

Cantag: an open source software toolkit for designing and deploying marker-based vision systems

Andrew Rice

Computer Laboratory

University of Cambridge

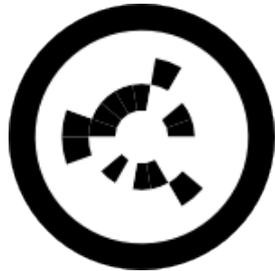
Marker Based Vision Systems

- MBV systems track specific marker tags in an image
- Scene is more constrained than for a general vision system
 - more efficient execution
 - more reliable tracking
 - accurate 3D position and pose
- Used for barcodes, augmented reality visual overlay and spatial reasoning

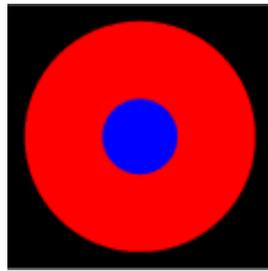
Many Vision Systems



CircleInner



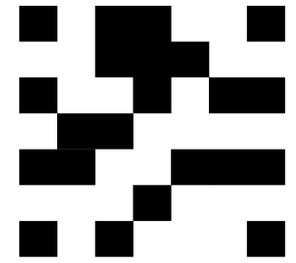
CircleOuter



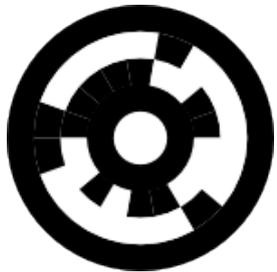
State



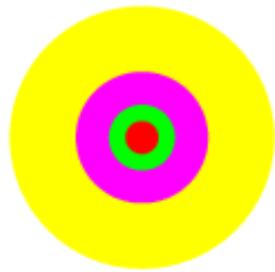
ARToolKit



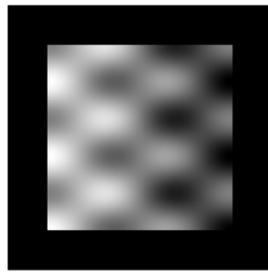
Cyber Code



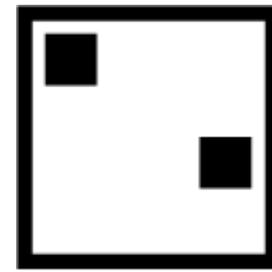
CircleSplit



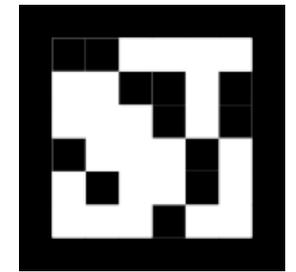
Cho



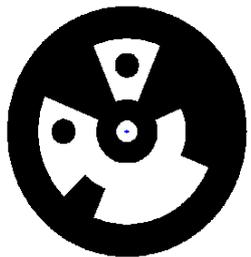
Owen



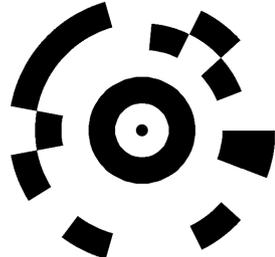
Zhong



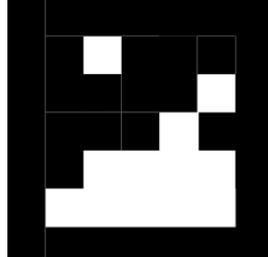
Square



Intersense



TRIP



Matrix



Rohs



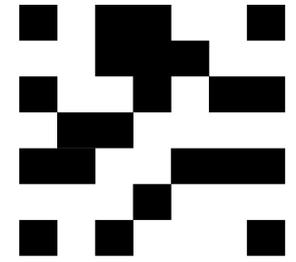
QRCode

Tag Shape

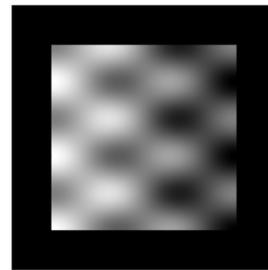
Square Tags find a correspondance between four corner points in object co-ordinates and image co-ordinates



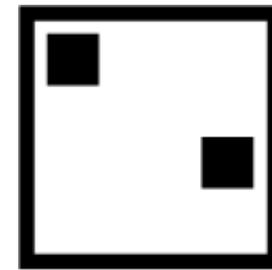
ARToolKit



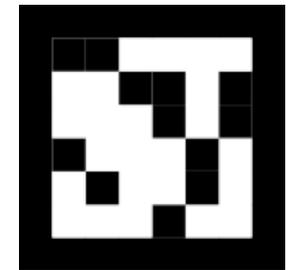
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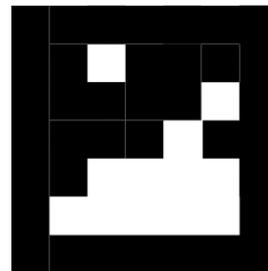
Owen



Zhong



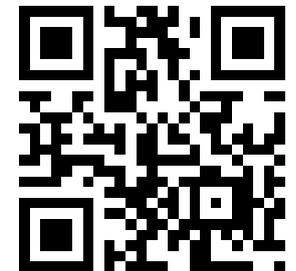
Square



Matrix



Rohs

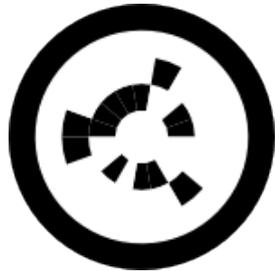


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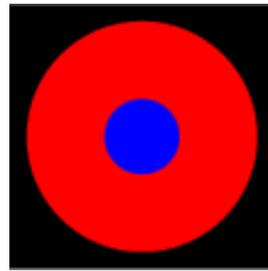
Tag Shape



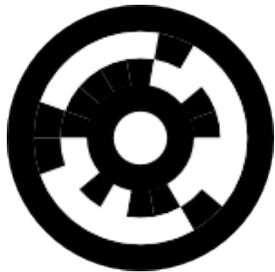
CircleInner



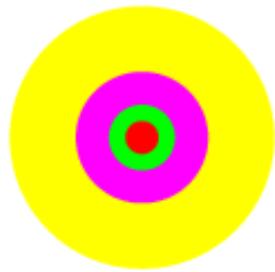
CircleOuter



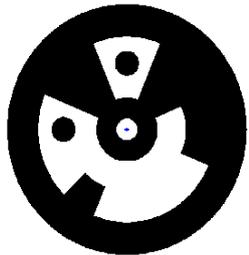
State



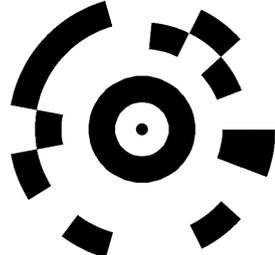
CircleSplit



Cho



Intersense



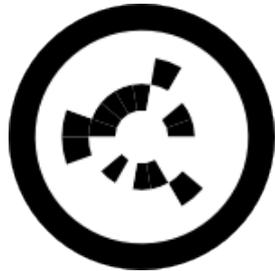
TRIP

Circular tags exploit the projective invariant that a circle transforms to an ellipse in the camera image

Tag Data Coding

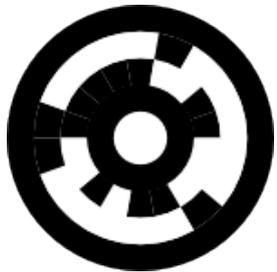


CircleInner

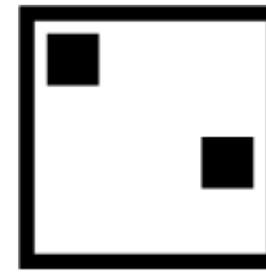


CircleOuter

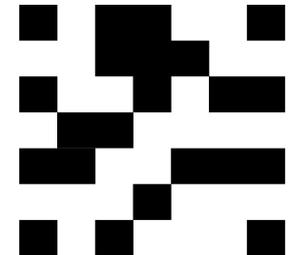
Symbolic coding schemes store a binary payload in tag data cells



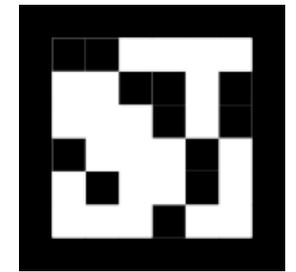
CircleSplit



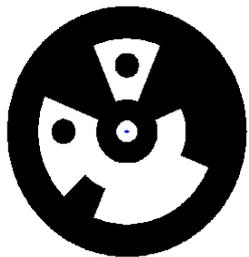
Zhong



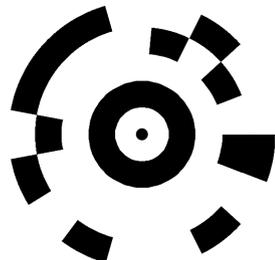
Cyber Code



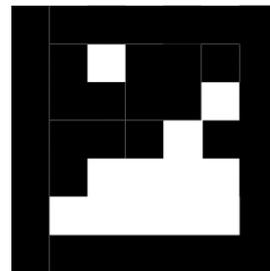
Square



Intersense



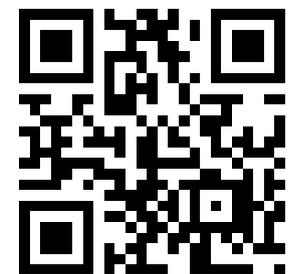
TRIP



Matrix



Rohs

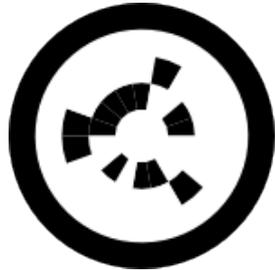


QRCode

Cantag

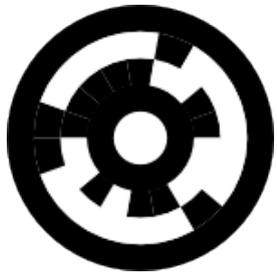


CircleInner



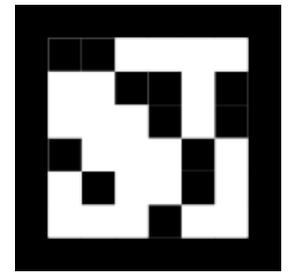
CircleOuter

Cantag combines multiple tag types and tag tracking algorithms in a single framework



CircleSplit

Users can change one processing step without affecting any of the others



Square

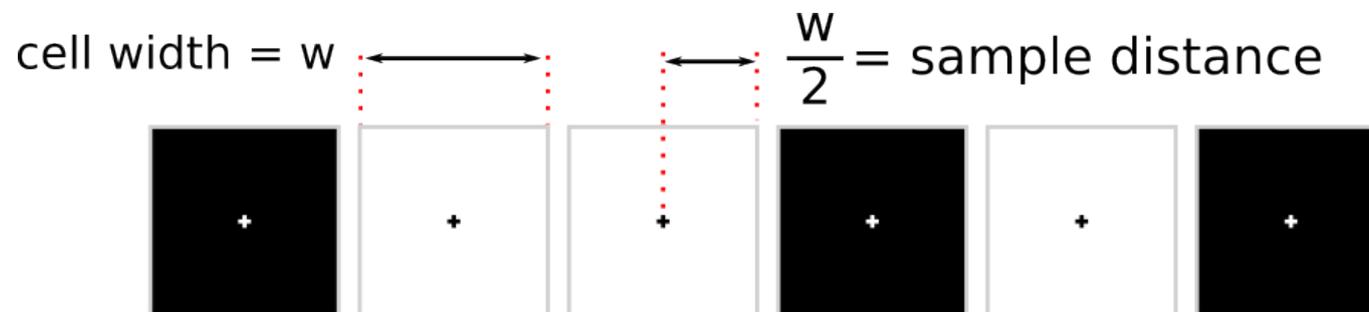
A platform for investigating the fundamentals of tag tracking systems

Limits of Tag Decoding

Consider systems operating on 1-bit black & white images only

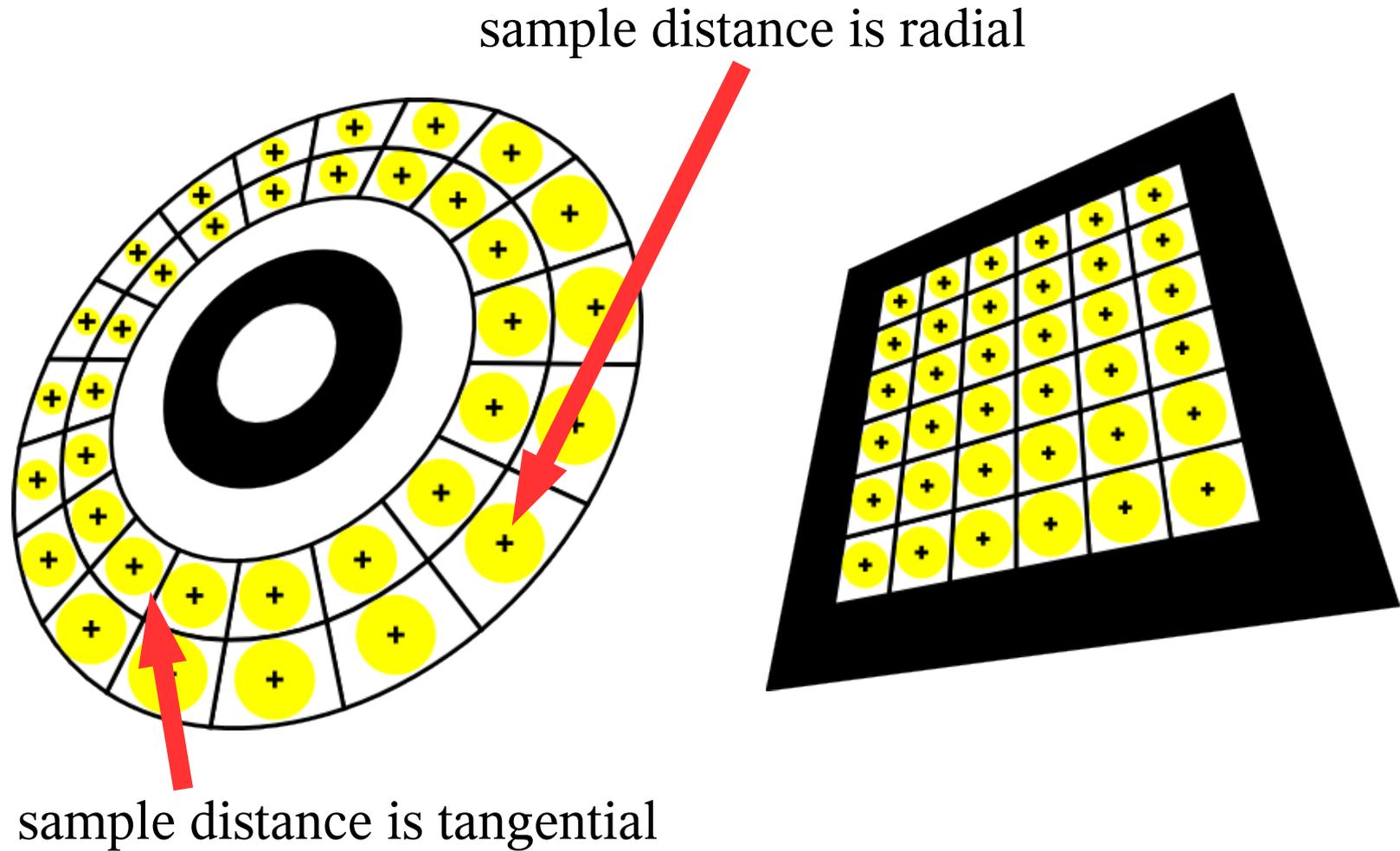
- this is common due to performance reasons

Sample Distance = shortest distance from data cell centre to edge

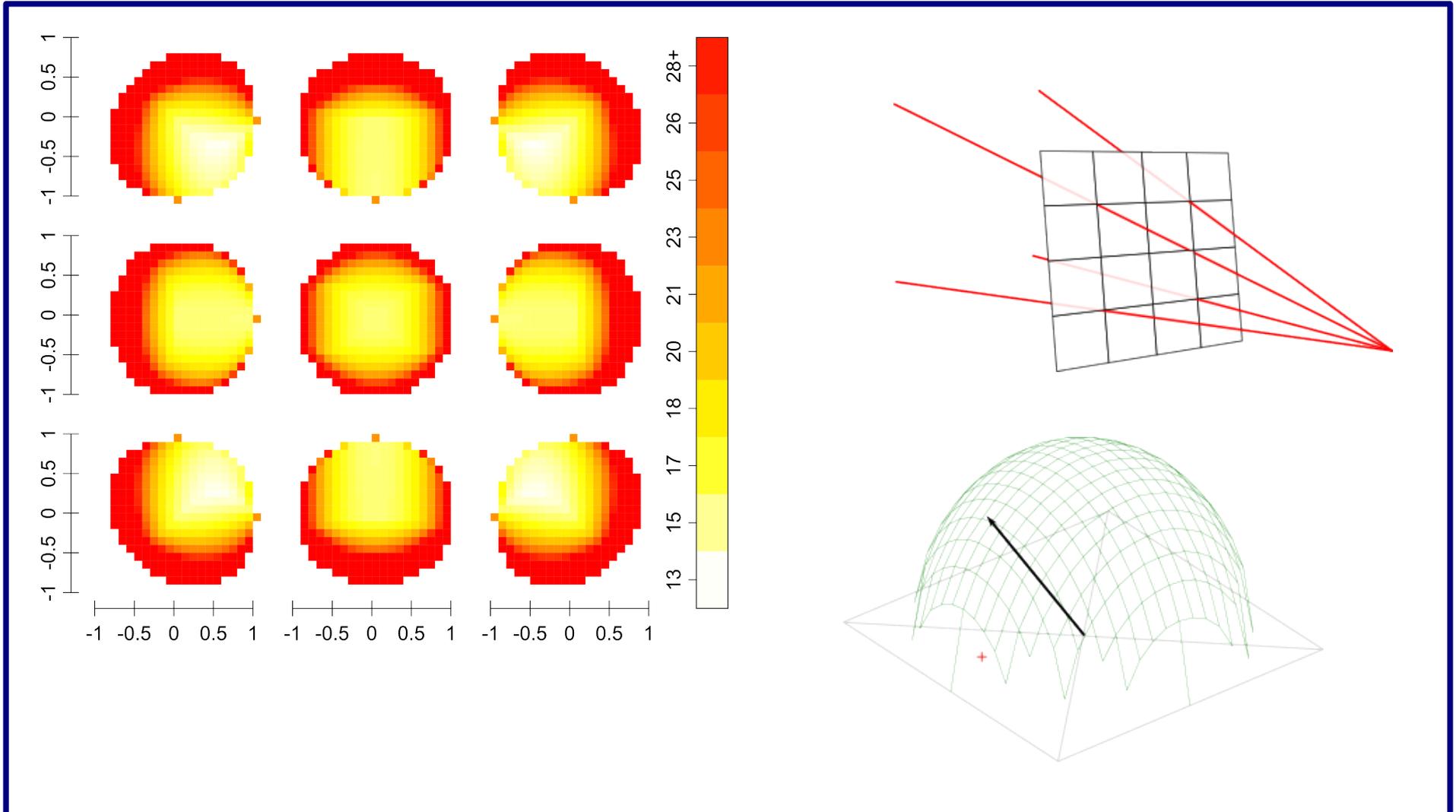


If sample distance < 1 pixel we might sample the value from an adjacent cell

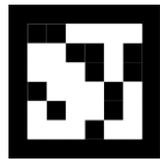
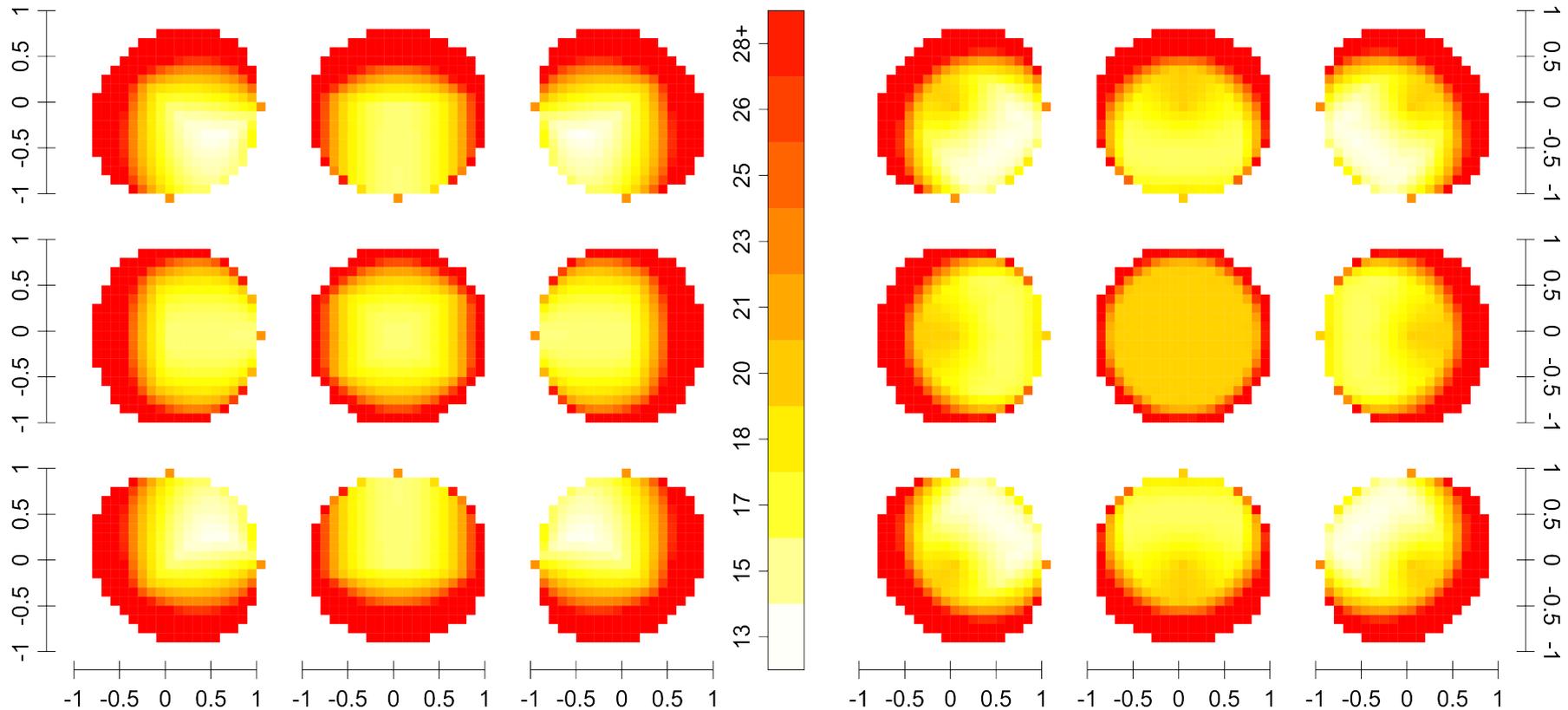
Sample Distance



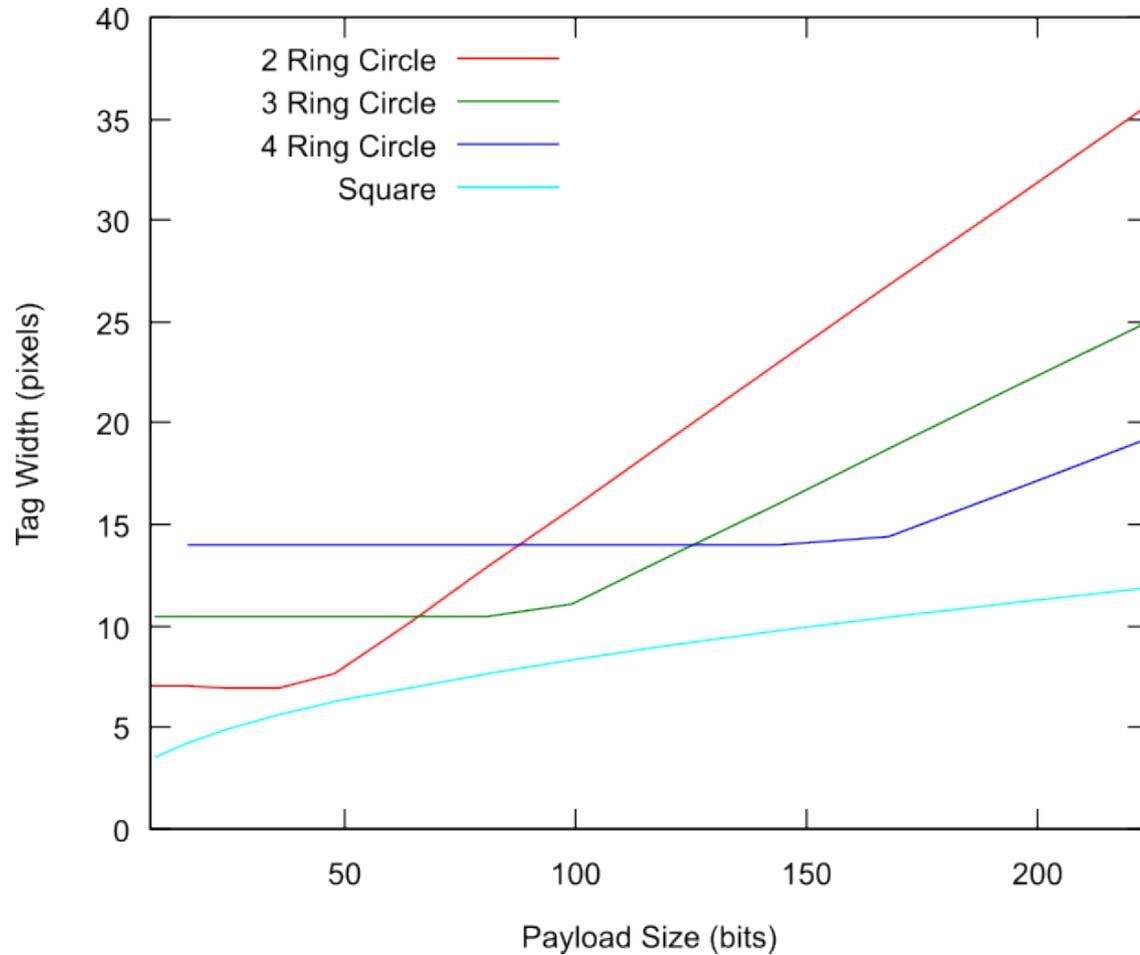
Minimum Sample Distance



Minimum Sample Distance

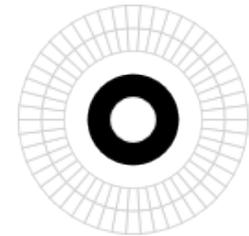
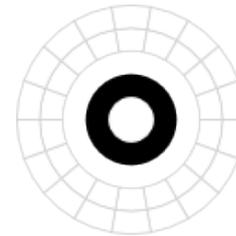


Optimising Tag Layout



36 bits

100 bits



2 rings

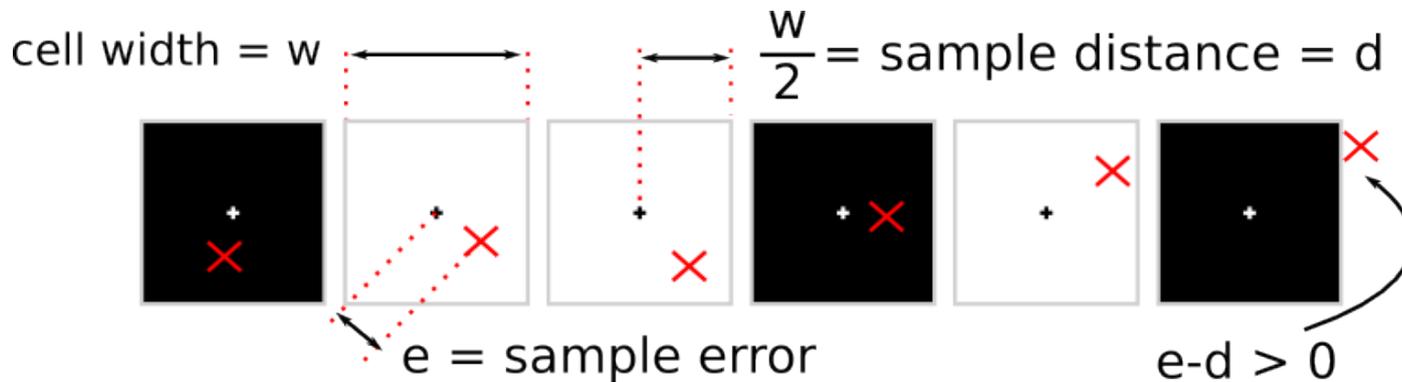


3 rings



4 rings

Sample Strength



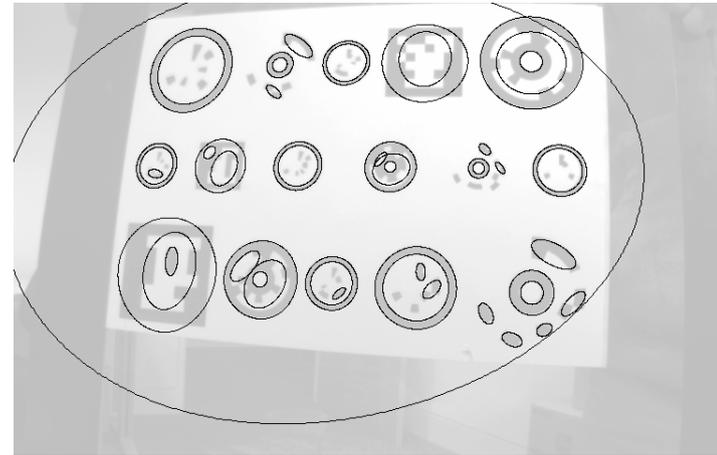
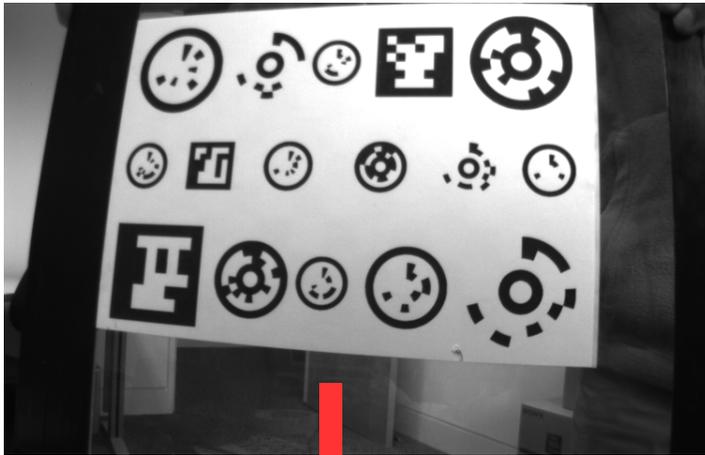
The estimate of the sample point will have some error in it

sample distance = proximity of sample point to edge of cell

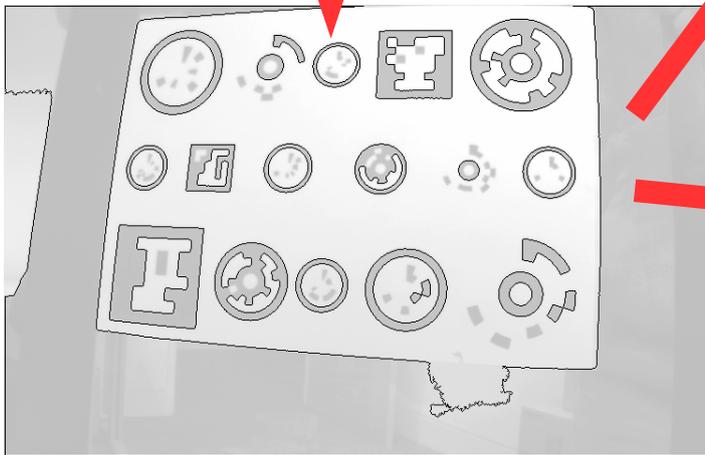
sample error = error in estimate of sample point

sample strength = error - distance

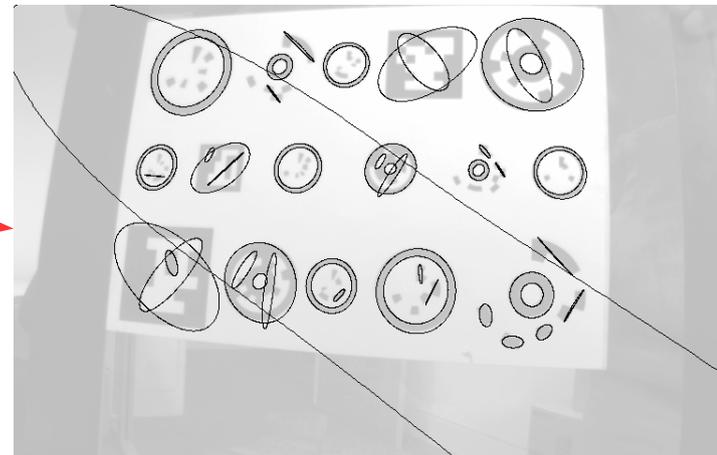
Shape Fitting



Circle: Least Squares Fit

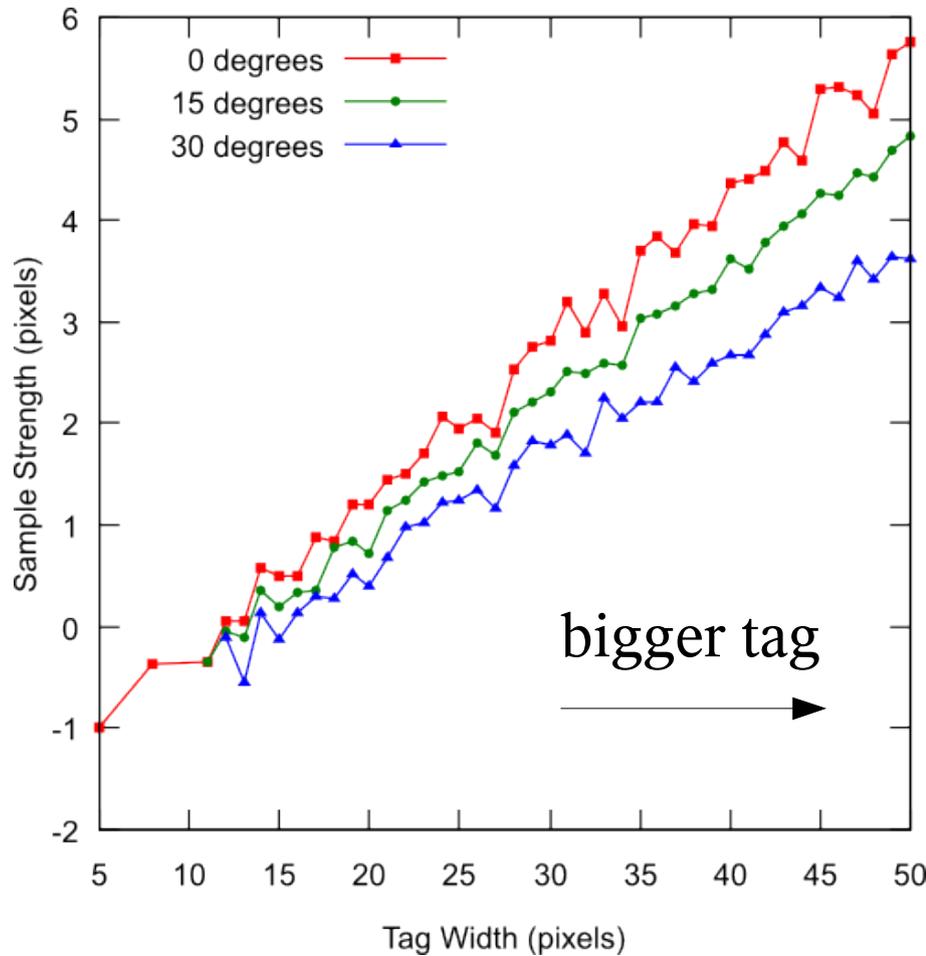


Contours

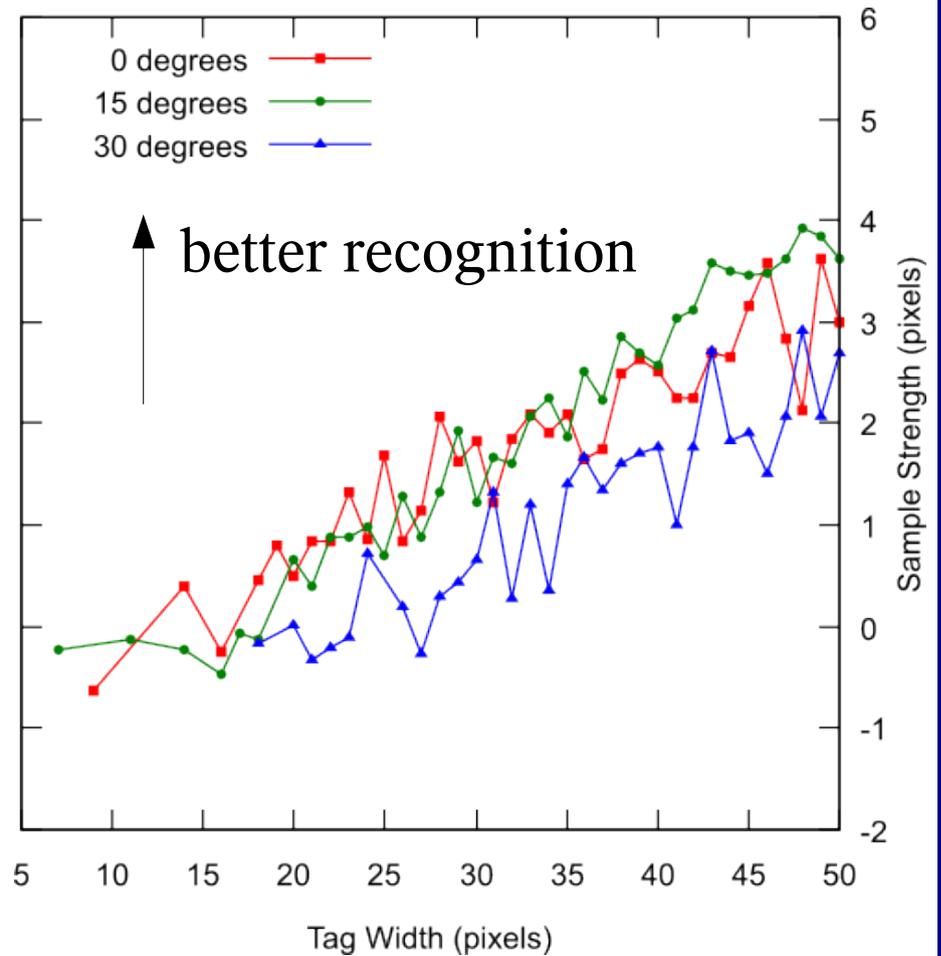


Circle: Simple Fit

Shape Fitting

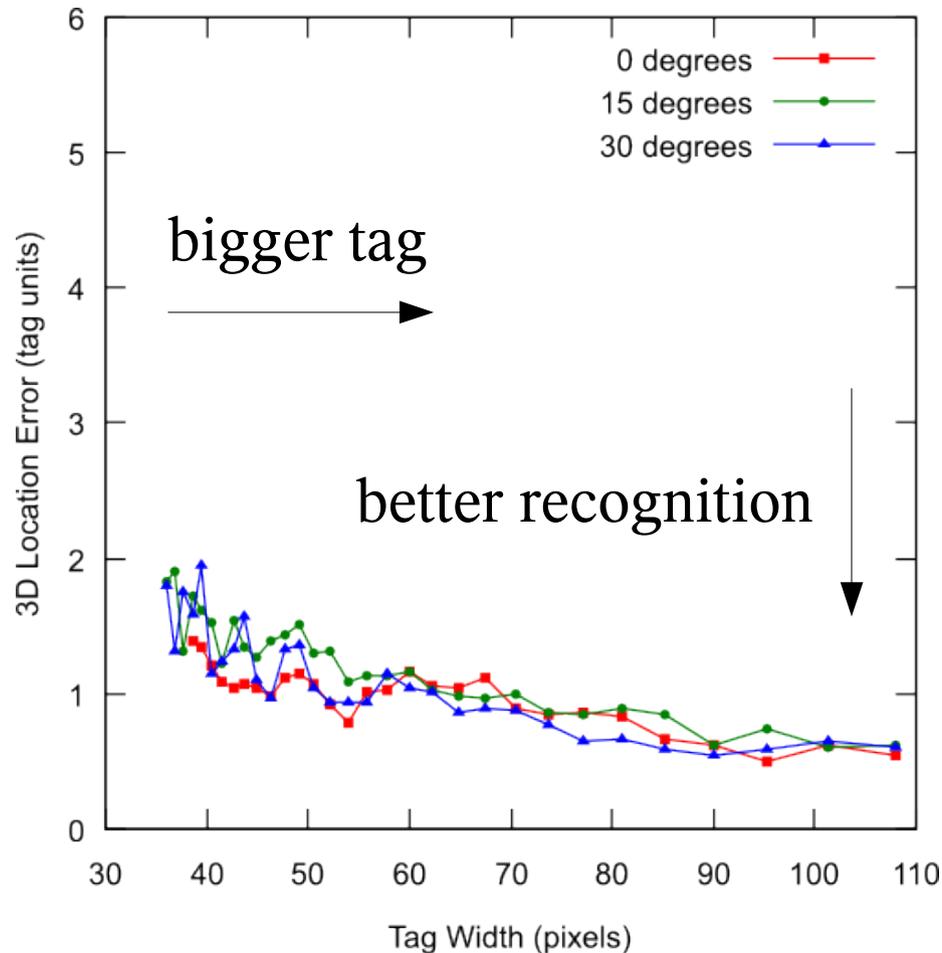


Circle: Least Squares Fit



Circle: Simple Fit

Real-World Results



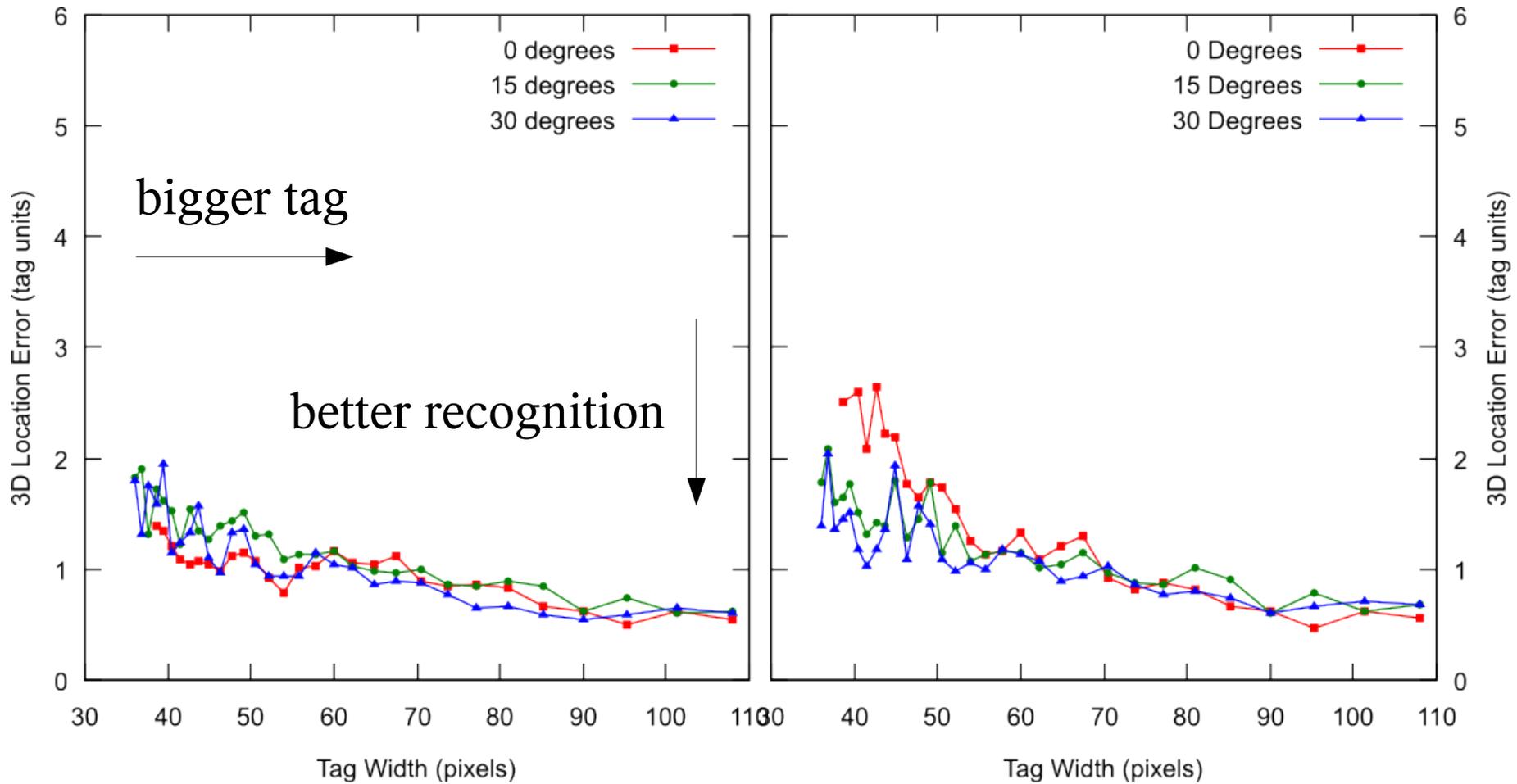
Circle: Least Squares Fit

Can't measure sample strength in the real-world

Location error should show the same trends

High sample strength should imply low location error

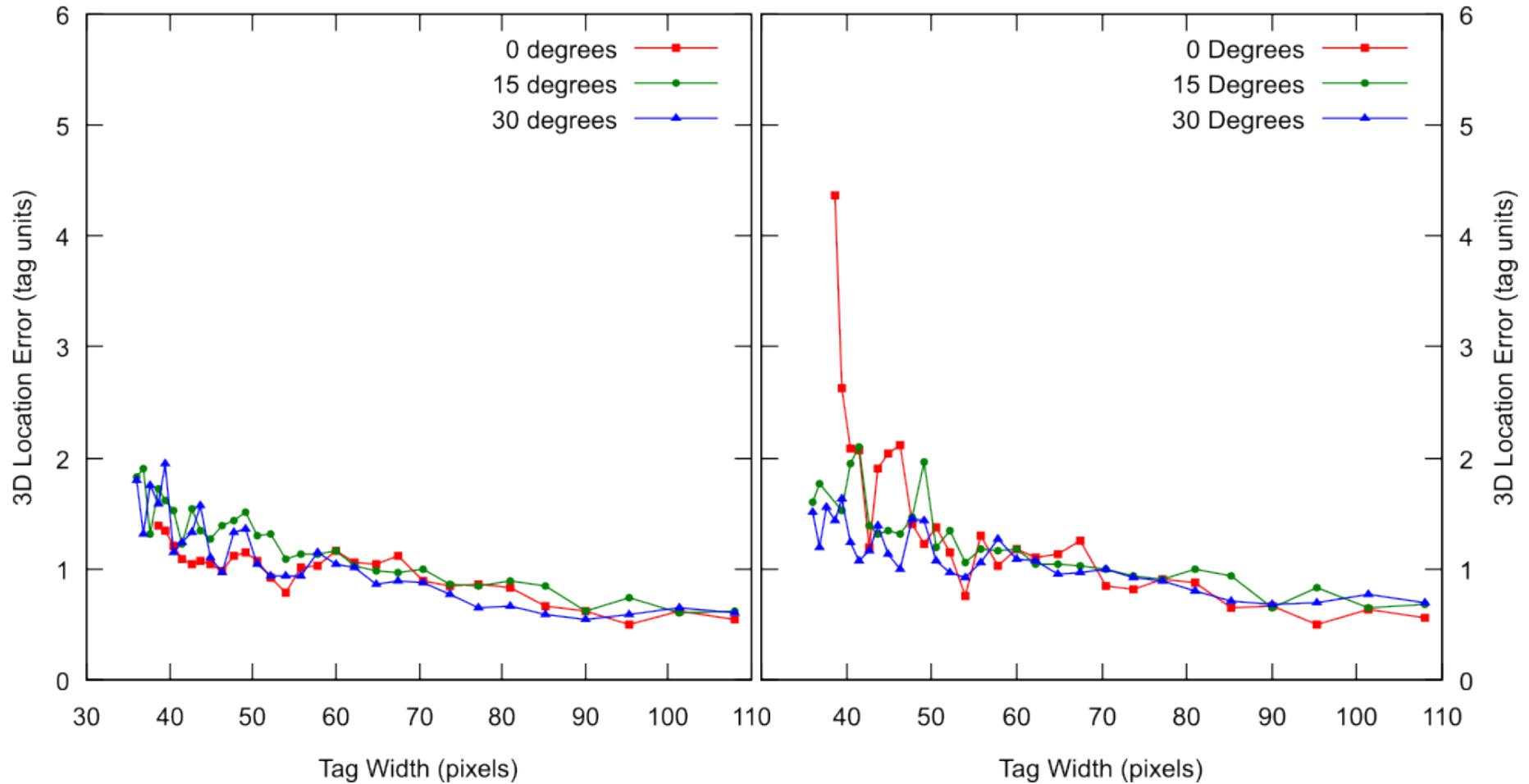
Real-World Results



Circle: Least Squares Fit

Circle: Simple Fit

Square vs Circle



Circle: Least Squares Fit

Square: Convex Hull + Repr

Conclusions

Sample distance is a theoretical model of the tag performance

- Independent of image processing algorithms used
- Allows high-level investigation in to tag properties

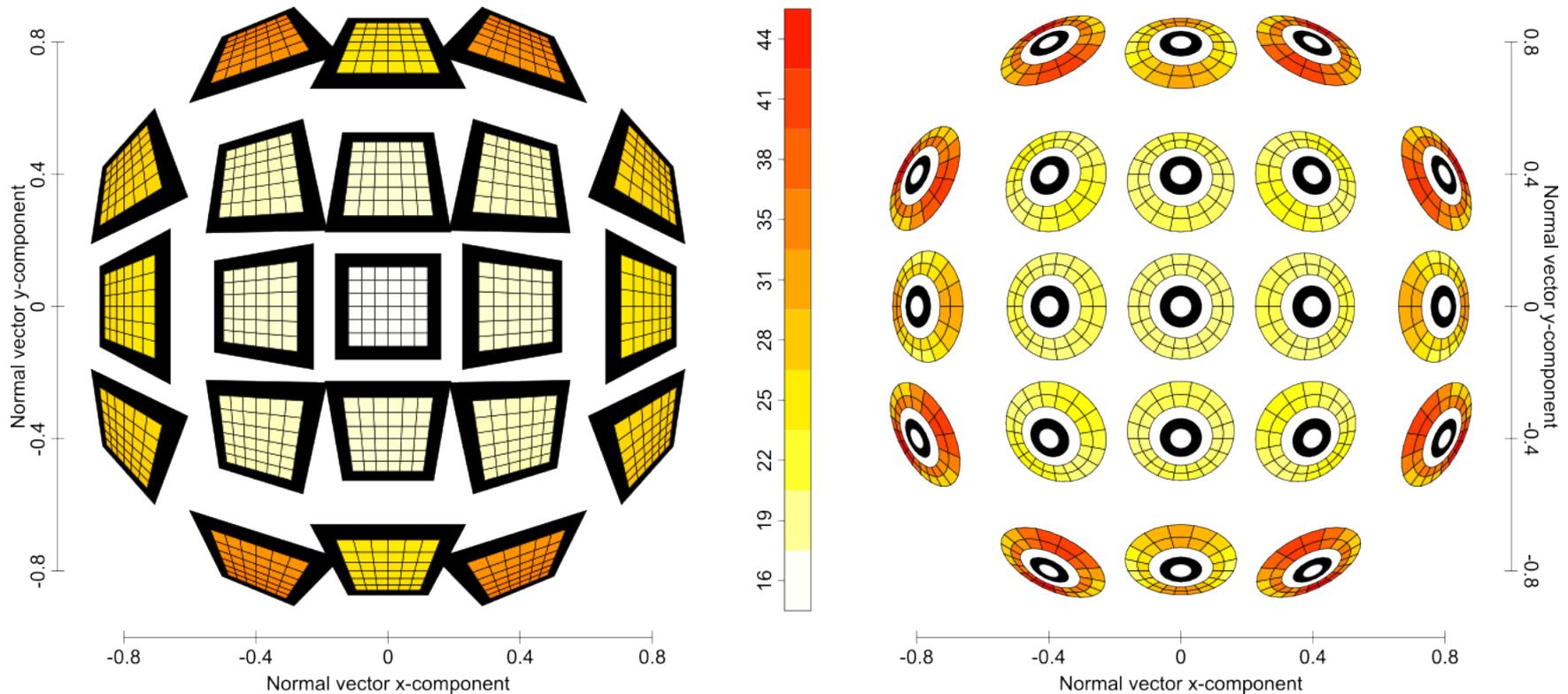
Sample Strength improves the analysis

- Simulated results from OpenGL have only pixel truncation error
- This is sufficient to predict real-world behaviour!

Results

- Square tags carry a larger payload
- Circular tags provide more robust location information
- Use as many points from the contour as possible for shape fitting

Recent Work



Measure the sample distance for each datacell

- Systematic errors due to the geometry of the tag
- Error correcting codes will not extend the read range of square tags

Finally...

Cantag is open-source code, available online:

<http://www.cl.cam.ac.uk/Research/DTG>