Computer display of large quasiperiodic random noise fields*

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In the course of studying the effect of random noise interference fields upon the detection of changes in spatial position (Pollack, 1971), we sought to present several random noise fields each containing a large number of dots. Within the temporal constraints of the study and within the spatial constraints of the program, we could not generate the dots in real time, and insufficient space was available to store several large fields of random dots within the limited capacity of the PDP-8 computer (4,096 words). Since we had storage available for one large field of random dots, and since high-speed rotation of numbers can be accomplished quickly upon the computer, a solution was suggested. We stored the random numbers for the coordinates for one field of random dots. By bit rotation of the random numbers, we could achieve other fields of random dots. With the 12-bit PDP-8 computer, one thus could store up to 12 random dot fields in the space allotted to only one field, before repeating the pattern of random dots. Technical details are presented in the Appendix.

At about the same time, we were searching for an analog of the Guttman-Julesz (1963) procedure within visual displays. In the Guttman-Julesz procedure, repeated segments of auditory random noise waveforms are presented to listeners. The task of our viewer was to detect the periodicity in the dot patterns.

The bit rotation procedure has one disadvantage for a large number of successive random dot fields: upon successive rotations, the numbers are repeated. This "disadvantage," however, is the essence for developing repeated dot patterns. In the 18-bit PDP-9 computer, up to 18 fields of random dots can be presented by bit rotation before repetition of the field. By varying the size of the rotation, any repetition period up to the maximum length of 18 can be achieved. For example, 3 successive rotations of bit length 6 will be periodic; 5 rotations of bit lengths 3, 3, 4, 4, and 4 will be periodic; 18 successive rotations of length 1 will be periodic The method also permits the study of the relative discriminability among different periods. Our preliminary findings suggest that the threshold for detection of periodicity within random dot patterns is about 300 msec, as measured by 75% correct performance in a one-interval test of "periodic" vs "random" fields.

APPENDIX Technical Details

PDP-8: A single 10-bit converter was available with a 12-bit word. Right rotation of the contents of Bit 0 into the LINK produces either a 0 or a 1 in the LINK; the

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contents of the LINK are then deposited in Bit 9. This process is repeated for the desired number of rotations. The method requires 36 microsec per point plus a dead time of 172.5 microsec, not including display time.

PDP-9: Two 9-bit converters were available with a single 18-bit word (Wojnarowski, Bachman, & Pollack, 1971). Nonintegral factors of 18 are achieved by successive subtraction; e.g., periodic rotation among five fields is accomplished by: $18 \div 5 = 3$; 15 (or $18 - 3$) $\div 4$ (or $5 - 1$) $= 3$; $12 \div 3 = 4$; $8 \div 2 = 4$; $4 \div 1 = 4$. Since smaller rotations take less time than larger rotations, dead time is inserted so that each frame requires 25 microsec per point and a frame time of 50 microsec. Fields of up to 5,500 random dots have been generated by this method upon the PDP-9 (8,192 words without external memory). We have also generated individual random dots at 100 microsec per dot in real time. Quasiperiodic sequences are generated by reinitializing the random number routines with the same starting numbers.

Program Sequence

The outline of the program sequence is:

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/ THE PLOT ROUTINE IS INITIALIZED BY TABLE
/ LOOK UP
/ THE SHIFT INSTRUCTION IS INSERTED INTO
/ LOCATION PLOT + 5
/ TO EQUALIZE THE TIME DIFFERENCE OF
/ DIFFERENT SHIFTS THE ASSOCIATED WAIT
/ CALL TO "WASTE TIME," AS JMP WT, IS
/ INSERTED INTO LOCATION PLOT + 4
/
PLOT   LAC*   10      / PICK UP X-Y
                        / COORDINATES
                        SNA      / ZERO SKIP, TO CHECK
                        / FOR END OF TABLE
                        JMP   PEND / IF TABLE END
                        LMQ      / READY FOR AC-MQ
                        / SHIFT
                        XX       / DEADTIME WAIT CALL
                        XX       / SHIFT INSTRUCTION, AS
                        / "LLS + N"
                        DXY      / DISPLAY X-Y USING D-A
                        DAC*   11 / RETURN SHIFTED POINT
                        / TO TABLE
                        JMP   PLOT
/
/ DEADTIME WAIT CALL
/ TYPICALLY, JMP WT, JMP WT + 1, JMP WT + 2, ETC.
/
WT      NOP          / WAIT 7 MICROSECS.
        NOP          /      6
        NOP          /      5
        NOP          /      4
        NOP          /      3
        JMP   PLOT + 5

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