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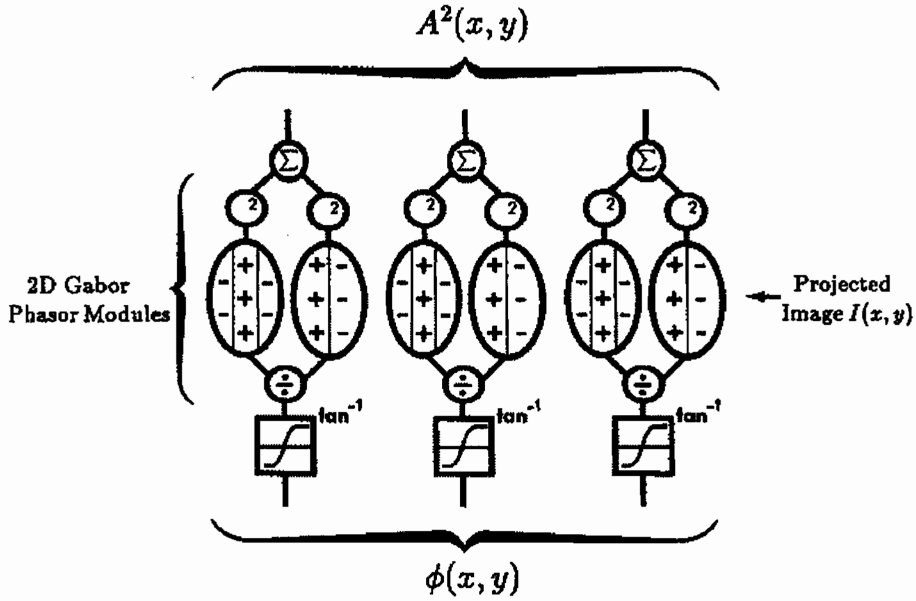
JGD

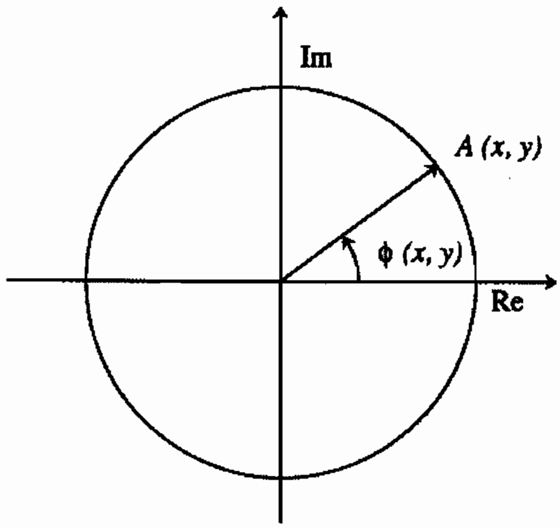
Model Answer: Neural Computing, Question 2. 2002

(Subject area: Neural Networks for image analysis)

A.
Sketch:

Quadrature Demodulator Network





[10 marks]

B.
The equations specify a quadrature demodulation network, which represents structures in the image in terms of locally computed amplitude and phase. The quadrature wavelets in the definitions of $g(x,y)$ and $h(x,y)$ resonate where they encounter structure in the image having a certain scale corresponding to the wavelet frequency ω, and in a particular orientation (because the cosine and sine components are functions only of x). By taking the sum of the squares of their two quadrature outputs, an energy $A^2(x,y)$ is computed which will be large wherever there are local undulations of the right scale and orientation – such the lips or the eyes in a person's face – and small elsewhere.

[4 marks]

(continued...)

C.

In the two-dimensional spatial frequency domain, the linear part of the network (the convolutions before they are combined into $A^2(x,y)$) performs bandpass filtering in a particular orientation (horizontal in this case). The preferred middle band of frequencies is centred around ω, and only image structures containing such a horizontally-oriented frequency band are extracted.

[3 marks]

D.

The biphasic demodulator receptive fields in the network diagram resemble strongly the class of neurones in the visual cortex called "simple cells," which are oriented, linear, and modulated with two or three alternating phases each, representing the operators $g(x,y)$ and $h(x,y)$. The class of non-linear cortical neurones called "complex cells" are represented by $A^2(x,y)$, the output emerging from the top of the network diagram. Their response is phase-independent and appears to be formed as the sum of the squares of the oriented but phase-sensitive simple cells. [3 marks]