Image Warping and Morphing

Review: Signal Processing

- **Fourier transform**
- **Filtering and the convolution theorem**
- **Sampling and reconstruction**
- **Nyquist frequency**
- **Aliasing and antialiasing**

Warping transformation: zoom in, zoom out, rotate, warp

Resampling

Magnification v. minification

Morphing

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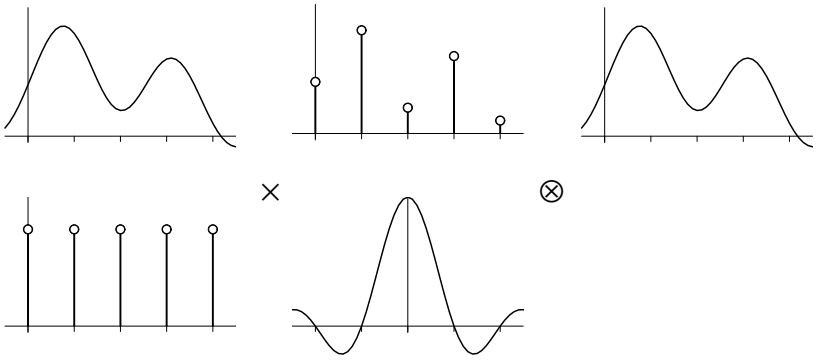
Sampling and Reconstruction: Space



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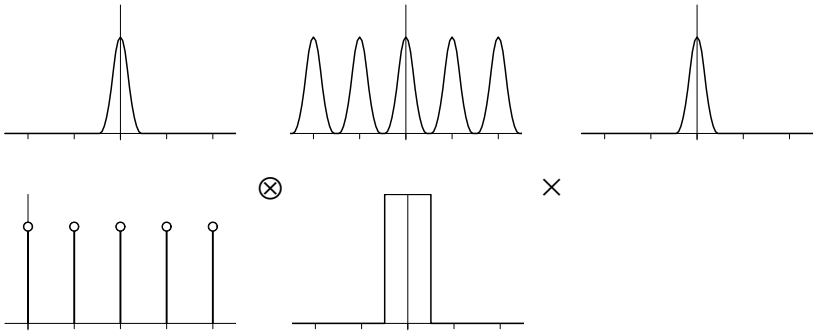
Sampling and Reconstruction: Freq



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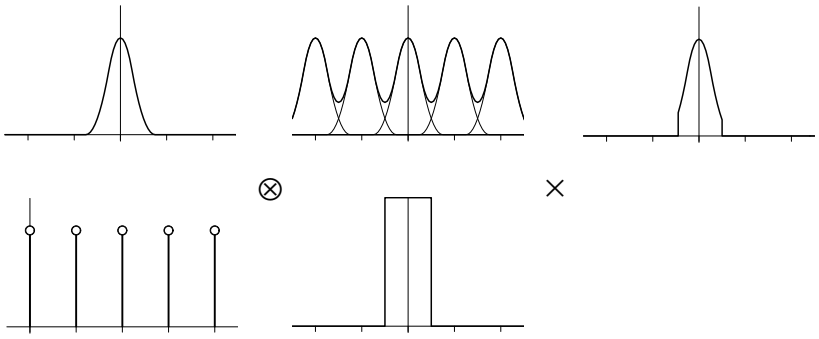
Undersampling: Aliasing



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Antialiasing by Prefiltering

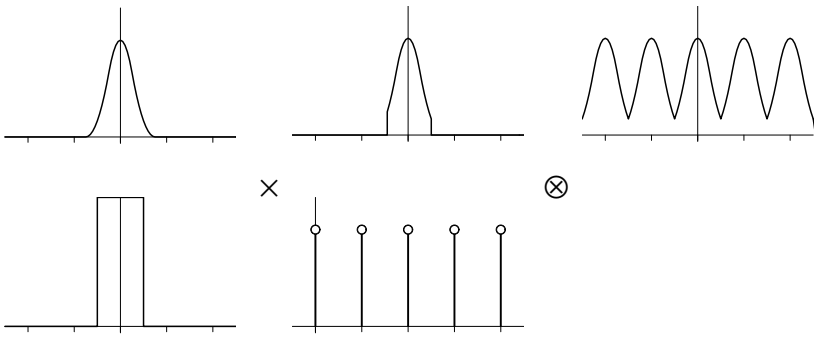

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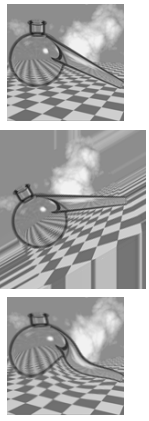
Image Warping and Morphing

- **Image warping**
  - **Transform an image:**
    - **Zoom up, down**
    - **Rotate, shear**
    - **Warp: control mesh**
    - **Later in the course: texture mapping**
  - **Resampling**
- **Image Morphing**
  - **Simultaneous warp and cross-dissolve**
  - **Feature-based warping**



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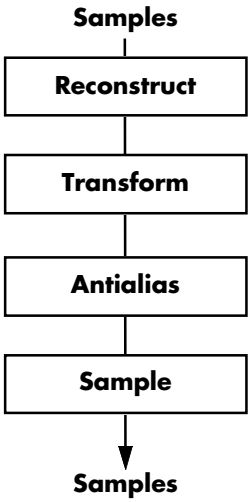
Resampling



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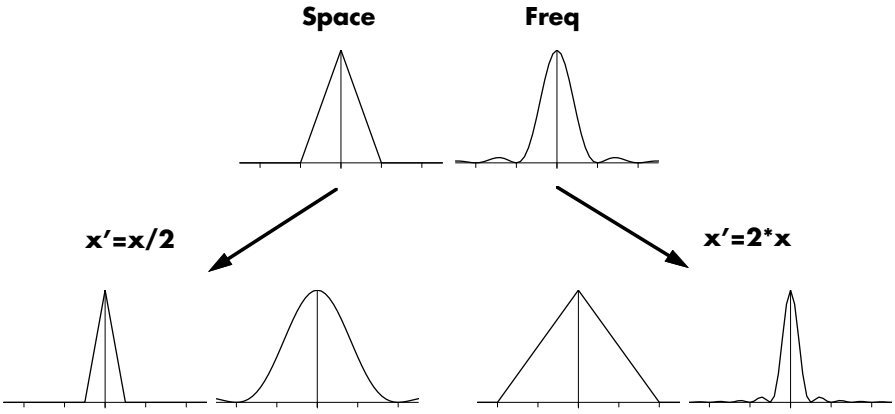
Scaling



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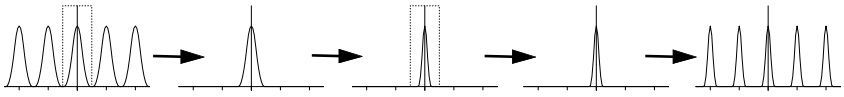
Magnification



Reconstruct **Transform** **Antialias** **Sample**
x′=2x

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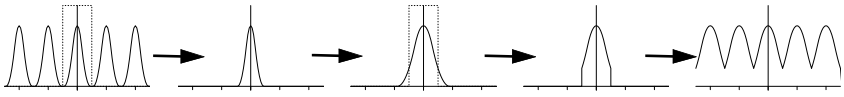
Minification



Reconstruct **Transform** **Antialias** **Sample**
x′=x/2

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Magnification

One to many ...

Just reconstruct, no need to antialias

Magnification

1. **Reconstruct**
2. **Transform**
3. **Sample**

Interpolation

1. **Transform**
2. **Reconstruct (interpolate)**

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Minification

Many to one ...

Just antialias, no need to reconstruct

Minification

1. **Transform**
2. **Antialias**
3. **Sample**

Decimate

1. **Transform**
2. **Filter (averaging)**

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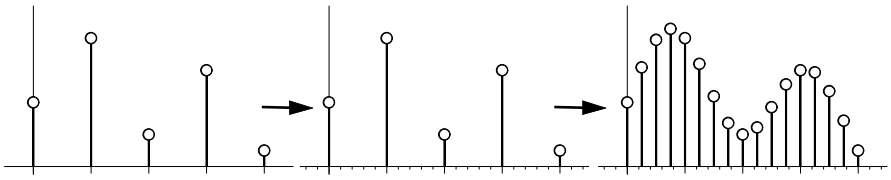
Interpolator



Upsample **Filter**

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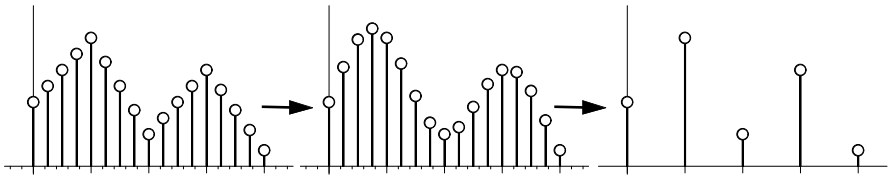
Decimator



Filter **Downsample**

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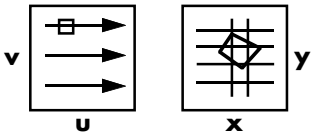
Mapping Algorithms

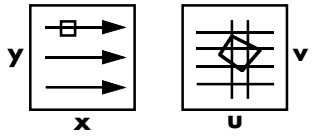
Forward mapping (video effects)

```
for all (u,v)
  (x,y) = f(u,v)
  image[x][y] = texture[u][v]
```



Backward mapping (workstations)

```
for all (x,y)
  (u,v) = f-1(x,y)
  image[x][y] = texture[u][v]
```



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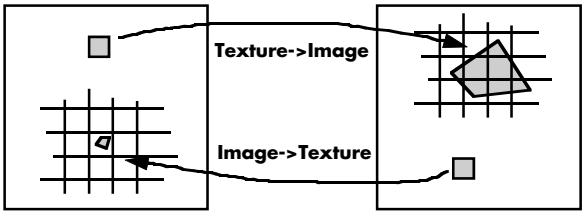
Filtering



Two cases:

1. **Magnification / Interpolation**
2. **Minification / Decimation / Averaging**

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