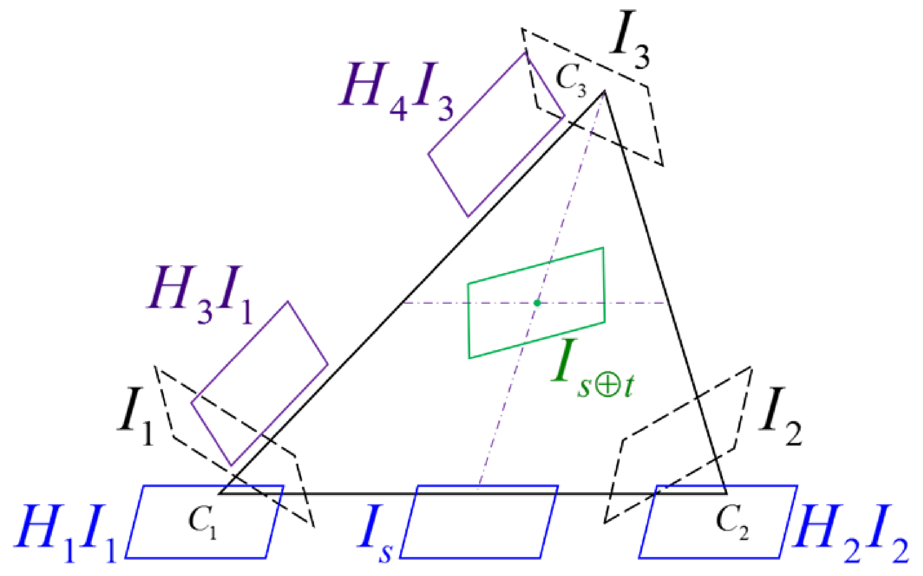
NANJING UNIVERSITY

REAL-TIME WALKTHROUGH OF OUTDOOR SCENES USING TRI-VIEW MORPHING

Qianqian Li, Yu Zhou, Yao Yu, Sidan Du, Ziqiang Wang
Nanjing University, China

Motivation

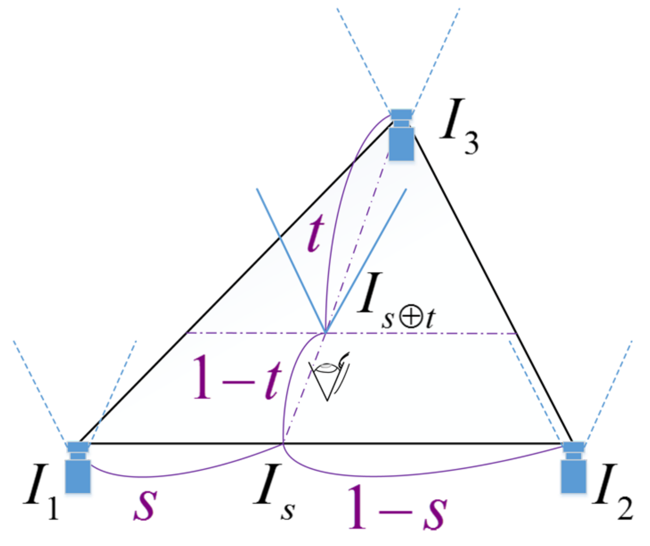

- The traditional two-step view morphing can not run at real time.
  - Morphing two images at a time.
  - Morphing the in-between image with the third image.
- Other image-based rendering techniques are not able to navigate at an interactive rate due to expensive computations.
  - Light field and Lumigraph.
  - Uncalibrated point transfer techniques.
- Real-time tri-view morphing
  - Extend traditional two-step view-morphing to tri-view morphing based on epipolar constraint.
  - Cope well with both complex outdoor scenes and wide baseline images.



A triple of images are the minimum unit for our algorithm.
Our method is implemented as three steps: *pre-warping*, *morphing* and *post-warping*.

Algorithm Overview

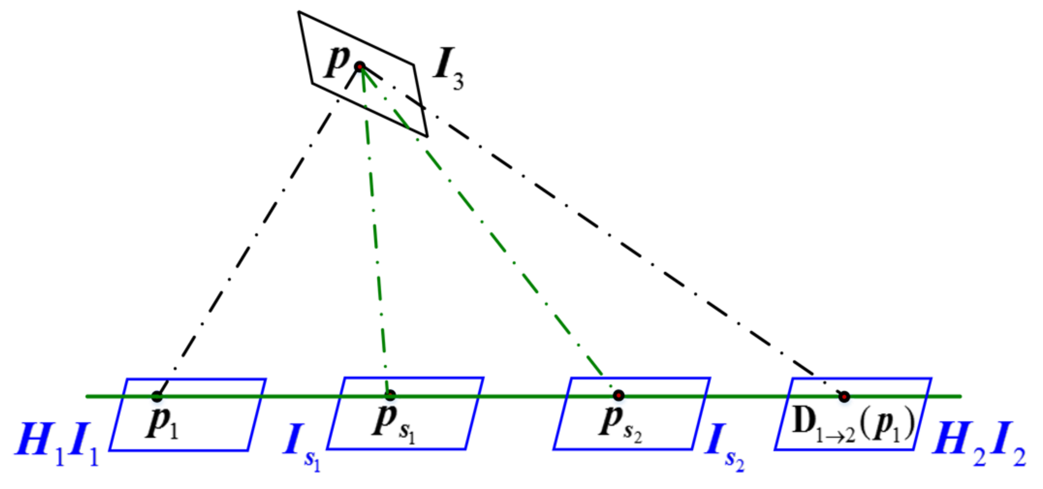
Two-step view morphing:



$$I_s = (1-s)\mathbf{H}_1 I_1 + s\mathbf{H}_2 I_2$$
$$= (1-s)\mathbf{H}_1 I_1 + s\mathbf{D}_{1\to 2}(\mathbf{H}_1 I_1)$$

$$\mathrm{I}_{s\oplus t} = (1-t)\mathbf{H}_6{}^s I_3 + t\mathbf{H}_5{}^s I_s$$
$$= t(1-s)\mathbf{H}_5{}^s\mathbf{H}_1 I_1$$
$$+st\mathbf{H}_5{}^s\mathbf{D}_{1\to 2}(\mathbf{H}_1 I_1)$$
$$+(1-t)\mathbf{H}_6{}^s\mathbf{H}_4{}^{-1}\mathbf{D}_{1\to 3}(\mathbf{H}_3 I_1)$$

Real-time tri-view morphing:



In the case of two image planes are parallel to each other, the epipolar lines of two images are horizontal. Following parallel-image epipolar constraint, we obtain:

$$p^T\mathbf{F}p_{s_1} = 0$$
$$p^T\mathbf{F}p_{s_2} = p^T\mathbf{F}(p_{s_1} + (\mathrm{s}_2 - \mathrm{s}_1)(\mathbf{D}_{1\to 2}(p_1) - p_1))$$
$$= (\mathrm{s}_2 - \mathrm{s}_1)\, p^T\mathbf{F}[\sigma \quad 0 \quad 0]^T = 0$$

So $I_{s\oplus t}$ can be written as $I_{s\oplus t} = t(1-s)\hat{I}_1 + st\hat{I}_2 + (1-t)\hat{I}_3$

Where

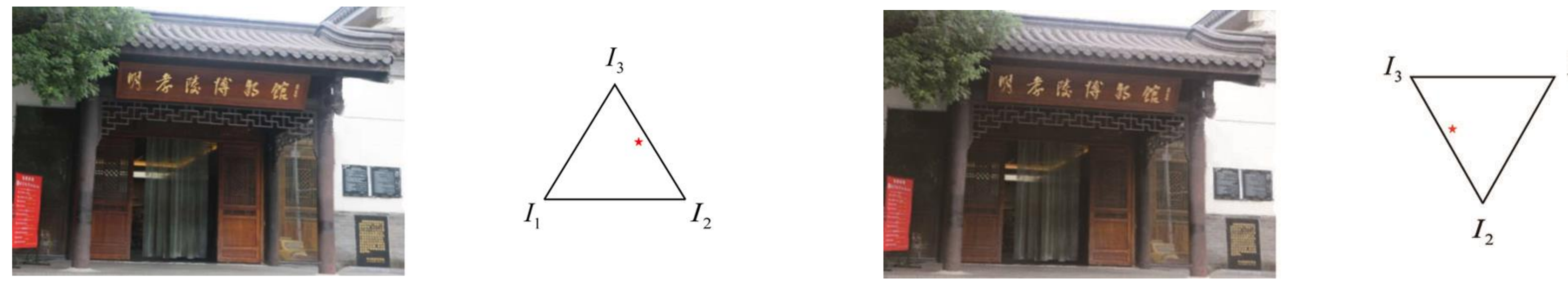
$$\hat{I}_1 = \mathbf{H}_5\mathbf{H}_1 I_1$$
$$\hat{I}_2 = \mathbf{H}_5\mathbf{D}_{1\to 2}(\mathbf{H}_1 I_1)$$
$$\hat{I}_3 = \mathbf{H}_6\mathbf{H}_4{}^{-1}\mathbf{D}_{1\to 3}(\mathbf{H}_3 I_1)$$

Post-warping:

We extend a two-image post-warp algorithm to work with three images and yield the normal view.

Experimental Results

Results of images taken with a hand-held digital camera. The first row are four uncalibrated sample images. The second row are a series of synthesized virtual views.



Results of automatic transition between triples to create a long smooth walkthrough.

Results of wide baseline images. The first row are three wide baseline sample images. The second row are a series of synthesized virtual views.