THE TEXTURAL ANALYSIS

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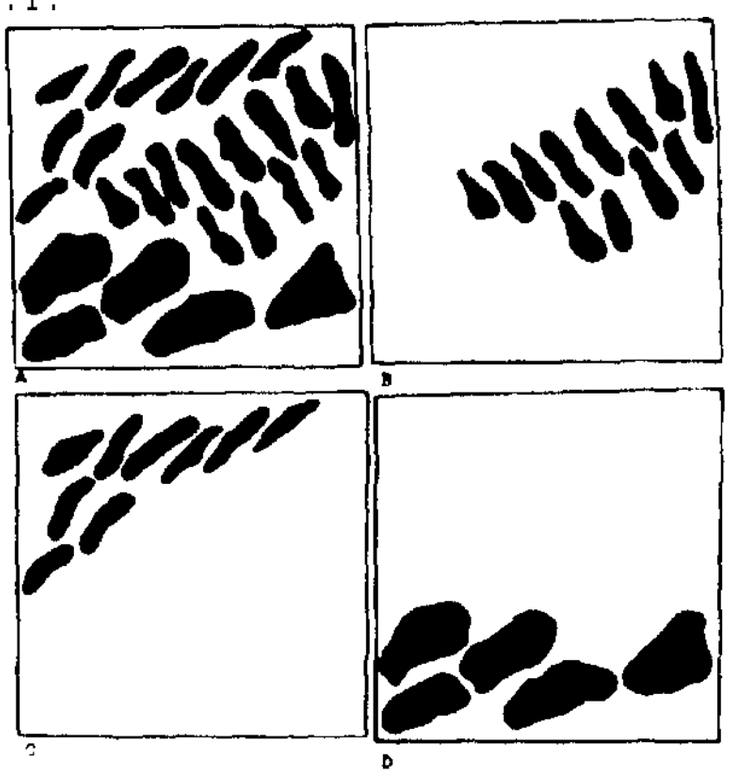
This paper contains an algorithm and a computer programm for a natural from the human point of view splitting into sections of a two -dimensional picture* Contemplating a picture, a human being draws in his imagination borders, sorting out sections, which he supposes to be homogeneous for the time being, in spite of their posessing an internal structure Some times such borders are drawn following some qualities of an object, which he expects to find in the picture, for example, when completing a partly detected image. In other cases the borders are drawn by analysing the characteristics of the picture itself. The sections, being separated in the latter case are usually known by the name of textures. An example of a picture, containing three textures, is shown on Pig.I.



An example of human textural analysis. A. The initial picture. B. Smaller fragments, inclined to the left. C. Smaller fragments, inclined to the right. D. Bigger fragments.

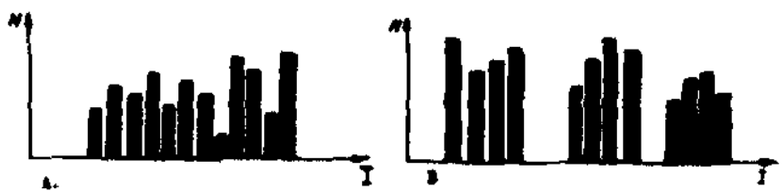
Figure I.

The main procedure of the approach applied in the present paper implies the measutement of a certain characteristic on each elemantery fragment, in which the basic picture was initially broken and then conbining the fragments posessing similar characteristics into one area. The necessity of analysing each single fragment separately in that case, seems to contradict the intuitive conception of textures and the main aim of the textural analysis, that is to say not taxing into consideration the internal structure of separated area. But the possibility of disregarding the internal structure is to be considered only as the aim or the result of textural analysis, but not as a procedure of it. The illusion of disregarding internal structure in the process of perception derives probably from the fact that the amount of information about the internal structure necessary for splitting the picture into sections is much lesser than the whole amount of in formation contained in the picture.

The most important problem in this case is the establishing of bondaries, in shich the characteristics of similar fragments can change, e.g the establishing of the system of thre aholds.

For solving this problem, in the present paper the phenomenon of "separation into groups" is used. The effecency of using this phenomenon in solving the problems of recognition was analysed in M.M.Bongard's book (I) and the phenomenon itself was applied by M.M.Maksimov for a learning programm of recognizing pictures (2). The fact that the human being does really use the phenomenon *of* "separation into groups" was shown in psychological experiments (3),

For establishing the threshold values, histogramms of elementary fragment's distribution according to the values of certain characteristics *were* drawn. Among the characteristics only those, the histogramms of which have a distinct separation of columns into groups were chosen. Examples of separable and non - separable histogramms are shown on Fig. 2



An example of histogramms. A.Separing into groups. B. Not separating into groups.

Figure 2

Thus the threshold values separating each groupare fixed.

We presume that there does not exist a way of measurement of elementary fragment's characteristic or distinguishing the fragments themselves equally suitable for sorting out all kinds of textures. But a criteria of suitability of a certain characteristic or a certain

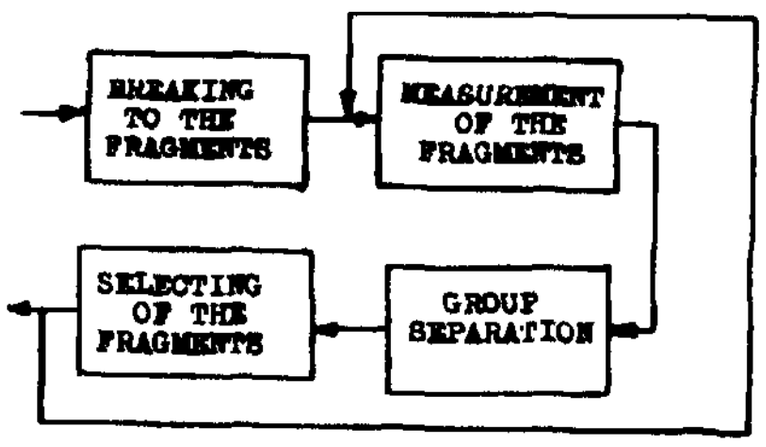
way of measurement does exist. So It is necessary to try all the ways of splitting into frag merits and measurement of characteristics, naturally according to the order in which their complication is increasing.

Prom this follows that the textural analysis is a protracted process, which takes place simultaneously with Che proces of recognition, independently, or in connection with it.

The textures, which for their separation demand a little amount of calculation are discerned earlier, whereas more complicated-later. For example, in the separating textural areas with different brightness only a minimal initial information is required. So this procedure certainlly can precede the process of recognition as a whole (it is possible that such an analysis is conducted in the level of ganglion cells of retine periphery, which have large receptive fields. One can presume that after averaging by such fields, a pattern with a small number of extreme can appear, which may be used for the final separation). On the other hand, for discerning two areas which have *the* same medium brightness, the same statistics of the first and the second order but which consist of different forms: e.g. the first of triangular forms the second of square forms, many stages of recognition are necessary, namely identification of triangular and square forms* analysis of their respective positione.t.c.

The general structure of algorithm

Fig.3 represents in the most general form the succession of operations used in solving the textural analysis problems.



The block-system of the algorithm.

Figure 3.

The presented picture is splitted into elementary sections.

The most simple and natural way of splitting seems to be discerning the continuous areas, posessing an almost identical brightness or colour. The allowed fluctuatuins of brightness or colour inside a single field depend on the number of used gradations and are considered as constants of algorithm, determining its discerning capacity. In case when only two gradations of brightness are used, and this carried out by the programme based on the proposed algorithm, one may confine in discerning only connected areas.

Some other ways of initial separation which imply more complicated proceding of picture may prove to be necessary too. Particularly, the program can fulfill the separating of lines between the knots.

Phe elementary fragments obtained as a result of analysis are numbered in a certain order. The numeration is used for connecting the values of characteristic with the fragments for which they are obtained, but the final separation of areas does not depend on the numeration.

The second stage of the analysis is the measurement of fragments! to each fragment is applied the same measure op#y rator (the same measurement procedure). From the logic of the approach follows that there are no measurement equally suitable for all cases. In all cases we use the same criteri of suitability: the criteria of separation into groups. So a successive examination of operators is necessary, which is conducted in the order of increasing complication of operators. Actually only simple operators were used in the program: measurement of the area, of the abscess and ordinate of the centre of gravity, of the length of greater and smaller half-axis, and of the angle of horizontal inclination of greater axis. As the number of operators used was rather small, so all the operators were used and the applicability of every one was examined.

Che ways of getting more complicated characteristics can be obtained, for example, from V.V.Maksimov*s program (2).

As a result of using one operator to the multitude of fragments one of several multitudes of numbers, one-to-one connected with the multitude of operator are formed. The multitude of characteristics are arranged according to the increase of fragment's numbers for recording on the computer's memory. Thus a line of characteristics is constituted.

x) Some operators can be unsuitable for certain fragments such fragments receive as the value of characteristics the number IOCO which is greater than any measured value of characteristic. All such fragments are sorted out in a separate area.

Every line of a characteristics matrix is treated by the operator of ''separating into *groups*" This operator designs a histogramm of fragments distribution according to the values of the examined characteristics and decides whether it can besplittinco a small number of compact groups. For thiaim a following algorithm is used. First of all a system of threshold is formulated by fixing them in the points where the histogramm takes the zero value (or has a local minimum). Phis procedure eplitts the histogramm into a number of groups of tne zero level, livery group then is estimated by two parameters: namely the volume (tne reLative number of comprised fragments) and compactness. The compactness is estimated by comparxiufc, the group's width (the standard deviation) with the distance between the centers of adjoining, groups* The smallest and the least compact group is fused with one of the adjoining groups by crossing out the corresponding threshold.The operation is repeated untill the smallest of the remained groups will surpass a certain value (in the program 1/8 of the amount of fragments), and the least campact one will be sufficiently compact (its standard deviation will be less than half of the distance towards its nearest neighbour). The criteria of size and compactness are the constants of the algorithm. If as a result more than one group remain, the characteristic is estimated as such which ie suitable for splitting into groups, and the obtained system of thresholds is used for further proceding and sorting out the fragments. In other cases the characteristic is rejected.

The sorting of fragments is conducted by means of compariing the values of characterictics of the examined fragment with the threshold fixing the groups. As the result of sorting the multitude of fragments is devided into several submultitudes, the number of each is equal to the number of groups. Only if the multitude of sorted out fragments is solid e.g not containing the fragment from other groups, it constitudes a textural area. The examination by compactness criteria was not conducted by us, but it could be done without and difficulty.

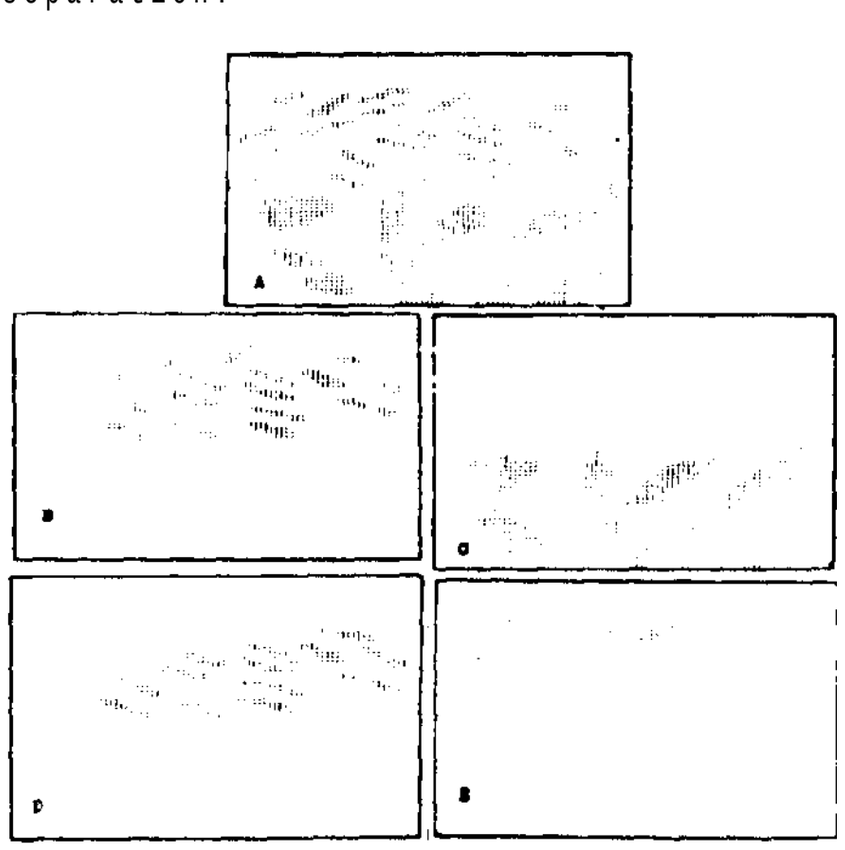
If as a result of separating procedure more one separating characteristic is found, it becomes possible to form several variants of splitting. In that case, beside initial devisinns their local functions are possible.

The second source of additional divisions is the splitting of the separated area. For this purpose the sorted out multitude of fragments is brought again to the entry of the program (the characteristics in that case are not evaluated again, but are taken from the previousmaterial).

The possibility of obtaining different Kinds of partitions seems to be a great advantage of the model, as it permits to chose in the process of the analysis the most adeguete partition for each given problem.

The discribed model was worked out as a program for the ICL-470 computer. The main part of the program was written in FORTRAN. The input rastr of the model is 80x80 units. The time of proceeding of one picture including the forming of all variants of partition is about 3 minutes, but it grealy depends on the qualities of the picture (especially by the amount of fragments). Most of the time is used for the procedure of splitting the picture into initial fragments.

Fig.4 shows an example of computer separation.



An example of program operating. A.The initial picture. B.Smaller fragments. C. Bigger fragments. D.Smaller fragments, inclined to the left. E.Smaller fragments, inclined to the right.

Figure 4

It is obvious that the computer draws natural divisions from the human point of view. It is uncertain yet as to which degree the proposed algorithm is an universal one, and how much it is close to the manner of proceeding of picture by the human vision. This can only be proved by further experiments with the program.

SUMMARY

A model of human proceeding of vision data for the tasks of splitting the picture into areas of the same textures

is proposed.

The *model* is based on the following principles:

1. The textural areas are formed by joining small, in a sense homogeneous fragments of the picture.
2. The characteristics used for comparing the fragments are selected separately for each problem (each picture).
3. In order to examine the adequacy of the characteristics and to chose the thresholds the criteria of "separating into groups" is used.

An algorithm was elaborated and a computer program was written in FORTRAN.

Further experiments must show:

1. In what extent the proposed model reflects the process of the human vision?
2. In what extent the proposed algorithm is applicable to real situations and real problems?

Literature

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