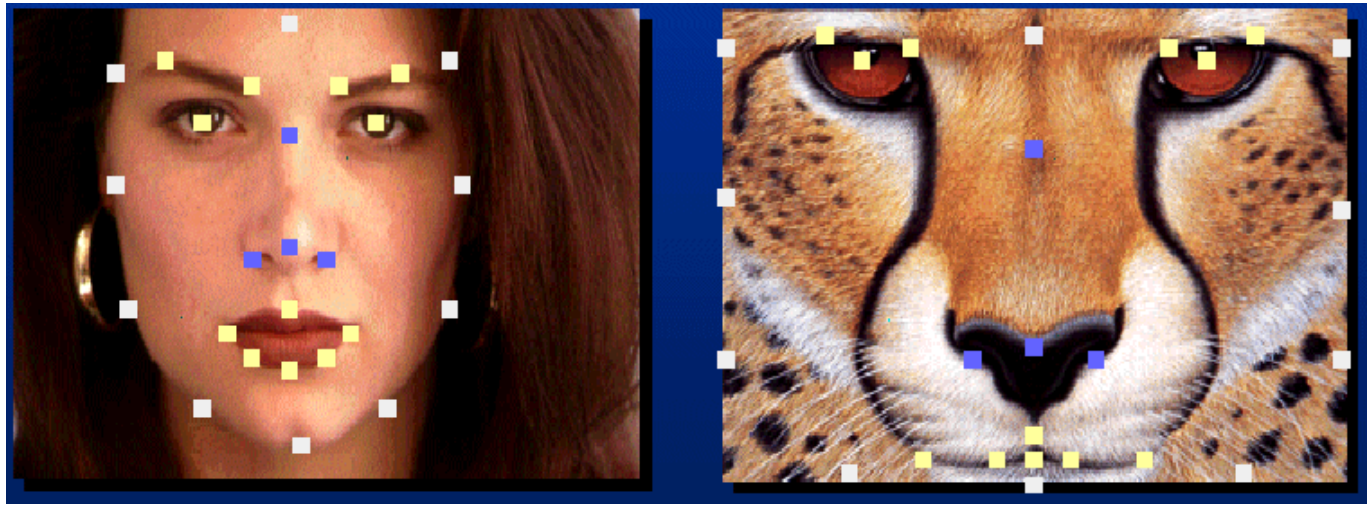
ECE5554 – Computer Vision
Lecture 9c – Image Morphing

Creed Jones, PhD

Today's Objectives

- Image Morphing
- Layered Scene Representations
- Layered Tracking

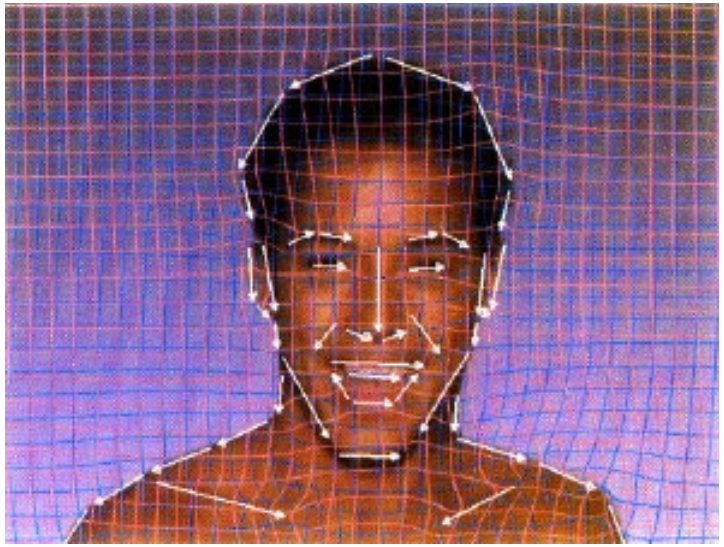
- Bibliography on Motion Tracking and Morphing



MORE GENERAL TRANSFORMATIONS: IMAGE MORPHING

Image Warping – non-parametric

- Specify more detailed warp function



- Examples:
  - splines
  - triangles
  - optical flow (per-pixel motion)

Image Warping – non-parametric

- Move control points to specify spline warp

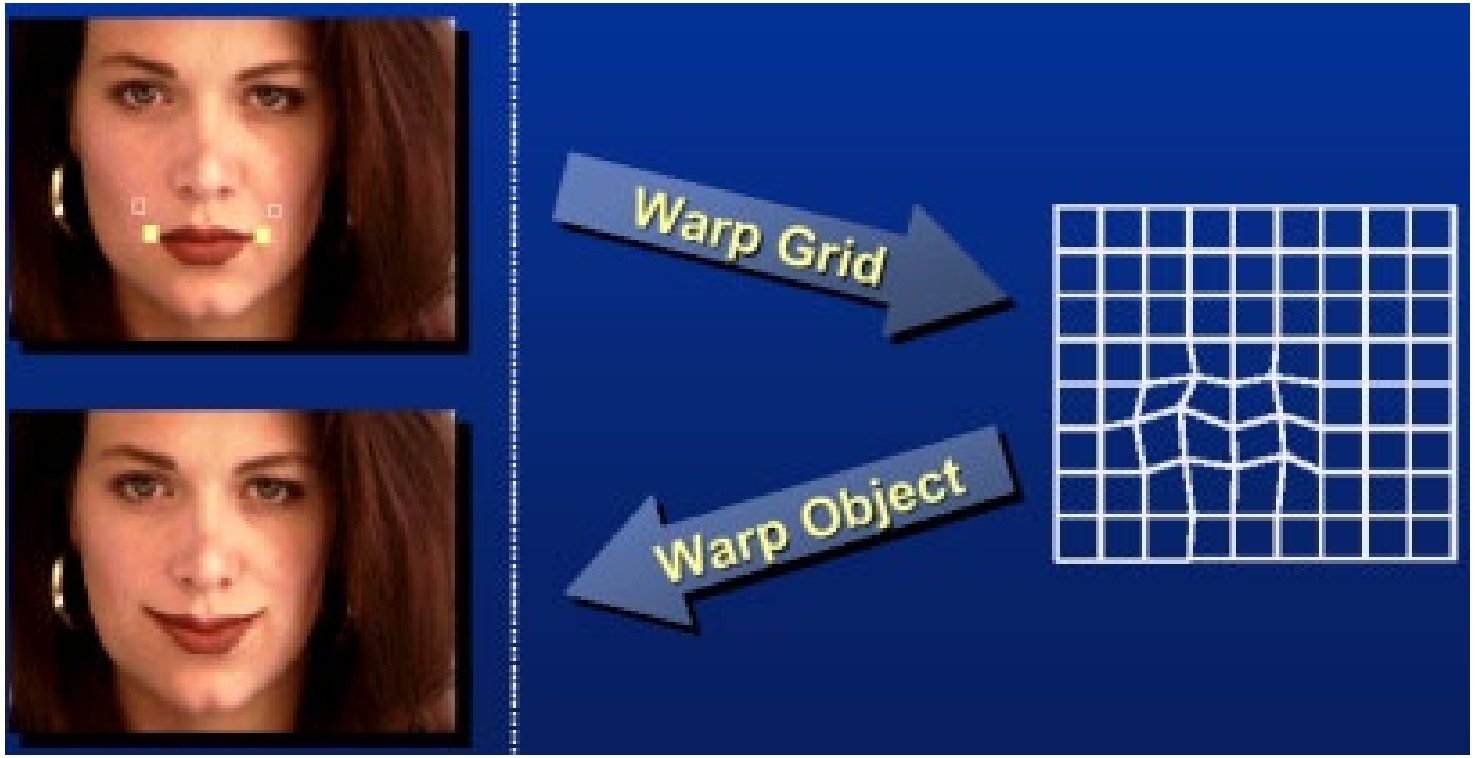
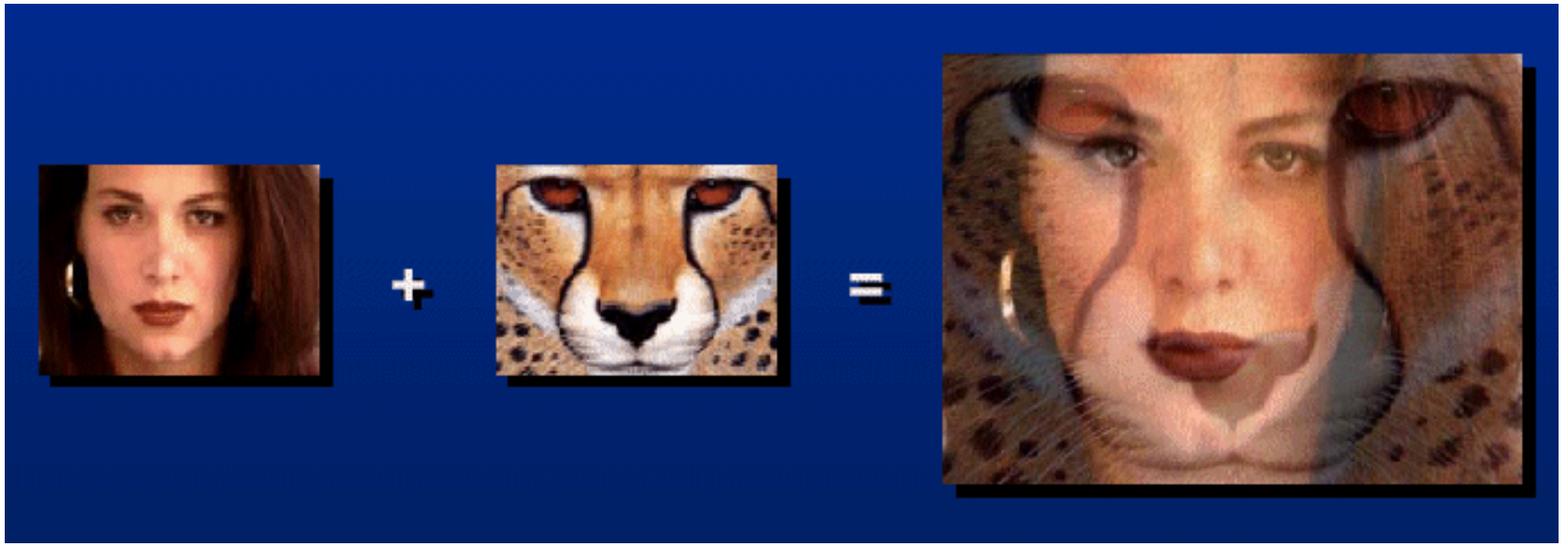


Image Morphing

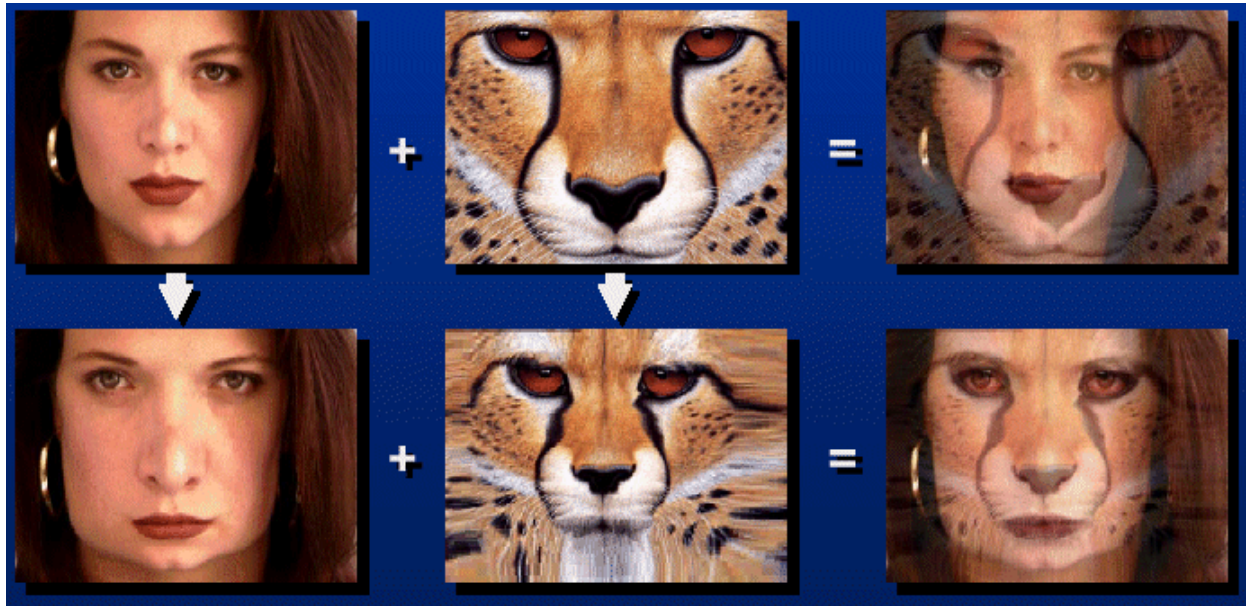
- How can we *in-between* two images?
  1. Cross-dissolve



(all examples from [Gomes *et al.*'99])

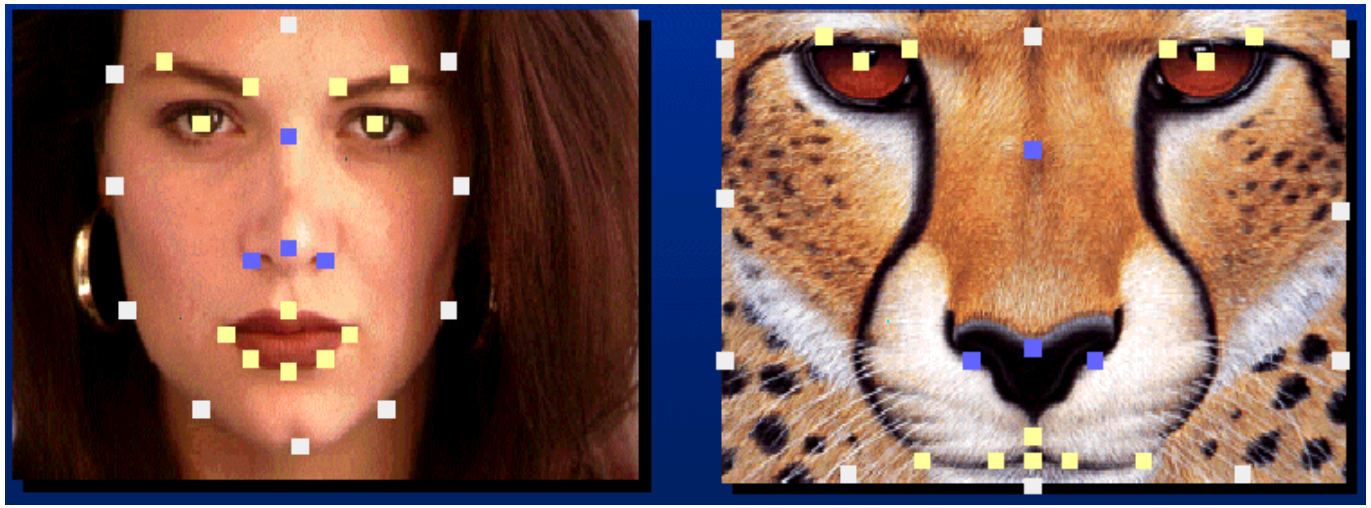
Image Morphing

- How can we *in-between* two images?
  2. Warp then cross-dissolve = *morph*



Warp specification

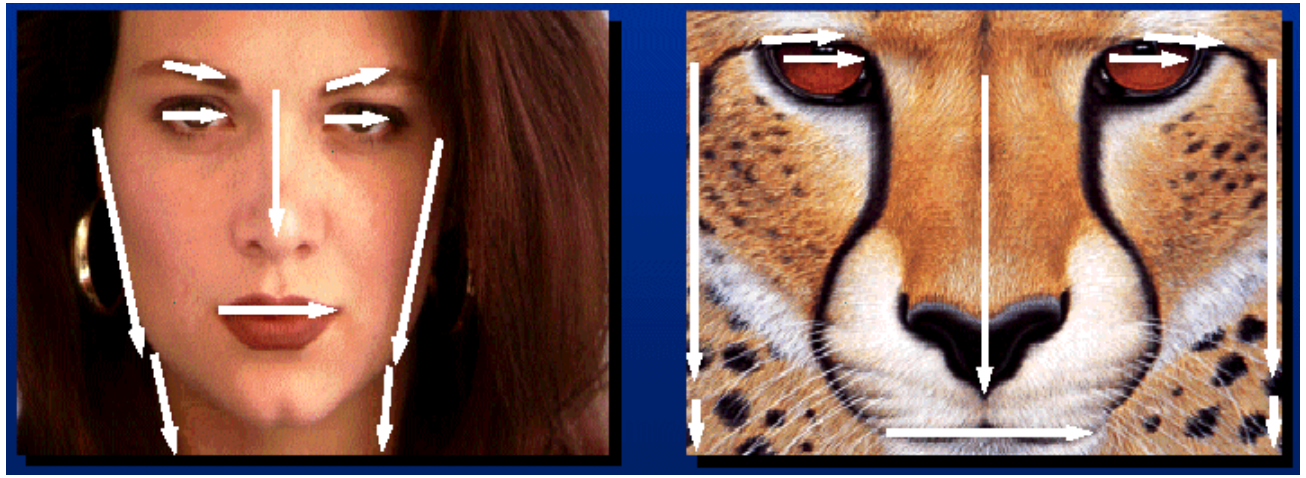
- How can we specify the warp?
  1. Specify corresponding *points*
     - *interpolate* to a complete warping function



Nielson, *Scattered Data Modeling*, IEEE CG&A'93]

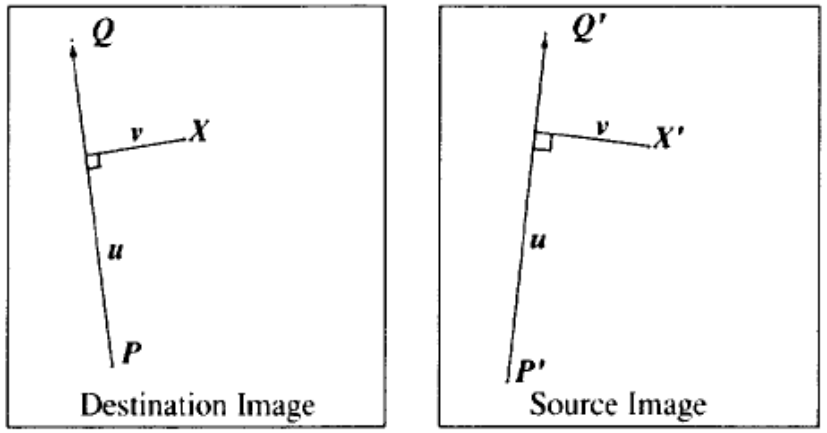
Warp specification

- How can we specify the warp?
  2. Specify corresponding *vectors*
     - *interpolate* to a complete warping function



Warp specification

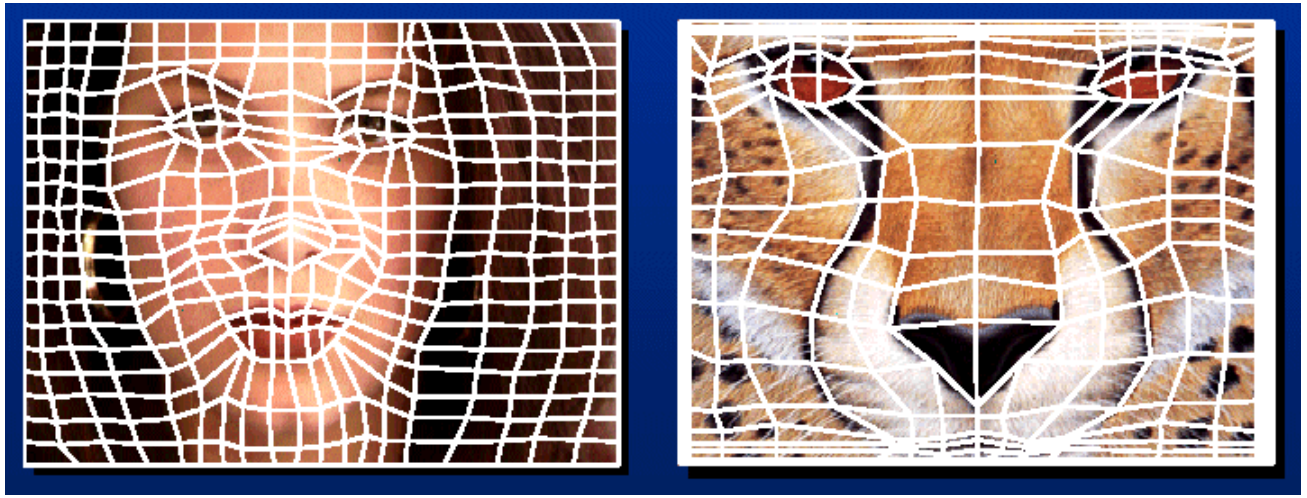
- How can we specify the warp?
  2. Specify corresponding *vectors*
     - *interpolate* [Beier & Neely, SIGGRAPH'92]



For each pixel X in the destination
  $DSUM = (0,0)$
  $weightsum = 0$
  For each line $P_i Q_i$
    calculate u,v based on $P_i Q_i$
    calculate X'_i based on u,v and $P_i' Q_i'$
    calculate displacement $D_i = X_i' - X_i$ for this line
    $dist$ = shortest distance from X to $P_i Q_i$
    $weight = (length^p / (a + dist))^b$
    $DSUM \mathrel{+}= D_i * weight$
    $weightsum \mathrel{+}= weight$
  $X' = X + DSUM / weightsum$
  destinationImage(X) = sourceImage(X')

Warp specification

- How can we specify the warp?
  3. Specify corresponding *spline control points*
     - *interpolate* to a complete warping function



Final Morph Result

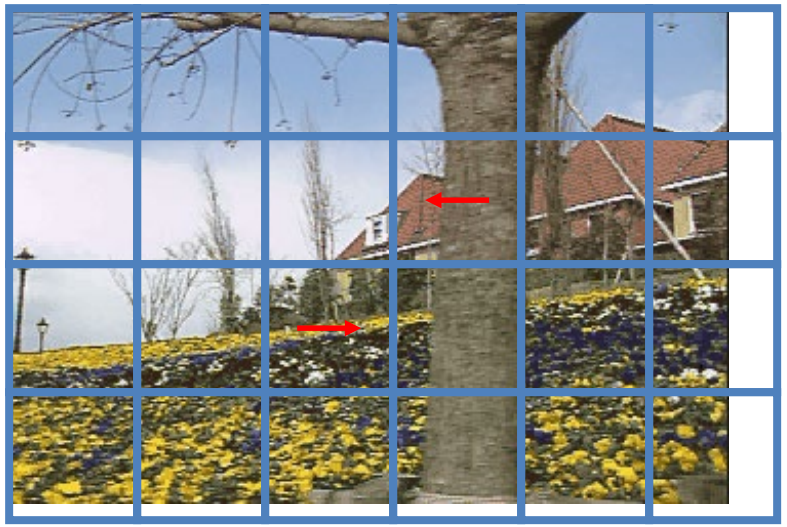
LAYERED SCENE REPRESENTATIONS

Motion representations

- How can we describe this scene?

Block-based motion prediction

- Break image up into square blocks
- Estimate translation for each block
- Use this to predict next frame, code difference (MPEG-2)



Layered motion

- Break image sequence up into “layers”:
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- Describe each layer’s motion

Layered motion

Advantages:

- can represent occlusions / disocclusions
- each layer's motion can be smooth
- video segmentation for semantic processing

Difficulties:

- how do we determine the correct number?
- how do we assign pixels?
- how do we model the motion?

Layers for video summarization

Frame 0

Frame 50

Frame 80

Background scene (players removed)

Complete synopsis of the video

Background modeling (MPEG-4)

- Convert masked images into a background sprite for layered video coding
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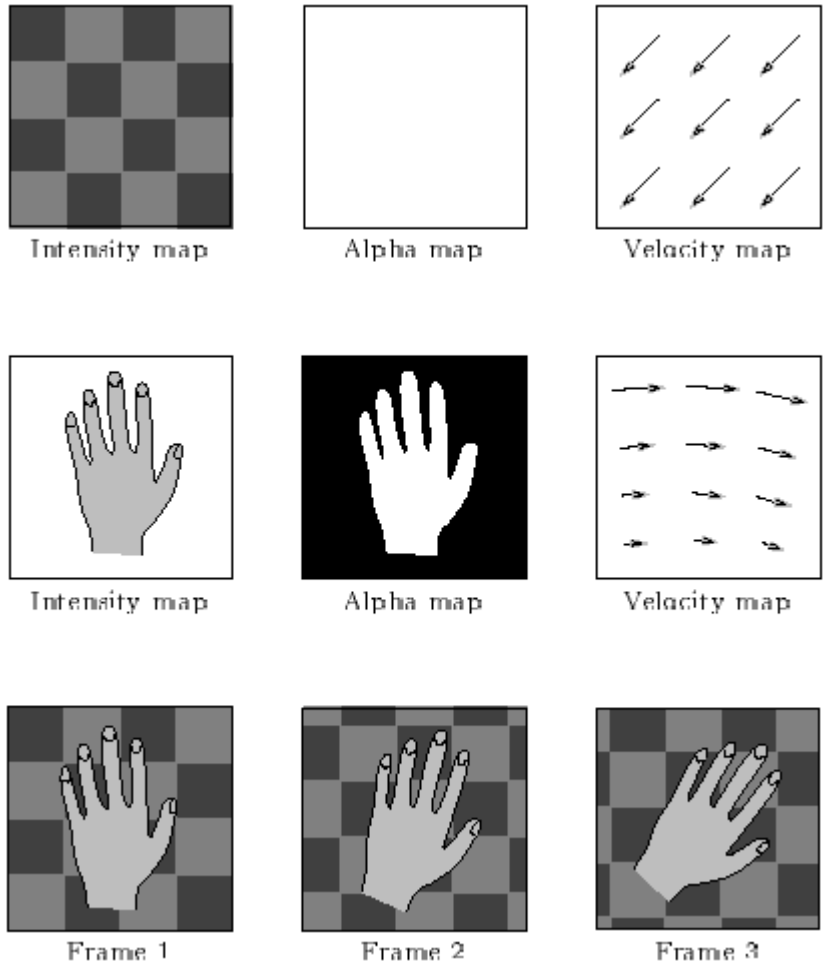
What are layers?

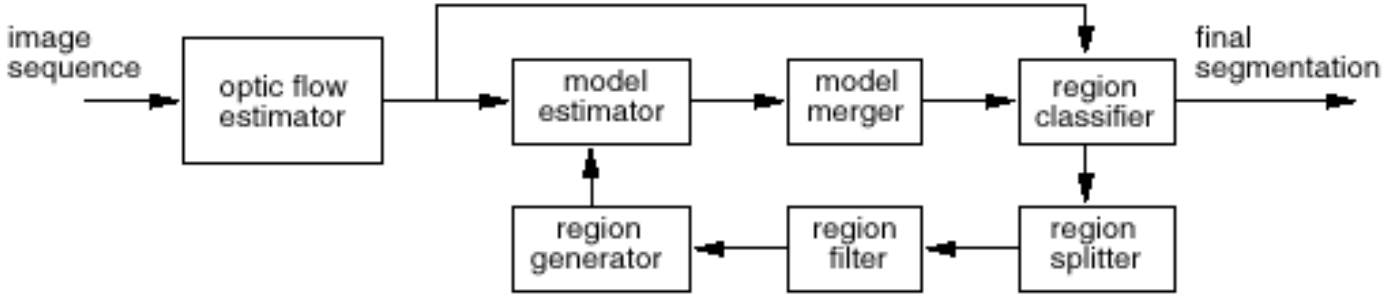
[Wang & Adelson, 1994]

- intensities
- alphas
- velocities



How do we estimate the layers?

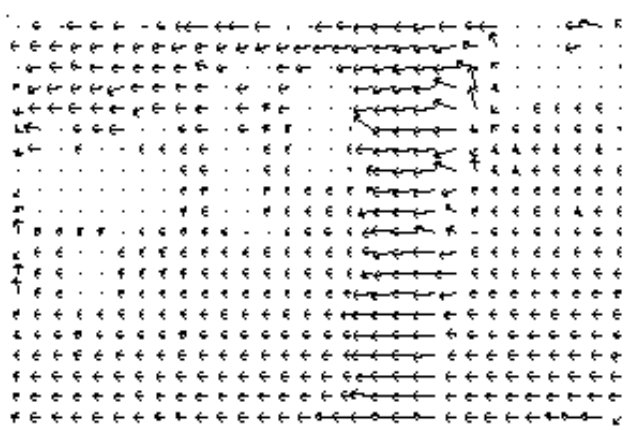
1. compute coarse-to-fine flow
2. estimate affine motion in blocks (regression)
3. cluster with *k-means*
4. assign pixels to best fitting affine region
5. re-estimate affine motions in each region…

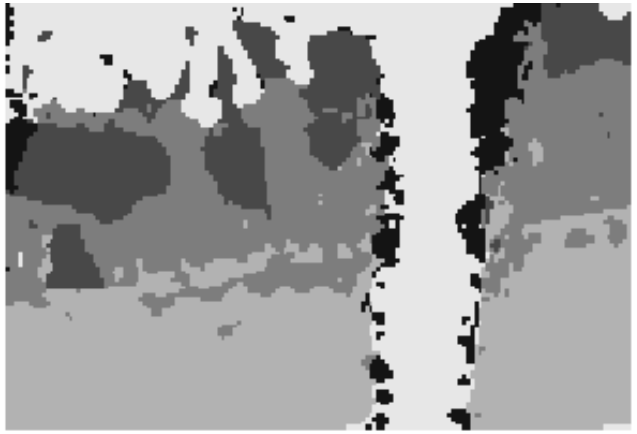


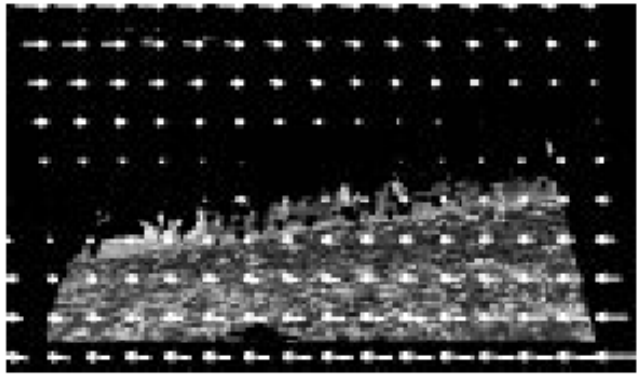
Layer synthesis

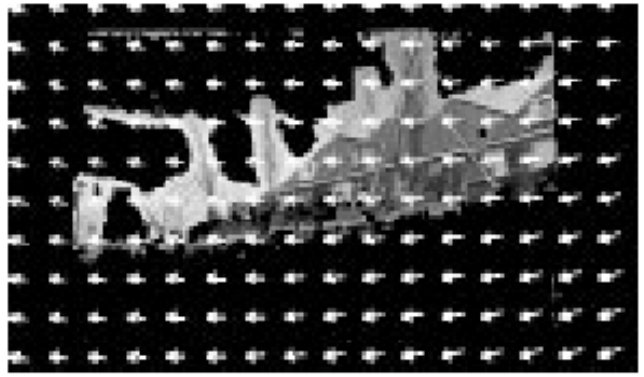
- For each layer:
- stabilize the sequence with the affine motion
- compute median value at each pixel
- Determine occlusion relationships

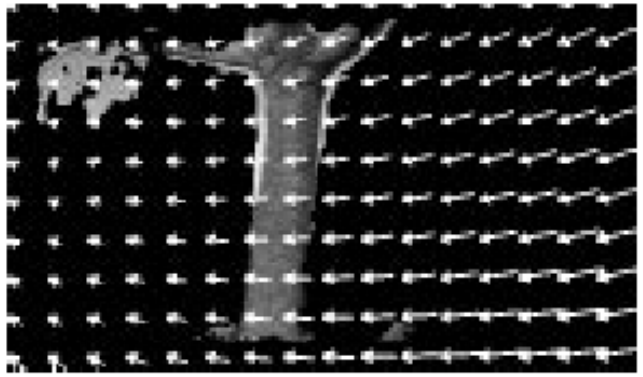
Results











Bibliography

- L. Williams. *Pyramidal parametrics*. Computer Graphics, 17(3):1--11, July 1983.
- L. G. Brown. *A survey of image registration techniques*. Computing Surveys, 24(4):325--376, December 1992.
- C. D. Kuglin and D. C. Hines. *The phase correlation image alignment method*. In IEEE 1975 Conference on Cybernetics and Society, pages 163--165, New York, September 1975.
- J. Gomes, L. Darsa, B. Costa, and L. Velho. *Warping and Morphing of Graphical Objects*. Morgan Kaufmann, 1999.
- T. Beier and S. Neely. *Feature-based image metamorphosis*. Computer Graphics (SIGGRAPH'92), 26(2):35--42, July 1992.
- J. R. Bergen, P. Anandan, K. J. Hanna, and R. Hingorani. Hierarchical model-based motion estimation. In ECCV'92, pp. 237–252, Italy, May 1992.
- M. J. Black and P. Anandan. The robust estimation of multiple motions: Parametric and piecewise-smooth flow fields. Comp. Vis. Image Understanding, 63(1):75–104, 1996.

Bibliography

- Shi, J. and Tomasi, C. (1994). Good features to track. In CVPR'94, pages 593–600, IEEE Computer Society, Seattle.
- Baker, S. and Matthews, I. (2004). Lucas-kanade 20 years on: A unifying framework: Part 1: The quantity approximated, the warp update rule, and the gradient descent approximation. IJCV, 56(3), 221–255.
- H. S. Sawhney and S. Ayer. Compact representation of videos through dominant multiple motion estimation. IEEE Trans. Patt. Anal. Mach. Intel., 18(8):814–830, Aug. 1996.
- Y. Weiss. Smoothness in layers: Motion segmentation using nonparametric mixture estimation. In CVPR'97, pp. 520–526, June 1997.
- J. Y. A. Wang and E. H. Adelson. Representing moving images with layers. IEEE Transactions on Image Processing, 3(5):625--638, September 1994.
- Y. Weiss and E. H. Adelson. A unified mixture framework for motion segmentation: Incorporating spatial coherence and estimating the number of models. In IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'96), pages 321--326, San Francisco, California, June 1996.

Bibliography

- Y. Weiss. Smoothness in layers: Motion segmentation using nonparametric mixture estimation. In IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'97), pages 520--526, San Juan, Puerto Rico, June 1997.
- P. R. Hsu, P. Anandan, and S. Peleg. Accurate computation of optical flow by using layered motion representations. In Twelfth International Conference on Pattern Recognition (ICPR'94), pages 743--746, Jerusalem, Israel, October 1994. IEEE Computer Society Press
- T. Darrell and A. Pentland. Cooperative robust estimation using layers of support. IEEE Transactions on Pattern Analysis and Machine Intelligence, 17(5):474--487, May 1995.
- S. X. Ju, M. J. Black, and A. D. Jepson. Skin and bones: Multi-layer, locally affine, optical flow and regularization with transparency. In IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'96), pages 307--314, San Francisco, California, June 1996.
- M. Irani, B. Rousso, and S. Peleg. Computing occluding and transparent motions. International Journal of Computer Vision, 12(1):5--16, January 1994.
- H. S. Sawhney and S. Ayer. Compact representation of videos through dominant multiple motion estimation. IEEE Transactions on Pattern Analysis and Machine Intelligence, 18(8):814--830, August 1996.

Bibliography

- M.-C. Lee et al. A layered video object coding system using sprite and affine motion model. IEEE Transactions on Circuits and Systems for Video Technology, 7(1):130--145, February 1997.
- S. Baker, R. Szeliski, and P. Anandan. A layered approach to stereo reconstruction. In IEEE CVPR'98, pages 434--441, Santa Barbara, June 1998.
- R. Szeliski, S. Avidan, and P. Anandan. Layer extraction from multiple images containing reflections and transparency. In IEEE CVPR'2000, volume 1, pages 246--253, Hilton Head Island, June 2000.
- J. Shade, S. Gortler, L.-W. He, and R. Szeliski. Layered depth images. In Computer Graphics (SIGGRAPH'98) Proceedings, pages 231--242, Orlando, July 1998. ACM SIGGRAPH.
- S. Laveau and O. D. Faugeras. 3-d scene representation as a collection of images. In Twelfth International Conference on Pattern Recognition (ICPR'94), volume A, pages 689--691, Jerusalem, Israel, October 1994. IEEE Computer Society Press.
- P. H. S. Torr, R. Szeliski, and P. Anandan. An integrated Bayesian approach to layer extraction from image sequences. In Seventh ICCV'98, pages 983--990, Kerkyra, Greece, September 1999.

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- Layered Tracking

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