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WORKSHOP ON REMOTE SENSING TECHNIQUES WITH APPLICATIONS TO AGRICULTURE, WATER AND WEATHER RESOURCES

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IMAGE PROCESSING SYSTEMS AND DESIGN CONCEPTS

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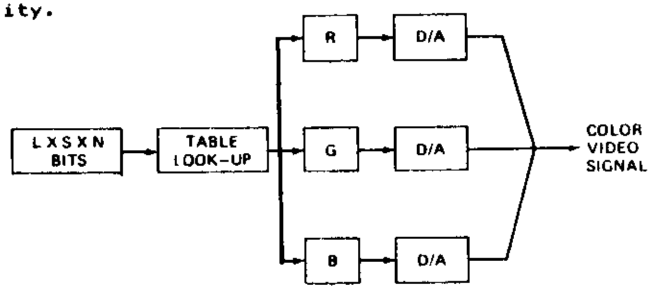

Figure 2 - Look-up table for black and white image display system

A look-up table is physically realized by solid-state memory. Standard tables are usually provided by the manufacturer and stored in ROM; user programmable RAM tables are generally included in the commercially available systems.

As an example of look-up table utility, contrast stretch can be implemented on every readout of the display memory so that the results of a new stored table look-up are viewed on the display screen immediately after the table values are stored. In most display systems, the total time to store a new look-up table is less than 1 second.

2.4. BLACK AND WHITE DISPLAY SYSTEM SELECTION

Fig.3. shows the architecture for a fully configured black and white image display system that includes full graphics and cursor capability. The major system components include the solid-state image memory, the graphics overlay plane driven by a character and vector generator and through direct software commands from the host computer, look up tables, and the interface with interactive hardware components.

The system designer must determine the nature of each of the components when selecting a display system. The selection process usually involves a trade-off between available funds and system capability. Most systems are provided with a minimum set of image memory for a basic price.

Display systems are now available with host microprocessors and local disk and/or tape storage devices, providing local input-output capacity and limited image processing capability within a self-contained display system. These systems also incorporate limited image processing capability so that the entire system can be run in a "stand-alone" mode.

Display systems are also offered as computer peripherals. The display system, including controller, memory, and graphics and interactive device options is provided with an interface to a host minicomputer, mainframe, or microprocessor host system that provides overall control functions to the display device. The host processor handles user interface support and utilizes its own peripherals for image storage and input/output functions.

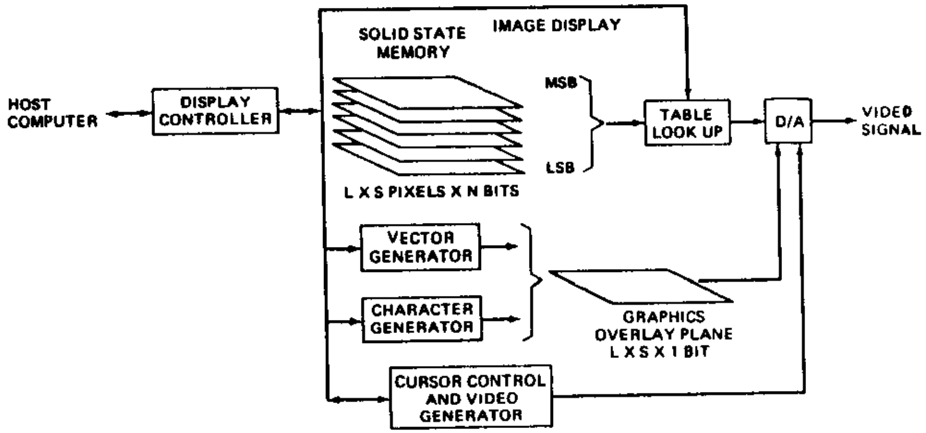

Figure 3 - Black and white image display system architecture

3. COLOR IMAGE DISPLAY SYSTEMS

A schematic block diagram of a color image display system is shown in Fig.4. The first color volatile display systems provided separate blocks of solid-state memory for storage of red, green, and blue components of a color image. Three separate look-up tables were provided so that separate manipulation of the three component images was possible. Manipulation of the three look-up tables could be used to achieve a variety of false-color enhancements without modifying the basic image data stored within the display memory.

Color graphics overlay can be provided through use of three separate bit planes, one for each color of overlay (red, green, and blue). Each of the three separate graphics planes can be addressed separately by the host computer and display controller.

Image display systems generally utilize special color video monitors that accept separate red, green, and blue input analog video signals. The separate color format, called RGB video, is not compatible with broadcast video, and hardware converters are available that convert from RGB format to NTSC format for applications in which NTSC format video transmission of signals generated by image display equipment is desired. The conversion does introduce some degradation in the color content of the imagery.

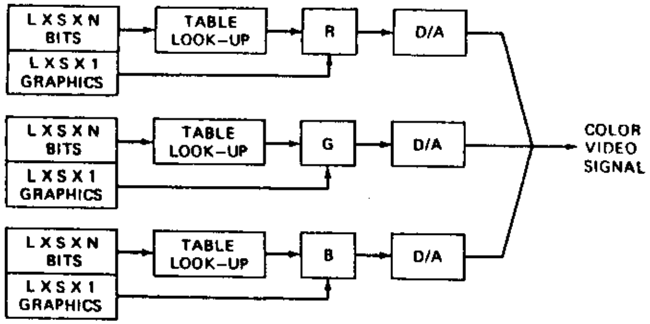

Figure 4 - Color image display system architecture

3.1. IMAGE DISPLAY MEMORY MANAGEMENT

Most commercially available image display systems allow flexible and dynamic utilization of the image display memory. As an example, a block of solid state memory that is 1024 lines by 1024 samples by 24 bits in size can be configured in several ways for image storage. Feasible configurations include the following:

i) One 1024-square three-color image (8 bit per color)
ii) Four 512-square three-color images (8 bit per color)
iii) Sixteen 256-square three-color images (8 bit per color)
iv) Three 1024-square black and white images (8 bit/pixel)
v) Twelve 512-square b/w images (8 bit/pixel)
vi) Forty-eight 256-square b/w images (8 bit/pixel)

ROAM and ZOOM. Most display systems can accommodate storage of images that are too large to be displayed by the TV monitor. As an example, a system configured with the memory described in the above example may have a display monitor that can display only color images that are 512 pixels square or less. Therefore many available systems are equipped with the capability to ROAM and ZOOM within the full image size contained in image memory when the display monitor cannot accommodate the full pixel resolution. The roam operation consists of extracting an image segment (window) for display at full resolution on the display screen. The zoom function consists of enlarging or shrinking a portion of the image in memory for display. As one example, consider a 1024-square three-color image memory associated with a display monitor that can accommodate only 512 square images. The user may initially display the full image at one-quarter resolution on the 512-square display by selecting every other image pixel from every other line in the display memory. The user may then choose to zoom into a particular region within the image, and a selected image segment can then be displayed at full pixel resolution on the monitor. In some applications, zoom is used to perform segment magnification, using either pixel replication or intensity interpolation to generate the pixels created by the magnification.

3.2. MICROPROCESSOR-BASED DISPLAY SYSTEMS

Self-contained display-based image processing systems are now available. These systems incorporate microprocessors that control display functions and support the user interface. The microprocessor can also provide limited image processing capability, and specialized arithmetic processors can also be incorporated to perform specific image processing operations.

The functions that can be performed by microprocessors or other arithmetic processors incorporated within display systems include the following:

- Support of user interface functions
- Contrast manipulation (including pseudocolor)
- Digital filtering
- Roam and zoom
- Image ratioing, differencing and averaging, using local display memory as both input and output
- Edge detection
- Multispectral classification
- Graphics manipulation

4. FUTURE TRENDS

The diversity of commercially available image processing and display systems is increasing rapidly. The basic options currently available have been outlined in this survey, but the field is quite dynamic, and improved capabilities and increasing flexibility continue to be developed rapidly. There is a clear trend towards increased local storage within the display system. The use of rapid-access high-density digital disks interfaced directly to the display system makes already available a large number of images for processing directly within the display system. Optical disks are increasing in use and utility due to the high density and reliability of recorded digital data. Unfortunately, their market is limited to Read Only disks (like Compact Disks) and "Write Only one time, Read Many times" (WORM) disks, for which both drives and disks exhibit low cost per data storage unit (Mbyte or Gbyte). Also video disks become inexpensive devices used for archival storage of large image data bases as the ability to convert imagery without significant loss of quality from this storage format to digital format, suitable for processing, becomes available.

In color displays, most available systems utilize the concept of separate red, green, and blue component images within their basic architecture. Future systems probably will incorporate other color coordinate systems directly, enabling more immediate user control of color image manipulation and enhancement. At present only some medium or high cost systems incorporate hue-saturation-intensity coordinates; such systems include a hardware conversion from red-green-blue coordinates to hue-saturation-intensity coordinates and direct user manipulation of the hue and saturation properties of the color image.

The trend toward increased local processing capability will continue. New systems incorporate advanced computational devices, including pipeline processors and digital array processors, within their architecture. Image processing will participate in the general trend toward distributed processing and linking of processing elements through local or distributed networks. The trend toward self-contained highly capable image processing and display units that are optimized to perform a set of operations supporting a limited number of applications will constitute another important aspect of this general trend. Finally, image processing technology will benefit directly from the trend toward development of customized VLSI (Very Large Scale Integrated circuitry) for high-speed execution of specific computational functions.

REFERENCES

1. Andews, H. C., "An Educational Digital Image Processing Facility", Photogrammetrica Engineering and Remote Sensing, vol. 43, pp. 1161-1168, 1977.
2. Castleman, K. R., "Digital Image Processing", Englewood Cliffs, N.J., Prentice-Hall Inc., 1979.
3. Eyton, J. R., "A Hybrid Image Classification Instruction Package", Photogrammetric Engineering and Remote Sensing, vol. 49, pp. 1175-1181, 1983.
4. Ince, F., "Digital Image Processing Systems and Remote Sensing", The International Journal of Remote Sensing, vol. 4, pp. 129-148, 1982.
5. Jensen, J. R., "Educational Image Processing: An Overview", Photogrammetric Engineering and Remote Sensing, vol. 49, pp. 1151-1157, 1983.
6. Jensen, J. R., Ennerson, F. A., and Hajic, E. J., "An Interactive Image Processing System for Remote Sensing Education", Photogrammetric Engineering and Remote Sensing, vol. 45, pp. 1519-1527, 1979.
7. Reeves, R. G. (Ed.), "Manual of Remote Sensing", 2 vols., American Society of Photogrammetry, Falls Church, Va., 1975