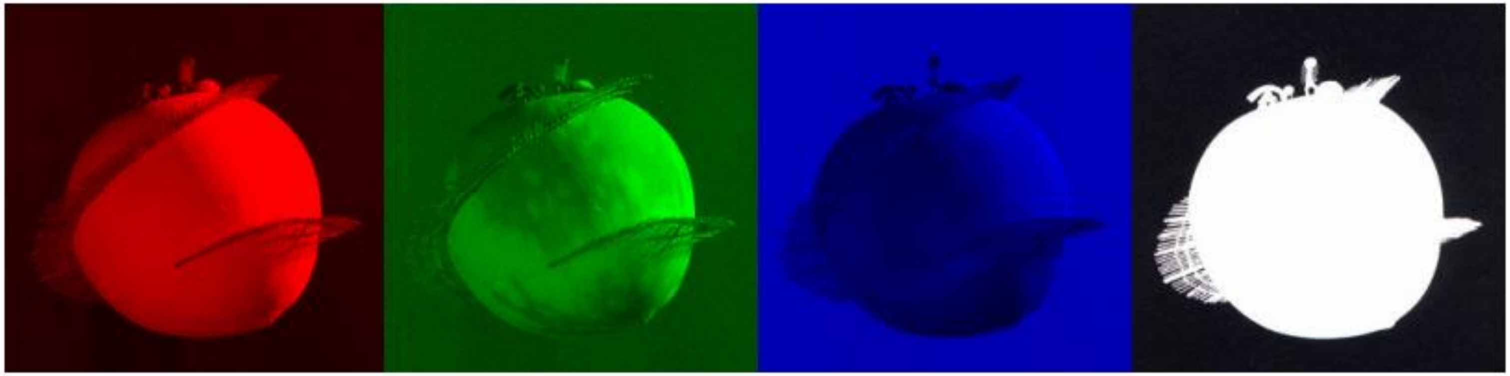
Plate 99 *An element featuring people that were on the ship.*

Plate 100 *An element featuring a group of people on the dock.*

2005)

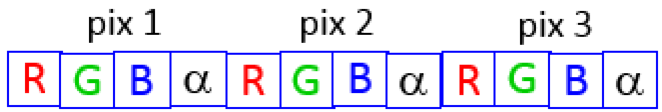
Key Idea: Adding an Alpha Channel

- α: 1 means opaque, 0 means transparent



The Alpha Pixel Component

Three rather than 4 components for each pixel:



- The fourth component is the <u>alpha</u> component
  - Value between 0 and 1
  - Defines pixel “transparency”

$$\begin{pmatrix} R \\ G \\ B \\ \alpha \end{pmatrix} := \begin{pmatrix} \alpha R \\ \alpha G \\ \alpha B \end{pmatrix}$$

Compositing: background replacement

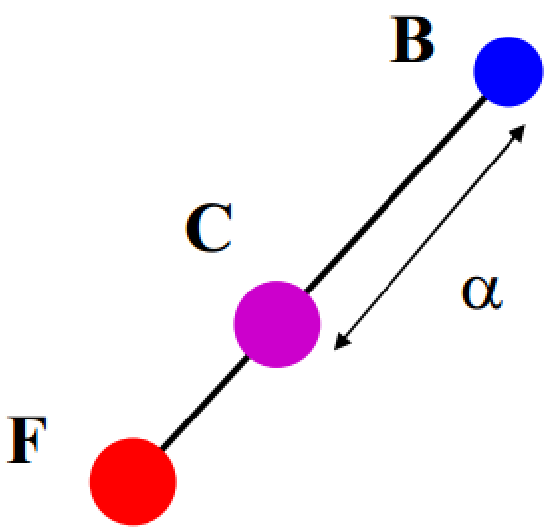
$C \qquad \alpha \qquad F \qquad 1-\alpha \qquad B$

Fundamental equation:

$$C=\alpha\, F+(1-\alpha)\, B$$

Compositing

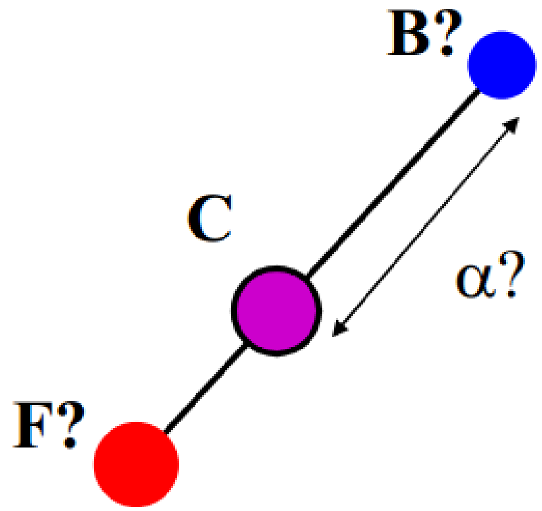
- ***The variables of interest:***
  Given the foreground color F=(Fr, Fg, Fb), the background color (Br, Bg, Bb) and α for each pixel
- **The compositing operation is: $C=\alpha F+(1-\alpha)B$**



Note: $0 <= \alpha <= 1$ interpolates a color C on the line between F and B

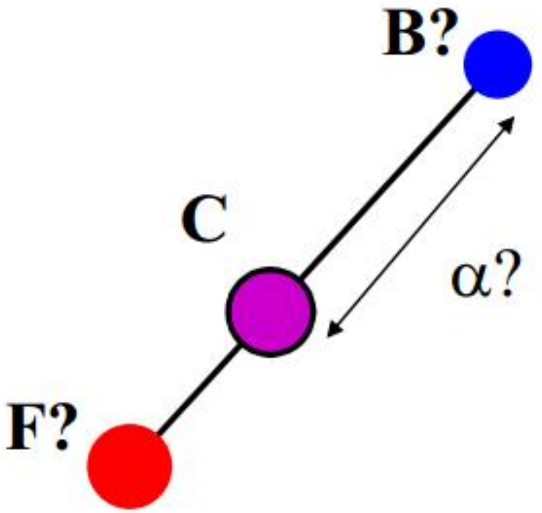
The Matting Problem

- **Inverse problem:**
  Assume an image is the α–composite of a foreground and a background
- **Given an image color C, find F, B and α so that $C = \alpha F + (1-\alpha)B$**



Why is Matting Hard?

- **C=α F+(1-α)B** *Note: this is for every pixel*
- **How many unknowns, how many equations?**



$$C_r = \alpha F_r + (1-\alpha) B_r$$
$$C_g = \alpha F_g + (1-\alpha) B_g$$
$$C_b = \alpha F_b + (1-\alpha) B_b$$

- **7 unknowns, 3 equations**
- **Bottom line: we need fewer unknowns (or more equations)**

Solution 1: Known Background

- If the pixel matches the background, α = 0. Otherwise, α=1
- Blue or green background colours typically used

Solution 1: Known Background

- Downsides:
  - Background colour must be known very accurately and must be constant
  - Foreground subject cannot have pixels similar to the background
  - No transparent objects/transitions between foreground and background (fractional alpha)

Solution 2: Blue Screen Matting

- Idea: assume there is no blue in the foreground, and only blue in the background
  - Note: because lighting could vary, it's not the case that the background is always (0,0,1) (could be (0,0,0.5))
- Developed by Petro Vlahos (Technical Academy Award 1995) (among others)

Digital Blue Screen Matting

- Assume no blue in foreground, only blue in background:
  - $F_b = 0, B_r = B_g = 0$

$$
\begin{aligned}
C_r &= \alpha F_r + (1-\alpha) B_r \\
C_g &= \alpha F_g + (1-\alpha) B_g \\
C_b &= \alpha F_b + (1-\alpha) B_b
\end{aligned}
$$

- Equations simplify to

$$
\begin{aligned}
C_r &= \alpha F_r \\
C_g &= \alpha F_g \\
C_b &= (1-\alpha) B_b
\end{aligned}
$$

- 3 equations with 3 unknowns => can figure out α for every pixel

Blue Screen Matting

- Downsides:
  - The assumption of no blue in foreground is very restrictive
    - People with blue eyes have the background as their eyes
    - No white, gray, pastel colours allowed either
  - Blue/Green Spilling: light reflected off the background hits the foreground, making it be blue/green

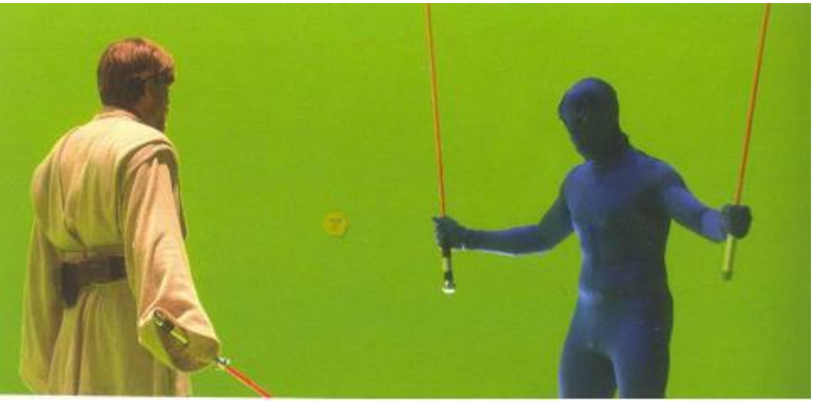
Blue spilling (note the fringes)

Plate 52 *(b) The element placed into the scene without spill suppression. Note the blue fringes on the subject, particularly in the hair.*

Blue spilling (note blue reflected on wings)

Figure 3. *Firefox Blue Spill Matte Series 1, original shot. Note blue reflected on wing surfaces from bluescreen -- undesirable but unavoidable on such surfaces.*

Bluescreen in Star Wars (2005)



Solution 3: Assume Gray or Skin-Coloured Foreground

- **Generalize a little**
  If we assume object is grey:

$$F_r = F_g = F_b = F \ , \ B_r = B_g = 0$$

- **Equations simplify to**

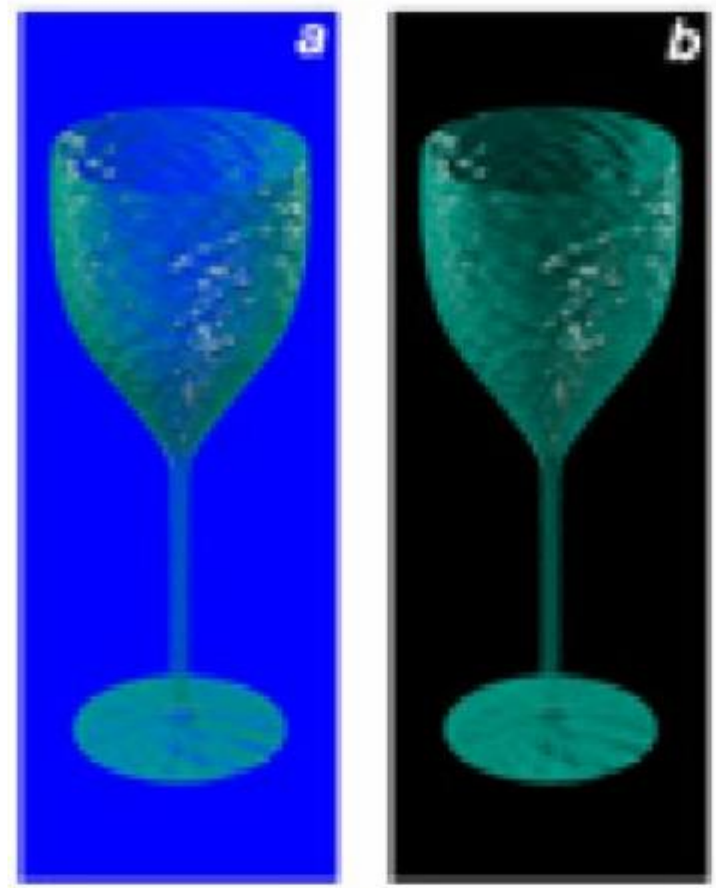
$$\begin{aligned} C_r &= \alpha F \\ C_g &= \alpha F \\ C_b &= \alpha F + (1 - \alpha) B_b \end{aligned}$$

- **Similar simplification if skin color:**
  F ~ (k , k/2 , k/2)

Triangulation Matting: Adding More Equations

$$C_r = \alpha F_r + (1-\alpha) B_r$$
$$C_g = \alpha F_g + (1-\alpha) B_g$$
$$C_b = \alpha F_b + (1-\alpha) B_b$$

- Take a picture of the foreground in front of two different background
  - The foreground colour and the alpha are the same
  - Only the background is different



Triangulation Matting: Adding More Equations

$$
\begin{aligned}
C_{r1} &= \alpha F_r + (1-\alpha) B_{r1} \\
C_{g1} &= \alpha F_g + (1-\alpha) B_{g2} \\
C_{b1} &= \alpha F_b + (1-\alpha) B_{b2} \\
C_{r2} &= \alpha F_r + (1-\alpha) B_{r2} \\
C_{g2} &= \alpha F_g + (1-\alpha) B_{g2} \\
C_{b2} &= \alpha F_b + (1-\alpha) B_{b2}
\end{aligned}
$$

6 equations in 4 unknowns

Triangulation Matting Examples