Lecture Notes #2 - Image Morphing

Reading:

- Beier & Neely, Feature-Based Image Metamorphosis, SIGGRAPH '92.

Optional:

- A. Lerios, C. Garfinkle, M. Levoy. Feature-based Volume Metamorphosis. SIGGRAPH '95.

Outline of lecture

- Cross-dissolving
- Morphing
  - Warping with one line pair
  - Warping with multiple line pairs
  - Interpolating lines

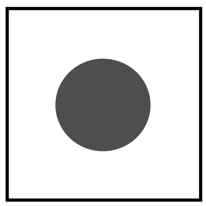
Image Morphing

Simplest type of metamorphosis is "cross-dissolve".

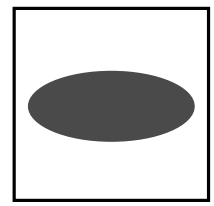
Each pixel p at time t in [0,1] is computed through linear interpolation.

$$\mathbf{p = (1-t)\ p(start) + t\ p(end)}$$

where p(start) and p(end) are the starting and ending pixel values.
Not very effective



Starting image



Ending image

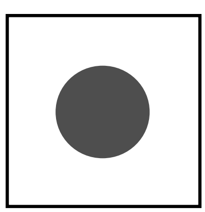
Morphing

"Morphing" involves a combination of

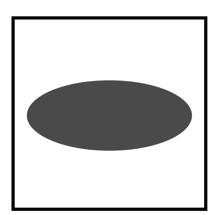
1. Image warping

2. Cross - dissolving

The middle image is key: if it looks good, the whole sequence will.



Starting image



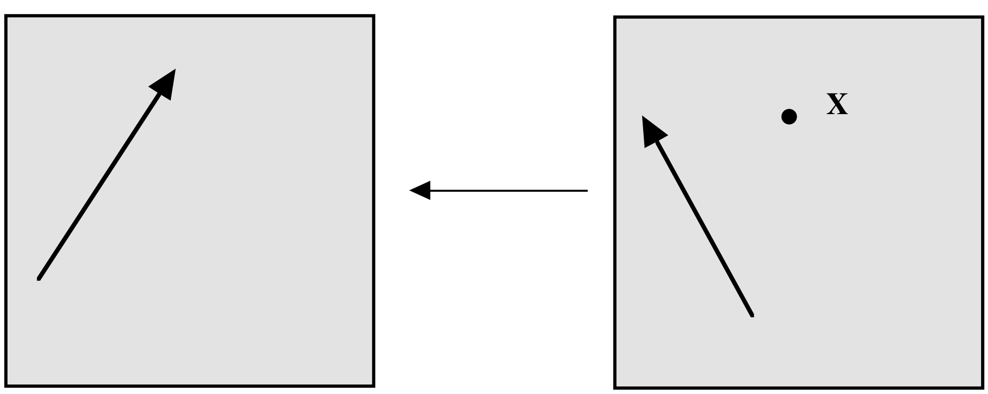
Ending image

Image Warping

- The image warping step is the difficult one:
- There are two basic styles:
  - Forward warping: pixels from the source image are warped into the destination image.
  - Reverse mapping: the opposite.
- Q: which style should we choose?

Warping by one Line-Pair

Beier and Neely use a pair of lines to specify the warp:

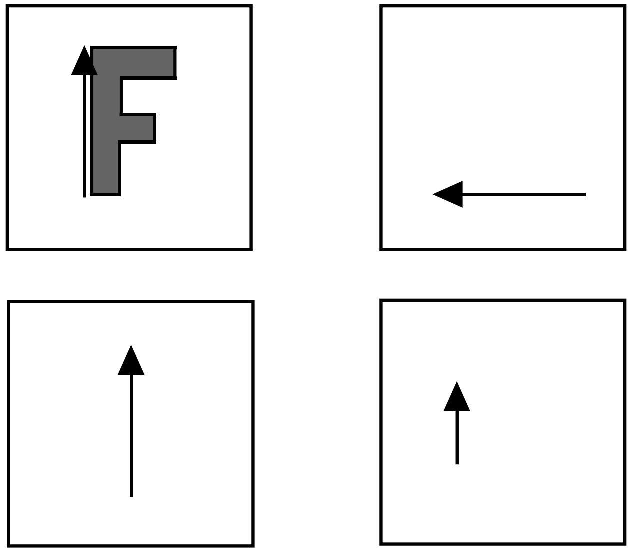


Source image **Destination image**

- u is a fraction
- v is measured in pixels

Warping with one line pair, cont.

• What happens when we warp with one line pair?

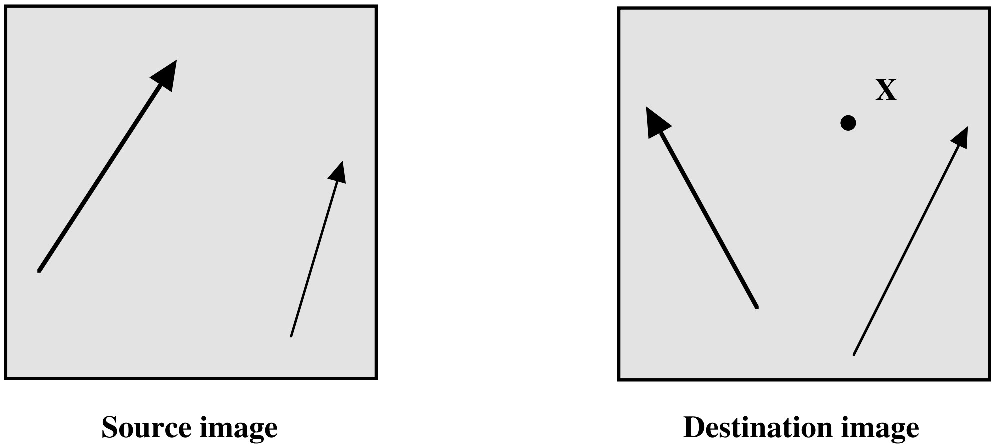


Non-linear Warping

For multiple line pairs, Beier and Neely use a weighted combination of points defined by some mapping.

Figure 4 Multiple line pair example

Warping by Multiple Line-Pairs



Warping Pseudo-code

```
WarpImage(SourceImage,  L'[...], L[...])
begin
    foreach destination pixel X do
        XSum = (0,0)
        WeightSum = 0
        foreach line L[i] in destination do
            X'[i]= X transformed by (L[i],L'[i])
            weight[i] = weight assigned to X'[i]
            XSum = Xsum + X'[i] * weight[i]
            WeightSum += weight[i]
        end
        X' = XSum/WeightSum
        DestinationImage(X) = SourceImage(X')
    end
    return Destination
end
```

Morphing Pseudo-code

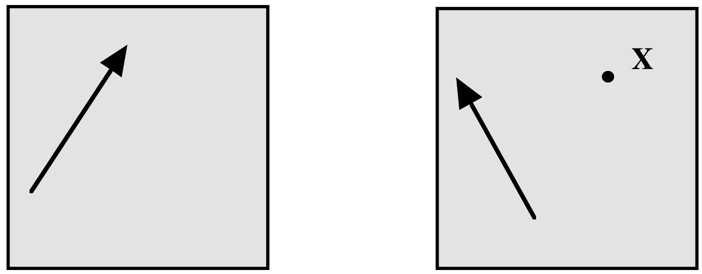
Here's how you create an animated morph:

GenerateAnimation(Image$_0$, L$_0$[...],Image$_1$, L$_1$[...])
begin
    foreach intermediate frame time t **do**
        for i=1 to number of line-pairs **do**
            L[i] = line t-th of the way from L$_0$[i] to L$_1$[i].
        end
        Warp$_0$ = WarpImage(Image$_0$, L$_0$[...], L[...])
        Warp$_1$ = WarpImage(Image$_1$, L$_1$[...], L[...])
        foreach pixel p in FinalImage **do**
            FinalImage(p) = (1-t) Warp$_0$(p) + t Warp$_1$(p)
        end
    end
end

Remaining Issues

- There are still a few unresolved details:
  - Exactly how to compute X' from X and a single line pair L, L'.
  - Exactly how to weight each X'.
  - Exactly how to interpolate between lines.

Computing X' from X and a line pair



Source image

Destination image

We need formulas for u and v:

Weighting each X'

To weight the contribution of each line, Beier and Neeley use

$$weight = \left(\frac{length^{\,p}}{a + dist} \right)^{b}$$

where:

- *length* is the length of L[i]
- *dist* is the distance from X to L[i]
- *a,b,p* are constants that control the warp (see paper)

Interpolating Lines

- Method 1: interpolating endpoints

- Method 2: interpolating midpoints, length and orientation.