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A Low Cost IBM PC/AT Based Image Processing System for Satellite Image Analysis: A New Analytical Tool for the Resource Managers

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Abstract

Low-cost microcomputer systems can be assembled which possess computing power, color display, memory, and storage capacity approximately equal to graphic workstations.

A low-cost, flexible, and user-friendly IBM/PC/XT/AT based image processing system has been developed and named as KMIPS(KAIST Map and Image Processing Station). It can be easily utilized by the resource managers who are not computer specialists.

This system can:

- directly access Landsat MSS and TM, SPOT, NOAA AVHRR, MOS-1 satellite imagery and other imagery from different sources via magnetic tape drive connected with IBM/PC;
- extract image up to 1024 line by 1024 column and display it up to 480 line by 672 column with 512 colors simultaneously available;
- digitize photographs using a frame grabber subsystem(512 by 512 picture elements);
- perform a variety of image analyses, GIS and terrain analyses, and display functions; and
- generate map and hard copies to the various scales.

All raster data input to the microcomputer system is geographically referenced to the topographic map series in any rater cell size selected by the user. This map oriented, georeferenced approach of this system enables user to create a very accurately registered(±1 picture element), multivariable, multitemporal data sets which can be subsequently subjected to various analyses and display functions.

1. Introduction

Numerous image processing systems have been developed around many levels of computers to provide a basis for computer assisted resource management. These systems can be grouped into two groups; low-cost education and training purpose systems(Table 1) and higher cost operationally oriented systems(Table 2). Generally the use of these systems involves time consuming data input and analysis processes requiring the skills of professionals specifically trained in computers, image processing, spatial data management, and display techniques.

Timely and accurate information on the land areas of interest is required by local agricultural and natural resource manager as a basis for making improved management decisions. The spatial information derived from remotely sensed imagery and its analysis with collateral data in a geographic information system provides a means for achieving this objective. Practical application of these spatial information for improved management requires that appropriate image analysis techniques be available to the local managers(Miller et al., 1985; Yang et al., 1983).

A microcomputer image processing system needs to be constructed to meet this goal. Low-cost microcomputer systems can be assemble which possess enough computing power, color display, memory, and storage capacity to meet this goal. This microcomputer image processing system must be a user-friendly, low-cost, high quality system. It has to have capability of constructing, analyzing, and displaying geographic information with inputs from satellite and air craft imagery, from existing maps(e.g. soil maps), and other spatially oriented computer data base(e.g. digital elevation grids). This assembled systems are more flexible than the workstaion based systems in meeting the end user's need because in this case the hardware components and peripheral devices can be selected to meet specific users requirement.

2. Hardware System

The IBM PC/XT/AT or compatible microcomputers are widely used by individual professionals in local offices and thus many potential natural resource managers already have direct access to a microcomputer upon which an image processing system can be constructed. In this context the new system was developed using a standard IBM PC/XT or AT, the MS DOS 3.0 operating system, Microsoft C, a Vextric VX/PC color display subsystem of 480 by 672 picture elements and 512 colors, a floppy disk drive, and 40 MB hard disk drive, a 18 by 24 inch X-Y digitizer, a 22 by 30 inch line plotter, and a 1600 bpi tape drive(Table 3). The tape drive provides means of directly access to various CCTs and relatively universal exchange of large files between these microcomputers and mainframes. The floppies provide a low-cost image storage media and relatively standard data exchange between this system and other microcomputer systems also developed for similar image processing.

Table 1. Lower-Cost Microcomputer Image Processing Systems for Educational and Training Purposes. Lower-cost Apple and Z80 microcomputer, image processing systems are used principally for educational and training purposes. The Apple-II computer is equipped with 48K byte memory and 140K byte disk storage space while typical Z80 computer provides 64K byte memory and 2.4M byte disk storage space. The image display size of Apple-II image processing software systems have much better resolution which is at least 256 by 256 picture element by 4096 colors.

Name	Developer	Processor	Disks	Minimum Memory	Display Characteristics	References
A/DIPS*	Univ. of Wisconsin	Apple Computer	140KB	48KB	40x40x16	Kiefer and Gunther(1983)
AIPE	CSC	Apple Computer	140KB	48KB	40x40x16	Kiefer and Gunther(1983), Gunther(1981a, 1981b,)
DIAS	Univ. of Oklahoma	Apple Computer	140KB	48KB	40x40x16	Harrington Jr (1981), Kiefer and Gunther (1983)
APPLEPIPS*	The Telesys Group	Apple Computer	140KB	48KB	40x40x16 or 140x96x6	Rose(1981), Welch et al. (1983),
MINI-LARS	Purdue Univ.	Apple Computer	140KB	48KB	40x40x16	Kiefer and Gunther(1983)
KARS Image Processing System	Univ. of Kansas	LSI-11/23	1.2MB	128KB		Gunn(1981)
IMPAC*	ESS	Z80 or 8088	315KB	64KB	256x240x4096	Egbert (1982) Welch et al. (1983)
Minnesota RIPS	Univ. of Minnesota	LSI-11			256x256x32,000	Meisner(1981)
RIPS**	EROS Data Center	Z80	1.2MB	64KB	240x240x4096	Holm(1981), Waltz and Wagner (1981)
V.I.P. Video Image Processor*	Spectral Data Corp.	Apple, IBM P.C.	1.2MB		256x240x4096	

* Commercially available
** Public domain software
\+ rows by columns by simultaneous colors

A/DIPS : Apple-II Digital Image Processing System
AIPE : Apple Image Processing Educator
APPLEPIPS : APPLE Personal Image Processing System
CSC : Computer Sciences Corporation
DIAS : Digital Image Analysis System
ESS : Egbert Scientific System
IMPAC : IMage analysis PACkages for microcomputers
KB : Kilo Bytes
MB : Mega Bytes
RIPS : Remote Image Processing System

Table 2. Higher-Cost, Operationally Oriented, Microcomputer Image Processing Systems.
These systems primarily consist of microcomputer image processing systems developed by commercial venders. They are built around 16-bit or 32-bit microprocessors using custom developed state-of-the-art colour display controllers. These systems are usually custom designed, dedicated systems and are more powerful and expensive than personally oriented systems. The display size of a typical system is 512 by 512 picture elements by 24 bits or 16.7 million colours.

Name	Developer	Processor	Hard Disks	Minimum Memory	Display Characters**	References
MIDAS	NASA/Ames	MC68000	140MB	256KB	512x512x17 million	Donovan and Hofman(1981), Erickson et al.(1983)
Aries-II*	Dipix, Inc.	LSI-11/23	330MB	224KB		Vincent and Flynt(1981)
Vicom*	Vicom Systems	MC68000			2048x2048x664000	Computer Graphics World(1981)
Log E/ISI*	Log Etronics Inc.					Pendergrass(1981)
Vision One/20*	Comtal	LSI-11/23	150MB		512x512x17 million	Clouthier and Andrews(1981)
Micro Image I*	Terra-Mar	I8088/8087	10MB	640MB	1024x1024x4096	
Decision Images*	Decision Images	I8088/8087	10MB	640KB	1024x1024x4096	
ERDAS	ERDAS	I80286	300MB	640KB	512x512x17 million	

* Comercially available
** Rows by colums by simultaneous colours

KB: Kilo Bytes
MB: Mega Bytes
MIDAS: Microcomputer based Image Display and Analysis System

Table 3. K-MIPS hardware components and capacity

Hardware	Model/Capacity
Microcomputer	IBM AT Compatible with 40MB hard disk
Line Printer	Epson FX-80, 80 CPS
Color Disply controller	Vectrix VX/PC, 480 by 674 pixels by 512 colors 16.7 mill. color palette
Color Monitor	Mitsubishi 13", 512 by 512 pixels
Tape Drive	Cipher(model F880), 100 ips, 1600bpi
Image Recorder	Celtic 35mm film recorder
X-Y Digitizer	Kurta, 18" by 24"
Pen Plotter	Houston Instrument DMP-52MP

3. Image Map Oriented Approach

The small scale topographic maps such as 1:25,000 and 1:50,000 maps have been used by natural resource managers for their decision making and policy shaping. It is therefore convenient to design the microcomputer based image processing system to operate upon subareas of the original satellite image which are called image map and which accurately correspond to these topographic maps. Thus, the system was designed such that the multivariate image maps of 1:25,000 and 1:50,000 scale maps can be extracted from original source tape of SPOT, Landsat MSS and TM, and MOS-1 satellite to floppy disk and/or hard disk for further analysis. Image maps of any other large scale such as 1/100,000 can also be specified, extracted, and processed.

The final image map's geographic position can be determined by the introduction of three or more control points with the X-Y digitizer. This calibration process georeferences or geoencodes the image map to within one picture element(e.g., plus or minus one arcsecond for a Thematic Mapper image).

4. Overview of Image Processing Capabilities

The summary of KMIPS image processing capabilities are as follows.

- extraction of images in a wide variety of formats from on-line magnetic tape drive and hard disk,
- flexible color balancing and display of multivariable images using RGB and HIS color transformations,
- contrast stretching of images for display using linear, logarithmic, exponential, gaussian and other transformations,
- general image annotating functions, including character and graphical annotaion, zoom, and rotation,
- two dimensional histogram displays and associated statistical computations to examine the relation by nearest neighbor, bilinear, and cubic convolution technique,
- altering the cell size and geometric properties of images and other rasters using interpolation by nearest neighbor, bilinear, and cubic convolution technique,
- filtering images by a variety of techniques,
- display of three dimensional perspective view,

- simple classification or interpretation of images using point or rectangular feature selection,
- combination of coregistered or multivariable images using a variety of transformations ranging from simple algebraic to specific satellite image biomass indicies to user defined mathematical transforms,
- preparation of complex polygon maps or drawings as raster overalys for images using an on-line x-y digitizer and an interactive "paint by number" approach.
- providing a comprehensive menu utility functions to support image processing users ranging from beginners to experienced programmers, and
- providing a number of user functions including fast save and restore of the currently displayed image, numeric display of image file data to console, dumping of any disk file to color map construction using the HIS and RGB color models, generating histogram directly from the displayed image, and others.

5. Other Functions

5.1. Analysis of Digitized Photographs

Photographs can be digitized directly on the system using a frame grabber subsystem(512 by 512 picture elements) or at very high spatial resolution using an off-line film scanner generating a standard computer tape. Using either approach black-and-white film transparency can be used to obtain a single digital image; or color filters can be used to separate a color transparency to yield co-registered red, green, and blue digital images.

5.2. Geographic Information System

Cellular elevation data can be extracted from digital terrain model tapes based upon an 1:25,000 topographic map name. This three arcsecond elevation raster can be resampled using a various resampling algorithms to match the geoencoded LANDSAT Multispectral or Thematic Mapper and SPOT image map. Slope, aspect, and other derivative surface planes can be computed from this elevation data plane. Polygonal oriented map data can be entered into the system using the X-Y digitizer. This processes employs a direct "paint-by-numbers" interactive graphics scheme which allows the user to easily "paint" sequential polygons in color(e.g. soil polygons) over a reference image on the display screen. This provides the user with easy geographic input which can be directly viewed and edited as it is created.

Any raster data, such as the cellularized polygons noted above, can be converted to and from vector form. Conversion of a rasterized soil or land cover map into a vector format enables its plotting to scale on a line plotter for overlaying back upon the original source map or any other map of similar scale. These rasterized input data can be easily combined into existing GIS data base since each of rasterized planes was geographically referenced to the base map and thus automatically registered to each other.

5.3. Hard Copy Generation

A Hue, Intensity, and Saturation(HIS), user-oriented display interface has been implemented to supplement the usual Red, Green, and Blue(RGB) color balancing approach(Buchanan and Pendergress, 1980; Haydn et al., 1982).

"Screen dumps" via computer tape of color image maps or any other derived geographic information products to 1/25,000 or other scales can be made on a large, off-line, ink jet plotter and then be overlaid with a transparent version of the corresponding official topographic map. "Screen dumps" of map products via computer tape can be made on off-line color film writers from 35 millimeters to nine by nine inches.

6. Future Plans

Future plans for the the evolution of this system include following possibilities.

1. Upgrade the IBM PC/AT based system to 32-bit microcomputer based system.
2. Direct access to on-line, high resolution, non-video, film digitizing capabilities.
3. Expanded use of on-line, low-cost, hard copy devices to allow direct reproduction of products at selected map scales.
4. Testing new equipment to allow a significant increase the ease with which a larger raster can be viewed by using the display as a window into a larger geographic space.
6. Experimentation with newly developed microcomputer user-oriented aids, such as ions and pull down windows, to increase the universality and simplicity of the current menu oriented system.

7. Conclusions

Low-cost, table-top, microcomputer based image processing system can be used by local managers to enhance the efficiency of their management of natural resources. This small-scale, personalized workstation can be designed as user-friendly, flexible system yet powerful enough to perform almost all necessary image analysis functions. The use of microcomputers by local managers are growing rapidly and this trend seems to continue in the future. The French SPOT satellite provides local managers with a 10 meter resolution images which has almost nine times better resolution than Thematic Mapper (TM) images. The technology for the receiving station of satellite image is also growing fast such that even the individual professionals can receive satellite data through small antenna installed outside of his office in real time fashion. We expect to see individual resource managers receive satellite images, analyze them with desk-top micro-computer based image processing system, and use the results for his decision making in resource management in near future.

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