PC-BASED IMAGE PROCESSING SYSTEMS FOR LABORATORY USE

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ABSTRACT

Several PC-based image processing systems developed for experimental measurements in our laboratory are described in this paper. They are a motion measurement system, motion picture analysis systems and color image processing systems for robotics. High quality with low cost image digitizing boards become available to use, and a capacity of RAM boards grows rapidly. So, PC-based automatic measuring equipments with image processing function for individual purpose can be constructed easily.

Characteristics and probrems to use commercial image digitizing boards for PC are pointed out. The important factors to use image processing system comfortably are data processing speed and available memory size. High speed color image processing program for PC (CIP-PC) was developed to save execute time and memory size. A CIP-PC contains many fundamental image processing programs coded by an assembler, and each subroutine programs is optimized.

INTRODUCTION

It becomes easy to make an automatic measuring system by a personal computer (PC) with image processing functions for experiments in a laboratory, because high quality with low cost image digitizing boards and RAM boards for a PC system are recently available to use. A visual motion measurement system composed by mini-computer is expensive and too large to move comfortable. So, this system is used in a special experiment, in spite of its superior ability.

A PC system becomes very compact, and has many interactive functions such as a video display terminal, a console, a mouse system, and many peripheral equipments controlled from I/O ports. A progress of computing ability of PC is also remarkable. A standard clock frequency is 10MHz; and maximum main memory size packaged in a PC is more than 1MB by using of a random acces memory (RAM) board. The highest capacity of a commercial RAM board for PC is 32Mb. High capacity disks as external data storages are also available. Therefore, an image processing system for laboratory use can be easily constructed by a PC with image digitizing boards and RAM boards. Several PC-based image processing systems developed for experimental measurements in our laboratory are described in this paper.

EXPERIMENTAL APPARATUSES

PC: A personal computer of PC9801 series made by NEC are used as a host controller of image processing systems. A PC9801 is the most widely used 16bits PC in Japan. Peripheral equipments and commercial softwares are also the most abundant. The proper operating system (OS) of this PC is N88DISKBASIC. A memory map of this PC is shown in Fig.1[1]. The OS of MS-DOS is also availble, but the N88DISKBASIC system was mainly used to save memory size, because the system was stored in ROM as shown in Fig.1. A primitive assembler called MONITOR which is included in the N88DISKBASIC was used to develop CIP-PC. The clock frequency used is 10MHz. A CPU of this PC is a V30 which is almost the same as the 8086[2,3]. Types of used PCs are E, VM2, VM21 and VX21. A main difference of these types are memory size. It is available to use four slots of interface card. Various kinds of interface card were used as necessary to meet the experimental requirement. They were image digitizing boards, RAM boards, DIO boards, A/D converter boards, and GPIB interface cards.

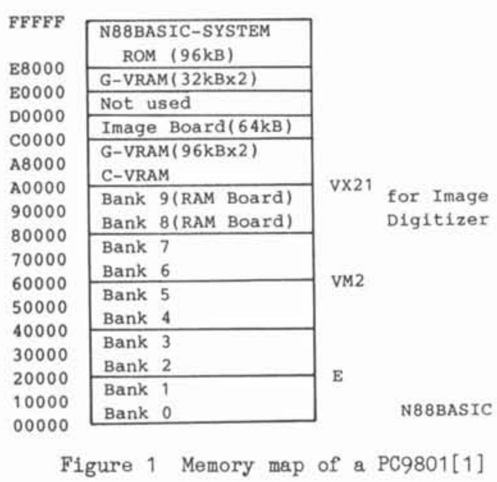


Figure 1 Memory map of a PC9801[1]

Image digitizing board: Table 1 shows Specifications of image digitizing boards used in the experiments. Image memory areas are directly mapped in a main memory of the PC in all boards. A price of image digitizing boards was rapidly reduced with a price of semiconductor memories. The prices of many image digitizing boards for PC are less than that of a standard PC system.

Table 1 Specifications of image digitizing boards used in the experiments.

	A *1	B *2	C *3	D *4	E *5
Color	B!	B	C!	C	C
Bit	1	8(6)#	8(6)#	6	6
Array	256x256	256x256	256x256	256x256	512x256
Frame	1	4	2	1	1
Bank	64kB	64kB	128kB	128kB	128kB
Address	Fixed	Dip SW	Dip SW	Fixed	Fixed
	80000H	C0000H	80000H	80000H	80000H
Acces	Byte	Byte	Word	Word	Word
Cycle	1/60 s	1/60 s	1/60 s	1/60 s	1/60 s

! B=B/W(Monochrome), C=Color.
8(6)=Tone:6bits, Cursor indicater:2bits.
*1 A :IMB-256S1 made by MITANI SHOJI K.K.
*2 B :FDM4-256 made by PHOTRON K.K.
*3 C :IMC-256S6 made by MITANI SHOJI K.K.
*4 D :Video98 made by NIHON BOARD COMPUTER K.K.
*5 E :PB9803 made by NIHON BOARD COMPUTER K.K.

A segment consists of 64kB for the 8086CPU and an address is designated by two bytes, so an image data array of 256x256 is very convenient to execute image processing. The main memory size of the PC9801 is 640kB. Two segments(128kB) of memory area are available to use as a RAM board area. Therefore, many image digitizing boards utilizes this memory area, but effective usage of RAM boards with image digitizing board is difficult in this case.

Address accessable unit of image memory is another important factor of image processing efficiency. Some low price image digitizing boards can access only a byte on its image memory. Execution time to access the image memory is longer than that to access the main memory as shown in Fig.2.

There is two address mapping methods for color image data. One is to record intensity informations of each color in the same address of different bank memory as shown in Fig.3(a). Another is to record those values continuously on the image memory as shown in Fig.3(b). Each methods has each own merits. The address is clear in the former case. Computing the color informations is easy in the latter case.

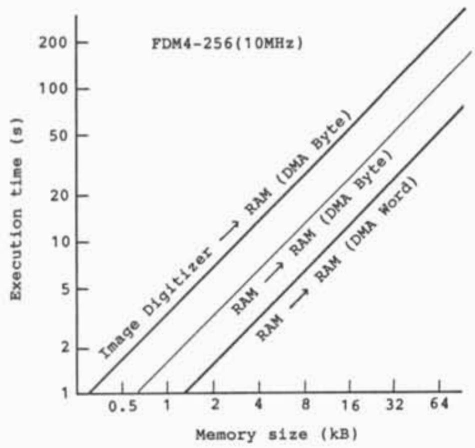
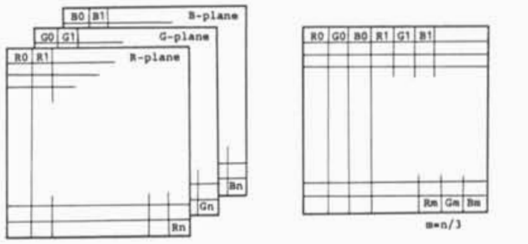


Figure 2 Relation between execution time and transfered memory size.



(a)Same address in different plane
(b)Sequential address in same plane

Figure 3 Address mapping methods for color image data.

VISUAL MOTION MEASUREMENT SYSTEM

A visual motion measurement system, which is composed of a PC and image digitizing boards with CCD video cameras, was developed to measure a dynamic behavior of flexible cables under water[4]. Figure 4 shows a schematic drawing of a motion measuring apparatus. A type of PC9801-VM2 was used as a host controller. Memory size of this system is 384kB. Two image digitizing boards (IFM/PC 256S1) were used to get image data from two lines of NTSC video signal synchronized each other. A digital storage scope connected to the PC by a GPIB cable was used to measure a dynamic behavior of the cable.

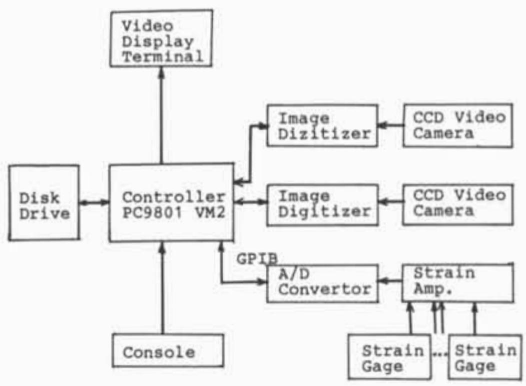


Figure 4 Schematic drawing of a motion measuring system

The purpose of this system is to measure a trangent motion of a mooring line and stresses on it, simultaneously. Some light emitting diodes (LED) were put on the cable, then the motion of the cable were represented by the moving luminous points. Stresses on the cable caused by motions were transduced to electric signals by using of strain gages put on the cable. The measuring sequence is shown in Fig.5. NTSC signals on a field were digitized to binary data of 256 x 256 array within 1/60 seconds, simultaneously. Gravity centers of each luminous points were calculated by the CPU of the PC, and displayed on the monitor in next 1/60 seconds, then the maximum digitizing frequency of this system is 30Hz.

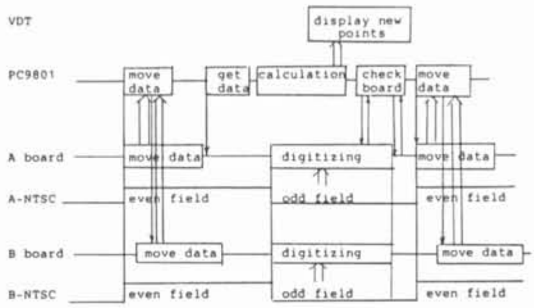


Figure 5 A measuring sequence of moving luminous objects.

MOTION PICTURES ANALYSIS SYSTEM

A motion pictures analysis system was developed to study the reaction phenomena of gas cutting for heavy-thick low carbon steel[5]. This system consists of a PC, a gray image digitizing board, a 4MB RAM board, a high speed video camera and an A/D converter board as shown in Fig.6.

The image board FDM4-256 made by PHOTRON K.K. has 4 frames of 256x256 pixels. Four continuous gray motion pictures can be obtained at video rate. A scene at the cutting front is stored in 1/60 seconds, and the significant data which shape is a stripe (256x32pixels) are transfered in the RAM board in next 1/60 seconds. Any interval time to get image data can be choiced for an experimental purpose. More than 500 motion pictures can be stored in the RAM board in this case. The relation between interval time and accessable image data size is determined by memory acces speed as shown in Fig.2.

The burning condition of cutting zone is considered by the time response of brightness distribution of image data. A value of brightness indicates the intensity of an oxidation reaction at the cutting zone. A shutter speed of 1/1750 seconds was used to observe burning phenomena correctly. Temperature profile is measured by a spot thermometer at the same time. An electric signal from the thermometer is measured by using of the A/D converter of the PC.

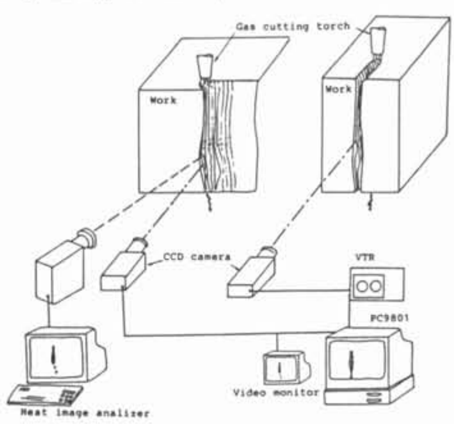


Figure 6 Schematic drawing of motion pictures analysis system.

COLOR IMAGE PROCESSING SYSTEM

A high speed color image processing system was developed to study the effective recognition algorithms for orange fruits in outdoor fields[6]. Figure 7 shows the system which consists of a PC, a color digitizing equipment, a color CCD video camera, a video tape recorder and a color video display terminal. This system contains many functions, and can be used in many image processing fields. The type of address mapping method for color image data of the image board used is the same as shown in Fig.3(a).

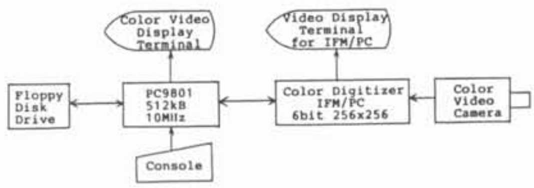


Figure 7 Schematic drawing of color image processing system.

All image processing is carried out by the software in order to study a suitable and robust algorithm to recognize orange fruits in an orchard. Figure 8 shows a memory map of this system. The whole program is stored in main memory to avoid loss time by disk access. This program has more than 170 modules named IMAGE.-BIN coded by the assembler, and each modules of them is contrived to proceed at high efficiency.

Memory address of image data is designated by an absolute address to save memory area. The address to save processed data is selected from a console. This system is interactive, and any commands can be selected from the console. A color video display terminal shows any frame of color image data set which is indicated by the system. An immediate display of a scene from a camera or a VTR connected to the equipment is also available. Usually, raw image data is

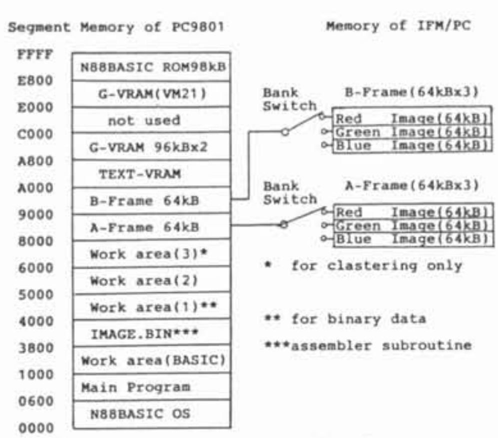


Figure 8 Memory map of color image processing system.

stored in frame A, and processed data is stored in frame B. An important data set can be saved in a disk. Executing condition of image processing is displayed on the monitor, then an operator can consider a validity of the executing image process. The longest processing time of a single subroutine is a smoothing operation with paticular weight for full color image data. It took at most 7.34 seconds, and this processing time for a PC is permissible for our purpose.

Memory addresses of particular variables are assigned to the designated area by the system. They are allocated to implicitly in each subroutines of the same group. So, the designation of these variables in the main routine is needless. If the values of these implicit variables are necessary for a record, they could easily be obtained by a subroutine call.

HAND EYE SYSTEM

A compact color image analysis system to controll a robot hand was developed for an indoor experiment to harvest mimic oranges[7]. A special program to recognize orange fruits developed by the color image processing system described above section is installed in this system.

This system consists of a PC, a color CCD video camera which is moved by a lineared motor, an image digitizer and a robot arm RM-501 made by Mitsubishi Electric Corp. as shown in Fig.9. The type of address mapping method for color image data of the image board used is the same as shown in Fig.3(b). The reduction of R,G,B relation is processed at first in this system. Therefore, Video98 made by NIHON BOARD COMPUTER is used for this system.

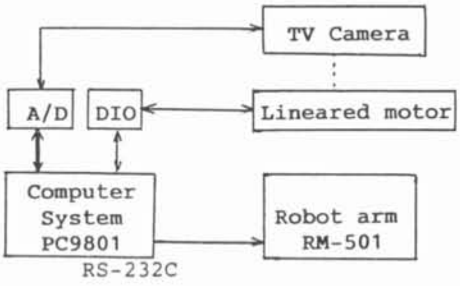


Figure 9 Schematic drawing of hand eye system.

Objects to be picked are recognized by their color features, and their positions are calculated by comparison from three different scenes. When the position is calculated, the robot arm moves to pick the object. This sequence is repeated while the object to be picked exists. It takes about four seconds to recognize and determine the position while the objects are separated each other.

The relation between the coordinates system of visual information and that of robot hand was determined automatically at first. The PC moves the hand of robot arm by the robot hand coordinate system, and the position of the hand in the TV camera coordinate is calculated. The relations between them are calculated by the method of least square.

Then, typical image data is processed for classification. The image data is clustered to 8 or 16 groups by their color characteristics, by using of the ISODATA method[8]. It takes about 1 or 2 minutes, respectively. The result is displayed on the monitor, and the operator chooses the group to be picked from the console. A color feature of pointed group is considered in detail by the system, and the selection rule of the particular color group is decided automatically.

An operation to harvest mimic oranges bigins after the setting up process described above is completed. A binary image data set of the first scene from the color CCD TV camera is obtained by using of the selection rule. A typical indexes of objects such as gravity center, area and line length of periphery are computed. The camera on the lineared motor is moved slightly, while the computing of the first scene is proceeding. The second scene with small disparity is taken. Rough matching process is carried out between these two scenes. The third scene with large disparity is taken at last. Detailed matching process of objects in 3-D space is carried out by using of results alredy obtained. If the occulusion of objects is existed, exact position of the front object will be computed by the consideration of correlations of scenes.

CONCLUSION

Several PC-based image processing systems developed for experimental measurements in our laboratory are described in this paper. They are designed for each own experimental purpose. The quality and cost of image digitizing boards for PC are good enough to use a PC-based automatic measuring equipment with image processing function for individual purpose, satisfactorily.

The important factors to use image processing system comfortably are executing speed and available memory size. A high speed image processing program for PC(CIP-PC) was developed to save execute time and memory size. The CIP-PC contains many optimized image processing subroutine programs coded by an assembler.

A PC machine is very comfortable to make an experimental measuring system because of its superior extendency and interactive ability.

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