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MAGNETIC RESONANCE TOMOGRAPHS MAY BE DISPLAYED AND PROCESSED ON A PC WITH VGA GRAPHICS

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ABSTRACT

Displaying and processing images from magnetic resonance tomography on high resolution VGA graphic boards is demonstrated to be cost-effective and versatile. Different image file formats may be read. The graphics output can be converted to standard video signals. The modular software structure is open to further enhancements, and has been recently adapted to the Windows 3 user surface on the PC. The solution is promising for demonstration and education in radiology and anatomy and resembles a possible terminal for image databases and networks, as required by PACS or IMACS.

Keywords: IMACS, image processing, MRT, PACS, VGA, video converter.

INTRODUCTION

Digitally computed pictures are ever more extending and partly replacing the more conventional techniques of medical imaging. After the advent of computed X-ray tomography (CT), also ultrasound (US) and magnetic resonance tomography (MRT) ect. produced genuinely computed images, and if computed radiography (CR) is established to replace even routine thorax and bone X-ray examinations, most pictures clinicians look at will be a result of pure computer power. The huge amount of such images, and the required storage and retrieval of images over a long period of time (>10 years) lead to the development of PACS or IMACS (Picture / Image Management, Archiving and Communication System). Only few complete systems have been installed yet, but partial solutions, e.g. in the form of networks in the radiology department, have frequently been developed. Major advantages of a PACS are the savings in time (archiving and retrieval) and material (film, paper), the better retrieval rate, and quick exchange of image information over large distances (Saranummi and Viitanen, 1990). Some obstacles to a rapid introduction of PACS are the required financial investments, standardization problems, and the necessity for improved display modalities; educational difficulties, training doctors and technical personnel, or competing clinical disciplines should neither be ignored.

For all these reasons, it was intended to show that medical images could be demonstrated with the widespread personal computer (PC) (Kurz and Hagenlocher, 1990). This will be particularly valuable for MRT, because usually not too many systems are available yet, but will be most promising for the future. Furthermore, it appears desirable to transfer the digital information from the MRT directly to any possible user of it in the original image output format. This may be accomplished with small networks and image databases with the PC acting as an intelligent graphics terminal.

This paper describes a hardware and software solution, which provides image acquisition, enhancement and video conversion from the original MRT files.

HARDWARE

MRT images as a rule are displayed in a 256x256 pixel matrix with 64 shades of gray. This resolution is not quite met by the VGA (Video Graphics Array) standard, which is 320x200,64. But practically all VGA boards on the market have the capability for a resolution of 640x400 or 640x480 pixels in 256 colors, which is equivalent to 64 gray levels. The tendency goes for 800x600 to be quite normal, but implementation of all these high resolution modes differs between VGA chip sets. The latter mode has been selected, because four images together with the menu etc. can be displayed simultaneously.

The minimum configuration should consist of the following components: IBM PC/AT or compatible with 640 kB RAM, diskette drive, and a variable frequency color monitor with a resolution of at least 800x600 pixels. The Eizo MD-B 10 VGA graphics board, or the Video Seven VRAM with 512 kB are well-suited for a correct display and manipulation of the image, but four different VGA chip sets (Tseng, Video Seven, ATI, Paradise) are supported.

Our configuration was a Pyramid 301 (80386/387) with 8 MB RAM, 160 MB SCSI Harddisks, EIZO MD-B 10 and EIZO 9070 S monitor.

Several adapters for converting the VGA output to PAL video signal are available, but they do not yet support a resolution of better than 640x480,64. This is accounted for with a special version of the software.

Screen images (cf. Fig. 1-4) were reproduced from color slides or negatives (Canon AE-1, Tamron 70 mm, film speed 100 ASA, aperture 5.6, exposure time 1 s).

SOFTWARE

The program was written in TurboPascal 5.5 with a specific VGA interface and needs only 64 kB RAM. A routine is implemented which first checks the make of the graphic chip set in the system, and thereafter uses the appropriate parameters. It runs under DOS 3.x or 4.x and is presently rewritten to make use of the new features in Windows 3.

Since MRT systems differ considerably in their image formats, the reading routine is tailored to the manufacturers documentation. Conversion from the commonly used 32 bit file structure is achieved either by the MRT host or by the PC.

The following items were realized to successively build a software engineered image enhancement system: menu oriented user interface, gray value manipulation and histogram, false colors and image inversion, addition of images with clipping at defined gray levels. Edge detecting filters and user defined 3x3 filters and a two-fold zoom with interpolation were also realized.

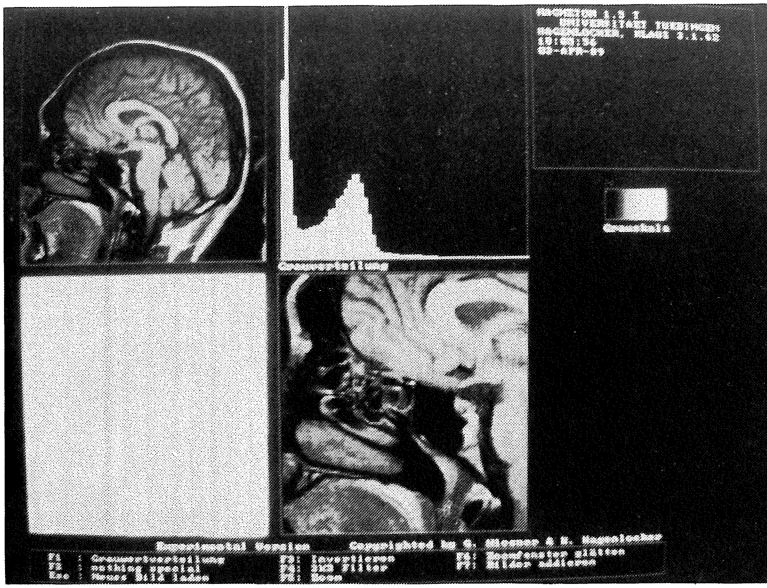

Figure 1. Full screen view of a MRT image (median sagittal slice), displayed on EIZO 9070S with MD-B 10 VGA graphics board. The original image is seen in the upper left quadrant and the gray value distribution is shown besides it. In the lower left quadrant, air, bone and liquor have been marked after subtraction of specific gray values from the inverted image. Part of the tomogram has been zoomed (lower right) and pixels have been smoothed (cf. Fig. 2).

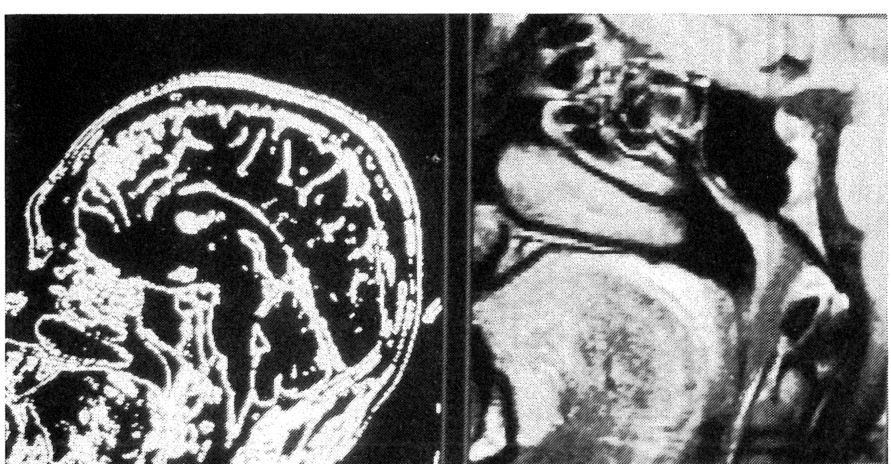

Figure 2. Same MRT slice as in Fig. 1, but only lower screen half. An edge detector (3x3 convolution) marks gyri and sulci, the brain stem and the cerebellum. The zoomed image shows ragged edges, because, before smoothing, only a 128x128 pixel matrix is displayed. Image quality is comparable to workstation monitors, and better than most hardcopies or reproductions in books.

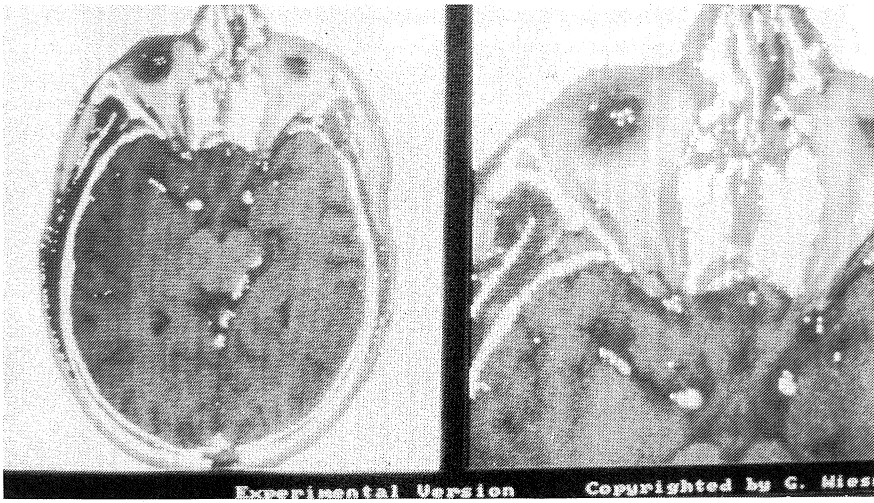

Figure 3. Horizontal slice (lower screen half), including the optic chiasma. Bone, vessels and air-filled sinus have been marked in white, with the steps described in Fig. 1. The original image has been added with its full gray scale to show muscle and nervous tissues as well. The zoomed part clearly shows the pituitary infundibulum, the optic nerve and eye muscles.

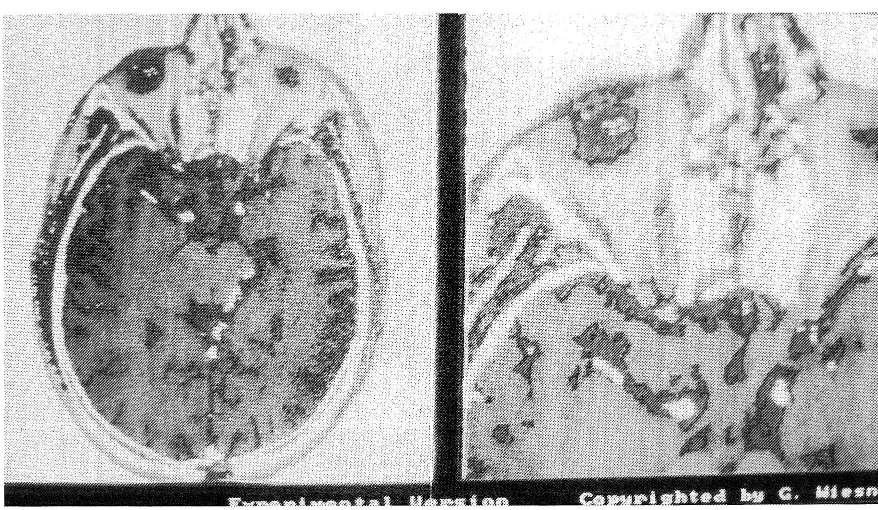

Figure 4. Same slice as in Fig. 3. The zoom window has been smoothed, and some of the sulci are outlined with red pixels. By repeating this image processing, isodensites, or areas of defined gray value can be constructed and measured. This may be employed by methods which rely on the detection of certain gray values or areas.

RESULTS

The image enhancement software described enables the MRT image file format to be read and displayed by a PC/AT with high resolution VGA graphics.
Any other file format can be read, if the file structure is known. If the file header is documented, a reading function for the picture file may be written to redesign it to the actual screen resolution.
The MRT output or other computed images like CT, US, CR etc. may thus be distributed to many users (in a clinic, for education e.g.) while retaining the entire image information. The VGA screen image appears clear and crisp and perhaps even better than on the MRT machine. The software provides with a variety of image enhancement tools which mostly are available only on special image storage boards or framegrabbers. Even without a numeric coprocessor, most image manipulations are carried out in about a second. Picture modifying algorithms, some of which are illustrated in Figs. 1-4, have been implemented into a modular image analyzing software.
A field in the upper right corner of the screen displays the header information concerning patient and image slice data. A matrix indicates the factors used for convolutions of the image, and a menu bar on the bottom line specifies the meaning of the function keys. The various images stored on disk may be viewed and selected in a file menu. The Windows 3 version takes advantage of the systems multi-window capabilities, which makes interaction more comfortable.

DISCUSSION

The development of medical imaging, particularly computerized tomography, has led to the consequence that the skills involved in the preparation and study of anatomical sections of the entire human body and its organs be reactivated. To study anatomy then also means to immediately compare the slice preparation with the computed image. This has already been considered to a varying extent in recent editions of anatomical textbooks and atlantes. But the full advantage of slice series for three-dimensional visualization and comprehension can not be employed. Students should therefore have the opportunity to get acquainted with the electronic display of medical images in addition to conventional studies.
The VGA was found to be adequate as a high-resolution, low-cost rendering device for MRT files. With the new 'XGA' standard of 1024x768 in 256 colors, up to 12 images could be demonstrated simultaneously on one screen. The PC may thus partly replace a full-sized graphics workstation which still is recommended as a PACS terminal.
The graphics board could not only display and enhance the image: adapters, which convert the output from the VGA to standard video signal (PAL or NTSC), make this combination particularly versatile. Such converters would make the screen image visible to a great audience, and extend the use of existing video equipment.
First experiences during a course in brain anatomy showed that there may be a startling effect to medical students: the obligation for more thorough anatomical studies became obvious, in order to be prepared for modern medical imaging.
With the capability for 3-D reconstruction functions, and with the advancing development of MRT imaging, which may immediately be transferred to the student, a cost-effective way of scientific and educational progress becomes possible.

The described equipment may also be valuable for research, when tomography-based investigations are to be carried out: computing resources in the CT or MRT and other expensive equipment can be liberated, and image analysis tasks may be performed on standard PC equipment. The modular concept makes addition of new functions like segmentation of the image and binary image operations possible.
One obstacle encountered was, to get hold of the manufacturer's information about the image format (header and pixel matrix definition). A minor problem was the file transfer from the MRT host computer to the PC. This was accomplished via terminal emulation or some serial interface.
Standardization is therefore strongly desirable and will result in mutual advantage for researchers, manufacturers and students, for clinical doctors and their patients.

CONCLUSIONS

Some problems involved with PACS may be lessened with the introduction of inexpensive PC equipment for the demonstration and manipulation of digital images. A brilliant display is available with the VGA screen, costs can thus be reduced, the medical student may be trained from the beginning, and the transfer of new imaging techniques from the clinic to e.g. anatomy may be alleviated. The described configuration may be used for image analysis in general, if the image is in digital format.

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