Cellular Automata in Image Processing

Cellular Automata based Edge Detectors

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One of the most important image processing tasks is the edge detection, which resumes to finding the best edge detector for a set of images. The scope of an edge detector is to find points that define the contour of an object or of more objects in an image. Edge detection might be used as a step in a more complex task, such as object detection, object recognition, object localization or any other. Many approaches were proposed in the current literature, some of them based on Cellular Automata (CAs). CAs are simple models of parallel computation that have been used extensively for various computational tasks. Such models are especially useful for image processing, as mapping automaton cells to image pixels is straightforward and intuitive.

We propose two edge detectors based on evolved CAs along with their variations, Binary Edge Detector (Binary ED) and Greyscale Edge Detector (Greyscale ED). The first approach, Binary ED is an edge detector designed for binary images implemented as an optimizer of a Cellular Automaton's (CA) rule. The scope of this approach is to find the most suitable CA's rule that may detect the edge points in binary images. Therefore, the chosen approach is evolving the rule of a Two Dimensional CA (2D CA) by the means of Evolutionary Algorithms (EAs). For that matter, two Genetic Algorithms (GAs) are implemented to evolve, once, the rule that should detect edge points, called Edge GA, once, the rule that should detect non–edge points, called NonEdge GA. Two versions of this approach are presented along with a study of the capabilities of the CA to detect edges, followed by an analysis of the proposed edge detector on a test set of images and finally, an asses of ability to generalize the behaviour of the proposed approach on multiple images.

The second approach, Greyscale ED is an edge detector designed for greyscale images. The scope of this approach is to find the optimal CA's transition rule that may detect the edge points. Therefore, the chosen approach is evolving the rule of a 2D CA by the means of a GA. Three versions of this approach are presented: the first version uses a GA to find the optimal linear rule according to some given parameters defined for the CA's transition rule, the second one uses a GA to find the three optimal parameters that define the CA's transition rule and the third one uses a GA to find the three optimal parameters but using an unsupervised fitness. The capabilities of the CA to detect edges are firstly evaluated, followed by an analysis of the proposed method on a test set of images and finally, an asses of the ability to generalize the behaviour of the

proposed approach on multiple images.

Keywords

cellular automata, edge detection, evolutionary algorithms, image processing, binary images, grey images

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