Software for the DSN Video Subsystem

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The Deep Space Network (DSN) video subsystem provides the flight projects at JPL with a real-time and near real-time tonal image (picture) processing and display capability. The software of the subsystem controls all components and processes the picture data which it receives from the DSN Telemetry System. The video software is designed to give the flight projects the capability to automatically process, display, and record the picture data as they are received from the spacecraft. Its design also includes an interactive capability for selective picture processing and display.

I. Introduction

As more planetary spacecraft are carrying cameras that will record tonal images (pictures), a decision has been made to develop a video subsystem in the Space Flight Operations Facility (SFOF) to provide real-time and near real-time processing and display of the pictures that are received from the spacecraft. The video subsystem is to be an added capability of the SFOF Telemetry System. The subsystem that is being developed consists of a number of different components. This article will describe the software portion of the video subsystem which controls the entire subsystem and processes the video data for display.

II. System Description

Figure 1 is a block diagram of the total DSN video subsystem. The main components of the subsystem are the digital computer and related software, the Video Image Display (VID) Assembly (Ref. 1), and the interface with the Mission and Test Video System (film recorders) (Ref. 2). Other elements of the subsystem include the following:

(1) The SFOF Closed Circuit TV Assembly for display of the standard resolution images produced by the VID.

(2) The Facility Digital TV Assembly for the display of the picture-related data. These data relate to the pictures being displayed on the high resolution and standard resolution VID subchannels.

(3) User communication with the DSN video system which is provided by the IBM 2260 input/output terminals. A set of input commands for this device is available to the video subsystem user that will allow him to control the video subsystem.

The video software operates under the control of the JPL operating system (JPLOS). This is a specially designed and built system for real-time operations at JPL; it is a multi-jobbing system, which operates in the IBM 360/75 computer. The picture data are provided to the video software by the spacecraft telemetry processor which also resides in the computer. Each line of the picture data is encased in a telemetry data frame. The telemetry software passes the synchronized telemetry frames (picture lines) to the video software where they are collected into complete pictures.

III. Design Goals

The initial design of the DSN video software was pointed toward the *Mariner* Mars 1971 mission, which will send two spacecraft to the vicinity of the planet Mars; each spacecraft will carry tonal image cameras. The design of the software, however, was kept as mission independent as possible so that changes that have to be made to it in order to handle the work of future missions can be kept to a minimum. Design also included the ability to process the data from a number of spacecraft (at least two) concurrently.

As the video subsystem is an advanced engineering effort, specific users' requirements were not available. Therefore, in designing the operating characteristics of the subsystem, it was realized that they must be as flexible to the prospective users' needs as possible. The operating characteristics of the subsystem were therefore designed in a way to give the users the greatest amount of capability. Operating characteristics include a fully automatic mode where the user can initialize the video software to process, display, and record the pictures that are being received from the spacecraft in real time and automatically, according to an initialized format. The initialization includes such items as what processing the computer is to perform on the pictures, and where and how the pictures are to be displayed. The system also will provide an interactive mode where the user can request special display and processing steps for a specified image. The interactive capability will also work in conjunction with the System Data Record that is maintained by the telemetry software. This record system stores all of the telemetry data that have been received from the spacecraft since they were launched. The data are stored on disk or tape. Through the use of this telemetry software, the video subsystem user can retrieve any picture that has been received from a spacecraft. Upon receipt of the picture by the video software, the user can process and display the image through the video system in any manner he desires.

Certain minimum enhancement and picture processing techniques were also included in the design. These include contrast stretch, contouring, and banding. Picture enlargement, or zooming, can also be done by the software on user-specified portions of a picture. Picture-segment averaging, which will fill in missing sections of a picture, is also provided. Other types of picture enhancement can be provided to meet specific project needs.

IV. Software Description

The video software is only one of several systems of software that reside in the IBM 360/75 computer. The system that is closely aligned with the video software is the telemetry system. The telemetry software provides the picture data to the video software. The data are passed, one line at a time, in a standardized format. The format is the same whether the data are being received directly from a spacecraft in real time or from the System Data Record, which is maintained by the telemetry system.

Figure 2 is a block diagram of the video software. The boxes depict program load modules which execute asynchronously from one another. The solid lines and small box depict data that are to be passed between the load modules. The broken lines depict a request to execute (invoke) the resultant load module. Not shown in the block diagram are the system interfaces which are in reality very much present, but would not add anything to the diagram.

Upon receipt of each telemetry frame of data (picture line) from the telemetry processor, the Video Input Control and Processor Module (VICM) will perform the necessary processing on the picture line, and store it on a direct access data set. All lines of the picture (700 in the case of the *Mariner* Mars 1971 spacecraft) are accumulated in the data set. When a complete picture has been received, the VICM will determine whether the picture is being received directly from the spacecraft in real time or has been recalled from the Telemetry System Data Record at the request of the system user. In the case of real-time data, the module will determine whether there is a user-initialized set of automatic processing and display requirements for the spacecraft's pictures. If a set of requirements does exist, they will be placed in a queue, and a system request is made to invoke the Video Output Control Module (VOCM). Pictures recalled from the Telemetry System Data Record are stored in a uniquely named data set. Upon receipt of the whole picture, the user is notified via the IBM 2260 input/output (I/O) terminal that the picture is ready for display processing. The user can then use his control messages to the 2260 to process and display the recalled picture. The recalled picture will remain in its data set until the user requests that it be removed.

Since the real-time data being received from the spacecraft continues uninterrupted from picture to picture, the VICM will store the lines of the following picture into another data set using a double buffer approach for storage of the pictures received in real time. It requires just over 4.5 minutes to receive all of the lines of a picture from the spacecraft; therefore, all output processing and display of a picture must be carried out within that time limit because the data set will again be required to store the picture that will be received after the following one.

The VOCM can be invoked by either the VICM (as described above) or by the User Input/Output Module. Upon execution, it will interrogate the output request queue that has been set up for it. The requests are for picture output to either the VID equipment or the film recorders in the Mission and Test Video System (MTVS). The output control module will set up the necessary linkages and invoke the appropriate module (see Fig. 2); it will then continue to operate until all of the display requests in the queue have been processed. Simple enhancement transformations which are to be performed on every picture element (pixel) of a picture in an identical manner are performed in this module. An enhancement transformation table is produced which is passed to the relevant output module for transformation of all of the picture elements of the picture. After all display requests in the queue have been satisfied, the VOCM will terminate.

The User Input/Output Control Module (UIOM) allows the video subsystem user to communicate with the video subsystem through the I/O terminal. The user can input a variety of requests to the video software. These requests include the following:

(1) Request that an image stored in a video data set (either a picture received from a spacecraft in real time or a picture recalled from the System Data Record) be processed and output for display or recording on a specified device.

(2) Change the automatic processing and display requirements for the pictures being received from the spacecraft in real time.

(3) Recall a picture from the Telemetry System Data Record for storage in a video data set.

(4) Bring the individual display and recording devices of the VID on or off line with the computer.

Other messages for the general housekeeping of the video subsystem are also provided to the user. As was mentioned above, the UIOM places the display requests into the display request queue and requests the system to invoke the video Output Control Module.

The VID Data Formatter Module (VDFM) and the MTVS Data Formatter Module (MDFM) are invoked to process, format, and output a particular picture. The film recorder appears to the MDFM as an individually addressable tonal grid containing 1024^2 elements. The picture, histogram (the histograms depict quantity of pixels as a function of tonal values), and the gray scales are formatted by the software for this grid, and output via the system software and the hardware. Related alphanumeric data that describe the picture and processing are placed on the alphanumeric field (29 characters by 28 lines) which is adjacent to the grid field. The related data include enhancement and any other special processing information that the software performed on the picture and picture identification data.

The VDFM formats the pictures for output to the Video Image Display Assembly. The problem is considerably different from that of the film recorder since there are a variety of end devices on the VID Assembly, plus a disk storage that is capable of storing up to 34 pictures and their related data. All pictures that are output to the VID Assembly for display and/or printing are stored on this disk file. Any picture that is stored on the disk can be retrieved, at the request of the software, for display or printing. The VDFM provides the VID Assembly with the picture's related alphanumeric data, gray scale data, and histograms. All of these data are output onto the VID printer; however, only picture data are output to the TV subchannels. Data are transferred from the computer to the VID Assembly in records that contain 16 picture lines of data.

The VDFM will also provide the picture-related alphanumeric data and histogram data to the digital television system. The data will relate to the pictures that are being displayed on the standard-resolution and high-resolution television monitors of the VID Assembly. The user will, therefore, be able to view the related information of the picture being displayed on the television subchannels. These data include a histogram of the tonal image, enhancement, and any other special processing information that the software performed on the picture and picture identifying data.

V. Conclusion

The DSN video software is designed to provide a versatile system to the user. It will process pictures in real time from more than one spacecraft and at the same time allow the user to process and work on selected pictures in a fully interactive manner. The software formats the pictures and related information for display or recording on a number of different types of end devices.

References

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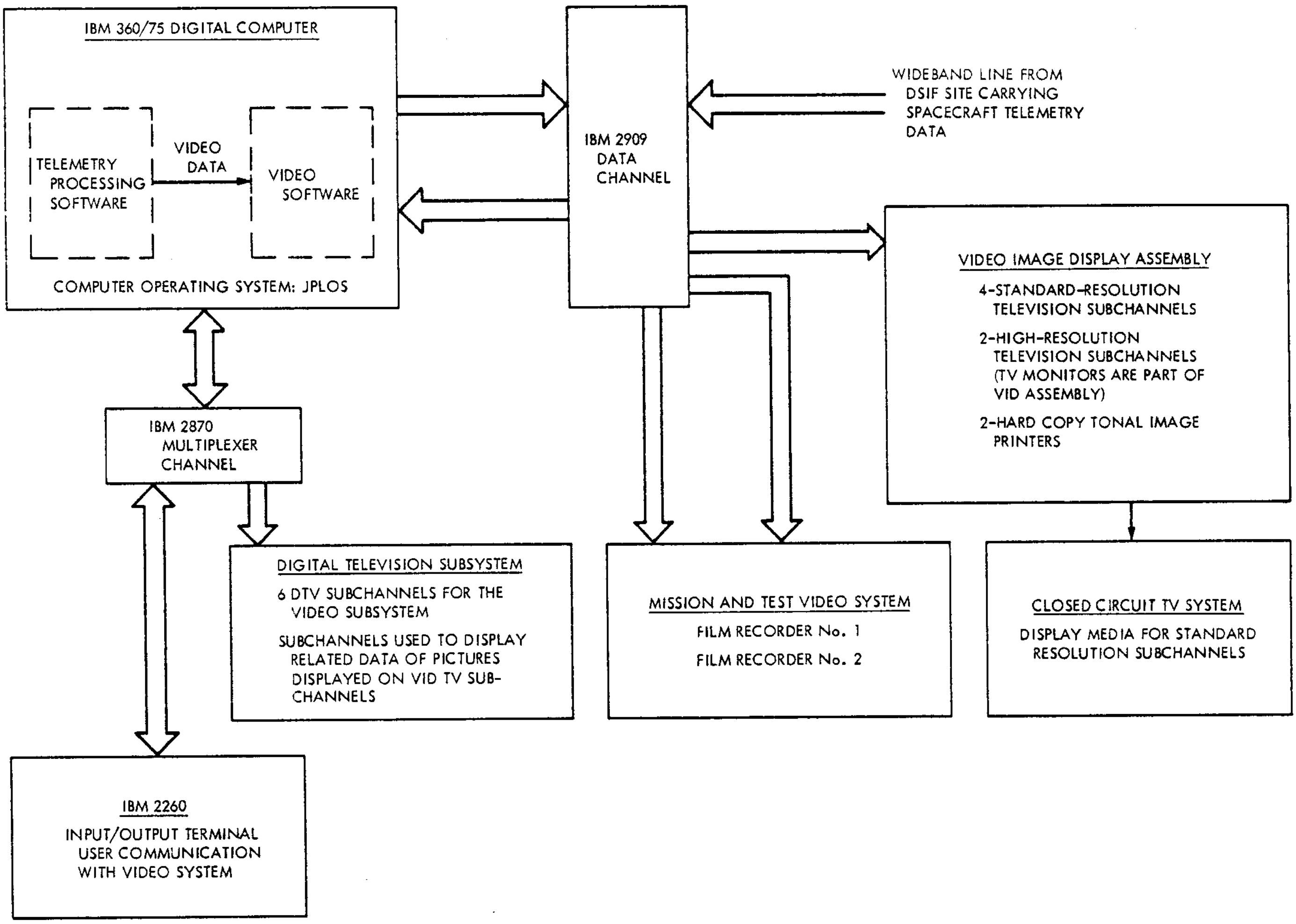

Fig. 1. Block diagram of video subsystem

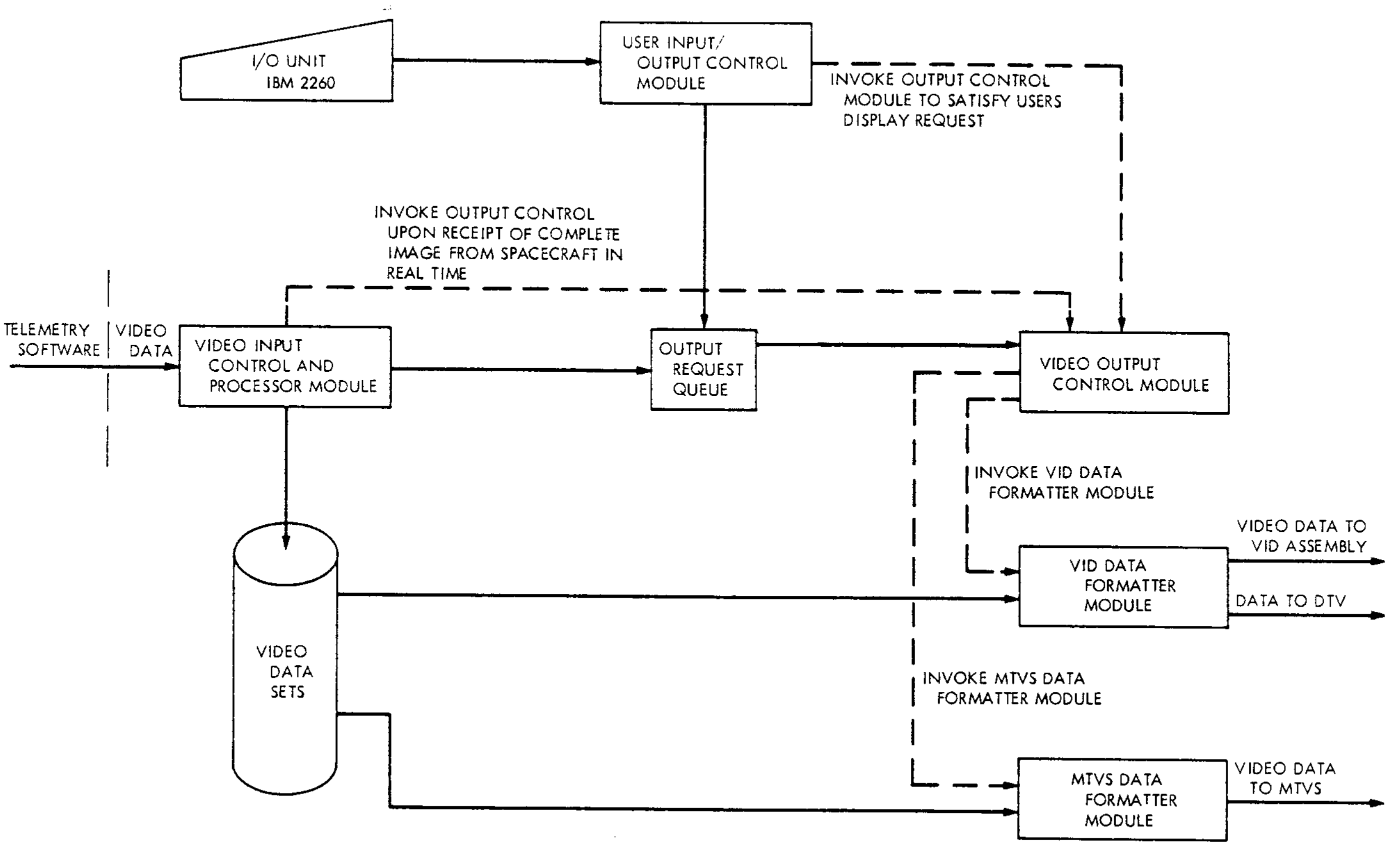

Fig. 2. Video software block diagram