

# Medical Image Processing for Interventional Applications

## Feature Detectors

Online Course – Unit 10

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Pattern Recognition Lab (CS 5)

# Topics

## Feature Detectors

Initial Considerations

Harris Corner Detector

## Summary

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## Feature Detectors

*How to identify distinctive locations efficiently?*

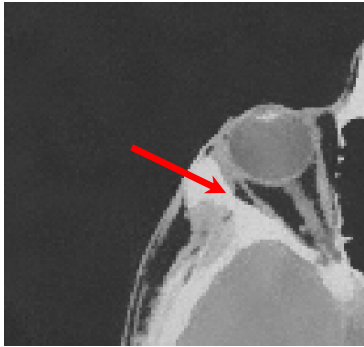


intensity profile

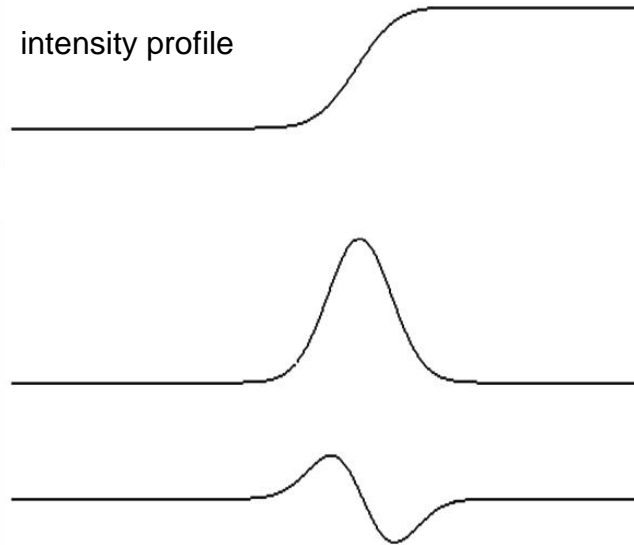


# Feature Detectors

*How to identify distinctive locations efficiently?*



- First order derivatives
- Second order derivatives
- Structure tensor, Hessian matrix



# Feature Detectors: Benchmark Study by [Schmid, Mohr, and Bauckhage \(2000\)](#)

*Which one to choose?*

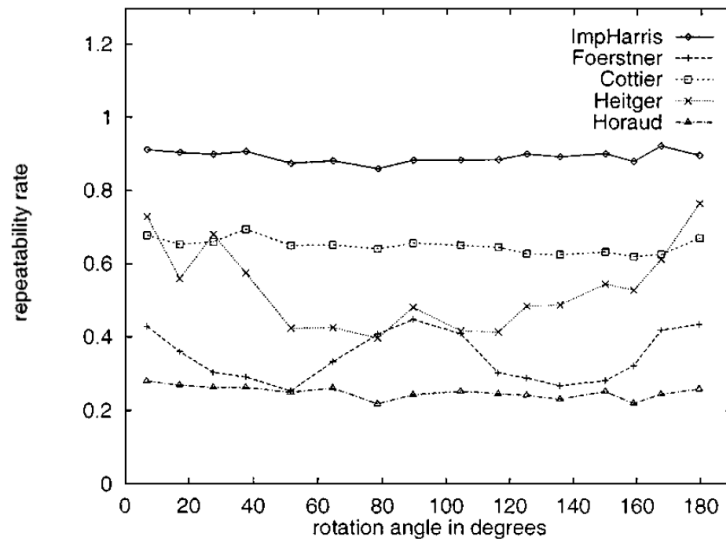


Figure 2: **Rotation** invariance

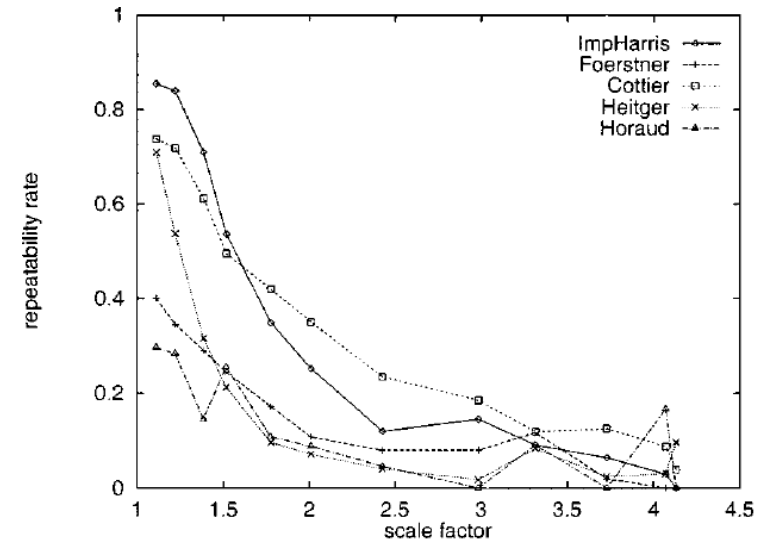


Figure 3: **Scale** invariance

# Feature Detectors: Benchmark Study by [Schmid, Mohr, and Bauckhage \(2000\)](#)

*Which one to choose?*

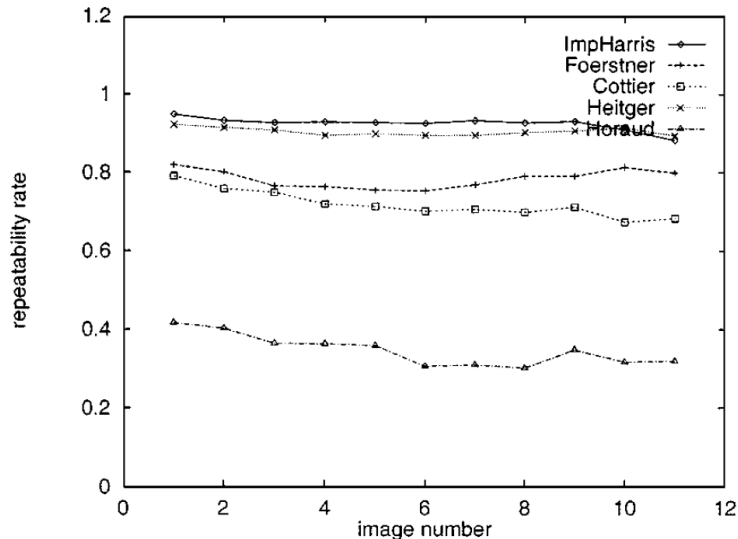


Figure 4: **Illumination** invariance

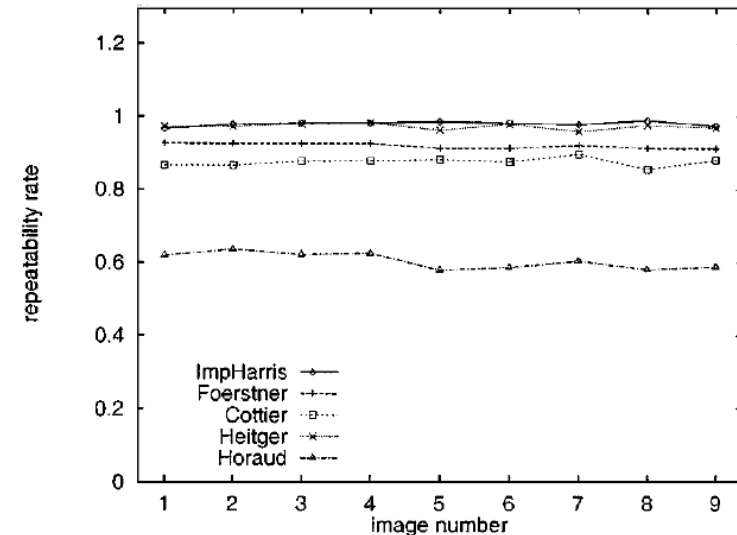


Figure 5: **Noise** invariance

# Harris Corner Detector

Basic idea ([Harris and Stephens, 1988](#)): A corner point should have large intensity changes in all directions.

Gradient approximation:

$$\mathbf{g}(x, y) = \nabla f(x, y) = \begin{pmatrix} f_x(x, y) \\ f_y(x, y) \end{pmatrix}$$

Structure tensor (autocorrelation):

$$\begin{aligned} \mathbf{G}(x, y) &= \sum_{i=-k}^k \sum_{j=-k}^k w(x, y) \mathbf{g}(x+i, y+j) \mathbf{g}^T(x+i, y+j) \\ &= \sum_{i=-k}^k \sum_{j=-k}^k w(x, y) \begin{bmatrix} (g_x(\dots))^2 & g_x(\dots)g_y(\dots) \\ g_x(\dots)g_y(\dots) & (g_y(\dots))^2 \end{bmatrix} \end{aligned}$$

# Harris Corner Detector

Eigenvectors and eigenvalues of structure tensor  $\mathbf{G}$  describe predominant directions of the gradient:

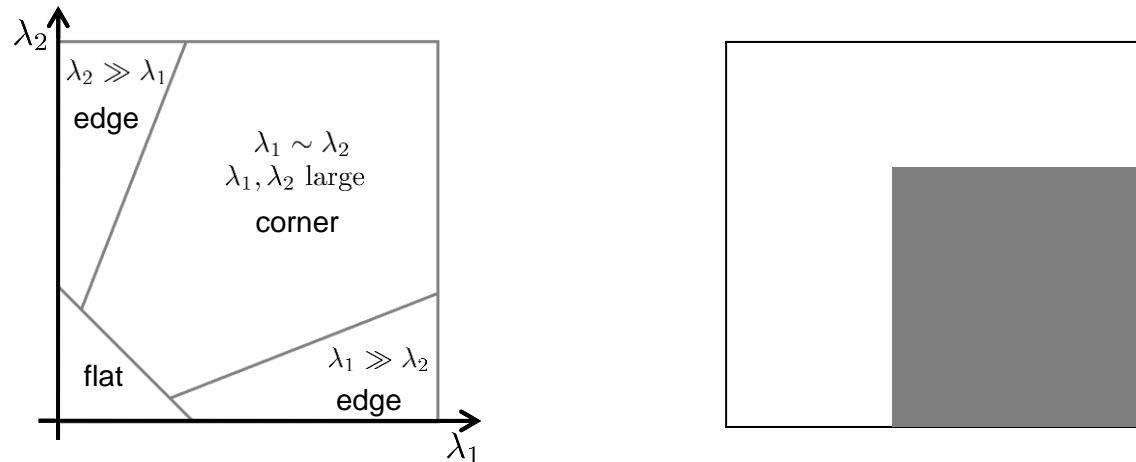


Figure 6: Schematic of relationship between feature categories and eigenvalues (left), example image with a corner, edges and flat areas (right)



# Harris Corner Detector

Eigenvectors and eigenvalues of structure tensor  $\mathbf{G}$  describe predominant directions of the gradient:

$$H(x, y) = \det(\mathbf{G}(x, y)) - \frac{1}{3} \left( \text{tr}(\mathbf{G}(x, y)) \right)^2$$

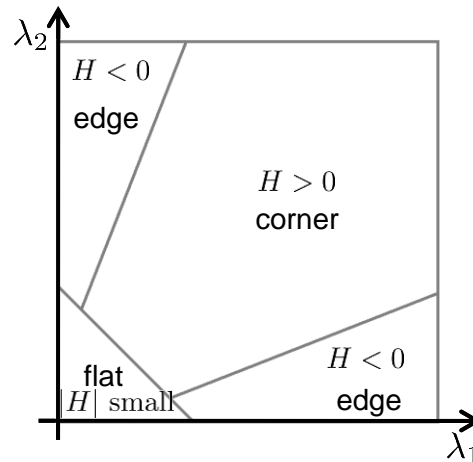


Figure 7: Structure described by value of  $H$  (left), example image with a corner, edges and flat areas (right)

# Harris Corner Detector

Eigenvectors and eigenvalues of structure tensor  $\mathbf{G}$  describe predominant directions of the gradient:

$$H(x, y) = \det(\mathbf{G}(x, y)) - \nu \left( \text{tr}(\mathbf{G}(x, y)) \right)^2 = \lambda_1 \lambda_2 - \nu (\lambda_1 + \lambda_2)^2$$

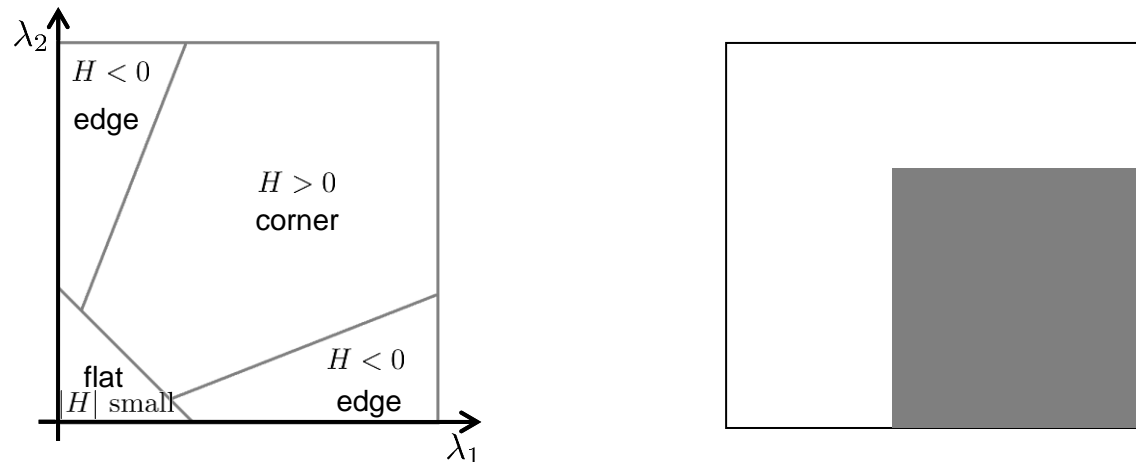


Figure 7: Structure described by value of  $H$  (left), example image with a corner, edges and flat areas (right)

## Harris Corner Detector: Workflow

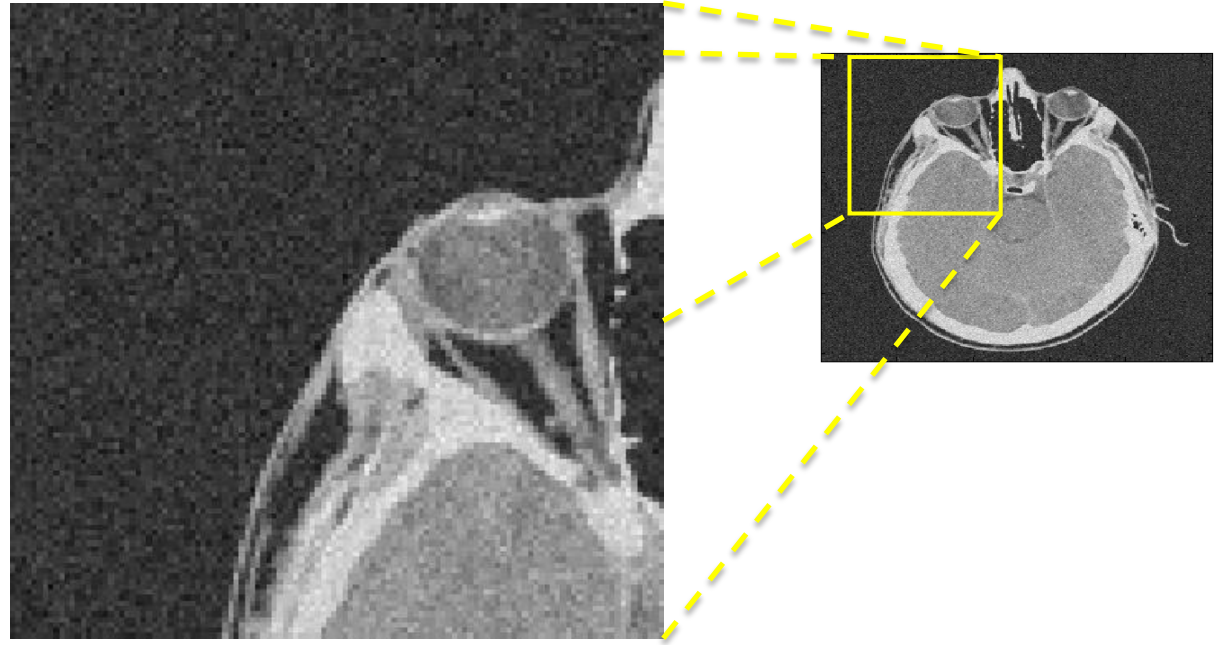


Figure 8: What about noise?

## Harris Corner Detector: Workflow

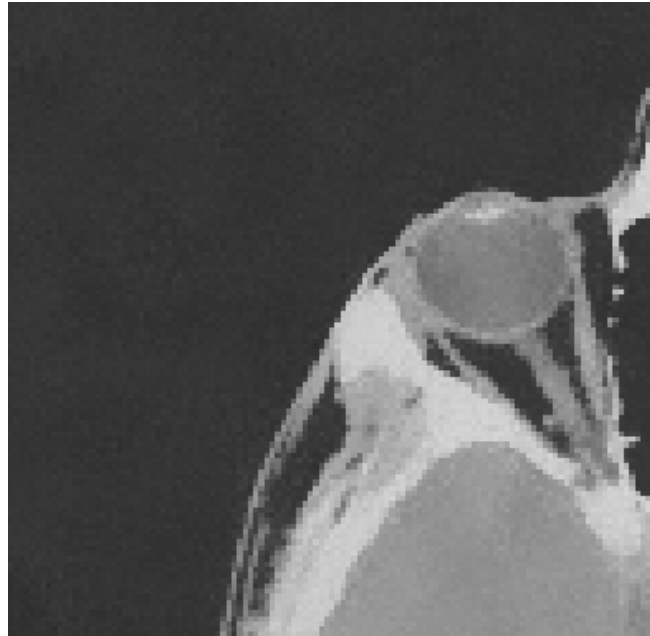


Figure 9: Edge-preserving denoising

## Harris Corner Detector: Workflow

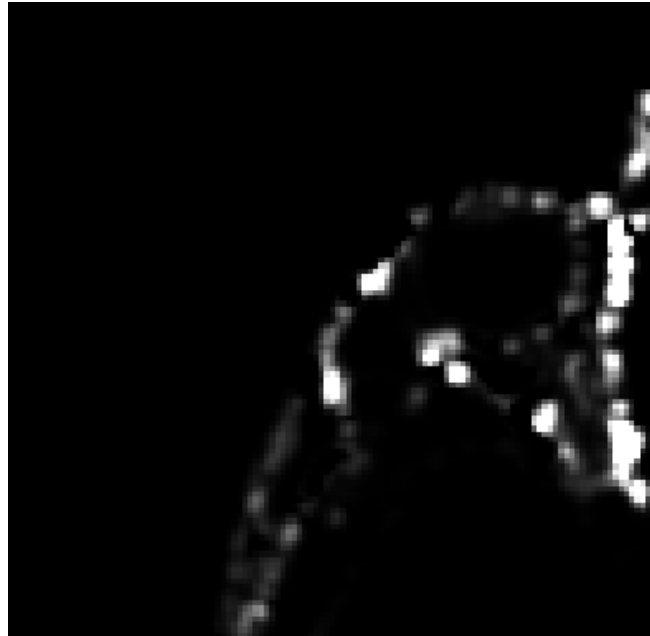


Figure 10: Corner response

## Harris Corner Detector: Workflow

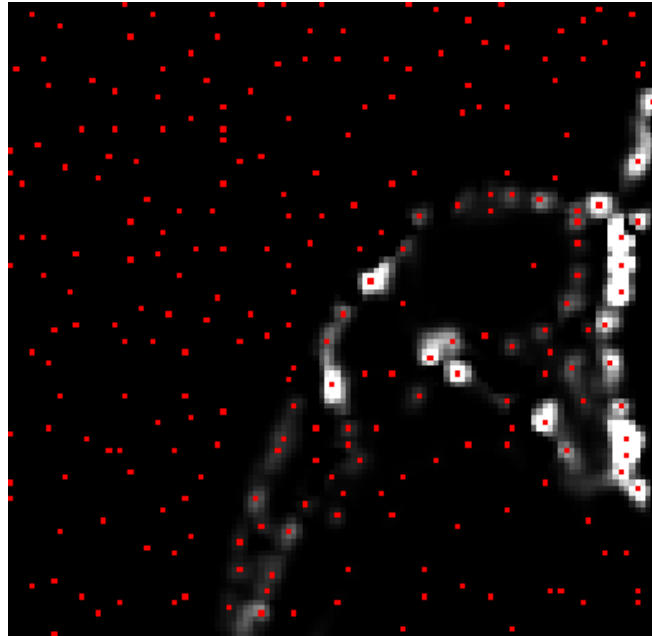


Figure 11: Corner localization, non-maximum suppression

## Harris Corner Detector: Workflow

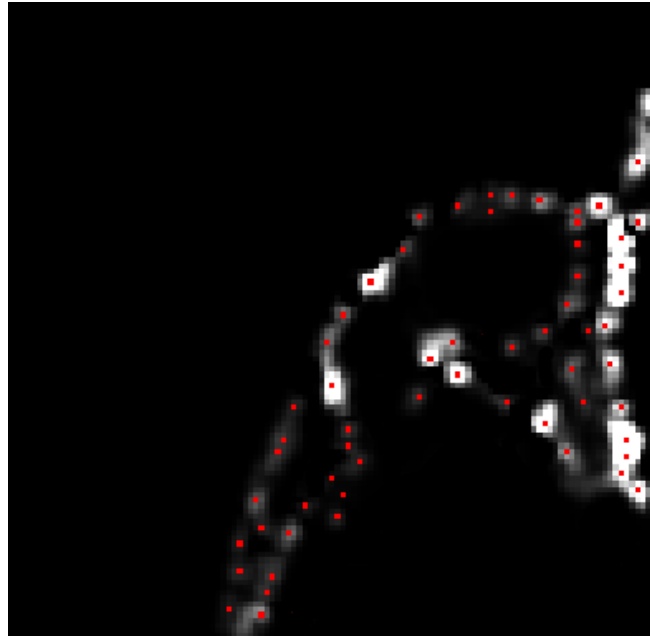


Figure 12: Corner selection

# Topics

## Feature Detectors

Initial Considerations

Harris Corner Detector

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Take Home Messages

Further Readings



## Take Home Messages

- An analysis of the derivatives in an image yields important information to build a feature detector.
- Best choose features which are invariant to certain transformations.
- The Harris corner detector utilizes the structure tensor to determine image points to be corners, edges or rather part of flat and homogeneous areas.

### Credits:

We acknowledge the contributions of F.F. Li, E. Angelopoulou, D. Lowe, and A. Berg for their material in units 9-14 (on feature detectors/descriptors).

## Further Readings

- Cordelia Schmid, Roger Mohr, and Christian Bauckhage. “Evaluation of Interest Point Detectors”. In: *International Journal of Computer Vision* 37.2 (June 2000), pp. 151–172. DOI: 10.1023/A:1008199403446
- Chris Harris and Mike Stephens. “A Combined Corner and Edge Detector”. In: *Proceedings of Fourth Alvey Vision Conference*. 1988, pp. 147–152