DESIGN AND FABRICATION OF NONLINEAR HALFTONE SCREEN

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ABSTRACT

A new model has been developed to determine halftone screen characteristics to achieve different functional dependencies of halftone transmittance on the input photographic transmittance. An advanced knowledge of the threshold transmittance is required.

INTRODUCTION

THE Halftone Technique[1] has recently proved useful in achieving different monotonic and nonmonotonic nonlinear characteristics in a coherent optical data processing system. Examples are Equidensitometry[2], Logarithmic Filtering[3–6], Pseudo-coloring[7], Level-slicing[8] and Analog-to-Digital Conversion[9–10]. A very fundamental difficulty in the nonlinear optical data processing is the realization of desired transmittance characteristics and its correspondence to the screen-design. In fact the logarithmic filtering experiment conducted by Kato and Goodman on an accidentally obtained Logarithmic Screen[3,4]. The complete restoration of signal from multiplicative noise couldn't be realised because of the lack of an Exponential Screen. In this paper we attempt to develop a newer design Algorithm for screen-design corresponding to the expected transmittance characteristics.

ALGORITHM

This particular approach of screen design involves the assumptions of (*a*) the threshold transmittance of the high contrast film be known in advance[11–13], (*b*) the input transmittance of the original remains constant over the region of any one screen-cell, (*c*) Yule-Nielsen Effect[14,15] in printing shall be neglected, and (*d*) positive high contrast film of infinite gamma[16] is used for the making of the halftone photograph.

The halftone screening process is emphasised completely in Fig. 1. A possible one-dimensional line screen transmittance profile, $T^S(x)$ is shown in Fig. 1 *a*. Fig. 1 *b* shows a possible constant input transmittance, T^P, which is optically multiplied together to the screen-transmittance to yield the transmittance profile of Fig. 1 *c*. This multiplication is optically accomplished by contact printing of input transmittancy and the halftone screen is photographically recorded on a high contrast copyfilm. The transmittance of the copyfilm is ideally either 1 or 0 because of its high-contrast characteristics. The region for which the product $T^S T^P$ exceeds the threshold transmittance T^{th}, develop to have a transmittance 1; otherwise the film becomes opaque. The halftoned version of the transmittance therefore results as in Fig. 1 *d*, accordingly.

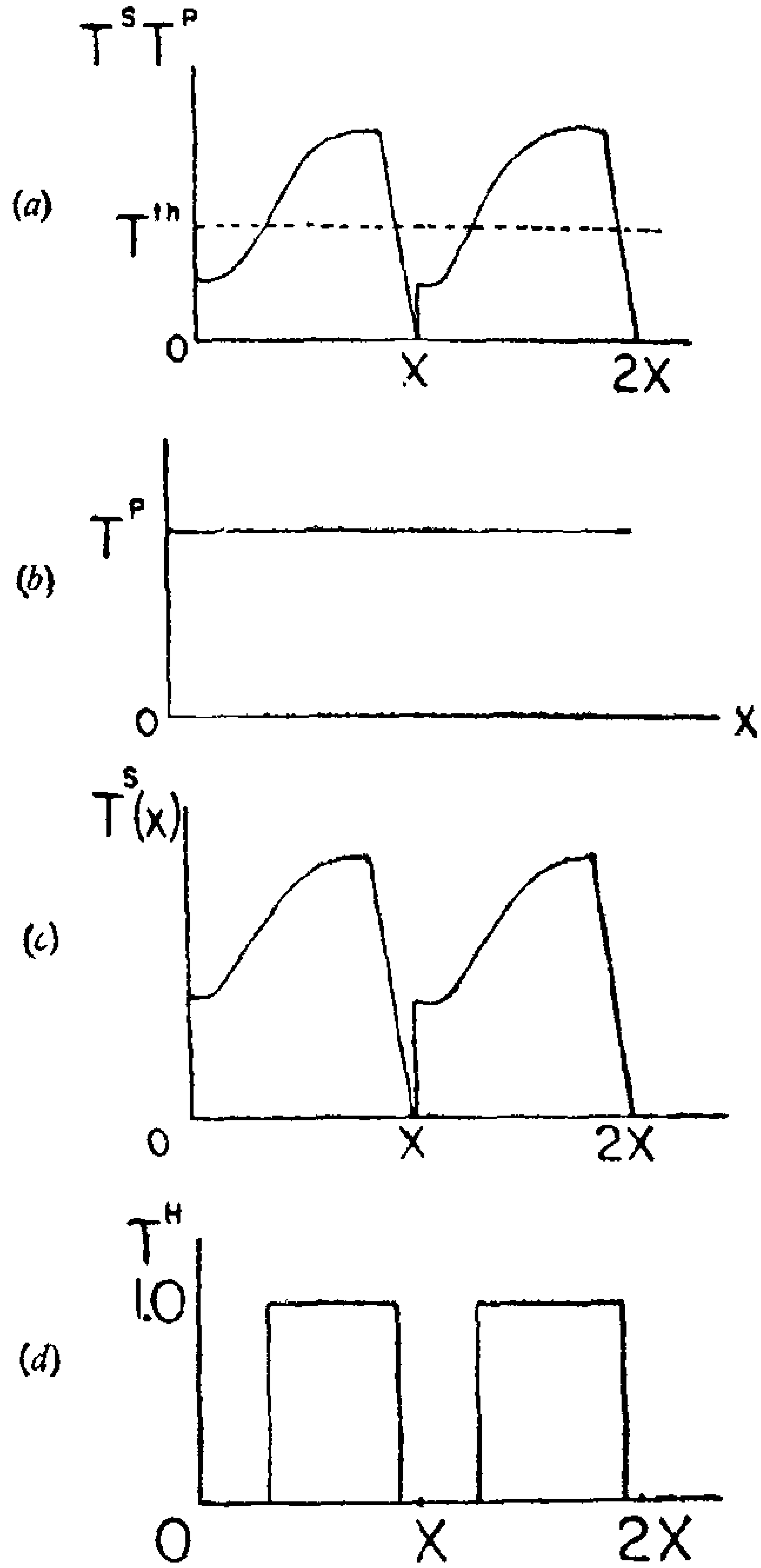

FIG. 1. Halftone process with screens of line-cells. (*a*) Screen transmittance of two cells. (*b*) Input photographic transmittance. (*c*) Combined transmittance of the screen in contact with the image. (*d*) Transmittance of the resulted halftone photograph.

It is of impoitance to identify now the tiansmittnce of the halftoned photograph, T^H, at least over the region of one unit screen-cell. T^H can be defined as the ratio of the transparent area to the area of the unit screen-cell.

For all values of photographic input trensmittance, T^P, in the region of $1 \geqslant T^P \geqslant T^{th}$, there will be one value of screen position in each cell measured from the cell-origin, at which,

$$T^S(x)\, T^P = T^{th}. \tag{1}$$

The halftone transmittance, T^H, over the area of a unit symmetric screen cell, of period X, where screen transmittance decreases monotonically on either side of the cell-origin, is given

$$T^H = \begin{cases} \dfrac{x}{X/2} & \text{for } 1 \geqslant T^P \geqslant T^{th} \\ 0 & \text{for } T^{th} > T^P \geqslant 0 \end{cases} \tag{2}$$

The desired functional relation in the most general term can be

$$T^H = f(T^P) \tag{3}$$

where $f(T^P)$ is any continuous function of T^P, limited by the obvious fact that for all transmittance T, $0 \geqslant T \geqslant 1$. Incorporation of eqn. (1) into eqns. (2–3) yields the halftone screen-criterion as,

$$T^S(x) = \begin{cases} T^{th}/T^P & 1 \geqslant T^P \geqslant T^{th} \\ 1 & T^{th} > T^P \geqslant 0 \end{cases} \tag{4}$$

and

$$x = \begin{cases} \dfrac{X}{2} f(T^P) & \text{Symmetrical } \underbrace{\text{monotonic}} \\ \dfrac{X}{2}[1 - f(T^P)] & \text{Symmetrical nonmonotonic} \\ X[1 \pm f(T^P)] & \text{Nonsymmetrical monotonic} \end{cases} \tag{5}$$

Eqns. (4–5) would provide the exact characteristics for screen-design for achieving the desired relationship $T^H = f(T^P)$. A multilevel screen can now be fabricated to meet the above criteria by means of a Ronchi-ruling translation-exposure method provided by Liu[15]. A screen so designed will have no error when the number of levels become infinite.

For a n-level of such symmetric screen, T^S, would be approximated to $n/2$ different values in the ranges of 0 to X/n, X/n to $2X/n$, ..., $(n-2)X/2n$ to $X/2$ respectively for even n and to $(n+1)/2$ different values in the ranges of 0 to $X/2n$, $X/2n$ to $3X/2n$, ..., $(n-2)X/2n$ to $X/2$ respectively for odd n.

A reasonably acceptable estimate would be to approximate theoretical screen transmittance $T^S(x)$, by $^S(x)$, such that in a multilevel screen for large n,

$$^S(x) = \frac{T^S(x_1) + T^S(x_2)}{2} \quad \text{for } x_1 \leqslant x \leqslant x_2 \tag{6}$$

where x_1 and x_2 are the two extreme values of x in each of the n levels of the cell-period.

Discussion

This particular algorithm has been utilized to fabricate a line logarithmic screen, corresponding to a range input photographic transmittance 0·01 to 0·63096. A very interesting comparative study involving logarithmic and linear filtering in their ability to separate multiplicative noise have been completed with the said screen[6].

Presently, work is in progress to make a halftone screen, such that the input and the halftone transmittance are equal. Incorporation of this algorithm in the fabrication of a screen would be useful in obtaining a high-fidelity screen. These works would be reported in future communications.

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