RAPPILLO

TEXTURE ANALYSIS :

A NEW APPROACH AND A COMPARISION

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INTRODUCTION.

In the broad and diverse landscape of the existing literature on automatic pattern recognition, one often comes across the definitions which are derived by appealing to the theory of form (Gestalt),which is the theory of the "totality". Nevertheless such an appeal is sometimes realized by making use of certain axioms proper to the theory of associations or atomistics to which the Gestalt theory is opposed. It has been said that the Gestalt is the theory of the totality (it is superfluus to add that in as much as the whole is something more than the simple sum of the parts, that the properties that the total set enjoys as a whole cannot be reduced to those of its single parts) of that very same totality which is necessary but not sufficient in order to define a structural analysis. In fact what is peculiar to a structural type of orientation is an explicative attitude toward the structures.
More precisely, one is not interested in considering them simply as " emerging totalities " in contrapposition to " atomic " entities, but one wants to analyze them with respect to their internal structure.
So, since the concept of structure works on all levels, one wants to consider them in terms of relations, namely as forms.
We have introduced the word " form " without giving a definition of it, not even a non-rigorous one. Since we have not found any satisfactory definition of " form ", we will try to explain such a concept defining its laws, which are laws of organization :

1) The form is distinguished for the relatively undifferentiated background, as a figure which constitues a unity;
2) The perceptive field, in analogy to the electric field, is a dinamyc system which tends towards an equilibrium state a good form, or structure;
3) The conditions of the field and the formal relations between its elements determine the emergence of forms. The relations are those of similarity, proximity, symmetry, closure, continuity of direction.

After having proposed some laws for the form, our aim is to try to work out a possible meaning for such a word, setting apart from the philosophical problem. The first meaning of the word form is the figure,the exterior picture of a thing. The form is then opposed to the different appearences caused by the changes of prospective, orientation and distance. Thus, one notices that this meaning coincides with one of the functions of the Gestalt theory. So, between Euclid's two fondamental geometric relations -equality and similarity between geometric figures- it is the latter which properly defines the form, since the form is invariant under the action of the group of its similitudes.

Let's go back to the dialectic between local and global or, in a more traditional way, to the " structural " understanding of the organized whole. We can interpret a structure as a system of transformations.This implies that we have certain laws which evolve through the transformation itself and which realize themselves in the universe under consideration.

Hence a structure enjoys the following features : totality transformations and self-regulation. A further fundamental characteristic of the structures is the following : they regulate themselves, and the self-regulation determine their conservation and a certain closure.

So the transformations inherent in a certain structure do not lead outside its borders, but generate elements which always belong to the same structure and which preserve its laws. It is in this sense that the structure is closed within in itself.

This doesn't imply that it can not be part of a second structure containing it. We can then talk about self regulation of the structure,and determination of the self-regulated structure leads us to conclude that we have arrived at a more intimate knowledge of the system.

So we have introduced two different types of magnitutes: structured and structuring and we have hinted at how the latter are bearers of information.

As an example the sound made by a single note hold to infinity or homogeneous natural scene don't give any informations or - and this is the case which interests us in this paper - don't give rise to any form.

We claim that the variations, or alterations of the structured magnitudesare the sources of the information.

In fact in natural scene, it is the variation among the various structures which allows the emergence of the contours, the forms or more clearly the object contained in the natural scene.

STRUCTURED MAGNITUDINES: AN EXAMPLE, TEXTURES

Two different motivations lead us to consider, in this paper, the problem of textures: the rule this plays in the entire process of perception and the problem in itself; indeed the study of textures can be considered a science in itself.

Obviously, texture also plays a determinant rule in automatic image recognition and the literature contains very many articles which illustrate a great variety of algorithms dedicated to the description of classification of texture.

In spite of this, still today there is no definition, not even a coarse one, of texture, and the entire problem of its elaboration and classifi-

cation has to be regarded as unsolved.
We think of a wett, or a texture, as a stazionary oscillation in a domain of arbitrary dimension. The wish to formalize our idea of texture leads us to:

Def. 1:
A discrete function $y=f(x,y)$ defined in a discrete two-dimensional domain is a texture if there exists at least a partition of the domain such that all partition-elements are isomorphic among themselves.

Def. 2:
The function $y=f(x,y)$, which is defined in a partition element, is called the "piece of the texture".

The following simple examples clarify the definitions given above. Let us consider the periodic function in fig.1. Such a function represents a texture since there exists at least a partition of the domain, whose amplitude equals the period of the function satisfying condition 1 (of the fig.2). It is worthy to notice that a generic traslation of the partition in the domain of the function, still satisfies condition 1. This fact implies that our definition is invariant under traslation of the partition (of fig.3). We notice that the arguments given so far for a unidimensional periodic function still continue to be valid for any discrete function $y=f(x,y)$ defined in a discrete unidimensional domain (of figg. 4,5,6).

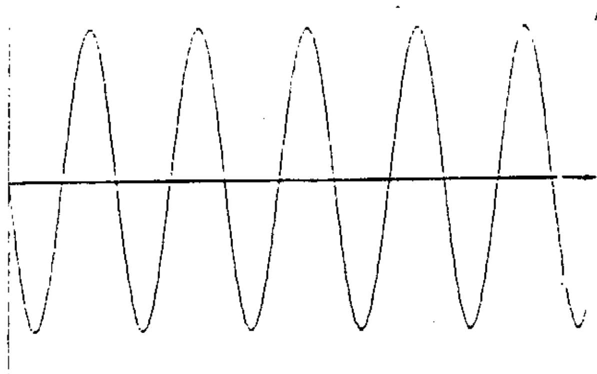


fig. 1

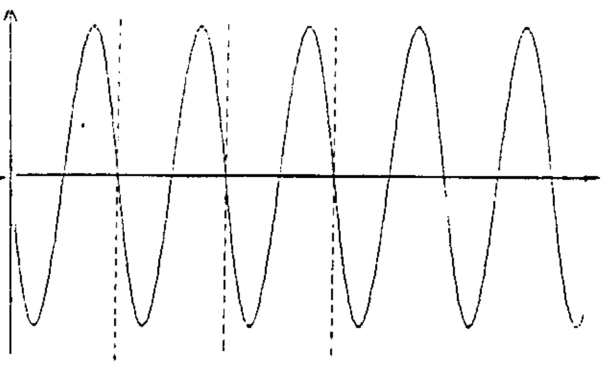


fig. 2

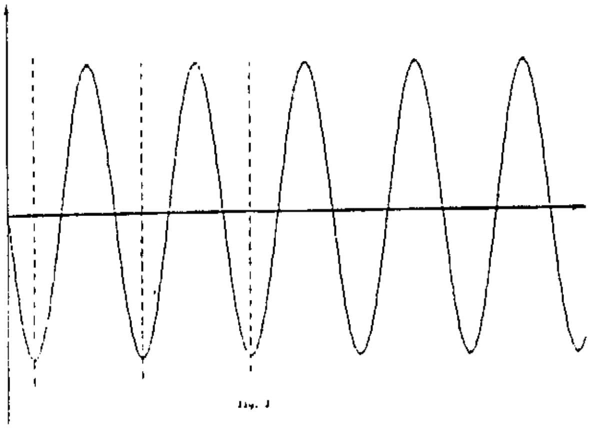
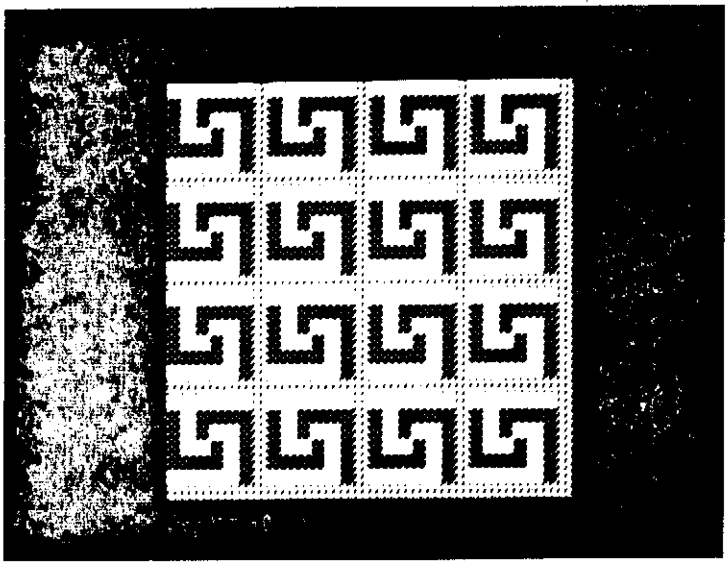
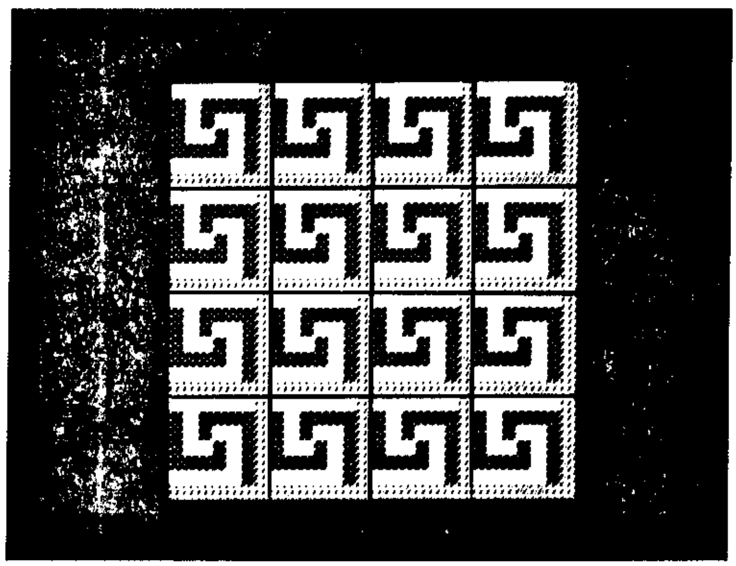
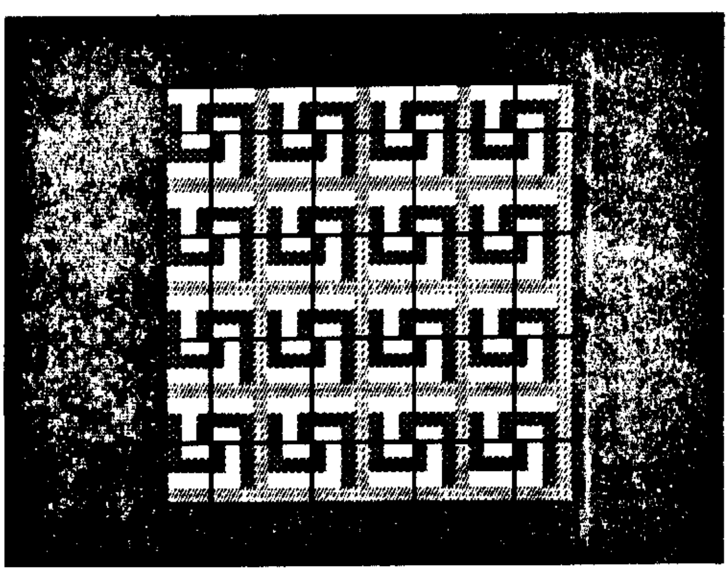


fig. 3







Each piece of the texture can be described by a structured which might be rather complicated or not; then it follows almost immediately that a texture is nothing but the very same structure which repeats itself as many times as the number of partition-elements occuring in the domain.
One immediately notices that once the structure is determined then a correct and complete description and classification of the texture follows naturally.
The entire problem of pattern recognition and the successive textures classification can be now rephrased as it follows: "one has to determine the partition-element in such a way that condition 1 holds ".
Fortunately we can easily solve such a problem; in fact it's sufficient to make use of the matrix of characteristics (1) in order to derive from it the information needed.
The unidimensional discrete signal of fig.7 and its corresponding matrix of characteristics, though simple, allow us a clarification of what was previously discussed; in fact from the matrix of characteristic one derives that the dimension of the partition-element is 6, and that the piece of the texture can be represented by the vector: " Piece of texture "= (0 1 2 3 2 1).

w d	0	1	2	3	4
2	0	29	0	0	0
3	0	9	19	0	0
4	0	0	18	9	0
5	0	0	9	17	0
6	0	0	0	25	0

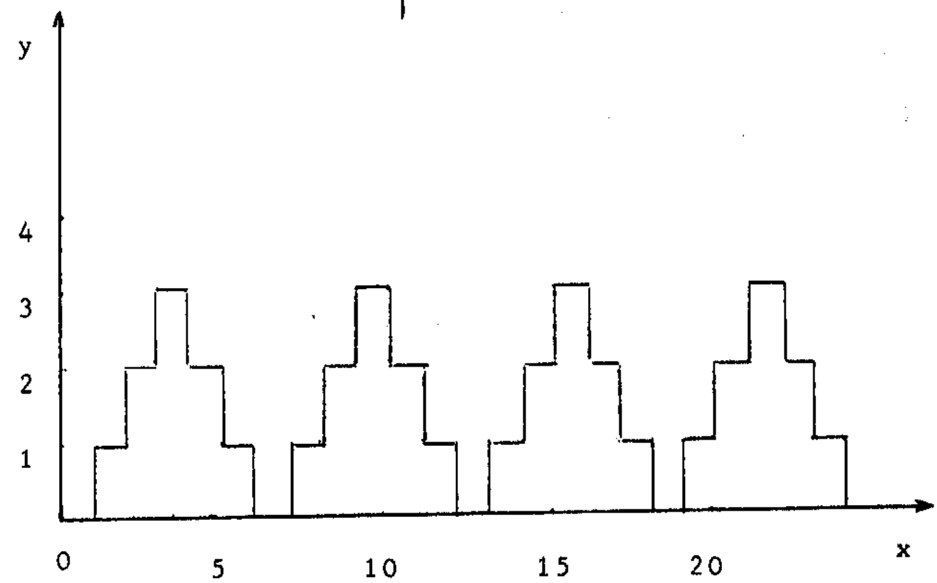


Fig. 7 Undimensional discrete signal and its characteristics matrix.

TEXTURE: A COMPARISON.

In this paragraph we intend to compare the algorithm that we have proposed, with the most well known algorithm in the related literature; namely the atomistic-statistic Haralick algorithm (2).
The author propose fourtheen characteristics, suitable for a classification of a texture, even if, himself in (3) and others claim that just few of them are useful for the realization of the task proposed.
In analogy with such authors in order to evidenziate the proposed comparison, we'll make use of the following characteristics: homogeneity (ASM), correlation (COR) and maximal cooccurence (MXP).
In table 1 we report the results obtained by making use of the two different algorithms and we report also the corresponding time-tables (time needed for calculation) into nine theoretic textures (1, 7, 3, 8, 5, 6, 9, 10, 11 of tab.1).It is worthy to notice that in each of the nine textures, Haralick's algorithm provides the same results, or in other words, this algorithm is not refined to distinguish among the differences which, according to us, are rather obvious.
In figg. 8 and 9 we report two of such textures.

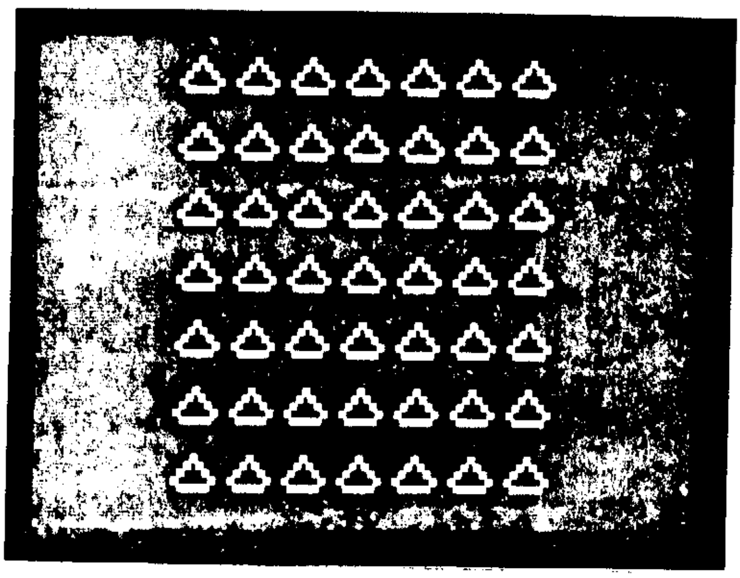


Fig.8 Tex1 of table 1

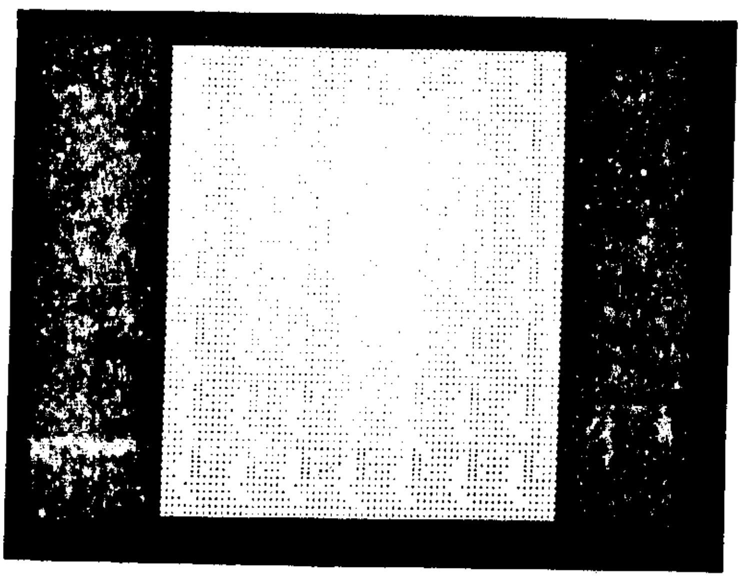
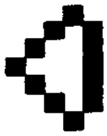


Fig.9 Tex7 of table 1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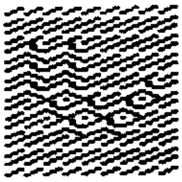
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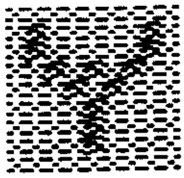
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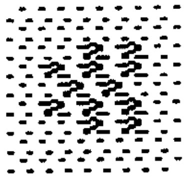
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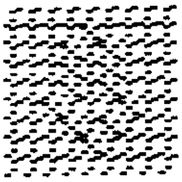
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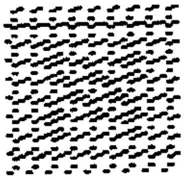
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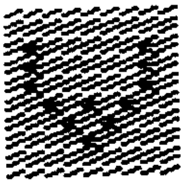
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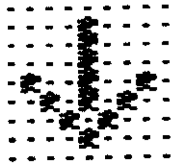
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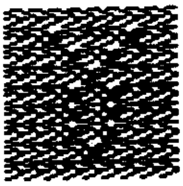
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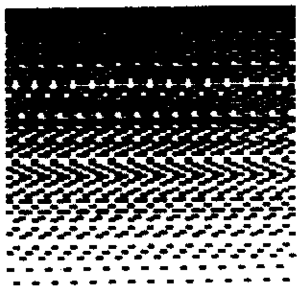


Table 1 Results of proposed algorithms

Number of images	Results of Haralick's alg.		Times of proposed alg.	Times of Haralick's alg.
Tex.1	ASM=0.566 MXP=0.730	COR=0.023	0'17"	4'12"
Tex.7	ASM=0.566 MXP=0.730	COR=0.023	0'17"	4'12"
Tex.3	ASM=0.566 MXP=0.730	COR=0.023	0'17"	4'12"
Tex.8	ASM=0.566 MXP=0.730	COR=0.023	0'17"	4'12"
Tex.5	ASM=0.566 MXP=0.730	COR=0.023	0'17"	4'12"
Tex.6	ASM=0.566 MXP=0.730	COR=0.023	0'55"	4'12"
Tex.9	ASM=0.566 MXP=0.730	COR=0.023	0'17"	4'12"
Tex.10	ASM=0.566 MXP=0.730	COR=0.023	0'17"	4'12"
Tex.11	ASM=0.566 MXP=0.730	COR=0.023	0'17"	4'12"
Tex.12	ASM=0.101 MXP=0.110	COR=0;052	0'04"	4'12"
Tex.13	ASM=0.071 MXP=0.125	COR=0.279	0'08"	4'12"

Let's consider the natural scene in fig.10 where we have several textures; in table 2 we report the comparison between the two algorithms and in fig.11,12,13 the textures derived by making use of our proposed algorithm.

Results of proposed alg. Number tex	No tex	Results of Haralick	Times of prop.alg.	Times of Haralick
3	0	ASM=0.115 COR=0.084 MXP=0.187	0'15"	4'12"

table 2

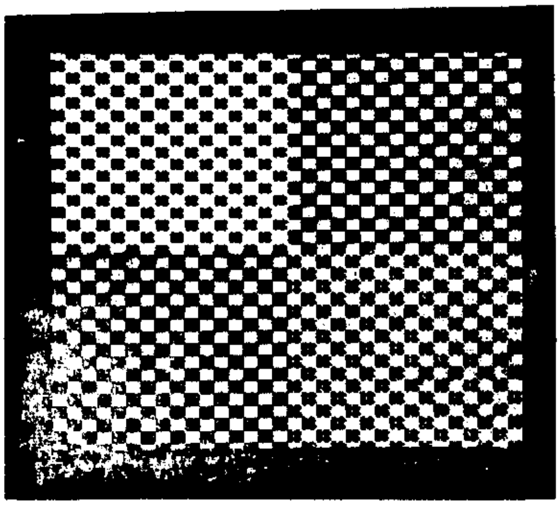


Fig.10 Natural scene containing several textures (tab.2)

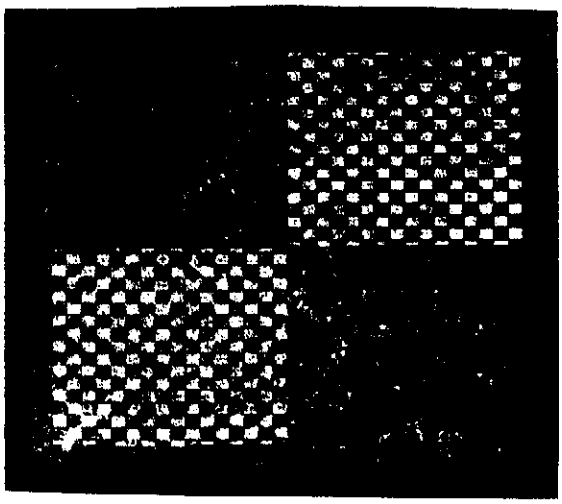


Fig.11 Extraction of one of the texture

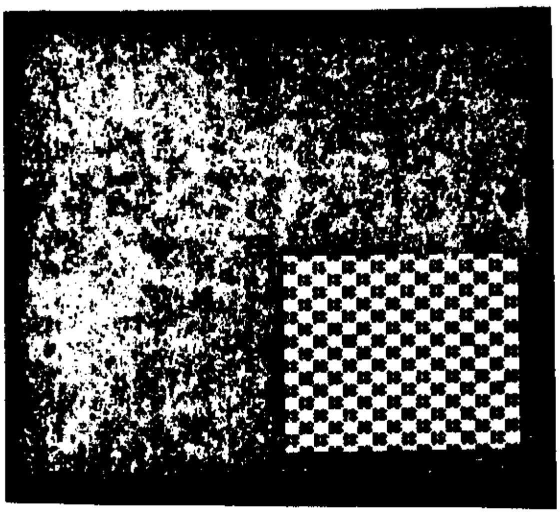


Fig.12 Extraction of a second texture

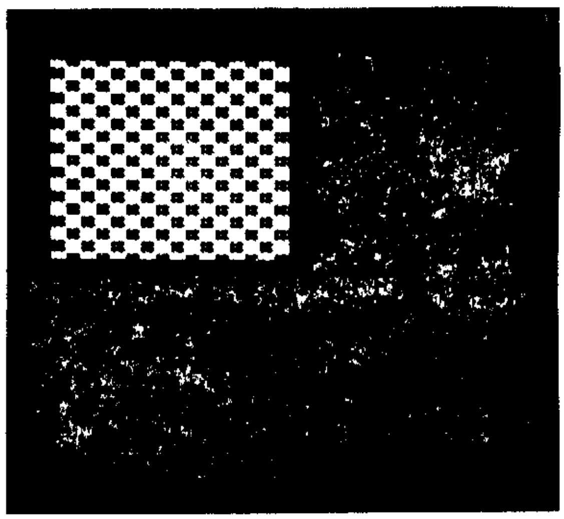


Fig.13 Extraction of a third texture

In fig.14 we report a natural scene which is classified by our algorithm like "non texture" and the results of Haralick's algorithm.

Results of prop.alg. Number tex No tex	Results of Haralick
Image is not a texture	ASM=0.064
	COR=0.308
	MXP=0.231
Times of proposed alg.	0'59"
Times of Haralick alg.	4'12"

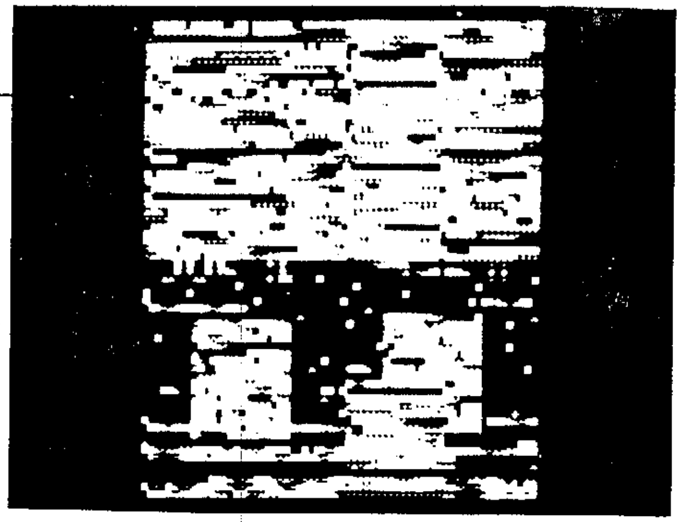


Fig.14

Infig.15,16,17 we report three textures derived from Brodatz |4| and scattered into 16 levels of grey by means of telecamera a c.c.d..
In table 2 we report the results obtained by making use of two different algorithms.

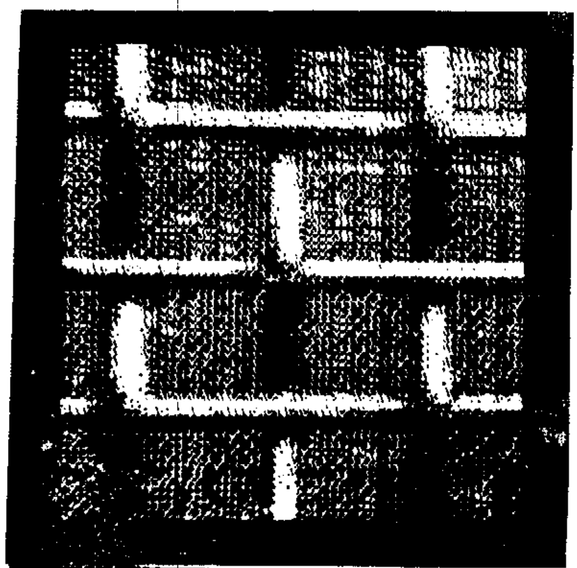


Fig.15
Natural texture
(texD1,table 2)

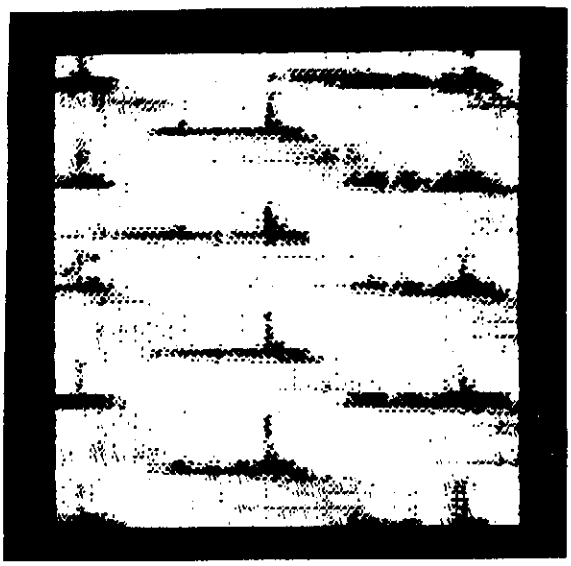


Fig.16 Natural texture
(TexD65,table 2)

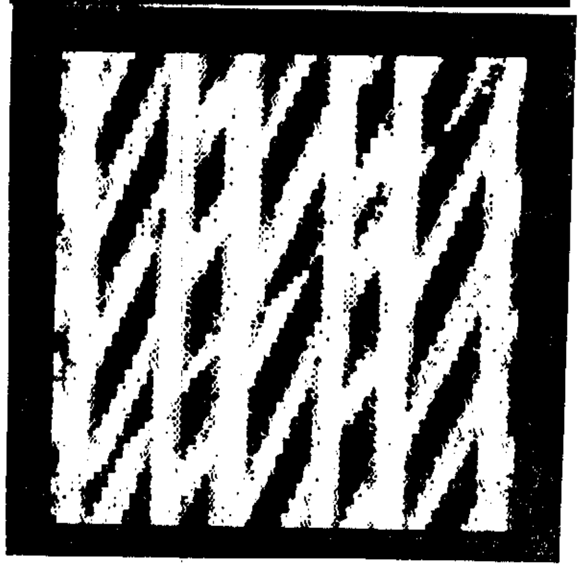
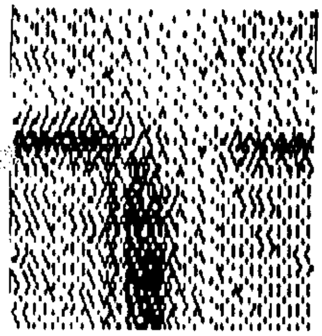
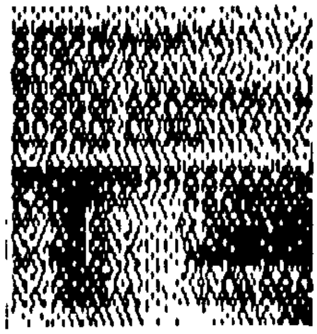


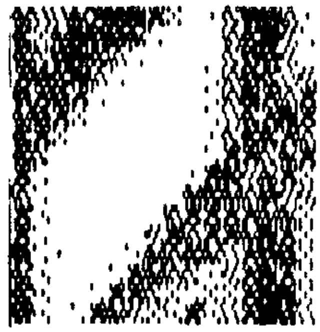
Fig.17 Natural texture
(TexD20,table 2)



D1



D65



D20

Name of images	Results of prop.alg. Number tex	No tex	Results of H.alg.	Times of prop.alg.	Times of H.alg.
TexD1	Image D1		ASM=0.048 COR=0.701 MXP=0.139	0'58"	4'12"
TexD20	Image D20		ASM=0.043 COR=0.820 MXP=0.186	0'58"	4'12"
TexD65	Image D65		ASM=0.013 COR=0.707 MXP=0.050	0'58"	4'12"

Table 2

CONCLUSIONS.

In this paper we have presented a different and according to us deeper application of the Gestalt theory, by appealing to structuralism. In fact we think that after hard work such a direction might lead us to a different approach of images elaboration and may be, to a more intimate knolage of problems such as figure/background, contours etc. Particulary first application of such an approach to texture recognition and classifications, has encuraged us to continue on this research. In fact several sperimental results from which just few of then are presented here and the comparison with Haralick, had conforted our study a little.

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