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The Display of Landsat Data at Large Scales by Matrix Printer

Color images of digital Landsat data may be conveniently and economically displayed on standard lineprinter paper by using a matrix printer.

Abstract: *Lineprinter images of digital Landsat multispectral data may be conveniently and economically displayed on standard lineprinter paper by using a matrix printer. DOTPRINT images at nominal scales of 1:24,000, 1:50,000, and 1:62,500 are produced. These images may be compared with maps and aerial photographs to locate terrain features within about a 1 percent scale error. Other smaller scales may be produced by averaging row-by-column pixels. More precise geometry is obtained by using control points and regression equations which permits features to be located to the nearest half-pixel over an area the size of a 15-minute quadrangle. Color infrared images and color classifications ("geological maps") may be produced from several DOTPRINTs by overprinting channel- or ratio-images of different colors on the same piece of paper.*

Introduction

A major problem which arises when working with Landsat digital tapes is the difficulty of locating the individual pixels on large-scale maps. One frequently used method of comparing the two data bases is to produce lineprinter symbols which represent shades of gray for each pixel. This method generates images with a scale of approximately 1:24,000 when the lineprinter symbols are spaced ten columns-per-inch and eight lines-per-inch, but no correction for skewness caused by the earth's rotation is usually made in these printouts, or "shadeprints" (Figure 1). Another alternative is to resample the data on a rectangular grid and produce "synthetic" pixels based on surrounding pixels, but this makes it extremely difficult to determine the original position and preserve the radiometric value of a pixel.

Discussion

The matrix lineprinter provides a convenient and economical method of displaying the original geometry of Landsat pixels on standard lineprinter paper at large scales of 1:24,000, 1:50,000, and 1:62,500 (Figures 1 and 2), or at smaller scales, by photoreduction (Figure 3), or by averaging N rows by N columns (thereby preserving the aspect ratio of the pixels). A 6×6 average produces 1:144,000, 1:300,000, 1:375,000 scales using the above lineprinter control patterns. This was accomplished by using the Printronix 300 Matrix Printer (Figure 4) (Printronix, 1975) to plot arrays of small dots generated by programs run on a PDP-10 computer. The matrix printer produces Landsat multispectral scanner images in the form of "dotprints" up to 13.2 inches wide and 18 inches long. The DOTPRINTS may have either exact or nominal scales, depending on the precision of pixel location required. The printer was programmed to plot period-sized dots (.), spaced 60-per-inch across the page and 72 dots-per-inch down the page. Although the printer has a potential resolution

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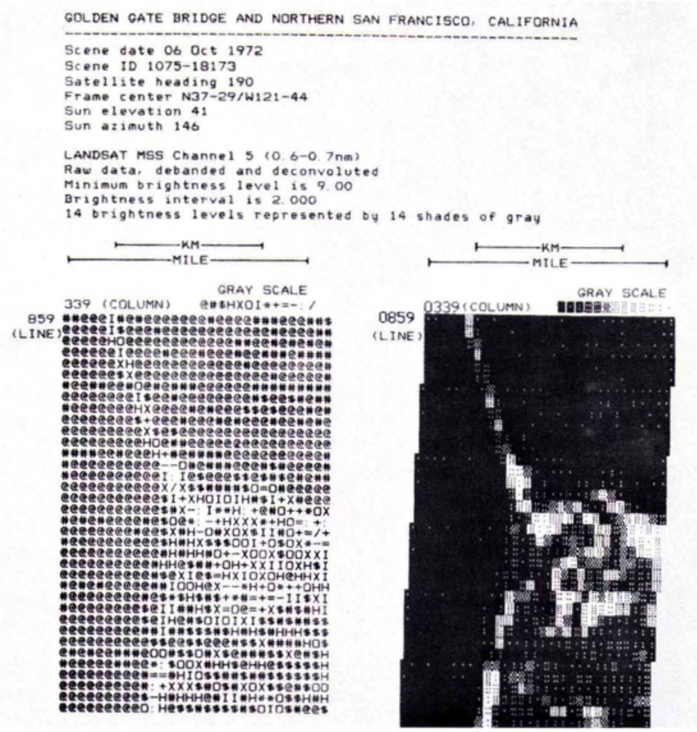

FIG. 1. Traditional lineprinter image with a scale of approximately 1:24,000 (left) and DOTPRINT of same area with a nominal scale of 1:24,000 (right). Both images have 14 shades of gray and display the Golden Gate Bridge and northern San Francisco, California as imaged on October 6, 1972 (scene number 1075-18173, channel 5). (Reduced 2×.)

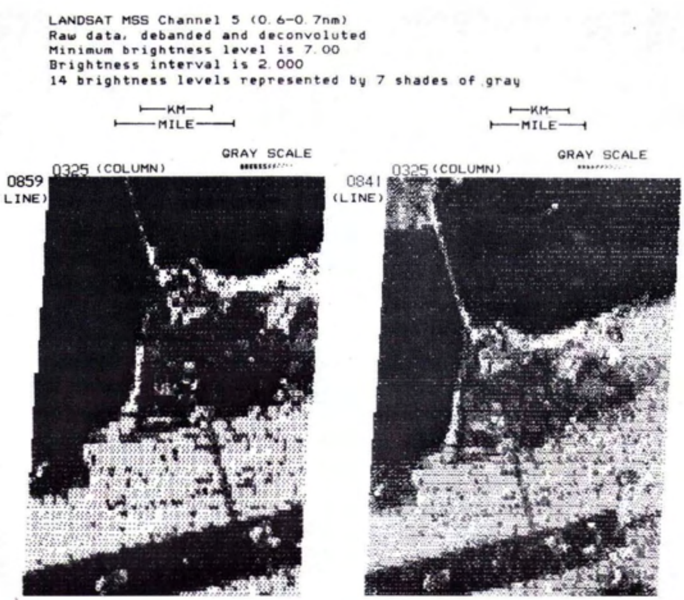

FIG. 2. DOTPRINTS with nominal scales of 1:50,000 (left) and 1:62,500 (right). Both images have 7 shades of gray and were produced from the same Landsat digital data as Figure 1 (scene number 1075-18173, channel 5). (Reduced 2×.)

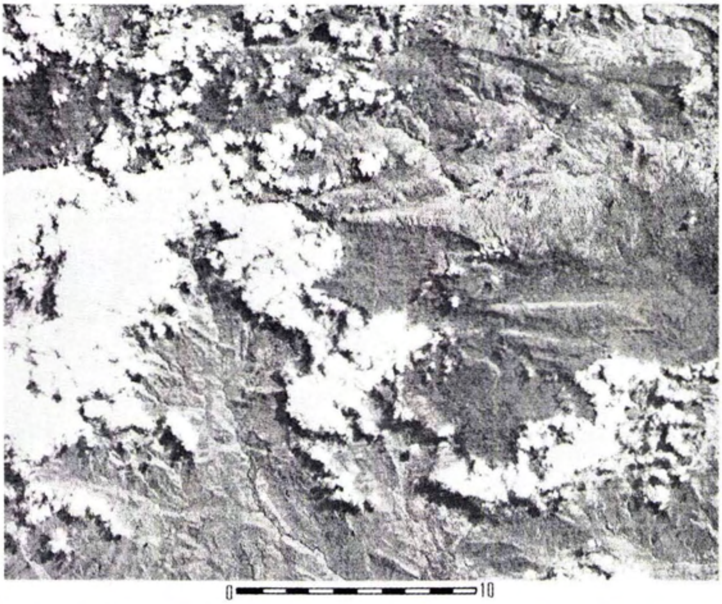

FIG. 3. Reduced DOTPRINT of central New Guinea Highlands originally at a scale of 1:62,500, and now photographically reduced, by a factor of 4.0, to a scale of 1:250,000. Mt. Fubilan (a porphyry copper deposit) occurs directly under the clouds in the left center. The Ok Tedi River runs from the the left center towards the lower center. The bargraph scale is in miles. (Reduced 2×.)

of 120 dots-per-inch across the page, the coarser spacing was used to reduce the array size of the plot files and to avoid using a spacing smaller than the size of the printed dots.

Pixel spacing for the three nominal scales used by the STANSORT computer program (Honey, Prelat, and Lyon, 1974) is 79 meters between scan lines and and 57 meters between pixel columns (NASA, 1972), with bands of six scan lines offset one-half pixel column from each other. The offset between adjacent sets of six scan lines is based on measurements made on a 1:1,000,000-scale Landsat image centered about 38 degrees north latitude and appears to be a suitable offset for images which are several degrees north or south of this latitude. Where spaces or "pull-aparts" between pixels occur, the system fills in with lines or columns of dots which match the gray level of the pixel immediately below or to the left of the pull-apart.

FIG. 4. Printronex 300 printer.

The true scale of the DOTPRINTs is generally within 1 percent of the nominal scale and has proved satisfactory for general terrain feature location. Images at exact scales are produced by using the UTM coordinates of control points visible on maps or orthophotos and the corresponding line-and-column coordinates of pixels as shown on nominal-scale DOTPRINTS to solve linear regression equations. The resulting equations are used to compute the spacing between scan lines and pixel columns and are also used to compute the offset between sets of six scan lines. The standard error of estimate for an area the size of a 15-minute quadrangle is about one-half scan line and less than one-half pixel column when 20 control points are used.

Both single-color and multi-color images may be produced by using a different color ribbon or "carbon" transfer paper for each image. Color infrared and color-coded classification maps also may be produced by overprinting three images on the same piece of paper. The classification maps made in this manner are especially convenient because they provide color images at nominal (or exact) scales and do not involve photographic processing. Images also may be printed directly onto frosted acetate, if this is secured by masking tape to the normal pagination with its precision sprocket holes.

Conclusions

Lineprinter images of Landsat multispectral data may be conveniently and economically displayed on standard linerprinter paper by using a matrix printer. DOTPRINT images at any of three different nominal scales are produced which may be overlaid on maps and aerial photographs and used to locate terrain features within about 1 percent scale error. More precise geometry is obtained by using control points and regression equations which permits features to be located to the nearest half-pixel over an area the size of a 15-minute quadrangle. Color infrared images and color classification maps also are possible when images of different colors are overprinted on the same piece of paper.

Acknowledgments

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References

Honey, F., A. Prelat, and R. J. P. Lyon, 1974, STANSORT: Stanford Remote Sensing pattern recognition and classification system: *Ninth Intl. Symp. on Remote Sensing of the Environment*, Ann Arbor, Mich., pp. 897-905.

Printronix, 1975, *Printronix 300 printer preliminary technical manual*: Printronix, Irvine, Calif., 32 p.

National Aeronautics and Space Administration, 1971, *Data users handbook* [for Earth Resources Technology Satellite]: NASA, Goddard Space Flight Center Doc. 71SD4249.

ISP Technical Commission Working Groups

Page 816 of the July issue of *Photogrammetric Engineering and Remote Sensing* listed the Officers and U. S. Correspondents of the Technical Commissions of the International Society for Photogrammetry. Within each Commission, Working Groups have been organized to carry out various tasks. Those who would like to take part in Working Group activities may contact the officers of the Working Groups listed below.

Commission I—Primary Date Acquisition

Working Group I/1—Image Quality, including OTF/MTF
Chairman: Dr. Roy Welch
Dept. of Geography
University of Georgia
Athens, GA 30601

Working Group I/2—Image Geometry with Camera Calibration
Chairman: Dr. Hartmut Ziemann
National Research Council
Ottawa, Ont. K1A OR6, Canada

Working Group I/3—Image Properties with Environmental Factors
Chairman: Mrs. Clarice Norton
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Working Group I/4—Sensor Orientation and Navigation
Chairman: Ir. F. L. J. H. Corten
ITC, P. O. Box 6
Enschede, Netherlands

Working Group I/5—Data Acquisition and Image Processing in Remote Sensing
Chairman: Dr. William A. Fischer
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