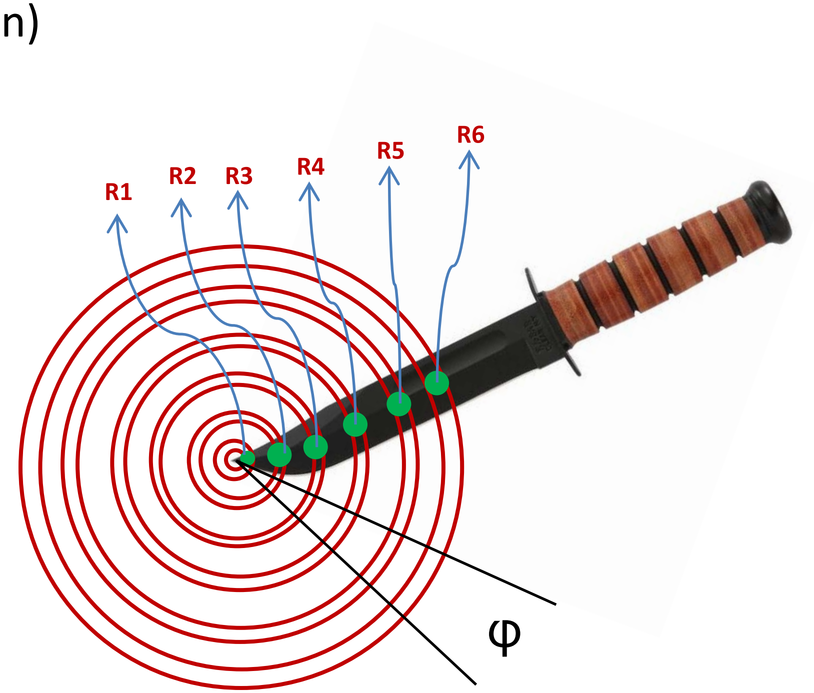
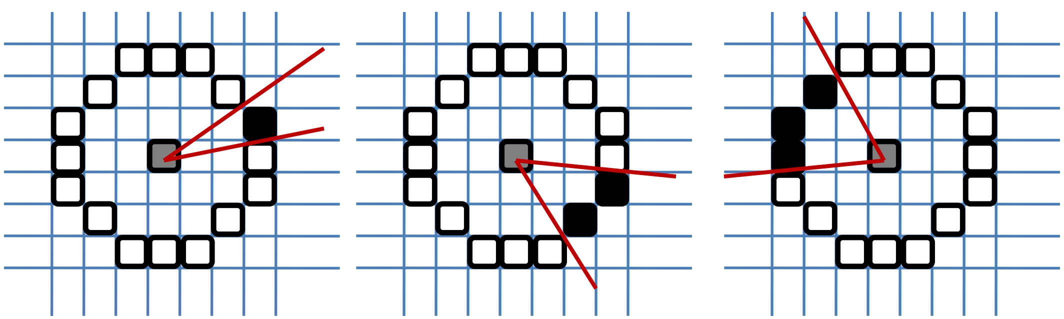
Multi-Resolution Sharp Corner Detection Algorithm
(Knife Detection)

We define knives as elongated objects , generally conical in shape, with a sharp tip.

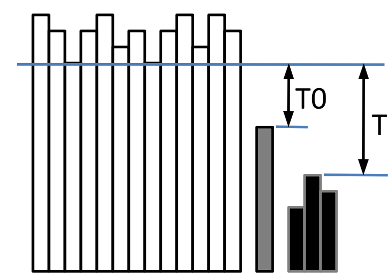
A knife roughly corresponds to small sectors in a series of concentric circles centered at the knife tip.

Our model has two parameters: the angle and the number of increasing radii. The angle describes how sharp or thin the knife is, and the number of radii describes how long the knife is.





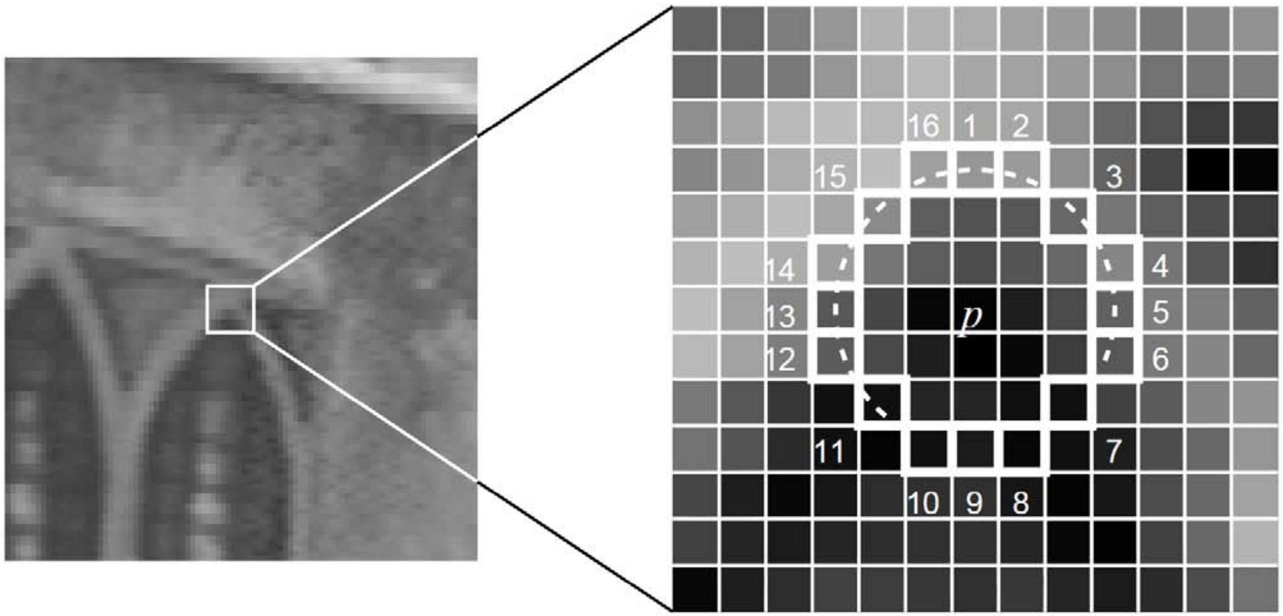
In digital space, corner is defined as a neighborhood of radius 3 where N consecutive pixels are all brighter than the center pixel by at least the threshold T0 and the remaining 16-N consecutive pixels are darker than the bright pixels by at least the threshold T. For sharp corners, N = 13, 14, 15 (usually, 14 and 15). This test is for dark objects on light background. There is a similar test for bright objects on dark background.



Pixel values in the neighborhood (for N=13)

FAST, FASTer, Sharper

We started with FAST (Features from Accelerated Segment Test) as described in: Rosten & Drummond "Fusing Points and Lines for High Performance Tracking“ and Rosten & Drummond “Faster and better: a machine learning approach to corner detection”.



12-POINT SEGMENT TEST: CORNER DETECTION IN AN IMAGE PATCH.
THE HIGHLIGHTED SQUARES ARE THE PIXELS USED IN THE CORNER DETECTION. THE PIXEL AT p IS THE CENTER OF A CANDIDATE CORNER.
THE ARC INDICATED BY THE DASHED LINE PASSES THROUGH 12 CONTIGUOUS PIXELS WHICH ARE BRIGHTER THAN p BY MORE THAN THE THRESHOLD.

This test is very fast, but it can’t be generalized to more than 12 points and because of this it can’t detect sharp corners required for knives.

Our generalization is slower, but:

- It works with any angle and
- It adds the second threshold T – between light and dark segments in addition to T0 – between the light segment and the center pixel. This reduces the number of false-positives.

Multi-Resolution Sharp Corner Detection Algorithm - 2

Rather than increase the radius of neighborhood, we apply the same neighborhood to images of decreasing resolution. Only the points that satisfy the sharp corner test at multiple resolutions are included in the final result. (The decreased resolution image is usually a sub-sampling of the original image by factors from 2 to ~10.)

Multi-Resolution Sharp Corner Detection Algorithm. Example 1.

(UTube-generated graphics is painted over)

Different symbols (cross, circle, triangle) and colors represent corner points detected at different resolutions.

If a compact cluster of points has at least a given number of resolutions present (usually, 3-4), then it goes into the result.

(Cluster is defined as a group of points that are closer in x,y-position and orientation than the given limit)

The requirement that a sharp corner point is detected at roughly the same place at multiple resolutions greatly reduces the number of false positives.

Result:

Tue positive	1
False positive	0

Multi-Resolution Sharp Corner Detection Algorithm. Example 2.

Result:

Tue positive	1
False positive	1

Multi-Resolution Sharp Corner Detection Algorithm. Example 3.

Result:

Tue positive	1
False positive	0

Multi-Resolution Sharp Corner Detection Algorithm. Example 4.

Result:

Tue positive	1
False positive	1

Multi-Resolution Sharp Corner Detection Algorithm. Example 5.

Result:

Tue positive	1
False positive	0

Multi-Resolution Sharp Corner Detection Algorithm
Future Work

Automatically determine the best angle parameter (sharpness, or the number of neighbors) for each knife and allow for different N at different resolutions. Specifically, allow for larger N at smaller resolutions.

Automatically determine the range of resolutions to use in calculations.

Analyze sequences of frames for the same object.