Digital Image Processing Hardware and Software Functions

A digital image processing system is the combination of the computer hardware and the image processing software.

Basic computer hardware for digital image processing:

Image analysts perform digital image processing on mainframe computer systems, workstations, or personal computers (Russ, 1992). The major difference is in the speed at which the computer processes millions of instructions per second (MIPS). Mainframes are generally more efficient than workstations that perform better than personal computers. The MIPS being processed on all types of computers is increasing logarithmically while the cost of a computer per MIP is decreasing.

Mainframe computer

- A mainframe computer system (> 32-bit central processing
- unit - CPU) usually uses batch or interactive mode from relatively *dumb*,
- alpha-numeric terminals. The advantage of the mainframe computer system
- is its high speed performance in routine processing. The disadvantage of
- the mainframe computer system is its coarse output (alphanumeric overprint
- or line plotter) and only occasionally have the opportunity to view the
- remote sensor data on a high resolution black-and-white or color monitor.

Workstation

Workstations are relatively inexpensive and generally consist of a sophisticated reduced instruction set computer (RISC) interfaced to a high resolution color display. RISC workstations function independently using their own operating system, CPU, and digital image processing software. They may also be networked (connected) to other workstations or to a *file-server* which contains the image processing software and remote sensor data. RISC workstations process information as rapidly as many mainframe computers, thus the distinction between mainframes and workstations is becoming less distinct (Berry, 1993).

Personal Computer

A personal computer (PC) system with the appropriate software may perform relatively sophisticated digital image processing. Typical machines cost < $1,500

including a color monitor with an 8-bit (256 color) look-up table. Educators often purchase PC based digital image processing systems because they are able to configure numerous systems for laboratory instruction at reasonable cost. PC maintenance agreements are also relatively inexpensive when compared to those for mainframes and workstations. Recently, the available of X Window Server software make the PC functioned as a part of the networked workstations that largely broaden the functionality of the PC systems.

Basic software functions for digital image processing:

The most important functions typically performed on digital image processing systems are summarized in Figure 3-1. Every function listed may now be performed on personal computer digital image processing systems as well as workstations and mainframe computers.

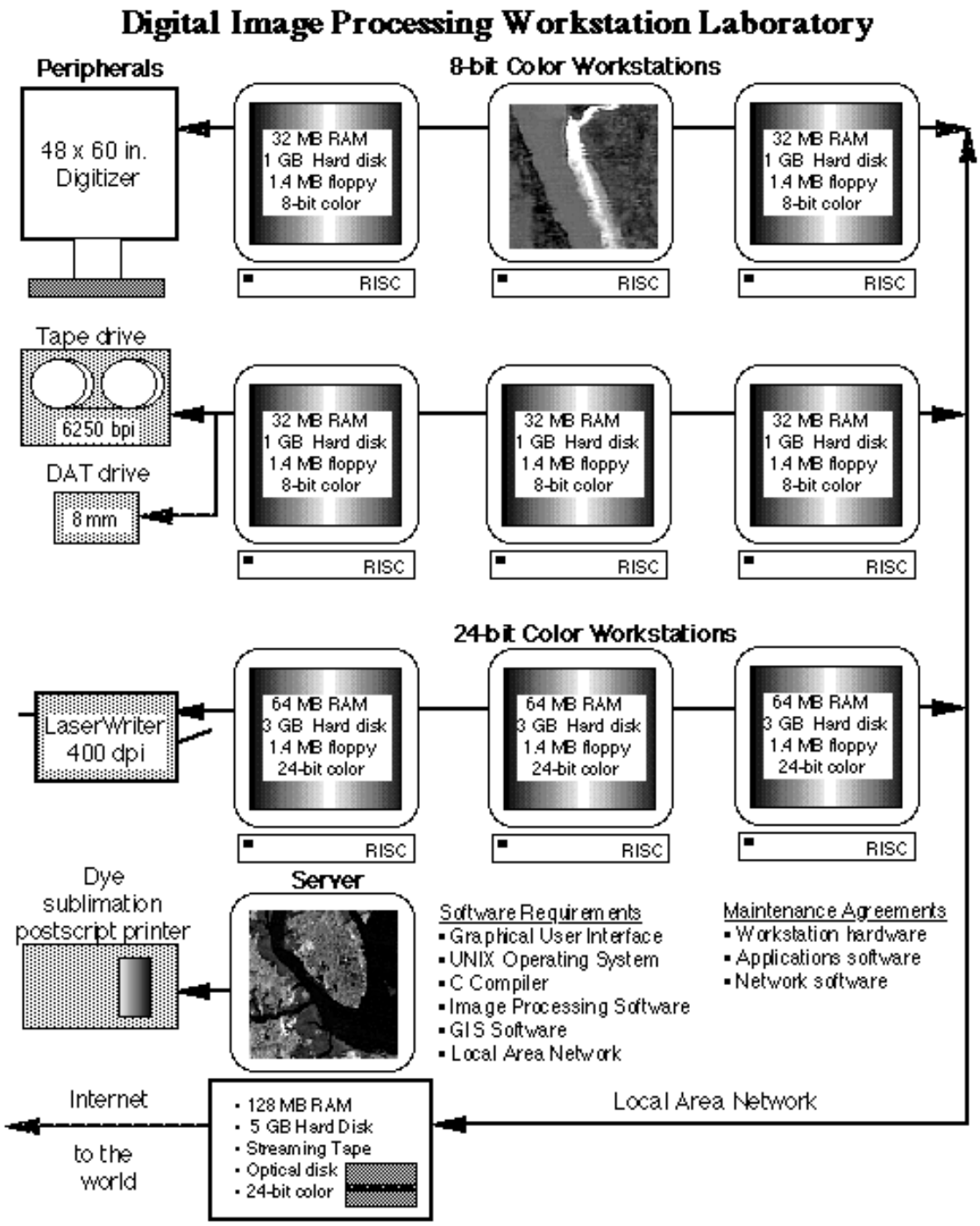

Figure 3-1. A hypothetical digital image processing laboratory consisting of 8-bit and 24-bit color workstations. Reduced instruction set (RISC) computer workstations and peripheral devices (e.g., digitizer, tape drives, dye sublimation printer) communicate via a local area network (LAN). Communication with the outside world is via Internet. Each workstation has sufficient random access memory (RAM) and hard disk space. UNIX is the operating system of choice in this

workstation environment. Digital image processing and GIS software ideally reside on each workstation (increasing the speed of execution) but may reside on the server. Compilers and network software normally reside on the server. Large remote sensing data sets may be placed on the server and accessed by all workstations, minimizing redundant data storage (Jensen, 1996). Image Processing Functions Found in Many Image Processing Systems

- **Preprocessing**
  - Radiometric correction (for sensor system and environmental effects)
  - Geometric correction (image-to-map, or image-to-image)
- **Display & Enhancement**
  - Black & white, color-composite display
  - Density slice
  - Magnification, reduction, roam, pan
  - Transects
  - Contrast manipulation
  - Image algebra (band ratioing, image differencing, etc.)
  - Spatial filtering
  - Edge enhancement
  - Principal components
  - Linear combinations (e.g., Kauth transform)
  - Texture transforms
  - Frequency transformations (Fourier, Cosine, Hadammard, Walsh etc.)
  - Digital elevation models (DEMs)
  - 3-dimensional transformations
  - Animation
  - Image compression
- **Information Extraction**
  - Supervised classification
  - Unsupervised classification
  - Contextual classification

- Incorporation of ancillary data during classification
- Radar image processing
- Hyper-spectral data analysis
- Soft copy photogrammetry to extract digital elevation models
- Soft copy photogramemtry to extract orthophotographs
- Expert system and/or neural network image analysis

- **Image Lineage**
  - Complete image or output GIS file history
- **Image/Map Cartographic Composition**
  - Scaled postscript level II output of images and maps
- **Geographic Information Systems (GIS)**
  - Raster (image) based GIS
  - Vector (polygon) based GIS (must allow polygon comparison)
- **Integrated Image Processing and GIS**
  - Complete Image Processing Systems (Functions 1 to 23)
  - Complete Image Processing Systems and GIS (Functions 1 to 33)
- **Utilities**

Network (Internet, local talk, etc.)

References

Berry, F. C., 1993, *Inventing the Future: How Science and Technology Transform Our World*. Washington, DC: Brassey's, 180 p.

Jensen, J. R., 1996, *Introductory Digital Image Processing: A remote sensing perspective, 2nd Edition*. NJ: Prentice-Hall, pp. 66-67.

Russ, J. C., 1992, *The Image Processing Handbook*. Boca Raton, FL: CRC Press, 445 p.