Simulation of Forest Fire Spread with Different Methods

Group 11

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1 Division of Labor

The division of labors is shown as follows:

- PDE: An, Xiaodong (Modeling and Writing), Avasarala, Srikanth (Parameter Searching)
- ABM: Ray, Pranoy (Modeling and Writing), Avasarala, Srikanth (Parameter Searching)
- Git Repository: An, Xiaodong (Setup and Collaborator), Avasarala, Srikanth (Collaborator), Ray, Pranoy (Collaborator)

2 Current Progress

We have set up a public Git Repository for this project, and the link is https://github.gatech.edu/xan37/CSE-6730-Group-Project.

2.1 PDE

The PDEs, from checkpoint 1, are listed below:

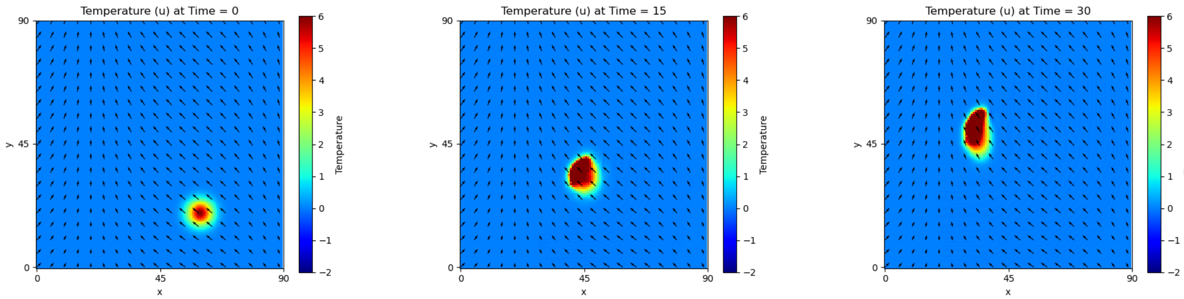
$$\begin{aligned}
&\boldsymbol{v}(\boldsymbol{x},t) = \boldsymbol{w}(t) + \nabla Z(\boldsymbol{x}),\\
&u_t = \kappa \Delta u_t - \boldsymbol{v}\cdot\nabla u_t + \mathcal{H}(u_t - u_{pc})\beta \exp\left(\frac{u_t}{1+\varepsilon u_t}\right) - \alpha u_t,\\
&\beta_t = -\mathcal{H}(u_t - u_{pc})\frac{\varepsilon}{q}\beta \exp\left(\frac{u_t}{1+\varepsilon u_t}\right),
\end{aligned}$$

We have coded the PDE model for forest fire spreading and did testing on it, as shown in Fig. 1, with the initial fuel set to be uniformly random and other parameters given in Tab. 1. The fire starts at $[60, 20]$ with a Gaussian distribution.

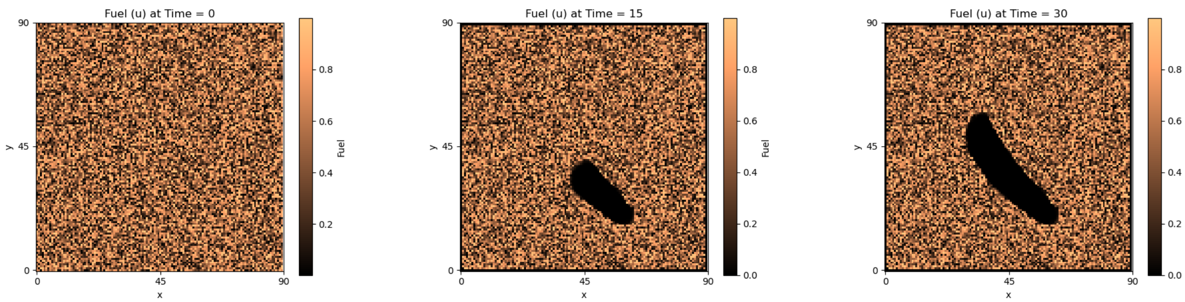
2.2 Agent based Model (ABM)

We setup an agent based model with two agents- trees, and wind. We propagate the fire probabilistically across the Moore neighborhood of a grid point in the 2D Cellular Automata (CA) model. Each "Tree" object represents an agent with states—unburned, burning, or burned—that evolves based on interactions with neighboring trees. Trees ignite and spread fire according to adjustable parameters, including the burn probability and wind effects. We use the following different types of wind flows - constant, vector, linear, radial, Gaussian, or sinusoidal, all of which modulates the likelihood of fire spread based on factors like distance, direction, and time. The model iterates over discrete time steps, using the CA framework where each cell (tree) checks neighboring cells to decide its next state.

Our follow up to the above would be to increase simulation complexity by adding natural agents like terrain etc, and then simulate mitigation using human agents for intervention. The integration of the above into the model is underway and we also plan on simulating usig real-world parameters for agents from https://archive.ics.uci.edu/dataset/162/forest+fires.



(a) Temperature at $t = 0$ (b) Temperature at $t = 15$ (c) Temperature at $t = 30$



(d) Fuel at $t = 0$ (e) Fuel at $t = 15$ (f) Fuel at $t = 30$

Figure 1: A testing for PDEs method. Arrows represent the wind effect.

Parameter	**Symbol**	**Value**
Diffusion coefficient	κ	0.1
Inverse of activation energy	ϵ	0.3
Natural convection	α	0.001
Phase change threshold	u_{pc}	3
Reaction heat	q	1
Map length	\	90
Simulation mash length	\	128
# of dt	\	1000
dt	\	0.05
The effect of wind	$\boldsymbol{v}(\boldsymbol{x}, t)$	$[0.04x + \frac{\sqrt{2}}{2}, 0.01y + \frac{\sqrt{2}}{2}]$

Table 1: Input parameters

3 To be done

We are going to set up comprehensive comparisons between these two methods we applied, including their running speeds and accuracies.

References