SANDIA REPORT
SAND87—0950 • UC—15
Unlimited Release
Printed May 1987

VISDTA
A Video Imaging System for Detection, Tracking, and Assessment

Prototype Development and Concept Demonstration

Daniel A. Pritchard

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
for the United States Department of Energy
under Contract DE-AC04-76DP00789

When printing a copy of any digitized SAND Report, you are required to update the markings to current standards.

SF2900Q(8-81)

Issued by Sandia National Laboratories, operated for the United States Department of Energy by Sandia Corporation.

NOTICE: This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government, any agency thereof or any of their contractors or subcontractors. The views and opinions expressed herein do not necessarily state or reflect those of the United States Government, any agency thereof or any of their contractors or subcontractors.

Printed in the United States of America
Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

NTIS price codes
Printed copy: A03
Microfiche copy: A01

Distribution Category
UC-15

SAND87-0950
Unlimited Release
Printed May 1987

VISDTA
A Video Imaging System for Detection, Tracking, and Assessment

Prototype Development and Concept Demonstration

Daniel A. Pritchard
Systems Engineering Division
Sandia National Laboratories
Albuquerque, New Mexico 87185

ABSTRACT

A prototype Video Imaging System for Detection, Tracking, and Assessment (VISDTA) has been developed to demonstrate basic operating principles. VISDTA consists of a high-accuracy panning and tilting camera platform, various imaging devices, digital image processing hardware, and a video/graphics display, all under control of a single-board computer. The operator, with the use of the keyboard, can move the platform, switch imaging devices, set up automatic scanning patterns, and put VISDTA into an automatic detection mode. Upon detection of unusual conditions, VISDTA will begin tracking these image anomalies. The operator has full control over VISDTA to assess these alert conditions, if desired. In this report, the hardware and software are described which were developed for this prototype.

ACKNOWLEDGEMENT

This effort was funded by the Defense Nuclear Agency. The contact is LtCol Timothy D. O'Toole, Chief, Nuclear Security and Safety Division.

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	7
2.0	FUNCTIONAL DESCRIPTION	7
3.0	HARDWARE DESCRIPTION	8
4.0	SOFTWARE DESIGN	17
5.0	IMAGE PROCESSING TECHNIQUES	19
6.0	OPERATIONAL SCENARIO	21
7.0	SUMMARY	22

LIST OF FIGURES

		Page
FIGURE 1.	VISDTA STAND-ALONE CONFIGURATION EXAMPLE	9
FIGURE 2.	VISDTA PROTOTYPE HARDWARE	10
FIGURE 3.	VISDTA PAN/TILT MOUNT AND SENSORS	11
FIGURE 4.	VISDTA PROCESSING AND CONTROL SUBSYSTEM	12
FIGURE 5.	IMAGE PROCESSING BOARD INTERCONNECTIONS	16

1.0 INTRODUCTION

It has been demonstrated that thermal imagers are an effective surveillance and assessment tool for security applications because:

(1) They work day or night due to their sensitivity to thermal signatures;

(2) Penetrability through fog, rain, dust, etc., is better than human eyes;

(3) Short or long range operation is possible with various optics; and

(4) They are strictly passive devices providing visible imagery which is readily interpreted by the operator with little training.

Unfortunately, most thermal imagers also require the setup of a tripod, connection of batteries, cables, display, etc. When this is accomplished, the operator must manually move the camera back and forth searching for signs of aggressor activity. VISDTA is designed to provide automatic panning, and in a sense, "watch" the imagery in place of the operator.

The idea behind the development of VISDTA is to provide a small, portable, rugged system to automatically scan areas and detect targets by computer processing of images. It would use a thermal imager and possibly an intensified day/night TV camera, a pan/ tilt mount, and a computer for system control. If mounted on a dedicated vehicle or on a tower, VISDTA will perform video motion detection functions on incoming video imagery, and automatically scan predefined patterns in search of abnormal conditions which may indicate attempted intrusions into the field-of-regard. In that respect, VISDTA is capable of improving the ability of security forces to maintain security of a given area of interest by augmenting present techniques and reducing operator fatigue.

2.0 FUNCTIONAL DESCRIPTION

The scope of this task was constrained to taking the first steps toward implementation of an advanced, fieldable sensor and assessment system. Demonstrable hardware and software was assembled in the time frame available, and will continue to serve as a baseline for follow-on development. VISDTA's software provides some very basic functions for stand-alone operation, and successfully demonstrates the concepts involved. The system is currently limited to the description which follows.

(1) The input to the system is an RS-170 video signal from an IR imager, and/or a similar signal from a day/night intensified CCTV camera. That image (or images) will be combined with graphical overlays for display to the operator on a color monitor.

(2) The user instructs the system to either monitor a fixed position for motion, or automatically pan a predetermined field-of-regard looking for warm objects which satisfy thermal difference and size criteria.

(3) The system determines by digital processing, whether or not interesting objects exist in the scene, and generates an alarm by audible and visual cues when that occurs.

(4) The system pauses (if in panning mode) to allow the observer to change view modes to make an assessment of the situation. Assessment can be made by viewing the display monitor and controlling the imaging devices and/or pan/tilt mount to improve the view of the object of interest.

(5) If it is determined that the observed object is not a threat, the system can be instructed to return to its previous mode for continued monitoring.

3.0 HARDWARE DESCRIPTION

The system consists of: 1) a sensor subsystem, 2) a processing and control subsystem, and 3) a hand-held controller (see Figures 1 and 2).

The sensor subsystem includes:

1) an infrared imager,
2) a black & white video camera, and
3) a computer-controlled pan and tilt mount.

The unit pictured in Figure 3 is the pan/tilt mount used in this prototype development. Also shown is a black & white video camera (small-lensed camera near center), the Inframetrics Thermal Imager (large lens and scanner unit shown at left side of pan/tilt unit), and, on top of the thermal imager, a hand-held laser rangefinder. (The laser rangefinder was a borrowed unit and included only for conceptual demonstration.)

The processing and control subsystem is a VMEbus-based chassis and enclosure that holds various electronic modules, and is presented in Figure 4. The components in this cabinet include:

1) a single-board, multifunction computer,
2) a disk controller,
3) specialized image-processing circuit boards,
4) a dual-axis, stepping-motor controller board,
5) power supply and drive electronics for the stepping motors,
6) a hard disk drive for program storage and recall,
7) control electronics for the imaging devices, and
8) a video monitor for display of the imagery.

The hand-held controller is a liquid-crystal display device integrated with a keyboard (see Figure 2). It serves as a "dumb terminal" to the control computer.

3.1 Infrared Imager

The IR imager used for this phase of system design is a unit purchased with USAF funds by Sandia National Laboratories. It is owned by the USAF. It is a commercially available thermal imager from Inframetrics, Inc. of Bedford, MA, Model IRTV-445. It was chosen because it is potentially available for loan to this program. The unit has TV-quality spatial resolution, and good thermal sensitivity as well. The thermal sensitivity is considered adequate, but not as high as one could get with an advanced, more costly, ruggedized imager. The thermal resolution is adequate for the testing and proof-of-principle evaluations expected during this program. Only the scanner assembly of the imager will be mounted on the pan/tilt mount. Weight of the scanner is about five pounds. Total power consumption is less than 15 watts.

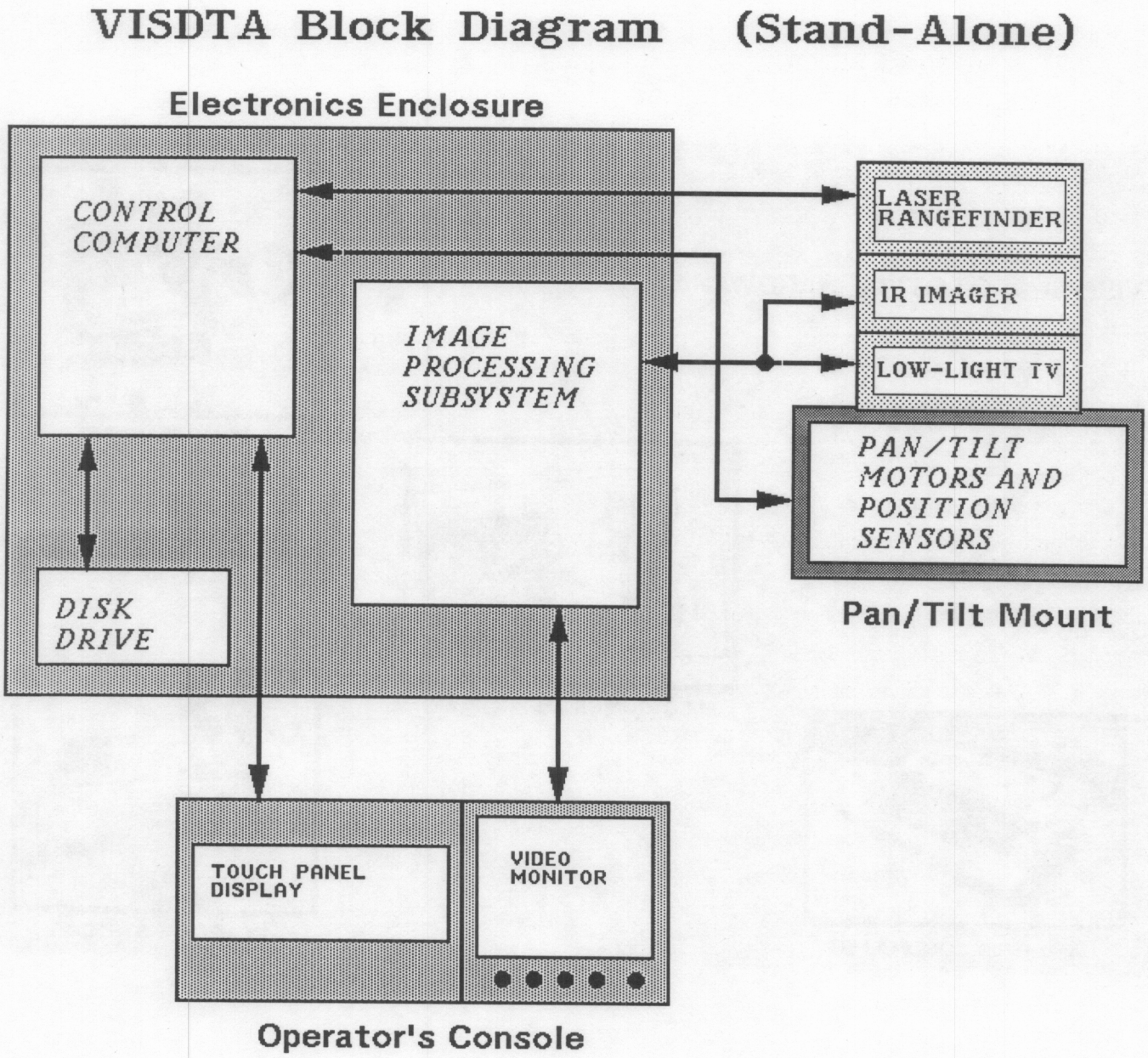

FIGURE 1. VISDTA STAND-ALONE CONFIGURATION EXAMPLE

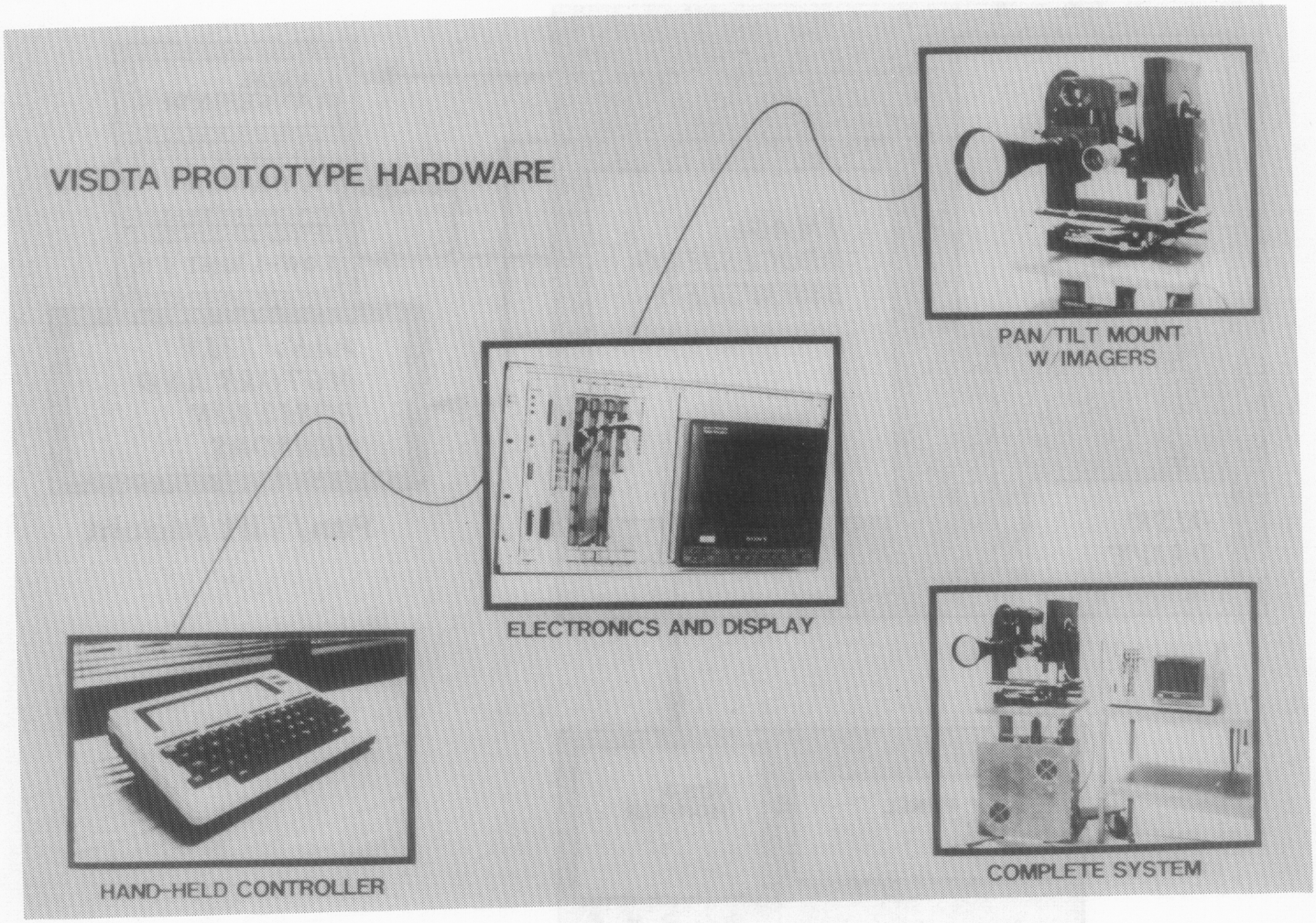

FIGURE 2. VISDTA PROTOTYPE HARDWARE

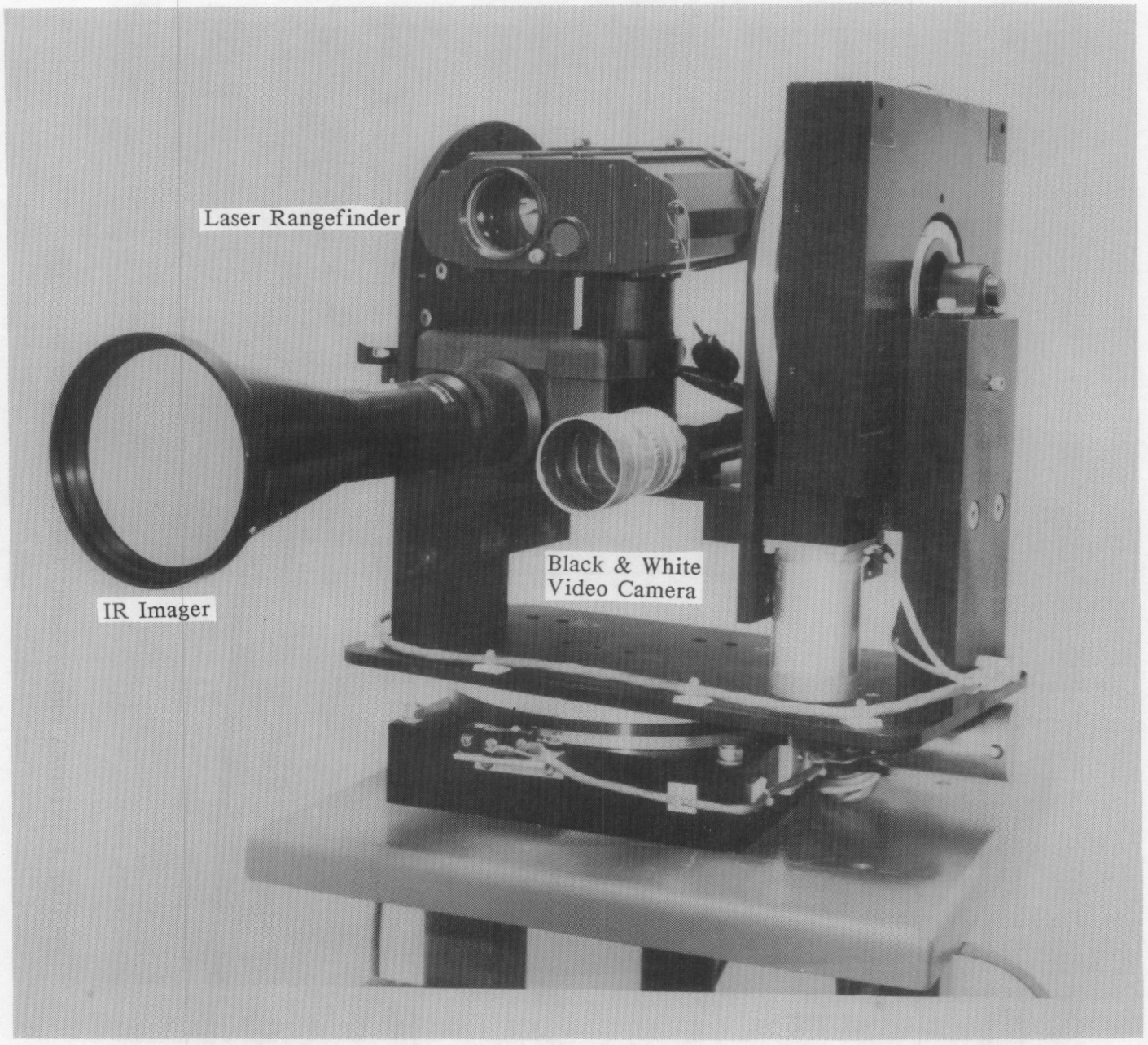

FIGURE 3. VISDTA PAN/TILT MOUNT AND SENSORS

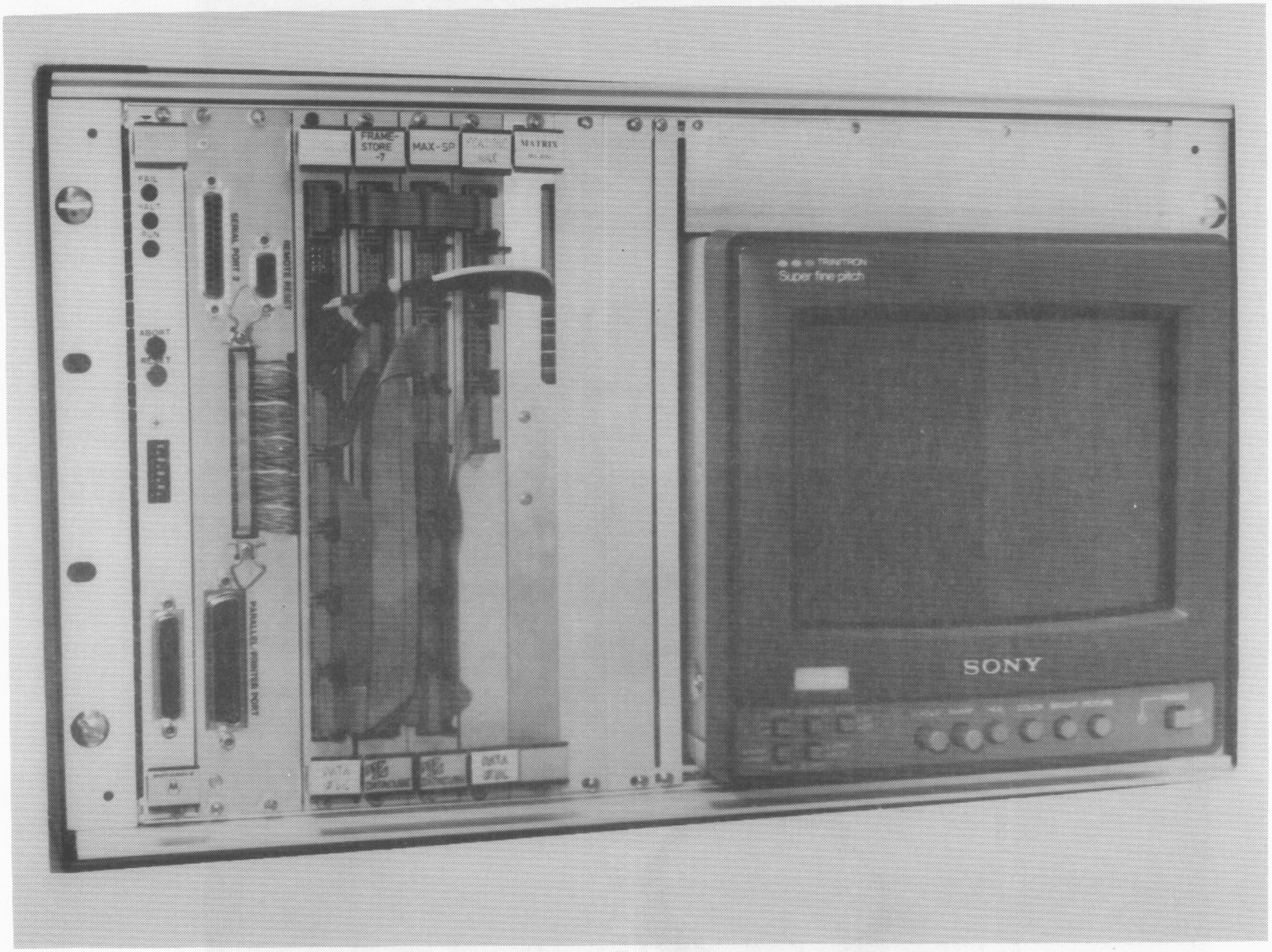

FIGURE 4. VISDTA PROCESSING AND CONTROL SUBSYSTEM

Video from the camera is routed to the input of the image processing subsystem. A parallel connection is to be made to the video switcher for routing video imagery to other viewing stations.

The imager operates like most thermal imagers; it uses a few detectors which are cooled to liquid-nitrogen (77 Kelvin) temperature, and scanning mirrors to sweep the image across the detectors to produce a video image. The video output is availlable for display on a standard RS-170 compatible video monitor. Optical options include an 8X lens (for 3.5 x 2.625 degree field-of-view), a 4X lens (7.0 x 5.25 degree FOV) and 1X (28 x 21 degree FOV); although these are not remotely switchable. Currently, this imager is cooled with liquid nitrogen.

The imager has full manual controls. There is no plan to automate the turn-on or setup of the thermal imager. A control panel provides a cool-down indicator light, and switches for:

1) focus (in/out),
2) contrast (low, medium, and high),
3) level,
4) polarity (black hot/white hot),
5) electronic zoom (1X, 2X, and 4X image overscan), and
6) power on/off.

The camera adjustments are set manually. The 8X lens will be used for maximum resolution at maximum range. The focus is manually adjusted. Once focused, no further adjustments are necessary. The constrast switch is to be set to low (scene contrast), indicating maximum thermal sensitivity. For proper detection algorithm operation, the polarity must be set to "white hot". The electronic zoom must be set to 1X, for proper panning coverage of the field-of-regard. Power is applied to the imager when power is applied to the electronics chassis.

The IR imager requires liquid nitrogen to maintain proper cooling of the detectors. A fill of approximately four ounces of liquid nitrogen will last about three hours. The imager is running on AC power, and batteries are not required. Thus, coolant is the only maintenance item.

3.2 Black and White Video Camera

For testing purposes, a small Sony/Pulnix solid-state video camera was mounted on the pan/tilt platform. This camera is owned by Sandia, and is small in size, has an automatic aperature lens, and no other special features. Video from the camera is routed to the input of the image processing subsystem.

3.3 Hand-Held Controller

To provide a low-cost keyboard/display, a Model 100 Computer was purchased from Radio Shack. This unit has a full keyboard with an eight line by 40 character LCD display. It was chosen for its low cost and easy interface to the single-board computer. It is not rugged, requires some ambient lighting to read the display, and is only useful for prototype demonstration functions. It is connected to the electronics cabinet with a multi-conductor cable to the serial port connector on the front panel of the single-board computer.

3.4 Pan/Tilt Mount

The platform which holds the sensors is manufactured by Security Software Systems of El Cajon, CA. It has a 140 pound payload capacity, and is driven by stepping-type motors. The limits of travel are as follows: +/- 180 degrees azimuth, +70/-15 degrees elevation. Limit switches are used to prevent travel past the software limits. Physical stops are in place to prevent damage in the event of limit switch failure. The maximum rate of travel for both azimuth and elevation is 15 degrees per second. Acceleration is accomplished by ramping the step rate at about 2000 steps/second/second. Weight of the pan/tilt mount (not including power supply and control/drive electronics) is 90 pounds. Power consumption for the pan/tilt system is about 500 watts.

The pan/tilt unit is fabricated from standardized components, such as the NEMA-23 frame size stepping motors, and the rotary tables which are mounted at right angles for the azimuth and elevation axes. The rotary tables have worm-gear drive mechanisms which permit positioning accuracies of 0.01 degree. Backlash is negligible. Although this unit has high payload capacity and high accuracy, a production unit need not weigh 90 pounds. Because of the standardization, the unit can be scaled down to fit the requirements. That is, smaller rotary tables and smaller motors can be used with the exact same stepping motor controller/driver circuits. Current weight of the payload on the pan/tilt unit with the IR imager, and black and white camera is less than 10 pounds.

3.5 Single-board Computer

The control computer for the VISDTA system is a Motorola MVME-117 single board computer. Some of the features are: one-half megabyte of read/write memory, two serial ports, and a real-time clock. The on-board processor is a Motorola 68010 cpu operating at 10 MHz. This board is the VMEbus controller for the computer system. It is the first board in the computer chassis. The interface ports are connected to peripheral devices for communications and control. The primary serial port is used for communicating to the handheld controller.

The software which resides in the on-board read-only memory consists of debug routines, some diagnostic and self-test routines, and the software which boots the operating system program from the hard disk drive. The software is booted when power is applied to the system.

3.6 Hard Disk Data Storage

The data storage device for the system is an industrial-type Seagate ST225 drive with a 21 Mbyte capacity. The industrial rating provides some degree of shock and vibration resistance, which is adequate for initial testing and evaluation, and most likely adequate for production units. The drive is shock-mounted in the electronics chassis. Power requirements for the hard disk drive and the SCSI controller board are less than ten watts.

3.7 Stepping Motor Controller/Drivers/Power Supply

The control and power driver circuitry for the stepping motors on the pan/tilt mount are from Matrix Corporation of Raleigh, NC. A MS-DSC dual-axis stepping motor controller is the main circuit board. Two unipolar driver boards are used to drive the motor windings. The controller board is VMEbus-based, and receives commands over the VMEbus. The controller sends pulse trains to the driver boards which in turn trigger high current pulses to the motor windings causing motion. All of this circuitry is contained in the electronics enclosure.

A 24VDC, 25 amp power supply is required to drive the motor windings and the series resistors. Five ohm, 100 watt resistors are placed in series with opposing motor windings to increase the R/L factor and increase step rates and improve performance. An option is available to lower the power consumption and increase performance (step rates). The use of a chopper-type motor driver would accomplish this.

3.8 Image Processing Hardware

The bulk of the processing on the imagery is done using image processing boards from Datacube, Inc. of Peabody, MA. Four VMEbus boards are used to digitize, store, histogram, process, and display the video imagery. Analog video signals are brought into the boards by a front panel connector. Digitized video data is routed between the boards over other front panel connectors (see Figure 5). Most processing operations occur at video rates (30 frames per second), and relieve the control computer of significant amounts of processing. All control and programming of these image processing boards comes from the control computer via the VMEbus backplane.

The digitizer/display board (Digimax) is responsible for selecting which analog video signal gets digitized. Once digitized, the signal defines the timing for the remainder of the processing elements. A digital video stream results from digitizing. This stream is routed to a board which stores video images (Framestore), and to a histogram module (Featuremax), and to an arithmetic operations board (Max-SP) which subtracts, scales, and otherwise processes the images, both live and stored. The control computer then analyzes a list of "different" pixels and declares alerts when abnormal conditions exist.

The Datacube image processing boards are available in two line resolutions; 384 pixels per line, and 512 pixels per line. The 384 pixel version is used here. The resolution of the IR imager is equivalent to about 400 pixels per line, so a good match exists. A higher resolution digitizer would not be particularly useful.

3.9 Equipment List

The equipment used in the VISDTA prototype system is listed below. The approximate value and present owner (via funding) is also indicated.

ITEM	COST(K)	FUNDED BY
Electronics enclosure/chassis	$ 5.0	Sandia/DOE
Digitizer/display board	2.0	Sandia/DOE
Featuremax board	2.5	Sandia/DOE
Framestore board	3.2	Sandia/DOE
Max-SP board	1.2	Sandia/DOE
Black & white camera	2.0	Sandia/DOE
IR imager and optics	60.0	Sandia/USAF
Hand-held controller	0.3	DNA
MVME-117 control computer	3.0	DNA
Hard disk drive	0.5	DNA
Hard disk controller	0.5	DNA

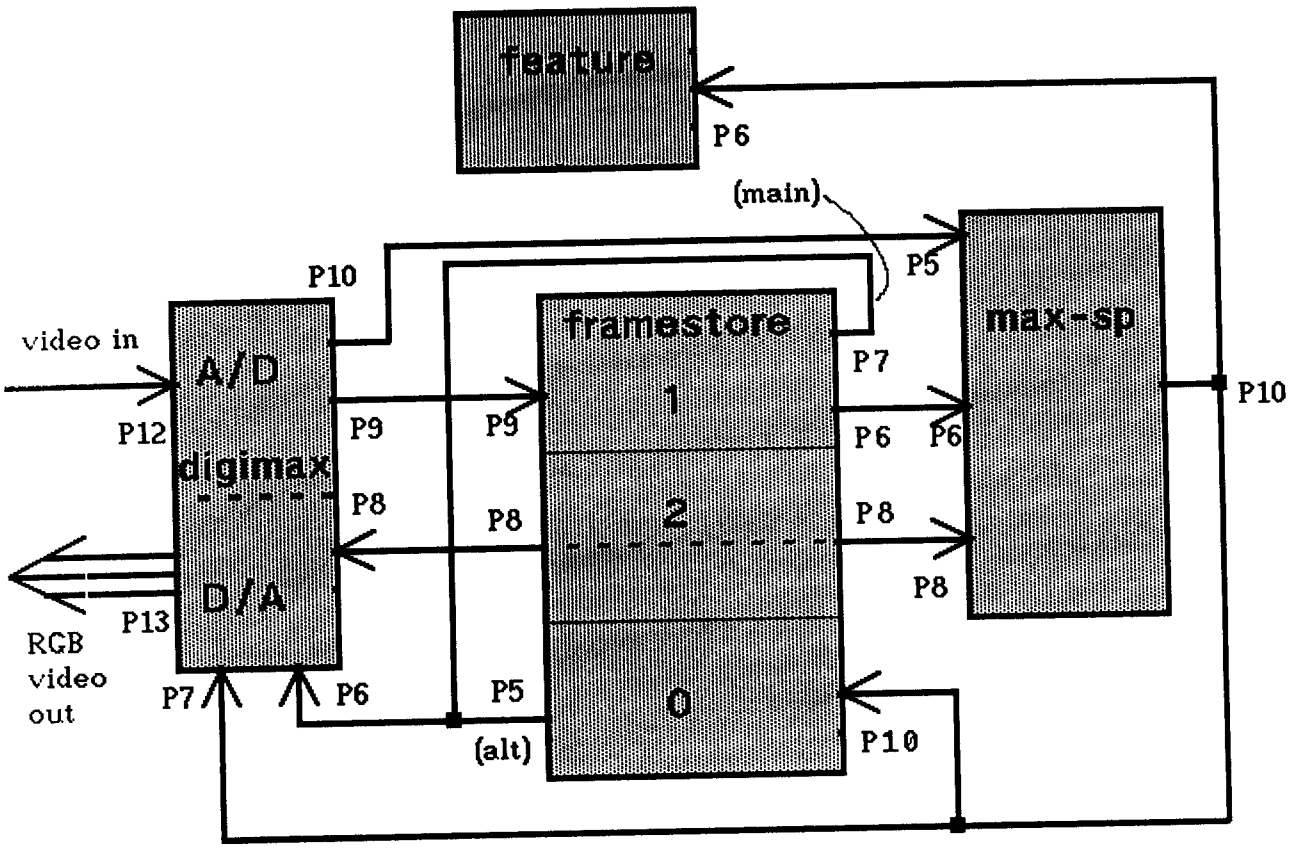

FIGURE 5. IMAGE PROCESSING BOARD INTERCONNECTIONS

ITEM (con't)	COST(K) FUNDED BY
Dual-channel motor controller	1.0 DNA
Dual motor driver board	0.8 DNA
Motor power supply	0.8 DNA
Pan/tilt mount	15.0 DNA

4.0 SOFTWARE DESIGN

Operating system software was by far the bulk of the development effort. The role of the software is to control the communications with the hand-held controller, command the pan/tilt mount to move to the required positions, initialize and trigger the image processing functions, and execute other miscellaneous tasks. The five general modes of operation are detailed in the following sections.

4.1 Boot/Initialize/Ready

As power is applied to VISDTA, a series of initialization sequences occur. The read-only memory (ROM) on the single board computer will begin the boot process which loads the program from the disk drive. The boot code begins by resetting and programming the serial channel controller, the disk interface circuitry, and performing other housekeeping tasks.

Other start-up tasks are required for the pan/tilt mount and the image processing boards. The motor controller for the pan/tilt mount must be programmed for proper operation of the motors. Parameters such as acceleration rate, maximum step rate, and minimum step rate are loaded into the controller. The azimuth and elevation limit switches are then read to determine which direction to move to get to a centered or "home" position. The azimuth and elevation axes are then centered in their range of travel, and the pan/tilt mount is then ready for operation.

The image processing boards are extremely flexible, and must also be programmed for proper operation. The digitizer is set up for the appropriate input and output video operations, an input channel is selected, the look-up tables are programmed, and sync rates and frame/field modes are specified. There are numerous other initialization functions for the framestore board, the arithmetic operations board, and the histogramming board. The net effect of this initialization is to provide a syncronized image from a functional camera to the output of the image processing subsystem.

Once these steps have been accomplished, VISDTA is placed in a ready mode and then monitors the communications port for further instructions. As new instructions are received, the appropriate actions are taken.

4.2 Full Remote Control

This mode can be entered at any time after the boot/initialization sequence has completed. The primary purpose of this mode is to allow the operator to control all of VISDTA's functions. These functions include:

1) Moving the pan/tilt mount,
2) Switching imaging devices,

3) Homing the pan/tilt mount, and

4) Entering one of the detection modes.

Movement instructions for the pan/tilt mount are entered by keystrokes at the hand-held display/keyboard. VISDTA then commands the motors for the appropriate motion. A single speed is available for manual control of the mount. The mount can also be commanded to move to its center-of-travel home position.

If desired, one of three detection modes can be entered at this point. One of these modes is designed for operation on a single scene, that is, no pan/tilt motion is allowed after entering this mode. Two modes operate on the whole scene, looking for either scene changes, or objects which exceed a video level threshold. (If using the IR imager, something warmer than the background would exceed the video level threshold.) Once a change or bright (warm) object is detected, the local alert mode is entered. The third mode provides region-of-interest video motion detection (ROI VMD). The user is requested to enter parameters for the setup of the ROI's, and then only the changes within those ROI's are considered for declaring an alert. The local alert mode is entered upon detection of deliberate motion across several ROI's.

4.3 Setup Mode

Under normal operation, after boot up, certain parameters must be setup before area scanning can begin. The most important is the home position map bearing. This is used to orient VISDTA with the world. The scan pattern must be initialized, either with some preset (default) pattern, or a new pattern based on uneven terrain. This scan pattern can be reviewed before scanning detection begins. The mode of detection must also be setup, either differencing detection (looking for scene changes) or the faster video level threshold detection which may be more appropriate for cool, uncluttered scenes. The input imaging device can also be selected during the setup phase.

Thresholds are an area of concern. Typically, default thresholds can be selected for all of the modes of detection, regardless of the environmental conditions. However, if false or nuisance alerts become too frequent, the thresholds may have to be selectively changed. There is a provision in the setup mode to use the default thresholds, or change the threshold of some particular detection mode.

4.4 Scanning Detection

This is the mode which VISDTA will be in most often. After setup, scanning detection begins. The pan/tilt mount sequences through each field of view (or viewing zone), and at each stop, a series of image processing and analysis steps are performed. The scan continues until the end is reached, then the pan/tilt mount moves rapidly back to the beginning and the whole process is repeated.

At any time during the scanning detection mode, a command can be received from the host to abort the scanning mode and enter either the setup mode or the remote control mode. Once a scanning detection alert is declared, VISDTA sequences into the VISDTA alert mode.

4.5 VISDTA Alert Mode

When entering this mode, an alert or abnormal condition has been detected during scanning detection. The azimuth and elevation angles are displayed for the operator. VISDTA then awaits further instructions from the operator.

5.0 VIDEO IMAGE PROCESSING TECHNIQUES

This section will describe the three basic algorithms used in VISDTA for detection. They are: 1) Video Level Threshold, 2) Reference Image Difference, and 3) Region-Of-Interest Tracking. The first two algorithms can be used during scanning; the third can only be used on single, stationary scenes. The simplest detection algorithm is video level threshold. This mode is useful for looking at cool scenes with an IR imager. If a warm body or vehicle enters the scene, it will undoubtedly be warmer than the background, and an alert is declared. In scenes where the background may also be warm, difference detection is used to find changes in the current scene from a previously-stored reference scene. If moving objects are a problem, such as tree limbs or blowing debris, a single scene can be extensively monitored with the region-of-interest tracking algorithm.

5.1 Video Level Threshold

Detection based on video level is the fastest and simplest algorithm. It is useable during field-of-regard scanning, or on single scenes. The idea is straightforward. The scene is assumed to be free of warm bodies or vehicles. The scene is also assumed to be somewhat cooler than a human. If a warm body or vehicle enters the scene, it will undoubtedly be warmer than the background. Some pixels will exceed the peak background threshold previously set, and an alert is declared.

The image processing boards perform the bulk of the computation. First, a reference scene is digitized by the Digimax and stored in a video memory on the Framestore board. The Featuremax performs a histogram operation on the stored image. A histogram is the result of counting how many pixels are of a particular grey value. The grey value range is from zero (black) to 255 (white). Thus, when complete, the sum of the pixel counts in each grey value "bin" is equal to the total number of pixels in the image.

The setup is generally automatic. For any given scene in the scan, a histogram is made and examined for the brightest picture element. This is used as the brightness threshold for the current scene. However, if the brightest pixel is between 250 and 255, the operator will be instructed to either adjust the IR imager, or use an alternate detection mode, because the imagery contains pixels which are already at the maximum value. If an acceptable threshold is found, any pixels in subsequent video frames which exceed this threshold are candidates for generating an alert.

The threshold is programmed into an eight-bit comparator on the Featuremax board. In one frame time (1/30 second), all pixels in the current video frame are passed through this comparator. Featuremax then generates a list of the X and Y image coordinates for each pixel which exceeds the threshold. This list is available to the control computer for analysis. A clustering algorithm is used for analyzing the list of "feature" pixels and for grouping multiple pixels together.

There are several parameters associated with the clustering algorithm. A minimum number of pixels is required to create a valid cluster. This is currently set to four. A minimum number of pixels is also required per cluster to be declared an object worthy of generating an alert. This is currently set to four also. A pixel belongs to a cluster if it is within a certain maximum X and Y distance (in image space) of any other pixel in an already established cluster. (If no clusters have yet been formed, a new cluster is started with the current pixel as the only member.) This distance is currently set to six pixels. These are software limits, but have been derived by extensive observation and testing.

The maximum number of clusters is limited to 127. The maximum number of pixels which exceed the threshold is limited to 5000. These limits may seem high, but do not effect the computation speed significantly. If the algorithm encounters larger numbers for these values, a warning message is emitted, and the operator should change thresholds or detection modes.

The clustering algorithm groups pixels together. It calls another function to highlight clusters by drawing a box around each one. Clustering is required to eliminate nuisance alerts from "noise" pixels. Further testing may indicate changes necessary to these parameters. In general, it is not necessary to allow changes to these parameters.

5.2 Reference Image Difference

This mode of detection is quite similar to that described in the above section. However, instead of detecting pixels which exceed a video level threshold, the current (live) image is compared to an image digitized about one half second before. Those pixels that are different by some significant amount are used in the clustering and declaration of alerts. It is useable during field-of-regard scanning, or on single scenes.

When viewing single scenes, a reference image is immediately digitized. After a small amount of time, a live image is subtracted from the stored image. If there have been any changes in the scene, it is likely pixel clusters will cause an alert condition.

Again, the image processing boards perform the bulk of the computation. First, the reference scene is digitized and placed in a Framestore video memory. The current image is digitized by the Digimax and subtracted from the reference scene at video rates without storage by the Max-SP board. The differences are stored in another Framestore video memory, and also passed on to the Featuremax. Featuremax then generates a list of the X and Y image coordinates for each pixel which exceeds the difference threshold. This list is analyzed, and input to the clustering algorithm described above.

There are several parameters associated with this detection mode, including those detailed in the clustering algorithm above. The primary difference is that a new threshold variable is used for declaring a pixel to be "different". This threshold is currently set to about 20, allowing for noisy pixels in the imagery. This threshold parameter can likely be selected to perform well over a wide range of scenes and imaging devices, but some changes may be necessary.

5.3 Region-Of-Interest Tracking

This detection algorithm is intended for use on single, static scenes. As the name implies, changes are tracked across regions of interest, and "motion" or an alert is declared only after there has been successive activations of adjacent regions. Random or cyclic motion of trees and bushes can be ignored.

Some setup is required, namely, the definition of the regions-of-interest (ROIs). For scenes where extraneous motion is expected, such as moving trees and bushes, or vehicles on a distant road, the ROIs can be defined only in the areas where intruder activity is anticipated. The user will first decide on the width and height of a single ROI. Then that ROI box is moved to the start of a "track" or an extended region which the user wants to closely monitor, such as a road or path or around an area where something abnormal may already have been detected by one of the two previous methods. The ROI track is then built by the user selecting various options from the display menu.

A reference scene is also required, and the user selects an appropriate video scene free of motion or unwanted objects. All following video frames are subtracted from this reference frame. A computation is made which sums the squares of the differences in each ROI, and the sum for each ROI is compared to the "change" threshold. If the sum exceeds the change threshold, that ROI goes into an "activation" state. If several ROIs in succession become activated, an alert is declared. The alert threshold for the number of ROIs sequentially activated is user-defined. A default value of three has proven to be generally universal, however.

In this detection mode, the image processing boards perform some of the computation. The reference scene is stored in one of the Framestore video memories. The current image is digitized by the Digimax and subtracted from the reference scene at video rates by the Max-SP board. The differences are stored in another Framestore video memory. The control computer then examines the difference image in Framestore memory. For each ROI, the sum of the squares of the differences is computed and used in the motion tracking algorithm.

The tracking algorithm looks for ROIs which have been activated, that is, ROIs which have excessive change within them. ROIs which are currently activated are compared to a list of those which were previously activated. If "tracks" of ROI activations are found, originating from either end of the string of ROIs, and that track length equals the alert threshold, several things happen. First, the current video frame is digitized and placed in a video memory. Then, a highlighting box is drawn around the ROI in activation which triggered the alert. This freezes the offending motion, and informs the user where the alert occurred. Several options are then available to the operator, including: view live scene, view stored scene, change thresholds, move pan/tilt mount, and continue operation.

There are two parameters associated with this detection mode. One is the number of ROIs which need to be successively activated before declaring an alert. Three is a number which provides good results, and has been selected as the default value. The other variable is the difference threshold. This threshold must be exceeded before an ROI is declared to be in an activated state. This threshold is actually a value for the average difference across the entire ROI. Both parameters can be changed under software control.

6.0 OPERATIONAL SCENARIO

This section provides an outline of an operational session with VISDTA, including the setup for detection operations, through to the assessment of alerts. Assuming that the system has properly booted the software, the following example will describe the system functions and features.

Initializing the map bearing of the home position is one of the first tasks for the operator. This orients the pan/tilt mount to a map coordinate system. This step is the first of a series of setup functions.

If it is night, and the ambient temperature has lowered to a point where the background has a somewhat narrow temperature distribution (isothermal) as viewed through the IR imager, then the video level threshold or brightness detection mode would give good performance, and could operate at rates of about one second per FOV zone.

The scan pattern is then setup from one of several options. If in a topographically flat environment, a standard zero degree elevation pattern could be used to scan the 360 degree horizon. Another option is for the user to adjust the elevation angle for each FOV in the field-of-regard to effectively follow the terrain.

When the ambient temperature increases to begin creating nuisance alerts, the detection mode can be switched to image differencing.

Scanning would commence and continue until interrupted by either:

(1) An alert condition has been detected,

(2) The operator requests re-entry to setup mode, or

(3) A remote control request was received from the operator.

A VISDTA-detection alert will be handled by first outlining the alert area on the monitor, and then displaying the current azimuth and elevation angles. A new menu is presented to the operator for further instruction.

Setup mode could be re-entered in order to change the scan pattern, review the scan pattern, change the detection mode or thresholds, use another imaging device in the detection mode, or in some other fashion affect the system operation.

Remote control mode can also be entered. This mode provides the operator with control over the pan/tilt mount, and image device switching. In addition, a separate detection state can be entered from the remote control mode where VISDTA performs video level or image difference detection or region-of-interest tracking on the current view zone. These detection modes are detailed above.

At the end of the scenario, the pan/tilt mount can be sent to the home position while in remote control mode before shutting down the system.

7.0 SUMMARY

This task has resulted in a prototype system for demonstrating the basic concepts of an advanced, fieldable sensor/assessment system. Sufficient hardware and software was assembled in the time frame available. This equipment and the software will serve as a baseline for follow-on development. VISDTA's software provides some very basic functions for stand-alone operation, and successfully demonstrates the concepts involved.

DISTRIBUTION:

UC-15 (310)

Commander CECOM
Ft. Belvoir, VA 22060-5677
Attn: NVEOC/AMSEL-L
Attn: NVEOC/AMSEL-NV-IT
Attn: NVEOC/AMSEL-RD-NV-GS

ESD/PSSD/TCB
Hanscom AFB, MA 01731

HQ AFOSP
Kirtland AFB, NM 87117
Attn: AFOSP/SPO
AFOSP/SPP

HQ/DNA (12)
Washington, DC 20305-1000
Attn: LtCol T. D. O'Toole

HQ USAFE/SPP
PSC Box 8264
APO New York 09012-5427

HQ USAREUR//AEAGC-NC/AEAPM-PS
APO New York 09403

Intelligence Division
USMC/DCEC
Quantico, VA 22134-5080
Attn: Sy Chapman

Naval Sea Systems Command
NAVSEA/643
Washington, DC 20362-5101
Attn: Dr. Michael Madden

Office of Safeguards and Security
DP-342.1
US Department of Energy
Washington, DC 20545
Attn: M. Seaton
Director of Threat Assessment
Attn: G. Hammond, Chief
Chief of Technical Development
and Implementation Branch

RAF Greenham Common
501st SPG/CC
APO New York 09150

RAF Lakenheath
7348th SPG/CC
APO New York 09179-5000

Department of Energy
Attn: OMA, DP-22
Washington, DC 20545

Headquarters
Federal Bureau of Investigation
Washington, DC 20535
Attn: Library

Headquarters
US Secret Service
1800 G Street, NW
Washington, DC 20223

Assistant To The Secretary of Defense
(Atomic Energy)
Washington, DC 20301
Attn: MIL APPL (COL Johnson)

Defense Advanced Research Project Agency
1400 Wilson Blvd.
Arlington, VA 22209-2308
Attn: W ISLER-EAO
Attn: STO N DOHERTY

Director
Defense Intelligence Agency
Washington, DC 20340-6537
Attn: RTS-2B

Director
Defense Logistics Agency
Cameron Station
Alexandria, VA 22314
Attn: DLA-SEE F HARRIS

Director
Defense Nuclear Agency
Washington,DC 20305-1000
Attn: STTI-CA
Attn: NSNS
Attn: OPNA
Attn: OPNS
Attn: DFOP
Attn: OPNO

Director
Defense Secretary Institute
Richmond, VA 2329-5091
Attn: Facilities Protection

Defense Technical Information Center
Cameron Station
Alexandria, VA 22304-6145
Attn: DD (12 copies)

Director
Interservice Nuclear Weapons School
Kirtland AFB, NM 87115
Attn: TTV 3416TH TTSQ

Joint Chiefs of Staff
Washington, DC 20301
Attn: J-5 Plans, Policy/Nuclear Division

Director
Joint STRAT TGT Planning Staff
Offutt AFB, NE 68113
Attn: JPPFD
Attn: JPEP

Commander
US EuropeanCommand/ECJ-4/7-LW
APO New York 09128
Attn: ECJ-4/7-LW

Under Secretary of Defense For Policy
Washington, DC 20301
Attn: Security Plans/Programs

Under Secretary of Defense (ACQ)
Washington, DC 20301
Attn: M/SP (TWP)

Commander-In-Chief
United States Central Command
MacDill AFB, FL 33608
Attn: CCJ3
Attn: CCFM

Technical Director
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333-5600
Attn: Commander

Headquarters
Department of the Army
Washington, DC 20310-0440
Attn: DAMA-CSC-ST
Attn: DAPHE-HRE
Attn: DAMO-NCS
Attn: DAMO-SWS

Deputy Chief of Staff for Personnel
Office of the Office of Army Law
Enforcement
Washington, DC 20310-0300
Attn: DAPE-HRE

Director of Supply Maintenance
Washington, DC 20310-0300
Attn: DALO-SMS

Office of the Chief of Engineer
Department of the Army
Washington, DC 20314
Attn: DAEN-MCD-D (Mr. Reynolds)
Attn: DAEN-RDM

Commander
Seneca Army Depot
Romulus, NY 14541-5001
Attn: Surety Office, SDSSE-AW
Attn: Provost Marshal
Attn: SDSSE-PQ

Commander
Sierra Army Depot
Herlong, CA 96113
Attn: Security Operations

Headquarters
Southern European Task Force
Department of the Army
APO New York 09168
Attn: AESE-GCT-S

Commandant
US Army Air Defense School
Fort Bliss, TX 79916-7709
Attn: ATSA-TSM-B

Commander
US Army Belvoir Road Center
Fort Belvoir, VA 22060-5166
Attn: STRBE-XI
Attn: AMC-PM-PSE
Attn: STRBE-X
Attn: STRBE-ZK
Attn: STRBE-ZPS
Attn: STRBE-ES
Attn: STRBE-N

Commander
US Army CCMB Arms Combat
Development Activity
Fort Leavenworth, KS 66027
Attn: ATZL-CAP-OPS

Commander
US Army Criminal Investigation CMD
5611 Columbia Pike
Falls Church, VA 22041
Attn: Director of Operations

Headquarters
US Army Electronic Warfare Lab
Intelligence MAT DEV/Support Office
Fort George Mead, MD 20755
Attn: DELEW-I-S (Security Systems)

Division Engineer
US Army Engineer Div. Huntsville
PO Box 1600, West Station
Huntsville, AL 35807-4301
Attn: HNDED-SR L ZIEGLER

US Army Engineer/Topographic Lab
Fort Belvoir, VA 22060-5546
Attn: B. Zimmerman

Commander-In-Chief
US Army Europe and Seventh Army
APO New York 09403
Attn: AEAPM-PS
Attn: AEAGD-SM-A
Attn: AEAGC-NC

US Army Human Engineering Lab
Aberdeen Proving Ground, MD 21005
Attn: SLCHE-CS
Attn: SLCHE-CC

Commander
US Army Intelligence Agency
Fort Meade, MD 20755
Attn: DELEW-I

Commander
US Army Material Command
5001 Eisenhower Avenue
Alexandria, VA 22333-0001
Attn: AMCPE-S
Attn: DRCNC (Nuc-Chem Office)

Commander
US Army Military Police School
Fort McClellan, AL 36205
Attn: ATZN-MP-CSS
Attn: ATZN-MP-CTC
Attn: ATZN-MP-CMS

Commander
US Army Nuclear/Chemical Agency
7500 Backlick Road
Building 2073
Springfield, VA 22150-3198
Attn: MONA-SU

US Army Strategic Defense Command
Department of the Army
PO Box 1500
Huntsville, AL 35807
Attn: BMDSC-LD

Commander
US Army Strategic Defense Command
Department of the Army
PO Box 15280
Arlington, VA 22215-0150
Attn: DACS-DMI

Commander
US Army Tank Automotive Command
Warren, MI 48397-5000
Attn: AMSTA-RR

Commander
USAS4A
Aberdeen Proving Ground, MD 21005-5071
Attn: AMXSY-CA

Commander
1st Special Operations Command (ABN)
Fort Bragg, DC 28307-5000
Attn: AFVS-GCO-N (MAJ Ogden)

Commander
59th Ordnance Brigade
Department of the Army
APO New York 09189
Attn: AEUSA-Z
Attn: Surety

Commander
David Taylor Naval Ship Center
Bethesda, MD 20084
Attn: Code 1203

Commandant
Marine Corps
Department of the Navy
Washington, DC 20380-0001
Attn: Code PPO

Commanding Officer
Naval Costal Systems Center
Panama City, FL 32407
Attn: Code 2230

Commander
Naval Facilities Engineering Command
200 Stovall Street
Alexandria, VA 22332
Attn: 04T5

Commander
Naval Ocean Systems Center
San Diego, CA 92152-5000
Attn: Code 442
Attn: Code 531

Commander
Naval Sea Systems Command
PMS-423
Washington, DC 20362-5101
Attn: SEA-06G7
Attn: SEA-90G
Attn: SEA-091322

Officer in Charge
Naval Surface Weapons Center
White Oak Laboratory
10901 New Hampshire Avenue
Silver Springs, MD 20903-5000
Attn: Code R-402

Commander
Naval Underwater Systems Center
Department of the Navy
Newport, RI 02840
Attn: 8092

Office of the Deputy Chief of Naval Operations
Washington, DC 20350-2000
Attn: NOP 009N
Attn: OPNAV 98/N/

Office of Chief of Naval Operations
Department of the Navy
Washington, DC 20350-2000
Attn: OP-009N

Commander
Space/Naval Warfare Systems Command
Washington, DC 20363-0001
Attn: PME-121-3

Director
Strategic Systems Program Office
(PM-1)
Department of the Navy
Washington, DC 20376-5002
Attn: SP-113

Commander-In-Chief
US Atlantic Fleet
Norfolk, VA 22511
Attn: N-73
Attn: N-324

Commander-In-Chief
US Naval Forces, Europe
FPO New York 09510
Attn: Security Officer

Commander-In-Chief
US Atlantic Command
Norfolk, VA 23511
Attn: J324

Headquarters
US Marine Corps
Washington, DC 20390
Attn: POS-30
Attn: POS-20

Air Force Logistics Command
Wright-Patterson AFB, OH 45433
Attn: AFLC/SP

Headquarters
Air Force Office of Security Police
Kirtland AFB, NM 87117
Attn: AFOSP/SPE
Attn: AFOSP/SPPC
Attn: AFSOP/SPOS

Headquarters
Air Force Systems Command
Andrews AFB, DC 20334
Attn: AFSC/SP

Air Force Weapons Laboratory, NTAAB
Kirtland AFB, NM 87117-6008
Attn: NTSMS

Department of the Air Force
Washington, DC 20330
Attn: AF/RDST
Attn: AF/IGS

DET 2, HQ SAC/SP
Norton AFB, CA 92409-6468
Attn: SP

Headquarters
Electronics Systems DIV/TCB
Brown Building 3rd Floor
Hanscom AFB, MA 01731-5000
Attn: Physical Security Systems
Director

Military Airlift Command
Scott AFB, IL 62225
Attn: SP

Director
Nuclear Surety
Department of the Air Force
Kirtland AFB, NM 87117
Attn: NTSMS

Commander-In-Chief
Pacific Air Forces
Hickam AFB, HI 96853
Attn: SP

Headquarters
Strategic Air Command/SPP
Department of the Air Force
Offutt AFB, NE 68113
Attn: SPP

Headquarters
Strategic Air Command/XPQ
Department of the Air Force
Offutt AFB, NE 68113
Attn: XPQ

Commander
Tactical Air Command/SPSC
Department of the Air Force
Langley AFB, VA 23665
Attn: SP

US Air Force In Europe/SP
APO New York 09012
Attn: USAFE/SPP
Attn: USAFE/SPO

Commander-In-Chief
US Air Forces in Europe
APO New York 09012
Attn: USAFE/SP

Central Intelligence Agency
Washington, DC 20505
Attn: R/D Subcommittee

Diplomatic Security Service
US Department of State
Washington, DC 20520
Attn: DS/ST/SDE-SA-7

National Bureau of Standards
Physics Building, Room 157
Gaithersburg, MD 20899
Attn: Law Enforcement Standards Lab
L. Elaison

US Department of State
(Office of Security)
Washington, DC 20520
Attn: Chief, Research/
Development Branch A/SY/OPS/T

BDM Corporation
7915 Jones Branch Drive
McLean, VA 22102-3396
Attn: Corporate Library

Booz-Allen/Hamilton, Inc.
776 Shrewsbury Avenue
Tinton Falls, NJ 07724-3006
Attn: Technical Library

Jaycor
1608 Springhill Road
Vienna, VA 22180-2270
Attn: Library

R&D Associates
1401 Wilson Blvd.
Arlington, VA 22209-2381
Attn: Library

RCA Corporation
Aerospace/Defense
Government Communications Division
Route 38, ATL Building, 145-3
Camden, NJ 08102-2399
Attn: Library

Science Applications International
Corporation
PO Box 1303
McLean, VA 22102-1303
Attn: Technical Library

Tracor Applied Sciences, Inc.
2361 Jefferson Davis Hwy
Suite 1100
Arlington, VA 22202
Attn: Library

1410	P. J. Eicker
5200	W. C. Myre
5210	J. J. Baremore
5214	W. F. Hartman
5220	A. A. Lieber
5230	M. L. Kramm
5231	E. R. Julius
5233	D. C. Hanson
5234	C. L. Schuster
5235	M. D. Perkins
5238	R. C. Beckmann
5238	M. R. Heying
5238	D. A. Pritchard (10)
5240	D. S. Miyoshi
5246	R. P. Syler
5250	T. A. Sellers
5260	J. Jacobs
5261	C. C. Hartwigsen
5267	J. R. Kelsey
9110	P. A. Stokes
9120	M. M. Newsom
9130	R. D. Andreas
9133	L. D. Hostetler
9240	G. E. Brandvold
3141	S. A. Landenberger (5)
3151	W. L. Garner (3)
3154-1	C. H. Dalin (28) For DOE/OSTI
8024	P. W. Dean