

SEGMENTATION BY EXTRACTION

Gisolfi A., Vitulano S.

Dipartimento di Informatica ed Applicazioni, Facoltà di Scienze
Università di Salerno (Italia)

INTRODUCTION

The idea that very close relationship must exist between the "physical world" and the "perceptive world" has been contradicted by a series of experimental findings which evidence "blindness" cases (those cases that even existing in the visual field we are unable to see) or "illusions" (in which case we see non-existing objects).

The information we receive from the external world, which is thereafter transformed by the eye into a new stimulus, poses the question of how the information could be during the perceptive process.

We are yet unable to answer this question and the only thing we can do is to introduce two theories which attempt to describe two different perceptive models.

Those two models are:

First, the Atomistic and associativistic psychology hypothesizes that to every nervous impulse there corresponds an "elementary sensation" (atom) with a bijective correspondence between the "proximal stimulus" and the sensations.

Superior mental faculties such as: memory, judgments, reasoning, would act in a more or less "unconscious" way on the elementary sensations yielding "wider" perceptive units

which are the objects of our experience.

We do not believe it is necessary to discuss in detail such a theory which (with its hypothesis) is not verifiable experimentally and seems to explain every process but actually ends up mixing the problems which lay at the basis of the perceptive process and assign to animals of the lowest rank of the zoologic scale, intellectual data not found in other researches.

Second, a completely different approach to the problem is that suggested by the Gestalt psychology (form) in which the "direct experience" is fundamental. It is a phenomenological method which consists in a "measure" of the interaction between the physical field of the perceived object and that of the perceiving person, without the need of interpretation or rationalization.

We have pointed out that the physical field of the object, rarely coincides with the whole visual field, (but depends on it) and thus we need to define the mutual "influences" between these two fields. In other words, which is the role played by the object and which is that of the background. The substantial difference between the Gestalt theory and the Atomistic theory is that the latter resorts to an "a priori" conscience of the perceived world, while the former obtains all the necessary information of the perceptive process from the context. From this follows the need of "laws" able to extract and organize the information content of the perceptive field or, in other words, the need for a determination of the laws able to transform the perceptive field into a structured set.

THE ROLE OF THE STRUCTURES

A serious discussion of the role of structures in the cognitive and perceptive processes can not exclude the remarkable contribution, after so many years of research effort, done by Bela Julesz, seeking a solution to such a problem. As a matter of fact, in his paper (1) Bela Julesz summarizes the main problem of cognitive and perceptive processes in his question:

Why, in vision, there exist two developed systems, one for the circumscribed examination of the form and another for the global perception?

concluding after:

The answer can be found in the fundamental dichotomy of perception, which separates the objects in figure and background. It is the "selective" attention which separates the figure from the background and the knowledge of the circumscribed form from the global perception of the structure. We can, thus, consider the global discrimination of the structures as a very general process which implies the perception of all objects falling outside the center of our attention.

From the above discussion the role that structures have in the cognitive and perceptive processes emerges and we think that a possible answer to the fundamental problem can be posed as follows: "In perceptive and cognitive processes we need two phases: the first one in which the recognition of all existing structures in the visual field is performed and, second, that in which a "compound" structure puts together the structures extracted in the first phase.

It is actually the structure generated in the second phase

which "describes" the "hosted" forms in the visual field. B.Julesz has proposed an original and interesting statistical method for the discrimination of structures, but we arrive at the conclusion that, for the problem in consideration, that is irrelevant.

We think that the main contradiction in the method proposed by B.J. is that he attempts somehow to fuse together the atomistic approach with the structural one. In fact, he starts his analysis by constructing a series of atoms, characterized by different statistics, and through them he tries to describe and discriminate the different structures. We think that the best way to illustrate our approach is given by an example: the textures.

Let us say, briefly, that the recognition and description of textures play an essential role in perceptive and cognitive processes, and many researchers have already proposed several approaches for its solution. We can thus consider the whole problem as a self-consistent science.

We think it is useful to recall some definitions of textures proposed by us several years ago (2):

DEF 1. A discrete function

$$y = f(x_1, x_2, \dots, x_n)$$

defined in a discrete n-dimensional domain is said texture if there is at least a partition

$$S = \{S_1, S_2, \dots, S_k\}$$

of the domain such that an isomorphism exists among every element of the partition.

DEF 2. The discrete function

$$y = f(x_1, x_2, \dots, x_n)$$

defined in a generic element S_i of S , is said a

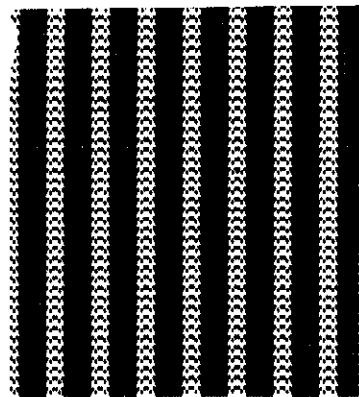
"piece of the texture".

We believe textures are a good example of structures and we propose, for their description, to use a "piece of texture" and the domain of the function $y=f(x_1, \dots, x_n)$.

In the next section we illustrate some proposals for the identification of the "piece of texture".

IDENTIFICATION OF TEXTURES

Let us consider a theoretical texture whose domain coincides with the whole visual field, (Fig.A).



Let us perform a partition of the whole domain and impose that the elements of the partition be all equal, e.g. a 2x2 pixels. Let us now verify if among all the elements of the partition there exists an isomorphic relation.

If one does exist, then we have characterized the structure and its description can be made through a vector which represents the behaviour of the grey tones inside the partition element and the dimensions of the texture domain.

If the isomorphism is not found, we increase the dimensions of the partition element until we reach the isomorphism. If there are several textures in the same visual field, we iterate the process as many times as the number of textures present. In this way we arrive at a segmentation of the visual field in relation to the texture-structure forming it. When we work with real images it is not possible to talk about isomorphism but instead we talk of likeness among the forms of the pieces (among the partition elements) and it is necessary to introduce a criteria of evaluation for the forms. Two of them are briefly described. The first acts on two different parameters: the first parameter results from the comparison of grey tones among the homologous pixels in different partition elements. The second parameter measures the form of the structure part contained in every partition element and then compares the extracted forms. All those elements that differ on the basis of their grey tones in relation to the threshold are then placed in the same structure.

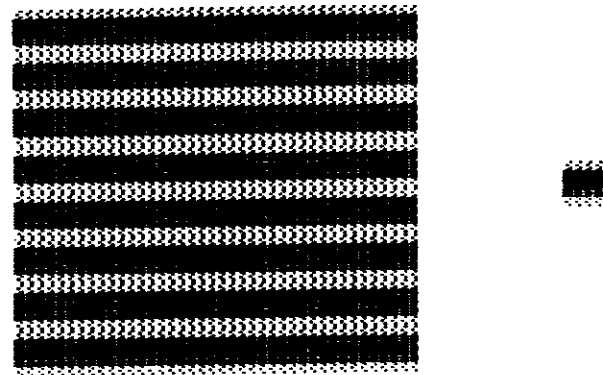
This threshold is determined "a priori" by the examination of the hystogram whose form satisfies a certain isomorphism. The second uses the "clustering" of all the partition elements and, according to the classes, codifies all the partition elements which belong to the same class as belonging to the structure.

EXPERIMENTAL RESULTS

In this paragraph, we would like to better illustrate several aspects pointed out in our previous discussion.

In fig.1 we present a theoretical texture which satisfies,

on the whole domain, definition 1. In fig.2 the substracted "piece" of texture which satisfies definition 2, is shown.



In fig.3 we present a real texture, the sea, digitized in a 512x512 pixels matrix with 256 grey levels.

In fig.7-10, we show the results obtained applying our algorithm to filagree.

Figs. 11 - 15 show the results obtained applying the algorithm to a T.A.C. image, by processing the radiography and not substracting the signal directly from the T.A.C. machine. It is useful to point out some observations regarding experimental results, briefly shown in this paragraph:

- a) only one algorithm has been used for all the images
- b) the experimentation on T.A.C. images, radiographies, and thermographies, has shown that it is possible to discover eventual malformations of inner, organs, when they present deformations of the same structure of the organ and blood vessels, with consecutive alterations in the case of

thermographies.

It is at the "development stage" that T.A.C. images, could represent organs and their respective structures in 3-D.

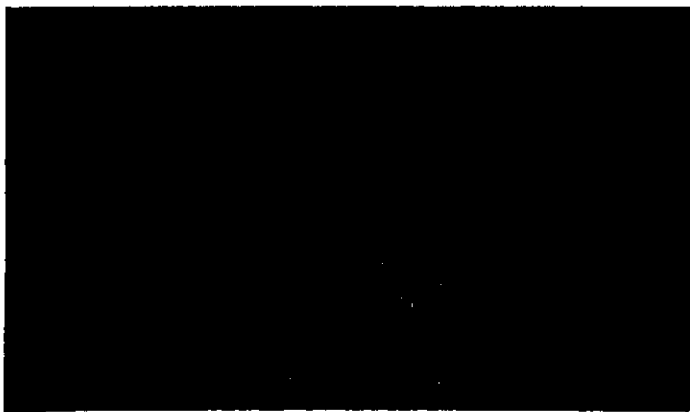


Fig. 3 - Real texture in false colors.

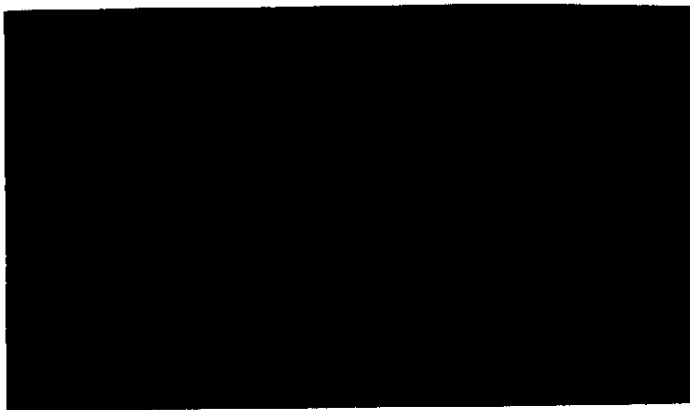


Fig. 4 - Several regions found in fig.3, every color represents a different region.

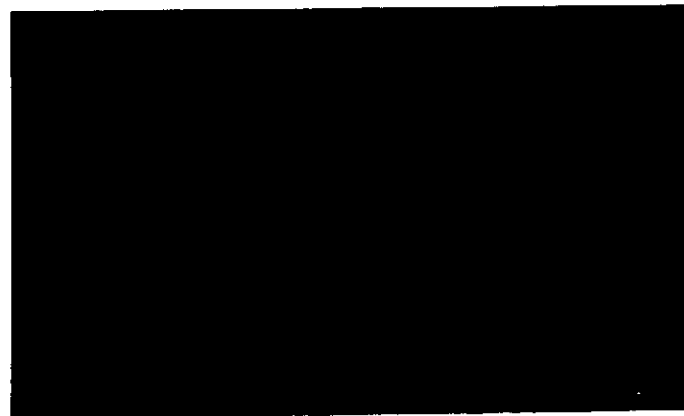


Fig. 5 - Suppression of a piece of region, structural magnitude of fig. 3 image.

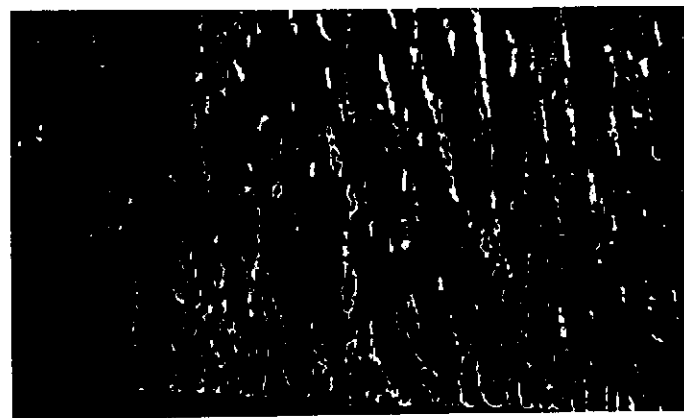


Fig. 6 - Contours of the individualized region of fig. 3 image.



Fig. 7 - Filagree, the star, embedded in the sheet structure.

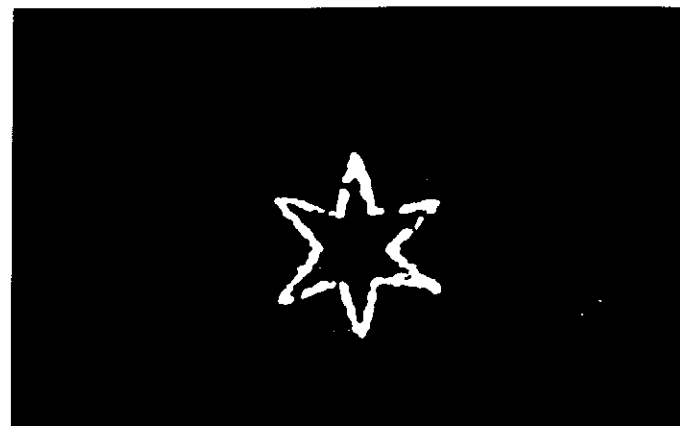


Fig. 9 - Filagree subtraction.

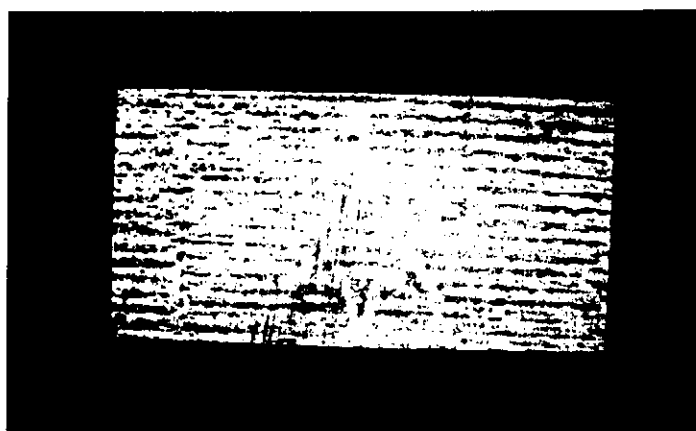


Fig. 8 - Background subtraction.

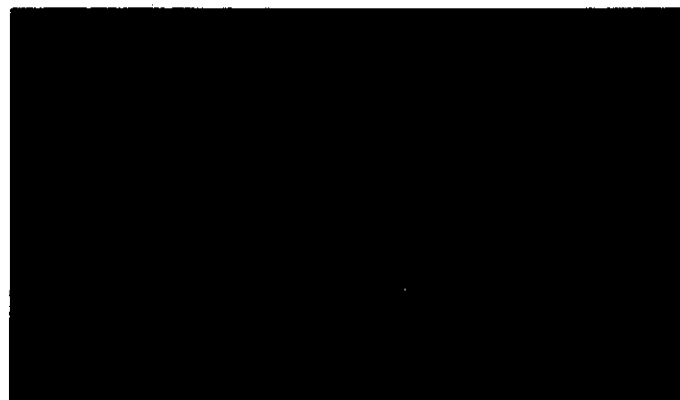


Fig. 10 - Filagree after thinning process.

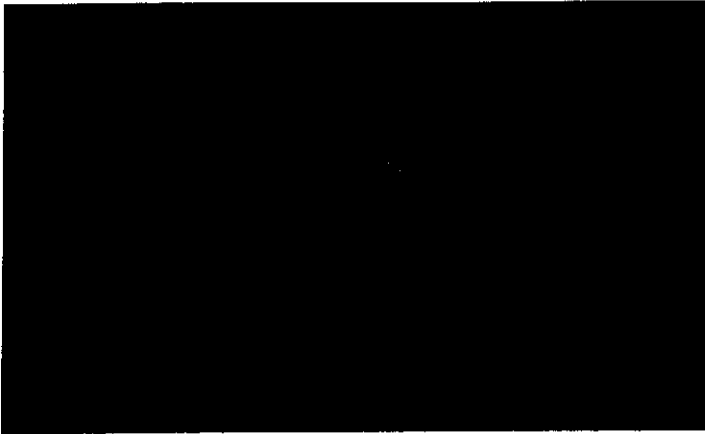


Fig. 11 - Original T.A.C. image digitized in a 512x512 matrix with 256 grey levels and represented with false colors.



Fig. 13 - Several evidenced regions, every color is a region.

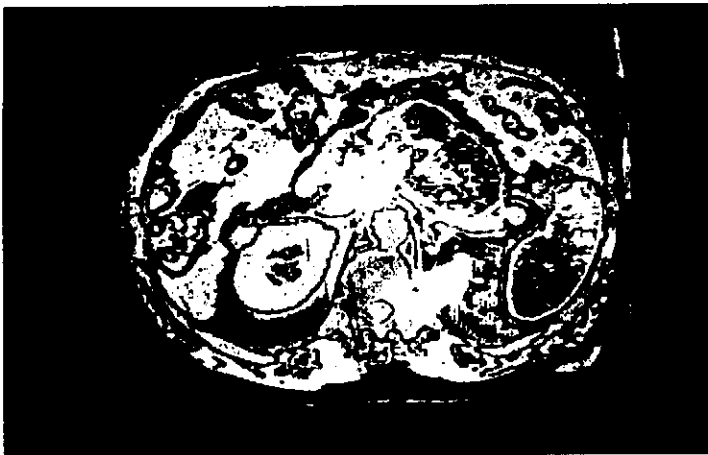


Fig. 12 - Background elimination.

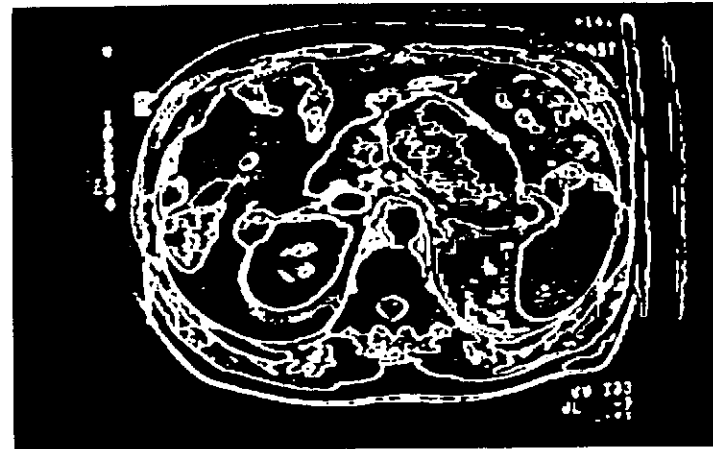


Fig. 14 - Contours of several regions.

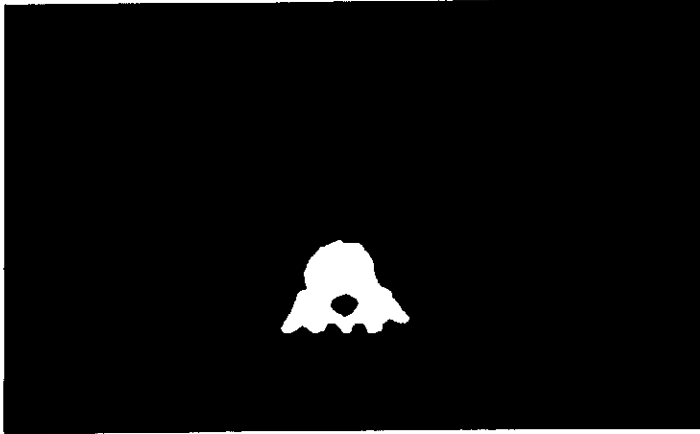


Fig. 15 - One of the regions.



Fig. 16 - A different T.A.C. image



Fig. 17 - The different evidenced regions.

CONCLUDING REMARKS

A few examples obtained applying the proposed algorithms are reported. From a methodological point of view our data agree with literature, even if several hypotheses, regarding the perception process have not yet been clearly understood. Such hypotheses are not only fascinating but have also induced us to continue our study in this direction. Our hypothesis of analysing the structures not in relation to certain abstract statistics nor to "atomistic" techniques, but according to certain "visual characteristics" such as, piece shape and its periodicity seems to us more "realistic" and "justifiable" compared to the whole perceptive process. These concepts can be extended to animal perception whose nervous system is very simple or reduced compared to that of humans.

The experimentally verified possibility of leafing through image, in relation to the structures therein contained, has led us to a second hypothesis.

Such a hypothesis is only mentioned here. We believe that it is necessary to make a more rigorous formalization of the statement at this stage. We attempt to introduce a "structuring" quantity that, by means of the information obtained from the transition zone (catastrophe) between the different structures (which form the pictorial scene) and the structures themselves would describe the shapes contained within the same scene.

The operation of substracting (to leaf through) the several structures forming the scene (computer processed) has shown how the algorithm, first wipes out the background.

This phase give us the objects in their complexity and then, step by step, the different structures forming the objects. Everything takes place following a hierarchy among the structures, of which the background, is the lowest step. Such hierarchies cause the objects to emerge even "visually" from the domain of the pictorial scene standing out from the background and projecting toward the observer. Such an experimental observation, has first induced us to build a palette, where at the place of colors stand the structures (in such a way that we could create or reassemble the images). In a second moment, the study of self conditionings among the structures, has given us the opportunity of establishing the laws which determine the structural quantities. This may be a small step toward a deeper understanding of the visual perception process.

Starting from the theories of the "Gestalt", the AA deal with the problematics in processing different types of images. They envisage an image as a compound of two basic components: a container and its contents. Their interest has been to extract the contents from its container.

In this paper, the AA report the results obtained from a series of images, some theoretical, some real and some of medical type. These images, are "leafed through" in relation to the structures therein contained. The procedure used points out the different structures composing the images, showing up a hierarchy, of which the background represents the lowest level, among the structure themselves.

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 - 2) A.Gisolfi, S.Vitulano, A.Cacace: "Texture analysis a new approach and a comparison" Int. Conf. on Image Analysis and Processing. Rapallo (Italia) 1985.
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