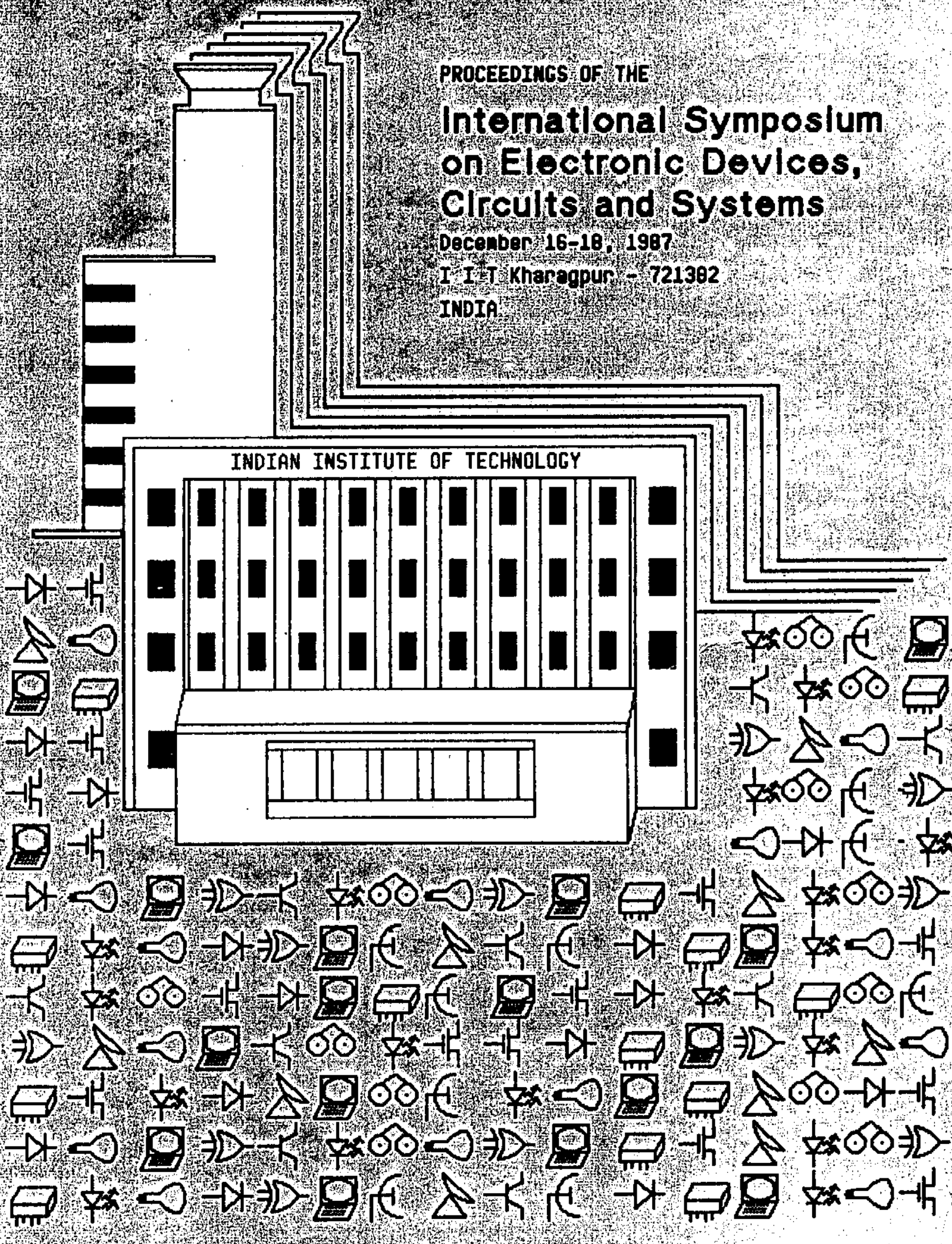
PROCEEDINGS OF THE

International Symposium on Electronic Devices, Circuits and Systems

December 16-18, 1987

I I T Kharagpur - 721302

INDIA



ISELDECS-87 **VOLUME 2** ISELDECS-87

PROCEEDINGS
OF THE

INTERNATIONAL SYMPOSIUM ON ELECTRONIC DEVICES, CIRCUITS AND SYSTEMS

16 - 18 DECEMBER, 1987

ISELDECS 87

INDIAN INSTITUTE OF TECHNOLOGY
KHARAGPUR - 721 302, INDIA

TEXTURE ANALYSIS AND CLASSIFICATION BY AN EXPERT SYSTEM

A.CACACE, A.GISOLFI, S.VITULANO

DIPARTIMENTO DI INFORMATICA ED APPLICAZIONI
FACOLTA' DI SCIENZE, UNIVERSITA' DI SALERNO
ITALIA

Abstract.
In this work the authors intend to propose an expert system that has been developed and experimented for texture analysis and classification. As well known, both the psychology and neurophysiology theories, attribute to the textures a fundamental rule in the entire perception process, and a lot of algorithms proposed in the latest years, to approach a wide range of pattern recognition problems, are based on texture extraction, analysis and classification.
However, still today, there is no formal definition of texture that can be considered as a general one.
The system is experimented on many images, particularly on biomedical pictures.
Experimental results will be presented in the paper.

Texture and Analysis classification.
Many algorithms for texture and analysis classification are already present in the literature, some are based on statistical analysis, other follow an analytical approach. Our classification model is inspired from the Gestalt and structuralism theories. Such theories allow us to consider a texture an structured entity coming from a structuring entity (background). A structured entity satisfy some uniformity rules; for instance those rules could be refered to the color, shape, the thread, etc. From the above theories come out the different rules that such structured and structuring entities have in the perception process. Indeed, analyzing the structured entities individually we obtain some information only on the visual field of that side where the structure talls. If we have a good knowledge about the relations and the rules that organize and describe the structures totally we can percept the forms and objects existing in the whole visual field.
As a first example of structured quantities, we study the concept of texture which we give a formal definition:
1)A discrete function $y=f(x_1,x_2,...x_n)$ defined in a discrete n-dimensional domain is said "texture" if there is at least a partition $S=(s_1,s_2,...,s_k)$ of the domain, such that an isomorphism exists among every element of the partition.
2)The discrete function $y=f(x_1,x_2,...,x_n)$ defined in a generic element s_i of S is said "piece of the texture". Of course, we can recognize the presence of more textures (structures) in our image.
Such texture definition finds immediate applicability in the theoretical texture analysis and study. By the way, for real textures, which are our more interesting research efforts, the isomorphism among several pieces of texture can be satisfied with certain approximation, Due to the presence of noise and little texture deformation. In order to use, for classification purposes, our mode"l, we have introduced a control system that evaluates how the isomorphism among the pieces is satisfied.

System description.
The system we have proposed, formalized and tested reflect a typical expert system architecture (fig.1).
The inference engine of our system is composed by two fondamental moduli: the first one produces a low level image analysis and this is responsable for the extraction of all textures for structures located in the input image. Moroever, the model identifies all the areas not classificable as structures since they are evidently place of transition (contours) from one texture to another. The output produced by this model is stored in the knowledge base of the system, in particular, are stored:

all the texture located, the places were they have been found (spatial coordinates), single pieces and relative dimensions. The second modulo of the system is responsable for a comparative analysis among the textures in order to put in correspondence through adequate similarity functions, different textures; stored in the knowledge base. This kind of analysis is necessary in order to determine if two textures previously classified as different, due to non uniform illumination or rotation or deformation, can be brought into the some cluster. Some of the similarity functions we use concerns with shape comparison, translaction, rotation and other spatial transformations among the pieces forming the texture. All these functions are coded as rules and are conveniently organized in the knowledge base of the system.

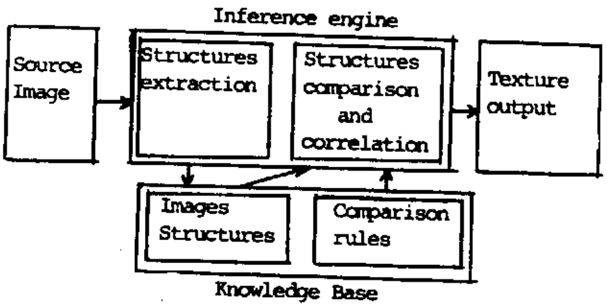


fig.1

In the following we introduce the rules presently available for the compared analysis:

1) Form comparison
2) Shift among textures
3) Rotations among textures
4) Distance Effect

Before describing some of the above rules, it is necessary to introduce the terminology used for the application of the rules themselves.

Let A and B two textures, we define: P_A and P_B respectively the pieces of textures A and B;

m_A, n_A and m_B, n_B respectively the numbers of rows and columns of P_A and P_B.

$P_A(x,y), P_B(x,y)$ the gray value of the pixels at coordinate (x,y) in P_A and P_B, with $1 \leq x \leq m_A$, $1 \leq y \leq n_A$, and $1 \leq x \leq n_B$, $1 \leq y \leq n_B$.

SHIFT among textures.

Def. "Two textures A and B have the same form and are shified among if $m_A = m_B$, $n_A = n_B$ and result

$P_A(x,y) - P_B(x+h, y+j) = k$ for each $1 \leq x \leq m_A$ and $1 \leq y \leq n_A$ and h,k,j integer constants.

For the application of this rule is necessary thath the piece P_A is reproduced three times both on rows and columns. After this phase the piece P_A is shifted both on rows and columns of the constructed texture.

For each shifted position of P_A the rule 1 is verified.

Results analysis and conclusions.

The images we present in this last paragraph have been chosen from the results of a big testing of the system. The first image represente a theoretical texture with relative processing and the others represente real textures. In order to make it clear that between two textures compared has been found a relation, those have been reunite in one texture. The output from each image has been put into four figures: in the first, we found the image "input" of the system; in the second are visualized the extracted textures with the first modulo of the system. In the third one, are pointed out the zones that the system has not been able to classified as textures; further, in the last one it is reported the classification respect to the input.

The algorithm for the extraction of textures has been constructed for working on real images in which the contours of the textures are almost always irregular and happens that on the contours only a part of the piece belongs to the texture transforming it as non classificable and belonging to the structure. In order to avoid the loose of information on the contour the algorithm for the extraction of the textures tests all the pieces adjacent to the structure for verifying whether a part of the piece belongs to that one and to obtain in such way its real contour. This improvement has given, in general, very good results on real images with exception of the case in which between two structures do not exist a transition zone big enough for which a structure, in search of its contour, can sometimes drill the contour of its adjacent structure. The first theoretical image on fig.2.1 rappresents a draughtboard on which has been placed on a second randomly and translated centraly drought-board identical to the first one. In the fig.2.2 can be seen how between the left structure and the central one, The algorithm has classified as belonging to the left structure also a zone which size is less than one piece and further enters slightly into the central structure because there exists an ambiguity zone.

The fig.2.3,2.4 rappresent the results after one comparison.

Fig 3.1 show real flower textures rotated by 180° and fig 3.2, 3.3, 3.4 the relative results. Fig 3.1 has been presented in order to make it clear the negative effects of the location of the contour where does not exist enough wide zone of transaction between the two textures.

Fig.4.1 shows two pieces of material on which do not exist a uniform illumination for which we can see three textures which are successively reunite in one unique structure to keep the form and rotation at 90° (fig.4.2; 4.3; 4.4).

The system, experimented on a great quantity of images both theoretical and real, gave us extremally confortable results, that encourage us to increase a wider experimentation, particularly on biomedical pictures (radiographies, T.A.C., echographies, etc.).

References.

F.Hays-Roth, D.A.Watermann, D.B.Lenat: "Building Expert Systems". Addison Wesley, Reading, 1983.

Rich: "Artificial Intelligence". International Student Edition, 1983.

A.Gisolfi, S.Vitulano: "A structural approach to image segmentation" Plat.Jub.Conf.on Systems & Signal Processing. Bangalore, India, 1986

A.Gisolfi, S.Vitulano, A.Esposito, A.Cacace: "Elaborazione di immagini biomediche: un approccio strutturale" Con.Int. Computer Graphics, Milano 1986

A.Gisolfi, S.Vitulano, A.Cacace: "Texture & Structure" In advances in Image Processing and Pattern Recognition. North-Holland Ed.V.Cappellini, 1986

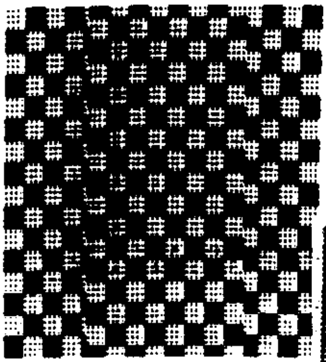


Fig.2.1

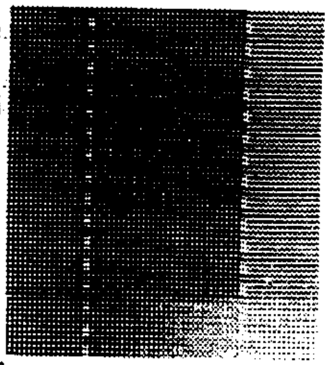


Fig.2.2

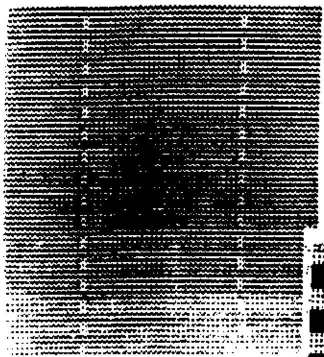


Fig.2.3

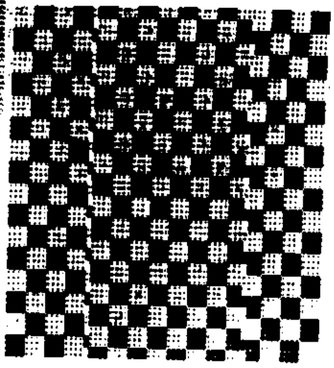


Fig.2.4

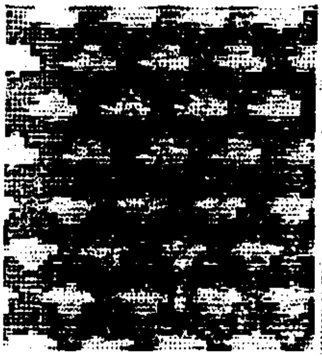


Fig.3.1

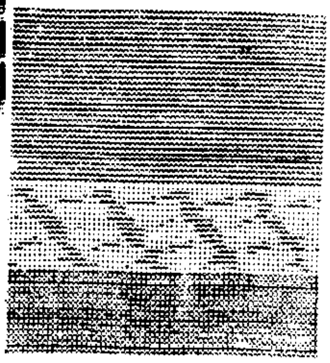


Fig.3.2

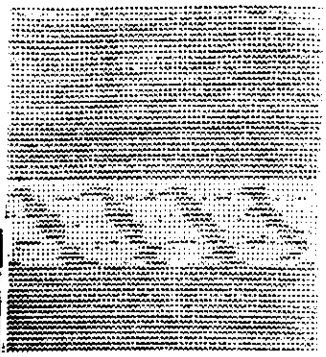


Fig.3.3

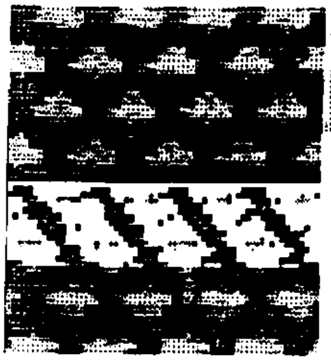


Fig.3.4

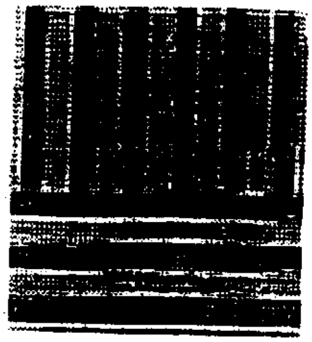


Fig.4.1

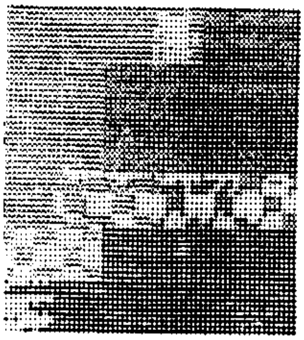


Fig.4.2

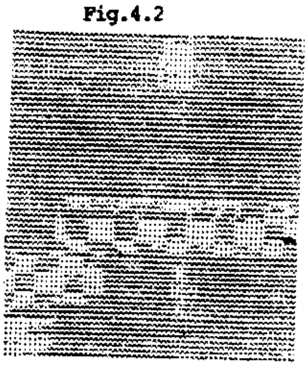


Fig.4.3

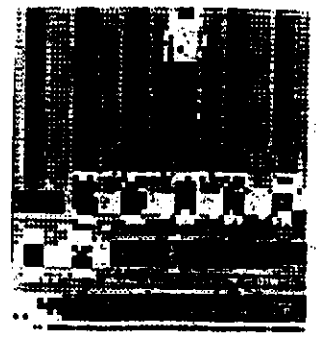


Fig.4.4