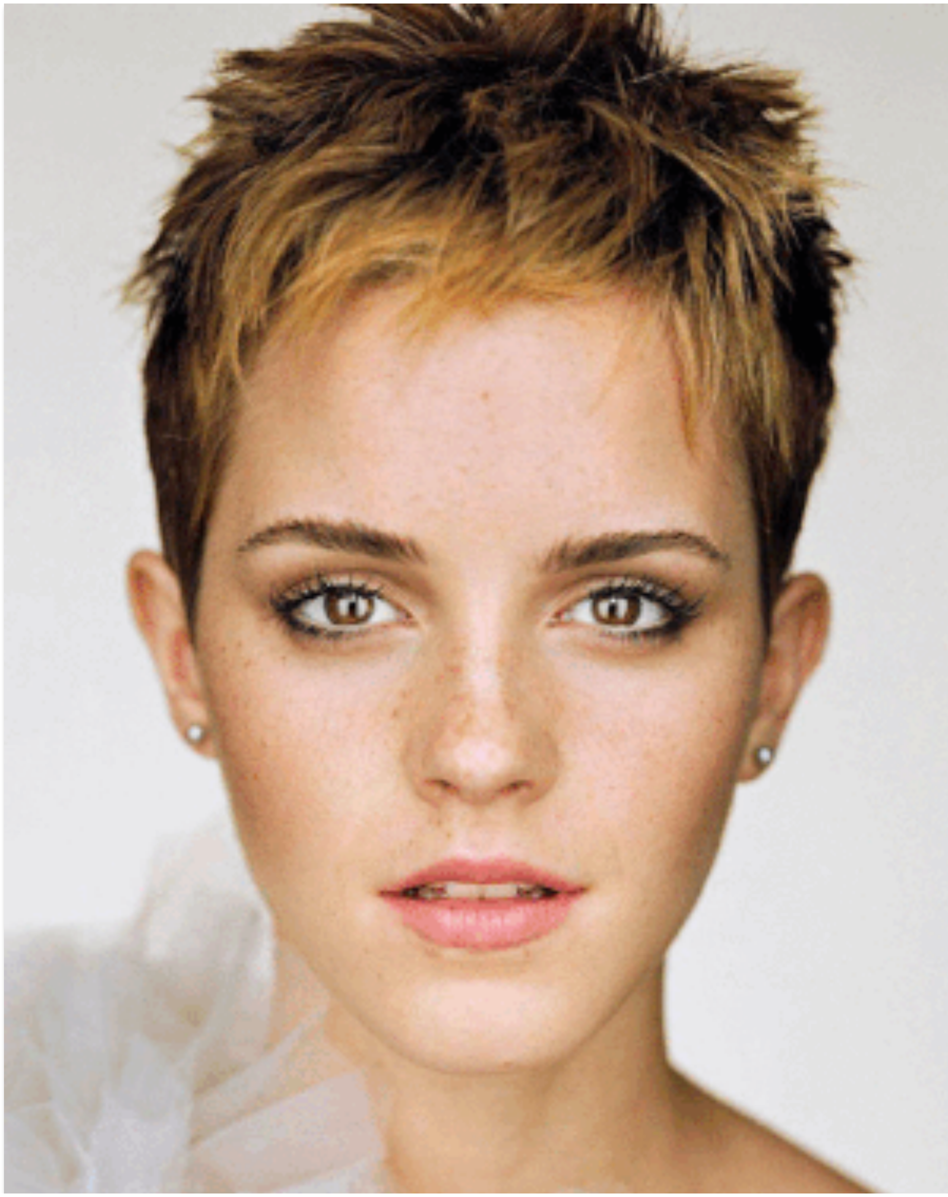
Morphing

CSE 5280



Click on the link to see video:

Source: http://0e303c09b5d540ddca1b-a32f9c73930f0077ec4cbda0c3141619.r85.cf2.rackcdn.com/project5.html

Examples

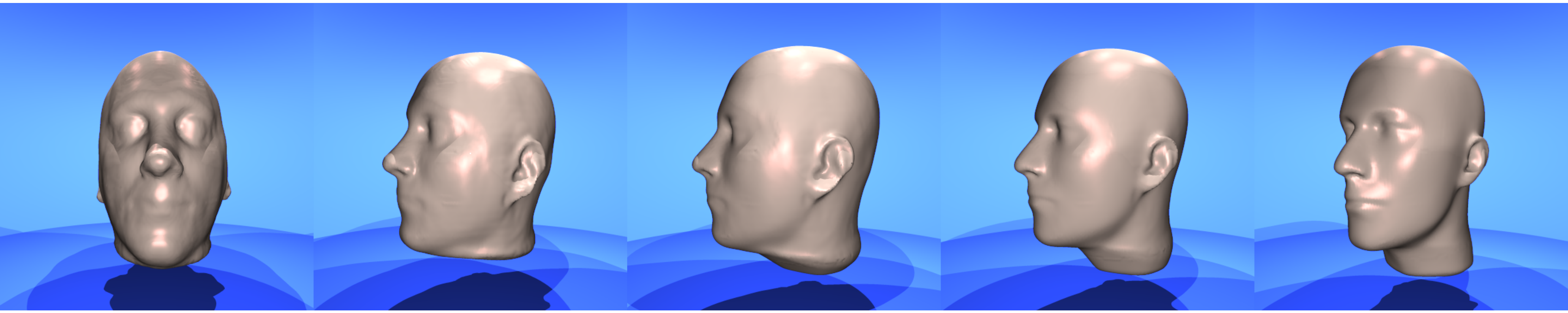
https://youtu.be/nUDIoN-_Hxs

https://youtu.be/-ZopSqoJOgo

Click on the links to see videos:

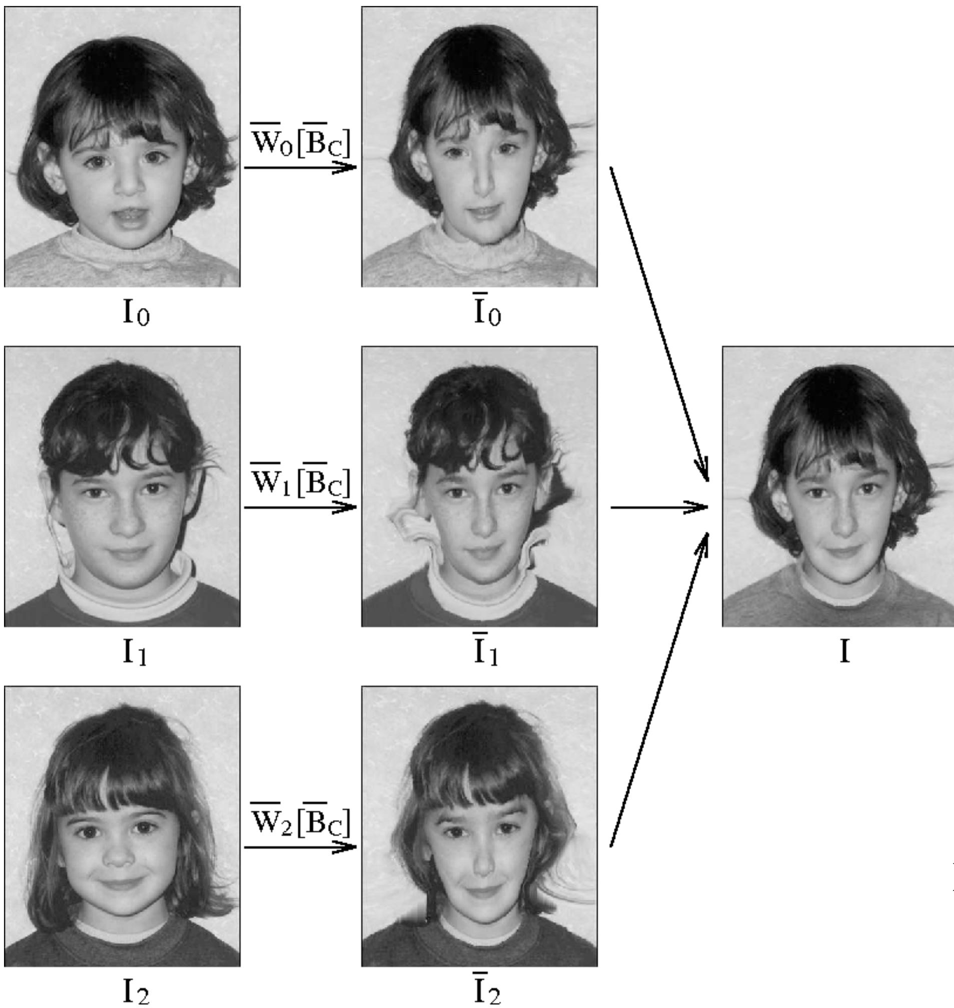
Examples

3-D morphing



https://www.cs.drexel.edu/~david/Abstracts/morph-diff-mods-abs.html

Examples



Combining multiple faces to form a new one

Paper: Polymorph:
Morphing Among Multiple Images by Lee et al. (1998)

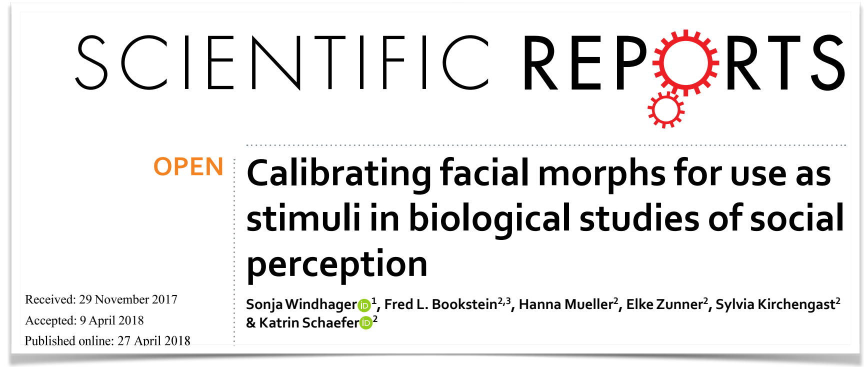
http://www-cs.ccny.cuny.edu/~wolberg/pub/cga98.pdf

Examples

Preview for plastic surgery

https://www.businessinsider.com.au/visual-plastic-surgery-2014-2

Examples


SCIENTIFIC REPORTS

OPEN

Calibrating facial morphs for use as stimuli in biological studies of social perception

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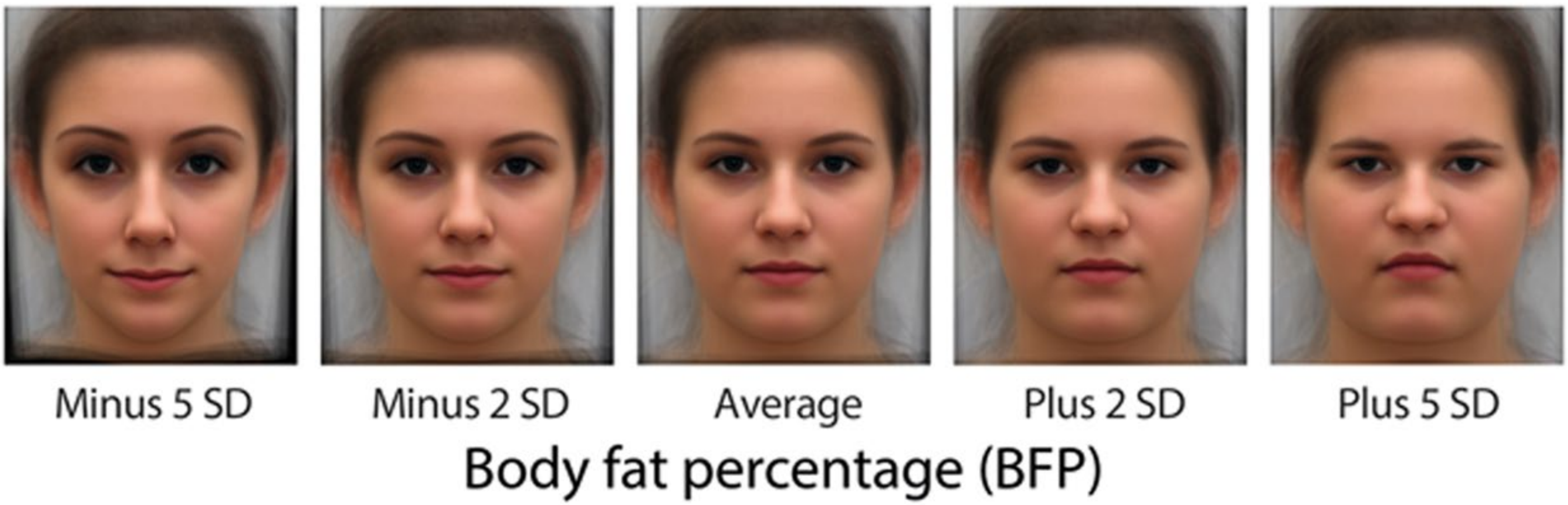
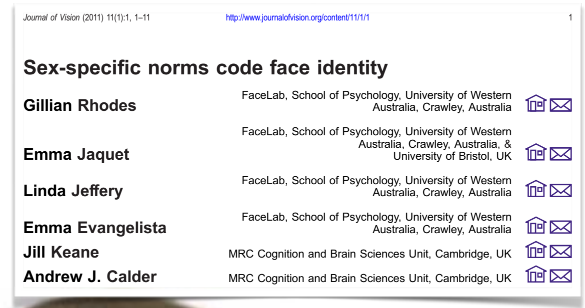
Sonja Windhager[1], Fred L. Bookstein[2,3], Hanna Mueller[2], Elke Zunner[2], Sylvia Kirchengast[2] & Katrin Schaefer[2]



https://www.nature.com/articles/s41598-018-24911-0.pdf

Examples



Journal of Vision (2011) 11(1):1, 1–11 http://www.journalofvision.org/content/11/1/1 1

Sex-specific norms code face identity

Gillian Rhodes FaceLab, School of Psychology, University of Western Australia, Crawley, Australia

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Linda Jeffery FaceLab, School of Psychology, University of Western Australia, Crawley, Australia

Emma Evangelista FaceLab, School of Psychology, University of Western Australia, Crawley, Australia

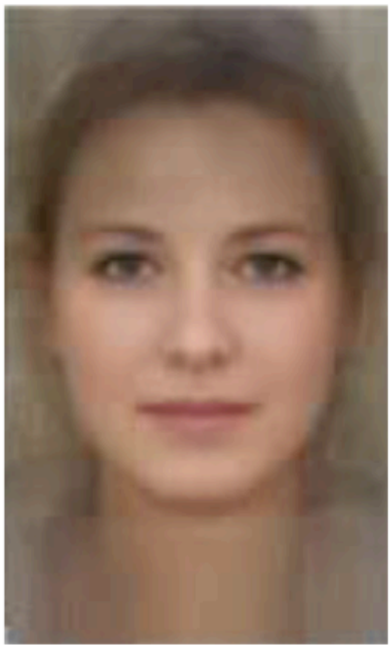
Jill Keane MRC Cognition and Brain Sciences Unit, Cambridge, UK

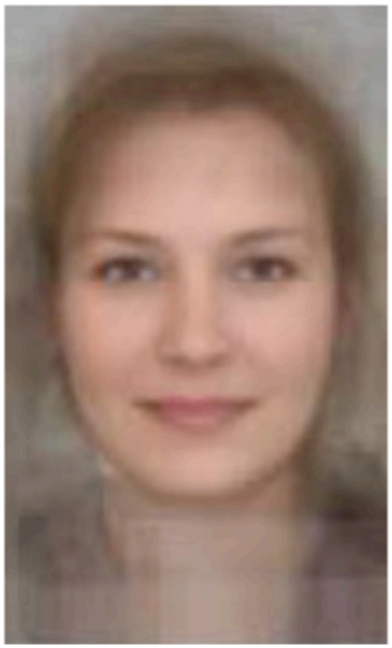
Andrew J. Calder MRC Cognition and Brain Sciences Unit, Cambridge, UK

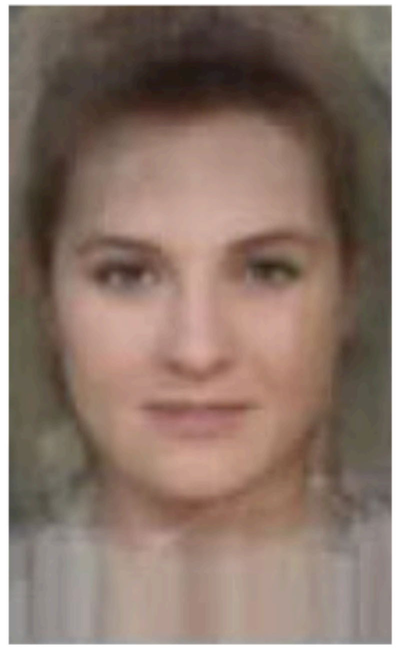
Figure 2. (Left) Male average, (center) female average, and (right) generic, androgynous average. The sex-specific averages were made by morphing together 24 male and 24 female faces, respectively. The generic average was made by morphing all 48 faces (24 males, 24 females).

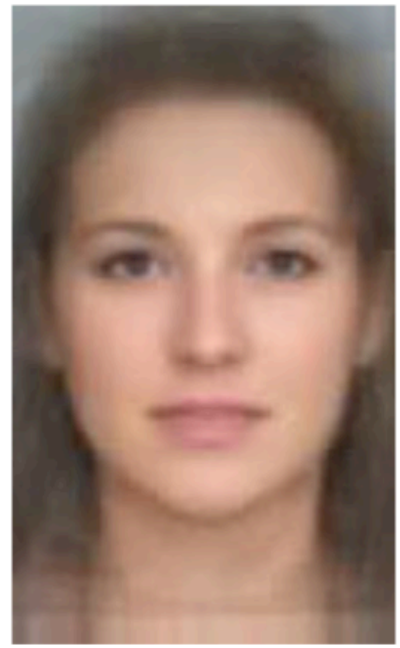
https://www.semanticscholar.org/paper/Sex-specific-norms-code-face-identity.-Rhodes-Jaquet/8d95e11d78fbec0db4add7d8d64f6545ba640f3d

Examples: playing with averages


German avg.


Finnish avg.

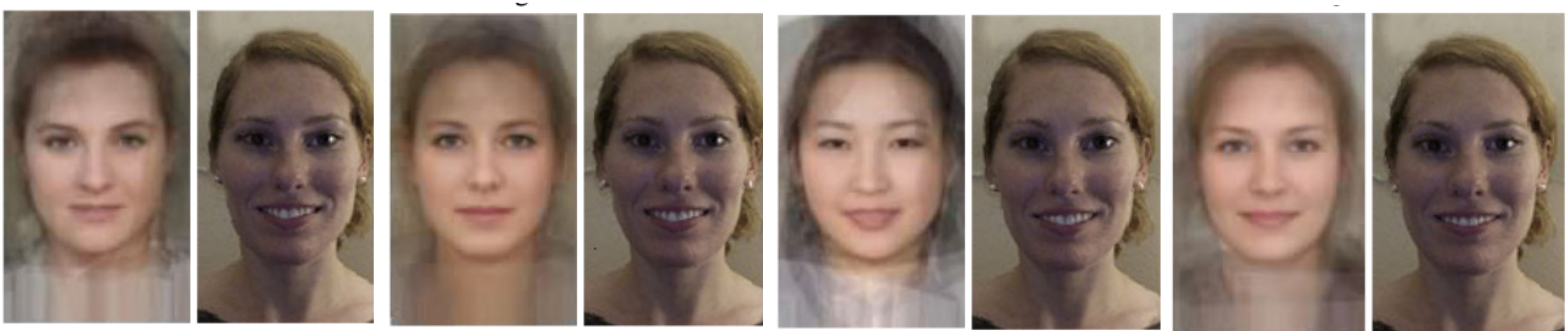

Irish avg.


American avg.


Mongolian avg.

Examples: transferring morphings

My face



Irish avg. More Irish German avg. More German Mongolian avg. More Mongolian Finnish avg. More Finnish

Project by Rachel Albert (UC Berkeley) http://0e303c09b5d540ddca1b-a32f9c73930f0077ec4cbda0c3141619.r85.cf2.rackcdn.com/project5.html

Show Efros' slides

What do you need to know?

- How to estimate an affine transformation given at least 3 pairs of corresponding points.

- How to use the inverse transformation (e.g., affine) to calculate the location of a pixel on the original (i.e., un-warped) image. This is the inverse mapping that you use to transfer pixel colors.

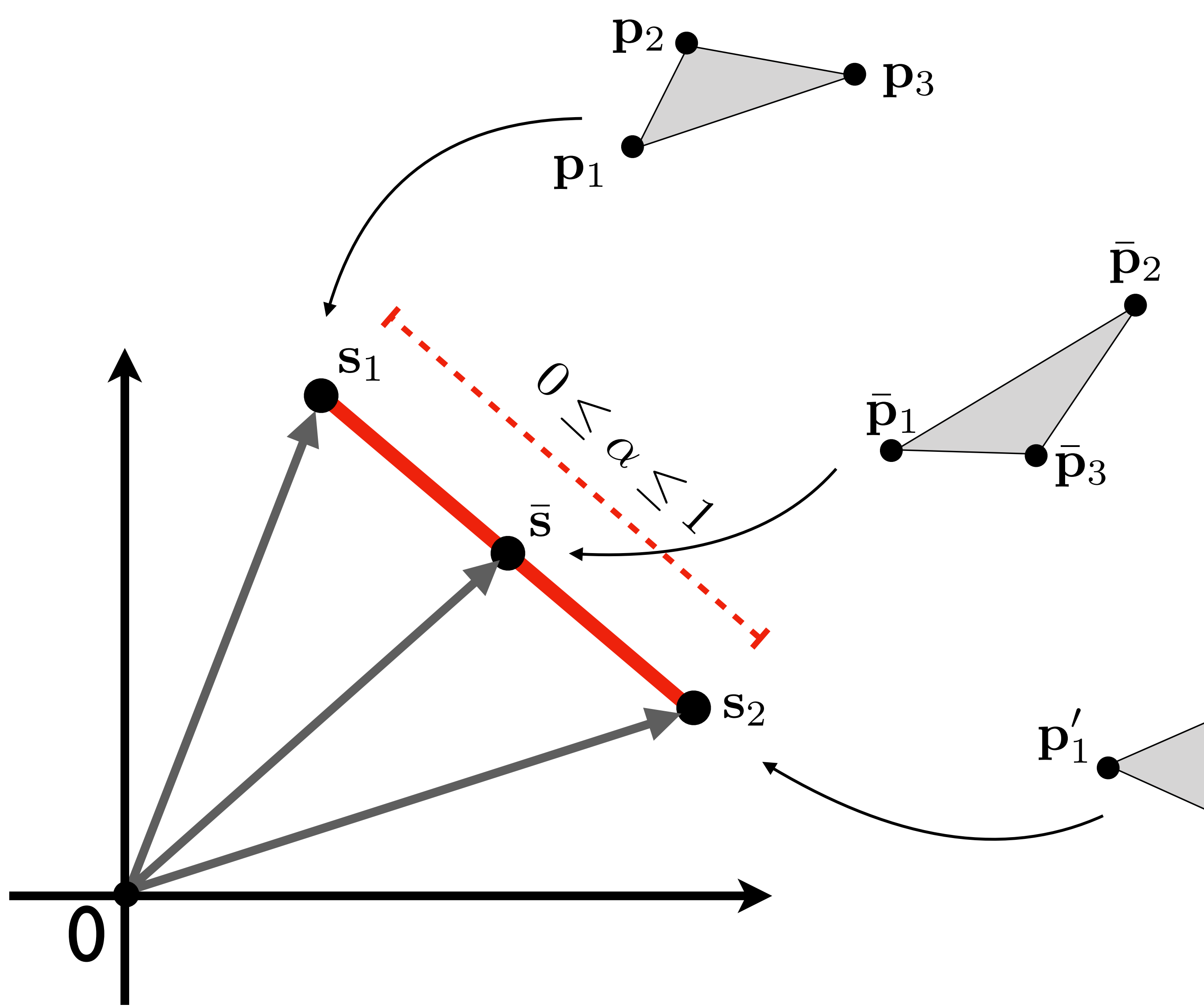
- How to calculate the average of a set of shapes described by ordered landmarks.

- How to transfer the edges (i.e., connections) from one triangulation to another.

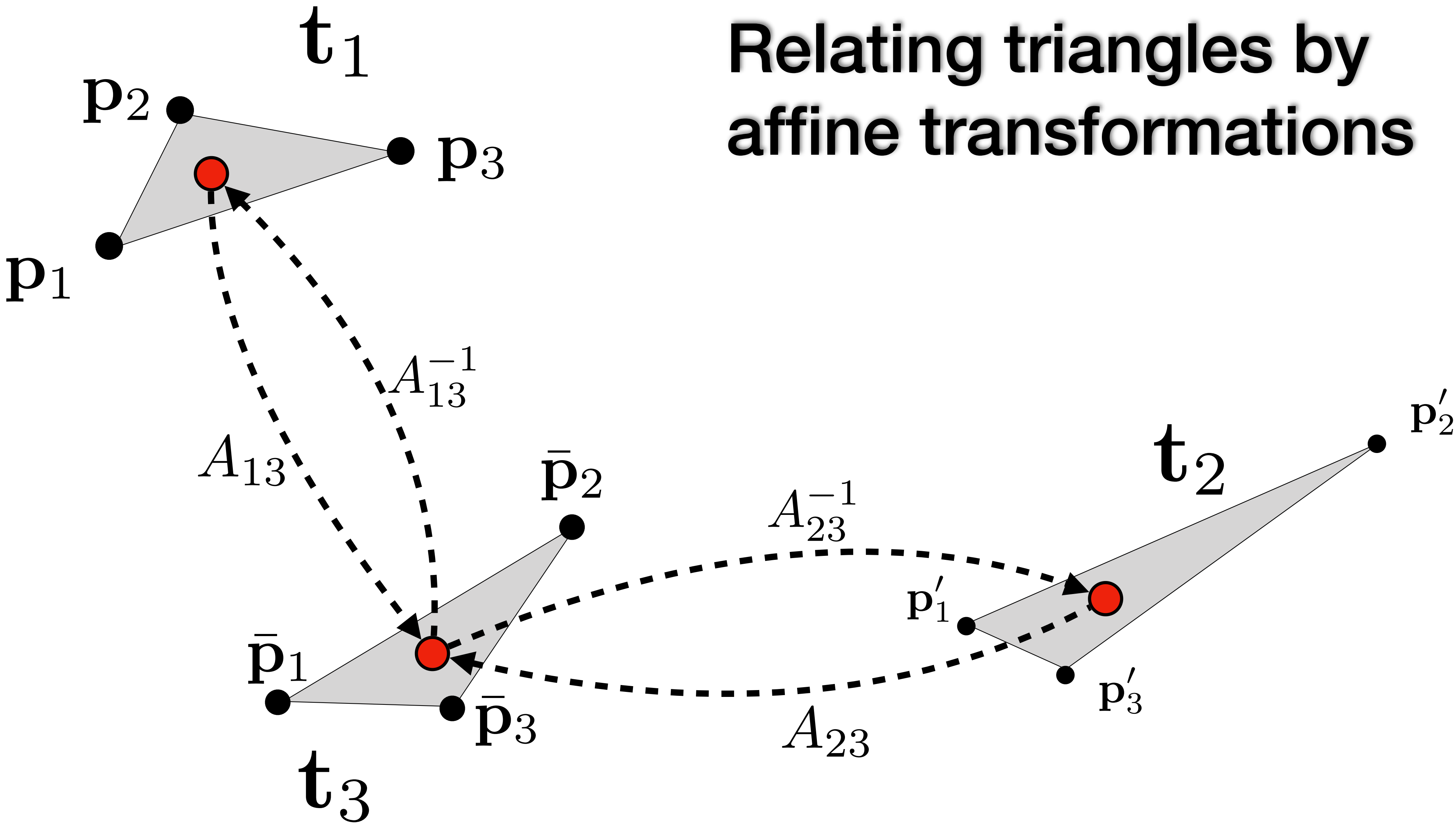
- How to use convex combination to synthesize new shapes and also to blend colors.

- How to determine if points are inside or outside a triangle

Interpolating shapes with convex combination



Relating triangles by affine transformations



Affine transformation and homogenous coordinates

Function form:

$$\vec{y} = f(\vec{x}) = A\vec{x} + \vec{b}.$$

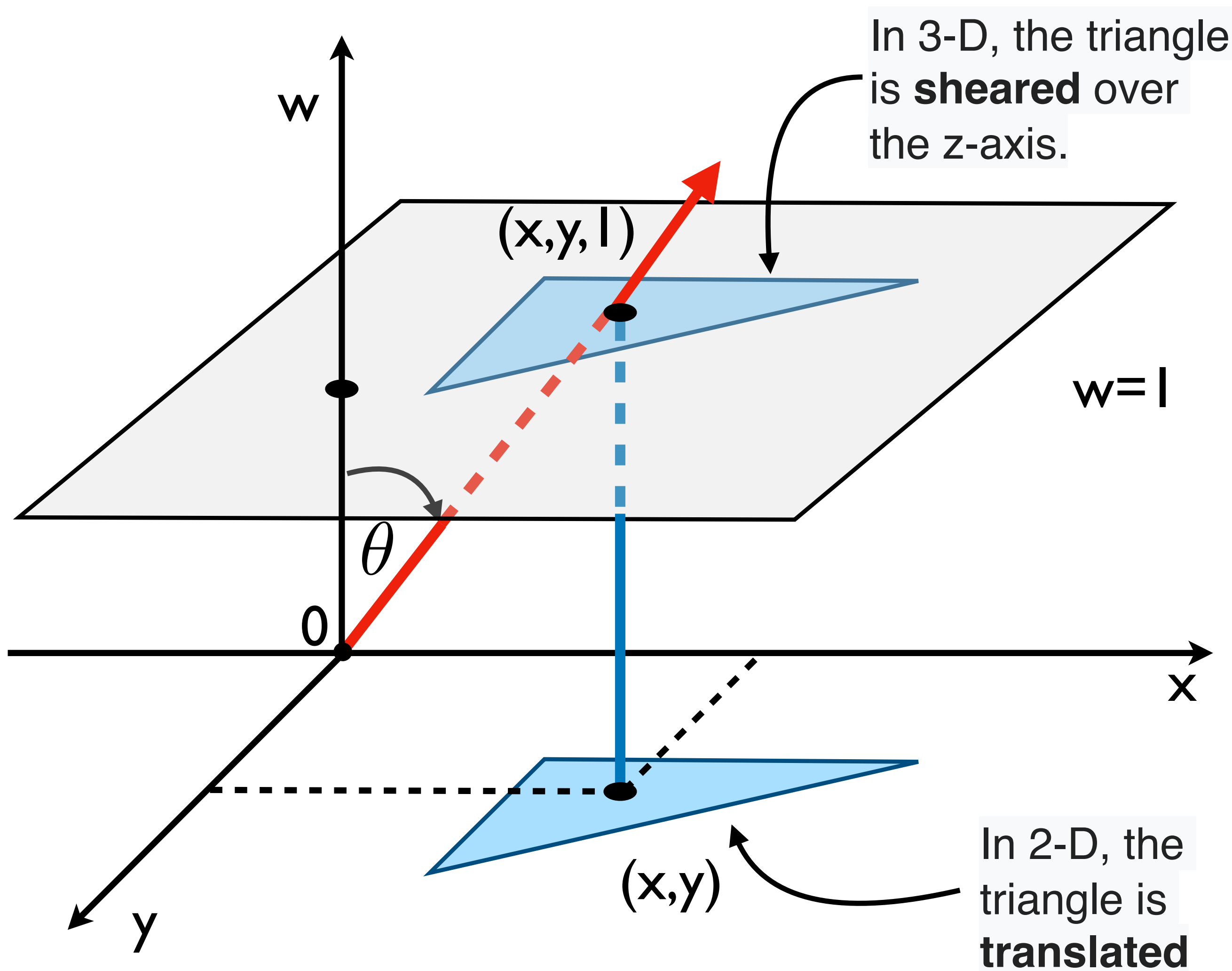
Homogeneous coordinates (augmented matrix form):

$$\begin{bmatrix} \vec{y} \\ 1 \end{bmatrix} = \left[\begin{array}{ccc|c} & A & & \vec{b} \\ 0 & \ldots & 0 & 1 \end{array} \right] \begin{bmatrix} \vec{x} \\ 1 \end{bmatrix}$$

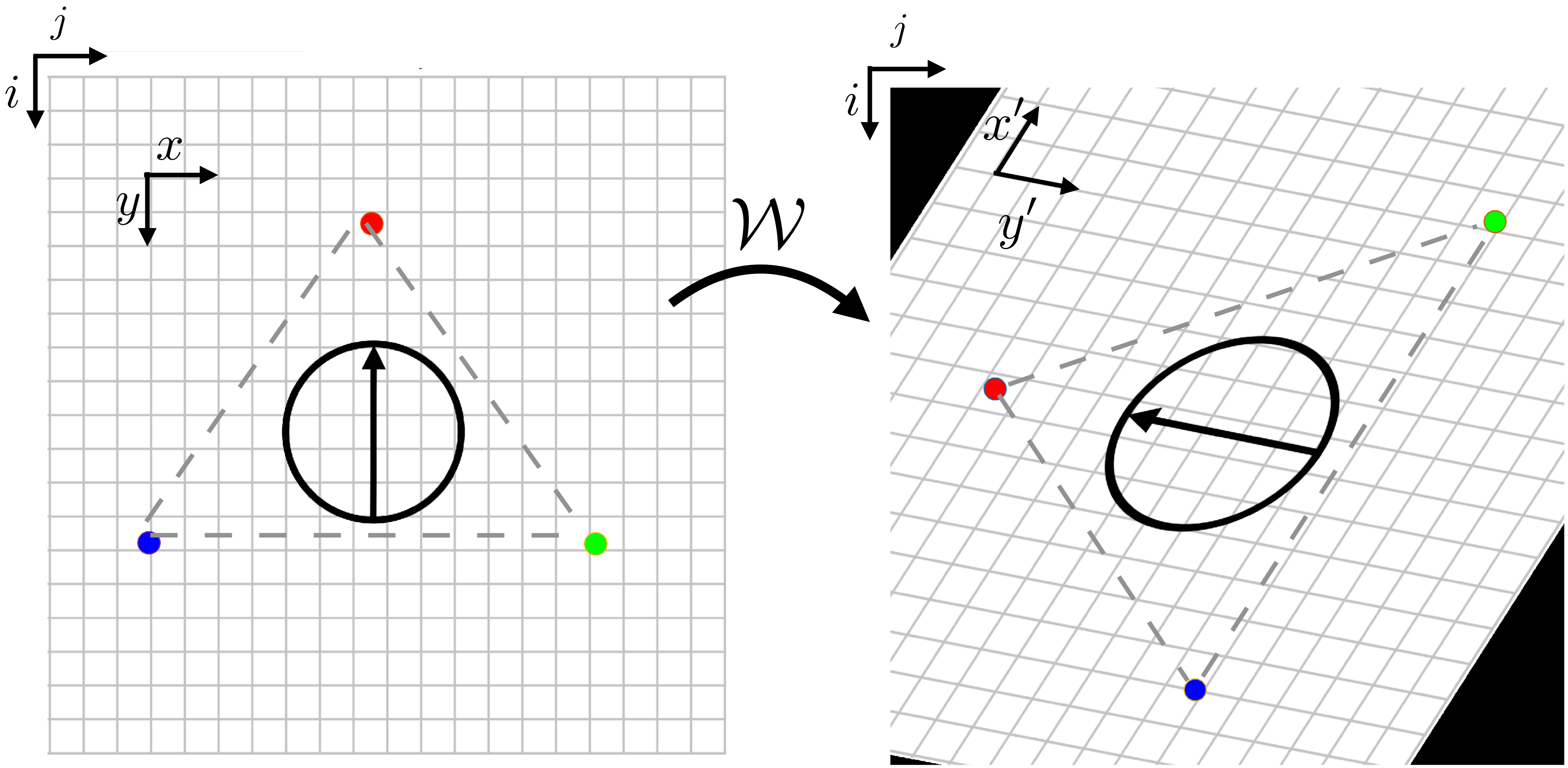
Affine transformation and homogenous coordinates

2-D affine transformations can be performed in 3-D. Translation is done by shearing along over the z axis, and rotation is performed around the z axis.

<u>Shear is a linear transformation</u> (i.e., it has a matrix form). Translation is not a linear transformation in 2-D) as it moves the origin.

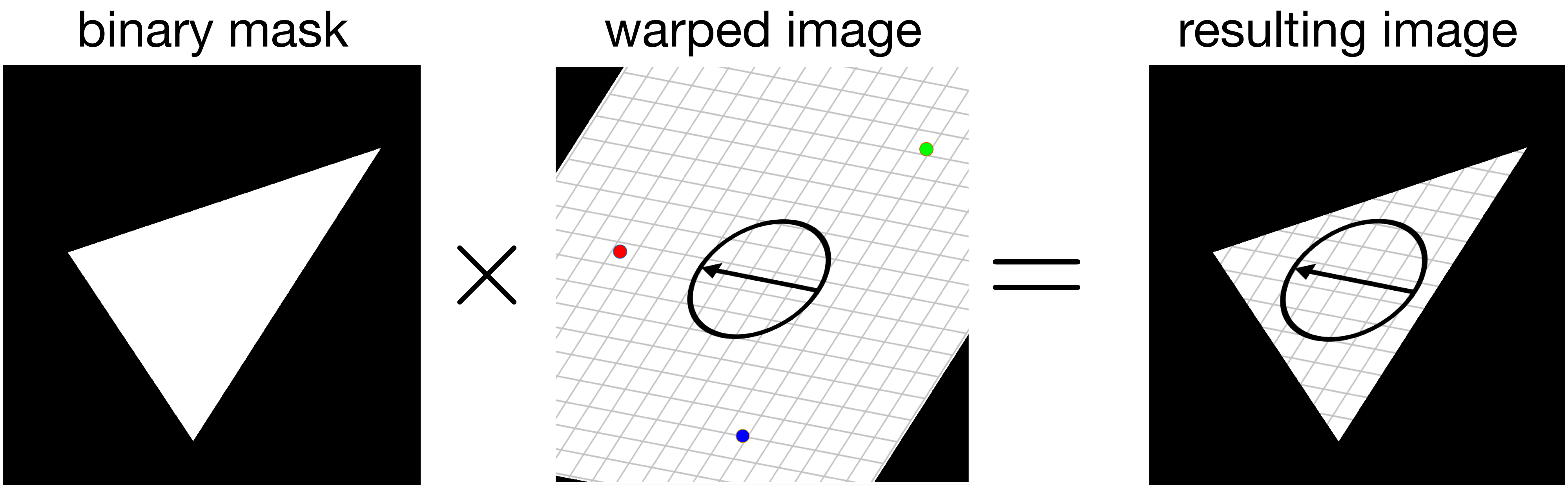


Mapping only points that are inside a triangle

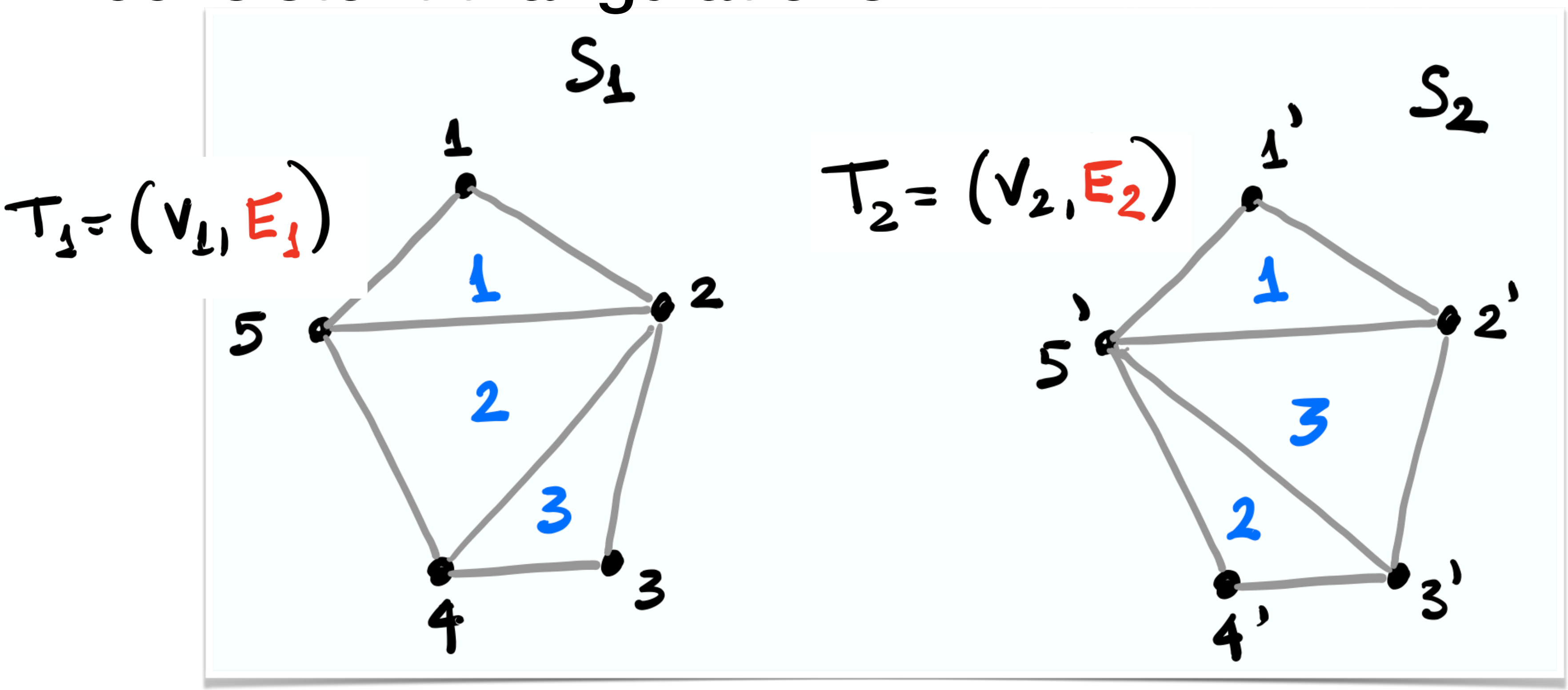


Mapping only points that are inside a triangle

We can create a binary mask with pixels inside a triangle, then transfer only pixel colors from inside the mask. Or we can warp the whole image and then multiply it by the mask.

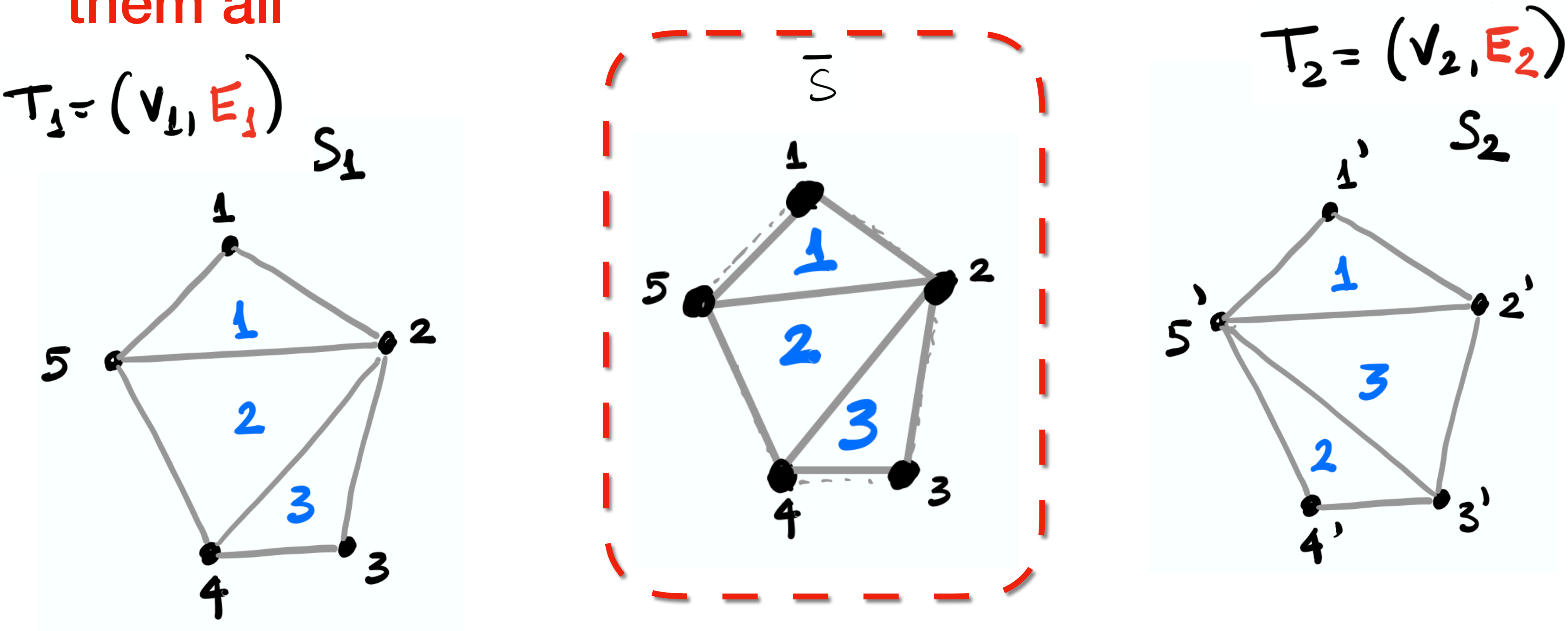


Slightly different shapes can yield highly inconsistent triangulations



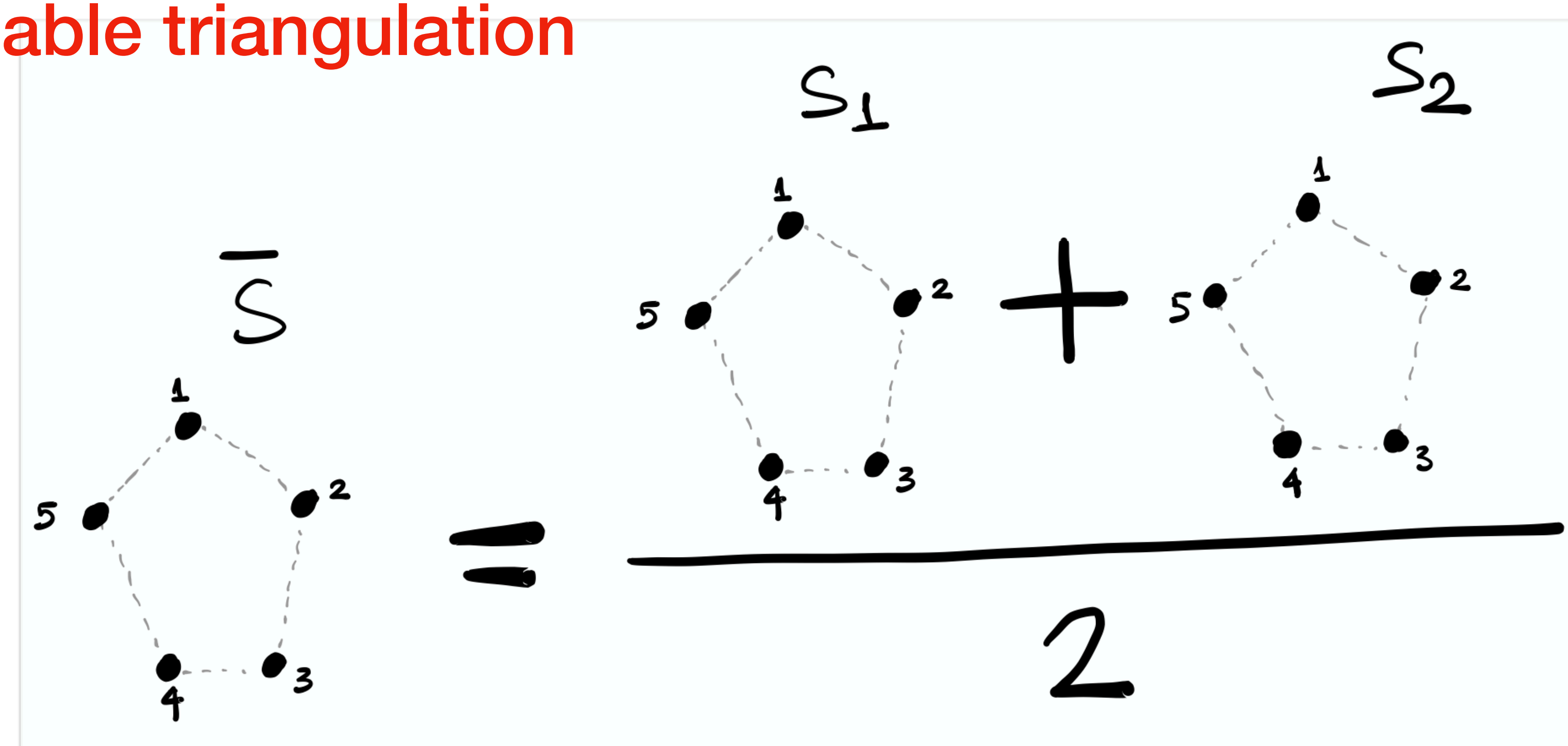
- Triangle order of in edges set varies. Total number of triangles may also vary.
- Inconsistent order means triangles cover different parts of image.
- Broken triangle-to-triangle correspondence: can't estimate consistent affine transformations.

Inconsistent triangulations: one triangulation to rule them all



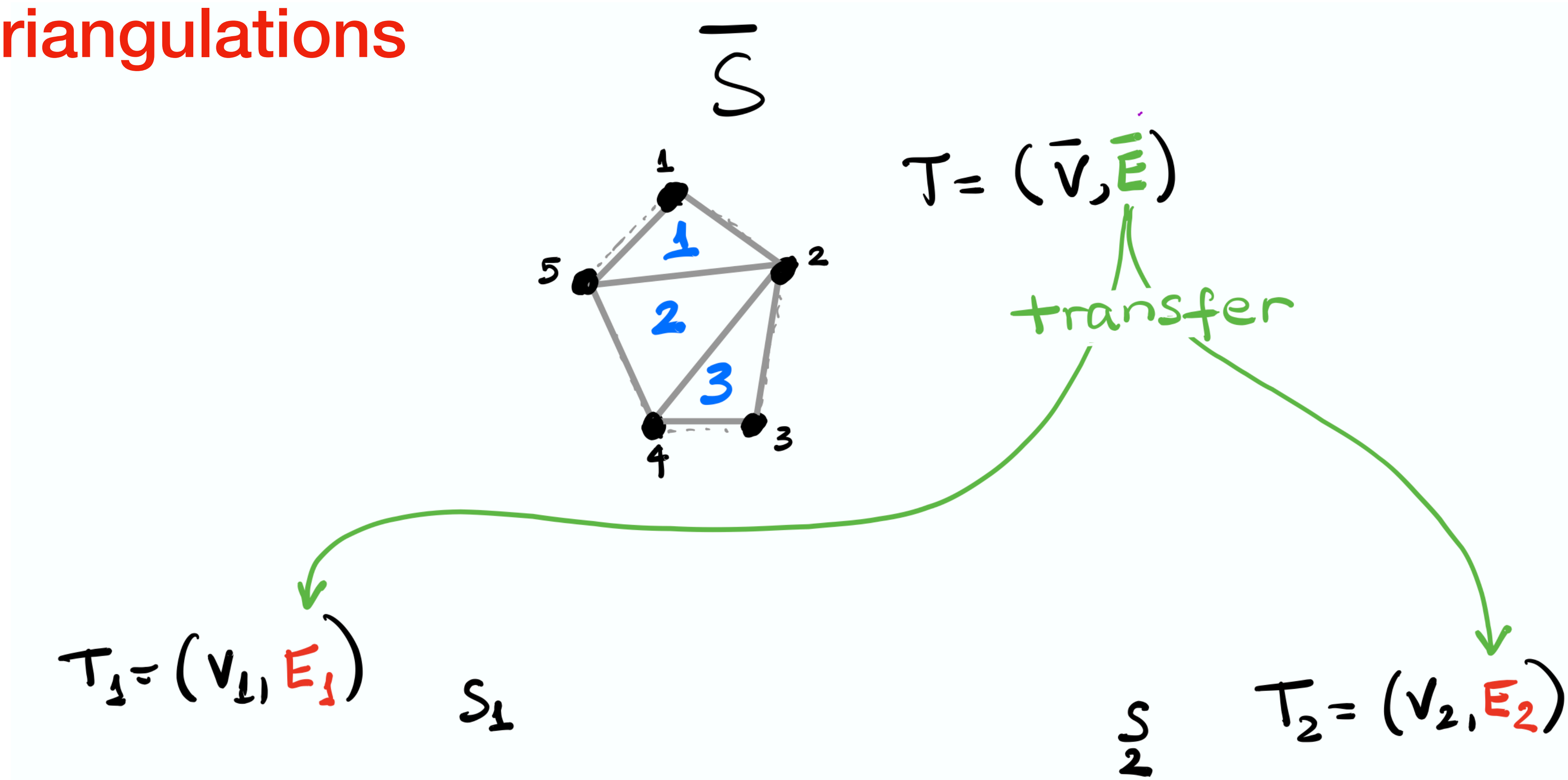
- Create a **single triangulation** to represent the connections for all triangulations.

Inconsistent triangulations: use the mean as the stable triangulation



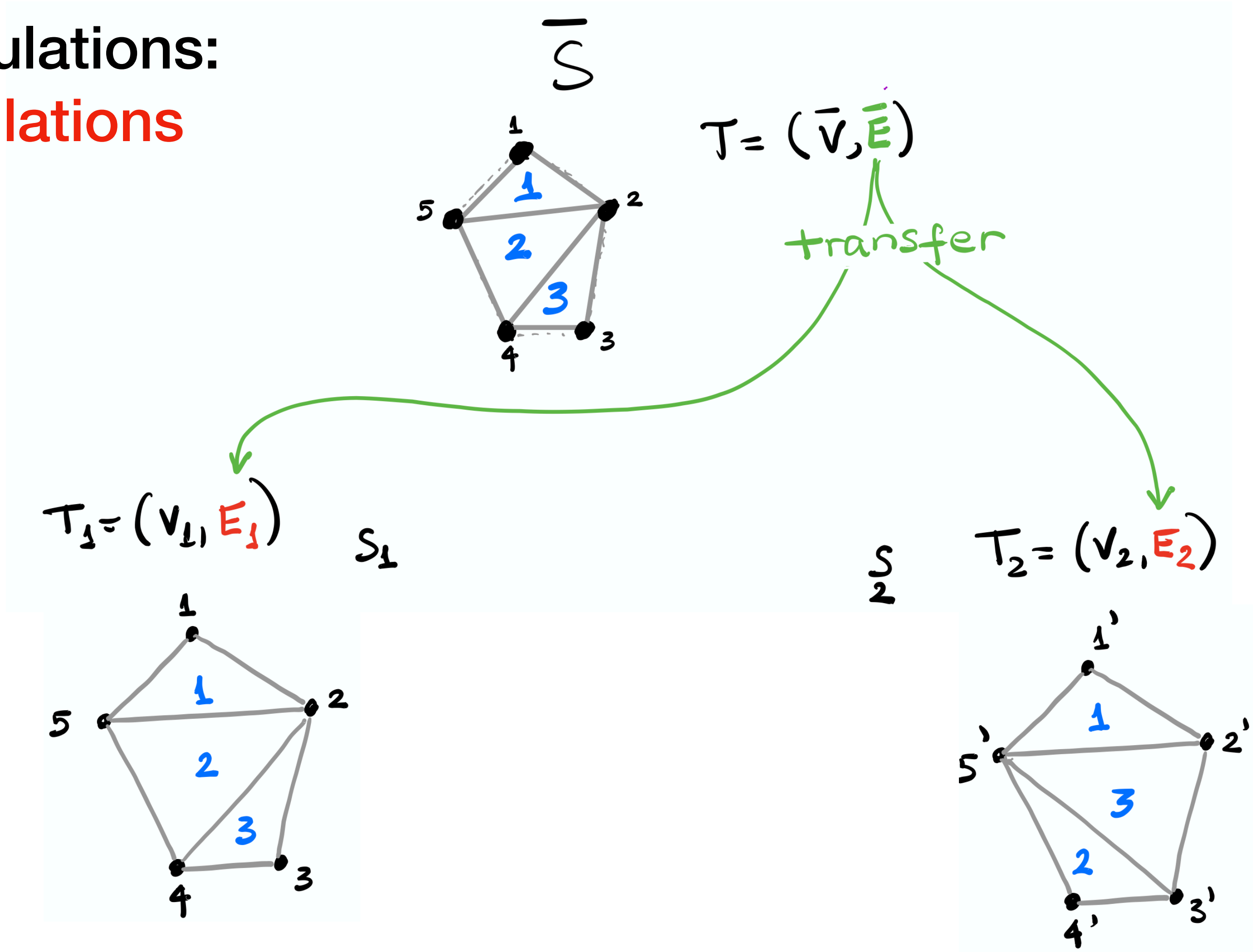
- **Use the mean triangulation:** The triangulation of the mean shape is the one most similar (statistically) to all shapes.

Inconsistent triangulations: transferring triangulations



- Transfer the edges. Keep the vertices

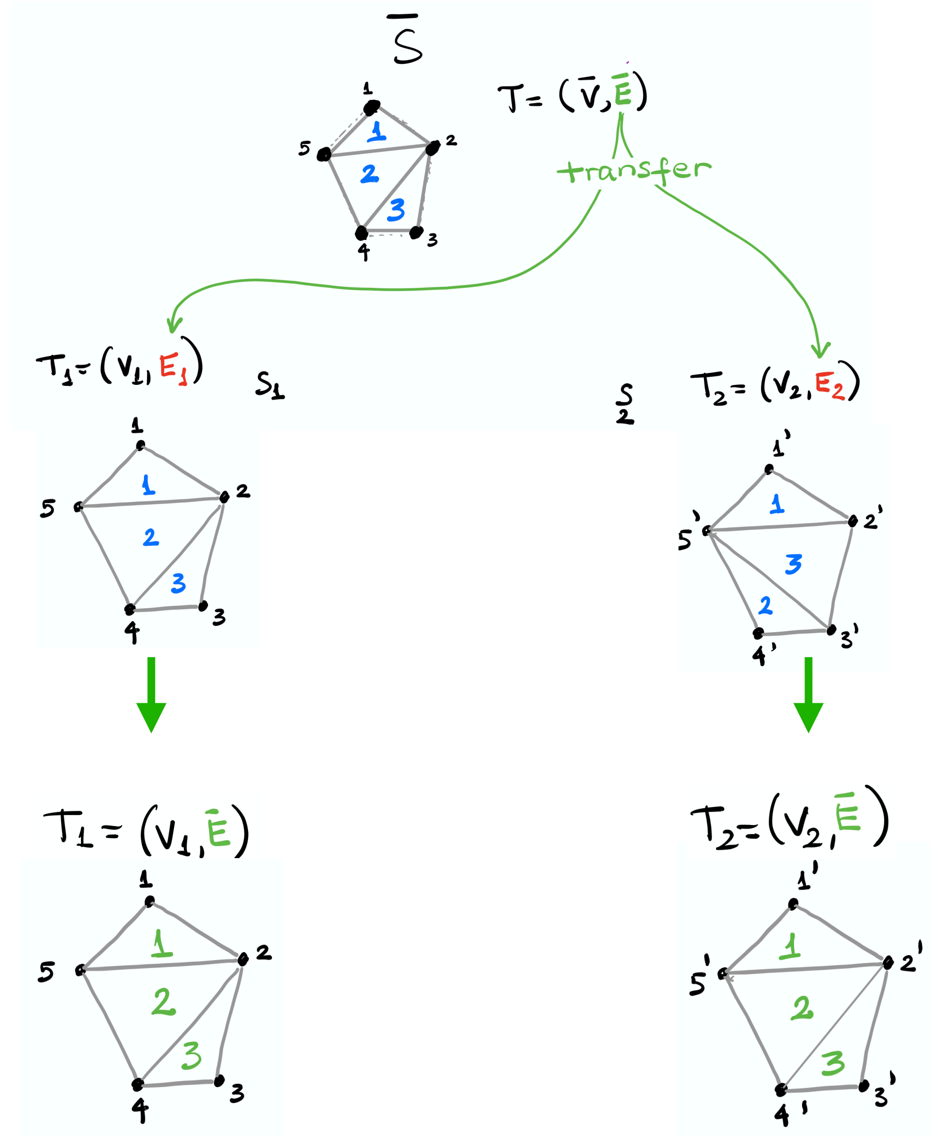
Inconsistent triangulations:
transferring triangulations



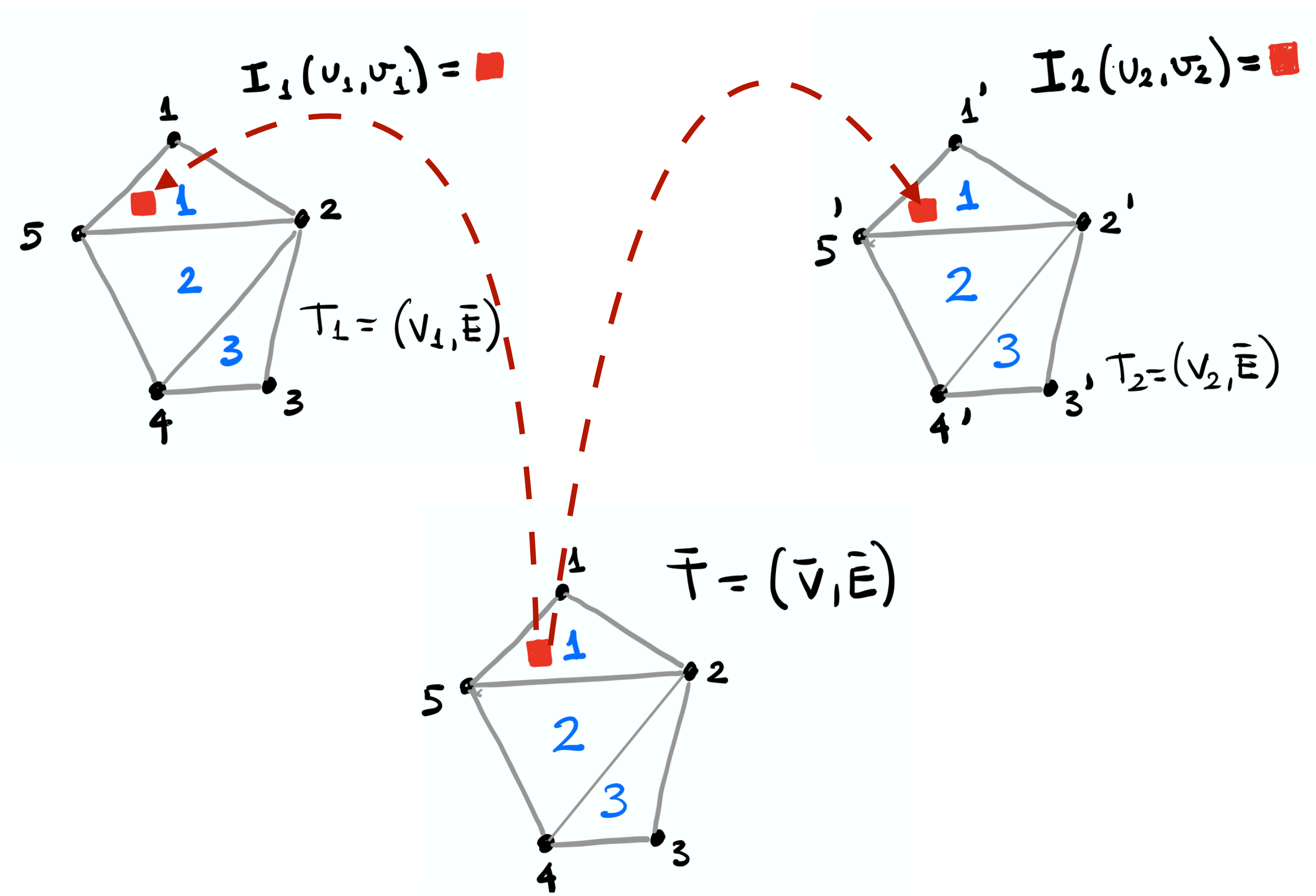
- Transfer the edges. Keep the vertices

Inconsistent triangulations: transferring triangulations

- Transfer the edges. Keep the vertices
- Once all triangulations are consistent, we can calculate the required affine transformations between pairs of corresponding triangles



Morphing: example with two triangulations

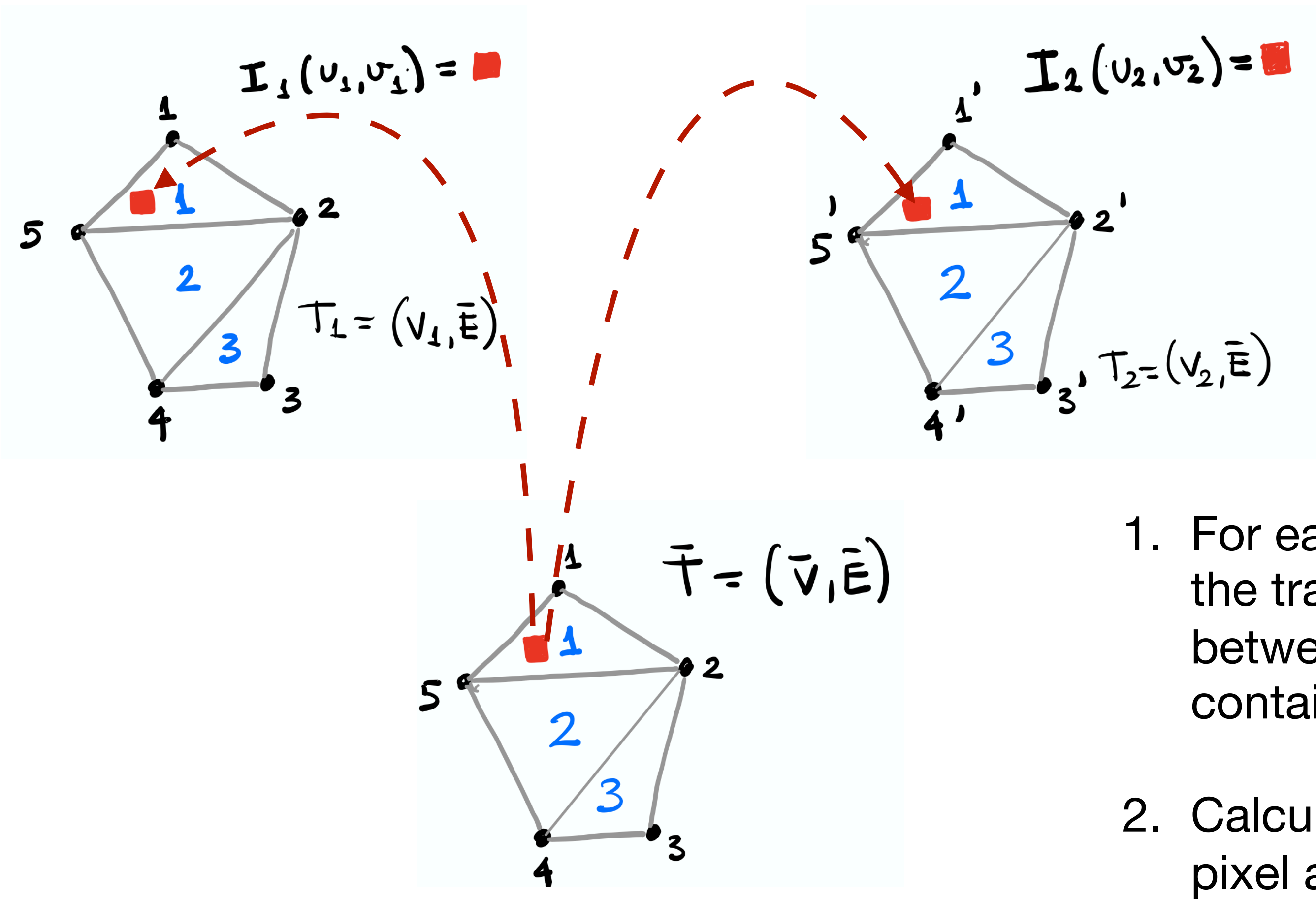


$$\bar{I}\,(x,y) = (1-\alpha)\,I_1\,(u,v) + \alpha I_2\,(u,v)$$

- Source triangulations and images

- Destination triangulation and image

Morphing: example with two triangulations

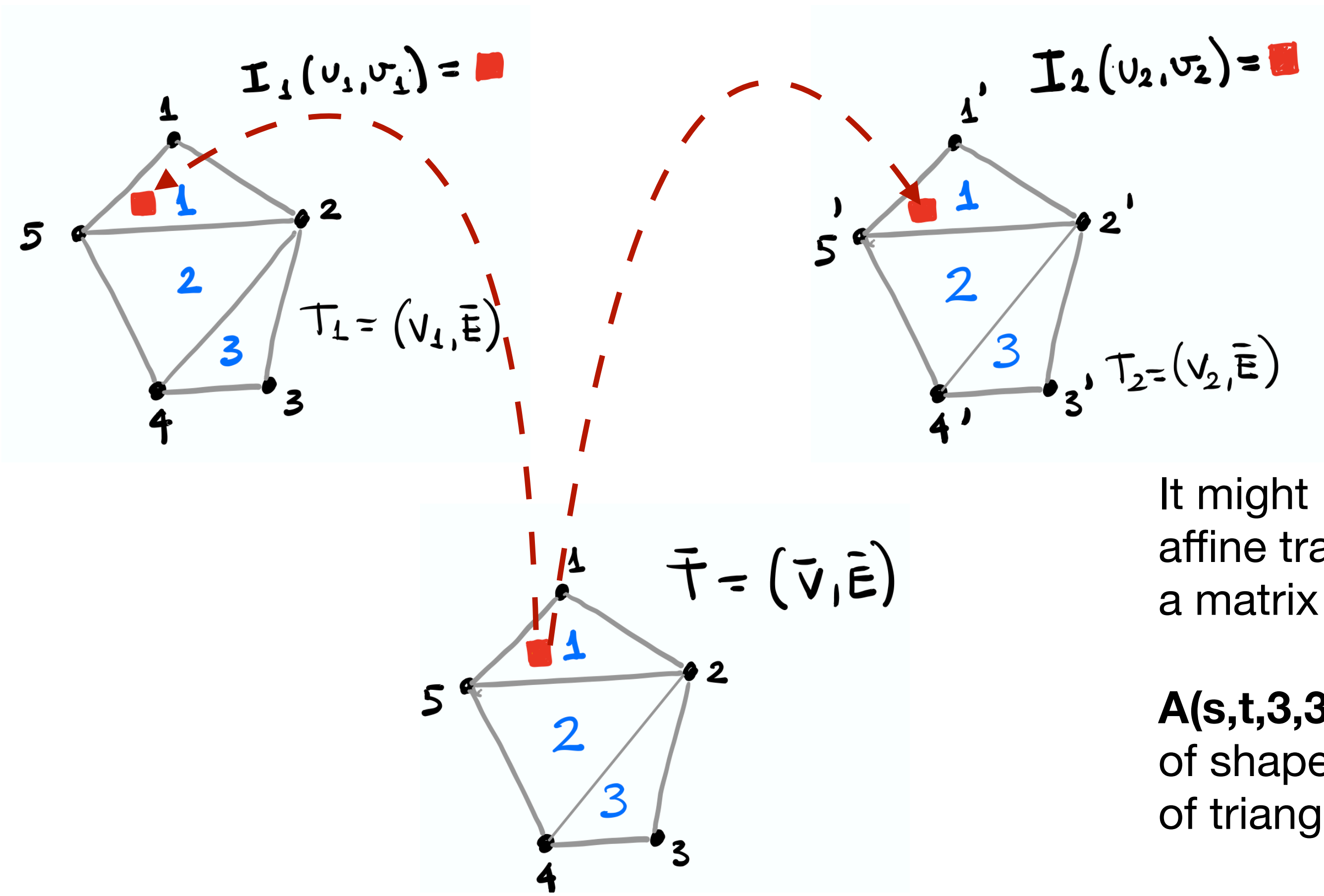


1. For each pixel (x,y) of dst image, find the transformation (i.e., affine between the corresponding triangles containing that pixel.

2. Calculate the color of the destination pixel at (x,y) as a blend of its corresponding pixels (u,v)

$$\bar{I}\left(x,y\right)=\left(1-\alpha\right)I_1\left(u,v\right)+\alpha I_2\left(u,v\right)$$

Morphing: example with two triangulations



$$\bar{I}\left(x,y\right)=\left(1-\alpha\right)I_1\left(u,v\right)+\alpha I_2\left(u,v\right)$$

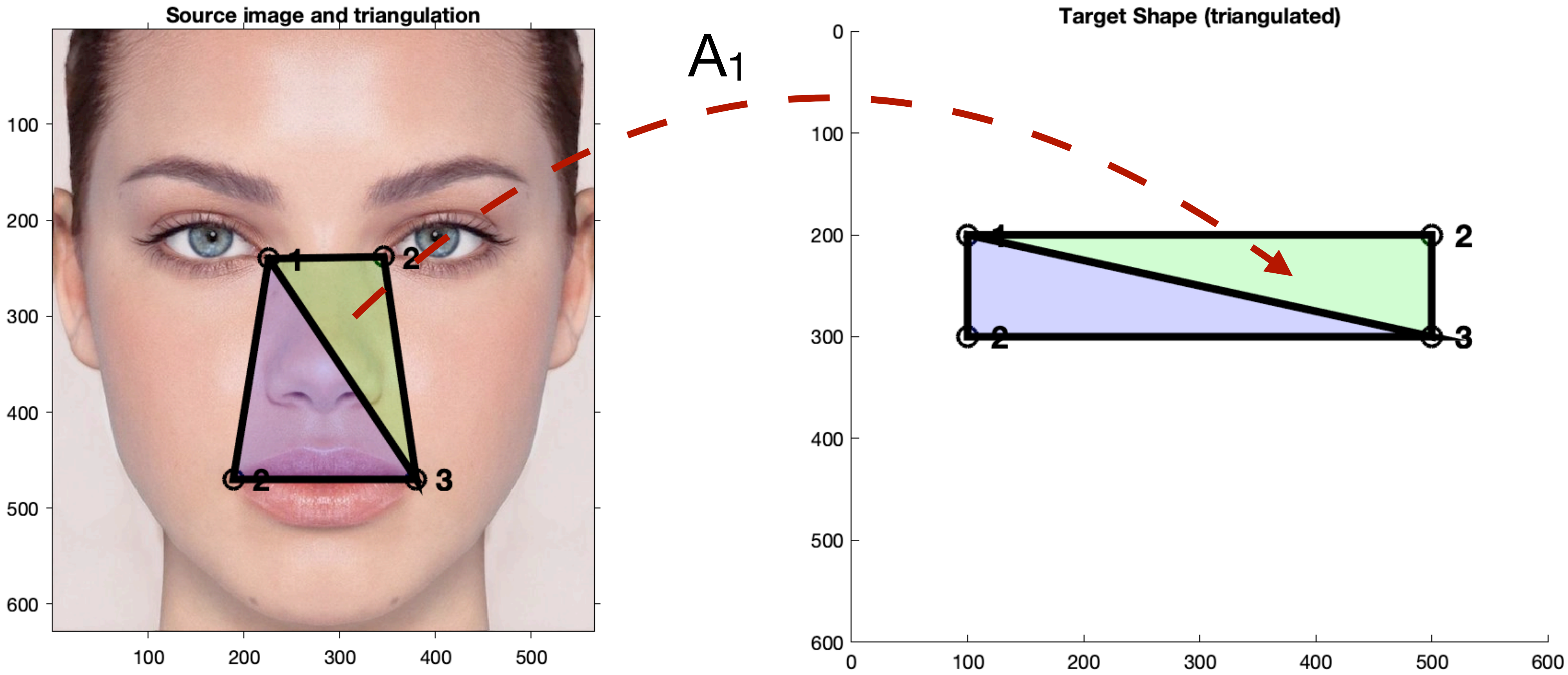
It might be helpful to pre-calculate all affine transformations and store them into a matrix or an indexed data structure, e.g.:

A(s,t,3,3) where s varies from 1 to number of shapes, and t varies from 1 to number of triangles.

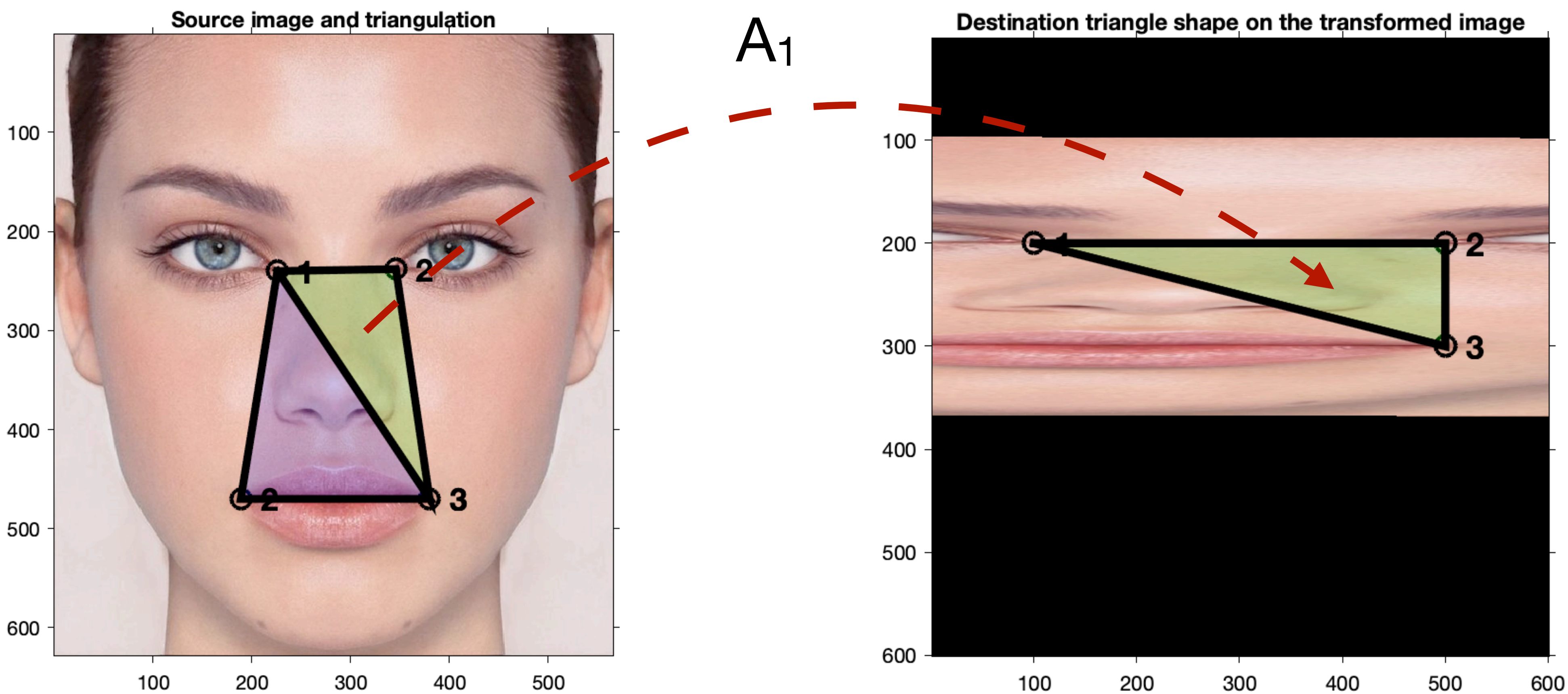
T(s,t).A where A is a 3x3 matrix, s is the shape index and t is the triangle index.

Example

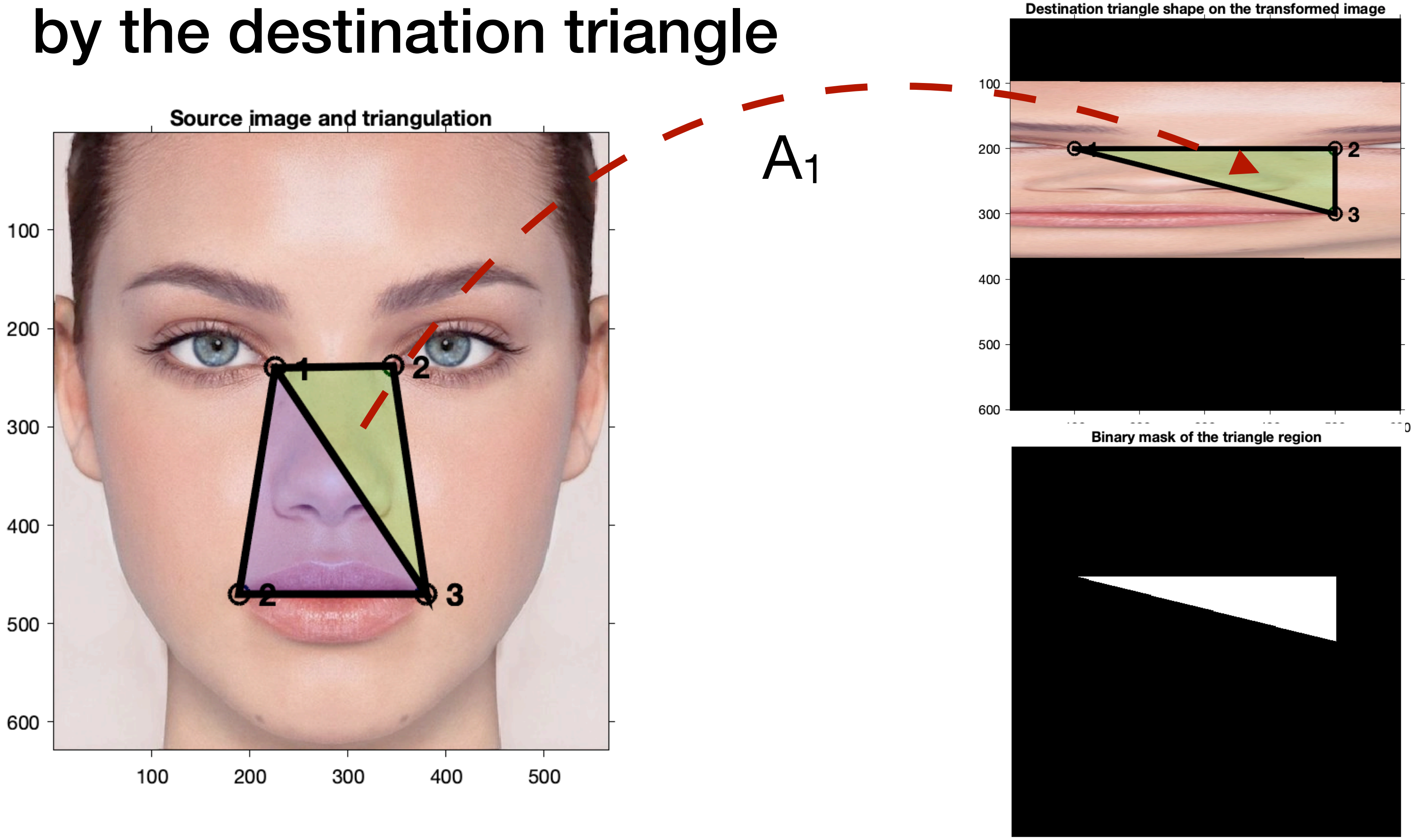
1. Calculate the affine transformation, A, between corresponding triangles



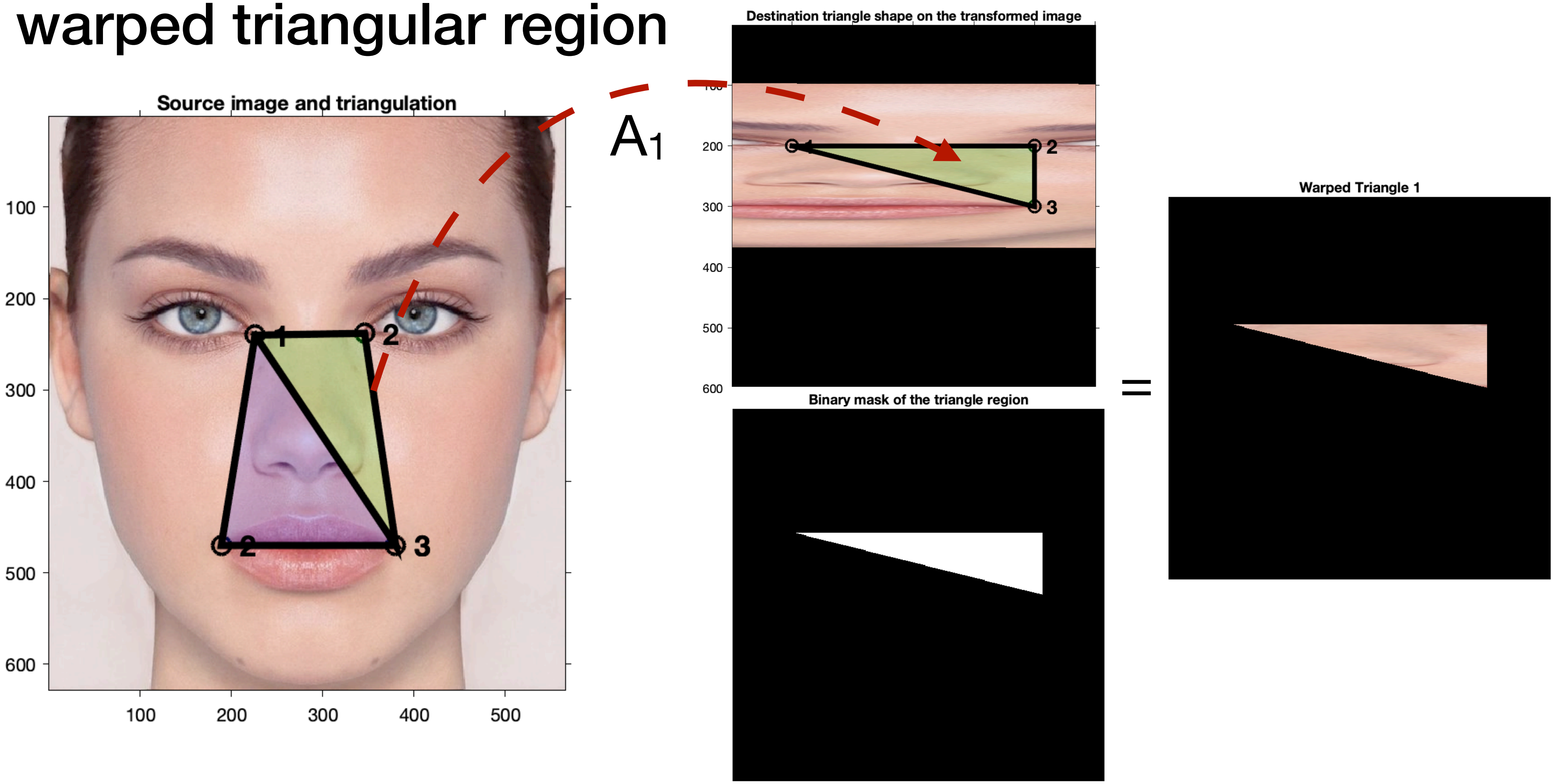
2. Warp the whole image using transformation A



3. Create a binary mask for the image region enclosed by the destination triangle



4. Multiply the mask by the warped image to get the warped triangular region



5. Repeat the process for each corresponding triangle pair incrementally building the final image