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INSTRUMENTATION DEVELOPMENT OF RASTER SCANNING DENSITOMETER.(U)

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Raster Scanning Densitometer is a digital video image densitometer/memory/processor which is a new, versatile and powerful tool for use in image processing and display tasks. The unit combines a fast analog to digital converter, a high capacity random access memory, and a high-speed arithmetic unit--all under microprocessor control--to perform a variety of digital video processing functions in real time. Among several other uses, a prime function

(Continued on reverse)

20. ABSTRACT (Concluded)

for the Raster Scanning Densitometer will be to scan and digitize fire control system video signals for the determination of modulation transfer function.

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ABSTRACT

The Raster Scanning Densitometer is a digital video image densitometer/memory/processor which is a new, versatile and powerful tool for use in image processing and display tasks. The unit combines a fast analog to digital converter, a high capacity random access memory, and a high-speed arithmetic unit--all under microprocessor control--to perform a variety of digital video processing functions in real time. Among several other uses, a prime function for the Raster Scanning Densitometer will be to scan and digitize fire control system video signals for the determination of modulation transfer function.

SECTION I. SUMMARY

1. BACKGROUND

Electro-optical technology is a fairly new and rapidly developing science which has several applications in the areas of automating field data acquisition and test support. The principal advantages associated with electro-optics are the real and near real-time availability of event data and the application of automatic entry of these data in computer compatible format. The most useful applications of electro-optical technology revolve around the utilization of standard, closed circuit, video cameras/recorders/monitors with newer state-of-the-art micro-electronic instrumentation interfaces to extract these real-time data. These integrated video/ADPE remote data entry terminal systems have significant advantages in terms of more rapid data turnaround time and lower operational costs compared to film systems which provide similar test data coverage.

The Raster Scanning Densitometer is an excellent example of a state-of-the-art microelectronic interface for automatic processing of standard, composite, video data signals. One of the prime functions of the Raster Scanning Densitometer is to digitize optical line scans for fire control systems. Test and evaluation of electro-optical imaging and fire control systems requires measurement of the Optical Transfer Function (OTF). This OTF is analogous to the familiar electronic and mechanical system transfer functions. The total system OTF is theoretically the product of all subcomponent OTFs. Subcomponent OTF measurements are made during manufacture; however, no method currently exists for dynamic field measurements of the overall system. These measurements will allow separation of operational testing variables such as vibrations, atmospheric effects, and operator skill. A theoretical approach is being studied which is based on utilizing reference targets through and around test electro-optical system. These targets are then scanned with this raster scanning microdensitometer and the data are averaged, convolved, correlated, and Fast-Fourier-Transformed in a Digital Processing System. The result will be composed of the Modulation Transfer Function and the Phase Transfer Function portions of the OTF. The OTF of an electro-optical system on-board a vibrating helicopter can be divided into OTF from an electro-optical system on a motionless helicopter to give the effect of vibration test results. Similarly, atmospheric effects and operator skill can be objectively quantified.

2. SYSTEM DESCRIPTION

The Raster Scanning Densitometer is, in fact, a digital image memory/processor and is a new, versatile, and powerful tool for use in image processing and display tasks. Figure 1 shows the relationship of

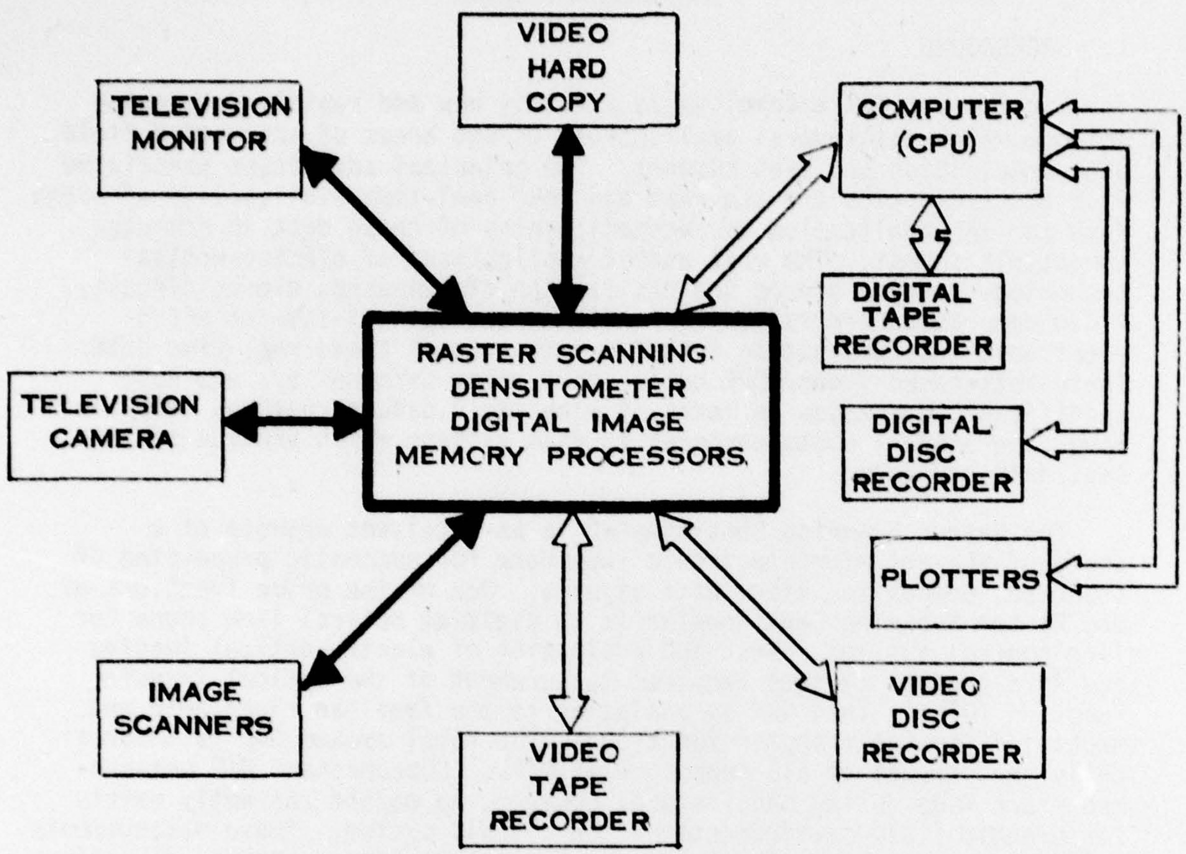

FIGURE 1. RASTER SCANNING DENSITOMETER RELATIONSHIP WITH OTHER INSTRUMENTATION

the Raster Scanning Densitometer with other video and digital instrumentation. The unit combines a fast A/D converter, a high-capacity, random access memory, and a high-speed arithmetic unit--all under microprocessor control--to perform a variety of digital video processing functions in real time. Image sampling is into a 512 X 512 picture element digital memory. Dynamic range is variable up to 12 bits per picture element (Pixel). The unit possesses both TV compatible analog input and output ports plus random access digital input and output capabilities which may be utilized simultaneously through a unique, memory, time-sharing technique. The unit can perform the following functions:

a. Digitize and store a television frame in 1/30 second

b. Add input image to previously stored images

c. Display difference between stored data and incoming data

d. Store difference between stored data and incoming data

e. Subtract accumulated background images from accumulated background plus signal images

f. Perform exponentially weighted sliding average on sequential input images

g. Subtract uniform pedestal from video prior to digitizing

h. Hold data in memory. Image display continues but new inputs are not accepted.

i. Grab next input and Hold for display

j. Automatically display the most active memory bits

2.1 FUNCTIONAL DESCRIPTION

The digital image memory/processor functions are shown in Figure 2. Composite video is received by the Video I/O board which strips composite sync and sends it to the Sync Regenerate board. This board phase locks to the signal and outputs comp sync and blanking signals.

The video signal is sent to the A/D converter where it is converted to parallel digital words at the system clock rate of 10 MHz. System clocking stops during retrace blanking intervals. Front panel controls select the video amplitude range to be linearly distributed between the lower and upper limits of the A/D converter.

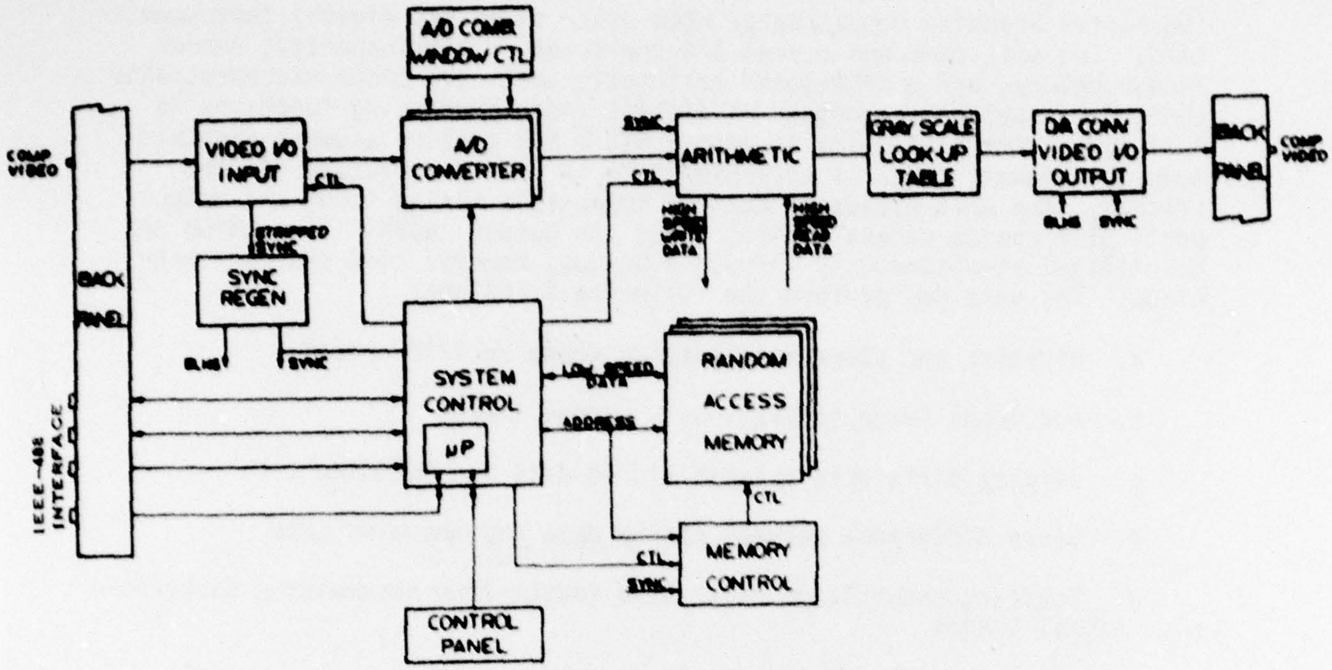

FIGURE 2. FUNCTIONAL DESCRIPTION

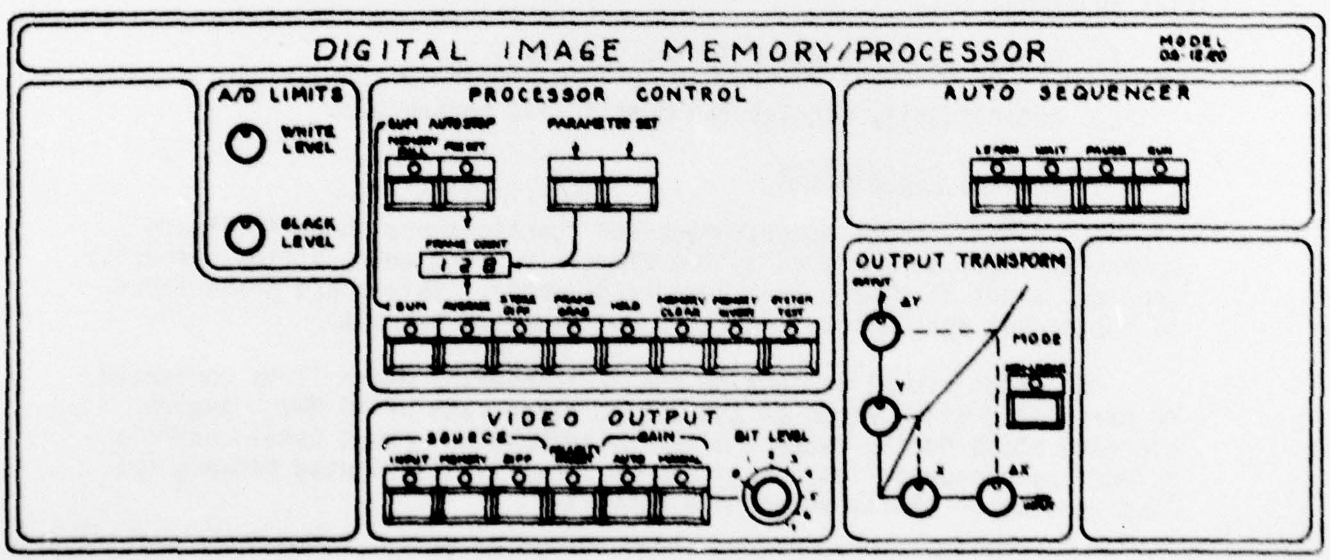

FIGURE 3. CONTROL PANEL

The A/D output is sent to the high-speed Arithmetic board while the same pixels are transferred from the Random Access Memory to the Arithmetic board. These two sets of pixels may be added, subtracted, or averaged according to instructions received from the System Control board.

The pixels transferred from Memory to the Arithmetic board are also shifted out at the system clock rate to the D/A converter on the Video I/O board and following addition of sync, blanking, and gamma correction, the resulting signal is sent to the Comp Video output terminal.

Data transfer to and from the memory is done in a fixed, time-shared cycle so that television read, television write, and random access input/output operations are transparent to each other. Thus, pixels are randomly accessible from external digital devices at 1.6-microsecond intervals while, simultaneously, new picture information is streaming into memory at TV rates and present picture information is streaming out of memory at TV rates for display and/or storage.

The System Control board contains a microprocessor which examines the state of the control panel once every 1/60 second and then sets the control lines to each subunit to the appropriate level. This miroprocessor is interfaced to a back panel connector so that the unit may be commanded from external devices.

An Output Transform is available as a programmable, digital, look-up table which can be switch-selected. A digital output word from memory will be exchanged for an alternate word in a look-up in order to modify the normally linear relationship between input and output. Front panel controls allow the operation to select two breakpoints on the input/output curve. This, in turn, allows the differential gain to be varied in three amplitude ranges. For example, the dark areas of the image may be increased in contrast at the expense of the midrange while leaving the contrast of the white areas at normal or even above normal values.

The Auto-Sequencer provides a means for performing a sequence of operations, once in the Learn mode and then repeating this sequence automatically every time the Run mode is selected. The Pause mode inserts a delay between each step so that the operator may monitor and control the process. The Wait mode requires that each step be preceded by a command pulse from an external device such as a computer.

In addition to the above capabilities, many other operations may be performed by post-processing of the stored data either with the internal microprocessor in the unit or with external computers which are afforded fast, direct access to the stored data via the random access I/O port. This computer computation capability can be used to produce the Fourier Transform of an edge scan. This Fourier Transform provides the OTF of the imaging system and is required in fire control system testing of aircraft armament. Independent of any other operation, the unit continuously displays on standard TV monitors whatever is in memory.

2.2 CONTROL PANEL

The control panel (Fig. 3) is divided into several subpanels: A/D Control; Processor Control; Output Control; Auto Sequencer; Output Transform; and Data In/Out. Major use is made of momentary contact switches with integral LED indicators. When the button is depressed, the LED turns on, indicating the labeled function is operative. It may be turned off by pressing the button a second time or, in some cases, by selecting a mutually exclusive function. The functions and operation of all controls are covered in Appendix B.

3. CONCLUSIONS

The Raster Scanning Densitometer is a digital video image densitometer/memory/processor and is a unique, state-of-the-art video interface which is a versatile and powerful tool for use in image processing and display tasks. The unit performs a variety of digital video processing functions in real time. A prime use of this system will be for scanning and digitizing fire control system video signals for the determination of modulation transfer function.

SECTION II. APPENDICES

APPENDIX A. SYSTEM SPECIFICATIONS

1. General.

This specification covers the requirement for a digital image memory and scene processor system for use as an interface between standard, RS-170 video compatible television transient images and digital computer.

2. Specifications.

2.1 Processor and control requirements.

a. Synchronize to an external composite video signal

b. Digitize and store a television frame in real time (1/30 second)

c. At least 8 bit analog/digital conversion resolution with at least 10 MHz sampling rate and adjustable voltage offset/gain controls

d. Store the television frame in a 512 X 512 array of random access memory which has at least 8 bits per pixel and is expandable to at least 12 bits per pixel. This stored frame must be capable of continuous output as a composite video signal.

e. Must have an IEEE-488 compatible Input/Output interface which shall provide data transfer, front panel control and gray scale table control; with connector, system handshaking and address switch selection in accordance with the IEEE-488/75 standard. This interface port shall allow random reading or writing to any of the 512 X 512 pixels within 2 microseconds.

f. Provide a composite video output and/or store in memory the difference between a previously stored scene and a real-time scene.

g. Provide the capability for integrating and for time averaging these stored scenes to increase the signal to noise ratio.

h. Provide the capability of acquring the next available video frame, subtracting from this next frame a previously stored background image and then storing and holding this resulting difference image.

i. Proper manual controls must be provided for all functions. Also, an Auto Sequencer for programming the automatic operation of these controls is required.

j. An adjustable output gray scale transform is required which will allow the operator to expand or compress the video gray scale around any digital level.

2.2 Input Requirements.

a. Standard EIA-RS-170 composite video with 2:1 interlace 525 line format

b. 115 VAC 60 cycle single phase power

c. Standard IEEE-488 signals

2.3 Output requirements.

a. Standard EIA-RS-170 composite video with 2:1 interlace 525 line format. This must switch selectably be the input video, memory stored video, or the difference between the two.

b. Standard IEEE-488 signals

3. Documentation.

Three copies of the operation and maintenance manuals must be provided.

SUPPORTING RESOURCES/APPROVALS REQUIRED AND STATUS

Initially, the use of an existing programmable calculator will be required and, eventually, the infrared collimator and High Resolution Pyroelectric Scanner will be required to support MTF data acquisition.

ECONOMIC ANALYSIS

Another scanning densitometer is available for $42,000 and would do the job almost as well.

ENVIRONMENTAL IMPACT: None

PROCUREMENT LIST

EDP Raster Scanner	$20,200

REPLACEMENTS: None

COST BREAKOUT:

a.	Out-of-house	$20,200
b.	In-house	800
		$21,000

CONTACT

Leo Weeks - Autovon 899-6648

AUTOMATED DATA INPUT

----YPG RASTER SCANNING DENSITOMETER 00021000

APPENDIX B. CONTROL FUNCTIONS

I. A/D Limits

WHITE LEVEL:	Determines the video amplitude which is encoded as full scale by the A/D Converter.
BLACK LEVEL:	Determines the video amplitude which is encoded as zero by the A/D Converter.

II. Processor Control Subpanel

SUM:	Causes digitized input image data to be added to data in memory. This is done on a picture element by picture element basis at the 10 MHz rate.
AVERAGE:	Causes digitized input image data to be divided by N and then added to (N-1)/N of data in memory. This process is also performed at the digitizing rate. The value of N is any power of 2 between 2^1 and 2^7 (128) and is selected by the PARAMETER SET switch pair and displayed in the FRAME COUNT LED display.
STORE DIFF:	Causes data previously stored in memory to be subtracted from input data and the resulting difference to be stored in memory.
IMAGE GRAB:	Causes the unit to replace the contents of the memory with the next input and then retain this input in memory.
HOLD:	Retains current data in memory. Prevents new data from replacing or modifying stored data via the high speed write port.
MEMORY CLEAR:	Causes zero to be written in every memory address.
MEMORY INVERT:	Causes data in memory to be inverted in sign. Used in background subtract process. New incoming data may be summed to bring resultant positive and suitable for display.
SYSTEM TEST:	Causes checks to be made on memory and processor operations.

SUM AUTOSTOP: The SUM mode operation may be stopped in three ways. It may be stopped manually by pressing the HOLD switch. It may be stopped when the brightest pixel reaches saturation by pressing the MEMORY FULL switch or it may be stopped after a reset number of inputs have occurred by pressing the PRESET switch and setting in the appropriate number of FRAME COUNTS in the adjacent LED display.

III. Output Transform Control

This subpanel allows the operator to modify the normally linear relationship between input and output.

Pressing the MODE switch to select the nonlinear mode causes digital data from the memory to be routed to a programmable look-up table.

One pair of controls selects an X, Y position for the first breakpoint on the transfer curve while a second pair selects a second breakpoint X, Y. These controls operate through an A/D converter to program the look-up table.

Through these breakpoint controls the transfer function can be modified to increase differentially the readout gain in one or two amplitude regions at the expense of the second or third.

IV. Video Output Subpanel

SOURCE: Selects one of three sources for output and display. Input video, memory output video, or the difference between the two.

INPUT: Connects the input to the output video terminal. Allows the operator to observe the signal coming into the unit.

MEM: Selects the data stored in memory for display.

DIFF: Selects the difference between the incoming video and the video arising from the stored image for display.

POLARITY INVERT: Inverts the polarity of the video signal prior to addition of blanking and sync. This process applies to all video regardless of source.

GAIN: Selects the memory read-out gain.

AUTO: Causes the highest nonzero bit level in memory to be connected to the most significant bit of the D/A Converter. As image data increases in depth in the memory, the readout gain will decrease in steps at periodic intervals to prevent brightness saturation on the display.

MANUAL: Allows the operator to select manually the readout gain desired using the BIT LEVEL switch.

V. Auto Sequencer Control

This subpanel has four switches designed to operate the unit automatically in certain repetitive sequences.

LEARN: When activated, a sequence of switch operations performed on the Processor Control are recorded in memory.

RUN: When activiated, the Processor Control will continuously cycle through the steps recorded in memory.

PAUSE: When activiated the system will introduce a several second delay between each step to allow operator interaction.

WAIT: The system will wait after performing each step in a recorded sequence until receiving an external command pulse to perform the next step.

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