CVPR2012 Providence, RI, USA

PCL :: Keypoint Detection

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Overview

Goal for today:

Introducing 2 new Feature Detectors in PCL

- Harris 3D/5D

- AGAST

Adaptive and Generic Corner Detection Based on the Accelerated Segment Test
E. Mair, G. D. Hager, D. Burschka, M. Suppa, G. Hirzinger

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Harris 3D/5D

How does Harris 2D work?

Find local patches where the SSE is high for small shifts $(\Delta x, \Delta y)$

$$c(x,y) = \sum_W (I(x_i, y_i) - I(x_i + \Delta x, y_i + \Delta y))^2$$
$$= (\Delta x, \Delta y) \cdot C \cdot (\Delta x, \Delta y)^T$$

C: Covariance Matrix of local image gradients

with

$$C = \sum_{i \in W} D_i \cdot D_i^T$$

D_i: image gradient at pixel (x_i, y_i)

Harris 3D/5D

How does Harris 2D work?

Find local patches where the SSE is high for small shifts $(\Delta x, \Delta y)$

$$C = \sum_{i \in W} D_i \cdot D_i^T$$

D_i: image gradient at pixel (x_i, y_i)

→ Corner if both eigenvalues of C are high

Harris 3D/5D

How does Harris 2D work?

Multiple ways of computing corner strength:

$$\text{Harris response} = det(C) - 0.04 \cdot trace(C) \cdot trace(C)$$

$$\text{Noble response} = \frac{det(C)}{trace(C)}$$

$$\text{Lowe response} = \frac{det(C)}{trace(C)^2}$$

$$\text{Tomasi response} = \lambda_{min}$$

Harris 3D/5D

How can we apply Harris on 3D data?

Replace gradients in Harris matrix by surface normals:

$$C = \sum_{i \in W} D_i \cdot D_i^T \longrightarrow C3D = \sum_{i \in W} N_i \cdot N_i^T$$

Image gradient

Surface normal

→ Corner is a point with the normals in its neighborhood pointing in different directions.

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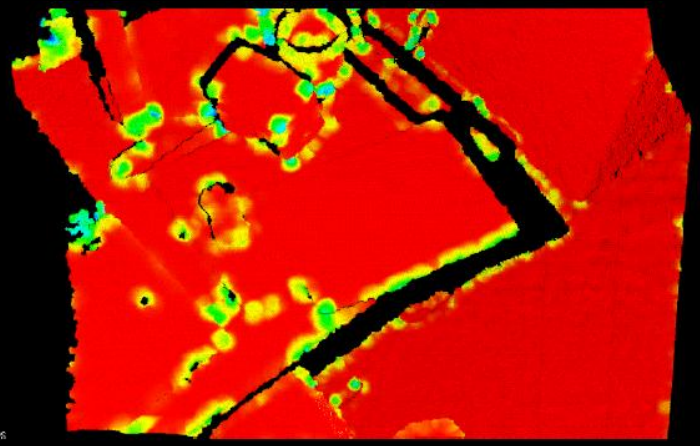
Harris 3D/5D

Results on Harris 3D:



Disadvantage:

- does only detect 3D corners
- ignores strong corners in texture

Harris 3D/5D

Solution: Harris 5D (actually Tomasi 5D)

Extend surface normals by intensity gradients:

$$G_i = (N_i^T, D_i^T)^T = (N_x, N_y, N_z, D_x, D_y, D_z)$$

→ 6D space, but only 5 degrees of freedom

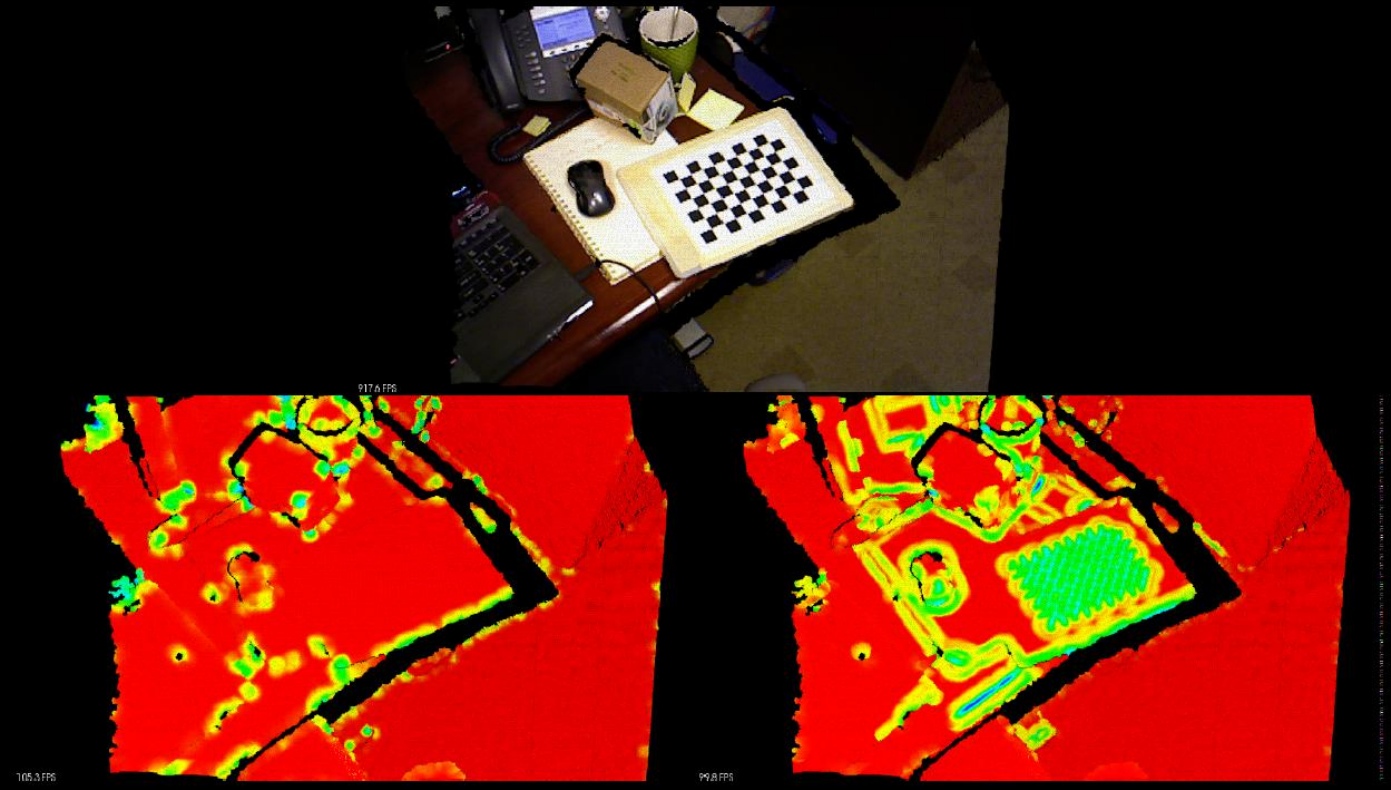
Corner Response:

3rd largest eigenvalue of Harris matrix

$$C6D = \sum_{i \in W} G_i \cdot G_i^T$$

Harris 3D/5D

Results on Harris 3D vs. 5D:



Harris 3D

Harris 5D

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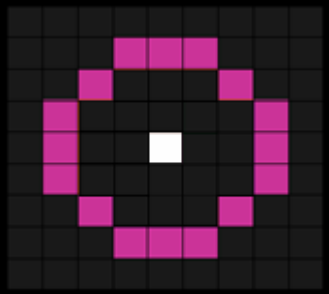
How can we detect keypoints really, really fast?

→ Accelerated Segment Test

Corner criteria:

- N connected pixels
- on a Bresenham‘s circle
- are either all brighter or all darker than the center



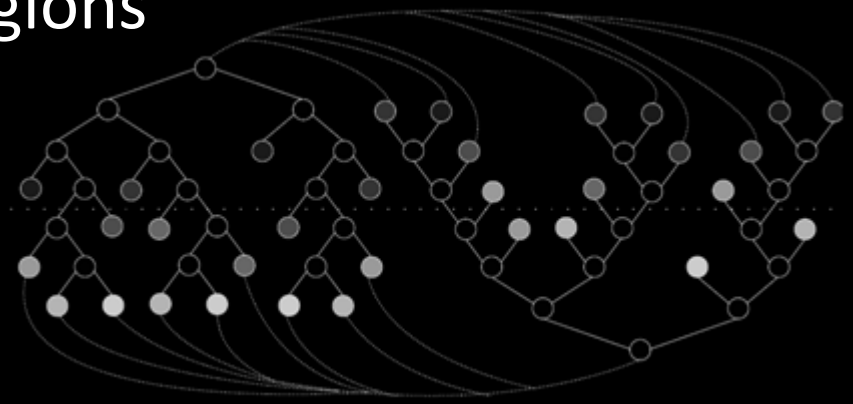
→ Test-order of pixels can be optimized for speed

AGAST

AGAST:

Adaptive and Generic Accelerated Segment Test

- Builds a decision tree optimized for processing costs
- Uses adaptive tree switching between
    - a tree for homogeneous areas
    - a tree for textured regions



Questions?

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