DIRECT SEQUENCE INTELIGENT APPLICATION CONSIDERING PATTERN RECOGNITION METHODS

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ABSTRACT

The paper will present some aspects concerning intelligent applications in microscopic medical image processing and a dedicated intelligent application in this domain. The application is developed using Microsoft Visual C++ 6 software and the MFC libraries. Some considerations concerning pattern recognition and multi-sensorial human perception are also presented.

1. INTRODUCTION

Pattern recognition is a very difficult task in image analysis. We developed an image analysis program, named FORMDET, which implements a pattern recognition and form detection method based on Fourier and statistical descriptors, [9]. For this implementation we used the latest concepts of visual and object oriented programming from Microsoft Visual C++ Development Environment under Windows'9x and NT.
The objective of this work is to create an efficient and powerful instrument for image analysis and pattern recognition for use in varied domains: medical applications (diagnosis, microscopic analysis), industrial applications (defectoscopy, granulometry, inspection), and others. The application is hardware independent considering an image frame-grabber, but has the possibility to consider the standard MCI (Media Control Interface) and Video for Windows offered by (semi) professional frame-grabbers and multimedia boards.

2. PATTERN RECOGNITION METHODS AND QUANTITATIVE MEASUREMENTS

In image analysis systems a lot of dedicated pattern recognition methods are used. These methods are:

-theoretical - decisional methods, based on different features

-syntactical methods, or structural methods

-combined methods.

We developed some program applications considering these methods, [8] and we try to improve all the facilities constantly in our new applications.
The pattern recognition methods are very dedicated to the process that must be measured. In some applications it is possible to use simple methods with good results but usually good results is very hard to obtain. Pattern recognition methods usually consider the human perception like a model but we do not know precisely in this moment how works the human perception and how human process information to make so fast and accurate decisions.
A lot of sophisticated methods are developed in this domain of pattern recognition but we think that human perception is more simpler and efficient and simpler methods could offer better results and simpler methods could offer better results.
In our application we used quantitative and frequencies features considering an image processing application. Image processing stages are, [4]:

- low-level processing (input and output data are images represented by pixel matrices)
  - acquisition, visualization;
  - image improvement;
  - emphasize of essential characteristics;
- intermediary processing (input data are images and output data are represented by symbolic structures)
  - feature extraction:
    - locals
    - global
- high-level processing (operating on symbolic representations)
  - image recognition based on patterns
- results interpretation.

The objective of image analysis is to determine the objects, which appear in the image, and to describe the surfaces of these objects. The input is a digital image and the output is a symbolic representation of the initial image. The first step in image analysis is to determine object boundaries. This can be made by edge detection techniques, followed by an algorithm of edges following and closing, or other local or global methods.
Another problem, which appears in image analysis, is region segmentation, by which it tries to identify the homogenous regions of the image. The final purpose is object recognition, which can be made by using a model database or other adequate techniques,

and in this mode to obtain a correct interpretation of the results.
The quantitative parameters of objects considered after measurements by our applications are: perimeter, area, form factor, eccentricity, regularity, undulation factor, mass center coordinates, minimum, medium and maximum axis. These parameters can be used for a first identification of image objects and a classification of these objects based on their size and the statistical analysis. The estimation of quantitative parameters is made as based on object area (A), perimeter (P) and edge points coordinates that are found first.

3. FREQUENCY SIGNAL DOMAIN AND PATTERN RECOGNITION

Fourier descriptors could be used to evaluate the contour of an object, [3]. After we have estimated objects edges from one image as points arrays, we can consider that one edge point (x(i) , y(i)) can be represented as a complex number, as follows:

u(i) = x(i) + j*y(i);

So the edge of one object can be considered as the function

u(n) = x(n) + j*y(n)   for n = 0,1,...N-1

which, for a closed edge, is a periodic function with period N.
Its DCT representation is:

$$u(n) = \frac{1}{N}\sum_{k=0}^{N-1} a(k)\exp\left(\frac{j2\pi k_n}{N}\right) \quad 0 \le n \le N-1$$

from where

$$a(k) = \sum_{n=0}^{N-1} u(n)\exp\left(\frac{-j2\pi k_n}{N}\right) \quad 0 \le n \le N-1$$

Complex coefficients from DCT transform applied to edge function u(n) are the ***Fourier Descriptors.*** These descriptors can be used for the recognition of similar objects even if they have different orientations or dimensions.
Considering a(k) and b(k) the Fourier Descriptors of the searched object u(n) and respectively, of the known model v(n). The shape of the object is similar to that of the model if the distance:

$$d(u_0,\alpha,\phi_0,n_0) = \left\{\sum_{n=0}^{N-1}\left|u(n) - \alpha v(n+n_0)e^{j\phi_0} - u_0\right|^2\right\}$$

, is minimal.
The parameters are chosen so that the translation, scaling and rotation effect is minimal. If u(n) and v(n) are normalized:

$$\sum u(n) = \sum v(n) = 0,$$

then, for a known translation u_0, distance d is minimal, when:

$u_0 = 0$

$$\alpha = \frac{\sum_k c(k)\cos(\Psi_k + k\phi + \phi_0)}{\sum_k |b(k)|^2}$$

$$tg\phi_k = \frac{\sum_k c(k)\sin(\Psi_k + k\phi)}{\sum_k c(k)\cos(\Psi_k + k\phi)}$$

, where

$$a(k) * b(k) = c(k)e^{j\psi k}, \phi = \frac{-2\pi n_0}{N}$$

and c(k) is a real number.

Considering a “multi-sensorial perception” based on different signals processing some philosophical papers consider that human perception could be considered as a discrete sequential environment perception with simultaneous, five (penta), different levels of processing. There are some other opinions [7], but we consider that only the visual perception don’t always represent the preponderant element in this complex process of perception. At any level we may consider some aspects concerning energy, frequency vibration, the form manifestation, etc. We may have feed-backs and influences among all these levels. Referring to intelligent applications we may consider multi-sensorial systems with different transducers that can process all the information and to assist the user in the analyzed process, including in the pattern recognition domain. Different types of information must be used to obtain a consistent decision.
We may consider a top-down or a bottom-up strategy. In each strategy and at each level perception it is possible to identify elements of pattern recognition. On a top-down strategy the 5 level of perception could be:
-First level, a potential state that the human analyze first globally. The form perception could be a circle or more general an ovoid in plane. The frequency perception considers in this case the sounds that could be heard by the ears. The color perception could be black or indigo. Form factors can be considered for image analysis.
-Second level, a movement level analyzed by touch. The mathematical morphology based on a hexagon grid is a very good methodology that could be used at this level considering image processing. The color that influence the human perception at this level could be blue.
-Third level is characterized by heat and eye perception (visual perception). In this case normal,

infrared or other cameras could be used to acquire images. An expansion process is characterized at this level. The color that could be considered at this level is red.
-Fourth level, the movement is limited at a well defined space considering a defined radius. The fluidity is specific for this level and the color perception could be silvery white. The specific form feature will refer to an ellipsoidal consideration of images.
-Fifth level, is the most rigid level and at this level the cohesion is specifically. The square is the form that may be considered in the activity of image processing. The color perception is clayey yellow. Being the most rigid level the earth frequency could be considered as a reference frequency.
On bottom-up strategy a fractal strategy could be considered.
It is possible that “the human signal perception” considers simple operations on a multi-level perception with a very efficient storage, communication and access of information. It is possible also that the holographic model could solve this very difficult problem of intelligent perception in dedicated systems.

4. PATTERN RECOGNITION METHODS AND DEDICATED MEASUREMENTS

The application FORMDET, [10] was developed as a general image processing application with different dedicated measurements. A DLL (Dynamic Link Library) strategy was considered for dedicated applications. Fourier and statistical descriptors were considered for the pattern recognition process. Mathematical morphology operators for gray-level images were also implemented. This application allows to obtain better results like our previous works, [8]. Some dedicated measurements obtained and confirmed by the FORMDET application will be presented as follows.
With the *quantitative parameters* of the objects (features) we can separate different pattern classes. Experimentally we separated circles, rectangles, squares, stars, and irregular objects. In medical applications, we used this method to separate nuclei, micronuclei, mitoses, using a dynamic adaptability model method, [2].
This dynamic adaptability model method can be used in a lot of domains of interest, [1]. In the recognition stage, we determine an attributed distance between the model features, $atrb_i.mod$ and the real features $atrb_i$ with:

$$d_{atrb} = \sqrt{\sum_{i=1}^{n} \left[\left(atrb_i.\mathrm{mod} - atrb_i \right) / atrb_i.\mathrm{mod} \right]^2}$$

We can impose weights to any feature, and in this case we will determine a weighed attributed distance.
The method is relatively simple and can be used in medical or industrial applications if the acquired image has a good quality, [6].
Considering this method we developed a dedicated application in the biotechnology vitro colony to determine sexual cells. We have performed a quantitative and qualitative study of ovocytes, gametes and embryos at the animals. We have determined the inner and outside diameters, obtaining the circles, and by extrapolation, the spheres, which approximate the ovule.
We can detect the development degree of the cell and the gamete density from the colony.
Another dedicated application was developed to detect the microorganism concentration in liquid solutions to analyze foodstuffs.
This application automatically determines the number (concentration) of the microorganisms developed in foodstuffs. This concentration is directly proportional to the quantity of light absorbed by the infected solution. In order to eliminate the errors, a reference area has been determined having a constant intensity. Upon analysis of the intensity of the reference area, we detected correction coefficients. This application allows to instantly establishing the concentration of microorganisms in a liquid medium. We made measurements on Stafiloccocus Aureus strains with a concentration up to 10^7/ml.
The recognition of corpuscles using microscopic images considers two methods of pattern recognition:
-a model pattern recognition method, based on comparison of the contours of bodies with models from a previously constructed model library. If the error is small enough, the detected body is considered identical to the library body. Tests on cocci of staphylococcus and streptococcus type and Antracis bacilli have been made. The recognition ratio was 80-90% for isolated cocci and 80% for isolated bacilli.
-recognition of bacilli by detection of parallel segments from the image. Being oblong shaped cells, the bacilli can be detected even from clusters. In this case, pairs of parallel segments are considered as one of its characteristics. According to the weight of these parallel segments, we decide if it is a single bacillus or a cluster of bacilli. This method was tested on Antracis bacilli and Pioceanic bacilli. 70% of the isolated clusters and 80% of the single microorganisms were detected.

Considering the *Fourier Descriptors* of the searched object we can determine α and ϕ_0, and the minimum distance for the matching process will be:

$$d = \min\left\{ \sum_{k}^{N-1} \left| a(k) - \alpha b(k) \cdot \exp[j(k\phi + \phi_0)] \right|^2 \right\}$$

This method offers good results considering microscopic images, [9].

Considering *invariant moments*, [4] we try to develop a pattern recognition method too. These method use invariant moments based on different degree inertial moments, but the results were irrelevant in the recognition process.

In the *DNA measurement* process we are trying now to use pattern recognition methods based on OD, optical density and color representation. If we consider the optical density of some regions, the intensity level can be irrelevant in some cases, the constancy of the color being a very important element. In this case, different algorithms were developed to maintain this element considering RGB representation and YUV representation, [11]. The results show that RGB representation is more adequate in pattern recognition techniques, Willemse, [11], C.D.Fermin, [5].

5. CONCLUSIONS

Image analysis and pattern recognition methods can be used in different dedicated applications from microscopic medical and industrial images to macroscopic image too, [6]. The adequate ratio, price/performance of multimedia boards allow to develop low cost application in different fields considering multi-sensorial signal acquisition.

6. REFERENCES

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