Indian Summer School on Cellular Automata

Cellular Automata based Modelling of Stock Market

Krishnendu Dasgupta
Mentor: Souvik Roy

August 23, 2022

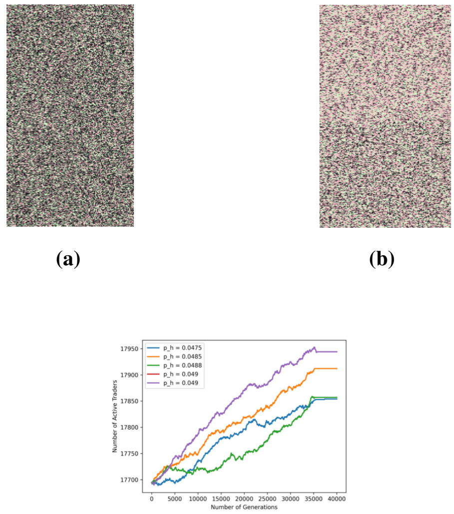
In this work, it has been tried to showcase the Dynamics of the Stock Market with the help of a 2D Cellular Automata. The Active Traders are characterised by the states +1(Buying Stocks) and -1(Selling Stocks). The Inactive Traders are characterised by 0 State. Some Simulation Rules(For changing the State of the Traders from Active to Inactive and Vice Versa) are applied and the simulation is done. Based on that Simulation, some Graphs are plotted. After that, Simulation rules are Tweaked. Instead of checking the Neighbours and keeping the condition on the basis of at least 1 Neighbour in the Simulation Rules, K and l Neighbours are respectively checked for the Rule(1) and Rule(2) of Simulation where K and l are taken from the Set 1,2,3,4. Graphs are obtained and along with that some Drastic Changes are also observed in the Dynamics of the Market. We witness the Strictly Increasing Graphs of the Simulation to become sometimes Strictly Decreasing when the K and l values are Increased. In the later part of the analysis, we take The Global Neighbourhood Condition for the Simulation to resemble the Real Life Stock Market. These Neighbours are Fully Random in nature. Since, we are considering 512×128 Grid, so we have 65,536 cells and out of those cells, these Global Neighbours are Randomly Chosen and preferably they don't collide with the Local Neighbours. There we observe some Interesting Changes in the Dynamics of the Market. The Graphs remain Strictly Increasing for a very long extent of time as compared to the Most Initial Model. A 512×128 Grid is taken where each cell can have 3 states, precisely, 0,+1 and -1. 0 indicates an Inactive Trader who is not involved in the Market; $+1$ indicates an Active Trader who is buying some stocks; -1 indicates an Active Trader who is selling some stocks.

Now, initially a Random Configuration is taken and then the simulation is continued for generations to get some Interesting Observations. The Initial Random Configuration guarantees to have not more than 27% of Active Traders. Von Neumann Neighbourhood is considered for the simulation. The rule is as follow,

1. If a Cell is in State 0 and at least 1 of its Neighbours is in State 1, then with Probability PH, it gets converted to State (+1 or -1).
2. If a Cell is in State 1 and at least 1 of its Neighbours is in State 0, then with Probability PD, it gets converted to State 0.
3. If a Cell is in State 0, then with Pc Probability, it gets converted to State (+1 or -1).

In Figure. 1, Black Cells represent Inactive Traders and Non-Black Cells represent Active Traders. As per the Instructions and values given in the Paper, we do the fine Tuning of the Value of P_H. We take Fixed values for $P_C = 0.0001$ and $P_D = 0.05$. Then we take 5 Different Values of P_H as $[0.0493, 0.0490, 0.0488, 0.0485, 0.0475]$. Then we simulate using these values and plot the Graph between Number of Active Traders(Y-Axis) vs Number of Generations(X-Axis) (see in Figure. 1c). The Graph obtained is Strictly Increasing and finally settles and becomes almost constant within the range of $35,000 - 40,000$.

In the Previous Main Model, as per the Given Conditions (1) and (2), only 1 Opposite Neighbour can make the cell toggle from its state to another on a certain Probability. But, if we changed that quantity of 1 to K and l maybe respectively for the Rules, then a very Interesting Result



(a) (b) (c)

Figure 1: Diagram for $P_D = 0.5, P_H = 0.6, P_H = 0.3$ and simulated for 1,00,000 Generations. (a) Initial State; (b) Final state; (c) The Graph;

comes in Picture. Where $K, l \in 1, 2, 3, 4$
Revised Rule(1): If a Cell is in State 0 and at least K of its Neighbours is in State 1, then with Probability P_H, it gets converted to State (+1 or -1).
Revised Rule(2): If a Cell is in State 1 and at least l of its Neighbours is in State 0, then with Probability P_D, it gets converted to State 0.
Till now, we have seen the Neighbours to be Local Von Neumann Neighbours to be considered for Simulation. But in this second version of the Extended Model, Global Neighbours have been taken into picture so as to get some Insights about the Effect of the Market as a whole to a Particular Cell(A Trader to be precise). But in Real Life, the Stock Market's Traders are not only dependent on their Local Neighbours, for being converted from Active to Inactive and vice versa, but also somehow dependent on the Global Neighbours. Since, we are considering 512×128 Grid, so we have $65,536$ cells and out of those cells, these Global Neighbours are Randomly Chosen and preferably they don't collide with the Local Neighbours. Following are the two cases Considered with respect to Global Neighbourhood Condition:

- 2 Local Neighbours(Randomly chosen from 4 Von Neumann Neighbours) and 2 Global Neighbours(Randomly chosen from the whole Board).
- 3 Local Neighbours(Randomly chosen from 4 Von Neumann Neighbours) and 1 Global Neighbour(Randomly chosen from the whole Board).