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Crowd Sourcing Forest Fire Extinguishing

Contents

1. Summary

This is the report of Guus de Jonge and Bas Bakx, made for DG703 - Complexity trough Simplicity. In this report we detail a model made to simulate the extinguishing of a forest fire in a realistic situation.

The model consists out of a forest with a variable amount of visitors in it (for the purpose of this report we use 10 people). Throughout the forest units that detect fire and contain a fire extinguisher can be placed at a variable distance. The visitors use these to extinguish a starting forest fire.

The purpose of this report is to document the creation and usage of the model. We will collect data from an experiment with the model and graph this. From the data we will be able to make conclusions about the model, exposing the strengths and weaknesses.

2. Introduction

In multiple regions around the world, forest fires are a serious threat. Currently there are multiple different fire extinguishing systems that can be installed in order to prevent or reduce the damage. A properly operating extinguishing system often requires high material and service costs. In order to protect forests with a lower budget, cheaper methods will have to be explored. One of the relatively cheap extinguishing methods is the crowd sourcing of fire extinguishing. During this assignment we are going to contribute to the exploration of this unique extinguishing method. A model will be created to simulate the different scenarios and explore the opportunities and threats. In this way we will investigate whether crowd sourcing of fire extinguishing is a potential method for the future or not.

3. Real world model

The goal is to place units, containing one fire sensor, alarm and extinguisher, inside a forest. The units will be placed inside a grid. Whenever a forest fire comes close to a fire sensor, the alarm will be activated. Visitors that have spotted a fire are also able to activate the alarm manually. Once the alarm is activated, multiple visitors might be willing to extinguish the fire. Those visitors are able to grab an extinguisher and start putting out the fire.

4. Mathematical model

We assume that all visitors are aware of the working of the extinguishing system. The following rules will be implemented in our model:

1. Visitors who are not aware of any fire walk around randomly
2. A visitor is able to become aware of a fire by;
    2.1 An activated alarm
    2.2 Spotting the fire
3. An aware visitor without an extinguisher will run towards the closest unit with an extinguisher
4. An aware visitor that reaches a unit when the alarm is still inactive will activate the alarm
6. An aware visitor with an extinguisher will run towards the closest fire
7. An aware visitor with an extinguisher that is close to a fire will blast water on the closest flames
8. When a fire has been extinguished and the alarm turns off, all visitors with an extinguisher will return the extinguisher to the closest unit without extinguisher

5. Creating the model

The creation of the model was an iterative process in which different ideas and methods were examined. This chapter will give you a view of the different paths and decisions that led towards our final model.

5.1. The location

The first aim was to extinguish a fire at the TU/e. The user was able to choose between different rooms, like the Auditorium and Hoofdgebouw. The rooms existed out of basic walls and furniture that all together schematically mimicked the real environment.

The firemen collided with objects and were forced to walk around them. This often resulted in firemen getting stuck. In order to solve this, different special patches were placed. Those patches forced the firemen to walk in certain directions. In this way their process of e.g. walking through a small door became more efficient.

Despite of the special patches, the firemen were not able to walk in a realistic way towards their target. They walked directly towards the target which often resulted in huge roundabout routes due to objects that blocked their way. Therefore the location had to be changed to a location that did not contain many and/or big objects. Considering multiple locations, a forest turned out to be a great opportunity. The new aim will therefore be to create a model that contributes to a more efficient forest fire extinguishment.

5.2. The people

The first model contained firemen that extinguished the fire. Firemen are trained professionals that work with different strategies to extinguish fires in the most efficient and safe way. The simple rules that made the firemen walk and extinguish the closest fire did not represent the way that firemen work. Therefore the firemen had to be replaced by other human beings that are more likely to follow those rules. Forest visitors are people with (on average) a low amount of experience with fire extinguishment. Therefore the decision was made to use forest visitors. This automatically changed the whole perspective of the model. By making forest visitors extinguish the fire, you actually crowd source forest fire extinguishment. Therefore the examination of crowd sourcing fire extinguishment became the new main goal of the model. The forest visitors are placed randomly in the forest and walk slowly in random directions. In this way the visitors execute the walking behaviour of individual visitors in a forest without any forest paths.

5.3. The equipment

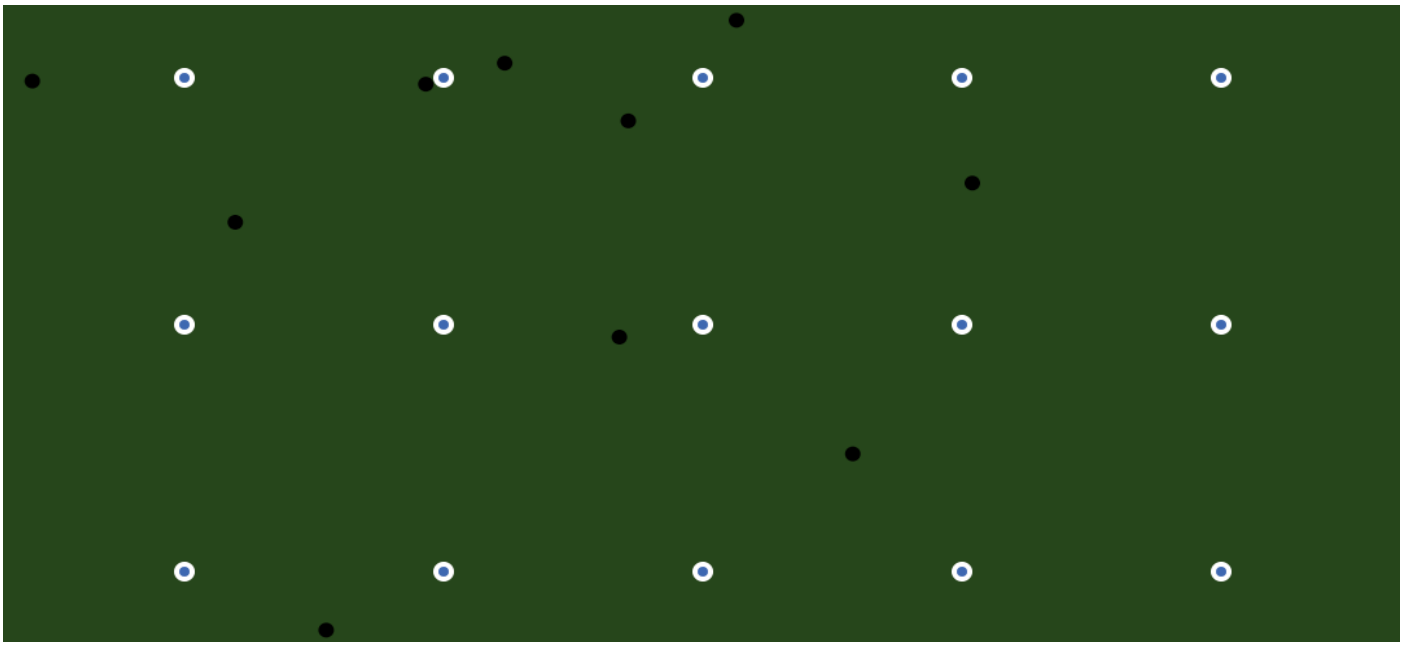
The first fire extinguishing equipment existed out of randomly placed fire extinguishers. The fire extinguishers can be used once and contain a certain pre-determined amount of water. Since the goal is to crowd source fire extinguishment in a forest it would not be efficient to spread the extinguishers randomly throughout the forest. Therefore the extinguishers will be placed in a grid. The size of the grid can be chosen by the user.

In the first model, the forest visitors immediately started to extinguish a fire from the moment it starts to burn. Even when no one was able to spot the fire, the fire 'alarm' immediately activated. This is unrealistic and so there was a need for new rules that activated the fire alarm after it has been spotted. In order to achieve this, fire sensors have been added. Those fire sensors are placed at the same spots as the fire extinguishers. This means that on every spot of the grid, a 'unit' will be placed that exists out of one sensor and one fire extinguisher. Once the extinguisher has been taken by a visitor, the sensor remains. When people spot a fire, they run to the closest unit and the alarm will be activated. The alarm will also be activated when a fires comes close to the fire sensor. Whenever a fire has been extinguished, the visitors that still possess a fire extinguisher will it to the closest unit.

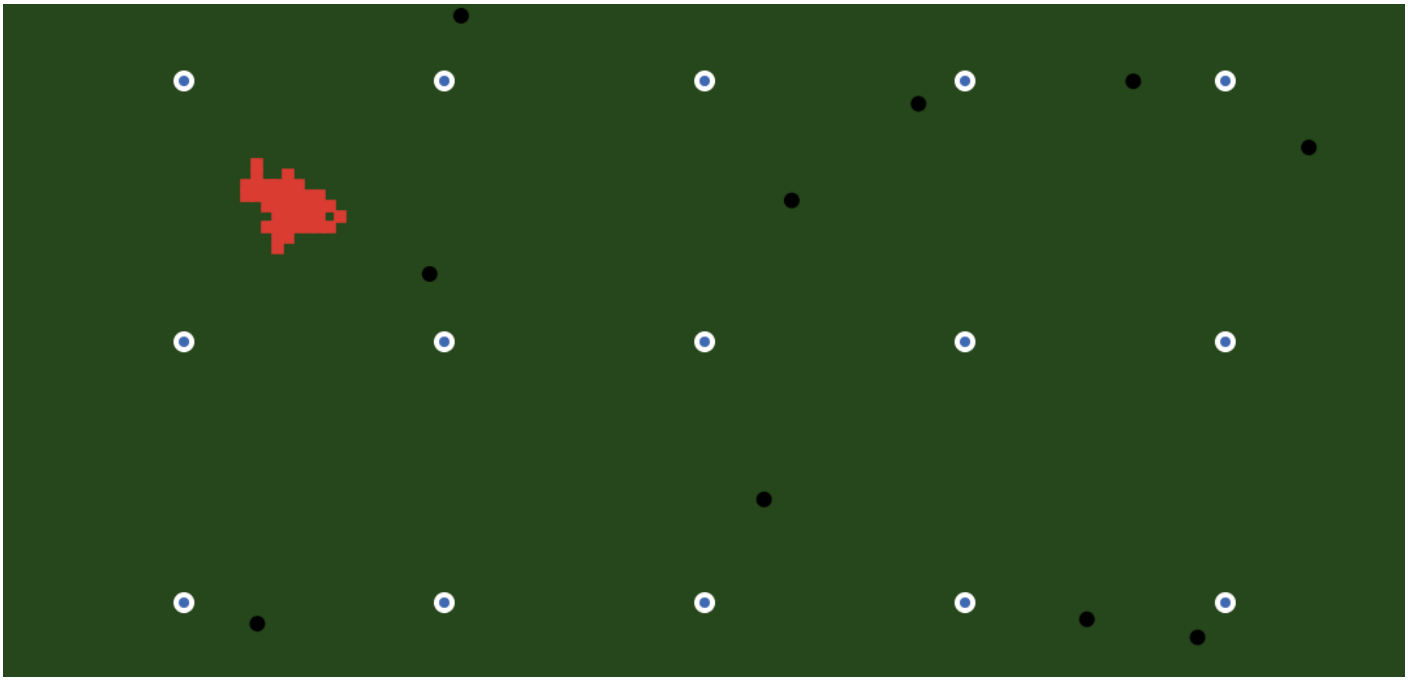
5.4. The fire

The user is able to start a fire on any patch of the forest by clicking on it. The fire consists out of red patches that are able to lit the patches next to them. The user is also able to set the fire speed. The higher the fire speed, the faster the fire will lit new patches. Fires are able to destroy fire extinguishers. A counter counts the percentage of burned forest. In this way the user is able to view the amount of damage the fire has been caused.

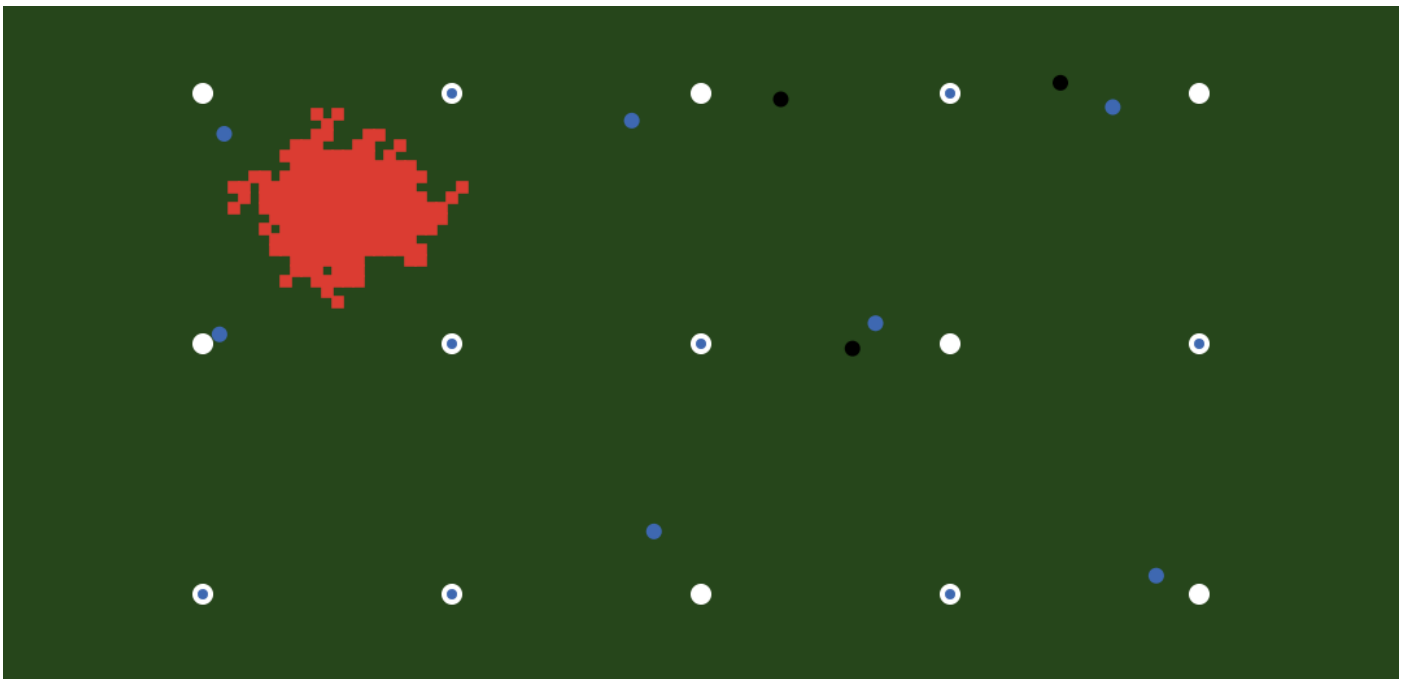
5.5. Final model



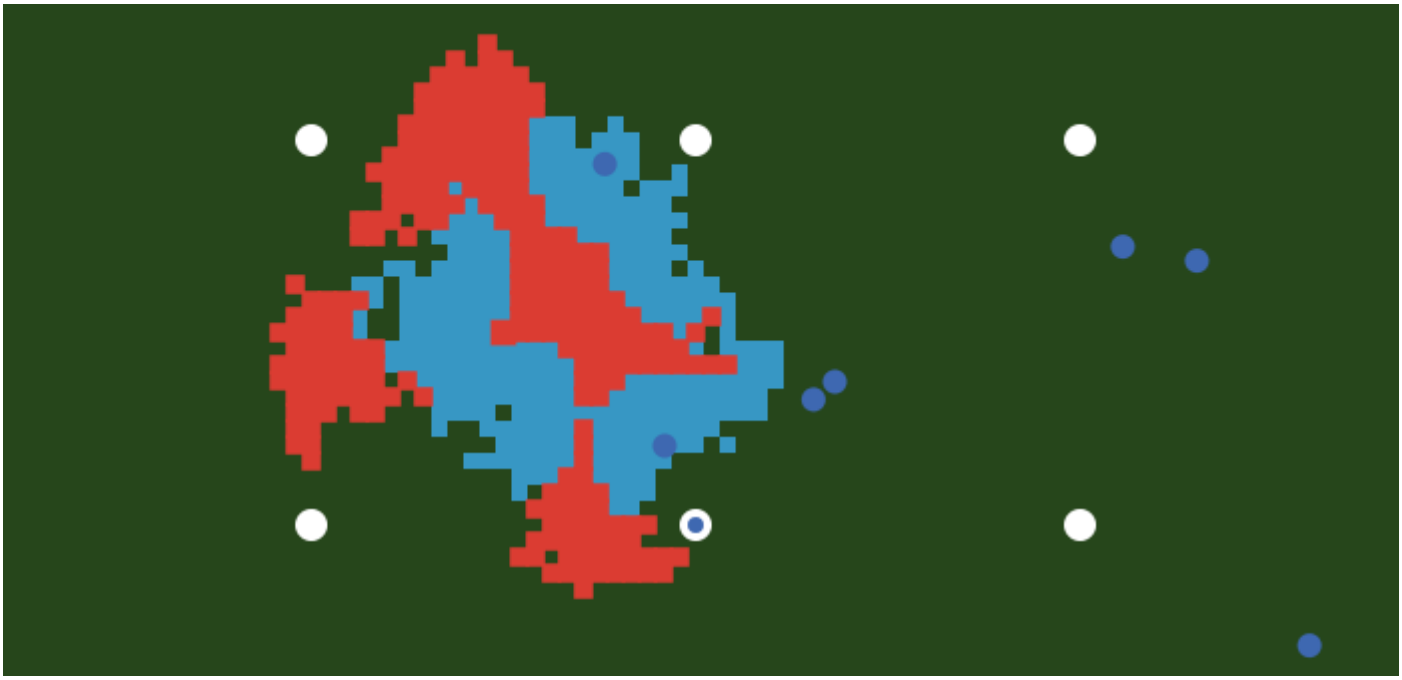
Phase 1: The following image visualizes the situation before the start of a forest fire. All of the green patches represent healthy forest and the black dots, which are moving around slowly, represent the visitors. The white dots serve as fire sensors and the blue dots as fire extinguishers.



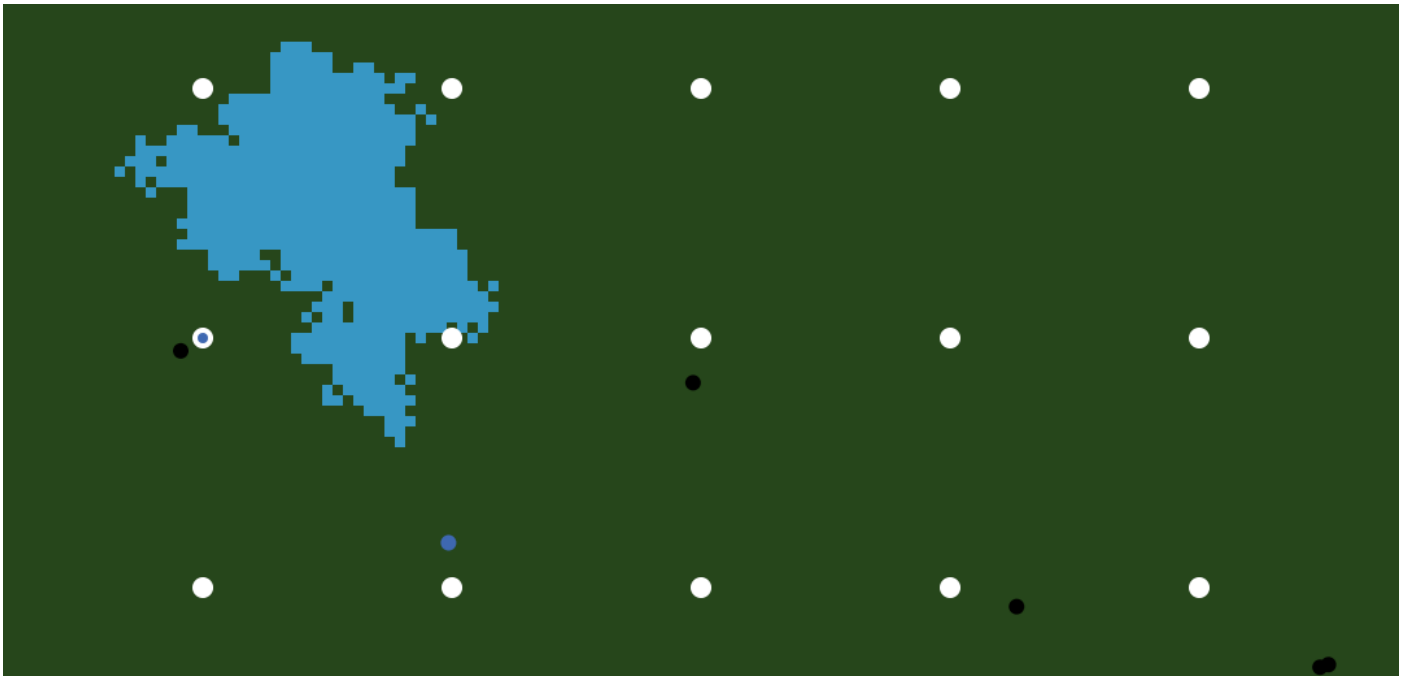
Phase 2: After clicking on a patch, a fire starts to burn and slowly spreads itself towards neighbour patches. The current fire has not been spotted by any visitor or fire sensor yet. Therefore none of the visitors is reacting on it.



Phase 3: The fire has ben detected and all visitors are running towards the closest fire extinguisher. The visitor turns blue after picking up the extinguisher and starts to run towards the closest fire.



Phase 4: The visitors blast water towards the fire, creating blue patches. Those blue are wet patches that cannot be lit on fire again. When a visitor's fire extinguisher gets empty, the visitor turns black again and runs towards the closest new fire extinguisher. Once a visitor touches the fire, he/she dies.



Phase 5: The fire has been extinguished. A blue visitor that still possesses a fire extinguisher will return it to the closest unit (fire sensor). The visitors turn black again and continue their forest walk.

6. Using the model

The main goal of the model is to examine the relationship between the amount of units (excisting out of one sensor and one fire extinguisher) and the amount of forest burned down. In order to consistently run the model, the following estimations have been made;

1. The amount of visitors in a forest depends on many variables. In this case we assume that an amount of 10 people are visiting the forest.

2. The fire speed relies on the situation of the environment. In this case we assume that the fire speed is 20, which means that the chance of a patch next to a fire to lit up is 2% per tick.

3. The fire will be started on the patch with the highest distance towards the closest fire sensor and forest visitor. In this way the worst scenarios will be simulated.

The distance between the units in the grid will be verified from 50% towards 1% with steps of 5% (so 50%, 45%, 40%, etc. including 1%). Every single distance will be tested 10 times. The amount of burned forest will be notated.

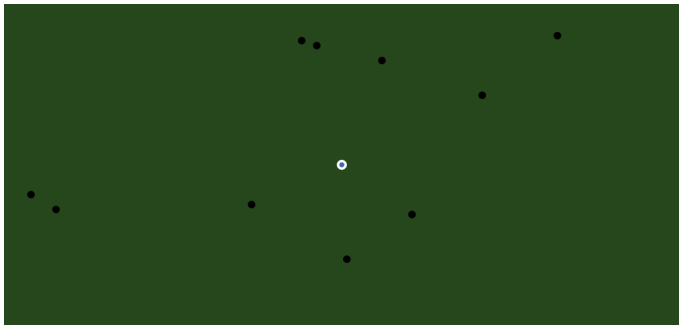
7. Hypotheses

The closer the extinguishers are placed to each other, the more extinguishers there will be in the forest. this makes it assumable that the likeliness of extinguishing succes increases when the distance between extinguishers decreases.

A linear connection is expected, double the extinguishers will double the chance of extinguishing and also half the amount of forest damage. It is important to repeat the test multiple times. The turtles are placed randomly throughout the forest and so the results with one certain unit distance might differ.

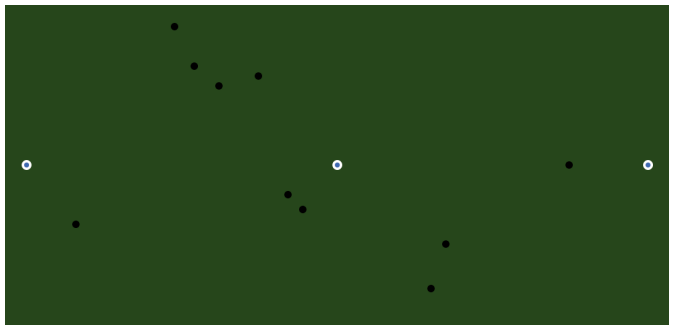
8. Results

8.1. Unit-Distance: 50%



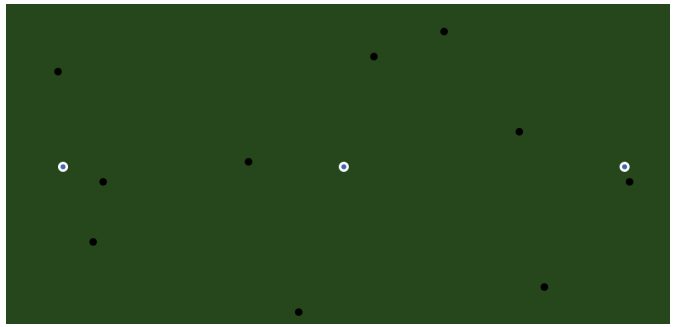
Run	Forest damage
1	100%
2	100%
3	100%
4	100%
5	100%
6	100%
7	100%
8	100%
9	100%
10	100%

8.2. Unit-Distance: 45%



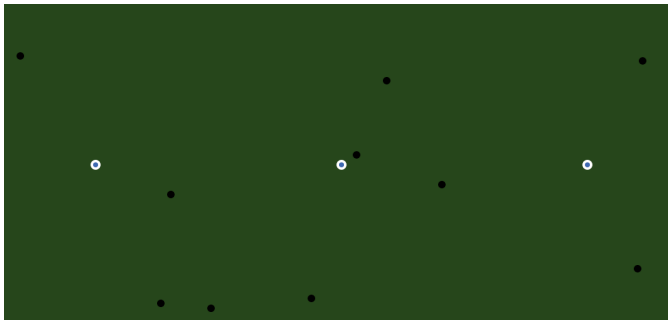
Run	Forest damage
1	100%
2	100%
3	100%
4	100%
5	100%
6	100%
7	100%
8	100%
9	100%
10	100%

8.3. Unit-Distance: 40%



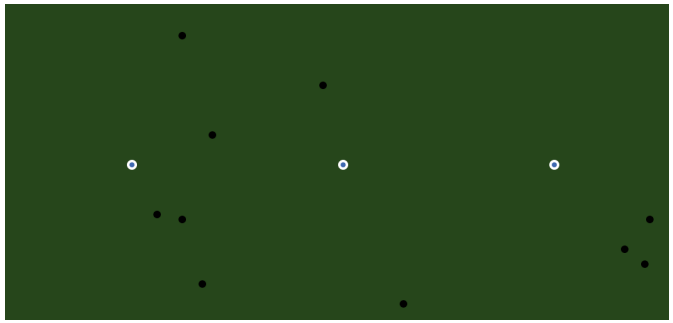
Run	Forest damage
1	100%
2	100%
3	100%
4	100%
5	100%
6	100%
7	100%
8	100%
9	100%
10	100%

8.4. Unit-Distance: 35%



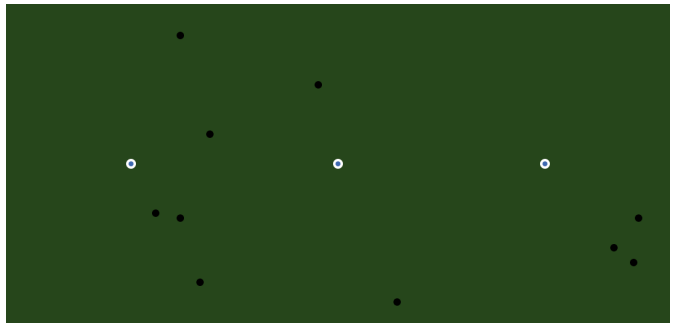
Run	Forest damage
1	100%
2	100%
3	100%
4	100%
5	100%
6	100%
7	100%
8	100%
9	100%
10	100%

8.5. Unit-Distance: 30%



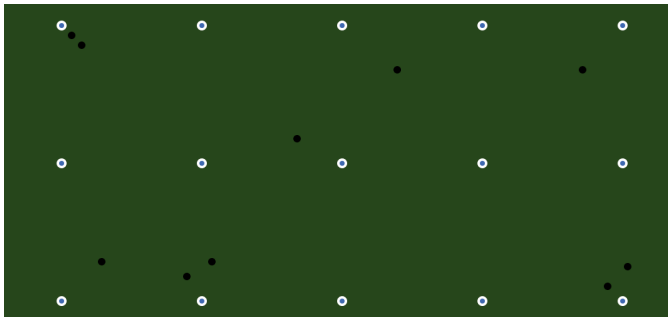
Run	Forest damage
1	100%
2	100%
3	100%
4	100%
5	100%
6	100%
7	100%
8	100%
9	100%
10	100%

8.6. Unit-Distance: 25%



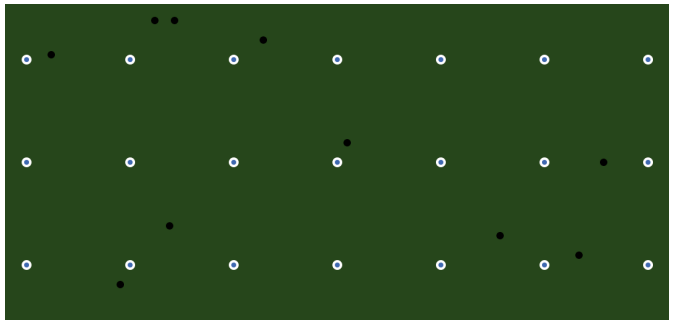
Run	Forest damage
1	100%
2	100%
3	100%
4	100%
5	100%
6	100%
7	100%
8	100%
9	100%
10	100%

8.7. Unit-Distance: 20%



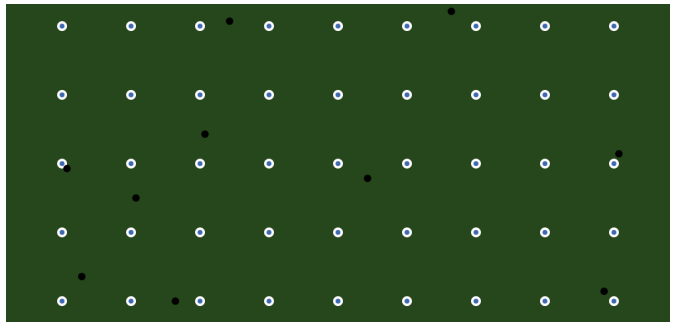
Run	Forest damage
1	100%
2	100%
3	100%
4	100%
5	100%
6	5%
7	100%
8	100%
9	6%
10	100%

8.8. Unit-Distance: 15%



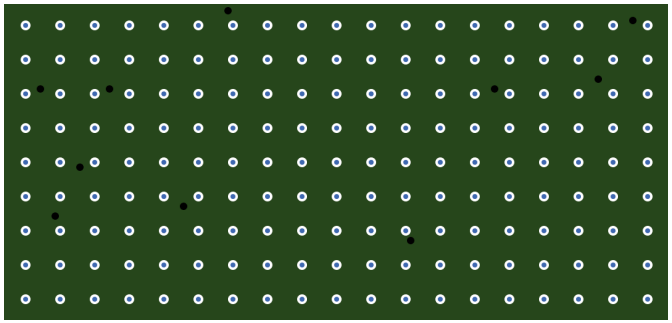
Run	Forest damage
1	2%
2	7%
3	4%
4	8%
5	5%
6	1%
7	10%
8	4%
9	100%
10	3%

8.9. Unit-Distance: 10%



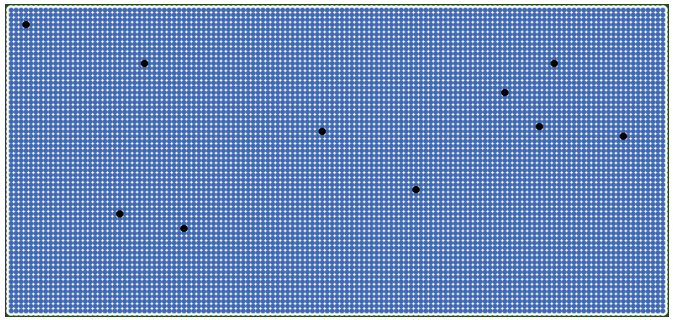
Run	Forest damage
1	2%
2	3%
3	2%
4	8%
5	4%
6	3%
7	2%
8	3%
9	0%
10	3%

8.10. Unit-Distance: 5%



Run	Forest damage
1	1%
2	0%
3	1%
4	1%
5	2%
6	0%
7	1%
8	0%
9	3%
10	1%

8.11. Unit-Distance: 1%



Run	Forest damage
1	1%
2	1%
3	0%
4	1%
5	1%
6	0%
7	2%
8	1%
9	1%
10	0%

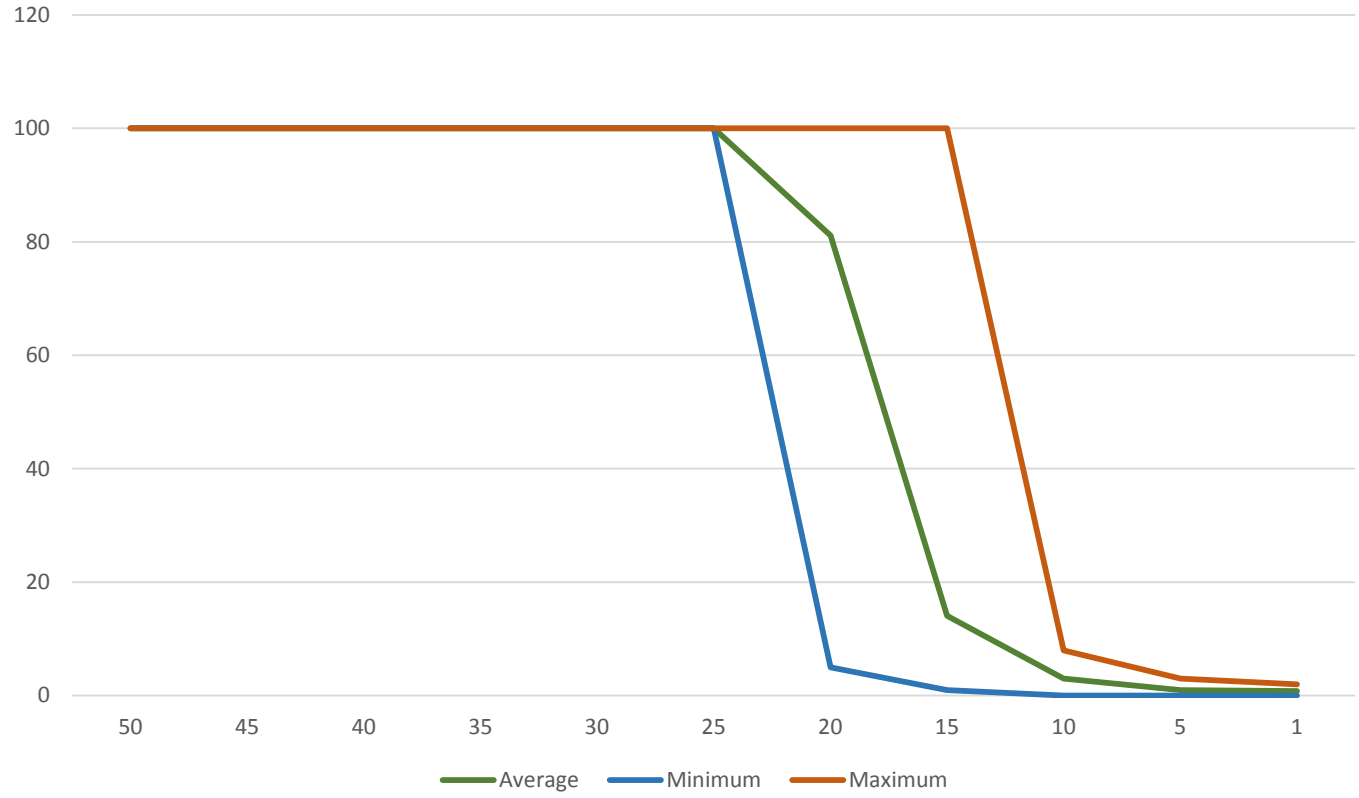
8.12. Summary

The following table shows the avarage, minimum and maximum % forest damaged of the executed simulations:

Unit-distance	Average Forest Burned	Minimum Forest Burned	Maximum Forest Burned
50%	100%	100%	100%
45%	100%	100%	100%
40%	100%	100%	100%
35%	100%	100%	100%
30%	100%	100%	100%
25%	100%	100%	100%
20%	81,1%	5%	100%
15%	14,4%	1%	100%
10%	3%	0%	8%
5%	1%	0%	3%
1%	0,8%	0%	2%

9. Conclusions

When we translate the summarized results of the previous chapter into a graph, we end up with the following graph:



The graph shows a sharp turning point, this is not as we hypothised. We expected a more linear progression. This result affords for a surprisingly concrete conclusion.

It is obvious, from the graph, that around 20% distance the forest damage dramatically decreases and starts to stagnate around 15%.

So for the specific forest we simulated in this test we can concretely say that units of fire extinguishers and alarms should be spaced between 20% and 15% of the total length of the forest. Any less will barely add to the safety. Any more is a waste of resources.

The results also lead to other conclusions. It was obvious that it is crucial to notice the fire early. If the fire was noticed early, in some cases only a single extinguisher was needed. This reveals that it is probably more economical to place more fire sensors than extinguishers since this is probably cheaper.

While the model obviously has it's limitations (some of the variables were assumed as opposed to mathematically determined) the sharp turning point makes us think that this model, if further elaborated on, could provide valuable data.

We see the model functioning in forests that are relatively well attended, but also prone to fires. The extinguishers and sensors will give the visitors of the forest the chance to stop the fire before it breaks out big.

Imagine a bush being on fire, you wouldn't be able to put it out without any help, and by the time the fire department has arrived it will have spread much further. A nearby extinguisher could provide a way out!