COMPUTER TECHNOLOGY

Computer generation of textures

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A method for displaying fixed or time-varying textured patterns under computer control is described. The luminance profiles of these patterns is fixed in one dimension (Y axis), but can be arbitrarily complex in the other dimension (X axis) since they are synthesized by software. An example of the use of the method in texture matching experiments is given.

Three intensive attributes of an object are brightness, color, and texture. Experimental methods for on-line control of object brightness and color have been available for many years (Maxwell, 1855; Wright, 1928). Only recently has technology progressed to the point where on-line control of textures has become possible (Julesz, 1962). This report describes a new method for generating textured patterns that has more flexibility than previous methods.

Texture is the attribute of an object which describes its grain or surface properties. Texture may be fine or coarse, complex or simple, and may have patterned elements, as in rugs, or may be homogeneous, as in sandpaper. The method to be described deals only with the synthesis of textured patterns, such as drapes, where the major modulation in luminance occurs in the horizontal direction across the ripples or folds. These patterns can be described by the luminance distribution along one dimension by means of Fourier analysis. In theory, one needs an infinite number of sinusoids to match a pattern perfectly, but we have found that one can approximate low-contrast patterns of this type quite well using only four frequencies (Richards & Polit, 1974). In other words, "one-dimensional" textured patterns can be matched quite well with only four independent sinusoidal luminance components.

In order to perform texture matching experiments of this kind, it is necessary to have two fields, one of which is illuminated with a combination of gratings having a sinusoidal luminance distribution, while the neighboring field contains the texture to be matched (see Figure 1). The "device" to be described follows this paradigm consisting of two textured fields; but depending on the experimental objectives, the two fields may be either compressed to one field or, alternatively, expanded to several independent regions.

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APPARATUS

Figure 2 shows a block diagram of the device. The display used is a Kratos Graphic CRT monitor (Model M321b) with an aluminized P31 phosphor (Kratos Manufacturing Co., 7825 Deering Avenue, Canoga Park, California). The display has a variable intensity beam which can be controlled by an analog voltage. The display is driven in a vertical raster mode. A 100-kHz sine-wave oscillator, connected to the Y axis input of the scope, generates the raster line. The amplitude of the sine wave determines the vertical extent of the pattern. The X and Z (intensity) axes are driven by computer-generated analog voltages. As the raster line is stepped in the X direction from left to right, the intensity of the beam is altered to create the desired luminance profile. At the end of a scan (642 lines), the beam is turned off for the flyback to the starting position. In experiments where the exact luminance distribution is important, it is necessary to know the relation between Z axis voltage and pattern intensity. Our method of calibration was to use a MacBeth illuminometer. The inverse of the function describing the relation between input voltage and mean luminance was used in the display program to compensate for nonlinearities.

Subjects communicated with the computer controlling the display by means of pots on a control box which allowed them to adjust the contrasts of the matching pattern's component sinusoids. Three "action" buttons (see Figure 3) allowed the subjects to signal to the computer that they either (a) wanted to change the contrasts as indicated by new pot settings, or (b) that they wanted merely to scale all contrasts uniformly up or down, or (c) that they were satisfied with the match. Contrasts were not updated continuously, since approximately 2 sec of computations were required to change a pattern. The control pots were in simple voltage dividing circuits whose outputs were sampled by a multiplexed A/D converter on every 10th display scan.

Figure 1. Photograph of display as formatted for texture matching experiments.

Figure 2. Block diagram of display system as used in texture matching experiments.

Figure 3. Control box circuitry. Channels 0 to 4 are pots for controlling contrasts of the component frequencies. Channels 5 to 7 are the "action" buttons.

DISCUSSION

This method was devised to permit a convenient means of studying texture. Its chief virtue is its flexibility in generating "one-dimensional" stimuli on-line. Clearly, the method is general, and can be used for many other types of studies. For example, the addition of a timing routine to the display program will extend the display capability to flashed and moving stimuli. Wilson (1976) has used this method of display to study dynamic aspects of binocular vision. We have also used the display to study the effects of spatial frequency adaptation on texture perception. Perhaps the greatest advantage of this method is that the pattern of luminance is specified by software, and thus complex nonlinear luminance distributions may be created as easily as sinusoids.

A listing of the computer program is available from the author.

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