proceedings

PRIP 78

MAY 31-JUNE 2, 1978
CHICAGO, ILLINOIS

IEEE Computer Society
Conference on

pattern recognition and image processing

78 CH1318-5C

TO EXTRACT A CONNECTED OBJECT OF ARBITRARY SHAPE FROM ITS BACKGROUND BY DECISION TREE METHOD

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Introduction

In picture processing, feature studies are based on the content of the picture object. For example, such studies can include texture measurements; the moments of the object; or the mode, median, and average according to the gray levels of the object. For such studies, it is necessary to develop a computer method which can separate the interior of the object from its outside background with a known boundary as input.

The boundary of a closed two-dimensional object can be expressed by points $P_0,\ldots P_i,\ \ldots P_n$, where $P_i = (X_i, Y_i)$ and the last point P_n is followed by the first point P_0. In our method, with a known threshold for the object and a starting point at the boundary, boundary points are generated by sequentially searching the 8-neighbors for an inside point as boundary point. Around this second point, search is continued for another inside point. This boundary search process will be terminated when it travels back to the starting point. A boundary segment is called a "blob-type" curve if the points of this segment have been passed once by boundary search process, and is called a "line-type" curve when passed twice. For a connected object with arbitrary shape, the boundary may contain both the blob-type and the line-type curves. Furthermore, several blob-and line-boundary curves may intersect at certain points. This paper is intended to develop a computer method based on a decision tree to extract a connected object region with a given arbitrary boundary, possibly intersected with blobs and lines, from its background. Thereafter, the features depending on the content of the object can be studied.

Method

For an object in a picture with connected boundary points $P_0,\ldots P_i,\ldots P_n$, which are generated in the 8-neighbor sense, our method is to search row by row, from left to right, starting at the top of the picture. Every searched picture point is the start node of a decision tree at zero level. The zero level records whether the point is a boundary point. If it is not a boundary point, the tree search is terminated, and a new tree search started at the next right point. The first level records the number of neighboring boundary points and whether there is a neighboring point in the same row on the right of the boundary point. If there is no neighboring boundary point on the right, the next several levels decide the relative positions of the neighboring boundary points and the tree will be terminated at an end point. At the end of tree (leaves), a conclusion-whether a boundary has been crossed or not-has been made. This conclusion at every leaf of the tree has been determined. Therefore, the object can be distinguished from its background.

At the first level, if there is a neighboring point in the same row, then the relative positions about the searched boundary point and this neighboring point will be both searched; such search will be continued until no other new neighboring point can be found in the same row. In the above case, the decision tree can be very deep.

Figure 1 demonstrates one of the boundary point and tree relation; the searched boundary point (in the middle of the left figure) has three neighbors and none in the same row; one neighbor point has been passed by the boundary search twice with the position "up" relative to the searched boundary point (marked "2U"), and the other two, once with one "up" and one "down" relative to the searched boundary point (marked "1U" and "1D"); the shaded lines mean the insides of the object. The tree relation corresponds to this boundary is shown on the right of the figure and the leaf of the tree (the node marked "1D") give the conclusion that the search just passed an object boundary; since the search is outside before, now, it is inside of the object after passing this boundary point.

Example

An EMI computerized brain scan of a patient with glioblastoma multiforme in frontal lobe is shown in Figure 2. The black-white window is limited in the soft tissue range, and all other tissue are in white color. Figure 3 is a 32-level letter print of the brain area with glioblastoma multiforme. The boundary points are outlined in Figure 4 with white color. The extracted glioblastoma multiforme tissue region by decision tree is shown in Figure 5. The diagonally connected objects are considered as one object. Since all local boundary configurations are put in decision tree relations, this method can be applied to any arbitrary object in general. The computing time depends on the number of boundary points and the complexity of the configurations. This tree is based on 8-neighbor connection; for 4-neighbor connection, this decision tree should be modified.

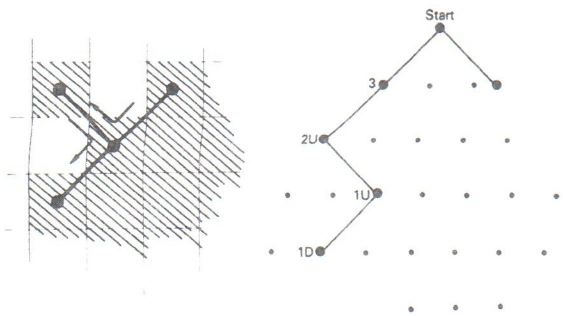

Figure 1.

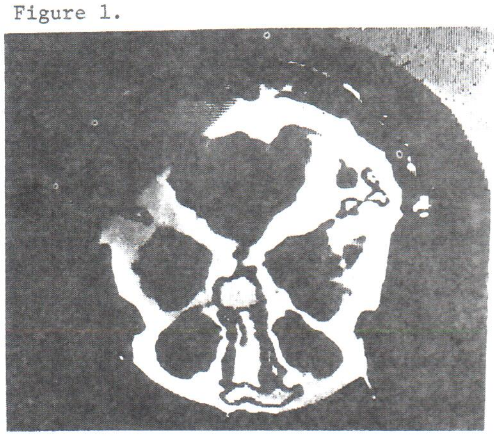

Figure 2.

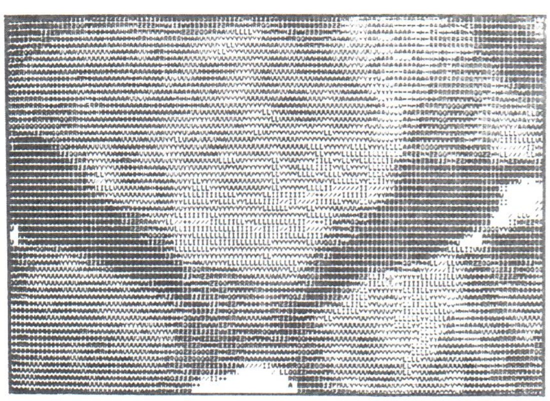

Figure 3.

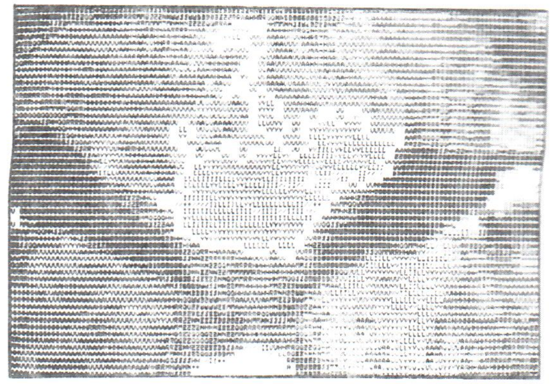

Figure 4.

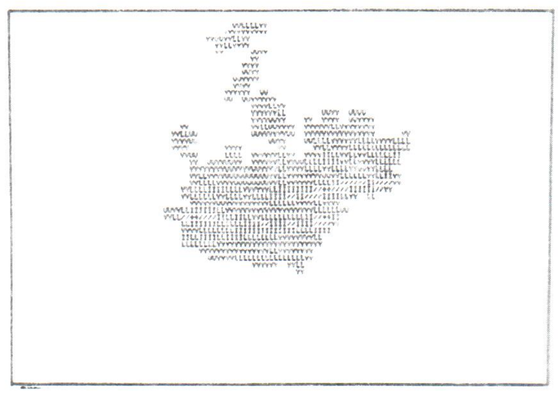

Figure 5.