1. **Cellular Automaton and properties:**
2. Simple Cellular automaton was developed for application of a particular rule on a string.
3. Given a rule vector and a size n (4<= n <=8), cellular automaton was deigned to apply the rule vector to all the possible binary strings (2n).
4. Given a size n (4 <= n <= 8) and an integer k, considering all the possible binary strings of size n, random rule vectors were applied k times.
5. Binary image of given rule by applying on a standard binary string <0…0 1 0…0> was drawn.
6. NCCA (Number Conserving Cellular Automata) rules for 5,6 and 7 bit strings were found which satisfies that

*For all binary strings of size k, 5<=k<= 7, uniform and some non uniform rules , weight[1] of input string is equal to the weight of output string where weight is considered as the number of 1’s in the binary string.*

Observations :

1. Class promoting and class demoting rule vectors were found for 5,6 and 7 bit uniform rules.

*Class : It is defined by the weight[1] of the binary string.*

*For example, considering the size k, there can be k+1 classes for it as class0 for weight 0 and similarly class k for weight k.*

*Class Promotion: If for all strings of size k, application of rule R upgrades all the classes of the string i.e. classp changes to classp+1 while not considering the boundary classes i.e. class0 and classk.*

*Class Demotion: If for all strings of size k, application of rule R degrades all the classes of the string i.e. classp changes to classp-1 while not considering the boundary classes i.e. class0 and classk.*

Observation:

No uniform rule of size n (4<= n <=8) was observed which either follows class promotion or class demotion for both null boundary and periodic boundary cellular automaton.

1. Given a particular rule vector, its diagraph was drawn i.e. the transitions of the rule multiple times was displayed.
2. Number promoting and number demoting cellular automata rules.
3. Weight increasing and weight decreasing cellular automata rules.
4. **Neural network analysis**

* Creating transitions of rules of size 4 and of same pattern as < x x x x >
* Analysis of all rules like classifying them as in which layer it converges or continues to stay in that particular pattern, no of elements in each layer and no of hidden layer.
* Complete graph adjacency list of all the rule vectors with weight.

**Day:**

* For all uniform rule vectors of size n>4,

On selecting any rule and creating a uniform rule vector of size n (n>4) called R.

Selecting a binary string S of size n and apply R on S by using periodic boundary cellular automaton and let the output string be S’.

1. There are certain rules which doesn’t decrease the weight of the input string , for all input binary string combinations of size n.

i.e. weight(input string, S) <= weight(output string, S’)

\*\*here weight is count of 1’s in the binary string.

The rules which follow the same are :

[170, 171, 174, 175, 184, 185, 186, 187, 188, 189, 190, 191, 204, 205, 206, 207, 220, 221, 222, 223, 226, 227, 230, 231, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255]

Total of 46 rules are there.

1. Similarly, there are 46 no of rules which don’t increase the weight of the string over all possible binary strings of size n.

i.e. weight(input string, S) >= weight(output string, S’)

The rules which follow the same are:

[0, 2, 4, 8, 10, 12, 16, 24, 32, 34, 40, 42, 48, 56, 64, 66, 68, 72, 76, 80, 96, 98, 112, 128, 130, 132, 136, 138, 140, 144, 152, 160, 162, 168, 170, 176, 184, 192, 194, 196, 200, 204, 208, 224, 226, 240]

1. There are certain rules which fall in the common category of both i.e. weight increasing as well as weight decreasing, that is they are the rules which neither increase nor decrease but make the weight of output string same and constant as of the input.

Those rules are :

[170, 184, 204, 226, 240]

\*\*\* There are no such rule, which on forming a uniform rule vector strictly increases or strictly decreases the weight of the string.

**Some Conclusions**:

Let for input string s1 on apply of rule R output string is s2.

Defining some property on the set of all possible strings of size x on application of uniform rule R,

Let property of the strings on application of rule R be

**P1**: the weight of s1 = weight of s2

**P2**: the weight of s1 >= weight of s2

**P3**: the weight of s1 <= weight of s2

**P4**: no particular defined weight order i.e. may increase or decrease some string’s weight.

1. **To satisfy P1 for all strings of size x, the uniform rule vector R must be within these rules of set S1.**

**S1** : < 170, 184, 204, 226, 240 >

1. **To satisfy P2 for all strings of size x, the uniform rule vector R must be from these rules of set S1 U S2. (41 + 5 )**

**S2** : < 0, 128, 2, 130, 4, 132, 8, 136, 10, 138, 12, 140, 16, 144, 24, 152, 32, 160, 34, 162, 40, 168, 42, 48, 176, 56, 64, 192, 66, 194, 68, 196, 72, 200, 76, 80, 208, 96, 224, 98, 112 >

1. **To satisfy P3 for all strings of size x, the uniform rule vector R must be from these rules of set S1 U S3. (41 + 5)**

**S3** : < 171, 174, 175, 185, 186, 187, 188, 189, 190, 191, 205, 206, 207, 220, 221, 222, 223, 227, 230, 231, 234, 235, 236, 237, 238, 239, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255 > U set of rules in P1

1. **The following rules of set S4 satisfy the property P4 on all possible strings of size x. {169 = 255-(41+41+5) }**

**S4** :< 1, 3, 5, 6, 7, 9, 11, 13, 14, 15, 17, 18, 19, 20, 21, 22, 23, 25, 26, 27, 28, 29, 30, 31, 33, 35, 36, 37, 38, 39, 41, 43, 44, 45, 46, 47, 49, 50, 51, 52, 53, 54, 55, 57, 58, 59, 60, 61, 62, 63, 65, 67, 69, 70, 71, 73, 74, 75, 77, 78, 79, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 97, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 129, 131, 133, 134, 135, 137, 139, 141, 142, 143, 145, 146, 147, 148, 149, 150, 151, 153, 154, 155, 156, 157, 158, 159, 161, 163, 164, 165, 166, 167, 169, 172, 173, 177, 178, 179, 180, 181, 182, 183, 193, 195, 197, 198, 199, 201, 202, 203, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 225, 228, 229, 232, 233 >

\*\*5. **For non uniform vector of size x, on all possible strings the following can be deduced.**

1. **Any combination of set S4 producing a non uniform rule vector R of size x, will only satisfy the property P4 only and can never satisfy properties P1 or P2 or P3. (**tested for 4 **<=** x **<=** 25**)**
2. **Any non uniform combinations of set P2 of size x producing a rule vector R, will either satisfy property P2 or P4 and nothing else. (**tested for random rules and 4 **<=** x **<=** 15**)**
3. **Any non uniform combinations of set P3 of size x producing a rule vector R, will either satisfy property P2 or P4 and nothing else. (**tested for random rules and 4 **<=** x **<=** 15**)**