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Medical Diagnosis Based on Image Analysis and Processing

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Abstract

The thematic approached by the present article is part of one important domain, belonging to the broad area of medical assistance. This is about the medical diagnosis of malignant tumors, assisted by computer. Here is presented the graphical processing, through preprocessing operations, made upon the images obtained in this respect. These operations have the role to remove the useless noises or data from the image, or they are simply restoration operations. This kind of processing is necessary to improve both the implementation times, as the results of different algorithms. The article resumes the main physical factors used in the medical imagistic, at the moment. Hereinafter, is presented a program which processes the microscopic images, devising the healthy cells from the ill ones, by shaping the complete cells (healthy).

Key words: *medical diagnosis, imagistic analysis, medical image analysis and processing.*

Introduction

Image (digital) processing represents a large area, self standing, based on a rigorously, well-sustained mathematical theory, but, generally, the implementation on different calculation machines involves quite a huge consumption of resources (calculation power, memory), especially if it is about the use of data in real time. An image is a two-dimensional signal; as a result, image processing can be also considered a branch of signal digital processing (including also audio processing, telecommunications, and so on). Image processing and, generally, signals digital processing requires quite a significant quantity of calculations and memory resources. The implementation of specific algorithms can be made on classic systems, but in case of dedicated, real time, systems is used a DSP processor (Digital Signal Processing), [6].

Image processing includes or is linked to more disciplines:

- taking over, compressing and storing images;
- images restoration and improvement by geometrical and radio metrical corrections, contrast settings, noise filtration, etc.;
- photogrammetric - measurements of some objects, phenomena based on images;
- shapes recognition (pattern matching, shape recognition, face recognition);
- artificial vision (computer vision, robot vision);
- artificial intelligence;
- image synthesis, images generated by computer.

The artificial intelligence and image processing are interconnected areas. An important number of performance algorithms used in image processing, are based on methods and techniques used in the artificial intelligence area, as: neural networks, fuzzy logics. On the other side, the artificial intelligence means to design and build systems able to fulfill the functions of the human brain: learning from experience, understanding the natural language, using a specific reasoning for solving problems or taking decisions. All these also need to acquire a certain quantity of data (a knowledge basis, background data, etc.). This information is taken over by the intelligent systems through sensors, creating a background image at the moment when the information is taken over (snapshot). From the image obtained in this way, it has to be drawn out the useful information.

Graphical processing

Further, is presented the graphical processing by preprocessing operations, made upon the images obtained. Those operations play the role to move the noises or useless data out of the image, or they are simply restoration operations. This kind of processing is necessary to improve both the implementation time, as the results of different algorithms.

a) Filtration

The filtration operation is used to remove noises and to emphasize the borders. Generally, are used the following three types of filters:

- low pass filter is used to remove noises; the image spectrum is homogenized;
- band pass filter is normally used to process the images come from teledetection (images taken over from satellite, airplane, etc.);
- high pass filter is used for pointing out the shapes, due to its deriver's bearing.

b) Images restoration

When the block of images is out, the result might be a twisted image, the distortion being caused by some known physical phenomena. A possible source of distortion is the optic system. The images acquired might present pillow, barrel or trapeze distortions. These errors can be corrected by a re-echeloning operation: to these types of geometrical distortions can be set the mathematical relations necessary when making the correction, and, by using those relations, it is calculated the value of each echelon (pixel) belonging to the new image, on the basis of a certain number of echelons being part of the twisted image.

c) Segmentation

Segmentation represents the process of partitioning the digital image into subsets, by assigning individual pixels to those subsets (also called classes), therefore resulting distinct objects. Segmentation algorithms are based, generally, on 2 principles [6]:

- discontinuity, having as main method shape detection;
- similitude, using threshold method and regions method.

d) Histograms. Operations.

An image histogram is a function which sets how many pixels have a certain grey level. Usually, the number of grey levels rises to 255 (one pixel is represented in 1 byte) and the histogram is described by function [6]: $f(g) = p$, where: g = grey level, g having a value between 0 and 255; p = number of pixels, having a g value.

e) Shape extraction

There are many operators for shape extraction. As reference point, many specialty books set the three classic operators: Sobel, Kirsch and pseudo-Laplace [6]. These operators represent the *sliding window* type. Shape extraction through these operators consists of a succession of convolutions between the initial image and operator core (mask). Facultative for each operator, at the end of the convolutions, could be made a threshold segmentation, in order to obtain a binary image of the borders *map*.

Images used in medical diagnosis

The expression "medical imagistic" make reference to obtaining data concerning the physiological or pathological status, based on the interpretation of the image representing a part of the body, as it may be seen also in [4]. Defined this way, the term is quite large, considering that the images got are based on different phenomena, therefore, they keep a different information. Nevertheless, they have common elements: represent built images, using advanced technical means, based on the way body responds to the interaction with physical factors. The physical factor can be carried out by a chemical factor, as radiopharmaceuticals. In this case, the biological structures interact with the chemical factor, but the physical factor is the information carrier.

The interaction with the physical factor involves the transfer of a part of tissue's energy. The bigger is the quantity of energy transferred, the higher is the probability that the investigation has important collateral effects. The image is made starting from the different degree of modification a factor parameter is submitted to, as result of interacting with some tissues, therefore, according to the features of those tissues. The values of that parameter are converted in luminosity degrees of image (shades of grey or colors conventionally associated). The higher is the difference between tissues features (from that factor's point of view), the higher is the image contrast. The image quality is brought by contrast, as the possibility to distinguish more details, especially by sensitivity and resolution. Image quality is affected by the noise covering the useful signal, and also by possible false images. These parameters depend on how tissue responds, but also on the features of the incidental radiation and technical processing of the response. The images obtained by different techniques are not alike, depending on:

- the physical factor and its parameters;
- the mechanism of interacting with the biological material;
- the technical means used to apply the physical factor and to register the response;
- the way to construct an image, usually on computer, at least in case of a tomography; this way, the image quality may be improved.

Any method becomes imagistics when handles with:

- a source of energy;
- a system of detection;
- an analog-digital system of taking over-processing, or one to store data on computer or a microprocessor;
- a digital-analog rendering system.

The main physical factors used today in medical imagistics are: X-Rays (radiology, X tomography or tomodensiometry), ultrasounds (ecography and tomography with ultrasounds); ionized radiations from radioactive substances, usually placed on specific tracers of the investigated tissue, the electromagnetic field (NMR tomography). In figure 1 is presented the way to carry out the projections at the computed tomographies.

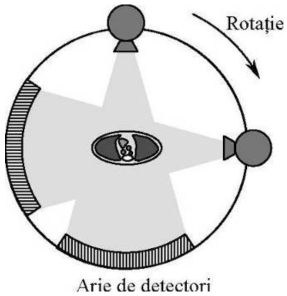


Fig. 1. Projections at computed tomographies [7].

Alternative solution by image processing having application in medical diagnosis

Generally, the manufacturers of specialized equipments (e.g. tomograph computer), used in medical investigation and diagnosis, based on images, are those in charge with the software meant for image interpretation. With a few exceptions, this kind of programs is made available to equipments manufacturers by other specialized companies. The financial resources involved by the acquisition of the equipments are very big and, if we add the software necessary to be acquired, the costs are obviously higher.

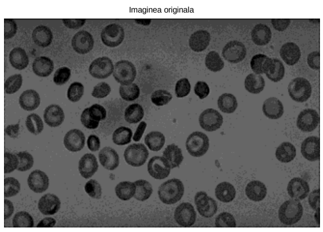
As a result, the use of some cheaper software resources, as Matlab® 7.5, might represent an alternative solution to set programs for medical diagnosis, based on image processing. A first step toward this direction is the mathematical modeling. Therefore, this could become a more accessible and more used area, for a better understanding of the physical and biological reactions. The interconnection between mathematics and medicine could become more comprehensible in time, and the diagnosis and the possibilities of treatment could be more and more accurate and specific.

Following this pattern, the author brings into attention a program which applies the mathematical simulation and modeling in medicine, aiming to faster and more accurate diagnoses, with the possibility to offer a simulation of the connection between patient, diagnosis, treatment, nutrients and the evolution of some diseases, as cancer, in order to set a curative, rigorous therapy. This kind of program has to be tested in a wide area, based on many experiments and simulations, and to be developed in a very long period of time. In consequence, the mathematical modeling area is considered as being pretty difficult to approach, but does represent the only possibility to anticipate the evolution of a treatment or a disease, just by a few seconds simulations, which, in reality, is possible only in very long periods of time (months, even years).

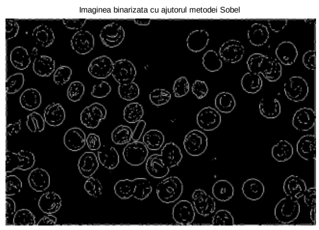
Taking into consideration all the above mentioned, it must be specified that the final goal of the program is to represent an appropriate work ground and, also, a start for the theoreticians and the experimentalists who would like to choose this way to carry out an automatic medical diagnosis, with the possibility to use it also in diagnosing tumors. Hereinafter, the author develops, on brief stages, a program processing the microscopic images and dividing the healthy cell from the contaminated ones, by shaping the complete cells (healthy). The stages covered are the following:

1. to detect the complete cells in the original image of the computed tomography (fig. 2a), by obtaining a binary image using the Sobel method (fig. 2b);
2. to obtain a magnified binary image (fig. 2c);
3. to fill the complete cells of the fig.2c (fig. 2d);

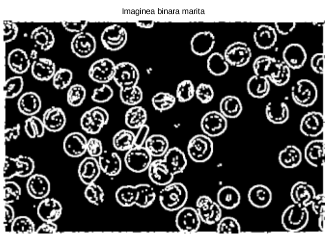
4. to erase the cells placed on image border of fig. 2d (fig. 2e);
5. to level the complete cells in the image of fig. 2e (fig. 2f);
6. to shape the healthy cells, the rest of shapeless cells being considered as tumor cells (fig. 2g);
7. to start over from step 1 for more images taken over by the tomograph;
8. according to the number of shapeless cells, it is determined if the organ investigated does have malignant tumors or does not.



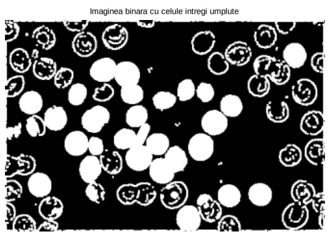
a) Original microscopic image.



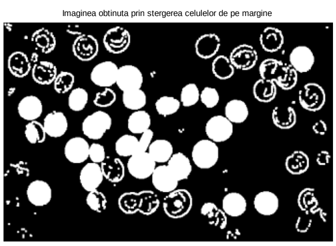
b) Binary gradient mask.



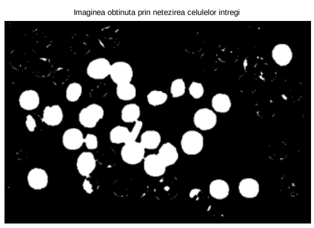
c) Dilated gradient mask.



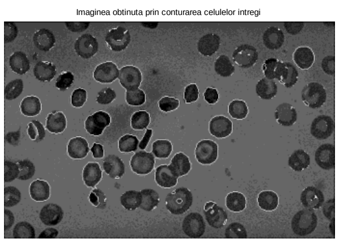
d) Binary image with entire filled cells.



e) Cells erased from the image border.



f) Leveling the entire cells.



g) Final microscopic image presenting the entire cells

Fig. 2. Microscopic image and processing results (from **a** to **g**).

Conclusions

At the moment, can be stated that the area concerning cancer biology reached the maturity stage regarding the mathematical modeling, the equipments and the techniques used in investigation and diagnosis. The most important target to be aimed is to discover the small size tumors, in order to diagnose early a case and, therefore, to increase the chances to cure the patient. Among all the modern imagistic methods, the computed tomography is the one which offered the best results in discovering the small size tumors. Although, the huge amount of data obtained by modern investigation-diagnosis methods, that a specialty doctor has to analyze, could be very difficult, requiring longer periods of time. Of course, medical errors are not excluded. The appearance and development of the computed tomography represented a huge step towards varied possibilities of exploring tumors.

The program proposed focuses on the interpretation of the microscopic images due to the fact that this kind of images were easy to obtain and the processing of other images implied the necessity to write sophisticated programs, involving a team effort and a longer period of elaboration.

The research methods applied in cancer investigation and diagnosis, are going to be developed all over the world, but cannot be ignored that the simplest solutions are usually the best ones to solve the important problems.

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Diagnosticarea medicală bazată pe analiza şi prelucrarea imaginilor

Rezumat

Tematica tratată în articolul de faţă este parte componentă a unuia dintre cele mai importante domenii ale asistenţei medicale, şi anume, diagnosticarea medicală a tumorilor maligne asistată de calculator. Sunt prezentate prelucrările grafice prin operaţii de preprocesare ce se efectuează asupra imaginilor achiziţionate în acest scop. Aceste operaţii au rolul de a elimina zgomotele sau informaţiile inutile din imagine sau sunt operaţii de restaurare. Astfel de prelucrări sunt necesare pentru a îmbunătăţi atât timpii de execuţie cât şi rezultatele diverşilor algoritmi. În articol sunt trecuţi în revistă principalii factori fizicii utilizaţi astăzi în imagistica medicală. În continuare este prezentat un program care prelucrează imaginile microscopice şi separă celulele sănătoase de cele bolnave prin conturarea celulelor întregi (sănătoase).