Evolutionary Cellular Automata Based-Approach for Convex Hull Detection

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***Abstract*—** Predicting the behavior of complex systems before their spreading, will be of fundamental importance in the near future. In this context, this paper present the use of an evolutionary process to seek a specialized powerful packet of Cellular Automata among a set of best transitions rules for extracting convex hull in a given black-white image of a polygonal and curved edge. This best set of local rules determines the future state of cellular automata in an asynchronous way. The Genetic Algorithm is applied to search the best cellular automata rules that can realize better the convex hull detection.

***Keywords*—** Genetic algorithm, Evolutionary Cellular automata, Convex hull detection.

I. Introduction

THE emergence phenomenon in complex systems is one of the key concepts that begins to be one of the solutions for solving difficult problems. We can understand the emergence of the property is a direct result of the interactions complexity into the system [1]. The actions of simple components with local information and communication give rise to coordinated global information processing. The convex hull of a set of points is a tool widely used in computer graphics and modeling [2]. The problem is to find the smallest polygon or curvature including all initial points.

The study of evolving Cellular Automata (CA) framework using evolutionary algorithms is a good example to show how evolution can create systems in which emergent computation takes place [3]. We are using Genetic Algorithms (GAs) as an optimization formalism in the search space CAs rules to perform computations that require global coordination. The convex hull of a set of points is a tool widely used in computer graphics and modeling. The problem is to find the smallest polygon or curvature including all initial points.

In this paper, we are interested into CA [4] and the convex hull detection. Among a variety of researchers having investigated the proprieties of CA, we can't miss to cite the works of John von Neumann [5], Stephen Wolfram [6], and John Conway [7]. CA are discrete dynamical systems, which are widely applied in modelling systems in areas such as pattern recognition and image processing [8], [9].

A cellular automaton consists of a regular grid of cells that can each cell take at a given time a state of a finite set. Time is also discrete and the state of a cell at time t + 1 is based on the state at time t of a finite number of cells called its neighborhood. With each unit of time, the same rules are applied simultaneously to all cells of the grid, producing a new generation of cells entirely dependent on the previous generation.

CA can be interpreted like a set of rules which through an Evolutionary CA (EvCA) [10], we can find sub-set or several appropriate rules for a definite problem. The idea of using one packet of rules in convex hull detection is in the merit of Rosin [11]. Moreover, Rosin studied these best rules in details and showed the interest of each one.

In this paper, we use a CAs to find convex hull in images of a polygonal or curved edge and we are using the GA to improve and generating the results to find a single powerful packet of rules for extracting efficiency convex hull in a given black-white image. Indeed, an EvCA is applied in order to determine the best local rules of the CA, using a GA on a population of CA candidates. After this introduction, Section 2 presents the EvCA for convex hull detection (EvCA-CHD) approach. Experimental results are reported in Section 3. Conclusions are drawn in the last section.

II. The EvCA For Convex Hull Detection

The proposed method of EvCA-CHD takes advantage of the calculating faculties of the CA, to transform the initial configurations defined by a binary image lattice as input discrete data in order to find its convex hull. In the CAs-CHD method, we seek the best packet of transition rules for convex hull detection of a black-white image. The CA unit is represented by a rectangle of 9 cells. Indeed, the problem is to find the best CAs for convex hull detection among 251 possible rules. In this broad area of research that we analyze, we must work with the inverse problem where we seek the optimal rules that gives the best detection of convex hulls in different formats outline objects in the image. In order to explore all configurations in the space research, we grouped the rules in packets [12]. CA can be interpreted like a set of rules which through an EvCA, we can find one or several appropriate rules for a definite problem of polygonal or curved convex hull.

The idea of using a set of rules in convex hull detection is reported in the work of Rosin [11]. It can be used in generally edge of convex hull detection. Moreover, Rosin studied the bests rules in details and shows the interest of each one. The result of its study showed that a set of best rules give a best convex hull in a binary image.