Asesorías y Tutorías para la Investigación Científica en la Educación Puig-Salabarría S.C.
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RFC: ATI120618V12

Revista Dilemas Contemporáneos: Educación, Política y Valores.
http://www.dilemascontemporaneoseducacionpoliticayvalores.com/

Año: VI Número: Edición Especial Artículo no.:70 Período: Marzo, 2019.

TÍTULO: Identificación de imágenes anatómicas patológicas y mecanismo de marco para analizar.

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RESUMEN: En el trabajo se contempla el problema que surge al diseñar la base de conocimientos (KB) para las imágenes anatomopatológicas y las dificultades asociadas con la presentación de este conocimiento para el procesamiento de la máquina; esencialmente, las propiedades de la celda se cambian con el tiempo. Por consiguiente, las imágenes anatomopatológicas son dinámicas. A partir de la definición de objetos dinámicos en imágenes de video, se propone un algoritmo de marco para diseñar KB para las imágenes anatomopatológicas. Este artículo analiza el algoritmo de reconocimiento de objetos utilizando los métodos de estadística matemática y lógica matemática.

PALABRAS CLAVES: patólogo, imagen, reconocimiento, lógica matemática, estadística matemática.

TITLE: Identifying pathologic anatomic images and frame mechanism for analyzing.

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ABSTRACT: In the work, there is contemplated the issue arisen in designing the knowledge base (KB) for pathoanatomical images, the difficulties associated with presenting this knowledge for machine processing; essentially, the properties of the cell are changed with time. Consequently, the pathoanatomical images are dynamic. Proceeding from the definition of dynamic objects on video images, a frame algorithm for designing KB for the pathoanatomical images is proposed. This paper analyzes the algorithm of object recognition using the methods of mathematical statistics and mathematical logic.

KEY WORDS: pathologist, image, recognition, mathematical logic, math statistics.

INTRODUCTION.

When designing knowledge bases (KB) for an engineer faces difficulties related to the representation of knowledge for machine processing, since basically cell properties change over time. Consequently, pathological anatomical screenshots also change. This is a very difficult and fundamental problem in creating information system for pathological anatomical diagnostic (Rustamov, Akimishev, 2011; For, 1989; Sadykov, Kan, Samandarov, 1990; Palmer, Clifford, 2017; Foster, e al. 2011; Ghosal, et al, 2008; Kalinski, et al. 2008; Pavlidis, 1982; Pocepaev and Petrov, 2003).

In practice, there is no framing method for representing knowledge given in the form of images. Developing of such a method would enable practitioners to diagnose blurry changing pathological anatomical images. As is known, the frame can be declarative, procedural and procedural-declarative type. Depending on the context, these frames can be connected to call other frames, etc. They are trying to make structure of frame more flexible and freer. In particular, the widely used concept «Holes» or slots (Pocepaev. 2003; Li, et al. 2008).

A frame is some structure of data for representing stereotypical situation. Moreover, inside the frame there is similar setting tool of procedural and declarative parts, in particular condition for identifying of slots. But not all objects or phenomena amenable for such perception. Especially, living objects whose properties change in the course of time. One of these objects is pathological anatomical images of cells. Due to change in properties (slot) cell shape change and it is reflected in pathologic anatomic images.

On micrographs, cell properties differ not only geometric shape but in color brightness as well. In this case slots of these objects transform to amorphous property. This is clearly expressed in the blur of pathological anatomical images. In such a situation the process of slotization is independent. If we can somehow to simulate this process, we will be able to create frame-based knowledge for the analysis of pathological anatomical images and such kind of KB is very in demand today (Musat, et al, 2012; Musat, et al, 2008).

DEVELOPMENT.

Objective.

To develop an algorithm for representing pathological anatomical knowledge in the form of frames for the treatment images given in the form of fuzzy.

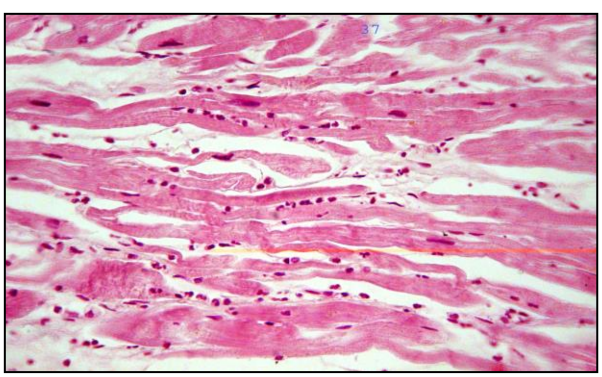
Method of solution.

To solve the problem, we process as follows. We assume pathological picture as a frame which has slots. Here slots express different structures of investigated cells (for example: core, vacuoles infiltrate etc.). Further on this frame is displayed in the digital space using of RGB program (Figure 1). Actually, this space expresses all patterns of studied object. It is necessary to be able to detect these patterns. The most difficult thing in this task is the structuring of this space to identify any consistent patterns. This kind of structuring is done by slotilization of frame images. When frame is slotilized it represents a specific fragment of general knowledge.

At the same time, we will have possibilities to find cause-effect relationships between these slots. The very procedure of identifying cause-effect relationships is equal to identifying of consistent patterns. As you know slot expresses a certain property of the object being studied. For example, we are given pathological anatomical image (Figure.1). At the first verbal analysis, it is difficult to identify any consistent patterns. To identify patterns of these images without processing the images itself, the image is displayed on the digital space using RGB program (Figure 2).

In practice, it is not possible to algorithmically slotilize such frames. Therefore, slotilize is partially carried by expert. He allocates certain slots on the frame which differ brightness in the image (2). Further on the basis of these slots determination of these slots is carried out.

Figure 1. Image frame of cell.



meaning RGB:

$$= A_{r,g,b} \qquad \begin{array}{l} R = \overline{0,...,255} \text{ - red} \\ G = \overline{0,...,255} \text{ - green} \\ B = \overline{0,...,255} \text{ - blue} \end{array}$$

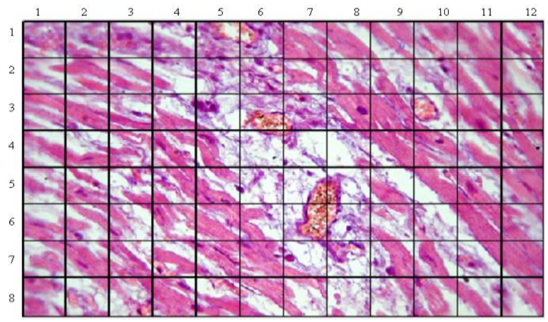
As it is seen in picture, pathological anatomical image (PI) has diffuse appearance. To get any information from this image, we need to define appearance of allocated slots on this frame. The interesting moment is that if the frame is not slotilized then we cannot get any information from it. Interpreting of property (value) of object inherent in image in frame of slots we can gain some knowledge about the object under study. Here slot takes role of information unit (ие_j).

The physical properties of object on image displayed as a brightness and a different shape. Since the image produced on the basis of lengthwise and crossing cut of object, the geometric shape of object on image can be expressed in different ways. And it makes more difficult to solve problem. But on brightness of image they are almost identical. Based on these considerations slotization can be done on the basis of brightness gradient. Actually, slotization of image is identical with structuring of data, for example in the form of table. In this case slots play role of attributes and allocation of time slots acquire independent task (Thompson, et al, 2012; Boser, Guyon, Vapnik, 1992; Ho, et al. 2006; Pantanowitz, 2010).

Pathological anatomical image as you see from picture 1 differs with its brightness of different figure and with their topological location. In order to gain any information from it, first of all we should analyze image which shows normal condition of part cell under study. After these procedures we could learn allocation of time slots. Actually, this task can be solved together with expert. In order to do this, first of all image with the help of RGB program is displayed in digital space. This space is fuzzy. It is indicated as $A_{i,j,\ell}^{k,m}$.

Hereunder slots it express frame content which is amenable to determinism, the structure of expressed object. On the picture 2 below frame image is shown and the image on RGB space.

$A_{i,j,\ell}^{k,m}$ =



→

	1	2	3	4	5	6	7	8	9	10	11	12
1	503	515	532	568	538	522	528	556	552	533	506	490
2	570	537	579	631	590	557	576	586	599	571	507	536
3	542	539	573	584	619	575	562	526	500	576	505	514
4	571	592	574	559	599	677	680	670	540	533	571	487
5	585	571	604	561	583	673	645	621	624	578	548	495
6	573	587	625	599	569	625	561	602	613	638	508	524
7	570	550	572	591	560	555	653	627	567	575	584	477
8	519	612	579	537	574	603	645	669	613	554	565	546

Figure 2. Pathological anatomical image digital space.

Display of frame image on RGB space, k=12, m=8

Slot in its content is a structural part of frame. Allocation of slot means to reduce blur. Slot allocation is as follows. Expert allocates the part of cell from image. Such part of cell can be cell nucleus, cell muscles, etc. As it is known that, cell structure is well studied. That's why expert looking at cell image could easily classify the cell structure. Each structure performs its function. When cell structure's mechanism of its function is broken, in our case it is with slots, and then pathological process is generated. These processes are reflected in the images of different brightness. Accordingly, digital space of the cell in the RGB space changes. It is clear that each slot (cell structure) on the levels of pathological changes in brightness in the image. This is reflected in the overall Pathological anatomical image (Figure 2). Allocation of slot is performed by expert:

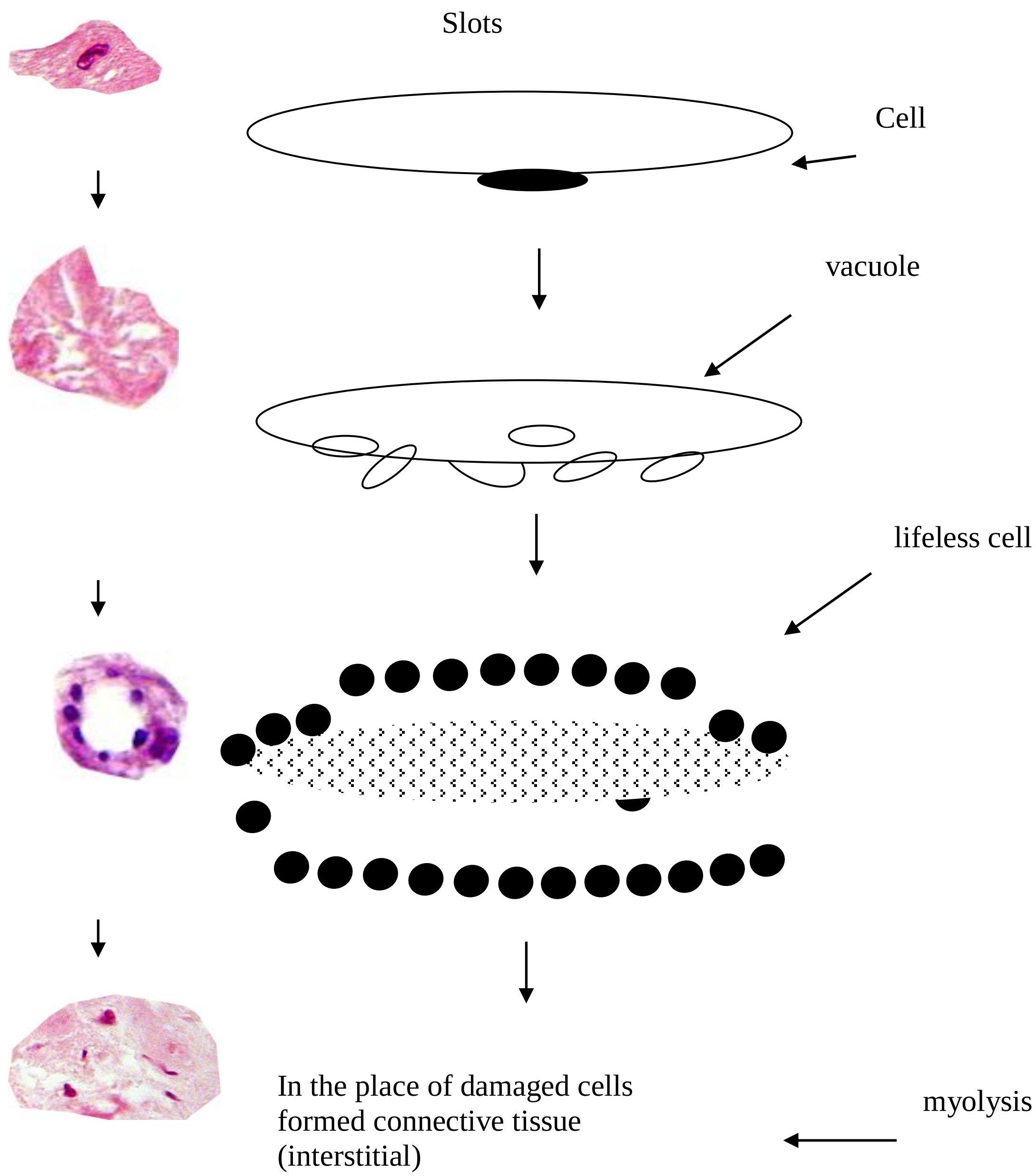


Figure 3. Slotilization of RGB image.

On the basis of these slots we build numerical criterion for ε - appearance of slot on sliding fragment. The building of such criterion is carried out on training images. Next, using of this criterion we determine appearance of slot on sliding slot (Weinstein, et al, 2009; Gilbertson, et al, 2006; Williams, et al, 2010; Della Mea, Bortolotti and Beltrami, 2009; Evans, et al. 2009; Villegas, Villegas, and Hidalgo, 2018; Difranco, et al. 2011). This determination is expressed in percentage appearance of slots on sliding fragment. After building RGB space of image, it will be determined how much place RGB - slot (its value) will take in the general RGB space frame - images. We will consider algorithm of slot allocation in the area of image changing properties of object, received from pathological anatomical image. In the picture of pathological anatomical image of same size (nxm) pixels which are defined by calorimetry is given in three color components.

$$c_1 = f_{C_1}(i, j), c_2 = f_{C_2}(i, j), \; c_3 = f_{C_3}(i, j) \;, \tag{1}$$

where $0 \le i \le n-1, \;\; 0 \le j \le m-1$. In color model of RGB components of color are changed from 0 to 255 (2).

If, color of pixels $p = (i, j)$ и $p' = (i', j')$ based (1) are given in the following proportions of color component (c_1, c_2, c_3) and (c_1', c_2', c_3'), i.e.

$$c_1 = p_{C_1}(i, j), c_2 = p_{C_2}(i, j), \; c_3 = p_{C_3}(i, j),$$

$$c_1' = p_{C_1}'(i, j), c_2' = p_{C_2}'(i, j), \; c_3' = p_{C_3}'(i, j).$$

The distances between colors are calculated in the following way:

$cd(p, p') = \max\{| c_1 - c_1' |, | c_2 - c_2' |, | c_3 - c_3' |\}$.

This kind of constant is introduced δ_c, if condition is followed $cd(p, p') \le \delta_c$, then points (p, p') are considered in same color. The distance between pixels are calculated by euclidean distance $\rho(p, p') = \sqrt{(i - i')^2 + (j - j')^2}$.

Let us suppose that $S = (S_{c_1}, S_{c_2}, S_{c_3})$ - is image of slots, $S^{\varepsilon} = (S_{c_1}^{\varepsilon}, S_{c_2}^{\varepsilon}, S_{c_3}^{\varepsilon})$ - a model for localization of information area.

The problem is formulated in the following way: it is necessary to find a localization fragment (slot) $S' = (S_{c_1}', S_{c_2}', S_{c_3}')$, to follow condition

$E_q = \left| S' - O(S^{\varepsilon}) \; \right| \le Th$.

Here $O = C \circ I \circ M \circ R$ – compositing sequences of operators:

$C : S' \to S'_0$ – perform converting color images to binary;

$R : S'_0 \to S'_1$ – perform rotation to center S'_0 to some degree;

$M_1 : S'_1 \to S'_2$ – perform conversion scale S'_1 on vertical and on horizontal;

$I : S'_2 \to S'_3$ – perform conversion to improve quality;

Th – adaptive threshold for S^{ε};

E_q is calculated by formula

$$E_q = \left| S - S' \right| = \frac{\sum\limits_{p \in S, p' \in S', \rho(p,p')=0} cd(p, p')}{\Omega},$$

where Ω – area $S \cap S'$.

For executing the statements O ($\circ$) we will use algorithms given in (1,2,4).

To solve the problem of identification of localized fragment we will use an approach based on reference points. For this, first of all perform pretreatment fragment, then - a compare with a standard.

Image preprocessing consists of several stages: low-pass filtering, median filter, edge detection. You can use the mask size 3x3.

In the next step the choice of reference points is carried out using the following function:

$$g(p,p')=\alpha\cdot\rho(p,p')+(1-\alpha)\cdot cd(p,p'),\ (0 \le \alpha \le 1).$$

Decision-making in access control systems is solved by classifiers depending on their applications and associated dynamic objects.

Next, we present an algorithm for recognizing numbers and numbers on the image. Preliminary form the standards of the images of characters A, B, ... Z, 0, 1, ..., 9, i.e. form the classes K_1, K_2, …, K_{36}. In each class of binary image objects encoded in 1 (Black - 0) and 0 (white - 255) . Writing a code line by line each localized area, binary image in a rectangular form is formed.

In general case image cod is expressed in this type x_1, x_2, …, x_n. Here n – number of squares, x_i – takes values 0 or 1. On the basis of informative feathers of binary images of these objects their standards are formed.

The algorithm of this process consists of the following steps :

1. Take the grid size n*m.
2. Set the image in the grid.
3. Code in the following way:

$$x_{ij} = \begin{cases} 1, \text{If the part of image is run into cell otherwies;} \\ \text{other} \end{cases}$$

4. Fold the columns of the resulting matrix and obtain the vector codes z.
5. Add the elements of the vector z, and assign the result of s.
6. We will divide s into element numbers z, different from zero, and obtained and obtain value is taken as the threshold δ.
7. We will form reference image with respect to the threshold δ.

$$Z_i^{Э} = \begin{cases} 1, \text{ if } z_i \geq \delta; \\ 0, \text{ if } z_i < \delta \end{cases}$$

8. Getting the training set T_{nml}.

Further, alogoritm defines the following properties of Slots:

1. Cause & effect identification. Slotilization (Figure 3) is to be calculated by identification of available separate slot percentage in digital RGB within frame space.

For this purpose, digital intervals in the space of is determined for each slots with help of RGB program. Namely these intervals will be criterion of the slots existence in ‹‹sliding fragment››.

II. Identification of slot content percentage in frame.

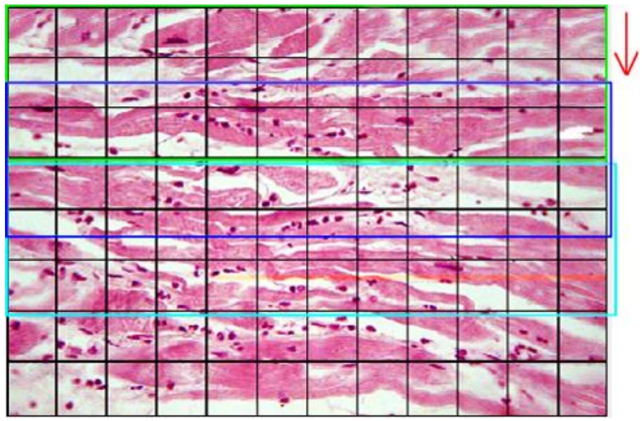
Identification of slot content percentage in digital RGB in space as:

$$\Gamma^{\rho}_{r,g,b} = A^{k,m}_{r,g,b} - B^{k'',m''}_{r,g,b} = \begin{cases} \varepsilon > 0 \text{ - Slot of interest in this pixel does not exist} \\ \varepsilon < 0 - \text{Slot of interest in this pixel exists} \end{cases} \quad (1)$$

Here $A^{k,m}_{r,g,b}$ - frame – image, $B^{k,m}_{r,g,b}$ - ‹‹sliding fragment›› in frame – image.

Procedure on identifying of existing slot (3) in fragment $B^{k'',m''}$ is performed with the help pixel subnet in this fragment. Images are represented with pixels. And for each pixel slot percentage is identified, which expresses its existing in the pixel. For selected slot digital RGB space is build (2). Digital meaning for this slot is identified in digital space and digital interval is built for this slot. From frame φ, $\varphi = A^{k,m}_{r,g,b}$ we separate fragment φ', $\varphi' = A^{k'',m''}_{r,g,b}$ and with the help of this fragment with sliding we cut all RGB space.

Fragment sliding



Pixel sliding

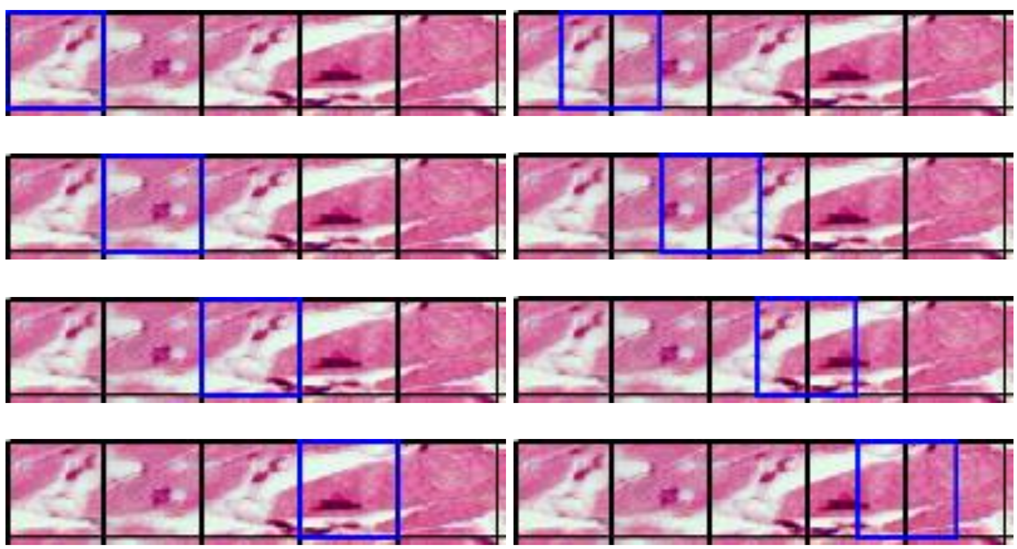


Figure 4. Algorithm of fragment sliding and pixel sliding.

The above described procedure is called procedure of training. Procedure of pathological anatomical diagnostic is performed by procedure of ‹‹election››. Election is performed by identifying meaning of percentage ratio of slot ε in recognizing frame φ.

Decision will be made by estimating the percentage.

$$L^{'}/L \cdot 100\% = Q$$

Here is the procedure of decision:

$$Q = \begin{cases} \varphi_1 \text{ - frame refers to the stage of the disease A, if } Q = b\% \\ \varphi_1 \text{ - frame refers to the stage of the disease A if } Q \neq b\% \end{cases} \tag{2}$$

CONCLUSIONS.

Application of this method in practice of pathological anatomical diagnostic gave very good result. Actually, the procedure (2) is pathological anatomical diagnostic. It is definition of common factors in pathological changes in cell.

On the basis of this procedure for frame-image, the slot gets its color and brightness (Gabril, Yousef, 2010; Patterson, Rayo, Gill, Gurcan, 2011; Huisman, et al. 2010; Evered and Dudding, 2010; Mora, 2016). After determining the percentage content of slot in frame we can solve the problem related to the diagnostic. For this purpose, we build frame for normal cells, identify percentage content of selected slot, on the basis of these values we build KB for this pathology. After creating KB, we can begin to solve problem of diagnostic, in other words recognition of it.

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RECIBIDO: 4 de febrero del 2019. **APROBADO**: 16 de febrero del 2019.