Convergence in 3-state Non-uniform Cellular Automata and Pattern Classification

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1-dimensional three-neighborhood binary irreversible cellular automata (also called elementary reversible cellular automata or ECA) is a well explored field both with respect to theory and applications. The irreversible behavior of such CA, convergence property for point attractors has been studied in detail for null boundary CA, as well as periodic boundary conditions. The feature set of this cellular automata consists of only binary numbers 0, 1. As a result, we may believe that this may lead to some restrictions of such a pattern classifier in its ability, accuracy, capacity and range of classification. Also, when compared to the real world data, a 2-feature CA really falls short as most data has the number of features spread across the discrete number space.

To solve this problem and test out the pattern behavior, classification and dynamics of the d-state cellular automata, we wanted to first use 3-state 1-dimensional CA (uniform and non-uniform) for pattern classification.

Since there was no pre-existing tool for studying the dynamics of 3-state cellular automata, finding the number of point attractors for each rule and the rule space being too large and unfiltered to work with, we devised a 2-step methodology to study the dynamics of the CA as well as reduce the rule space to some extent to reduce complexity.

1. We derived a mathematical formula to subgroup d-state CA into d^{n+1} such groups based on some conditions, which we proved correct as well as extended along the discrete number space for any d-state CA.
2. We then used the rule numbers from within the selected groups that would be a good fit for our classifier by studying the dynamics of the 3-state CA rules using a self-designed algorithm. We only select those rules for classification that give only point attractors as reversible configuration can give misleading results for our classifier.

As future scope for our research, we wish to extend our work and implement a pattern classifier using these selected rules from the reduced rule space. We also plan to find more rules in lower number groups that may be suitable for implementing pattern classifiers.