Log-Polar Trasform for Rotation Invariant Object Classification

A Rotated object will result in the same correlation pattern with a given filter except for a shift

Here’s two identical patterns one shifted form the other:

Chart

Description automatically generated

Convert these two patterns to the frequency domain (or just don’t inverse transform the correlation) and produce the magnitude and phase of the two patterns.

Mag:

Graphical user interface, chart

Description automatically generated Graphical user interface, chart, line chart

Description automatically generated

The frequency spectrum of the two are identical. Can we use this property to build a naturally rotation invariant network?

The phase of the two signals are not identical. Furthermore the spectrum alone can’t be used in a lower level FC network because we can’t back propagate through it. It is not a holomorphic function according to the Cauchy-Riemann constraint meaning the derivitive can’t be computed. So the error can not be propagated throught he spectrum (alone) and back to the filters.

A correlation between the two patterns would yield a peak that identified the shift in the patterns that could be used to know the angle between them. A normalized correlation would let us know when to trust the peak.

# The CyclicVectorTransformer

To test the training method I used the Base training result. This is a network trained on easy to identify samples. I picked one sample and applied 0, pi/4, -pi/4, and pi/12 (so that a non-whole number was tested) to the Affine rotation transform. Then transformed to LP, then corrected the output column vector by the same amount.

NOTE: It appears that the affine transform rotates in one direction but the shift applied to the column vector acts in the other direction. In general, if a rotation is predicted then an application of the negative of that rotation would undo the rotation. In the current code the sign change is not applied yet the rotation is corrected. Below the first graph shows the input value U due to the applied rotations and the corrected output values V (achieved with no sign flip).

Input U vectors show the expected shift due to the rotation of the image. The pattern stayed surprisingly similar given that the rotation was applied in the cartesian domain.

A graph with different colored lines

Description automatically generated

Corrected Column vectors. It works well!

A graph of a number of objects

Description automatically generated

Convert angle in radians to point shift with this equation:

Shift = 16 \* angle / PI. This assumes 32 rows to the LP transform. 16 = 32 / 2.

The cyclic special transformer seems to work but also does not provide that much additional accuracy for the single branch LP system.

The purple trace below is the one for the cyclic transformer assisted system, the blue is for the standard single branch SNBranchMNIST system.

A graph with different colored lines

Description automatically generated