ON PATTERN RECOGNITION AND DESCRIPTION USING MANY SORTED PREDICATE CALCULI

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A pattern is a set of binary or ternary relations. A description of the pattern is a formula of many sorted predicate calculus with metric spaces defined on indices of predicate constants which is satisfied by the given pattern. The pattern recognition problem is to find whether the formula is satisfied by the given relation. The pattern description problem is to form from the given pattern the corresponding formula. To solve this problem usual training methods[1] are applied together with techniques used for program synthesis[2]. The limitations imposed by these techniques imply limitations to our approach.

[1]M.Minsky and S. Papert, "Perceptrons: An Introduction to Computational Geometry," The M.I.T. Press, 1969

[2]Z.Manna and R.J. Waldinger, "Towards automatic program synthesis." Comm. ACM 14, 151 (1971)

AUTOMATIC RECOGNITION OF HANDWRITTEN CHARACTERS USING STRUCTURAL FEATURES

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A system has been developed to automatically recognize handwritten letters by means of a data base composed of structural features rather than the more common technique of physical matching. Each letter is first separated and then concatenated into the handwritten word itself. The data base associated with each letter is encoded as a binary matrix representing basic invariant structural features. Recognizing procedures, both parallel and sequential, determine the relational height of each letter and the word itself and the height and width of each letter. Extracted features, such as continuity, loops, ovals and circles, openness and bowls are searched for and analyzed. Initially, the procedure is parallel, but then a sequential search of extra features, determined by the results obtained, is conducted to arrive at the final decision. The system permits context-free recognition of individual letters, thus allowing use of the system in a wide range of applications, such as in the detection of abbreviations. In addition, the resource and execution times of the system are modest so that it can be implemented on a wide range of computing equipment. Testing the system then for recognizing the six letters--a, b, e, h, i, and l--indicated an overall accuracy of 93% which was competitive with results obtained by human readers.

A NEW BINARY CODE FOR PATTERN RECOGNITION BY PARALLEL COMPUTATION

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In most pattern recognition schemes, common geometric transformations such as rotation, translation, and perspectivity require computations whose complexity and execution time increase rapidly with increasing grid resolution (number of grid cells). A new code which embodies such transformations as simple, locally applied algorithms (such as rewriting substrings of code as single digits) has been found. By applying these algorithms to the code, the problem of recognizing straight lines on the quadratic lattice has been completely solved. Recognition is achieved by applying a sequence of affine transformations to reduce lines to standard position. This corresponds to reducing a code string to a single digit. The recognition algorithms are parallel (applied simultaneously to entire code string) and are independent of the number of cells in the grid and the slope and position of the line relative to the grid. They are based on some interesting connections between the new code and continued fractions, Farey series, and affine transformations.

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A CELLULAR AUTOMATON FOR PATTERN RECOGNITION BY PARALLEL COMPUTATION

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A cellular automaton that recognizes arbitrary straight lines projected on grids has been designed. All cells interact simultaneously with their nearest neighbors. The interactions correspond to the rewriting algorithms of Rothstein's code for straight lines (see immediately preceding abstract). The logical design and number of states are fixed, i.e. independent of the slope and position of the line and the number of cells in the grid. Simple changes in the transition graph of this automaton yield other automata that recognize polygonal approximation of curves and detect such properties as topological connectivity. These designs are also fixed in the above sense. The code operations corresponding to line recognition can be interpreted as the application of a kind of Euclidean division algorithm to the slope of the line. Thus, the cellular automaton can be seen as a parallel computer whose fundamental operation is base-independent parallel division.

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RECONSTRUCTION METHODS FOR MULTIPLE PROJECTIONS

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Two approaches are involved in this study, namely, the multiple-gray-level (direct) approach and the binary-level (indirect) approach.

In the direct approach, a new reconstruction method called Minimum Ray-Sum Difference Technique (MRDT) is introduced. The algorithm is applicable for any even number of projections which consist of pairs of perpendicular projections. Comparative studies with respect to other methods[1] are conducted.

In the indirect approach, a multiple-gray-level pattern is decomposed or coded into a set of dependent or independent binary patterns. Projections are obtained for each binary pattern for processing or transmission. A multiple-gray-level pattern has to be reconstructed. A modified algorithm introduced by Chang[2] is used in this study.

[1] G.T. Herman, "Two Direct Methods for Reconstructing Picture from Thin Projections - A Comparative Study," SJCC (1972).

[2] S.K. Chang and G.L. Shelton, "Two Algorithms for Multiple-View Binary Pattern Reconstruction," IEEE-T-SMC, 1, (1971).

CHARACTERIZATION ALGORITHMS OF BINARY PICTURES

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Given a vector A of m row projections and a vector B of n column projections, efficient reconstruction algorithms of a binary picture Z from A and B have been developed by Chang.[1] The set of projections S=(A,B) is empty, unique or multiple if it determines no binary picture, exactly one binary picture or more than one binary picture respectively. Two binary pictures are similar if they are determined by the same set of projections. A binary picture Z is ambiguous if it has at least another similar binary picture, otherwise it is unambiguous. A complete characterization of binary pictures with respect to their projection sets is summarized in two questions. Given a binary picture Z, is it unambiguous? Given a set of projections S=(A,B), is it empty, unique or multiple? Two algorithms based upon the idea of Ryser are presented.[2] The first algorithm answers the first question and the second algorithm answers the second question.

[1] S.K.Chang, The Reconstruction of Binary Patterns, Comm.ACM 14, pp.21-25, 1971

[2] H.J.Ryser, Combinatorial Mathematics, Wiley, New York, 1963
