

THE PROGRAMMING SYSTEM IMG FOR THE PROCESSING AND EVALUATION
(UNDERSTANDING) OF PICTURE INFORMATION

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The paper describes the present possibilities of general purpose software system IMG for the processing and evaluation of raster image data. The aim is the evaluation of the picture content, the understanding of its informational content. The system is in routine operation on the computer SMEP and is being continuously developed. The state of development at the beginning of the year 1987 is presented in this paper.

The Key Words : digital picture (image), processing, recognition,
picture information analysis.

1. INTRODUCTION

The creation of computer systems capable of processing and understanding of visual information is a task the satisfactory solving of which is of great importance. We can mention at last medicine, remote sensing of Earth, automated or robotized industrial production to show the wide range of fields where the problems connected with machine processing of picture information are being solved.

At our department of control we have been paying attention to the creation of compact system for picture processing and evaluation for many years. At first we were gaining experience with the pictures of the size 128 x 128 pixels in 16 grey levels but since 1984 we have been intensively working on the creation of systems using pictures as large as 512 x 512 pixels in 256 grey levels. The aim is the creation of a system for fundamental operations with images, for their pre-processing, segmentation, description and understanding of the content of image data, which could be usable on any microcomputer and which would be independent on the connected hardware for digitalization and visualization of the image. It is obvious that the system IMG (image) has two different parts. The first of them (the control program) is closely connected with the computer used, with its operational system as well as its attached image peripheral device. The control part must be naturally modified when implemented on a new equipment. The second part of the system - a great number of more or less algorithmically complex users' programs which directly solve the problems of image analysis do not change with the change of equipment. A development system for the creation of new algorithms for digital image processing has originated as well as the means of their common employment.

At the initial stages of our work we paid attention mainly to the control program [1]. At present the control program is ready in its fundamental form, it has been tested in common operation and it has been universally verified. The further work on control program tends to more significant utilization of technical possibilities of the used image processor TESLA VUST. Simultaneously we create control programs for IBM-PC and for VAX-11. Owing to the modulator conception control program and programming language (PASCAL) the adaption is relatively easy.

At present the main effort is devoted to the extension of the possibilities of the system from the user's point of view, it means the completion of the whole string from high-quality scanning including scanning of colour patterns to the description of the content of input image data - the pattern recognition. When writing user's program we consider the view point of applicability as well as universality and the speed of processing. The user's programs are written in Pascal, Fortran and exceptionally in assembler [2].

From the utilization point of view the system is adapted for practise, e.g. at any moment it is possible to gain information about user's programs by means of "HELP". The programs allow interactively communication among user, picture peripheral device, input TV camera, output raster TV monitor and host microcomputer. We also expect that an usual user would be a layman in the field of computers but at the same time an expert in the field where the image processing is required. His usual work would be the creation of problem oriented program as a sequence of calling general-purpose library programs and only partially the development of new algorithms. Software also allows very simple usage by an unqualified operator.

2. CONTROL PROGRAM

The fundamental unit for solving some problem of image processing is an applicational task, which can use the service of the control program IMG by means of calling user's procedures and programs. The control program IMG fulfills two basic tasks [3].

1. It ensures the access of user's program to the image (picture) data on a disk or in visual peripheral device.
2. It accepts statement lines from the file of indirect statements, it decodes the names of user's programs and starts them.

The user's program and control program IMG are two separated tasks (task in the terminology of operational system RSX-11) therefore auxiliary routines IMG for the access to data and statement lines do not occupy place in a 64kB address space of user's program.

Digitalized image of the size 512 x 512 pixels in 256 brightness levels represents 256kB. For its processing on a minicomputer the segmentation of picture is desirable because the address space of the task is smaller (usually 64kB) than the size of the picture. The picture is stored on a disk and only the part which is being processed is transferred to the memory. This mechanism of access of image data from the disk to the main storage is called virtualization. To find out the independence of particular picture peripheral device, the control program IMG supposes that input and output image files are on the disk.

Three methods have been chosen for the access of user's programs to image data :

1. Pixel virtualization which is slowest but the simplest for the user.
2. Window virtualization. It is much quicker but the user is responsible for the work with pixel within the window. Window is a common rectangular cut of a picture. Usually window means one row of a picture.
3. Block access which transfers one or several disk blocks into the buffer in the main memory. This approach is the quickest because it is determined only by the speed of disk operations.

To compare the access let us give the times for one passage through the picture of the size 512 x 512 pixels in 256 brightness levels on the computer SM 4-20. It is 70 s for pixel virtualization, 28 s for window virtualization with one row size window and 4 s for the block access. For speeding up the program it is possible to use time sharing or data transmission from the disk or picture processor and computation in a processor.

One part of the control program IMG is also standard for a format of image file. With the exception of its own picture data it contains an identifying head with information. Further it can contain a histogram, complementary alphanumeric text and a record about the history of picture processing.

3. USER'S PROGRAMS

User's programs represents fundamental steps leading to the complex processing and evaluation of an image [4]. The description of algorithms and precise specification of a function and applicability of the program are included in user's manual of the system IMG [5]. In the following paragraphs we shall concentrate on the survey of user's existing programs and we shall very briefly outline their functions.

The following programs have been created for the collaboration with picture processor TESLA VUST :

- PIS - the scanning of a picture and its disk record
- ZOB - representation of image data on a raster TV monitor
- INB - a program which enables the transfer of a statement line to a microcomputer of an image processor. In this way it is possible to use its hardware.
- KUR - interactive work with a picture by means of a cursor.

To facilitate the work and debugging of the program the following auxiliary programs have been created :

- HLV - listing and working with head, complementary text and history of picture disk file

- KNV - the conversion of a picture of non-standard formats, connecting of pictures of different sizes, cut-outs from a picture etc.
- OKN - listing of a part of image data on an alphanumeric display of a computer
- NOI - superposition of various kinds of noise with a given picture.

The whole series of practical applications is based on the brightness properties of an image. Therefore we have implemented:

- HST - the computation and representation of a histogram of picture brightness and its placing into the head of a picture file
- LOK - location of the area of two pictures, which differ in the brightness by the value from the required interval
- DIF - the difference of two pictures
- MAS - the application of a mask of given form on a picture which means permission or prohibition of performing determined operations over the masked parts of a picture
- STD - grey level picture transformation.

From the geometric picture transformation we have included :

- SCA - zooming of a picture by a real coefficient
- TRN - turning of a picture by a common angle.

Special attention has been paid to the work with binary pictures. We have elaborated mathematical morphology in a grid and by means of quick pseudoparallel way when 16 pixels of a picture is processed in one access we have implemented :

- AND - logical product (conjunction) of two pictures
- DIL - dilatation (expansion) by a common erase element of the size 3 x 3
- ERO - erosion by a common erase element of the size 3 x 3
- NEG - negation
- ORA - disjunction of two pictures
- SUB - subtraction (difference) of two pictures
- SKL - computation of the skeleton of the object
- VBS - binary pre-processing.

For high quality input of a picture we have created programs for scanning with removing errors of scanning string :

- FSP - filtering by means of grey area
- REP - repeated scanning and averaging of a static pattern.

For the successful image analysis it is substantial to eliminate as much unuseful information from the picture as possible and simultaneously to point out the useful information. This problem is solved by an elaborate system of pre-processing :

- FIL - a series of filtering operators and techniques with emphasis upon filtering preserving edges
- GRO - computation of a size and direction by many differential operators.

The automation of image processing and image analysis depends on the effective system of segmenting processes which do not require the interaction with an operator. So far we have created:

- PRA - a file of threshold methods of segmentation with automatic choice of a threshold
- PRI - segmentation based on the information about the occurrence of edges in a picture.

It is necessary to distinguish segmented objects in a picture from the another. The following program serves this purpose :

- BAR - identification of all objects by a non-repeating identifying number.

A necessary step for understanding the content of an image is the description of single objects and their recognition. It is solved by the following programs :

- POI - a set of methods for an attribute description of single objects
- ARE - the determination of the total area of all objects in a picture
- DER - the determination of the number of objects with holes
- KLA - the methods of determination and classification of objects described with attributes
- SHL - the methods of cluster analysis.

In addition to more common programs solving single steps of image analysis a whole series of independent procedures is available. They can be used in creation of further highly specialized programs. It enables easy application of e.g. pseudoparallely implemented method of work with binary pictures, the work with a head or history etc. when creating new programs.

The integral part of every greater program is user's documentation. The documentation IMG is kept in an up-to-date form by means of text processor DATEL [6] on a computer. In the description of each program there is information about the author, the language used, about the size of program, the possibilities of application, algorithm, the speed of processing, the examples of the calling of program, remarks and recommendation. At present the documentation of user's programs of the system IMG for image processing represents approximately 130 computer text pages.

4. CONCLUSION

The present paper was devoted to the complex system IMG for processing and evaluation of image data. Special attention has been paid to existing and used user's programs, which are considered to be the basis of a rounded-off system for image analysis. At the present form the system is tested and can be applied in practice. The control program, user's program and individually applicable procedures are placed on distribution media and after the agreement with the authors and the institute TESLA VUST it is possible to use them also by other institutions. The experience verified that the programs under the control program IMG can be written and debug conveniently and that they take full advantage of the possibilities of a microcomputer.

For further possibilities of implementation a control program for IBM-PC and VAX-11 is being created, the user's programs being unchanged. In the field of the development of user's programs we concentrate to the creation of intelligent segmented programs and to the enlarging of the classification possibilities. The further task is the creation of special oriented software for particular applications e.g. for the design of integrated circuits according to patterns, collection of information for the control of line for filling bottles etc.

The programming system IMG for the processing and evaluation of image information was in 1986 estimated by the Council of fundamental research trend of the Czechoslovak Academy of Sciences as a significant result of a research in the branch of technical cybernetics.

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