Cognitive Biases Impact on Social Simulations (in reaction to bushfires)

Pierre Blarre

TER Project
Grenoble-Alpes University
June 28th, 2018

Project goal :
Build a model implementing the Belief-Desire-Intention (BDI) paradigm and some cognitive biases.

Beginning

- Cognitive biases
- Agent-Based Modeling and Simulation
- Belief-Desire-Intention paradigm
- Behavior profiles from the Black Saturday interviews.

The Role of Cognitive Biases in reaction to bushfires

Proposed approach : Apply ABMS to crisis management. Build a **Belief-Desire-Intention** model with algorithms for three cognitive biases : **The neglect of probability, the Semmelweis Reflex, the Illusory of Truth**.

No model was ever implemented therefore the main goal of this work.

Requirements

For a successful prototype

- Bushfires simulation (GAMA)
- Behavior profiles
- BDI architecture
- Cognitive biases algorithms
- Experimentation
- Extractable data on cognitive biases impacts

The Model

Structure

Structure of a crisis situation

- Environment
  - Time
  - Nature
  - Buildings
  - Natural disaster
- Residents / inhabitants
- Emergency services

BDI agents

- Physical & psychological attributes
- Beliefs,desires and intentions
- Rules
- Perceives
- Plans
- Cognitive biases actions
- Sub-species with variations on previous components to represent behavior profiles

Beliefs, Desires, Intentions

Beliefs

- There is no danger.
- There is a potential danger.
- There is an immediate danger.
- There is a risk of fire today.
- I can defend my house or workplace.

Desires

- I want to relax.
- I want to go to work.
- I want to go home.
- I want to call emergency services.
- I want to defend my house or workplace.
- I want to escape.

Perceptions and Rules

Perception

- I can see distant smoke or flames. This will add the potential danger belief to the agent.
- I can see a fire or smoke close to me. This will add the immediate danger belief to the agent.
- The distant and close distances are configurable parameters.

Rules (Automatically add desires when beliefs are added)

- No danger belief = go to work or stay at home desires
- Potential danger belief = call emergency services
- Immediate danger belief = escape desire
- Can defend belief = desire to defend

Cognitive biases

How?

- Separated actions
- Can be used anywhere on any agents that implements BDI
- Random distribution of biases throughout the population
- Influence beliefs strength
- The BDI engine does the rest

Where and when?

- When agents perceive something (Smoke, fire, sirens)
- When agents receive messages
- When surrounding people

Cognitive biases influence

Cognitive biases distribution : Distribute cognitive biases throughout the population with the help of a distribution probability (which is configurable through the interface). We can count how many have agents are under influence and by which bias.

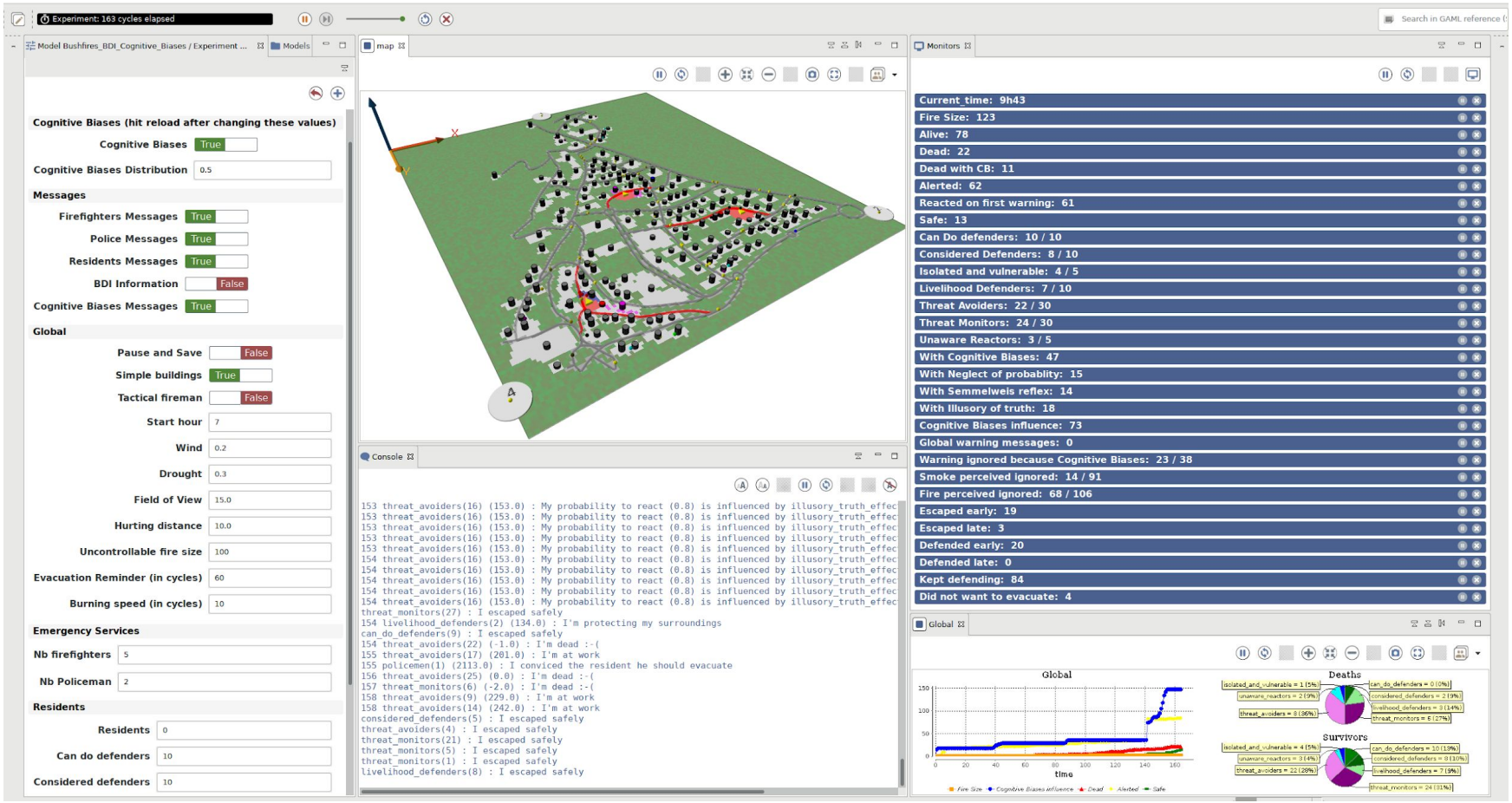
Cognitive bias operation : The algorithms will add, remove or modify beliefs and beliefs' strengths. Within specific situations, we can test and record if an agent is missing a belief after cognitive bias influence. For example seeing a fire should add the belief for potential danger. If it's missing after a smoke detection, it means the agent has made an irrational judgment.

Monitoring

What we want to know

- Time and fire size (monitor and csv)
- Emergency services information (console)
- Amount of survivors by behavior profiles (monitor and csv)
- Information on agents beliefs, desires and plans (console, possibly csv)
- Cognitive biases influence (monitor, console message and csv)

Interface


Experiment: 163 cycles elapsed
Search in GAML reference (
Model Bushfires_BDI_Cognitive_Biases / Experiment ...
Models
Cognitive Biases (hit reload after changing these values)
Cognitive Biases
True
Cognitive Biases Distribution
0.5
Messages
Firefighters Messages
True
Police Messages
True
Residents Messages
True
BDI Information
False
Cognitive Biases Messages
True
Global
Pause and Save
False
Simple buildings
True
Tactical fireman
False
Start hour
7
Wind
0.2
Drought
0.3
Field of View
15.0
Hurting distance
10.0
Uncontrollable fire size
100
Evacuation Reminder (in cycles)
60
Burning speed (in cycles)
10
Emergency Services
Nb firefighters
5
Nb Policeman
2
Residents
Residents
0
Can do defenders
10
Considered defenders
10
map
Console
153 threat_avoiders(16) (153.0) : My probability to react (0.8) is influenced by illusory_truth_effec
153 threat_avoiders(16) (153.0) : My probability to react (0.8) is influenced by illusory_truth_effec
153 threat_avoiders(16) (153.0) : My probability to react (0.8) is influenced by illusory_truth_effec
153 threat_avoiders(16) (153.0) : My probability to react (0.8) is influenced by illusory_truth_effec
153 threat_avoiders(16) (153.0) : My probability to react (0.8) is influenced by illusory_truth_effec
154 threat_avoiders(16) (153.0) : My probability to react (0.8) is influenced by illusory_truth_effec
154 threat_avoiders(16) (153.0) : My probability to react (0.8) is influenced by illusory_truth_effec
154 threat_avoiders(16) (153.0) : My probability to react (0.8) is influenced by illusory_truth_effec
154 threat_avoiders(16) (153.0) : My probability to react (0.8) is influenced by illusory_truth_effec
154 threat_avoiders(16) (153.0) : My probability to react (0.8) is influenced by illusory_truth_effec
threat_monitors(27) : I escaped safely
154 livelihood_defenders(2) (134.0) : I'm protecting my surroundings
can_do_defenders(9) : I escaped safely
154 threat_avoiders(22) (-1.0) : I'm dead :-(
155 threat_avoiders(17) (201.0) : I'm at work
155 policemen(1) (2113.0) : I convicted the resident he should evacuate
156 threat_avoiders(25) (0.0) : I'm dead :-(
157 threat_monitors(6) (-2.0) : I'm dead :-(
158 threat_avoiders(9) (229.0) : I'm at work
158 threat_avoiders(14) (242.0) : I'm at work
considered_defenders(5) : I escaped safely
threat_avoiders(4) : I escaped safely
threat_monitors(21) : I escaped safely
threat_monitors(5) : I escaped safely
threat_monitors(1) : I escaped safely
livelihood_defenders(8) : I escaped safely
Monitors
Current_time: 9h43
Fire Size: 123
Alive: 78
Dead: 22
Dead with CB: 11
Alerted: 62
Reacted on first warning: 61
Safe: 13
Can Do defenders: 10 / 10
Considered Defenders: 8 / 10
Isolated and vulnerable: 4 / 5
Livelihood Defenders: 7 / 10
Threat Avoiders: 22 / 30
Threat Monitors: 24 / 30
Unaware Reactors: 3 / 5
With Cognitive Biases: 47
With Neglect of probablity: 15
With Semmelweis reflex: 14
With Illusory of truth: 18
Cognitive Biases influence: 73
Global warning messages: 0
Warning ignored because Cognitive Biases: 23 / 38
Smoke perceived ignored: 14 / 91
Fire perceived ignored: 68 / 106
Escaped early: 19
Escaped late: 3
Defended early: 20
Defended late: 0
Kept defending: 84
Did not want to evacuate: 4
Global
Global
time
Deaths
Survivors

To test the model

You can go to https://github.com/ierpe/Cognitive_Biases_BDI

The readme explains how to get started.

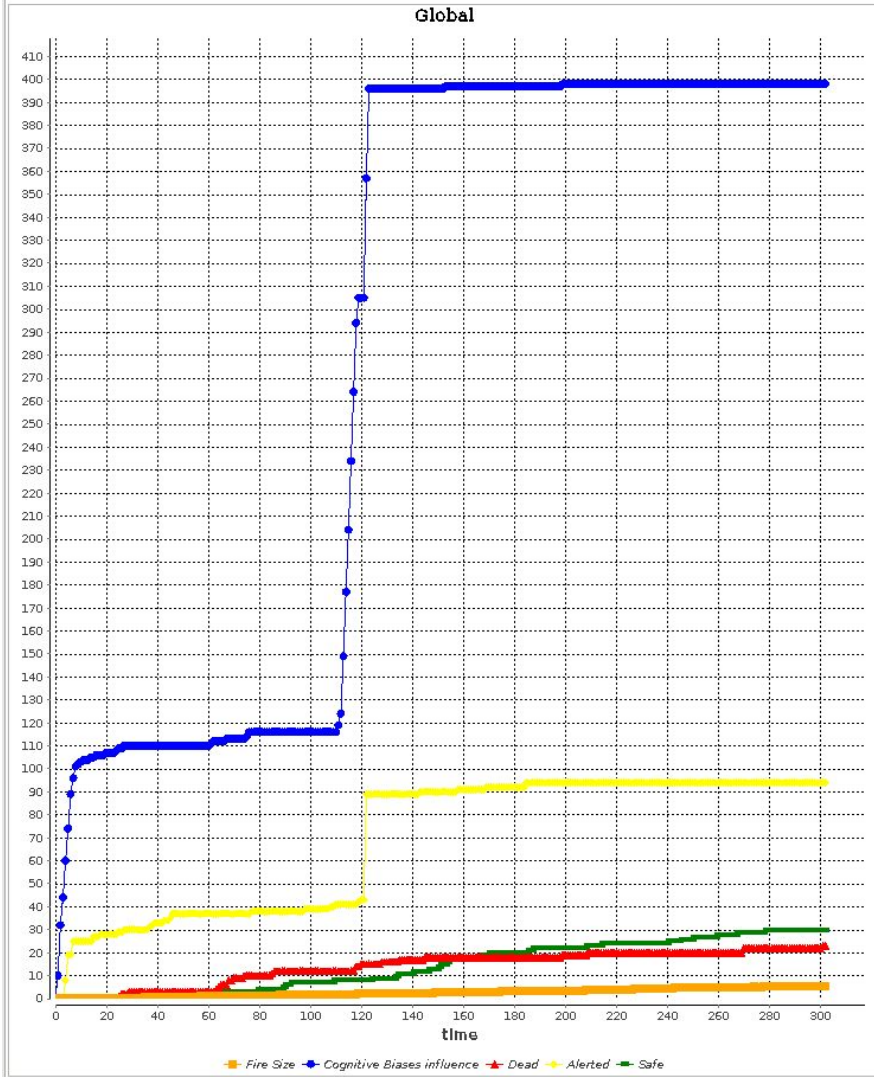
The doc folder contains my article and this presentation.

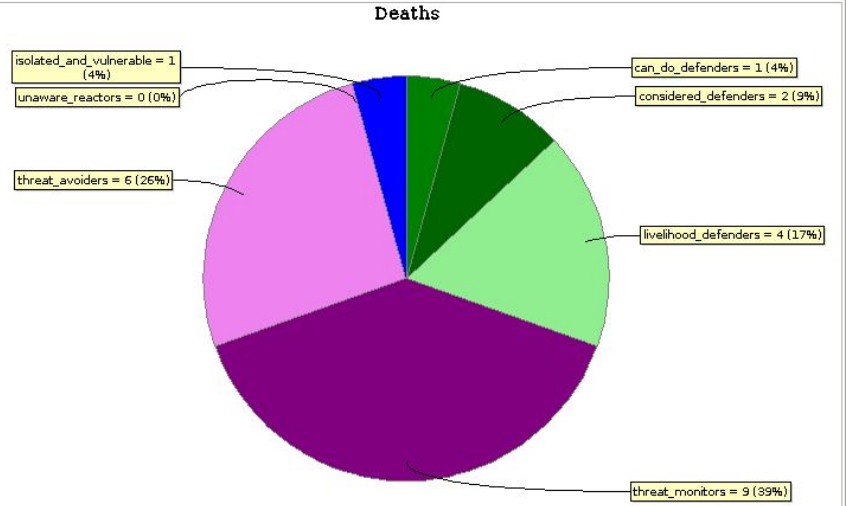
Experimentations and results

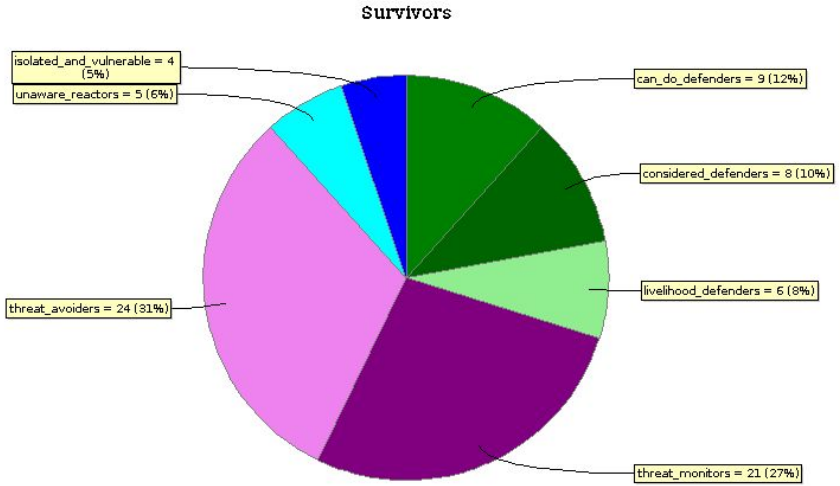
Examples of Residents data extracted

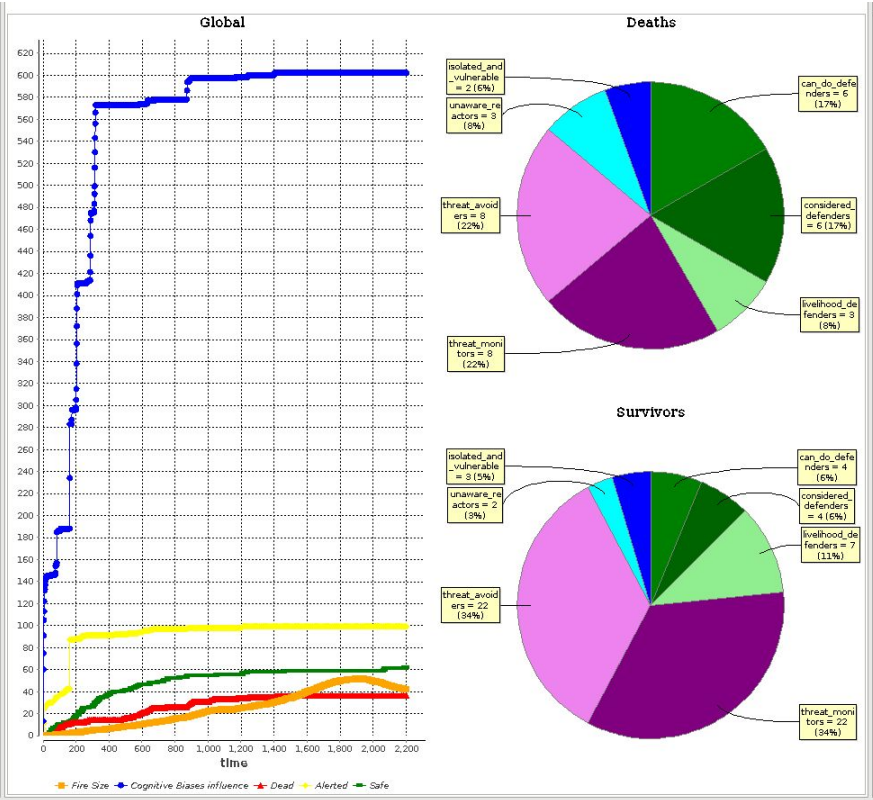
Main experiment (3 fires that will become uncontrollable)

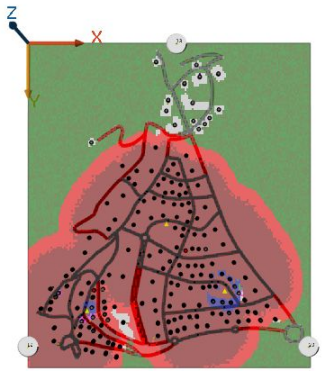
- Cycles : **300** - Fire size : **275 plots**
- Alerted : **71 / 100**
- Dead with cognitive biases influence : **23 / 100**
- Cognitive Biases influence : **363**
- Warning ignored because Cognitive Biases : **18 / 85**
- Smoke perceived ignored : **18 / 85**
- Fire perceived ignored : **69 / 85**
- Escaped early : **120**
- Escaped late : **1**
- Defended early : **114**
- Did not want to evacuate : **2**


Global
time
Fire Size
Cognitive Biases influence
Dead
Alerted
Safe


Deaths
isolated_and_vulnerable = 1 (4%)
unaware_reactors = 0 (0%)
threat_avoiders = 6 (26%)
can_do_defenders = 1 (4%)
considered_defenders = 2 (9%)
livelihood_defenders = 4 (17%)
threat_monitors = 9 (39%)


Survivors
isolated_and_vulnerable = 4 (5%)
unaware_reactors = 5 (6%)
threat_avoiders = 24 (31%)
can_do_defenders = 9 (12%)
considered_defenders = 8 (10%)
livelihood_defenders = 6 (8%)
threat_monitors = 21 (27%)



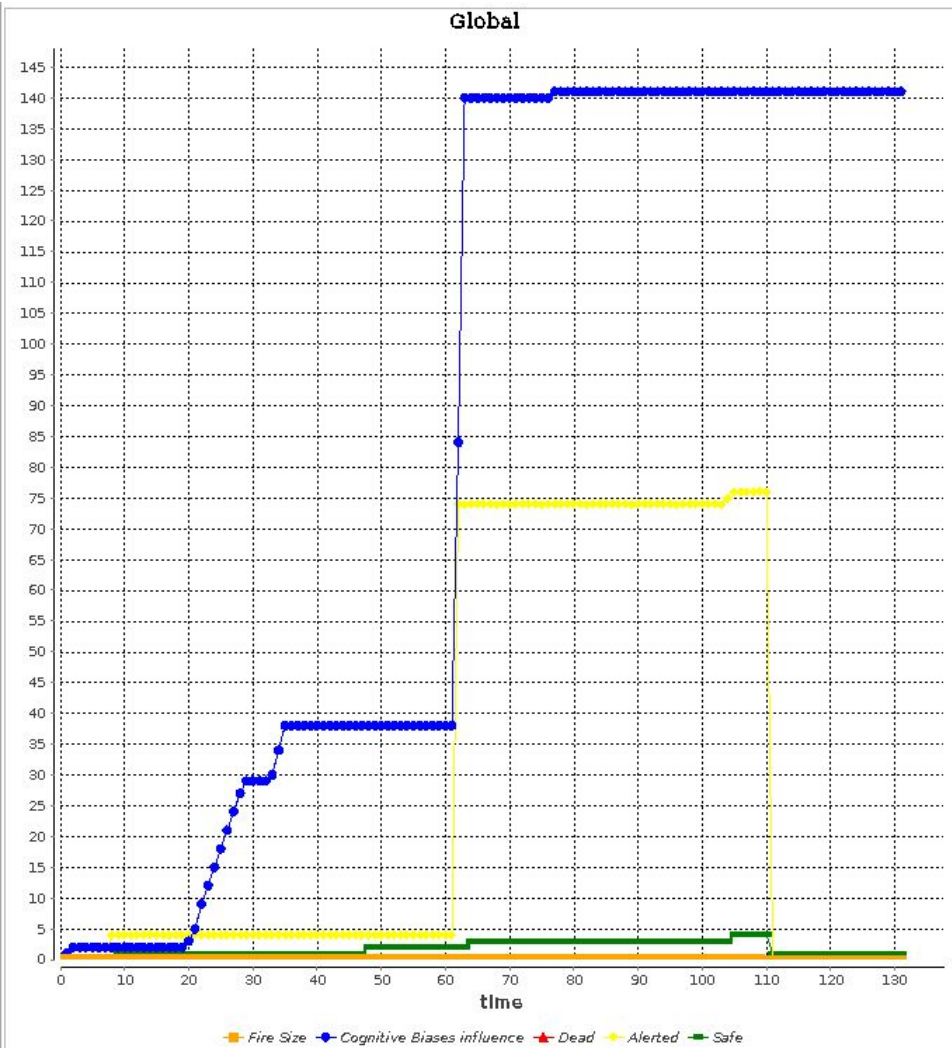


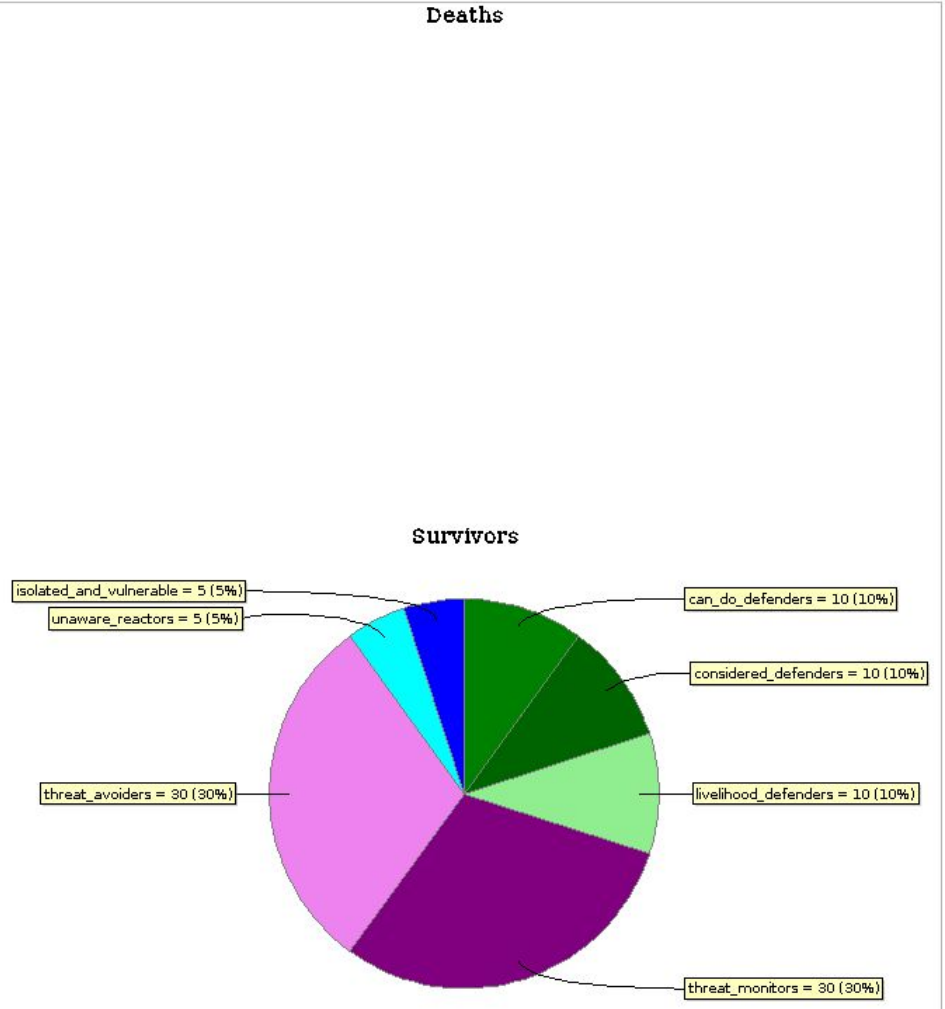
- Current_time: 19h42
- Fire Size: 2106
- Alive: 64
- Dead: 36
- Dead with CB: 36
- Alerted: 63
- Reacted on first warning: 66
- Safe: 62
- Can Do defenders: 4 / 10
- Considered Defenders: 4 / 10
- Isolated and vulnerable: 3 / 5
- Livelihood Defenders: 7 / 10
- Threat Avoiders: 22 / 30
- Threat Monitors: 22 / 30
- Unaware Reactors: 2 / 5
- With Cognitive Biases: 100
- With Neglect of probablity: 46
- With Semmelweis reflex: 47
- With Illusory of truth: 53
- Cognitive Biases influence: 559
- Global warning messages: 34
- Warning ignored because Cognitive Biases: 23 / 89
- Smoke perceived ignored: 220 / 243
- Fire perceived ignored: 113 / 136
- Escaped early: 170
- Escaped late: 3
- Defended early: 143
- Defended late: 0
- Kept defending: 0
- Did not want to evacuate: 5

Example of Residents data extracted

One fire experiment (fire will be extinguished quickly)

- Cycles : **130** - Fire size : **0 plot**
- Kept defending after end message : **21**
- Cognitive Biases influence : **85**
- Warning ignored because Cognitive Biases : **47 / 100**
- Smoke perceived ignored : **23 / 26**
- Fire perceived ignored : **5 / 6**
- Escaped early : **24**
- Defended early : **6**


Global
time
Fire Size
Cognitive Biases influence
Dead
Alerted
Safe


Deaths
Survivors
isolated_and_vulnerable = 5 (5%)
unaware_reactors = 5 (5%)
can_do_defenders = 10 (10%)
considered_defenders = 10 (10%)
threat_avoiders = 30 (30%)
livelihood_defenders = 10 (10%)
threat_monitors = 30 (30%)

Remarks on the model and Gama

- Cognitive Biases implementation still have to be validated
- Physical and Psychological values distribution by profiles should be refined
- Need to review all the BDI scenarios to make sure things are going as they should
- GAMA bug with batch experiments, issue opened on Github
- Not sure Eclipse was the best choice for a simulation software
- Error reporting is really bad
- Not enough issues... I think they would need a dedicated Stack overflow
- Many things remain a mystery, I would need another GAMA training

Conclusions

In a BDI model, the cognitive biases algorithms influence agents beliefs by diminishing or strengthening them. The human behavior is better mimicked. Good stuff.

This model aims to be a prototype for a generic crisis simulation framework.

Next steps

Model optimization

- BDI for emergency services
- A better behavior profiles and cognitive biases distribution
- Multiple maps
- More experiments
  - 100% of each agents
  - Time comparison with and without cognitive biases
  - More biases
  - Terminal batch experiments
- GAMA plugin for cognitive biases
- Norms
- Emotions
- Negotiation

Social simulations

- Update and finish the report
- Keep reading
- Keep working with GAMA
- Communicate and promote
- Offer modeling as a service
- A thesis in a year or two?

Thank you.