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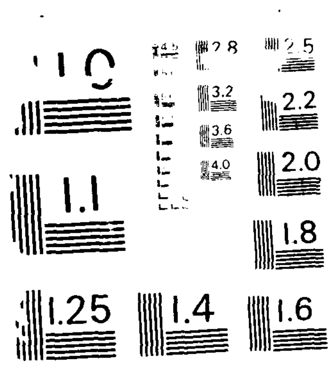

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This report describes the progress of research in texture perception. The goal of the research included perceptual grouping in dot textures, where the goal was to segment a given dot pattern into its perceptual components, and developing a computational theory for an integrated representation of texture.

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TEXTURE PERCEPTION AND SHAPE FROM TEXTURE

Final Report for 1986-87

Narendra Ahuja
Coordinated Science Laboratory
University of Illinois
1101 W. Springfield Ave.
Urbana, Ilinois 61801

The objectives of our research have been two-fold. The first part of our research concerns perceptual grouping in dot textures. The goal here is to segment a given dot pattern into its perceptual components, i.e., to identify regions and curves that coincide with the segmentation provided by humans. These regions and curves may be defined by dots, or by groupings of dots, thus making the perceptual structure recursive. In the second part of our research, we have been developing a computational theory for an integrated representation of texture that takes into account many relevant aspects of texture, rather than just the properties of the texture elements at one level of resolution. The various aspects of texture integrated in our approach are: the basic variability characteristic of homogeneous textures which has been addressed by classical models of texture, the multiscale information present in image texture reflecting the hierarchical nature of the scene structure, and the systematic distortion introduced by the geometry of the textured surface and the camera. The shape-from-texture problem concerns the seperation of the spatial variation in the texture into its two components: one, characteristic of the original texture before imaging, and the other introduced by the distance and orientation changes in the imaging process. Since we are not imposing any constraints on the complexity of the original texture, the problem in general involves separating the ambient, homogeneous, possibly anisotropic, part of the texture from a smooth, nonhomogeneous, geometric distortion due to distance gradients and geometry of the textured surface.

We have completed the develeopment of the theory and an implementation of our approach to perceptual grouping in dot textures. The tokens resulting from the lowest level grouping stage, are further (hierarchically) grouped according to their geometric properties. Such geometric properties include size, orientation, proximity, terminators and positions of the lowest level tokens. Thus, for a given dot pattern, the algorithm provides a hierarchy of groupings where ecah level of the hierarchy is defined by homogeneity of one of the above geometric properties.

In our work on shape form texture, we have addressed the problem of identifying texture elements in images where the texture elements are partially occluded or are themselves textured at a finer scale. A primary goal of our research has been to demonstrate the feasibility of extracting useful measures of texture gradients from images of natural (as opposed to man-made) textures. The textures present on man-made objects frequently exhibit regularities such as parallel lines, perpendicular lines, equally-sized texture elements, or equally-spaced texture elements. Several existing shape-from-texture algorithms exploit these regularities; however, most naturally occurring textures are too variable to permit successful application of these methods. The algorithms we have developed provide good surface-orientation estimates even in the face of significant sub- and supertexture. We have argued that correct interpretation of texture gradients requires explicit identification of image texels, especially when textures show three-dimensional relief, when texels exhibit significant subtexture, or when it is unknown a priori which texture gradients carry surface-shape information. Texture elements cannot be identified in isolation since texels are defined only by the repetitive nature of the texture as a whole. Therefore, we have claimed that the identification of texture elements is best done in parallel with the estimation of the shape of the textured surface. Further, texel identification permits correct analysis of textures containing subtexture. Explicit texel identification also permits a unified treatment of the various texture gradients that may be present in an image. Previous researchers have avoided texel identification because it is quite difficult to do in real images. Instead, indirect methods are used to estimate texel features.

We have integrated the extraction of texture elements with the recognition of scene layout. We have developed a method for identifying texture elements while simultaneously recovering the orientation of textured surfaces. We use a multi-scale region detector, based on measurements in a Laplacian-of-Gaussian scale-space, to construct a set of candidate texture elements. True texture elements are selected from the set of candidate texture elements by finding the planar surface that best predicts the observed areas of the candidate texture elements. We have demonstrated the power of the integration approach on a variety of natural textures, including waves, flowers, rocks, clouds, and dirt clods.

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