Matting

Computational Photography (CSCI 3240U)

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Acknowledgements

- Content adapted from the excellent slides by Alexei Efros

Summary

- Image matting
- Blue screen matting
- Semi transparent objects
- Environment matting
- An example of a most recent method for image matting

Superman (1978) - IMDb

The problem of image matting

- Definition
  - The separation of an image C into
    - A foreground object C_o
    - A background image C_k
    - And an alpha matt α
  - C_o and α can subsequently be used to composite the foreground object into a different image

The problem of image matting (also called chroma key compositing)

- Definition
  - The separation of an image C into
    - A foreground object C_o
    - A background image C_k
    - And an alpha matt α
  - C_o and α can subsequently be used to composite the foreground object into a different image
- Hard problem
  - Even if α is binary, this is hard to do automatically (this is often referred to as the image segmentation problem)
  - Given that we need to do that for each pixel, doing it manually is often infeasible
  - We need to make some simplifying assumptions to solve this problem

Blue screen matting

- Petros Vlahos invented blue screen matting in the 50s.
  - His Ultimatte® is still the most popular equipment.
  - He won an Oscar for lifetime achievement.
- Most common form of matting in TV studios and movies

Blue screen matting

- A form of background subtraction
- Assumes a known background
  - Blue screen
  - Uniform color
- Compute α as $\mathrm{SSD}(C, C_b) > \tau$, where τ is some pre-defined threshold
  - Another option is to use Vlahos' formula: $\alpha = 1 - p_1(B - p_2 G)$
- Hope that the foreground object does not look like background
  - No blue ties, shirts, etc.

Blue screen - green screen

- Why Blue screen?
  - Historically, cameras were more sensitive to blue light
  - Blue color is less likely to be found in human skin
  - Blue light creates less spills compared to, say, red light
    - Spills are easier to fix post production
- Digital cameras are more sensitive to Green color, so now often Green screen is used

Semi-transparent mattes

- An α-matte must include semi-transparency
- The α values between 0 and 1

The matting equation

$$C = \alpha_0 C_o + (1 - \alpha_0) C_k$$

We can re-write it in terms of the RGB components

$$R = \alpha_0 R_o + (1 - \alpha_0) R_k$$
$$G = \alpha_0 G_o + (1 - \alpha_0) G_k$$
$$B = \alpha_0 B_o + (1 - \alpha_0) B_k$$

Solving the matting equation

$$R = \alpha_0 R_o + (1 - \alpha_0) R_k$$
$$G = \alpha_0 G_o + (1 - \alpha_0) G_k$$
$$B = \alpha_0 B_o + (1 - \alpha_0) B_k$$

Solution #1: No Blue

Since foreground contains no blue, $B_0 = 0$. This leaves us with 3 equations and 3 unknowns.

$$R = \alpha_0 R_o + (1 - \alpha_0) R_k \quad \longleftarrow \quad \text{3. Solve for } R_0$$
$$G = \alpha_0 G_o + (1 - \alpha_0) G_k \quad \longleftarrow \quad \text{2. Solve for } G_0$$
$$B = (1 - \alpha_0) B_k \quad \longleftarrow \quad \text{1. Solve for } \alpha_0$$

Solving the matting equation

$$R = \alpha_0 R_o + (1 - \alpha_0) R_k$$
$$G = \alpha_0 G_o + (1 - \alpha_0) G_k$$
$$B = \alpha_0 B_o + (1 - \alpha_0) B_k$$

Solution #2: Gray or Flesh

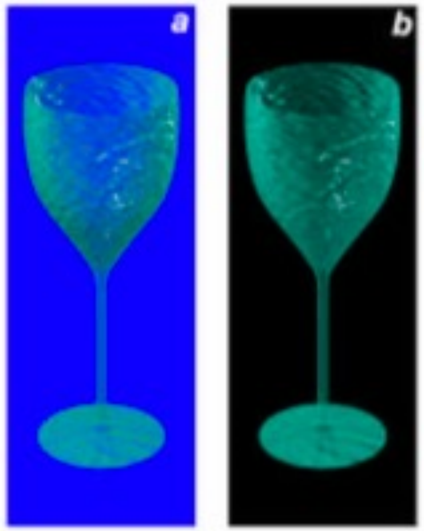
If we know that the foreground contains gray, that means $R_0 = G_0 = B_0$. This leaves us with 3 equations and 2 unknowns.

Solving the matting equation

$$R = \alpha_0 R_o + (1 - \alpha_0) R_k$$
$$G = \alpha_0 G_o + (1 - \alpha_0) G_k$$
$$B = \alpha_0 B_o + (1 - \alpha_0) B_k$$

Solution #3: Triangulation Matting (Smith and Blinn)

Increase the number of equations, instead of reducing the number of equations. One way to achieve is to photography the object against two different backgrounds.



We get 6 equations (3 per backgound) with 4 unknowns.

Pixels are processed independently, so the backgrounds don't need to be a constant backing color

Examples of Triangulation Matting (SIGGRAPH 96)

Source images

Problems with matting

- Images do not look realistic
- Lack of *refracted* light
- Lack of *reflected* light

Environment matting equation

$$C = \alpha_0 C_o + (1 - \alpha_0) C_k + \Phi$$

Contribution of light from the environment that travels through the object

α-matte | Environment matte | Photograph

Deep Image Matting (CVPR 2017)

Huang et al.

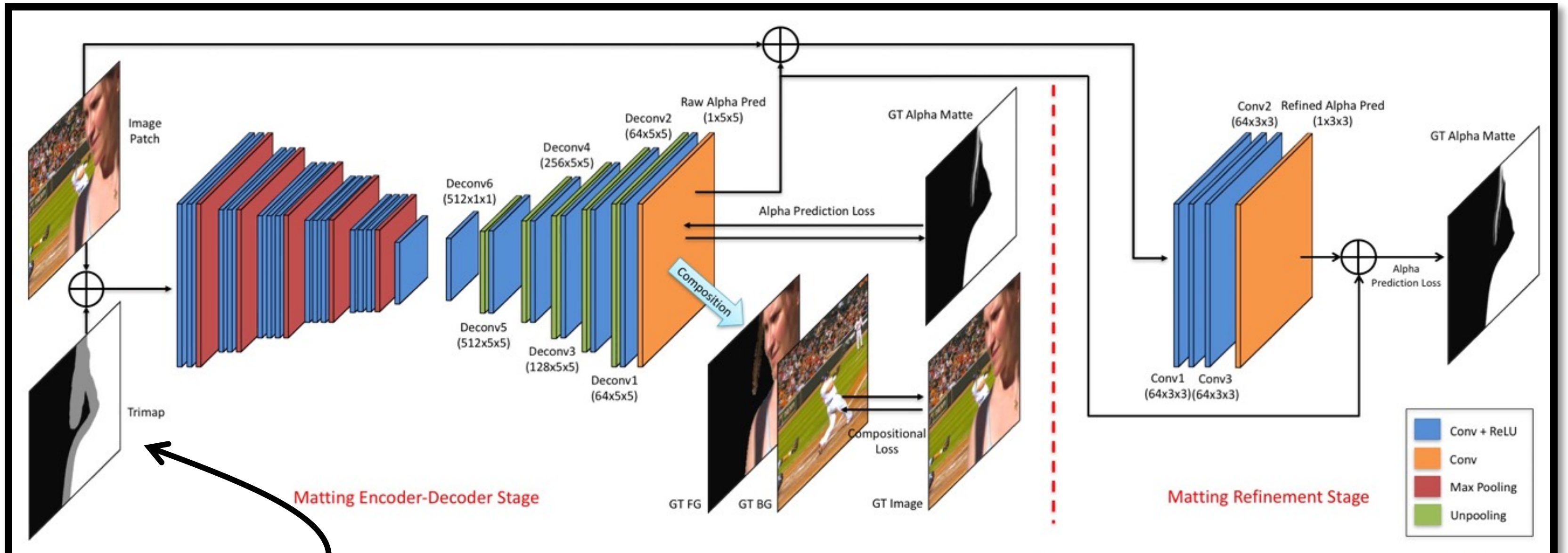


Figure 3. Our network consists of two stages, an encoder-decoder stage (Sec. 4.1) and a refinement stage (Sec. 4.2)

Requires an extra input: the trimap

Trimap
An image where each pixel can have one of three values: *foreground* (white), *background* (black), or *unknown* (gray)

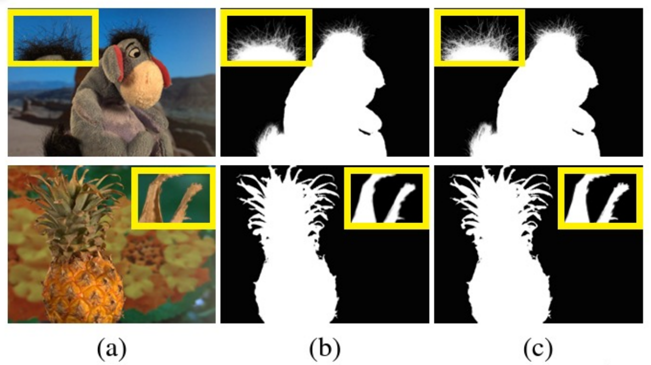


Figure 4. The effect of our matting refinement network. (a) The input images. (b) The results of our matting encoder-decoder stage. (c) The results of our matting refinement stage.

ModNet (2020)

Lau et al.

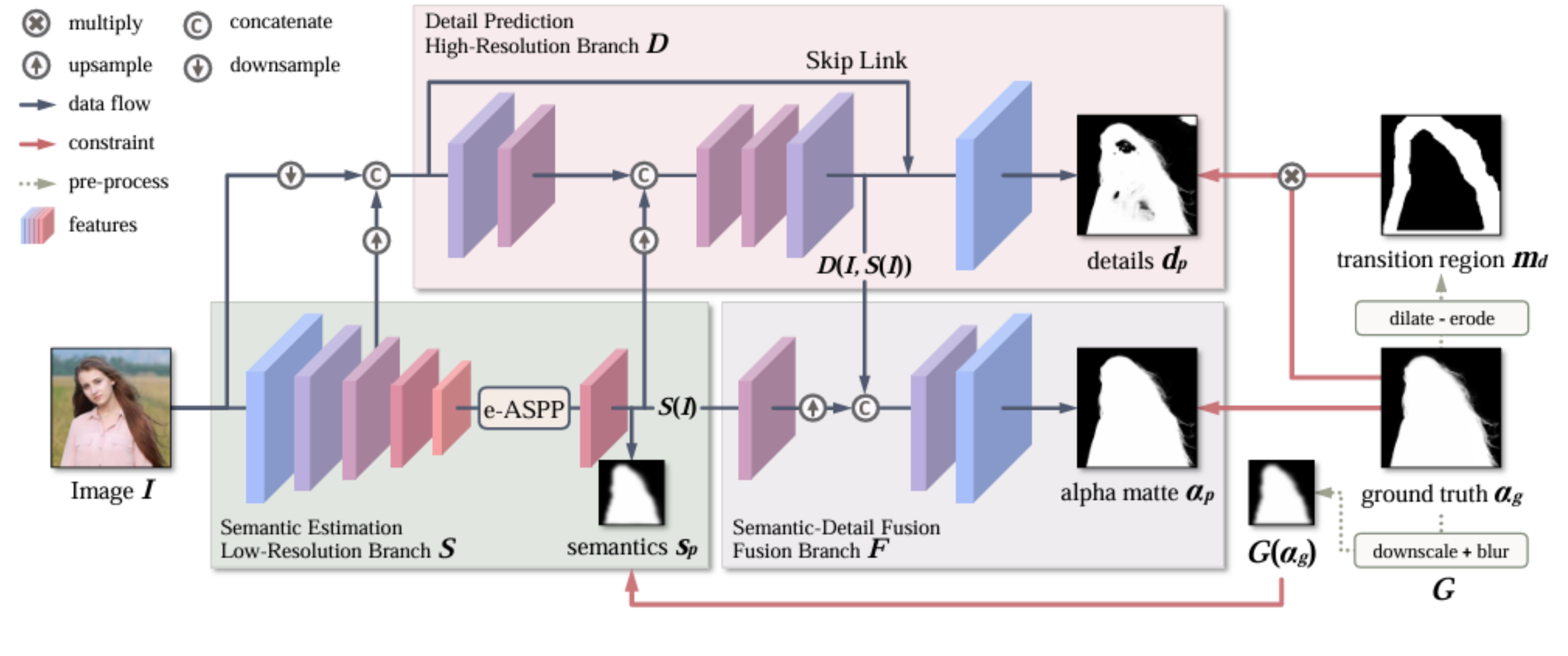
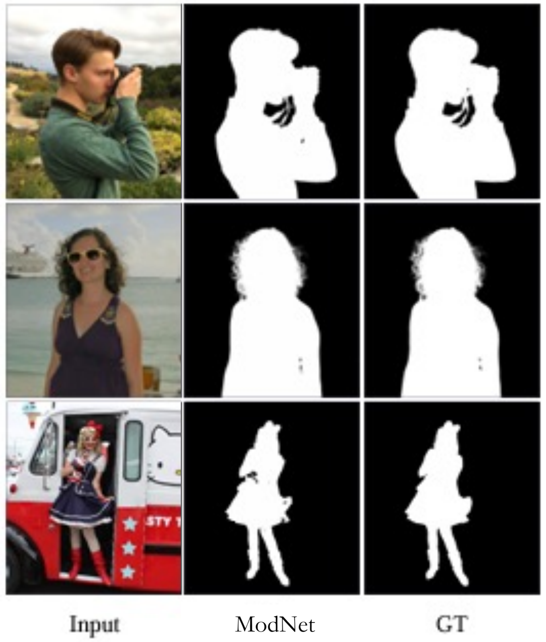


Figure 2: **Architecture of MODNet.** Given an input image I, MODNet predicts portrait semantics s_p, boundary details d_p, and final alpha matte α_p through three interdependent branches, S, D, and F, which are constrained by explicit supervisions generated from the ground truth matte α_g. Since the decomposed sub-objectives are correlated and help strengthen each other, we can optimize MODNet end-to-end.

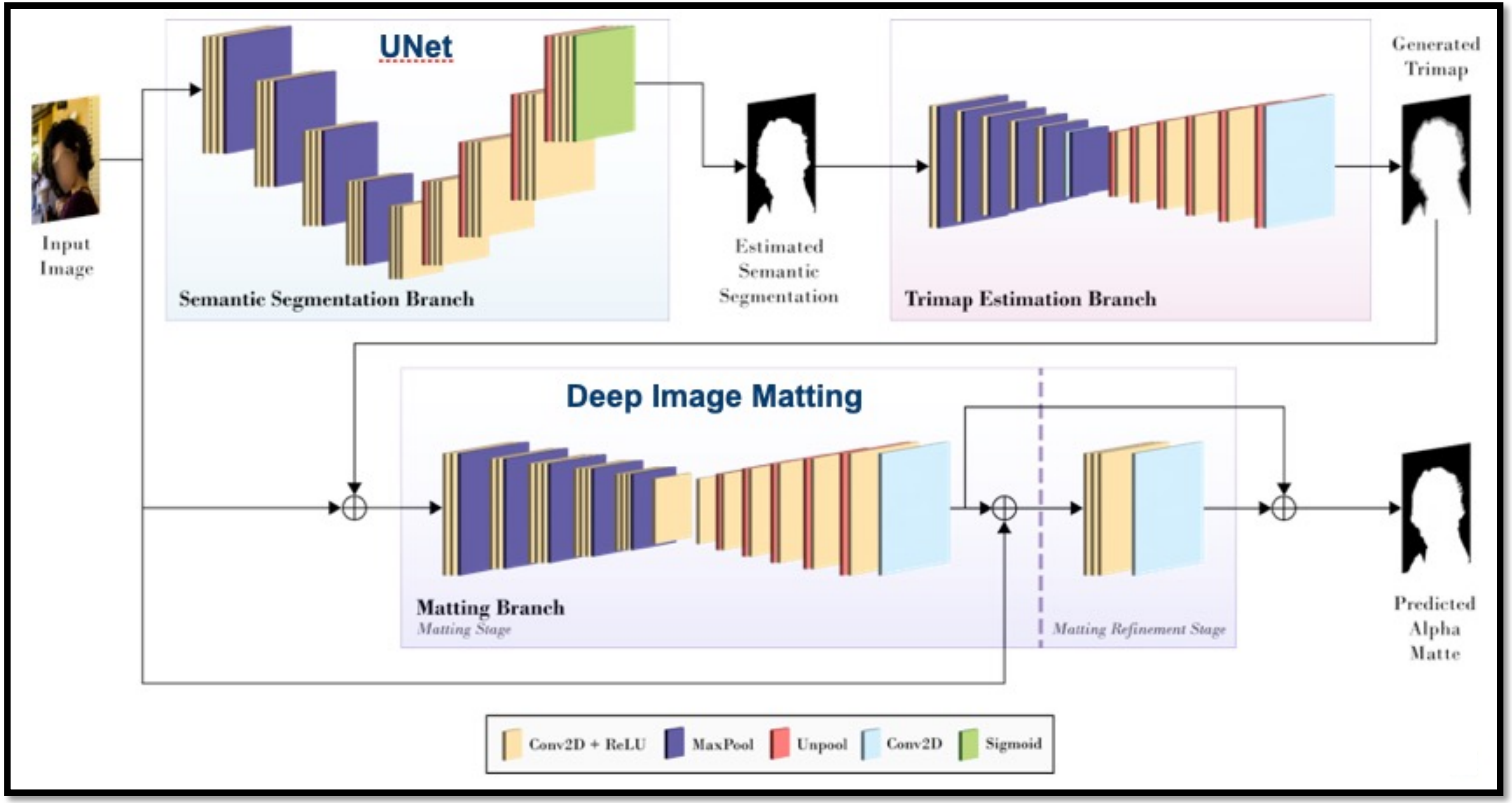
Trimap free

Real-time



A modular approach to image matting (2022)

Talpur



User Interaction

Summary

- Image matting
- The matting equation
- Semi-transparent objects
  - No blue assumption
  - Gray or Flesh assumption
  - Triangulation matting
- Environment matting
- An example of a more recent approach to the problem of image matting
- Check out recent work on image matting at https://paperswithcode.com/task/image-matting