

MEDICAL IMAGE CONVERSION

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ABSTRACT

The paper deals with the problem of converting medical images from one format to another. In solving it the structure of the most commonly used medical image formats are studied and analysed. A mechanism for medical image file conversion and a Medical Internal Image Format (MIIF) is proposed as a solution. A medical image conversion system (MICS), designed and implemented to perform conversions between the most common medical image formats, is described as well .

Keywords: Image Analysis, Image Processing, Image Conversion, File Formats.

1. INTRODUCTION

Since the invention of the microscope and the discovery of the x-rays, physicians have been using images to diagnose ill patients and to get better understanding of the basic principles behind physiology and biology. The imaging modalities used in medical science are based on a variety of physical phenomena such as light, electrons, lasers, x-rays, radionuclides, ultrasound and nuclear magnetic resonance. The challenge of imaging science in biomedical research is to provide advanced capabilities for acquisition, processing, visualisation and quantitative analysis of biomedical images in order to significantly increase the faithful extraction of useful information which they contain [5].

The main difference between the general image formats and the medical image formats is that the latter usually contains more information such as patient's name and the settings of the equipment used to produce the image. The image data includes the pixel image data and information such as the numbers of bits per pixel, the binary storage of the pixels, the size of the image and the number of images per file. Usually medical image data includes additional information such as description of the image, results of the analysis on the data, a history of the processing of the data. There are many formats for storing medical image data. The most used are

the TIFF (tagged image file format) [4] used in various PC and MACINTOSH applications, the ACR-NEMA 2.0 format (American College of Radiology (ACR) and National Electrical Manufacturers Association (NEMA)) [3] which is usually produced from medical equipment, the ICS (Image Cytometry Standard) format [2] for image cytometry data files and used in the SCILIMAGE package and the ANALYZE format which has been developed in the Mayo clinic (Rochester, USA) [5] and is used in the ANALYZE package. There are also different vendors formats, such as GE Medical Systems (General Electric Medical Systems, Milwaukee, USA) format [1], which is used in the GE Research Workstation package.

Many commercial processing systems have been developed to help the analysis of medical images. The problem with most of them is that there is discrepancy between their available input formats and the format of the produced image. Conversion systems are in need to solve the problem. Existing conversion systems such as HAIJAC are designed to convert between different PC and MACINTOSH image formats, such as BMP, PCX, GIF and PIC, but they do not solve the problem of conversion between medical image formats.

The system we discuss is able to solve the above problem. It makes use of a third internal file format called MIIF.

2. MEDICAL IMAGE FORMATS

There are two methods for medical image data storage. The first is characterized by having all data relevant to the image stored in a single file. The second uses different files to store the pixel and the header data.

The main advantage of the first method is that it is better organized from a data integrity prospective because all the image information is stored in a single file. On the other hand problems may arise when extracting or modifying information from the file because of its size and complex structure.

The main advantage of the second method is that the descriptive information can be written in ASCII, which is a directly printable and editable code. As well the results of the image analysis could be written in a separate file in a form that is compatible with spreadsheets, database programs and word processors. The main disadvantage of this method is that the data file is virtually indecipherable without information from the header file.

For the storage of a 3D image there are two main approaches. While in the first the 2D images, which create the object, are saved in a single file, in the second each 2D image is stored in a separate file.

There are three main types of header organization: a) the header data is presented as a fixed structure; b) the header data is presented as a number of free structures; c) the header data is presented as an ASCII text containing different parameters and their values.

a) header as a fixed structure

The header data is stored in a fixed structure. Such headers are used in the ANALYZE and the GE Medical System formats.

ANALYZE format

The header in ANALYZE format is a fixed structure that contains: the dimensions of the x, y and z coordinates, the number of bits per pixel and the minimum and the maximum value of the pixels of the image. Another feature of this format is that a single file is used to store a 3D image and its header information. The structure of the ANALYZE format is given in Fig. 1.

x dimension	y dimension	z dimension	number of bits per pixel	min value	max value	pixel data 1	pixel data 2	...	pixel data n
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Fig. 1. ANALYZE format

GE Medical System format

The header data is stored in a structure with fixed field names. It contains the x and y dimensions, the header size, different settings of the medical equipment (such as slice thickness, phase-encoding steps, repetition and echo time, field-of-view and imaging time), patient information (such as name and address) and user comments. Every 2D image is stored separately. The header information is stored together with the pixel data. The structure of the GE Medical System format is given in Fig. 2.

x dimension	y dimension	header size	settings	patient information	comments	pixel data 1
x dimension	y dimension	header size	settings	patient information	comments	pixel data 2
...						
x dimension	y dimension	header size	settings	patient information	comments	pixel data n

Fig. 2. GE Medical System format

b) header as a number of free structures

This header data is stored as a number of variable structures. Examples of such headers are the headers in the TIFF and ACR-NEMA 2.0 formats.

TIFF

The TIFF header begins with an Image File Directory (IFD), describing the field entities. Each IFD entry contains the Tag, the type, the length and the value offset of the field. The entries in the IFD must be stored in ascending order by Tag. Byte, ASCII, short, long and rational are possible field types. An image is defined to be a rectangular area of "pixels", each of which consists of one or more "samples". With monochromatic data, we have one sample per pixel and "sample" and "pixel" can be used interchangeably. RGB colour data contains three samples per pixel. Basic fields are fields that are fundamental to the pixel architecture or the visual characteristics of an image such as: bits per sample, colour map, colour response curve, compression, grey response curve, grey response unit, image length, image width, photometry interpretation, resolution unit, rows per strip, strip byte counts, strip offsets and x and y resolution. Informational fields are fields that can provide useful information to a user, such as the source of the image. As well there are private fields. Every 2D image is saved separately. The header information is stored together with the pixel data. The structure of TIFF is given in Fig. 3.

IFD	IFD entry 1	IFD entry 2	...	IFD entry m_1	pixel data 1
IFD	IFD entry 1	IFD entry 2	...	IFD entry m_2	pixel data 2
...					
IFD	IFD entry 1	IFD entry 2	...	IFD entry m_n	pixel data n

Fig. 3. TIFF

ACR-NEMA 2.0 format

The ACR-NEMA 2.0 header contains several groups of structures. The group 0000 contains the command information such as message ID, priority data set type, display format, image borders and copies magnification. The group 0008 is used to store the identification information. It includes the study, series and image time and type. The group 0010 includes the patient information

such as patient name, birthday, sex, age, height, weight, address. The group 0018 includes acquisition information such as device number, start and stop time, special resolution, exposure time, transmitting coil, pre-processing functions. The group 0020 contains the relationship information such as study, series, acquisition and image identification, patient orientation, image position and orientation. The group 0028 includes image presentation information such as image dimension, number of rows and columns, pixel size, compression type, window centre and window width. The group 4000 contains text, describing the image. The groups 6000-601E describes the overlay information. The group 7FE0 contains the pixel data of the image itself. The 3D image is stored in a single file together with the header information. The structure of the ACR-NEMA 2.0 format is given in Fig. 4.

group	group	group	group	group	group	group	group	...	group	pixel data	pixel data	...	pixel data
0000	0008	0010	0018	0020	0028	4000	6000		601E	1	2		n

Fig. 4. ACR-NEMA 2.0 format

c) header as an ASCII text

The header data is stored as an ASCII text containing a list of parameters and their values. Example of such formats is the ISC format.

ISC format

In the ISC format the header information is arranged in four major categories. The layout includes the image dimension and the number of bits per pixel. The representation includes the format of the image data. The parameter contains the units of measurement and the history includes the creation information. When using the ISC format there may be additional files containing the results of image analysis. The 3D image is stored in a single file. The header information is stored separately. The structure of the ISC format is given in Fig. 5.

layout	representation	parameters	history	pixel data 1	pixel data 2	...	pixel data n
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Fig. 5. ISC format

3. MICS

MICS is a system for medical image conversion. It converts between the most common medical image formats. It does it by converting from the modalities output format to the MIIF internal format (specifically developed for the system) and then from it to the processing application

input format.

3.1. MICS architecture

The MICS architecture is shown in Fig. 6. The major advantage of using the MIFF format is that it allows for a new format to be introduced to the system by writing only the module for converting between it and the intermediate format. If such a format did not exist the addition of the new format would have required conversion modules between it and all the input/output formats. The addition functions of the system allow easy image data editing, which could be of help before sending the image to an image processing package.

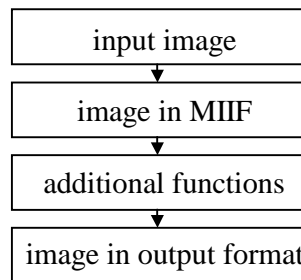


Fig 6. MICS Architecture

3.2. Structure of MIFF

The MIFF includes the pixel data and two structures. The first structure is a fix structure that includes the dimensions of the image and the number of bytes per pixel in it. The second structure contains the union of the minimum information needed from the image processing packages that are supported by MICS. In the current version it includes: patient name, patient ID, pixel dimension, window centre and window width. The structure of the MIFF image is given in Fig. 7. The current version of the system supports conversion to the image formats of ANALYZE, GE Research workstation, SCILIMAGE, IGS Technology IAP and some PC and MACINTOSH commercial applications such as Image and Photo Finish.

x dimension	y dimension	z dimension	number of bytes per pixel		fix structure
patient name	patient ID	pixel dimension	window centre	window width	specific data
pixel data 1	pixel data 2	...	pixel data n		pixel data

Fig. 7. MIFF format

3.3. Addition functions

Usually when an image is converted between two formats additional functions may be

needed. The MICS supports rescaling the image data, averaging pixels, choosing a region of interest (ROI), byte swapping and image displaying.

3.3.1. Rescaling the image data

If in the input image the pixel data is stored in two bytes, but in the output in one the user is forced to rescale the pixel value. If this is not the case, pixel rescaling is an option. The input data for rescaling the image is the range of the value of the input pixel (from u_1 to u_2) and the output pixel (from v_1 to v_2), Fig. 8.

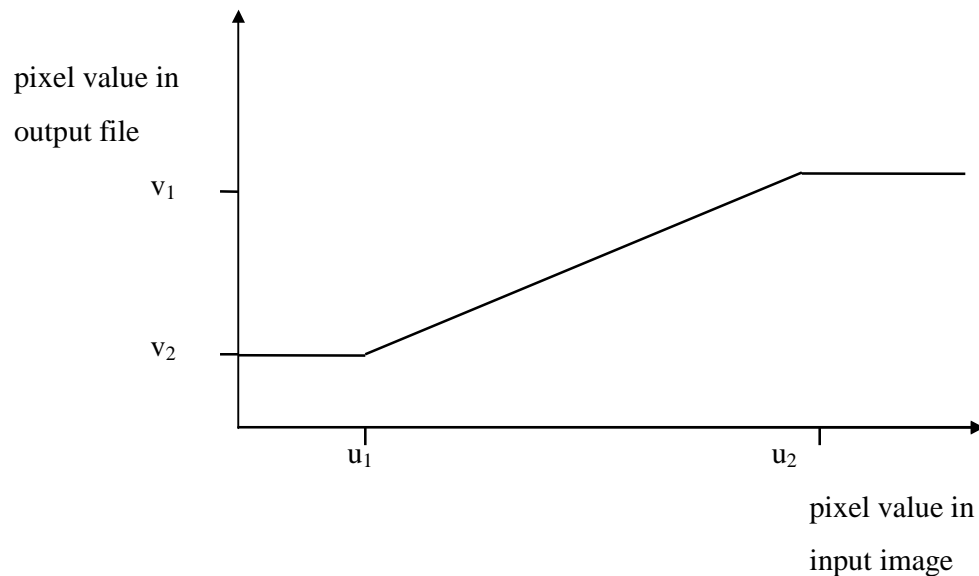


Fig. 8. Rescaling function

3.3.2. Averaging pixels

The average function condenses the image. It uses a user defined averaging argument to determine the number of pixels that are condensed into one. The averaging function can be used when the converted image is too big for its destination (the package that is going to process it).

3.3.3. ROI

Another way to reduce the size of the converted image is to select only a part of it, i.e. a ROI. It can also be used to enlarge a particular part of the image, which is of particular interest to the user.

3.3.4. Byte swapping

If the output file format has two bytes per pixel, the user has the option to swap them. This option is mainly used when converting images between a SUN workstation and a PC.

3.3.5. Image display

This option allows the user to view the converted image before it is send for processing.

3.4. List of currently supported input and output formats

The current version of MICS can convert between any two of the ACR-NEMA 2.0, ANALYZE, ICS, TIFF, GE Medical Systems Format and HEADER_LESS (type 1 and 2) file formats. When using the HEADER_LESS format of the first type the 3D image is presented as a single file containing the pixel information. On the other hand an image of the HEADER_LESS format of the second typed is separated into files containing each of the 2D image slides.

4. DISCUSSIONS AND CONCLUSION

MICS is realised on the SUN workstation (SUN Microsystems, Mountain View, California), using the C software language. The system is user friendly and allows for user guidance trough the conversion process. For example if information necessary for producing the output image is not found in the input image, the system asks the user if he or she can supply it. Another feature of the system is that, when it uses the TIFF output format, it sends the images in a format that can be correctly interpreted by all the target processing systems. The system can be improved in the areas of reading coloured images, compressed images and images that contain overlay information. In the current system only TIFF coloured or compressed images can be read. They are transfer in grey uncompressed data before being converted to the MIIF. The system ignores all overlay information and all such data from the input image is lost in the output.

The potential users of the MICS are medical centres, working with different medical equipment and using different image processing packages for their image analysis. At present the system is implemented in the University of Toronto.

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6. REFERENCES

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