AUTOMATIC ANALYSIS OF REPRODUCTION COPY FOR OPTIMUM TONE REPRODUCTION

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Abstract: The Carlson Company has introduced two devices which employ the technique of histogram picture analysis. One device is designed for the analysis of reflection originals where the information is used to control black and white halftone exposures. The second is designed for analysis of transmission or reflection color originals where the information is used for pre-scan analysis.

The technique employed by these devices has the ability to evaluate the tonal quality of the original. From this information, the system is able to derive the tone reproduction curve best suited for optimum reproduction. Identification of highlight and shadow densities and correction for "keyness" and the effects of over and under exposure are thus determined automatically.

Examples of picture evaluation are shown. Both systems are fully described and illustrated.

Introduction

Various techniques can be used for enhancing and restoring the appearance of a picture, particularly when digital imaging is involved. Although these techniques have been known for some time and some investigations using them have been made in the graphic arts, relatively little practical application has appeared in the way of actual hardware until very recently.

An early graphic arts investigation comes from the USSR. Ovchinnikov, et al (1973), was perhaps first to present the details of "an analyzer of image statistical parameters" for graphic arts application. Their analysis system shows a scanner of the revolving drum type. The output of the scanner is first converted to density

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and then finally to a visually uniform scale similar to Munsell Value. This signal is then passed to a "statistical sampling" block which has the ability to separate out the background (non-informational) parts of the image. The result is that only the "informational" parts of the picture being scanned are passed. Data, thus selected, are used to generate a frequency histogram of the detailed parts of the picture.

Using their device to evaluate various originals, Ovchinnikov shows that the lightness distribution of pictures with high subjective quality is always similar. Furthermore, it is claimed that the preferred distribution for good subjective quality approaches a normal Gaussian curve.

Finally, the Ovchinnikov publication shows how the lightness distribution of any picture can be compared to a preferred distribution to derive a required tone reproduction curve.

Practical Applications

The Carlson Company has developed two types of image analyzers which employ the technology just described. One is a flat bed scanner designed for the analysis of black and white reflection copy where the output is used to control halftone exposures. The other is a digital camera for analyzing color transparencies and color prints which provides input to a pre-scan analysis system. Both units employ solid state receptors and high speed array processors.

Figure 1 schematically shows the flat bed scanner and its association with multiple computer/timers for black and white halftone production.

Copy to be analyzed is placed on the traveling bed of the scanner. As the copy passes under the illuminated slit, density values across the width of the copy are collected line by line. The linear CCD array, used for measurement, contains 256 sites over its length. This corresponds to an effective spot size, at the copy, of approximately 1/20th inch.

As the copy is scanned, its analysis is in progress. The processor first finds potential highlight and shadow densities. In this process, data clusters below a certain minimal size are ignored. At the end of the scan, the operator is presented with the lowest highlight density found. He can either accept this density or ask for the next density level found. Shadow densities are handled in a

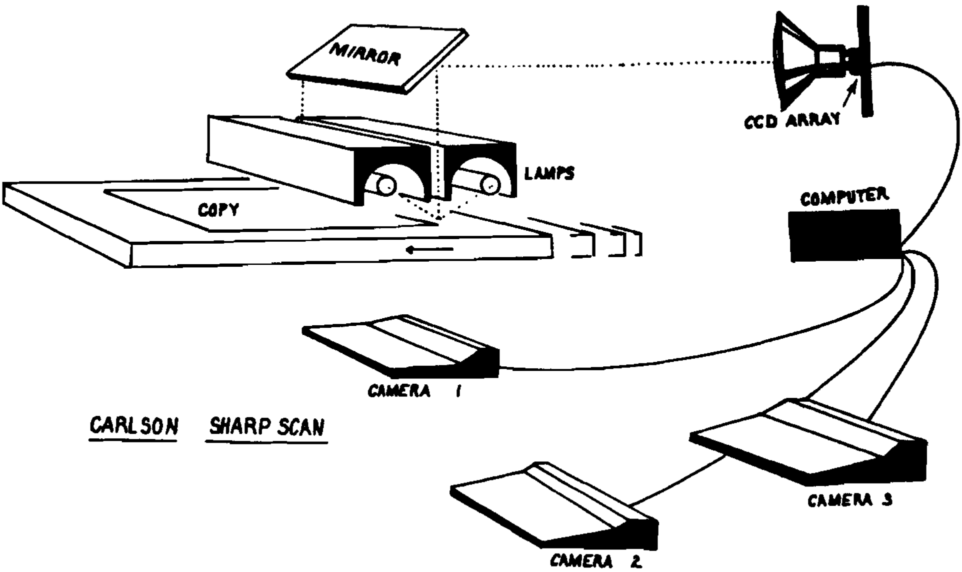

Figure 1. The Carlson copy evaluation system for black and white copy. Shown with multiple exposure/computers for halftone exposure control.

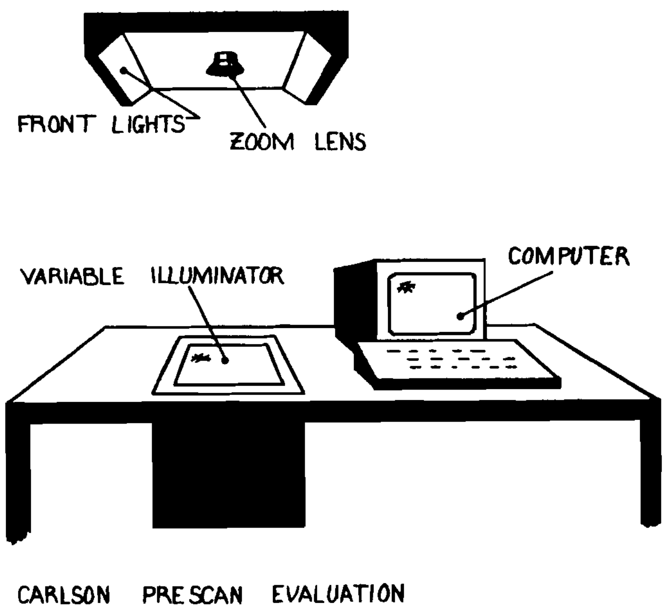

Figure 2. The Carlson copy analyzer for color transparencies and color prints. Shown as part of ScanCal, the Carlson pre-scan evaluation system.

similar manner starting with the highest density found. A manual entry of highlight or shadow density can be made if necessary.

With the highlight and shadow densities of the copy established, the processor continues with its analysis. All data points over the entire copy area are evaluated. Data points which fall within uniform areas, e.g. clear skies and backgrounds, are ignored. Only data points which are part of detailed areas and fall between the selected highlight and shadow are used for deriving the recommeded tone reproduction.

For black and white halftone production the recommended tone reproduction takes the form of a midpoint density range (MDR), which is the optimum placement for the selected midpoint dot (normally 50%). The recommended MDR must be determined in conjunction with the MDR preferred for normal copy, i.e. normal keyness. Preferred MDR values depend upon individual printing conditions and the associated amount of dot gain.

For each piece of copy evaluated the system assigns a copy number. At the end of each evaluation a lable is printed for attachment to the copy. Each lable gives the copy number, percent magnification, highlight and shadow densities, and recommended MDR.

The black and white analyzer is also capable of direct communication with special exposure computer/timers located remotely at individual cameras. The present system will handle up to three computer/timers simultaneously. As each copy is scanned, the information appearing on the lable is also stored in memory. When the camera operator keys in the copy number, all information required for exposure calculation is downloaded to the computer-/timer. Exposure times are then calculated automatically and ready for exposure. No further entries are required by the operator.

Figure 2 is a schematic showing the arrangement used for pre-scan evaluation. Here the copy is placed beneath a scanning camera. The copy does not move. Instead the CCD array scans across the projected image inside the camera. A zoom lens is provided to adjust the area being scanned. This arrangement allows copy between 35mm to 8 by 8 inches to be evaluated with equal accuracy. Housed with the camera are two light units which provide front lighting at the copy plane.

To illuminate transparencies, a special illuminator is mounted flush with the counter top. Color content and intensity of the light from this unit can be adjusted in known amounts. Color is adjusted using three levers which control, plus or minus, the cyan, magenta and yellow content of the light. Its operation is very much like the color head for a photographic enlarger. Overall brightness of the light can be adjusted by a fourth control which is calibrated in density. The color balance of the light remains constant when the density control is adjusted.

Density values from the camera and control setting values from the transparency illuminator are sent directly to the computer which does all calculations.

For transparent copy the operator begins by placing the transparency on the face plate of the illuminator and then places a mask over the transparency to block extraneous light. Masks are provided with openings for all of the standard transparency sizes. Each mask is numbered. This number corresponds to a preset position for the zoom lens. The masks are completely opaque with a matt white finish.

With the transparency in place the operator asesses its color balance. This assesment is especially easy with the matt white surround which provides a standard white reference. If color cast correction is required the operator adjusts the C,M & Y controls of the illuminator until correction is achieved. If the transparency is unusually dark the density control can be used to lighten the transparency, making cast correction easier. The density control is also very useful in determining the subjective highlight density of transparencies which do not have a measurable highlight density. Ahrenkilde (1971) demonstrated how this method of highlight determination can be quite accurate. Normally, where measureable highlights exist, the scanning camera readily finds the highlight density as well as the shadow density.

When cast correction and density adjustment, if necessary, have been made, the scanning camera is started. As the copy is scanned, a low resolution representation of the transparency appears on the monitor of the computer. The location of the minimum density found by the camera/processor is identified by a flashing cursor. The numerical value of the density is displayed in the margin. As with the black and white scanner, density sites below a certain minimum size have been ignored by the camera/computer. The operator can display the locations of the next density level found by keyboard control until he is satisfied that the correct highlight level has been established. Shadow density locations are displayed and manipulated in similar manner beginning with the maximum density found by the camera/computer.

With the highlight and shadow densities established the computer proceeds to compute a recommended tone reproduction for the copy scanned. Simultaneously, the operator is free to enter all other data pertainent to the job. When keyboard entries are complete the copy analysis is also complete. At this point the recommended tone reproduction is displayed graphically on the monitor. The preset gradation curves of the color scanner, stored as part of the data set, are searched and the one which best fits the prescribed tone reproduction is identified. The tone reproduction that will result from this best fit is superimposed on the monitor along with the prescribed tone reproduction. The operator now has three options: 1) go with the gradation of best fit, accepting its tone reproduction as satisfactory, 2) match the prescribed tone reproduction exactly, using the gradation of best fit as a starting point, 3) go to a manual mode which allows you select your own tone reproduction.

Reflection copy can be similarly evaluated using the scanning camera. The overhead lights provide illumination for scanning. Cast correction, when necessary, must be made using viewing filters. CC values are entered manully.

Analysis Results

Figures 3 through 8 show the results of histogram analysis obtained with various types of copy. These results have been plotted using "Darkness", which is a visually uniform scale modeled after Bartleson-Brenemann Brightness. (Darkness equal 100 minus Brightness) In this space a straight line is usually considered good tone reproduction for a normal subject.

A dashed line is used where all data values above the highlight have been used. A solid line is used where only "informational" data points above the highlight have been used.

Figures 3,4 & 5 illustrate the analysis of a normal subject, high-key subject and a low-key subject respectively. Figures 6,7, & 8 illustrate the effectiveness and importance of using only "informational" data points for analysis.

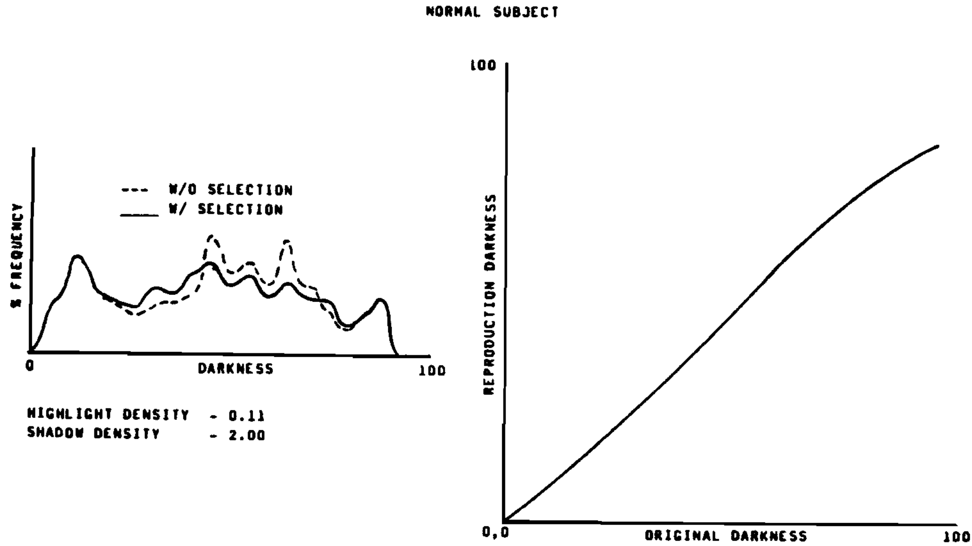

Figure 3. Results obtained from "normal" copy, i.e. neither high-key nor low-key. (Black and white original)

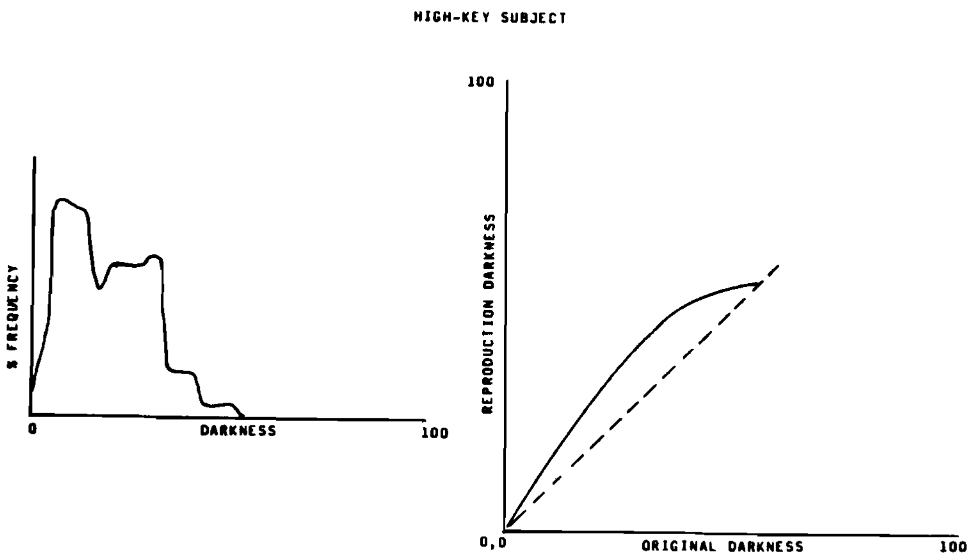

Figure 4. Results obtained from high-key copy. (Color transparency original)

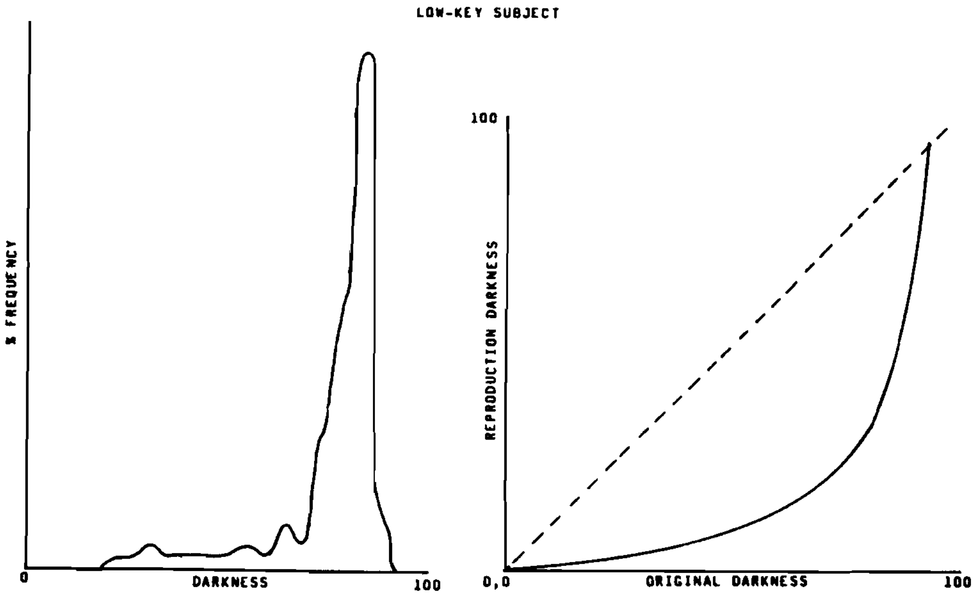

Figure 5. Results obtained from low-key copy. (Color transparency original.)

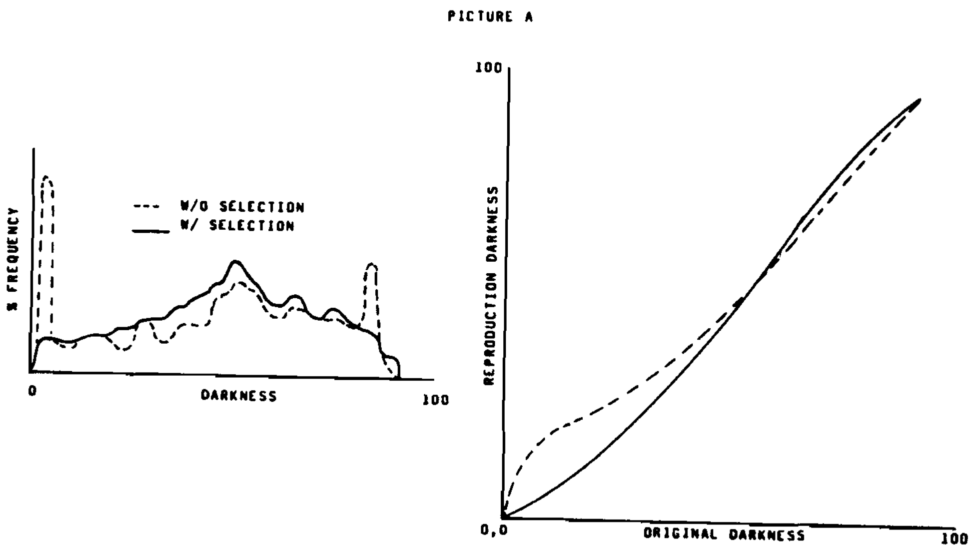

Figure 6. Analysis of subject with light background. (Color print original)

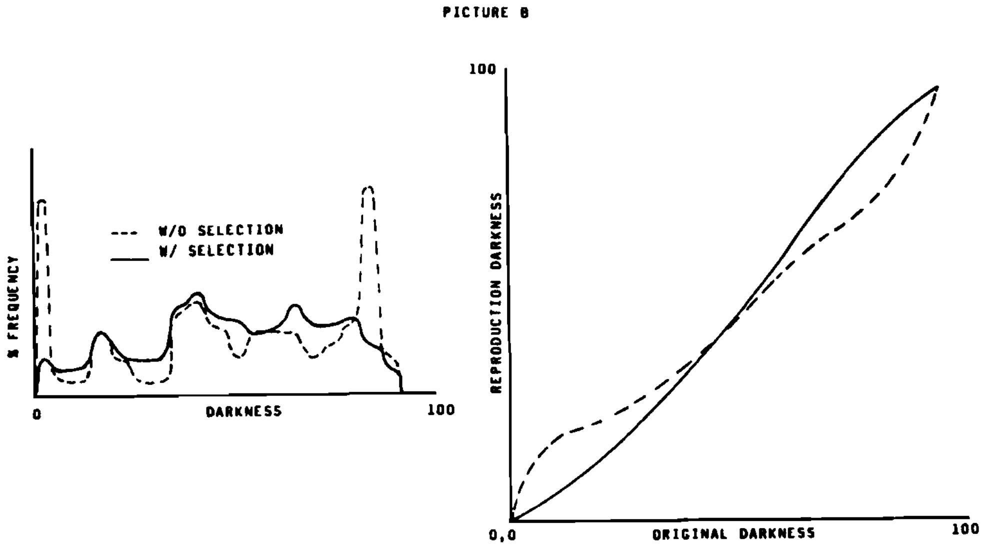

Figure 7. Analysis of subject with dark background and non-detailed white areas. (Color print original)

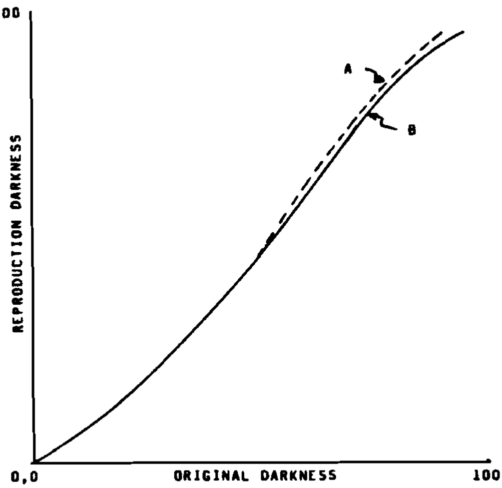

Figure 8. Comparison of the final tone reproduction curves of figures 6. & 7.

Acknowledgments

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