# High-Resolution Panoramas Using Image Mosaicing

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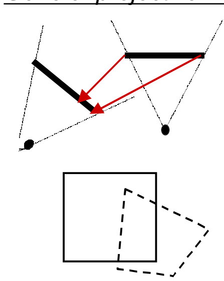
## Intro: Projective Geometry

- Goal is to stitch together many shots to get a wide-angle panorama.
- Need to define a model for the camera and its motion
- We restricted ourselves to the case of a single view-point

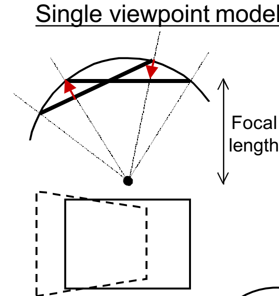
*General projective model*



8 parameters homogeneous transforms

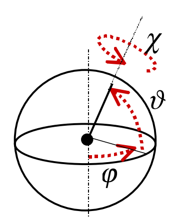
$$\begin{pmatrix}\hat{x}\\ \hat{y}\\ \hat{w}\end{pmatrix}=\begin{pmatrix}a&b&c\\ d&e&f\\ g&h&1\end{pmatrix}\begin{pmatrix}x\\ y\\ 1\end{pmatrix}\qquad \begin{cases}x'=\dfrac{\hat{x}}{\hat{w}}\\ y'=\dfrac{\hat{y}}{\hat{w}}\end{cases}$$

Single viewpoint model




3 parameter rotational transforms

$$\begin{pmatrix}x'\\ y'\\ z'\end{pmatrix}=R(\theta,\varphi,\chi)\begin{pmatrix}x\\ y\\ z\end{pmatrix}$$

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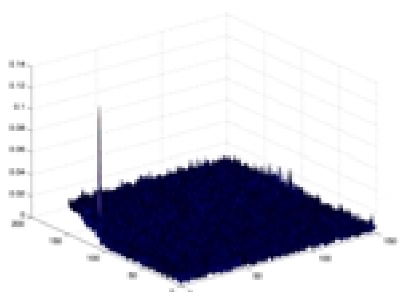
# Registration

## Registration: Phase Correlation

• Remember translation theorem: The Fourier transforms of translated images are related by

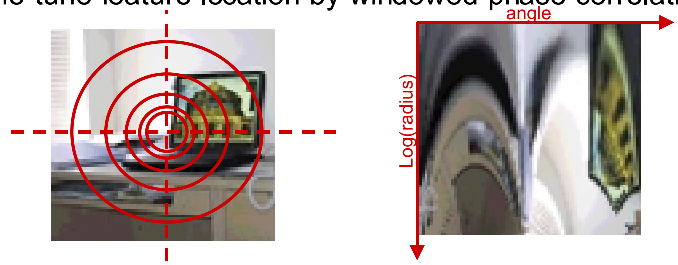
$$F_2(\omega_x,\omega_y) = e^{-j2\pi(\omega_x x_0 + \omega_y y_0)} F_1(\omega_x,\omega_y)$$

$$\Rightarrow \frac{F_1(\omega_x,\omega_y)F_2^*(\omega_x,\omega_y)}{|F_1(\omega_x,\omega_y)F_2(\omega_x,\omega_y)|} = e^{j2\pi(\omega_x x_0 + \omega y_0)} \overset{IDFT}{\leftrightarrow} \delta(x + x_0, y + y_0)$$



## Registration: **Feature-Based**

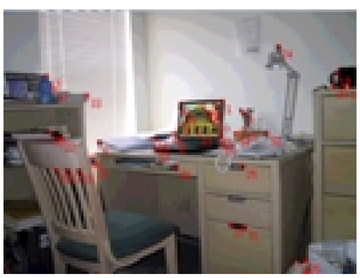
- Locate a number of features in both images
  Using the Harris corner detector with the Deriche gradient
- Find best matching features
  Comparing pairwise correlations of polar-parametrized windows.
- Compute 8-parameter transform from the feature locations
  Which requires 4 pairs of matching points .
- Fine-tune feature location by windowed phase correlation

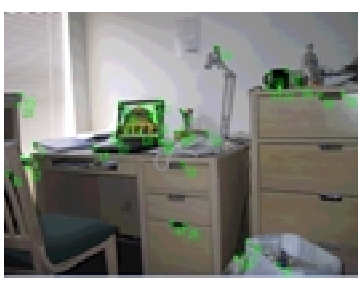


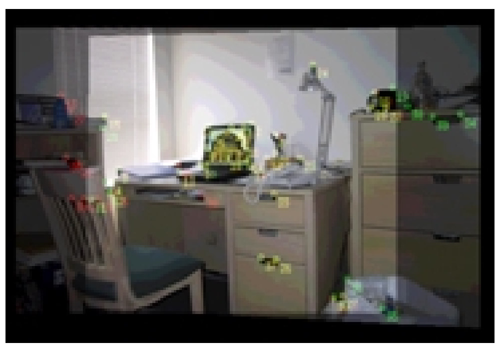

**Polar parametrized windows:** *rotation and scale turned into shifts*




## Registration: **Feature-Based**





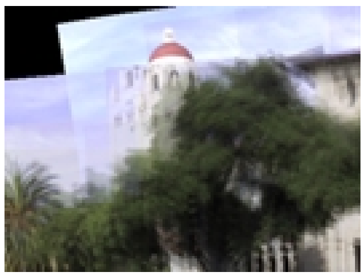


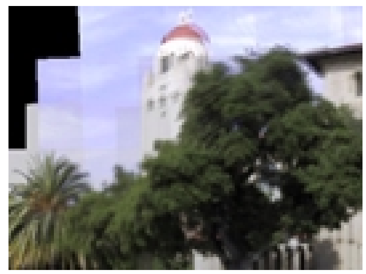
## Registration: Global Registration

- We have possibly $\binom{n}{2}$ different registrated image pairs
- In general a highly overdetermined equation system:

$$P_i = A_{ij} P_j \quad \forall i, j$$

  – With P absolute rotation matrices, A relative rotation matrix
- Solve in a least squares sense to yield optimum solution:





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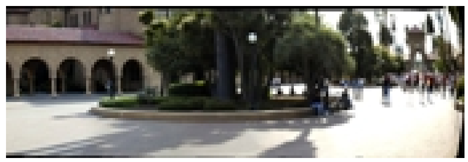
# Composing

## Composing: Projection

- Once we know each image's rotation matrix, we can project on arbitrary geometries:
  - Planar

  - Spherical

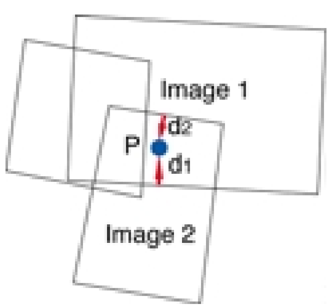


  - Angular




## Composing: Blending

- Problem: Smoothly blend over between images to hide seams
- Rather complicated math
- Instead: Use simple heuristic
  - Every pixel is weighted with the distance to the closest image boundary to the nth power




$$f(P) = \frac{d_1^{\,n} f_1(P) + d_2^{\,n} f_2(P)}{d_1^{\,n} + d_2^{\,n}}$$

$$n = 3...4$$

## Composing: Blending

without blending

## Composing: Blending

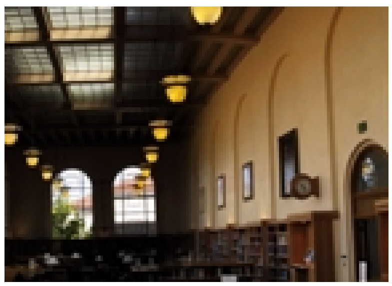
with blending

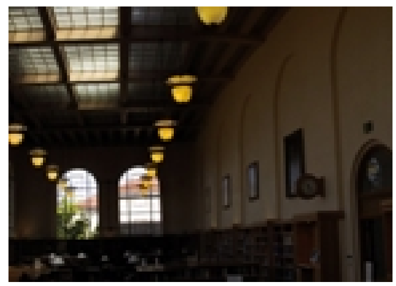
## Composing: Exposure Compensation

- Digital Cameras have automatic gain control, leads to different exposure levels in adjacent images
- Compensate by computing the mean luminance for each image in the overlap area, derive a relative gain
- Run all the relative gains through the least-squares global optimizer and adjust the image brightness in the composing step

without compensation

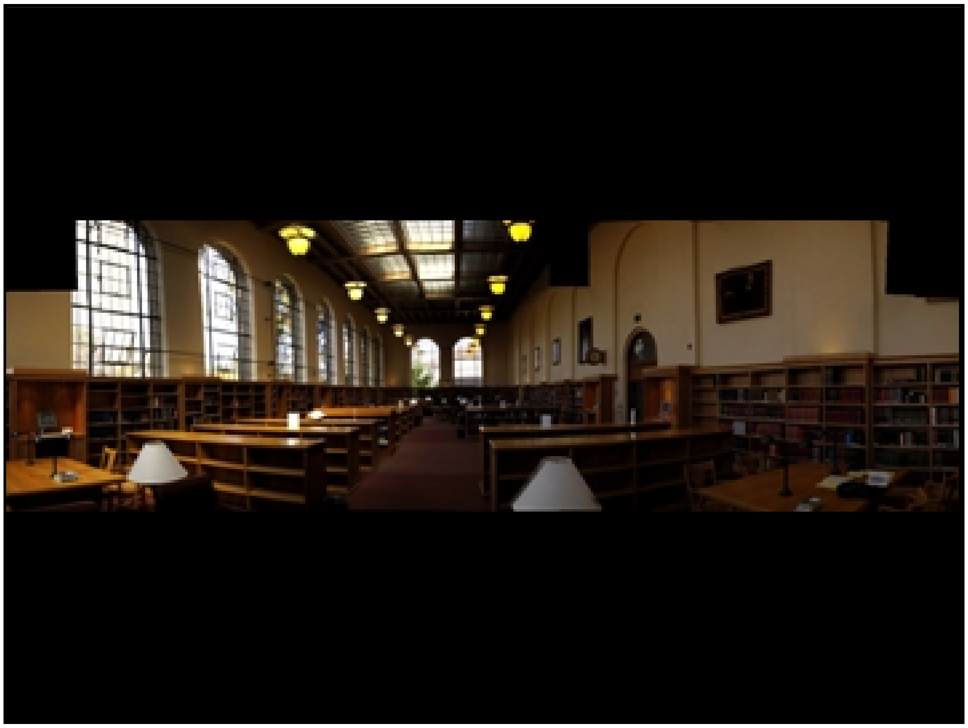


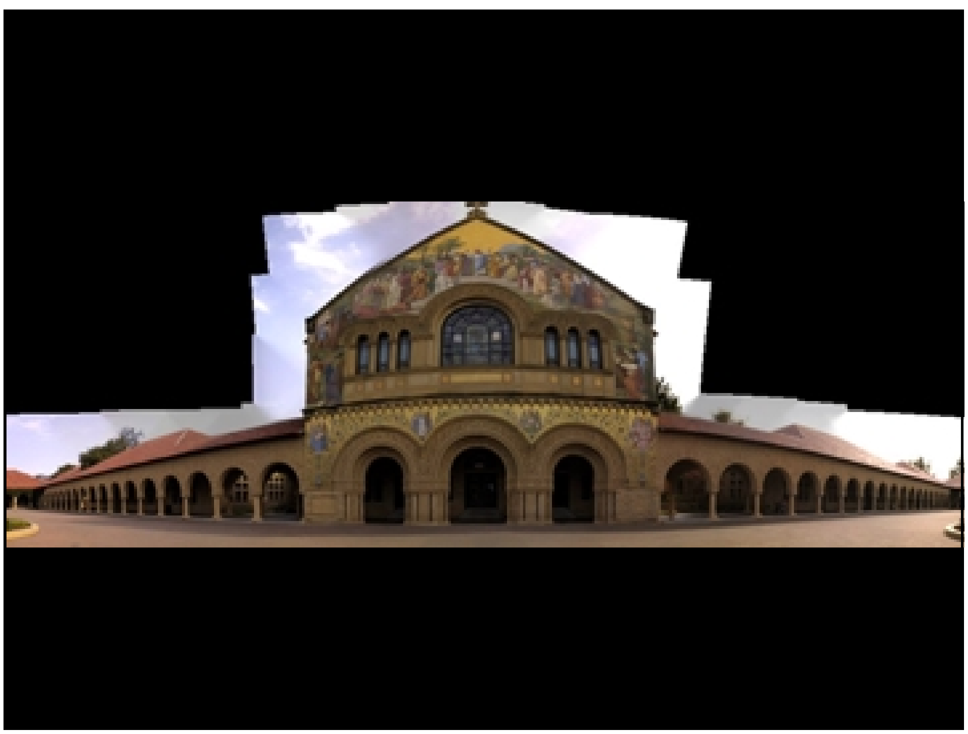
with compensation






## Examples



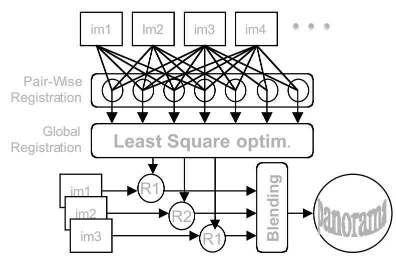


# Examples: The Quad - QTVR

# Conclusion

We implemented a **spherical panorama image mosaic generator**, whose general framework is shown on the following figure:




We compared two different methods for pair-wise image registration

- ***Phase-correlation*** *is fast and reliable for cases where rotation and projective distortion between images are small.*
- ***Feature-based*** *registration is capable of handling any kind of projective transform, but is sensible to noise and significantly slower*

Performance of our C implementation (on UNIX machines) :

- ***Registration*** *of 50 images (1225 pairs) is taking around 2 mins with phase correlation and 10 mins with feature-based registration.*
- ***Blending*** *images into a screen-size panorama takes approximately 1 min.*

## The End

# Thank You

# Q & A

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