A Conversational Picture Processing System by Computer

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Abstract

A new conversational picture processing system has been developed. By giving the picture-processing commands via the character CRT, the operator can use interactively software and hardware facilities provided by the system: input and output of pictorial data, basic picture-processing capabilities such as differentiation, enhancement, windowing, composition of two pictures, etc.

The remarkable features of the system are: (1) fundamental pictorial data I/O devices and picture-processing routines are both available; (2) by means of the color-TV display, multiband photos and color pictures can be processed very conveniently; (3) the editing and correction of the picture-processing commands can be performed in the same fashion as conversational programming; (4) employing a computer complex structure, the system can be adapted easily to various classes of picture processing problems.

1. INTRODUCTION

In computer picture processing it is very rare to get expected results by the first trial, and many trial-and-errors are inherently involved: image digitization, selection of applicable processing techniques and algorithms, execution, evaluation of the result, improvement of the algorithm, re-execution, and so on. So long as the developmental process of the algorithm proceeds in this way, the efficient research in picture processing requires on-line, real-time capabilities for all the stages from input, processing through output display of pictures, and interactive usage of them.

We describe here a new conversational picture processing system which has been designed and developed to fulfill those requirements.

2. SOME REMARKS ON HARDWARE

Fig.1 shows the hardware structure. It is organized by the computer complex with a medium-sized host computer NEAC 2200/250 and a high-speed minicomputer MACC 7/F. The two computers are channel-to-channel connected, and the data transfer rate is 750 kbit/sec, which is remarkably faster than the ordinary telecommunication line [1].

As one of the basic principles, full program control by the minicomputer was intensively pursued in the control of picture I/O devices. The high-speed minicomputer can keep the reasonable I/O speed. This results in highly flexible control and parameter setting. Modification of device control, which is particularly important for research purposes, may be accomplished merely by changing the program.

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Detailed description of computers and I/O devices can be found in [2] and [4]. In this paper, only the color-TV display unit is described which is the main displaying device of the system and has several characteristic features. It employs 32 k-Byte MOS IC random-access memory for refreshing and can display an arbitrary half-tone color image on a conventional color-TV set.

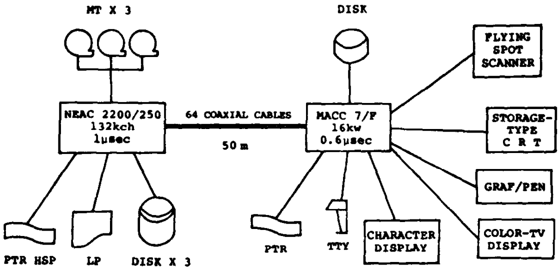


Fig.1 Hardware structure.

The unit has three modes for the display scheme:

(a) Direct mode -- The display frame consists of 128 x 128 pixels. For each pixel, 15 bits of main memory are assigned to represent the color: 5-bit brightness for each primary color R, G, and B.

(b) Indirect mode A -- The display frame has 128 x 128 pixels. In this mode, the submemory of 256 words x 15 bits Bipolar IC memory is employed as a color table. As shown in fig.2, the main memory contains 8-bit number (0-255) for each pixel, which is used as the address in referring the submemory that contains an R-G-B data table of 256 colors. The content of the referred word of the submemory is then fed into three D/A converters to produce analog color signals.

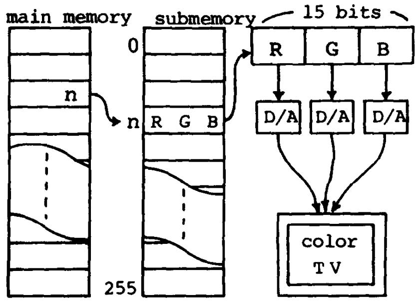


Fig.2 Indirect mode of the color-TV display.

(c) Indirect mode B -- This mode is similar to (b) except the difference in the memory assignment. The display frame consists of 256 x 256 pixels. Instead, since 4-bit number is given to each pixel, only 16 colors can be displayed.

For man-machine interaction, the unit is equipped with a cursor to specify a point on the display frame and with a joystick which enables to select arbitrary color intuitively on the chromaticity diagram.

3. SOFTWARE FACILITIES OF THE SYSTEM

3.1. Command System for Conversational Picture Processing

(1) Generally a command consists of the following parameters;

- function name: the name of the program to be applied,
- m old-picture names (m=0,1,2,...): the names of the pictures to be processed,
- n new-picture names (n=0,1,2,...): the pictures yielded by the processing are identified by these names,
- numerical values necessary to specify the processing,
- display device names: color-TV, storage CRT, and/or line printer.

(2) The user would feel much inconvenience if he must input all the parameters in the correct format on his own responsibility. Our system offers an interactive help in entering parameters, so that the user not so familiar with the system could use it easily.

(3) The sequence of commands, to which line numbers are attached, can be edited in the

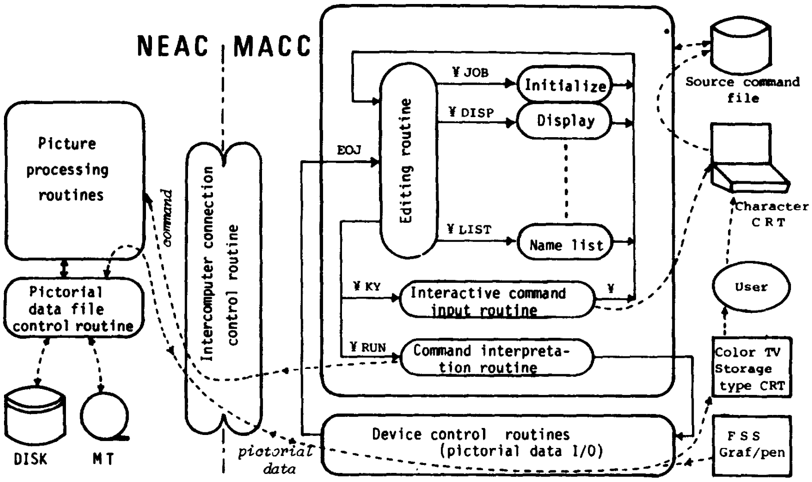


Fig.3 Software organization of the conversational system.

same fashion as conversational programming: partial correction of the parameters, execution of a part of the sequence, and so on. (4) Since all the picture data stored in the system are given individual names and filed in the disk or the MT of the NEAC in the standardized format, the picture to be processed or displayed can be specified by its name in the command.

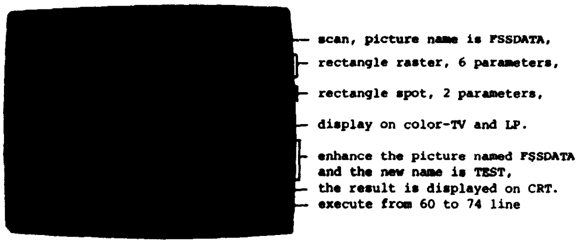


Fig.4 Display of picture-processing commands.

Fig.3 shows the software organization with data and control flow. The system has three running modes: editing (E-mode), command input (C-mode), and execution (X-mode). In the C-mode, the user inputs the commands interactively and they are stored into the source file with line numbers generated by the system. By the input of "¥", the mode is changed to E-mode, in which the user manipulates the source command file using the following control commands.

¥JOB: to initialize the system.

¥DISP m: to display the source command sequence from the m-th line on the character CRT.

¥STORE: to store the commands into the source file.

¥LIST: to display the name table of the pictures stored in the system.

¥KY: to shift to C-mode and to enable the interactive command input.

¥RUN m n: to shift to X-mode and execute the commands from m-th through n-th line.

In the X-mode, the command interpretation routine translates a users' command into

° scanning by FSS	° printout picture on LP
° picture data transfer	° display picture on CRT
° enlargement/reduction of picture size	° display picture on color-TV
° differential operation	° color composition
° enhancement	° static/dynamic pseudo-color enhancement
° film output by FSS	° mesh-scale generation on CRT
° film transfer of FSS	° 1-st order geometrical transformation of picture
° windowing	° multiband picture processing
° statistics of gray levels	° classification
° mathematical operations between two pictures	° data scale transformation

Table 1 A part of picture-processing functions.

the specially formated parameter sequence and activates the corresponding picture processing routine implemented in the NEAC. When errors such as undefined picture names and wrong parameter values etc. are detected in the command interpretation or execution phase, they are indicated on the character CRT to inform the operator to correct them.

Table 1 shows a part of the functions provided by the system. At present, all of these except for the device control routines are implemented in the NEAC. Fig.4 illustrates an example of commands displayed on the character CRT.

3.2. Flexible Scanning Program

Among the various device control routines prepared in the MACC, one of the most important is the flexible scanning program of flying-spot scanner. The basic idea is to realize any combination of beam type (contrast, range and scale of gray levels), spot (shape and operation of scanning light beam), raster (place and way of moving the spot in the whole 1024 x 1024 raster), transformation of data (e.g. binary), and manipulation (feature measurement, storage, or display). Fig.5 shows the repertoire for each category. All these functions except for the beam type are realized in terms of software, taking advantage both of the random sampling capability of the FSS and the high-speed calculation of MACC 7/F.

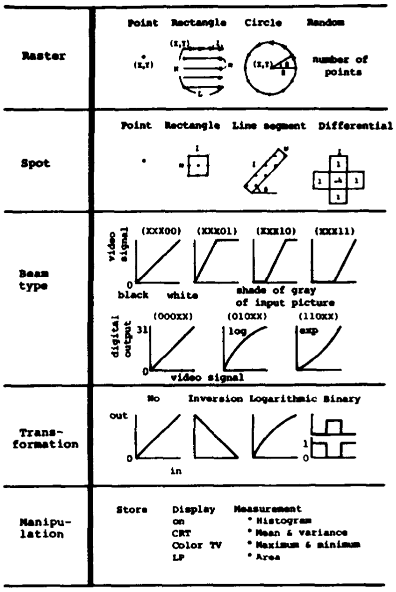


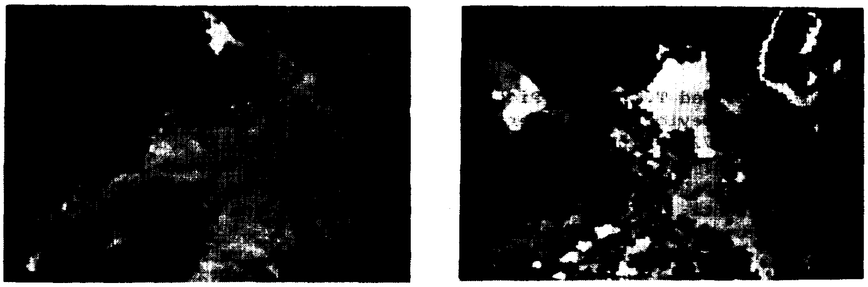
Fig.5 Repertoire of scanning program.

4. SOME APPLICATIONS

The system has been applied to various picture processing problems: on-line analysis of a human face photograph [2], pictorial analysis of traffic flow, composition of pictures by computer, design and generation of dot patterns of Chinese characters [3],etc. Here we describe two other examples.

4.1. Interactive Analysis of Multiband Photos

For this purpose following functions are specially added to the system: FIRST (positional registration of multiband photos), COLOR-COMPOSITION, CLOSE-UP(enlargement of a part of the color picture displayed on the color-TV), CLASSIFY (region-cover classifi-



(a) Color composite image from ERTS-1 showing the Kinki district.

(b) Result of classification.

Fig.6 Processing of multiband photos.

cation based on the nearest neighborhood scheme), and RESULT-DISPLAY (display of the results obtained by the classification), etc. Fundamental processing in the remote-sensing data analysis can be performed using these functions in cooperation with the basic functions such as COMPOSITION (operation between two pictures) and TRANSFORMATION (scale transformation of gray level). Fig.6(a) shows the color composite image of the Kinki district obtained by the multispectral scanner of ERTS-1. The successive execution of the following functions gives the result shown in fig.6(b); CLOSE-UP of the Kyoto area; CLASSIFY the surface into the categories such as towns, suburbs,mountains, lake, and bare soil area; RESULT-DISPLAY of the classified picture.

4.2. Dynamic Pseudo-color Enhancement of X-ray Image

As described in 2, the indirect mode A or B of the color display is quite suitable for pseudo-color enhancement; in fact the submemory is nothing but a table of colors assigned to each value of pixels (i.e. gray level). Periodical rotation of the assignment realizes dynamic pseudo-color enhancement which is far more appealing than the usual static one. It can combine the high-speed processing of computer and the overlooking ability of human, and will make it easy to examine the detailed structure of objects. Fig.7 shows a snapshot of the dynamic pseudo-color enhancement of a chest X-ray image which is digitized by the FSS with logarithmic transformation applied. The chart on the right is the color sample for interactive manipulation of the color table.

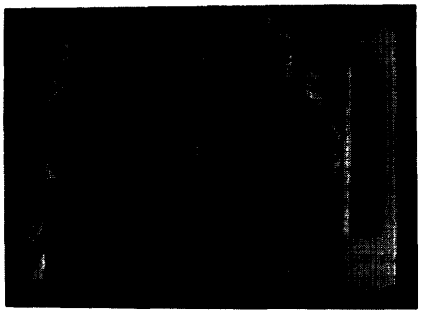


Fig.7 Dynamic pseudo-color enhancement of a chest X-ray image.

5. CONCLUSION

We are encouraging the research staffs in the laboratory to write their own picture processing programs in accordance with the specification of this system, so that the developed programs and the data can be readily incorporated into the system, thereby enabling other people to share the achievements directly with them. The results accumulated in this way will form the core of a large-scale picture processing system.

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