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INTERACTIVE ANALYSIS OF DIGITAL TERRAIN ELEVATION AND
SURFACE FEATURE DATA BASES(U) DEFENSE MAPPING AGENCY
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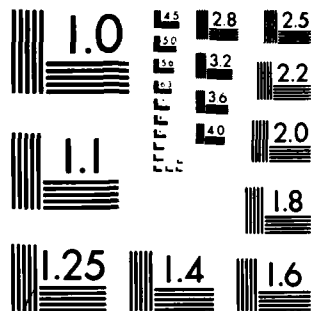
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INTERACTIVE ANALYSIS OF DIGITAL TERRAIN ELEVATION
AND SURFACE FEATURE DATA BASES

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1.0 ABSTRACT

The Defense Mapping Agency produces digital data bases that describe the physical appearance of the surface of the earth. A dramatic impact has been made in the ability to analyze these digital data bases by applying state-of-the-art digital image technology processing and display concepts. For purposes of quality control and data base applicability investigations, DMA has developed the Sensor Image Simulator (SIS), a very high speed data base edit station and static scene simulator that allows for interactive query and manipulation of individual features in the data base displays and/or simulated sensor scenes to determine the corresponding data base elements responsible for the simulated features. The SIS was installed at DMA in 1981, and plays a key role in determining the applicability of prototype data bases for use in advanced training simulators, as well as to ensure the quality of, and coherence between, the various digital data bases prior to new data insertion into the master cartographic data base files.

2.0 BACKGROUND

- 2.1 The Defense Mapping Agency produces digital data bases that describe the physical appearance of the surface of the earth. These data bases include, but are not limited to, terrain elevation, culture including landscape characteristics, and vertical features. This data is collected from digitized source maps, from optically or digitally correlated stereo-pairs of photographic imagery, and from digital multi-spectral sensor data. A dramatic impact has been made in the ability to analyze these digital data bases by applying state-of-the-art digital image technology processing and display concepts. These include a variety of color and/or black and white displays of not only intensity/color coded matrix data, but also image processed data using specialized convolution filters, texture discrimination, and special color representation techniques. In addition, computer generated imagery from these data bases serve as a final analysis tool.
- 2.2 For purposes of quality control and data base applicability investigations, DMA has developed the Sensor Image Simulator (SIS), a very high speed data base edit station and static scene simulator that allows for interactive query and manipulation of individual features in the data base displays and/or simulated sensor scenes to determine the corresponding data base elements responsible for

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the simulated features (see Figure 1). The SIS was installed at DMA in 1981, and plays a key role in determining the applicability of prototype data bases for use in advanced training simulators, as well as to ensure the quality of, and coherence between the various digital data bases prior to new data insertion into the master cartographic data base files.

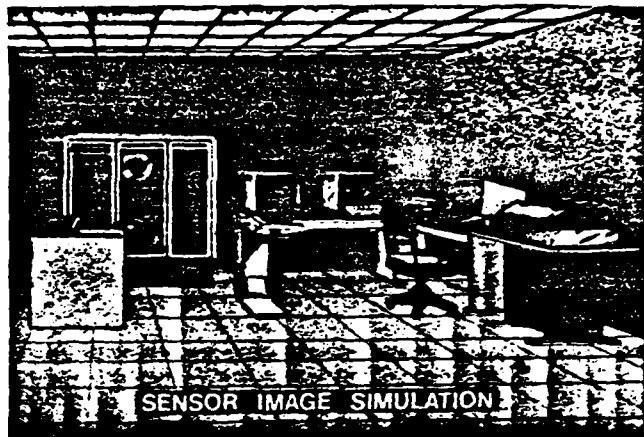


Figure 1. The Sensor Image Simulator

3.0 DATA BASE CONTENT

- 3.1 The current IMA standard production data bases (Level 1) contain large area cultural information, and digital terrain data sampled at a 3" interval. The cultural data consists of point, linear, and areal features described by

characteristics such as surface material category, generic identification, predominant height, structure density, and percentages of roof and tree cover. The cultural data is in lineal (planimetric boundary) format and, although feature sizes may vary depending upon local circumstances, reflects a resolution on the order of 500 feet. Smaller features are aggregated into homogeneous features described by predominant characteristics. The current high resolution (Level II) data bases contain small area cultural information and digital terrain elevation data sampled at a 1" interval. This translates to a resolution of about 100 feet, with smaller features aggregated. Detailed information is available in "Product Specifications for Digital Landmass System (DLMS) Data Base" (1).

- 3.2 The terrain elevation data is produced by contour digitization from charts or directly from stereo pairs of photographs using advanced analytical stereoplotters. The cultural data is produced from both charts and photographs with a much higher level of manual effort required in order to perform the complex feature analysis. Because of the labor intensive nature of the task, the production of Level II cultural data ranges from 10 to 50 times the production cost of Level I data, depending upon the area.

4.0 SIS CONCEPT

- 4.1 The natural evolution of sensor simulation at DMA led to the design and fabrication of the Sensor Image Simulator (SIS), a dedicated mini-computer-based image processing system capable of performing simulations in an interactive mode.

The Sensor Image Simulator performs five major functions:

1. Digital Data Base File Input and Output.
2. Off-Line to On-Line Data Base Transformation.
3. Sensor Simulation.
4. Interactive Data Base Editing.
5. Software Development and Maintenance.

- 4.2 The SIS brings together, in a self-contained integrated hardware/software facility, a significant capability to evaluate the digital data bases. All operations are conducted under interactive control. Both the software structure and operations sequence reflect a top-down implementation philosophy wherein principal control

functions are resident at the top of the hierarchy and functions concerned with processing individual data elements are at the lowest. The system is implemented in such a fashion that future changes in processing can be accomplished at the highest level of system software support. Detailed information on SIS operations, hardware, and software has been previously published (2).

5.0 TECHNIQUES AND RESULTS

- 5.1 With results similar to those from manually compiled classical mapping and charting displays, digital terrain elevation data may be used to generate standard contour plots and corresponding tint plates in which the areas between contour lines are either color or gray level coded. An alternative is to color or gray level code the matrix terrain data directly. While analysis of these matrix image displays is superior to trying to perform analysis by visual inspection of the data in printed numerical matrix format, they only provide for a low spatial resolution analysis capability. Shaded relief display with variable illumination adds additional information for analysis of all types of matrix data, and is particularly meaningful for cartographic data because of the relationship to the physical world. Higher spatial resolution analysis of the shaded relief display may be gained by applying photogrammetric models to generate pseudo-stereo-pairs of images in which spike points are apparent under stereoscopic analysis. These techniques, used singly or in combination, allow for data base analysis far superior to techniques of a decade ago, but they are not enough.
- 5.2 In order to perform high resolution anomaly analysis of data bases for the purpose of either quality control or information gathering, advanced techniques are required. These techniques include convolution filtering, texture discrimination, and specialized color representation. Details about the algorithms used in these techniques are described in reference 3.
- 5.3 Convolution filters have been used very effectively to enhance matrix data to show processing anomalies as well as where data has been merged from different production equipment, different stereo models, different production methods, variable requirement specifications, and even from different analysts. These types of filters are used extensively by the image processing community to detect edge differences, and then to reapply the differences to sharpen the original image. They also have been shown to be a powerful tool for the analysis of cartographic data bases.
- 5.4 Texture analysis has proven to be very powerful for discriminating small area data that has been merged into larger matrices. For example, digital elevation data produced at a one arc second interval was sampled and merged with three arc second data. This data merge is not apparent in the gray level coded elevation display (Figure 2.a.). Because of inherent higher frequency information in the one arc second data, there is a noticeable difference between the textures of the

levels of data in the shaded relief display, and an even more apparent difference in the convolution display (see Figures 2.b., 2.c.). A similar difference is noticed when high frequency digital culture data is merged with lower resolution data.

6.5 For the purpose of determining compatibility between data types, such as between digital terrain and culture data, simple color coding and overlay in Red-Green-Blue (RGB) space may not be sufficient. A more powerful technique employs coding each data type along an Intensity-Hue-Saturation (IHS) axis and then converting from the IHS space to RGB space prior to display. Since the visual perception process can distinguish variation between IHS, the data types can be overlaid without a merging of colors, and therefore, without an information loss.



FIGURE 2a. GRAY LEVEL CODED ELEVATION DISPLAY

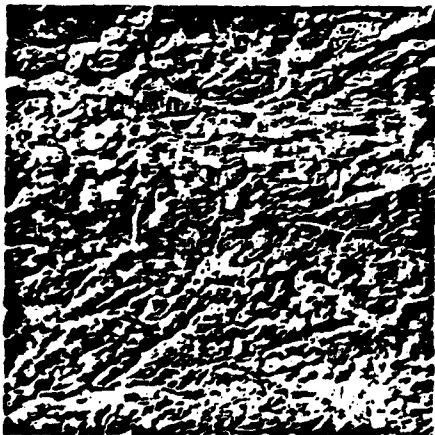


FIGURE 2b. SHADED RELIEF DISPLAY



FIGURE 2c. CONVOLUTION DISPLAY

5.6 Finally, and probably unique to cartographic data bases, is the technique of computer generating landform scenes as seen by various visual and electro-optical sensors. This allows for a final quality control analysis of information content, and also has been very valuable in the definition of data base requirement specification.

6. IMPACT

6.1 The impact of this interactive system development to data base display and analysis has been enormous. Not only has there been a greatly increased capability for the degree and sophistication of quality control, but there is an associated cost savings in both the quality control review process, and in the resultant expense of using cartographic data bases containing anomalies.

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1. Defense Mapping Agency; 1977; "Product Specifications for Digital Landmass System (DLMS) Data Base," St. Louis AFS, MO.
2. Faintich, M. B.; Figura, P. C.; Quinn, E. W.; 1981; "The Sensor Image Simulator," Proceedings of the Third Interservice/Industry Training Equipment Conference, Orlando, FL, November 1981, pp. 386-390.
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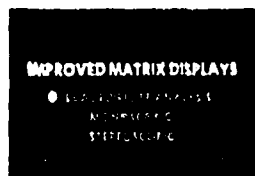
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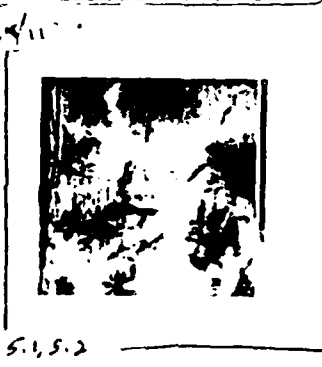
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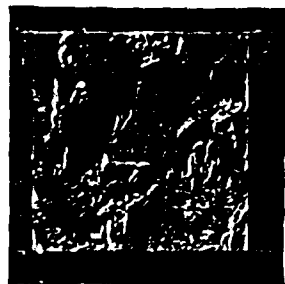
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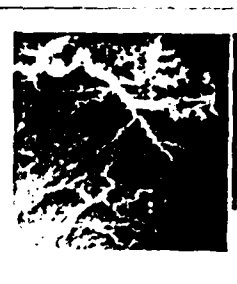
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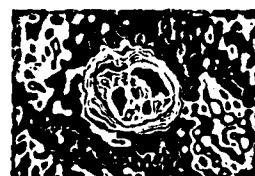
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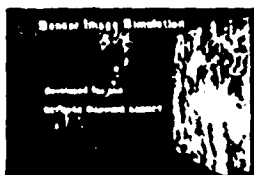
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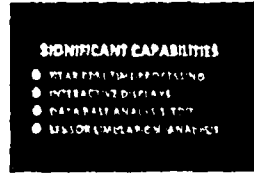
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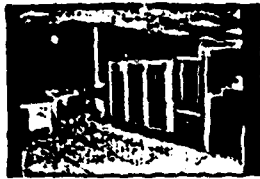
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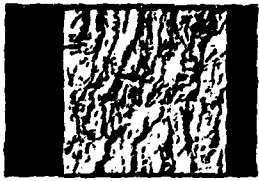


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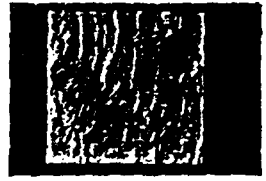
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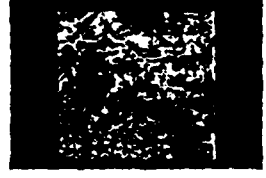
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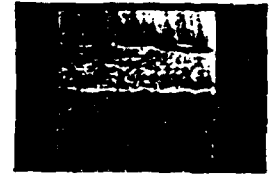
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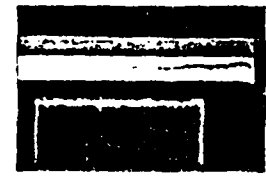
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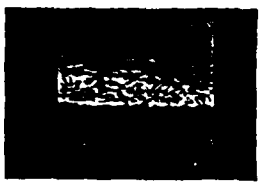
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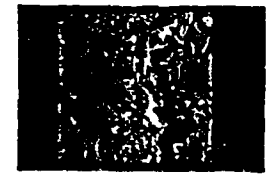
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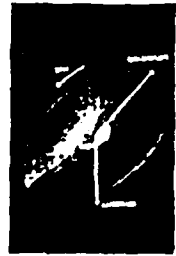
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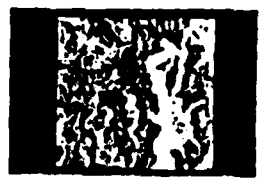
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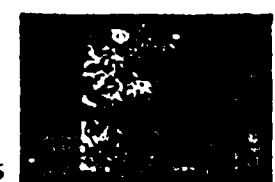
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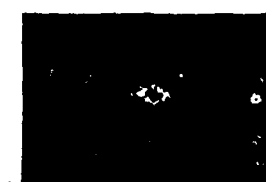
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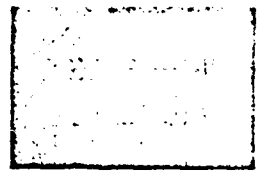
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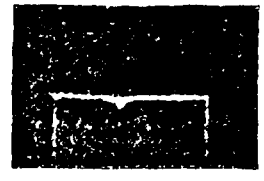


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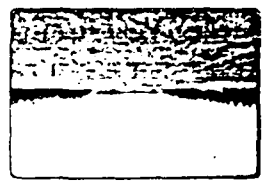
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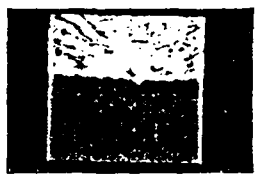


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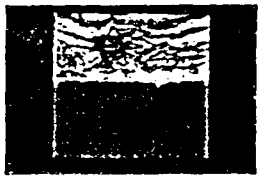
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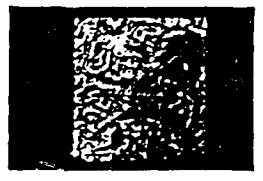
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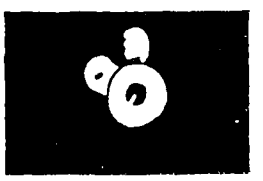
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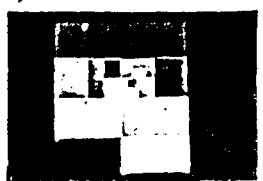


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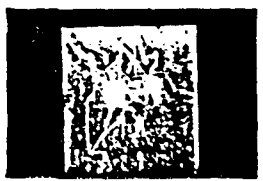
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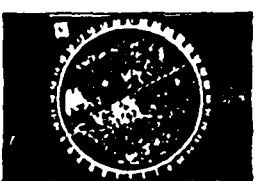
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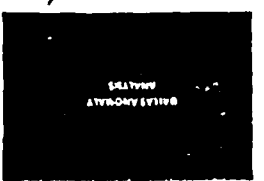
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