Finding the Most efficient Way to Stop Percolation through the use of a Firewall in the Forest Fire Model

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ABSTRACT

Through the use of computer simulation, the optimal way to stop the spread of forest fires with a firewall was examined. Forest fires were modeled with a 2-D percolation lattice near the percolation threshold (p_c = .5962). The effectiveness of the firewall as a function of its half-width (*hw*) and distance (*d*) from the starting point of a fire was determined. Our results suggested that the effectiveness of the firewall could be characterized by the function $tan(\theta)=hw/d$. For a site occupation probability of 0.62 we found that the optimal angle (θ) to be ≈ 60º. At this value of θ, the firewall is at its maximum distance from the fire and has a blocking effectiveness of 50%.

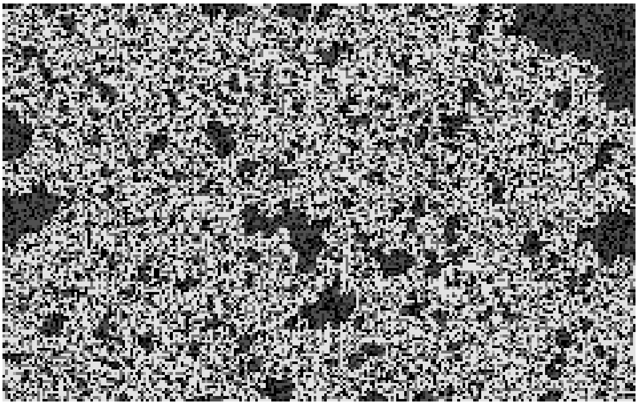
INTRODUCTION

In the on going battle to stop the spread of wildfires, one of the common methods of confinement is through the use of a firewall. A firewall is a line cut perpendicular to the direction of propagation of the fire where all of the fuel (e.g. trees, brush, grass, etc.) has been removed.

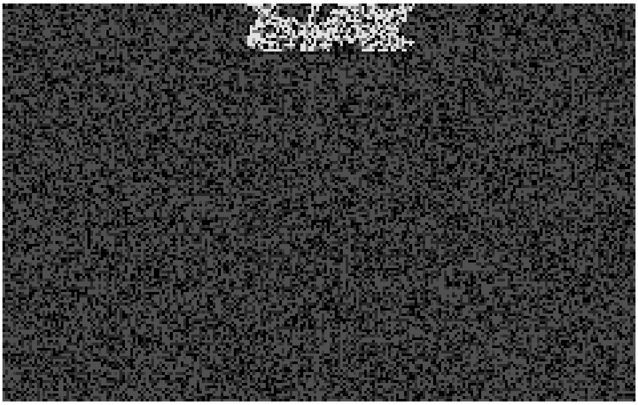
To obtain a better understanding of the effectiveness of a firewall, a 2-D forest has been simulated with a percolation lattice near the percolation threshold (p_c = .5962). A forest of dimension 320 x 200 $pixels^2$ was filled with a site probability of 0.62, where each pixel represents a tree. A firewall was then cut into the forest, and the forest was burned from a point source in the middle of the top row. The fire was allowed to spread to the nearest neighbor (no diagonal burning) only if a tree occupied that site. The fire was observed to see if it reached the bottom row of trees.

Simulations were run using two half widths of the firewall, hw = 25, and hw = 50. A hundred iterations were used at each distance d from the origin of the fire. The data was plotted and compared to the model.

Shown below is single forest filled with p = 0.62. Notice that without a firewall, the fire spreads to the bottom. In the second frame, you see that with the addition of the firewall, the fire is extinguished.

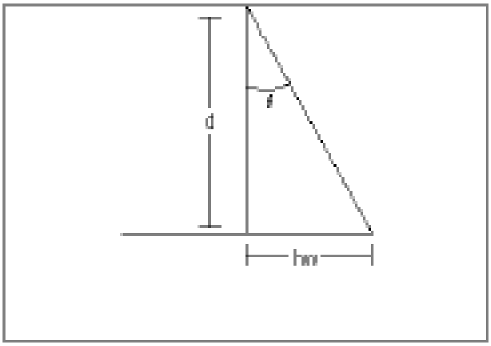


Percolating fire, no fire wall, p = 0.62



Same fire as above, with firewall

Data: The model that was used to describe the dimensions of the system is shown below.



Data was taken at two different hw (hw = 25, hw =50) and by varying d from 100 to 0.

hw = 25		hw = 50	
d	Normalized number of percolating fires	d	Normalized number of percolating fires
100	0.782608696	100	1.5625
95	0.782608696	95	1.484375
90	0.869565217	90	1.40625
85	0.869565217	85	1.328125
80	0.898550725	80	1.25
75	0.913043478	75	1.171875
70	1	70	1.09375
65	0.942028986	65	1.015625
60	0.956521739	60	0.9375
55	0.927536232	55	0.859375
50	0.826086957	50	0.78125
49	0.811594203	49	0.765625
48	0.84057971	48	0.75
47	0.898550725	47	0.734375
46	0.84057971	46	0.71875
45	0.739130435	45	0.703125
44	0.884057971	44	0.6875
43	0.884057971	43	0.671875
42	0.956521739	42	0.65625
41	0.913043478	41	0.640625
40	0.956521739	40	0.625
39	0.68115942	39	0.609375
38	0.797101449	38	0.59375
37	0.753623188	37	0.578125
36	0.695652174	36	0.5625
35	0.811594203	35	0.546875
34	0.768115942	34	0.53125
33	0.855072464	33	0.515625
32	0.782608696	32	0.5
31	0.913043478	31	0.484375
30	0.753623188	30	0.46875
29	0.84057971	29	0.453125
28	0.724637681	28	0.4375
27	0.768115942	27	0.421875
26	0.695652174	26	0.40625
25	0.710144928	25	0.390625
24	0.623188406	24	0.375
23	0.666666667	23	0.359375
22	0.623188406	22	0.34375
21	0.565217391	21	0.328125
20	0.695652174	20	0.3125
19	0.536231884	19	0.296875
18	0.52173913	18	0.28125
17	0.463768116	17	.265625
16	0.579710145	16	0.25
15	0.565217391	15	0.234375
14	0.507246377	14	0.21875
13	0.376811594	13	0.203125
12	0.289855072	12	0.1875
11	0.246376812	11	0.171875
10	0.246376812	10	0.15625
5	0.057971014	5	0.078125

This data was then plotted and measurement were taken to find where the firewall was effective 50% of the time.

From this graph the hw/d ratio where the firewall was 50% effective was determined to be 1.9, and $\tan^{-1}(1.9)$ is approximately 60º.

RESULTS

From the above graph we determined that both of the firewalls stopped the fire 50% of the time when hw/d = 1.9. This ratio corresponds to an angle of ≈ 60º. However, further work is need to test is hw/d is a good scaling parameter for characterizing the effectiveness of a firewall.

Moreover, this research is a stem that could be used to further study other more in depth problems dealing with the effectiveness of a firewall.

ACKNOWLEDGEMENTS

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REFERENCES

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