**Research Paper**

I chose to research and base this report on the cellular automata model which was not covered in this class. While researching automata models, I stumbled across a report stating the use of an automata model to predict wildfires in an area. Through the use of cellular automata scientists were able to simulate wildfire spread which in turn helped firefighters combat these dangerous fires.

The idea of cellular automata was proposed by John von Neumann as models of self-reproducing organisms in the 1940s. The descripting for these automata is a one-dimensional array of cells which could alternatively be shown as a two-way infinite array. Time points are essential in this automata model and each cell in each timepoint is one of a finite set of possible states. Each cell in the array changes state at each clock tick, whereas the new state is determined by the present state of the cell and its left and right neighboring cells. Although no input is present in this model, the collection of cell states at a given time point are referred to as a global state of the cellular automation. The magic of this automata is that it is essentially a self-producing automata which can replicate and follow a set of instructions which are present in its cells. Cellular automata are also capable of universal computation since it can perform simulation of a single tape Turing Machine. (Zhang)  
 Well how does this all tie in to create a model which can simulate and show us wildfire spread? Scientists have proposed Firegen which is an “evolutionary stochastic cellular automaton model that predicts forest fire growth.” (Green) After feeding the model various different data pertaining to wildfires such as topology, climate factors, and local trends Firegen is able to simulate a relatively accurate model which serves as a roadmap of where wildfires are likely to spread to. The accuracy of this model is at 74% which gives firefighters an upper hand in the fight against what appear to be unpredictable fires.

Cellular automata are perfect for creating simulations that spread throughout a grid which in this case shows the spreading of a wildfire through land. Attributes are given to each site on the grid which describe its unique state. The fire spreads throughout the grid when cells adapt according to their neighbors. The relations in wildfire simulation the interests are in the relations with “ignition probability and local environmental factors, such as wind speed and direction, temperature, and relative humidity.” In our model as time passes, fire that is in one cell would spread to other cells neighboring it based on the calculated probability using the parameters that are learn-able. As shown in figure 1 below in each time step in the model, cells that are next to a cell with a present fire are calculated and candidates for ignition. Using a probability distribution, the model determines if the cells will also ignite. This specific model uses six different features which help the prediction accuracy (temperature, humidity, state, wind direction, wind speed, and elevation).

Chart

Description automatically generated

Figure 1: Depicts an example of what the cellular automata model would look like for the wildfire situation. The state map is shown while outlying the different features in the background.

Typically, cellular automata model’s probability distribution which decides if a given cell will follow the behavior of its neighbor is static and given by the cellular automata modeler. In this wildfire care, the spreading function “evolves through symbolic regression.” Through each time periods simulation, the model runs for x amount of time steps where simultaneously the cells are being updated based on the attributes given by neighbors in the spreading of a given wildfire. By the end of the run of the simulation we have a good idea of the trajectory and direction of the wildfire by the cells which indelicate ignition.

I have found the subject of cellular automata to be very interesting and plan on continuing my research into the automaton. The application of cellular automata into wildfire prediction has proven to be useful in many different situations and I believe we can use it in other aspects of simulation software. Although this automaton was not covered in class, I believe it is relatively similar to some of the models we learned throughout this semester such as Turing Machines.

**Citations**

Green, M. E., DeLuca, T. F., & Kaiser, K. W. D. (2020). Modeling wildfire using evolutionary cellular automata. *Proceedings of the 2020 Genetic and Evolutionary Computation Conference*. https://doi.org/10.1145/3377930.3389836

Shin, S.-H., Jeon, J.-C., Lee, G.-J., & Yoo, K.-Y. (2014). Design of a cellular automata cell with rule 30 on quantum-dot cellular automata. *Proceedings of the 29th Annual ACM Symposium on Applied Computing*. https://doi.org/10.1145/2554850.2559923

Zhang, C., & Sarjoughian, H. S. (2017). Cellular automata DEVS. *Proceedings of the 10th EAI International Conference on Simulation Tools and Techniques*. https://doi.org/10.1145/3173519.3173534