MODELS FOR SIZE-INVARIANT PROCESSING IN THE VISUAL SYSTEM

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Since the Mellin-transform has been used successfully for the size- and rotation-invariant description of images (Casasent & Psaltis, 1976; West & Reitboeck, 1979), there has been speculation whether it could also serve as a model for size-invariant processing in the visual system.

The two-dimensional Mellin-transform $M\{f(x,y)\} = M(r,s)$ of an image $f(x,y)$ can be written in the form

$$M(r,s) = \int_0^\infty\int f(x,y)\; x^{-j2\pi r-1}\; y^{-j2\pi s-1} dx\, dy$$

which is equivalent to the Fourier-transform of the logarithmically scaled image:

$$M(r,s) = \int_{-\infty}^{+\infty}\int f(e^{x'},e^{y'})\; e^{-j2\pi(rx'+sy')}\; dx'\, dy'$$

with $x' = \ln x$, $y' = \ln y$.

The retino-cortical mapping to area 17 for the central 20^o of the visual field of many mammals can be described in good approximation by a function (Schwartz, 1979)

$w = \ln (z+a)$ where w and z are complex numbers, indicating points in cortical respectively retinal space

$z = x + jy = r\,(\exp(j\varphi))$.

It has been proposed, that this logarithmic mapping, together with a subsequent shift-invariant transform, such as the absolute value of the Fourier-transform, would yield a size-invariant representation of the image in the visual system. Although there is psychophysical as well as neurophysiological evidence for the existence of spatial frequency channels in the visual system, there is no evidence that a true Fourier-transform would be performed.

The required shift-invariance, however, can be realized with other transforms also; attractive as a model for neural networks is the R-transform (Reitboeck and Brody, 1969), since it requires lateral inhibition and summation only.

This transform, in combination with the logarithmic mapping function, thus yields a size- and rotation-invariant representation of pattern.

1) Casasent,D. and Psaltis,D., (1979), Opt. Eng. 15, 258.
2) West,G. and Reitboeck,H., (1979), Elektronische Informationsverarbeitung u. Kybernetik 15, 5o7.
3) Schwartz, E.L., (1979), Vision Research 2o, 645.
4) Reitboeck, H. and Brody, T.P., (1969), Information and Control 15, 13o.