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BY A MULTISCALE BOUNDARY CONTOUR SYSTEM
AND FEATURE CONTOUR SYSTEM

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ABSTRACT: An improved Boundary Contour System (BCS) and Feature Contour System (FCS) neural network model of preattentive vision is applied to large images containing range data gathered by a synthetic aperture radar (SAR) sensor. The goal of processing is to make structures such as motor vehicles, roads, or buildings more salient and more interpretable to human observers than they are in the original imagery. Early processing by shunting center-surround networks compresses signal dynamic range and performs local contrast enhancement. Subsequent processing by filters sensitive to oriented contrast, including short-range competition and long-range cooperation, segments the image into regions. The segmentation is performed by three “copies” of the BCS and FCS, of small, medium, and large scales, wherein the “short-range” and “long-range” interactions within each scale occur over smaller or larger distances, corresponding to the size of the early filters of each scale. A diffusive filling-in operation within the segmented regions at each scale produces coherent surface representations. The combination of BCS and FCS helps to locate and enhance structure over regions of many pixels, without the resulting blur characteristic of approaches based on low spatial frequency filtering alone.

1. Introduction: Synthetic aperture radar sensors can produce range imagery of high spatial resolution under difficult weather conditions (Munson, O’Brien, and Jenkins, 1983; Munson and Visentin, 1989), but the image data affords some difficulties for interpretation by human observers. Among these difficulties is the large dynamic range of the sensor signal (five orders of magnitude), which requires some type of nonlinear compression merely for an image to be represented and viewed. Also, inherent sensor noise results in a grainy appearance (speckle). Figure 2 (top) shows a SAR image in which the logarithm of each pixel value is displayed to reduce the dynamic range. To date most approaches to automatic segmentation and to improving the appearance of SAR images for human interpretation have involved reconstruction filtering using pixel-based statistical estimates of signal distributions for a variety of compositions of clutter material, such as grass, trees, or snow. Our approach capitalizes instead on the form-sensitive operations of a neural network model in order to detect and enhance structure based on information over large, variably sized and variably shaped regions of the image. In particular, the multi-scale implementation of that neural model reported here is capable of exploiting and combining information from several nested neighborhoods of a given image location to determine the final intensity value to be displayed for that pixel.

2. Description of the approach: The neural network model used is a refinement of the Boundary Contour System (BCS) developed by Grossberg and Mingolla (1985a, 1985b, 1987) and the Feature Contour System developed by Cohen and Grossberg (1984) and

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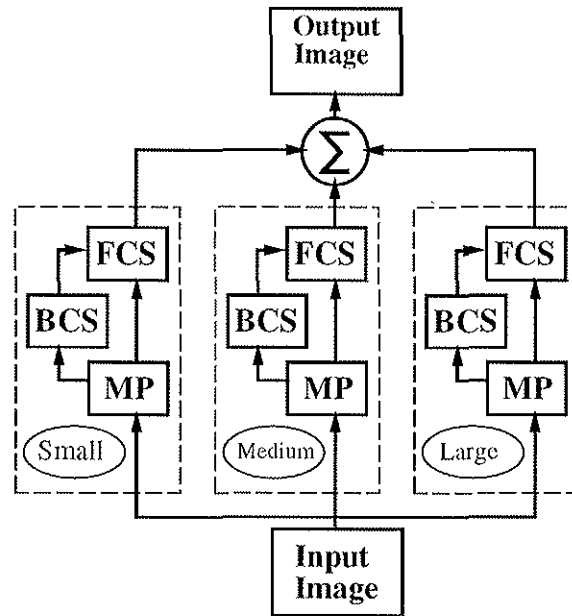


Figure 1: Multiple scale BCS/FCS system. Each processing scale consists of a Monocular preprocessing (MP), which is a center-surround shunting network, followed by a BCS and FCS stage.

Grossberg and Todorović (1988) through an analysis of biological vision. A recent and detailed description of model equations is contained in Gove (1993). The BCS locates and complete boundaries that delimit regions for filling-in with featural (color and brightness) signals. In the present work separate BCS representations are computed at small, medium, and large scales. (See Figure 1.)

3. Results and conclusions: As shown in figures 2 and 3, the multiscale BCS/FCS is capable of enhancing coherent image structure. Note that just as aggregations of stars in the sky result in perceptually salient constellations, image contrasts can be grouped by the BCS – and FCS diffusion can be contained – into a variety of shapes for which no single set of convolution filters (eg. difference-of-Gaussians, Gabor, etc.) could ever be simultaneously optimal.

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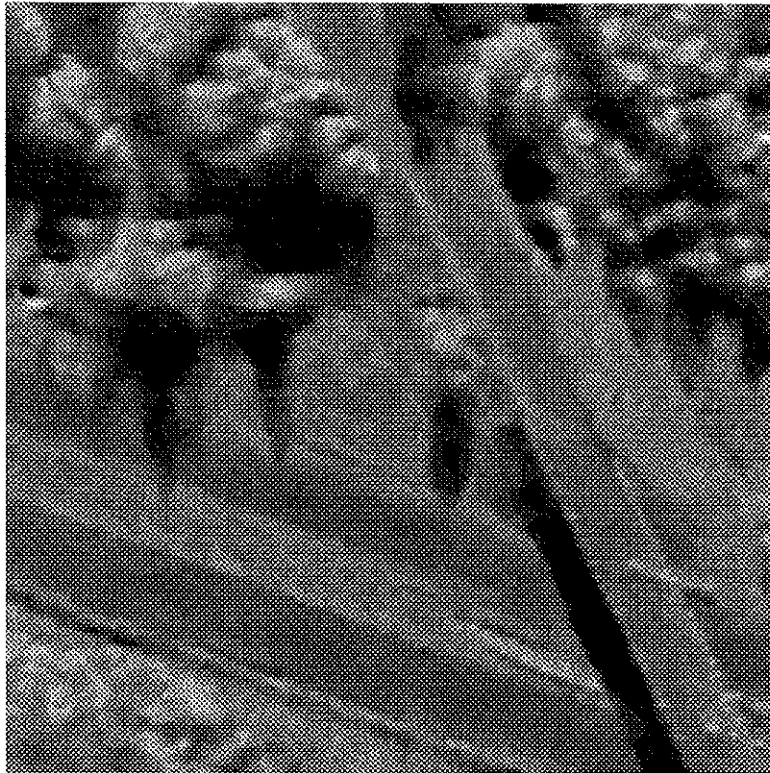


Figure 2: Top: Logarithm-compressed SAR image. Bottom: Multiple scale filled-in output image. See text for details.

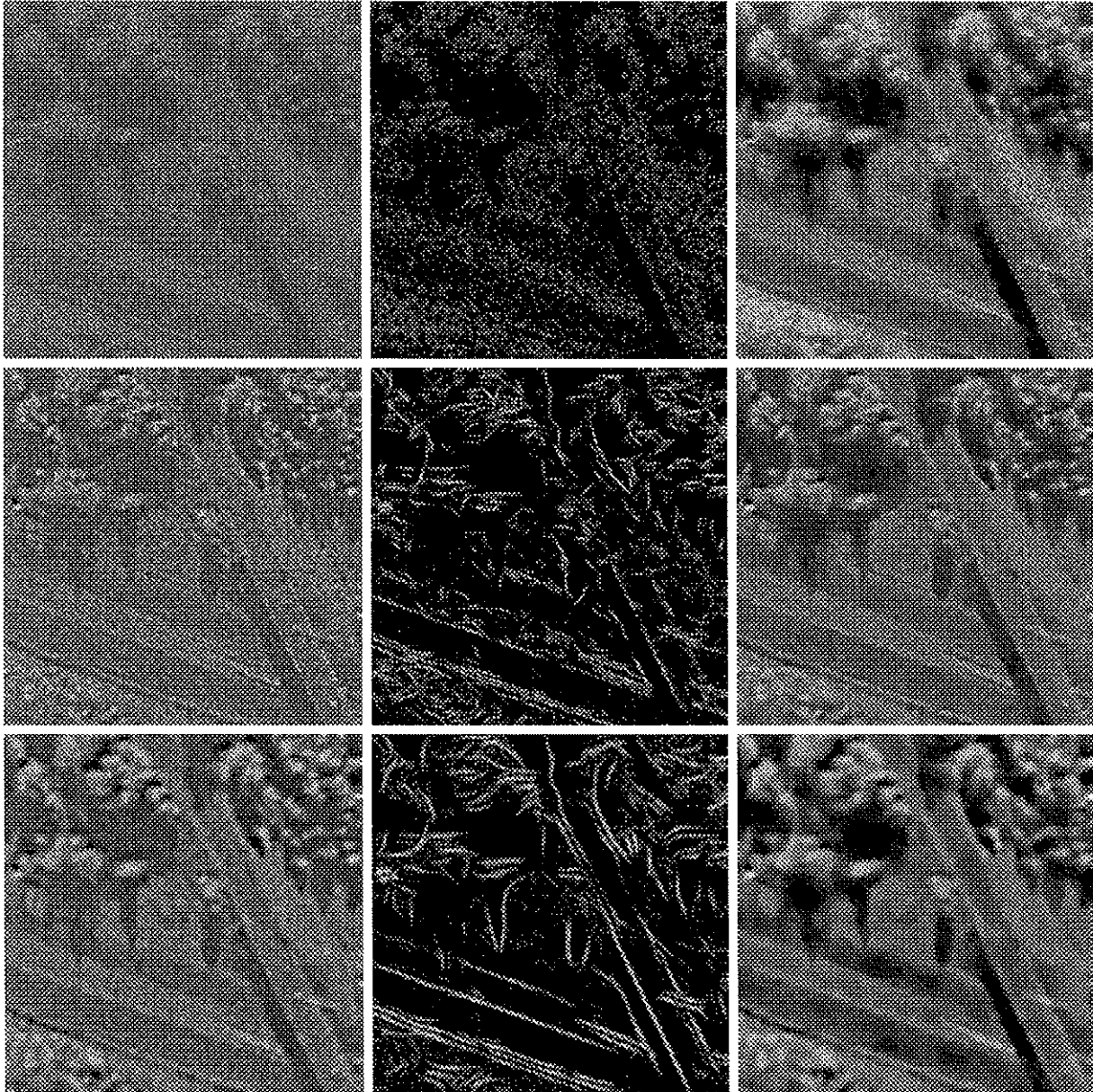


Figure 3: Rows 1-3: Small, medium, and large scales. Columns 1-3: Monocular preprocessing (MP), BCS, and FCS stages.