Practical Paper

Image Processing Approaches Using the Macintosh

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ABSTRACT: Macintosh computers and low-cost software were used to process Landsat digital data for enhancing lineaments in the Wichita Mountains of southern Oklahoma. NIH-IMAGE (public domain) and ADOBE PHOTOSHOP (low cost) software were found to be rapid, user friendly, and potentially inexpensive alternatives for generating 8-bit and 24-bit subscene images. Coupled with relatively low Macintosh hardware costs, the system appears to be a viable platform for many image processing techniques often applied to satellite digital data.

INTRODUCTION

GEOLOGIC INTERPRETATION OF IMAGE DATA usually includes mapping faults and fractures in areas of interest (Sabins, 1987). Enhancement techniques are often used to produce images with improved characteristics for lineament analysis. These enhanced images can yield dramatic results and be very beneficial to geologic mapping projects (Morgan *et al.*, 1988).

Many scientists, engineers, managers, or students are initially impressed with the results of image processing techniques and show a great interest as potential new users but may be turned off by such factors as software costs, hardware requirements, and training time. To help alleviate this problem in our university classes, at workshops, and in demonstrations, we have been experimenting with Macintosh computers and some easy-to-use, inexpensive software for geologic applications, including processing satellite digital data for fracture trace analysis. Macintosh software currently exists to introduce and demonstrate such things as 8-bit and 24-bit color images, various three-band false color composites, and many image convolutions using either Landsat or SPOT digital data. The Macintosh interface and display has proven to be both educational and powerful for the rather low investment costs.

For the past few years, we have been conducting field studies and image interpretation in the Cambrian-aged Wichita Mountains of southern Oklahoma (Donovan *et al*, 1987). These exposed igneous rocks represent intruded, uplifted, and exhumed portions of an ancient regional weakness known as the Southern Oklahoma Aulacogen. Thousands of fractures are found in these rocks, indicating a major tectonic imprinting during aulacogen development.

In this paper, we will show how Landsat TM digital data can be processed on the Macintosh to produce imagery for demonstration and analysis purposes. We will also provide information on software/hardware options involved in setting up an inexpensive Macintosh image processing station.

HARDWARE CONFIGURATION

This project was carried out on a Macintosh IIfx workstation with 8 megabytes of RAM, a 600 megabyte hard drive, and a Syquest 40 megabyte removable cartridge drive. The images were displayed using an Apple 824 color graphics card.[1]

The minimum recommended Macintosh CPU configuration required for image processing would be a 5 megabyte RAM Macintosh IIsi with a floating point coprocessor card. It would also be possible to set up a system using the much lower cost Macintosh LC, but performance would be greatly sacrificed.

Although a 24-bit color card was used, it is not mandatory for generating 24-bit images. COLOR QUICKDRAW, part of the Mac operating system software, will produce dithered 8-bit color images that approximate 24-bit colors. We used the Apple 13-inch RGB monitor, though larger format screens and cards could also be used. The minimum configuration would include a 12-inch color monitor and the 48 color card.

The amount of hard disk storage space required is a function of available money, the size of the images to be processed, and the amount of storage "dead-space" you need to store images in uncompacted format. A 40 or 45 megabyte hard drive is probably the smallest recommended drive for processing and storage of larger images.

SOFTWARE

We used ADOBE PHOTOSHOP, which supports 1- through 32-bit pixels, to produce merged RGB images and NIH IMAGE (1- through 8-bit pixels with conversion from 16-bit) for single band linear enhancement and measurements. PHOTOSHOP was developed as a tool for working with printed media and film, but is excellent for many aspects of scientific image processing, containing interactive color manipulation tools that are intuitive and easy to use. PHOTOSHOP also has a wide range of import/export file format options. Another very useful feature is that it provides its own virtual memory routines and can work with images as large as your existing free disk space. PHOTOSHOP is widely available and the best prices can be found in discount software stores. Although ADOBE PHOTOSHOP can perform most of the filtering operations used in this study and at faster speeds than IMAGE, we choose to use IMAGE for our single band convolutions because it also contains a variety of tools for measurement and spatial calibration.

IMAGE 1.40 is public domain image processing software, from the National Institutes of Health, that requires a minimum of a two megabyte (RAM) Mac II with a color monitor. It was designed for performing image processing and spatial and density calibrations on single 8-bit "bands" but includes some rudimentary GIS-type features such as single band pixel classification using interactive thresholding and calculation of areas and perimeters of pixel regions or drawn polygons as well as many other measurements. IMAGE has a PASCAL-like macro language, and supports external filter kernels and user-designed color

[1] Use of a particular combination of hardware and software does not constitute an endorsement.

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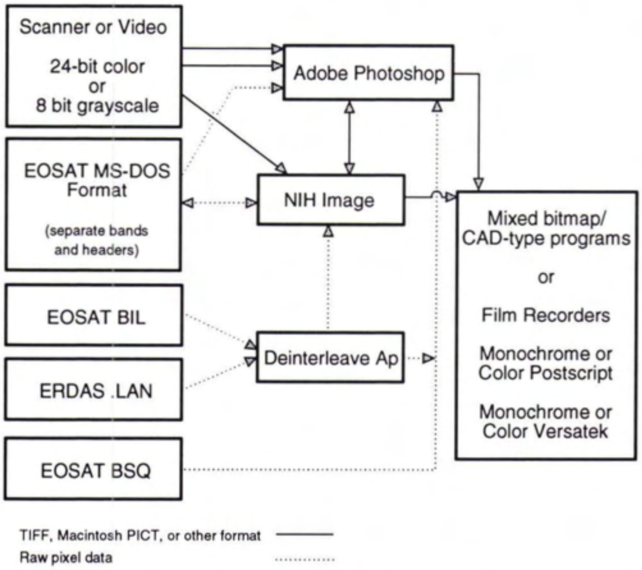

FIG. 1. Flowchart for processing image data with NIH IMAGE and/or ADOBE PHOTOSHOP.

lookup tables (LUTS). The program is available by anonymous Internet FTP from alw.nih.gov [128.231.128.251] in the directory /pub/image. Enter "anonymous" as the user name and anything you like as the password. The /image directory contains the latest version of IMAGE, along with PASCAL source code, instruction manual, and other helpful aids. It was developed for image processing of X-rays and electrophoretic gels, but handles Landsat data with ease.

IMAGE PROCESSING

For our study over the Wichita Mountains we first chose a quarter scene from a Landsat TM image over southern Oklahoma. Separate quarter-scene bands were loaded into ERDAS on a SUN IPC, and 1024- by 1024-pixel subscenes were combined in a Band Interleave (BIL) format ERDAS .LAN file. Though we could have done this subscene operation in ADOBE PHOTOSHOP, we needed to perform additional analyses and felt it was easier to do the initial subscene extraction in ERDAS. The .LAN file was FTP'd over to the Mac IIfx and stored on the external hard drive. The .LAN file was split into seven separate raw image band files using a small program we developed. Figure 1 shows a flow chart for image processing using IMAGE and/or PHOTOSHOP.

A 24-bit false color image was made by loading the separate subscenes into PHOTOSHOP in raw pixel mode and performing a 4,3,2 (R,G,B) merge. An interactive histogram stretching control (color level adjustment in PHOTOSHOP) was used to perform a linear stretch on each band's histogram separately, and finally the brightness/contrast tool was used for final image touches. As input and output color levels are adjusted with a sliding virtual control, the color of the image changes in real time, allowing the user to produce a finished image in just seconds. PHOTOSHOP will automatically perform a nonlinear stretch (equalization) but the best results were obtained with simple linear histogram stretches. Starting with the raw data and performing single band histogram stretches, the final 24-bit color image was produced in about 5 minutes on the Mac IIfx.

The entire RGB scene (all three bands) can be rotated to true north using bicubic interpolation. From this rotated scene, a smaller subscene from band 3 over the Wichita Mountains was cropped and sharpened (952 by 508 pixels, Figure 2) in IMAGE for further analysis.

As mentioned earlier, the igneous rocks of the Wichita Mountains contain multi-directional lineations associated with faults and fractures. To demonstrate in our classes and workshops how the Macintosh can be used for fracture/fault mapping, we utilize IMAGE and PHOTOSHOP to easily perform a variety of directional and nondirectional convolution filters.

After performing a simple linear stretch on the band 3 subscene histogram, we used three filters in NIH IMAGE because they are easy to edit, load, and execute. The resulting processed

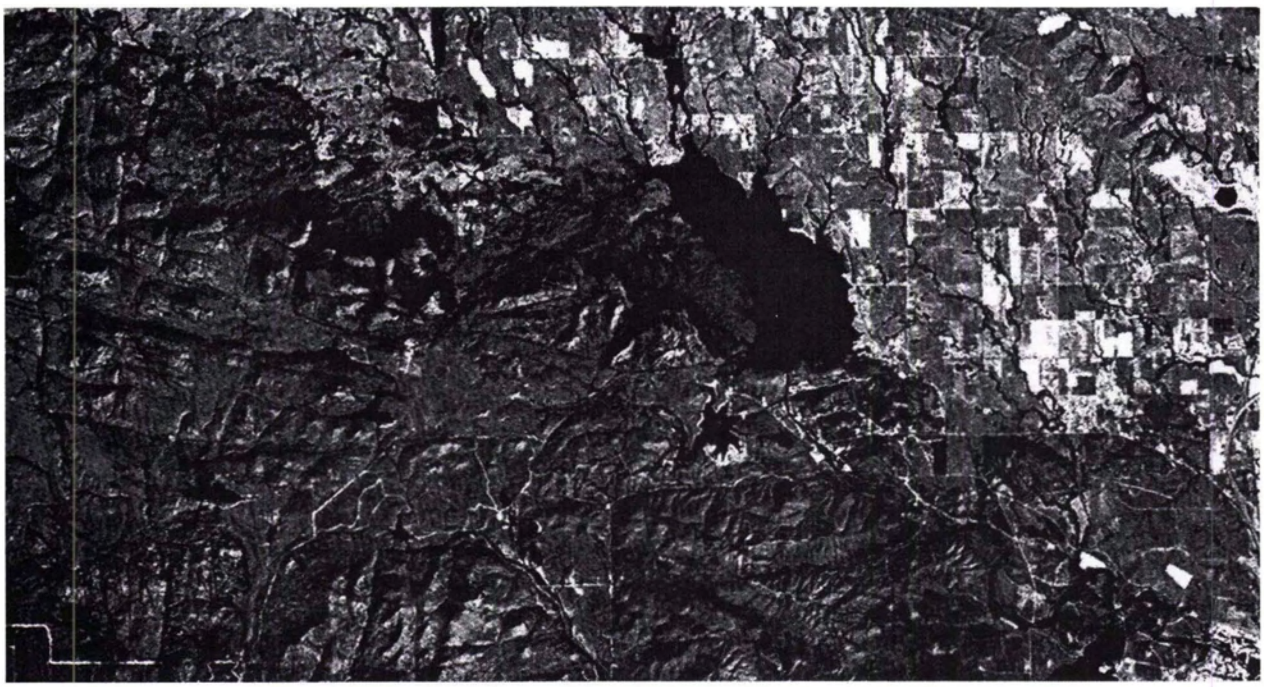

FIG. 2. Rotated Landsat TM band 3 image over a portion of the Wichita Mountains in southern Oklahoma. This image is 952 by 508 pixels at a scale of 1:160,380.

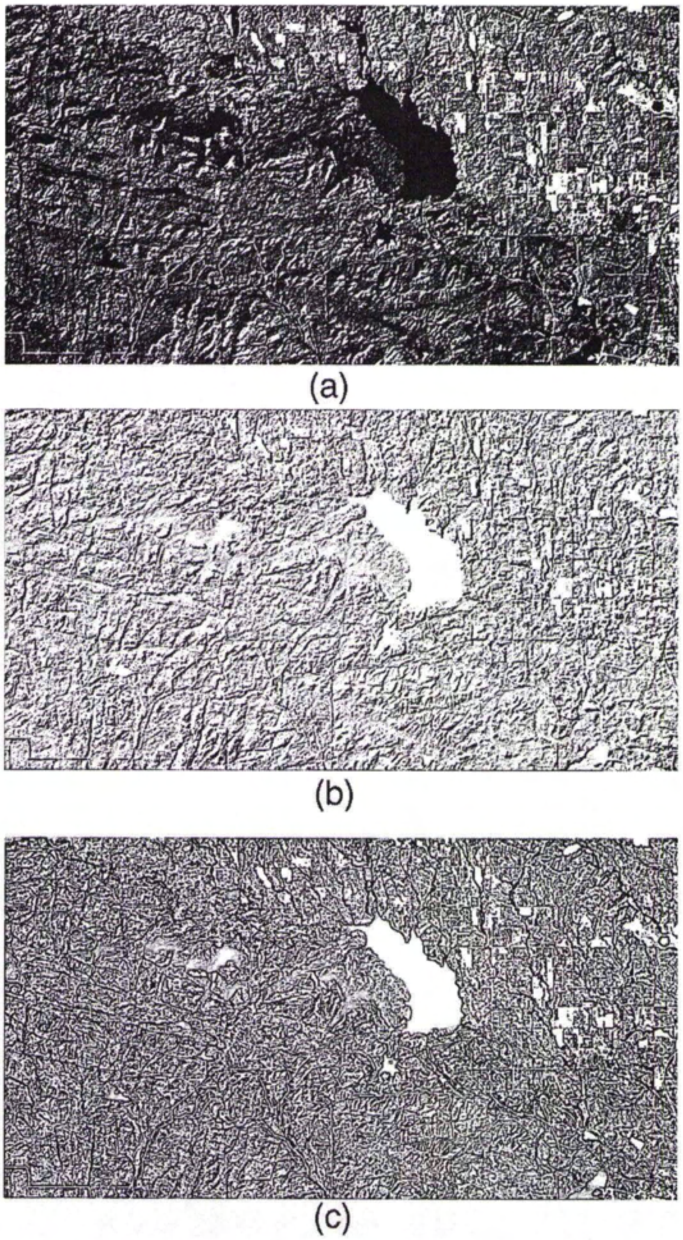

FIG. 3. Montage of filtered TM band 3 images showing three different edge enhancements: (a) shadow, (b)_gradient (northwest) 3 by 3 kernel, and (c) Laplacian 5 by 5 kernel over the Wichita Mountains area.

images can be sent to a 300 DPI Postscript laser printer and/or saved in TIFF or PICT formats for the film recorder software. We chose shadow, gradient, and Laplacian filters for demonstration in this paper. These standard convolutions are found in most image processing software and are often utilized to enhance fracture patterns in geologic terrains (Lillisand and Kiefer, 1987; Sabins, 1987). The shadow filter is built into IMAGE, whereas gradient (3 by 3 kernel), and Laplacian (5 by 5 kernel) filters were externally loaded. Each of these image processing applications took from 5 to 30 seconds to complete on the Macintosh fx computer.

To demonstrate how these filtered images can be brought together for display and comparison on the Macintosh, a three-image montage (Figure 3) was created by cutting and pasting the individual graymaps, processed in IMAGE, and saved in either TIFF or PICT format into a new window in PHOTOSHOP. The PHOTOSHOP image was saved in PICT format for the film recorder software. Note that each processed image shown in Figure 3 emphasizes different fracture patterns. A quantitative analysis of the differences of the various fracture patterns is beyond the scope of this paper. Our purpose is to show that these convolutions and the resulting montage can be easily and rapidly created on the Macintosh II platform.

An image processing cycle involved (1) performing a filter operation, (2) printing the results on a laser printer, (3) saving the results in either TIFF or PICT format for additional annotation and the film recorder, and (4) reloading the original image for the next filter. The complete image analysis and printing (on a monochrome laser printer) of images, starting from the original EOSAT data, to the final RGB image and accompanying processed 8-bit images, and making the montage, took less than 30 minutes on the IIfx.

In both programs it is easy to copy an image into the Mac clipboard and paste it back on top of another band, specifying a variety of logical and mathematical operations to be carried out between the pixelmaps. It is especially easy to do this in IMAGE, and we found that this leads to user "experimentation" with different effects.

ANNOTATION

Although annotation can be added in IMAGE and PHOTOSHOP, lines and fonts are rasterized along with the image at image resolution and this results in a blocky appearance in the final image from the laser printer or film. For higher resolution annotation, images can be imported (in PICT format) into a CAD-type program such as MacDraw or Canvas in which raster layers and vectors can coexist. Then, merely by adding annotation in a vector layer, a final image is produced with sharp text and lines. To demonstrate this, the Wichita Mountains image shown in Figure 2 was saved from IMAGE in PICT format, imported into Canvas 3.0 and annotated in a vector layer (Figure 4). The paint-bucket tool in Canvas was used to make the water bodies white, but all other annotation, including the inset map of Oklahoma, was added as a vector layer and can be easily edited. The map of Oklahoma was originally in POSTSCRIPT format, translated into PICT format by Canvas 3.0, reduced in scale, and added to the final image.

RESULTS AND CONCLUSIONS

Our study of the potential for utilizing the Macintosh platform for image processing is encouraging. Using either NIH-IMAGE or ADOBE PHOTOSHOP software, it takes less than 30 minutes to download a Landsat quarter scene, perform multiple convolution filters, and assemble a final montage of enhanced images for geologic interpretation. Most processes take a few seconds to about 1 minute to perform (only image rotation took several minutes).

The public domain (free) software, NIH-IMAGE, proved excellent for 8-bit image processing, convolution filtering, and very limited GIS applications. If 24-bit color display is desired, then PHOTOSHOP offers flexibility and easy-to-use interactive controls. The software used in this study has some disadvantages when compared to more conventional image processing/GIS packages on the market for other computers.

NIH-IMAGE is only 8-bit and must rely on 8-bit color look-up tables. It cannot make conventional multiband color merges and is limited to images with a maximum width of 2048 pixels. Also, only single band classifications can be performed.

ADOBE PHOTOSHOP is excellent as an image processing package, providing more controls over the image than any other

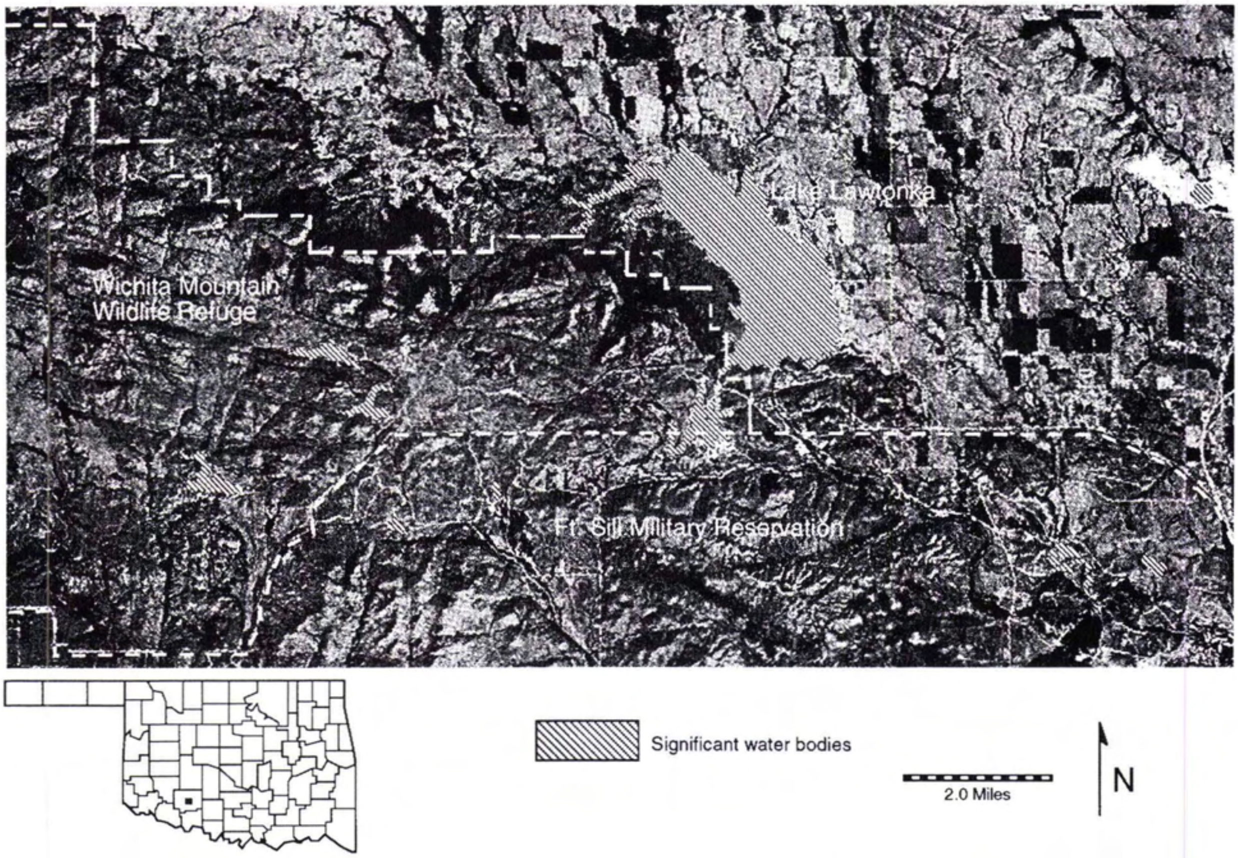

FIG. 4. Annotated image of a portion of the Wichita Mountains in southern Oklahoma produced from NIH IMAGE and CANVAS 3.0 software on a Macintosh fx.

package we have seen. However, band ratios cannot be generated. Also, spatial calibrations cannot be performed on image data; therefore, GIS-type function capabilities do not exist at this time.

Warping, multi-band classification techniques, and more sophisticated techniques such as principal component analysis are not possible in either IMAGE or PHOTOSHOP at this time (although there is a version of IMAGE that can perform FFT analyses).

However, the advantages of the software used in this study are numerous, and include user friendly, interactive controls that greatly increase the ease of processing. This also facilitates rapid user training due to the portability of the Macintosh user environment and to the well designed program interfaces. Both programs operate on any Macintosh II platform, provide flexible input/output formats, and rapid program execution.

We are finding the Macintosh platform very beneficial to our fracture mapping efforts utilizing satellite digital data in the Wichita Mountains of southern Oklahoma. The interface makes training, demonstrating, and mapping fast and easy to accomplish. Coupled with the relatively low investment costs ($6,000 to $12,000), the Macintosh appears to be a viable platform for processing Landsat and SPOT data.

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REFERENCES

Donovan, R. N., K. M. Morgan, and S. Wilhelm, 1987. Lineaments in the Slick Hills, S.W. Oklahoma-An Application of Remote Sensing Technology, *Trans. of Southwest Section-American Association of Petroleum Geologists (AAPG),* Dallas, Texas, pp 74-79.

Lillisand, T. M., and R. W. Kiefer, 1987. *Remote Sensing and Image Interpretation,* 2nd Edition, John Wiley & Sons, Inc., New York, N.Y., 721 p.

Morgan, K. M., D. G. Koger, and D. R. Morris-Jones, 1988. Application of Landsat MSS and TM Data to Geological Exploration, *Space Commercialization: Space Technology* (F. Shahrokhi, C. C. Chao, and H. G. Harwell, editors), American Institute of Aeronautics and Astronautics, Vol. 110, pp. 361-372.

Sabins, Jr., F. F., 1987. *Remote Sensing: Principles and Interpretation,* 2nd edition, Freeman and Co., New York, N.Y. 449p.

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