Optimized Hough Circular Transform for Pupil Detection

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Table of Contents

Motivation: Pupil Detection

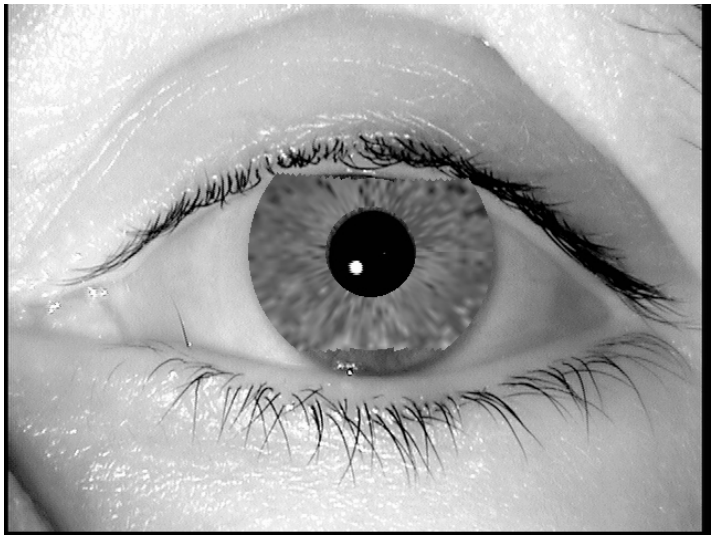

Figure: before detection

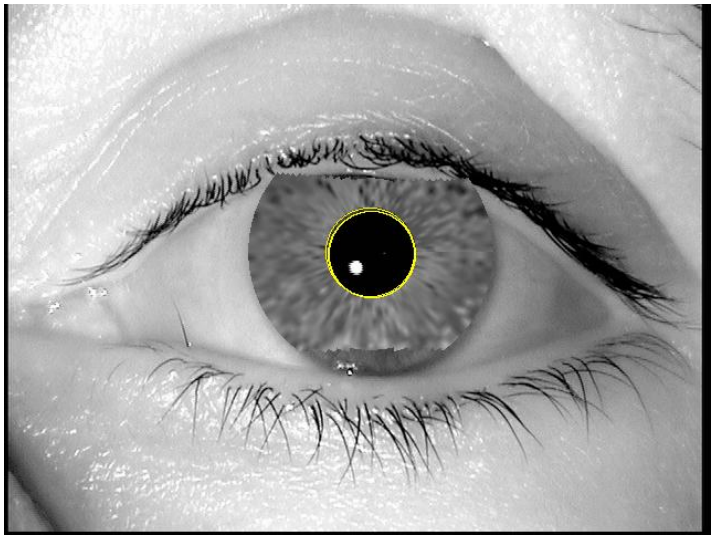

Figure: after detection

Image from: www.wired.com

Algorithm: Circular Hough Transform

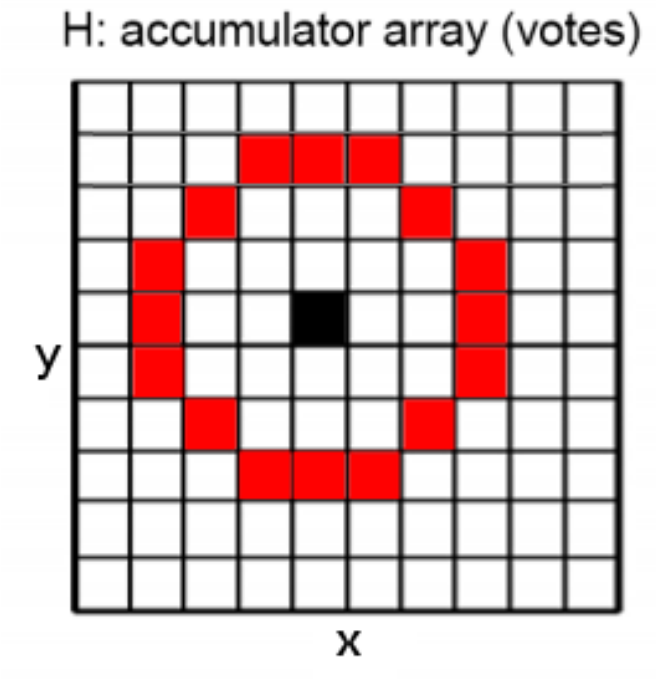

Figure: 2D Hough Voting Space, Single Radius

- every edge pixel (BLACK) assumes it is on the edge of a circle
- vote for the possible centers of the circle (RED)
- pixels with enough votes is detected as a circle
- robust, able to detect even partial circle
- slow, cache-unfriendly
- Baseline from Github repository: *marcbowes/Hough-Circle-Detector*

Optimization: Parallelization Scheme I

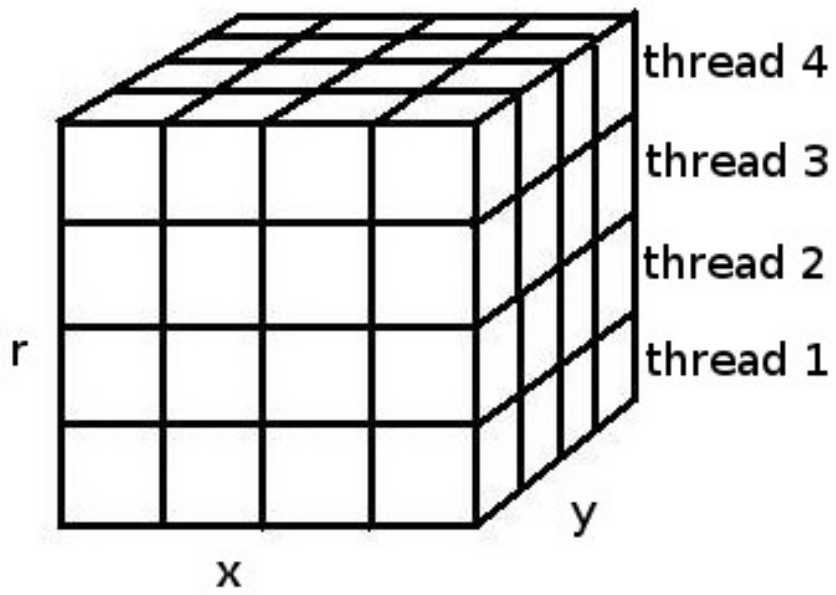

Figure: parallelize by radius

- divide work by radius
- no shared writable data between threads
- no lock/synchronization required
- works poorly for small range of radius

Optimization: Parallelization Scheme II

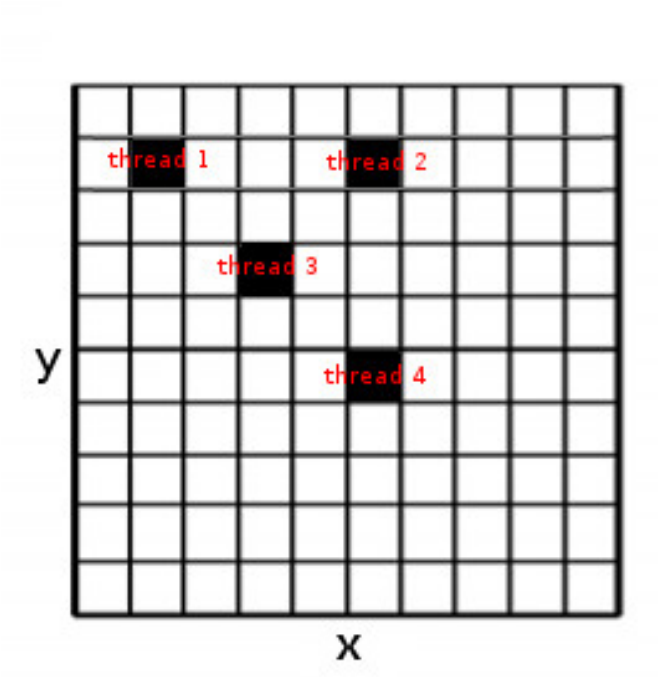

Figure: parallelize by pixel

- divide work by pixels
- shared voting space
- require locks, or
- parallel histogram counting algorithm

Optimization: Grouped Votes by Row

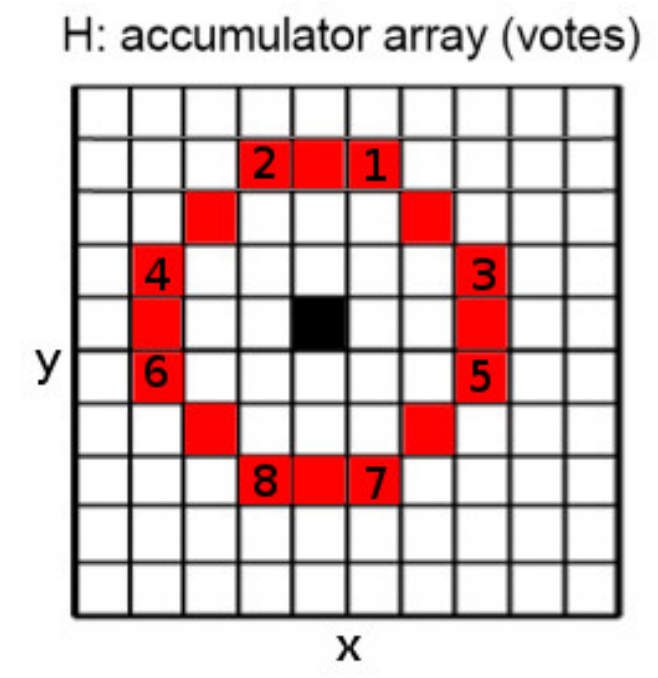

Figure: Midpoint Circle Algorithm: memory access pattern

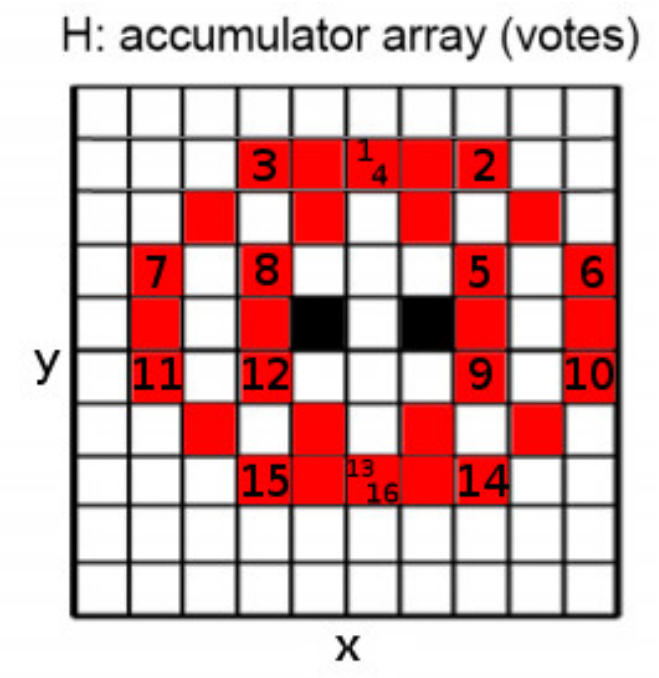

Figure: Grouped Voting: memory access pattern

Optimization: Boundary Check Removal

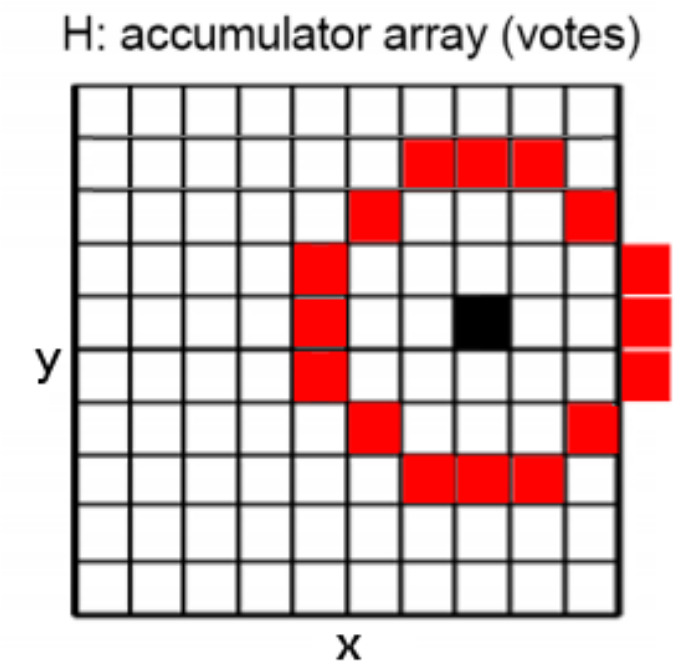

Figure: Out of Voting Space

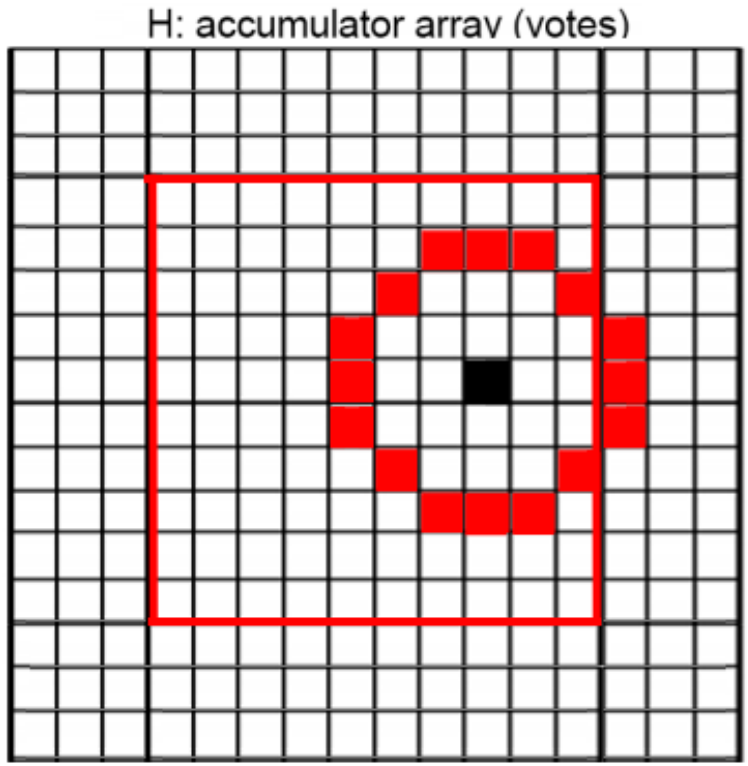

Figure: Padded Voting Space

Results

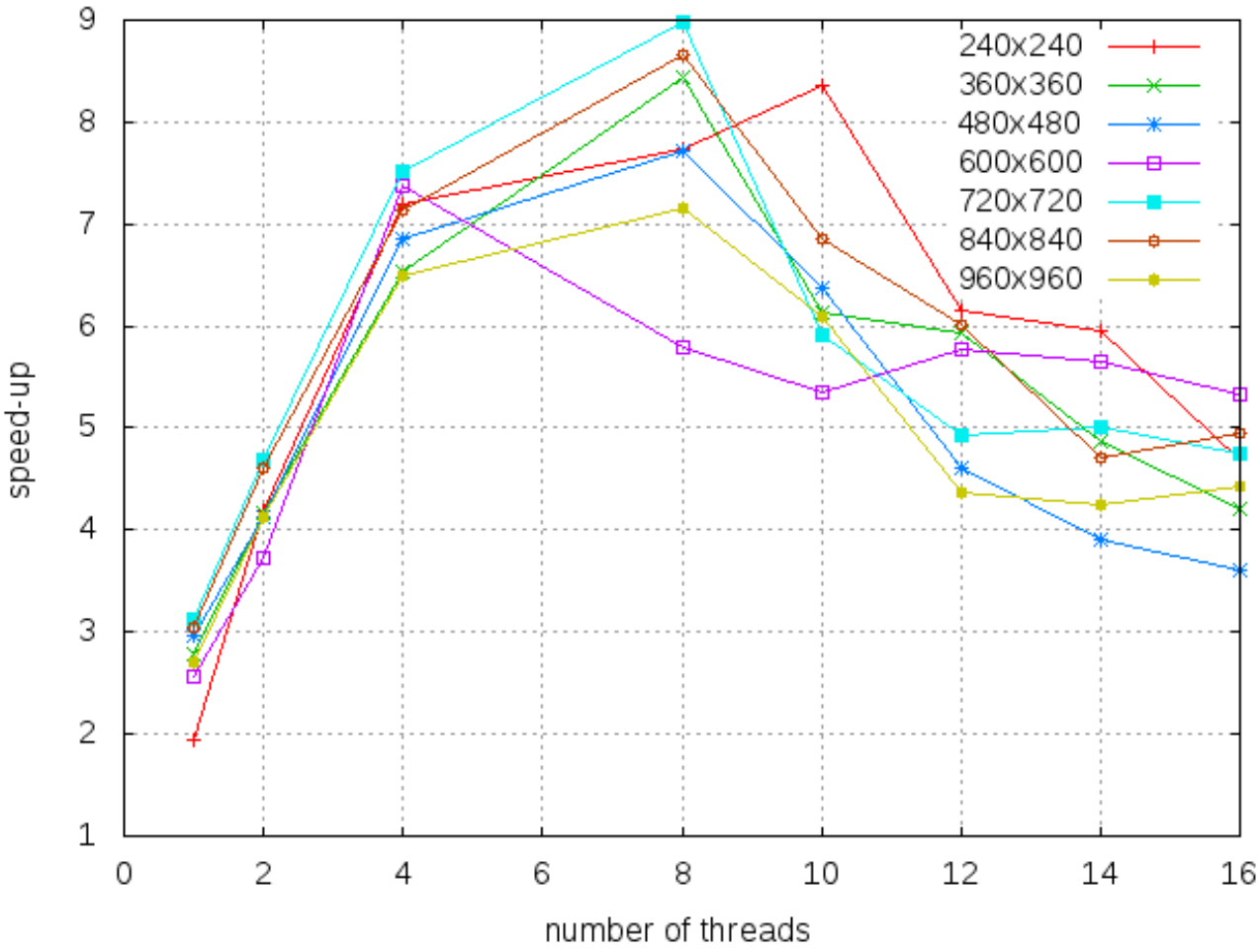

Figure: Scalability vs. Number of threads

References

H. C, "Method and means for recognizing complex patterns," Dec. 18 1962.
US Patent 3,069,654.

D. G. Kourie and B. W. Watson, "An assertion-guided derivation of a circle drawing algorithm."