Robert G. Best
Jack R. Smith
Remote Sensing Instttute
South Dakota State University
Brookings, SD 57007

Photographic Contrast Enhancement of Landsat Imagery

Film type, developer, and development time are varied selectively to produce higher contrast.

Abstract: *A photographic technique for contrast enhancement of Landsat imagery is documented and illustrated. An increase in photographic contrast (gamma) results in greater density differences among scene features and better radiometric resolution providing the maximum interpretation potential of Landsat imagery. The process involves selectively varying film type, developer, and development time to produce higher contrast in the reprocessed image. The technique has applications in any project which utilizes Landsat imagery.*

Introduction

For many applications standard Landsat film products lack the tonal contrast required to easily distinguish scene features. Sixty-four brightness levels in each of the four multispectral scanner (MSS) bands are recorded by the satellite. This signal is calibrated and expanded in MSS bands 4, 5, and 6 prior to generating standard film products. When the film product is exposed, the brightness levels must be recorded within the density range of the photographic emulsions used. The radiometric range or exposure latitude of most films is only approximately two standard density units. In numerous scenes, primarily in MSS 4, there is a relatively uniform scene reflectance, and the total density range of the film is not utilized. In Landsat prints, if the scene reflectance information does not cover the full density range of 2.0, the exposures are adjusted so that saturation occurs at the second darkest step on the standard transmission gray wedge.*

During exposure of the original Landsat image, a film gamma corrector is used to adjust the slope of the D-log E curve to $\gamma = 1$ and to straighten the toe and shoulder in an attempt to produce a linear relationship between film transmission and MSS digital count. However, if the minimum film transmission (T_{min}) is not equal to zero, the D-log voltage curve deviates from $\gamma = 1$ at high densities, resulting in lower contrast in the darker portions of the image. Succeeding generations available to the user are reproduced at $\gamma = 1$ on the linear portion of the curve of film used.*

It was demonstrated in this project that the degree of image contrast could be adjusted in a modestly equipped photo laboratory using relatively simple photographic principles. Contrast in a reprocessed image can be increased by selectively varying film type, exposure, developer chemistry, and the duration of development. This report documents and illustrates the technique that was applied.

Photographic Contrast Enhancement Theory

Film "contrast" or "gamma" (γ) is the slope of the straight line portion of the characteristic curve (D-log E) and is usually

* *Landsat Data Users Handbook*, Document No. 76SDS4258, NASA Goddard Space Flight Center, Greenbelt, Maryland 20771. Sept. 2, 1976. pp. 16-24.

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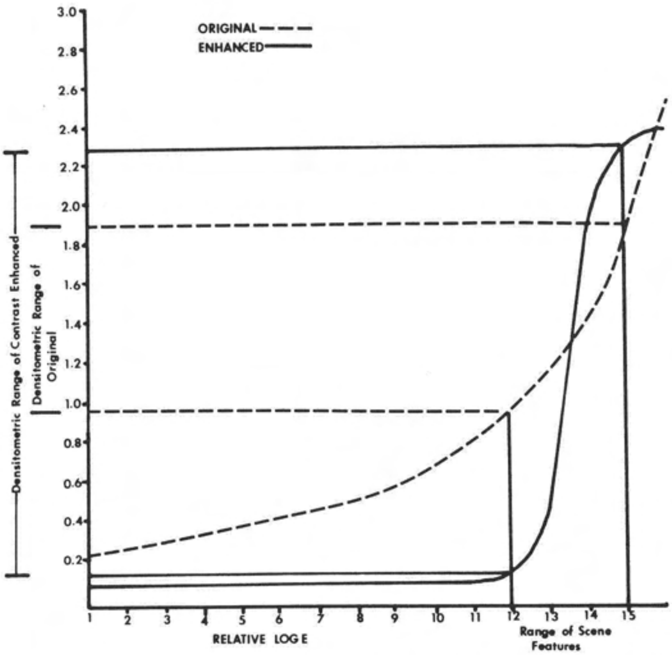

FIG. 1. Graphic illustration comparing the characteristic curves of standard product and contrast enhanced image. Data plotted for MSS 4 of Landsat image #2337-07292.

measured at the tangent formed by a projection of the straight line portion of the curve and the log E axis. The curve describes the photographic characteristics of the film for a given developer and development time. Different gammas can be obtained by using different film and developer combinations and by varying development times. In general, gamma increases for a specific film-developer combination with increased development time if developer temperature remains constant.

The effect of increasing contrast can best be explained graphically. Figure 1 illustrates the characteristic curves for a contrast enhanced reprocessed image as compared to the characteristic curve of the standard product. The gamma of the standard product is approximately equal to one. As in many MSS 4 images, the scene features utilize only a short range of the potential recording capability of the film and cover only a short density range. The contrast enhanced image has a gamma greater than four and "stretches" the informational content over a much larger density range. This results in greater density differences among scene features providing a more interpretable image, where tonal differences are a criteria for interpretation of scene features. It is also apparent on the graph that for a given densitometric resolution the best radiometric resolution occurs with the higher contrast. The technique is applicable to all bands; however, the stretch generally required for MSS 5 and 7 is in the range of γ = 1.5 to 3.0. It should also be noted that it is possible to increase contrast to a greater degree for selected scene features with a subsequent loss of the information that does not fall within the gray-level region to be stretched.

The effect of photographic contrast enhancement is similar to the computerized "contrast stretch" of digital Landsat computer compatible tapes (CCT's). In the digital stretch the data range is expanded to the maximum range of the recording system.

MATERIALS AND METHODS

The procedure developed in this project involved selecting various film types, developers, and development times to produce a range of gammas in the reprocessed image from below one to greater than four. Kodak films and developers were used because of their availability; however, the technique is applicable for other brands of film and developers.* Sensitometry was exposed on

* Inclusion in this report of registered trade name or trademarks does not constitute an endorsement by the authors or the Remote Sensing Institute.

TABLE 1. GAMMA RANGES PRODUCED BY VARYING DEVELOPMENT TIME FOR FILM DEVELOPER COMBINATIONS.

Film	Developer	Gamma Range
Professional Copy 4125	D-76	<1 − 1.90
Professional Copy 4125	D-19	1.80 − 2.7
Kodalith Ortho Types 3 6556	Kodalith	>4

each of the film types and development time varied with each developer. The developer temperature was maintained at 18 ± 0.5° C. The characteristic curves were plotted for each combination and gamma determined. Table 1 is a list of film and developer combinations and the resulting gamma range for each. For a given film-developer combination, increased development time increased gamma.

Prior to reprocessing, the Landsat image was analyzed on the Spatial Data Systems Datacolor Model 703, an electronic density slicer, in order to determine the densitometric range of scene features in the image relative to the gray scale. The image was contact printed onto the selected film and developed for the specific time required to produce the correct degree of contrast enhancement without loss of information content. Images with a densitometric range less than 0.95 standard density units were processed to $\gamma = 4.0$. Imagery with ranges of 0.95 to 1.25 or 1.25 to 1.75 standard density units were processed to $\gamma = 2.75$ and $\gamma = 2.15$, respectively. Any image with a densitometric range greater than 1.75 standard density units was not enhanced in order to prevent losses of informational content. Exposure was controlled so that the data remained in the straight line portion of the characteristic curve in order to maintain the linear relationship between film density and digital count.

RESULTS

The effect of contrast enhancement is evident on the reprocessed imagery when it is compared to the standard product (Figures 2 and 3). Figures 2 and 3 are positive contact prints of MSS 4 standard and contrast enhanced imagery. The density range of the scene features in the standard product is 0.94 density units (0.95-1.89) as compared to 2.19 density units (0.08-2.27) in the "stretched" image. A graphic illustration can be seen in Figure 1. In general, less stretch is required in bands MSS 5 and 7 and the effect is not as evident on imagery. Color composites of reprocessed imagery exhibit a wider range of hues and chromas than do standard color composites.

FIG. 2. Positive print of scene #2337-07292 in Sudan which reflects the tonal contrasts apparent in the original standard transparency.

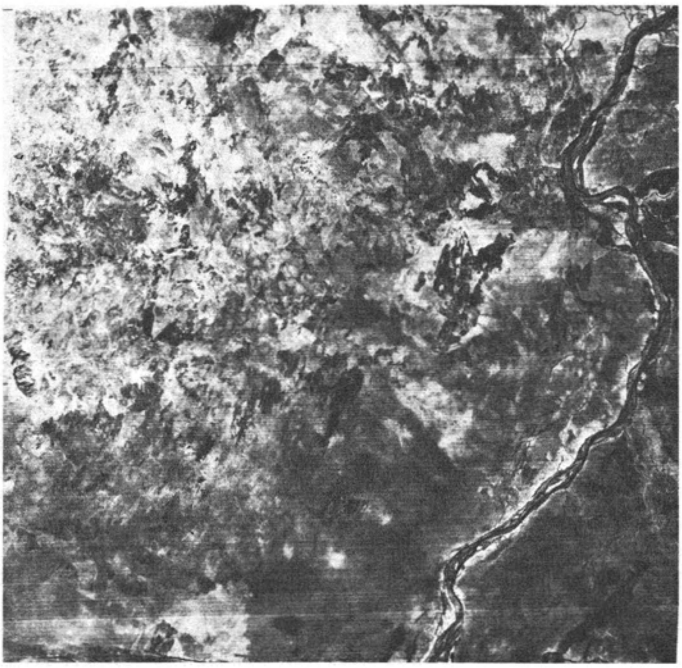

FIG. 3. Photographically contrast enhanced MSS 4 image of the same Landsat scene in Figure 2.

CONCLUSIONS

The use of photographically contrast enhanced imagery has applications in any project which utilized Landsat imagery. This particular technique was developed for use with Landsat imagery; however, with slight modifications it would be applicable for use with other types of photographic data. The products, either black-and-white or color composites, provide the user with the maximum interpretative potential. Contrast enhancement to some degree may provide better color saturation for additive viewing and diazo false color composites.

The results are similar to those produced in a computerized contrast stretch of digital CCT data, but the photographic enhancement can be prepared at a fraction of the cost. The contrast enhanced imagery can be produced in a modestly equipped photo laboratory. The technique has many applications in developing countries which do not have the resources or technical expertise to purchase or man an extensive computer system. Gamma manipulation can be used to adjust reflectance differences in adjacent scenes in order to produce black-and-white or color tone-matched imagery for photo mosaics.

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