# Forest Fires Practical Handout 1

| COURSEWORK DETAILS | | | |
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| **C/W NUMBER** | 1st | **CONTRIBUTION** | 15 % of the module final mark |
| **C/W TITLE** | Forest Fire Detection and Suppression Reactive Agent (FFDSRA) | | |
| **C/W TYPE** | Individual Practical | | |

| LEARNING OUTCOMES |
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| Upon completion of this piece of coursework, a student will be able to:<br>▪ understand in depth the reactive agent architecture, its advantages and disadvantages<br>▪ design a simple reactive agent to perform a task<br>▪ build a simple prototype of a reactive agent system on a multi-agent simulation platform (NetLogo)<br>▪ evaluate the design choices made based on simulation results. |

| ASSESSMENT CRITERIA | |
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| ▪ Correctness, originality and justification of the proposed agent architectures | 40% |
| ▪ Implementation and code documentation | 35% |
| ▪ Analysis and presentation of experimental results | 15% |
| ▪ Presentation of the report (clarity, structure) | 10% |

## DETAILED DESCRIPTION

**Forest Fire Detection and Suppression Reactive Agent (The FFDSRA System)**

A modern forest service requires constant detection and control of fires in the area of its responsibility. Such a task requires constant monitoring of the forest area as well as quick action to be taken in a case of a fire spot, so that fire spreading is disallowed and creation of fire fronts is avoided. A preliminary research on past cases of forest fires has demonstrated that in many cases, if detection is immediately followed by a suppression action (extinguishment), even with limited means, then in a large number of cases large fires can be prevented.

Given that constant monitoring of the forest area is a hard task and that even when a spot is detected a certain amount of time is needed for the ground units to arrive at the spot, the forest service is currently investigating the development of autonomous ground fire-fighting units that will constantly patrol the forest area and act appropriately, i.e. an agent based system.

Such a system consists of a number of agents that are responsible for detecting and extinguishing spots of fire. One approach to such an MA system is to model each ground unit as a reactive agent; the overall behaviour of each agent is a result of individual behaviours organised in a subsumption architecture, as proposed by Brooks. Each such behaviour is expressed as a rule that defines the course of action taken given the current state of the world, which is perceived by the set of sensors.

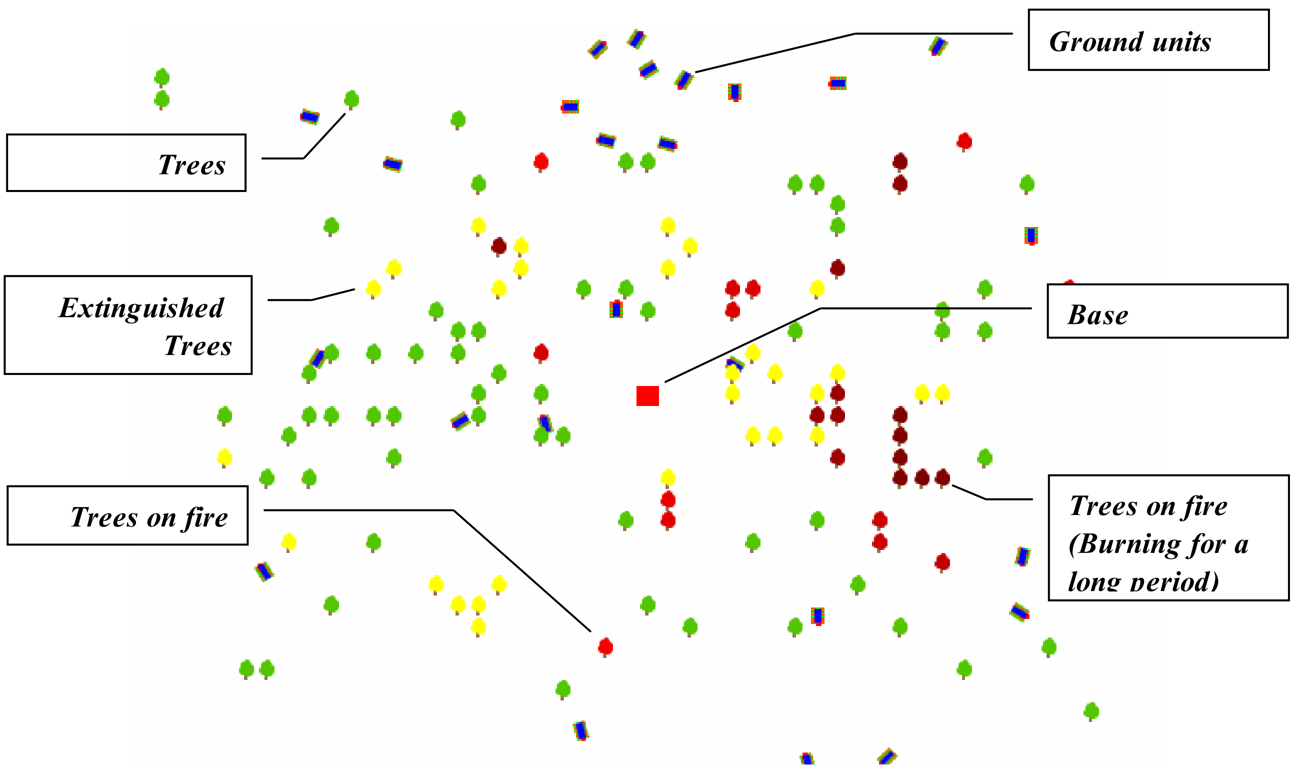


**Figure 1 The Forest Simulation Environment**

In such a detection/suppresion system we are concerned with two factors:

- The number of dead trees, i.e. trees that the agents could not extinguish on time.
- The number of saved trees, i.e. trees that were on fire but the agents managed to extinguish.

Of course an ideal system would in all conditions, extinguish fires with the minimum number of dead trees and this is the aim of the final system.

A simulation of the above application scenario has been implemented as a model in the NetLogo platform, as shown in (see Figure 1) and the code of the model is provided through the web page of the course. The model contains:

- The code for simulating ground units, i.e. facilities for creating the initial population of such units (`fire-units-num`), a number of sensors (`detect-obstacle`, `detect-fire`, etc), a number of effectors (`put-out-fire`, `move-ahead`, `turn-randomly`, etc) and a preliminary implementation of the agent's behaviour, following the subsumption architecture. Currently the design of the agent contains only the following two rules that allow the agent to move around and avoid obstacles (i.e. other units and trees on fire):

1. *if detect-obstacle then avoid obstacle*
2. *if true then move-randomly*

- The code for creating a base (red patch) and setting up a radio signal that can be used to guide agents towards the base.
- The code for simulating fire events in the forest. The simulation environment includes creation of the initial forest environment with a varying number of trees (`tree-num`), a mechanism for randomly creating a number of initial fire spots (`number-of-fires`) and a simple behaviour model for fire spreading in the forest area. In this simulation, each tree that "ignites", spreads the fire to its neighbouring trees (if any) and burns for a number of execution cycles. The tree on fire gradually changes its colour to darker red as it burns and if the fire is not extinguished after a number of cycles, the tree dies.
- Facilities for monitoring various parameters of the performed experiment such as number of dead trees, number of saved trees, etc.

In the NetLogo model, ground units are represented as turtles of breed `units`, "live" trees as turtles of breed `trees`, trees on fire as turtles of breed `fires` and extinguished trees as turtles of breed `fires-out`. Fire spots are created randomly and with a probability on each execute cycle, so that fire events occur in different time points. Simulation stops automatically when all fire spots have been created and all trees on fire either have died or have been extinguished by the ground units.

1) As it stands the model is not very useful since ground units, do not put out any fires. Using the set of sensors and detectors provided, extend the reactive agent architecture so that it is able to extinguish fires. In your design you should consider that each ground unit can carry a limited amount of water, which is consumed as units extinguish fires in the forest. One unit of water is required to extinguish fire on one tree. If the water supplies of the unit are exhausted, then the unit must return to the station to reload (service). Provide a brief description and justification of the architecture you propose, as well as run a small number of experiments, with various parameters to demonstrate its viability.

2) The speed of ground units depends on the amount of water they are carrying; units that are loaded with a large amount of water are moving more slowly, than units loaded with less water. On a first approach it seems to be a wise design choice to load units with as much water as possible. Does this choice increase the efficiency of the system? Justify and support your answer by performing a set of experiments on the given model for a varying number of agents.

3) Ground units are small enough so that they can move inside the forest (over `tree` turtles). However, they cannot move over areas that are on fire or other ground units. Occasionally the system agents are trapped in areas on fire and are destroyed. Implement this behaviour in the provided NetLogo model and run a set of experiments with the new model. Your code should be able count the number of units destroyed because of such accidents.
<u>Implementation note</u>: A ground unit is destroyed if it is located on a patch where there also exists a tree on fire.

4) Propose improvements to the above agent system that could increase its efficiency, bearing in mind that the ground units can have a limited range of sensors. Your proposals should include both the design (architecture) of the agent, its implementation in NetLogo as well as experimental data that prove its efficiency. Any improvements are acceptable, as long as they follow the reactive architecture. Be imaginative!

5) Discuss the advantages and disadvantages of the reactive agent approach to the specific problem. Briefly describe other "real-world" situations in which the above agent architecture could be used without modifications in order perform monitoring/prevention/suppression tasks.

| **SUBMISSION** |
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| Students are expected to submit:<br>▪ A written report that contains<br>• Appropriate answers to all the questions that appear above.<br>• Descriptions of the experiments carried out.<br>• A printout of the code implemented, **highlighting in bold characters the changes implemented to the original code given.**<br>• References<br>▪ A floppy disc containing the documented NetLogo code. In all cases the results obtained by the submitted code should match those appearing in the report. |