Algorithm of support for the detection of the Acute Lymphoblastic Leukemia

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Abstract. This project bases on the worry that Acute Lymphoblastic Leukemia Infantile is the most common type of cancer in children, generally it deteriorates rapidly but it can be treated in time. ALL is a disease in which white blood cells attack the infections (so called lymphocytes), which are immature in big quantities in the blood and bony marrow of the child. There is an algorithm designed that helps detect the cancer ALL, this one must be a support for the doctor. The samples that are taken of bony marrow dress in the microscope. Our algorithm is based on the programming on Mat lab, this one consists of four stages of processing: Image of entry, Segmentation, Classification, Recognitions and Exit. First the image that is selected of a bank of information is read, where all our images of tests are read as well, the original image turns into a scale of gray image, in the stage of segmentation 6 Edge's methods are analyzed to see which is most indicated for our needs, an object can be discovered easily in an image if the object has the contrast of sufficient bottom, this is done in the same stage of segmentation.

Keywords: Acute Lymphoblastic Leukemia (ALL).

1 Introduction

ALL is a type of cancer for which the bony marrow produces too many lymphocytes (a type of white blood cell).
The ALL is a cancer of the blood and the bony marrow. This type of cancer generally deteriorates rapidly if it is not treated fast. It is the most common type of cancer in the children. Normally, the bony marrow mother elaborates blood cells that turn, with the time, into blood mature cells.

The mother cell-amyloid turns into one of three types of blood mature cells:

1. Red blood cells that transport oxygen to all the fabrics of the body.
2. White blood cells that fight against the infections and the diseases.
3. Platelets that help to anticipate hemorrhages that form clots of blood.

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In the ALL, too many mother cells can turn into a type of white blood cells called lymphocytes. These lymphocytes also call lymphoblast or leukemia cells. There are three types of lymphocytes:

Lymphocytes B that produce antibodies to help to fight against the infections.
Lymphocytes T that help lymphocytes B to generate the antibodies that help fight against the infections. Aggressive natural cells that attack the cancerous cells or the virus.

2 Devlopment

Evolution of a blood cell.
A mother blood cell goes through several stages to turn into a red blood cell, a platelet or a white blood cell.

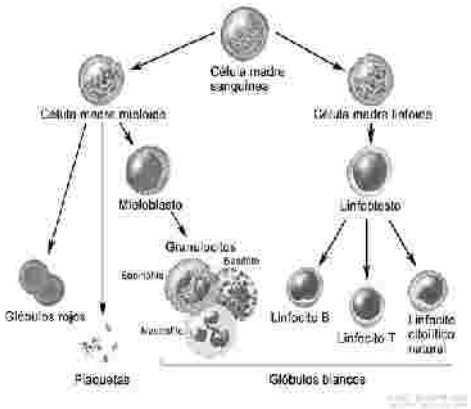


Fig. 1. Evolution of a blood cell.

In the ALL case, the lymphocytes cannot fight very well against the infections. In addition, as it increases the quantity of lymphocytes in the blood and the bony marrow, there is less place and space for the white blood cells, the red blood cells and the healthy platelets. This can lead to infections, anemia.

There are subgroups of child ALL.
Four of the subgroups of child ALL are based on the type of blood cells that are affected, if they present certain changes in the chromosomes and the age in the moment of the diagnosis:

ALL of cells T.
Positive ALL for the chromosome Philadelphia.
ALL diagnosed in a breast-fed baby.

ALL diagnosed in 10-year-old children of age or more, and in teenagers.

The exhibition to radiation and the family precedents can take part in the risk of suffering from child ALL.

A factor of risk is anything that increases the risk of contracting of a disease. People who have a factor of risk lets us know that one is going to contract cancer; not to have a factor of risk means that one is not going to contract cancer. The people who think that they can be in risk, must consult this topic with their doctor. The possible factors of risk for the ALL include the following aspects:

- To have a brother with leukemia.
- To be of white race or of Hispanic origin.
- To reside in the United States of America.
- To be exposed to the X-rays before the birth.
- To be exposed to radiation.
- To have had a previous treatment with chemotherapy or other medicines that debilitate Immunological system
- To suffer from certain genetic disorders as Down's syndrome.
- The possible signs of infantile ALL include fever and bruises.

These and other symptoms can be caused by the infantile ALL. Other affections can cause the same symptoms. It must consult with a doctor if one presents any of the following problems:

- Fever.
- Bruises or bled easy.
- Petequia (flat spots, like dots under the skin produced by the bled one).
- Aching bones or joints.
- Masses that do not hurt in the neck, the armpits, the stomach or the groin.
- Pain or sensation of satiety under the ribs.
- Weakness or sensation of weariness.
- Loss of appetite.
- To detect and diagnose child ALL, there are tests that examine the blood and the bony marrow.

You can use the following tests and procedures:

1. Physical examination and precedents: examination of the body to check the general signs of health, inclusive the checkup of signs of disease, as masses or any other thing that seems to be abnormal. There take also the medical precedents of the diseases and the previous treatments of the patient.

2. Blood complete inventory (RSC) with differential: procedure by means of which a sample of blood is taken and the following aspects are analyzed:

- The quantity of red blood cells and platelets.
- The quantity and the type of white blood cells.
- The quantity of hemoglobin in the red blood cells.
- The part of the sample composed by red blood cells.

3. Aspiration of bony marrow and biopsy: extraction of a sample of bony marrow, blood, and a small chunk of bone, this is done with the insertion of a needle in the bone of the hip or the breastbone. A pathologist observes the samples of bony marrow, blood and bone under a microscope to check if there are signs of cancer.

4. Analysis cytogenetic: this procedure is done by observing under a microscope the cells of the blood sample or the bony marrow to check if there are certain changes in the chromosomes of the lymphocytes. For example, in the ALL, part of a chromosome moves to another chromosome. This is called "chromosome Philadelphia"

5. Immunophenotyping: this procedure is done by observing under a microscope the cells of the blood sample or the bony marrow to check if the malignant (cancerous) lymphocytes started by being lymphocytes B or lymphocytes T.

6. Studies of the chemistry of the blood: procedure in which a sample of blood is examined to measure the quantities of certain substances liberated to the blood for the organs and fabrics of the body. A slightly common quantity of a substance can be a sign of disease in the organ or the fabric that elaborates it.

7. X-ray photography of thorax: X-ray photography of the organs and bones of the interior of the thorax. An X-ray is a type of bundle of energy that can cross the body and to take form of a movie that shows an image of the interior of the body.

Certain factors affect the forecast (possibility of recovery) and the options of treatment. The prediction and the options of treatment depend on the following aspects:

The age and inventory of white blood cells in the moment of the diagnosis.
How rapid and how much diminishes the concentration of leukemia cells after the initial treatment.
The kind and the ethnic race.
If the leukemia cells originated in lymphocytes B or in lymphocytes T.
If certain changes demonstrated in the chromosomes of the lymphocytes.
If the leukemia has been spread up to the brain and the spinal marrow.
If the child suffers from Down's syndrome.

Fig. 2. a) Healthy blood cell b) Blood cell with ALL

2 Stages of processing

Where do we want to get?

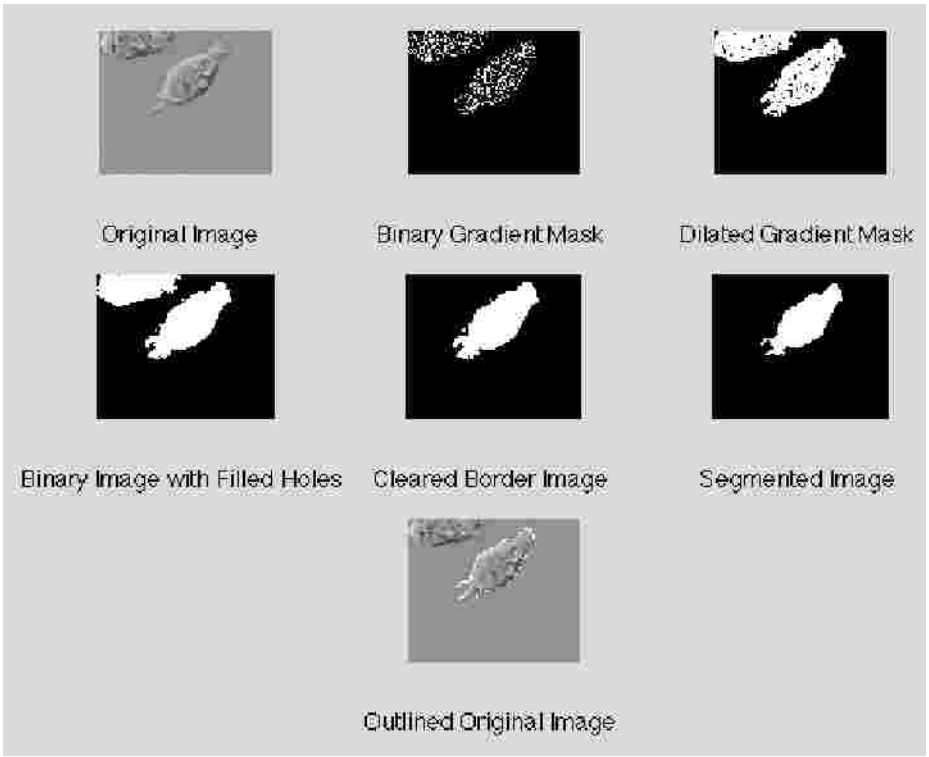


Fig. 3. To obtain a good segmentation in the images, there are methods of contour detection and basic instruments of morphology that later I will describe.

3 To read the image

In mat lab a scale of gray image is represented by a two-dimensional counterfoil of m x n elements where n represents the number of pixels of width and m the number of pixels of length. The element v11 corresponds to the element of the top left corner, where every element of the counterfoil of the image has a value of 0 (black) to 255 (white).

To read images contained in a file to the environment of mat lab the function is in use imread, whose syntax is imread (' name of the file ').

Where name of the file is a chain of characters containing the complete name of the image with its respective extension, the formats of images that are supported by mat lab.

To introduce an image saved in a file with one of the formats specified in the previous table, only the function has to be used imread and assign its result to a variable that will represent the scale of gray image.

Formato	Extensión
TIFF	.tiff
JPEG	.jpg
GIF	.gif
BMP	.bmp
PNG	.png
XWD	.xwd

Fig. 4. Format of image

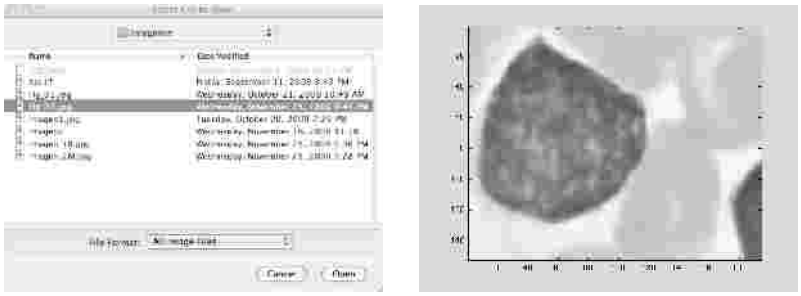


Fig. 5. An image is selected inside the bank of information that wants to be analyzed.

4 Segmentation (Detection of edges)

We spend to the second part of the stages of processing.

Functions for the extraction of edges x

In a computer like vision we proceed to the recognition of objects or segment regions, to extract the edges of objects (that theoretically delimit its sizes and regions). The function edge gives the possibility of obtaining the edges of the image. The function allows to find the edges from two different algorithms that can be chosen, *canny and sobel.* The format of this function is:

$$ImageT=edge\ (ImageS,\ algorithm); \quad (1)$$

Where ImageT is the image obtained with the extracted edges, ImageS is the variable that contains the image in scale of gray to which one tries to recover its edges, whereas algorithm can be one of the two canny or sobel. In such a way that if

to the image in scale of gray contained in the variable image gray its edges they want to recover him using in algorithm canny that would be written in line of commands:

$$ImageR=edge\ (imagegray,\ canny); \quad (2)$$

Definition of edge: to the pixels where the intensity of the image changes abrupt form. Significant reduction of the quantity of information and it leaks or filters the unnecessary information. It is the calculation of a local operator of derivation.
We detect edges using the operators of derivation:

Using the first derivative we have:

- Positive: change the levels of gray so the image is more clear.
- Negative: opposite case.
- Zero in zone of uniform grey.
- And for the second derivative we have:
- Positive value: dark zone of every edge.
- Negative value: clear zone of every edge.
- Value zero: gray zone is a constant value.

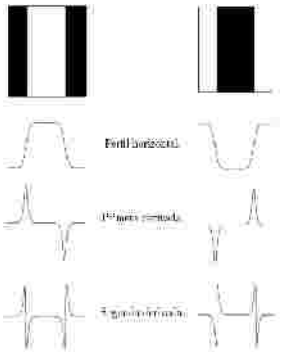


Fig. 6. We detect edges using the operators of derivation:

The value of the magnitude of the first derivative serves us to detect the presence of edges. The sign of the second derivative indicates us if the pixel belongs to the clear zone or to the dark zone. The first derivative in any point of the image will be given by the magnitude of the gradient the second derivative will be given by the operator Laplacian.

5 Edge's Methods.

EDGE finds edges in intensities of the image. EDGE takes an intensity or a binary image and returns a binary image BW of the same size that where the function finds edges. EDGE supports six different methods that find edge:

The Sobel method finds edges that use the approximation Sobel to the derivative. This returns edges in those points where the gradient of I is the maximum.

The Prewitt method finds edges that use the approximation Prewitt to the derivative. This returns edges in those points where the gradient of I is the maximum.

The Roberts method finds edges that use the approximation Roberts to the derivative. This returns edges in those points where the gradient of me is the maximum.

The Laplacian of Gaussian method finds edges for search cross zero after the filtration I with a Laplacian of Gaussian filter.

The method Zero-cross-country race finds edges looking for crossings for zero after the filtration I with a filter that you specify. The method Canny finds edges of the local maxim of the gradient of I. The gradient is calculated using the derivative of a Gaussian filter. The method uses two thresholds, to discover strong and weak edges, and includes the weak edges in the exit only if they are connected to strong edges. This method is therefore less probable than the others to be "cheated" by the noise, and more probably to discover real weak edges.

The parameters that are possible to give differ according to the method that you specify. If there is no specified method EDGE, it uses the method Sobel.

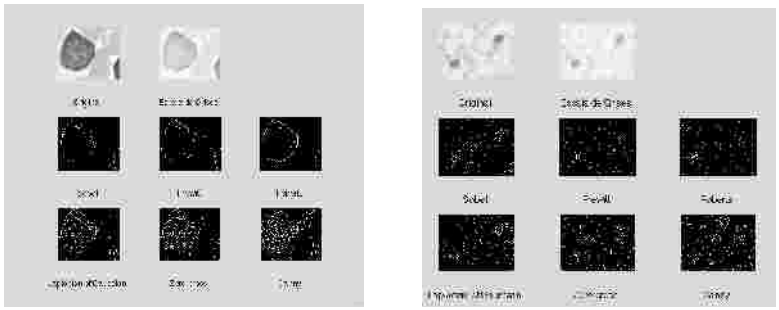


Fig. 7. Segmentation: a) Healthy blood cell. b) Blood cell with ALL

6 Histogram

The histogram is the representation of the density of probability of every value of grey for this image.

Both the histogram, and the hie histogram equalization, are vectors.
Equalizer the Histogram is to do everything possible to flat and separate everything. This is what the pixels do to distribute a whole range of values (from 0 to 255) and that in the image equalized will highlight details that before were not evident.

To generate an image with the histogram equalized several steps are needed:

1. The histogram of the image is calculated
2. To normalize the histogram (to divide it between the total number of pixels).
3. To calculate the histogram accumulated (the pixels to be added from the value 0 to 255, this will originate an increasing graph)
4. The application of the algorithm (since it is a question of counterfoils, it must be inside two sheltered curls):

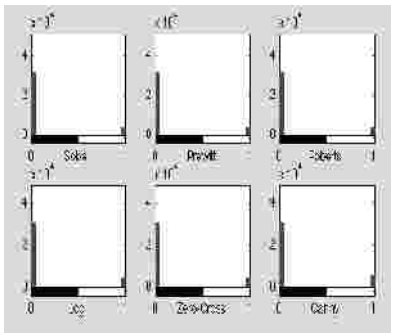
For values of the original image different from zero:

Imagen_ecualizada (i, j) = histograma_acumulado (imagen_original (i, j)) (3)

For equal values of the original image to zero:

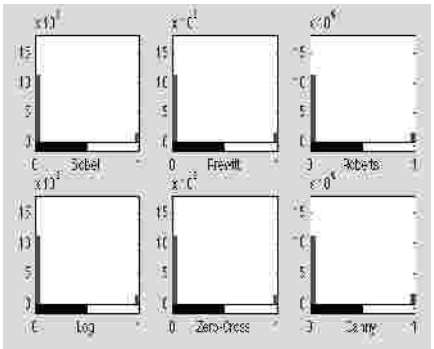
Imagen_ecualizada (i, j) = histograma_acumulado (imagen_original (i, j) +1) (4)

Where what goes in brackets is the index, or indexes, of every pixel of the image or of every value of the histogram. This way " original_image (i, j) " comes to indicate the index of the vector of the accumulated corresponding histogram. Hereby it is assigned to every pixel of the image equalized (or image with the histogram equalized) the density of accumulated probability corresponding to the value of the pixel of the original image. As this algorithm is done for Mat lab, and as Mat lab does not handle equal indexes to zero, it is considered that the histogram goes from 1 to 256, instead of 0 to 255. This way the density of probability of the value zero will be the one that is in the index 1 in the vector of the histogram.



Métodos de Detección.	Y
Sobel	520
Prewitt	505
Roberts	553
Laplacian of Gaussian	1628
Zero-Cross	1628
Canny	2374

Fig. 8. Histogram of the blood cell recovers of six methods Edge



Métodos de Detección	Y
Sobel	22915
Prewitt	22873
Roberts	22150
Laplacian of Gaussian	37880
Zero-Cross	37880
Canny	47156

Fig. 9. Histogram of the blood cell with ALL of six methods Edge.

7 Morphologic operations

One of the operations mostly used in vision on images before binarizadas is the morphologic operations. The morphologic operations are operations realized on binary images based in forms. These operations take a binary image as an entry

returning an image also binary. The value of every pixel of the binary image is based on the value of the corresponding pixel of the original binary image and of its neighbors. Then choosing appropriately the form of the neighbors to consider, morphologic operations sensitive to a form can be constructed.

The principal morphologic operations are the expansion and the erosion. The operation of expansion adds pixels in the borders of the objects, while the erosion removes them. In both operations like I mention there is a grid used that determines neighboring, which of the central element of the grid will be born in mind for the determination of the proved pixel. The grid is a checkered arrangement that contains *some and zeros*, in the places that it contains *some* will be the neighbors of the original image with regard to the central pixel, which will be taken in consideration to determine the pixel of the image, whereas the places that have *zeros* will not be born in mind.

$$ImageR=erode\ (ImageS,w); \quad (5)$$

$$ImageR=dilate\ (ImageS,w); \quad (6)$$

The image shows graphically the effect of the grid on the original image and the result in the final image.

Since it shows the figure only of the yellow pixels in the original image take part in the determination of the red pixel of the image that is finally revealed.

Morphology

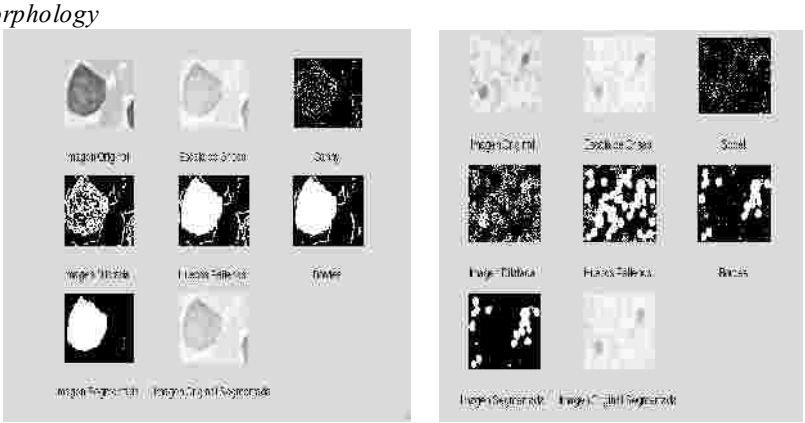


Fig. 9. Morphology: a) Healthy blood cell. b) Blood cell with ALL

Fig. 10. Comparison Image Segmentation: a) Healthy blood cell. b) Blood cell with ALL

8 Characteristic

Table. 1. Scales for the detection of the ALL morphologic classification of the ALL

Characteristic	L1	L2	L3	Mathematical Form
Cellular size	Small	Big	Big	Area or perimeter
Cromatina nuclear	Thin	Thin	Thin	Texture or histogram
Forms of the nucleus	Regular can have cracks	Irregular can have cracks	Irregular can have cracks	Circularity
Nucleus	Indistinguible	Big Nucleus prominent	Big Nucleus prominent	Area or perimeter
Cytoplasm	Scanty	Abundant	Abundant	Area or perimeter

Some formulas that we can use:

- Nucleus and Cytoplasm area,

$$area = \sum_{i} \sum_{j} seg(i,j) \tag{7}$$

where $seg(i,j)$ are pixels of segmented object.

- Perimeter: The perimeter is the sum of the pixels of the contour of the object.

- Circularity:

$$Circularity = \frac{4\pi \cdot area}{perimeter^{2}} \tag{8}$$

In our work we need an algorithm that helps us to classify the cells that are going to use the method of the diffuse logic. The diffuse logic is a technology of the computer like intelligence that allows to manipulate information with high degree of imprecision, it differs from the conventional logic that works with definite well and precise information.

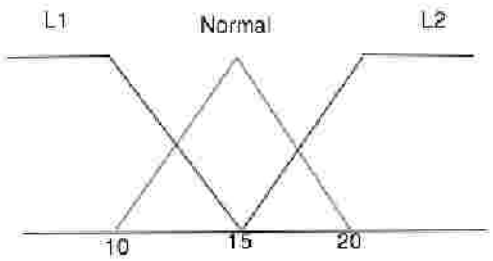
9 Fuzzy Logic.

WHAT IS THE Fuzzy LOGIC? The fuzzy logic is a methodology that provides a simple and elegant way of obtaining a conclusion from information of vague, ambiguous, vague entry that is incomplete, in general the fuzzy logic imitates how a persona takes decisions based on information with the mentioned characteristics. One of the advantages of the fuzzy logic is the possibility of implementing systems based on both hardware and software or in combination of both.

Normal Cell: 10-20 u diámetro.

L1: -20%

L2: +20%



10 Conclusion

We used two types of cells, a healthy cell and a cell with ALL. This way we could observe the differences between one and the other.
We considered six methods of segmentation for each of the cells, we also applied the morphology for each one.

We saw that the method Edge is not sufficient for the segmentation of the image with ALL, so I have decided to use another method (Histogram Equalization).

We are working on the extraction of characteristics of the cells this way we can implement the diffuse logic, the different diffuse sets are realized.

In the method of segmentation we use the function EDGE which has six methods: Sobel, Prewitt, Roberts, Laplacian of Gaussian, Zero-cross-country race and Canny.

We observed that the Canny method is the one that preserves more details, this way in the process of classification and recognition we are going to have a major certainty of analysis for it, I use the histogram of the images.

The part of the morphology is used to have a contrast of sufficient bottom; it is still necessary to improve some details to this part. we are still working on the extraction of characteristics of the cells, this way we can implement the Diffuse Logic, the different diffuse sets are realized.

Acknowledgements

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