**Image Morphing**

**Outline**
- Image transition
- Cross-dissolving
- Image morphing
  - Mesh-based morphing
  - Feature-based morphing

**What is Image Morphing**
- **Objective:**
  - Generate fluid transition between two images
- **Application:**
  - Special effects

**Image Transition**
- A sequence of images are needed to show the transition between the two images
- Parameter $t$ controls position of the transition
  - $t=0$: source image
  - $t=1$: target image
  - $0<t<1$: intermediate images to be generated

**Cross-Dissolving**
- Blend two images using alpha compositing:
  - Set alpha for bottom (source) image to 1
  - Alpha for top (target) image varies from 0 to 1
- Software implementation:
  - $result(u,v) = (1-t) * source(u,v) + t * target(u,v)$

**Cross-Dissolving Results**
**Image Morphing**

- Combine image warping & cross-dissolving
- Use warping to change the shape
- Use image composition to change color
- Problems involved:
  - How to generate intermediate images through warping?

**Mesh-based Morphing**

- Proposed by G. Wolberg in 1990
- Basic idea:
  - Break the images into a grid of quadrilaterals.
  - Deform the quadrilaterals to match the source and the target.
- Steps:
  - User specify a set of corresponding points.
  - The algorithm generate a grid mesh.
  - Each pixel is warped using the 3 closest grid points.

**Corresponding Grid Points**

**Algorithm Evaluation**

**Pros:**
- Fast and intuitive
- Efficient algorithms exist for computing the mapping of each pixel from the control grid

**Cons:**
- Need to specify the number control points to use in advance.
- Points left unmodified are still used by the warping algorithm.
- Moving mesh points around may not always provide the desired effect

**Feature-Based Morphing**

- Proposed by Beier & Neeley in Siggraph 1992
- Use in Jackson’s MTV “Black & White”
- Basic steps:
  - Use line segments to define features in both source & target images
  - Interpolate line segments for the intermediate frames
  - Warp both source & target images to the intermediate frame
  - Blend between the warped results

**Define Control Lines**

- Draw control line segments along the key features of the source and target images
- Corresponding features should be show using corresponding control lines
Interpolate Control Lines
- For a given intermediate frame $t$:
  - Calculate the position of control line segments in frame $t$.
  - Can be done by linearly interpolating between the positions of corresponding line segments in source & target images.

Warp from Source
- Warp source image to intermediate frame:
  - Apply backward warping.
  - Use control lines defined in both intermediate frame & the source image.
  - The result distorts the source image to the shape defined by the control lines in the intermediate frame.

Warp from Target
- Warp target image to intermediate frame:
  - Use the same technique.
  - The result distort the target image to the shape defined by the control lines in the intermediate frame.
  - Key features line up with the warping results obtained from the source image.

Blend between the Two
- Blend the two warped images using the over operator:
  - i.e., apply cross-dissolving on the warped images.
  - The alpha value used depends on the parameter $t$.

Blend between the Two

Pseudocode for Morphing
```plaintext
for each intermediate frame $t$ {
    for each pair of control line segment $i$ {
        $L_{inter}[i] = (1-t)*L_{src}[i] + t*L_{tgt}[i]$;
    }
    for each pixel $P$ in intermediate image $t$ {
        $P_{src} = \text{warping}(L_{inter}, L_{src}, P)$;
        $P_{tgt} = \text{warping}(L_{inter}, L_{tgt}, P)$;
        $\text{inter}_img[t][P] = (1-t)\ast\text{src}_img(P_{src}) + t\ast\text{tgt}_img(P_{tgt})$;
    }
}
```