LU2IN013 – FINAL REPORT

Made onApril 25, 2024

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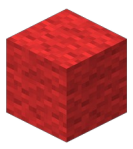
Year 2324. Coming to Mars was a big step, but now the effort begins to make the red planet a habitable paradise. We will start this adventure with the small dome of Noctis City at strategic coordinates in the heart of Mars, from which we will deploy our humans. Some of them will be elected to help develop the ecosystem, but the planet is not so welcoming. They will not only have to be wary of sandstorms and epidemics, but also watch out for the Martians who are ready to do anything to defend their precious territory.

ENVIRONMENT

Map
- Grid generated at 'Start' with Perlin Noise
- 26 ≤ size ≤ 100set by the User at launch
- with ice areas (IceBlock), fertile land areas (OrangeMarsBlock) and habitation/normal land areas (LandBlock).

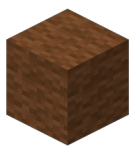
Blocks



NoctisCityBlock
This block is always placed in the middle of the map.

TerraformedLandBlock
Block representing the earth on Mars for dwellings*Before* terraforming

⋯ changes into ⋯ upon terraforming



LandBlock
Block representing the earth on Mars for dwellings*Before* terraforming

GrassBlock
Block representing arid land on Mars*Before*terraforming

⋯ changes into ⋯ upon terraforming

OrangeMarsBlock
Block representing fertile land on Mars*After*terraforming

WaterBlock
Block representing water

⋯ changes to ⋯ upon terraforming OR when an OceanHuman decides to melt ice

⋯changes to⋯ when an OceanAlien walks over it and freezes the water into ice

IceBlock
Block representing ice.

Noctis City(inspired by the real Martian geological feature NOCTIS LANDING/NOCTIS LABYRINTHUS)
- Center of the grid
- takes¼from the grid
- Recognizable thanks to the completely red blocks (*NoctisBlock*)
- Visual transformation upon terraforming: 'Dome City' building pre-terraforming and 'Burj-Khalifa' post-terraforming.
- Place where humans appear at the start of the simulation.
- Aliens can't go into Noctis City.
- Trees cannot be planted and Oceans cannot be dug in Noctis City.

Long term variables: Oxygen and Temperature
- oxygen and temperature are float tq {oxygen ∈ℝ |oxygen ∈ ⟦0;100⟧ }And{temperature ∈ℝ |temperature ∈ ⟦0;100⟧ }

> Effects of simulation on these variables:
- Planting a tree ⇒ (oxygen+=2) & (temperature+=4)
- Casting an IceBlock into a WaterBlock ⇒ (oxygen+=4) & (temperature+=2)
- Freezing of a WaterBlock to IceBlock ⇒ (oxygen−=2) & (temperature−=1)
- Setting fire to a tree ⇒ (oxygen−=1) & (temperature−=2)
- Extinguishing a tree fire ⇒ (oxygen+=1) & (temperature+=3)

> Effects of these variables on the simulation:

- If ((oxygen=max=100) & (temperature=max=100))⇒MarsTerraformed ⇒Humans hunt aliens to kill them.

> Progress Bars

- The real-time value of these variables is indicated by Progress Bars.

The Progress Baroxygenis centered at the top of the screen inredand that oftemperatureis aligned to the right of the screen inblue.

Trees

- Trees are all planted by humans, more precisely ForestHumans
- 2 tree colors: Pink (oxygen ∈〚0;50〛)and Green (oxygen ∈[50;100〛)
- Planting a tree⇒ (oxygen+=2) & (temperature+=4)

Pink Tree

Green Tree

Fire

Only trees can catch fire in this simulation.

You can tell that a tree is on fire by the blue or orange flames on the tree.

> Appearance: The fire is blue when (oxygen ∈〚0;50〛)and orange when (oxygen ∈[50;100〛)

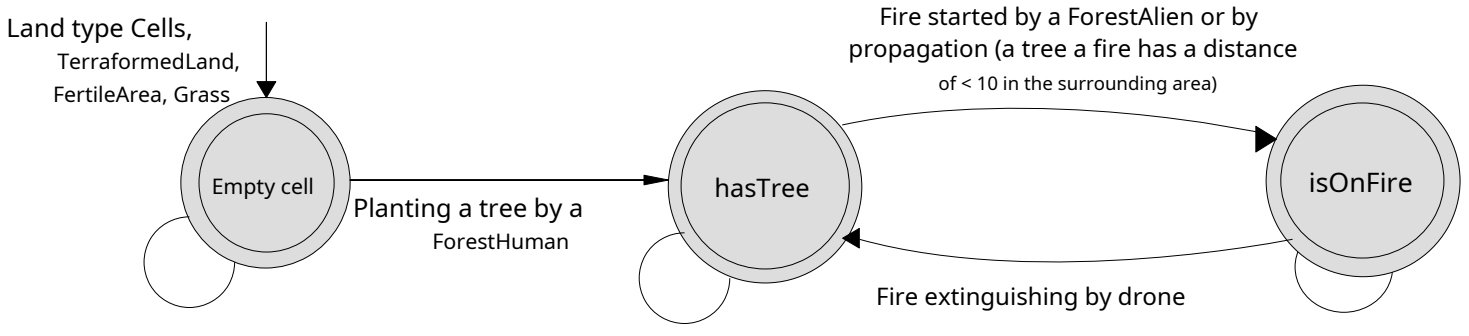
> How does a tree get on fire? It's a ForestAlien that sets a tree on fire when it finds one.

> How is a fire put out? A drone puts it out when it flies over a square with a burning tree.

> Fire Spread: Grace has a recursive function, a burning tree sets other trees on fire as well within a radius of 10 units around it. So, when the density of trees is high in an area, the fire spreads easily.

- Setting fire to a tree ⇒ (oxygen−=1) & (temperature−=2)
- Extinguishing a tree fire ⇒ (oxygen+=1) & (temperature+=3)

Tree and fire management is summarized by this automaton:



Automaton 1

Ice and Oceans

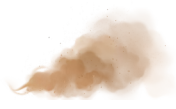
- OceanHumans change an IceBlock into a WaterBlock⇒ (oxygen+=4) & (temperature+=2)because they want to make the planet as habitable as possible.
- Conversely, when an OceanAlien passes over a WaterBlock,⇒ (oxygen−=2) & (temperature−=1)because they want to reduce the pace of terraforming of their planet.

Random Event: Sandstorm

- duration:26 ≤ random duration ≤ 100
- this event occurs randomly every 30 to 60 seconds.

> How does this affect the simulation? A human is randomly chosen to be infected. He will propagate his virus with the SEIR method defined in the 'Agent' section.

- the virus continues to spread even after the storm has passed.



Day-night system

- A day/night cycle lasts 1 minute in this simulation.
- Most activities in this simulation are independent of the day-night system except human reproduction which only occurs at night. This is to limit an exponential increase in humans.

Tipping Point: Terraforming

On the environmental side, during terraforming, there is only a visual transformation. It is the behavior of certain agents that changes.

UI

- Progress Bars oxygen (red) and temperature (blue)
- 360° rotating camera with (limited) Zoom.
- Display of important data at the bottom left (thanks to the same canvas of Progress Bars)
- Main menu with buttons to facilitate the entry of the grid size desired by the User and to start the simulation and exit the application

AGENTS

2 main agent types: Humans and Aliens

Humans:
- the prey of our game.
- easily recognizable thanks to their colors.
- divided into 3 subcategories:

Human
Represented by a red astronaut

ForestHuman
Represented by a green astronaut

OceanHuman
Represented by a blue astronaut

The Aliens:
- the predators of our game
- can be distinguished quite easily thanks to their dark color
- also divided into 3 subcategories:

KillerAlien
Represented by a Venom

ForestAlien
Represented by an EnderDragon

OceanAlien
Represented by an EnderMan

Secondary agent:Drone
- Agents that interact only with the environment
- are neither prey nor predators. (can be considered as emergency services such as firefighters)

Drone

Spawn System:

Human
The number of humans depends on the size of the grid. (eg. grid size 50, → 30 humans at the start)
Appears in the center of the grid in NoctisCity.
The type of humans that will appear is chosen according to probability: 34% Human, 33% ForestHuman & 33% OceanHuman

Alien
the number of aliens at the start also depends on the size of the grid. (eg. grid size 50 → 9 aliens at the start)
Spawn randomly on the grid except on NoctisCity.
The type of aliens that will appear is chosen according to the following probability: 50% KillerAlien, 35% ForestAlien & 15% OceanAlien

Drone :The number of drones that appear at the start of the game is 2 regardless of the size of the grid. They appear randomly on the map.

Movement of agents:

Human
- move randomly on the grid.
- can move on the 8 squares surrounding them.
- rotate according to the direction of their movement
- do not have the ability to move on water and ice.

Alien
- have the same movement system as humans
- are not allowed to move in NoctisCity but they are allowed to move on water and ice.

Drone :Drones have the same movement system as humans and aliens. Their special feature is that they have no restrictions on their movement.

Reproduction system:

Human
reproduce when at least 2 humans are present on the same square, and that among these humans there are at least 2 who have the ability to reproduce.
can breed with any type of human. (The probability of choosing exactly the same human created is the same as when it first appeared.)
the ability to reproduce only when it has made 300 movements. After reproduction, the counter is reset and the human must again make 300 moves to be able to reproduce again.

Alien
This is that the KillerAlien who have the capacity to reproduce. that they are night
the same principle as with humans except that there will only be of the type of KillerAlien that will be created.

Hunting system:
KillerAlien have the ability to see if there is a human on the 8 squares around them. If there is a human, the KillerAlien moves towards him, otherwise it moves randomly. If a KillerAlien is on the same square as a human, it will kill that human. Note that only KillerAlien can kill humans.

Leakage system:
Humans have the ability to see if there is a KillerAlien on the 24 squares around them. If there is a KillerAlien, the human heads in the opposite direction (paying attention to the borders) otherwise he moves randomly. Note that humans move slower than Aliens.

Tree and fire management:Reference toAutomaton 1
Drones and ForestHumans intentionally do not have a “smart” system to move towards trees or fires more quickly, because otherwise the fires are started and extinguished too quickly.

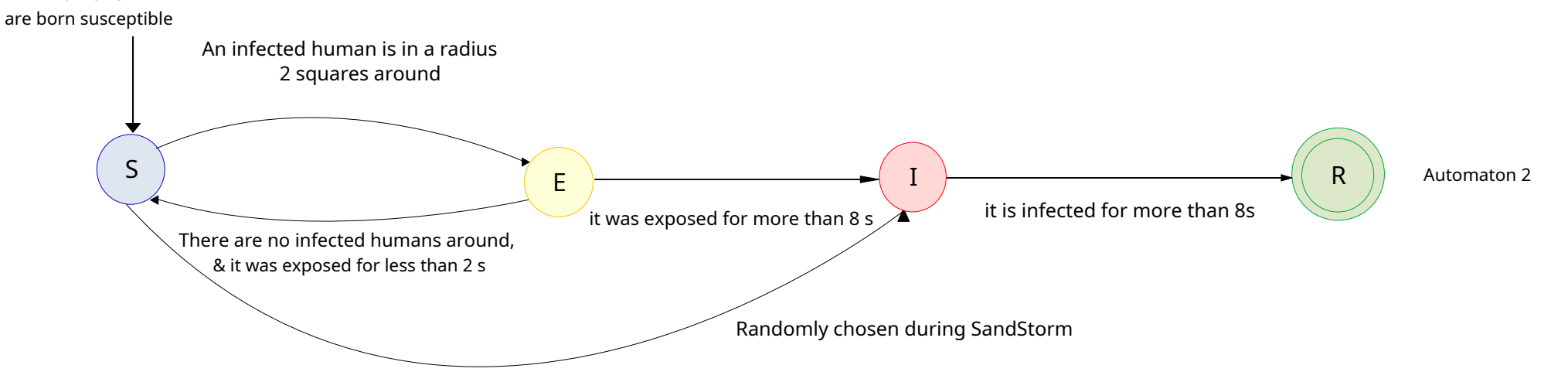
Ocean management:-An OceanHuman melts an IceBlock into a WaterBlock when there are any on the 4 tiles directly around him with a probability of 15%.
- An OceanAlien freezes a WaterBlock into IceBlock but only before terraforming

Lifetime management:
- KillerAlien have a randomly chosen lifespan between 30 and 200 seconds, and humans between 30 and 300.
- The other agents are invincible.

System to prevent the extinction of one of the species:
- If the human or KillerAlien population falls below a certain threshold then a new wave of humans or KillerAlien will be generated to prevent the extinction of the population.

Tipping Point: Terraforming
- In the Agent part, there is an adaptive behavior of humans to terraforming: the roles are reversed and they hunt the KillerAliens.
- Aliens always think they can kill humans and so they always head towards humans. (which is to their disadvantage)

SEIR system(Susceptible-Exposed-Infected-Recovered)
- Extended version of SIR with added 'Exposed' state



(Note: Transitivity arrows have been ignored for all states of this automaton because the states are very dynamic during the simulation)

According to the scheme, a human is immuised for life after infection with the virus (much like chickenpox).
Infected humans are marked with a*InfectedHumanPrefab*pink(purple) in the simulation.
When a human is healed, he does not necessarily become what he was before. He becomes one of the 3 types of humans at random. (The prefab changes accordingly)

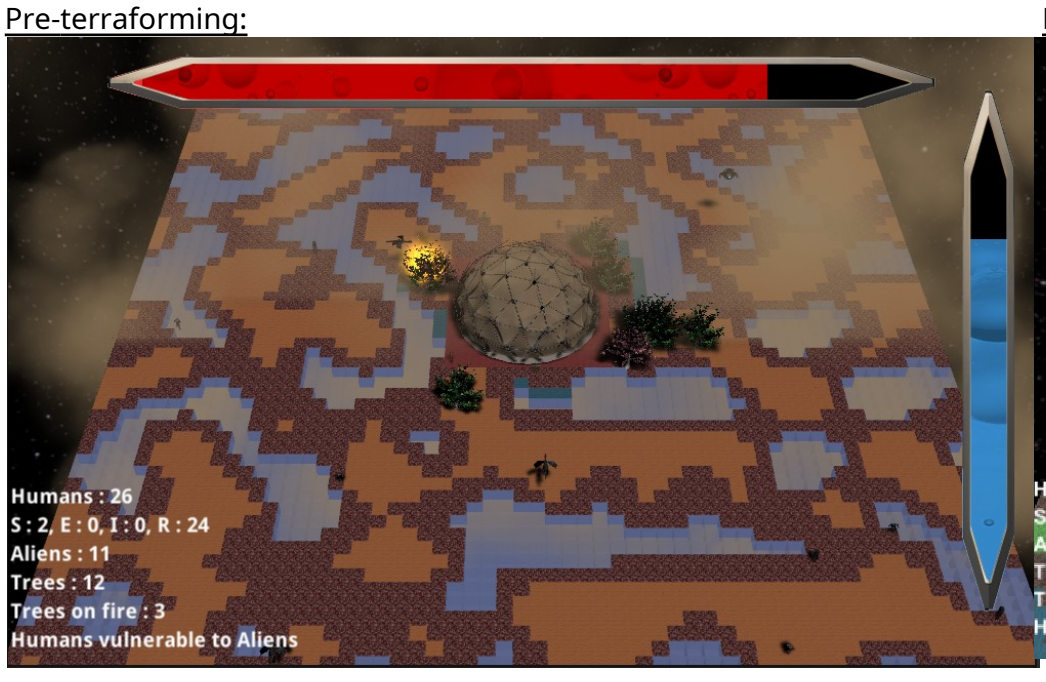
InfectedHumanPrefab

Adaptive behavior

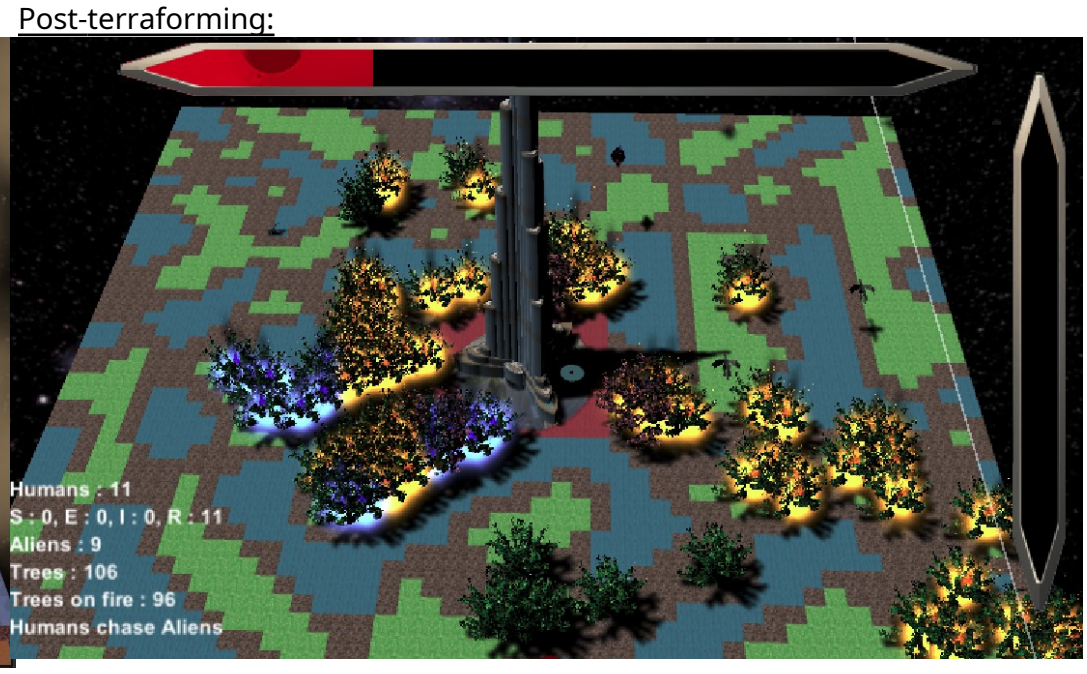
A human in an infected state does not plant trees or dig oceans. He does, however, continue to move and reproduce.

SCREENSHOTS

Pre-terraforming:

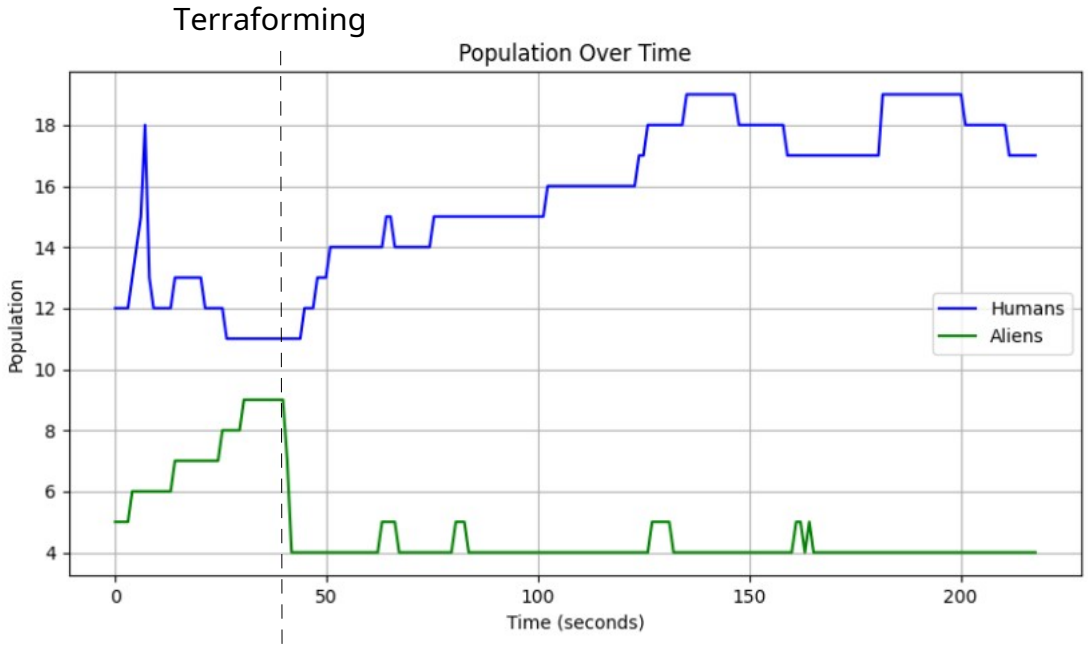


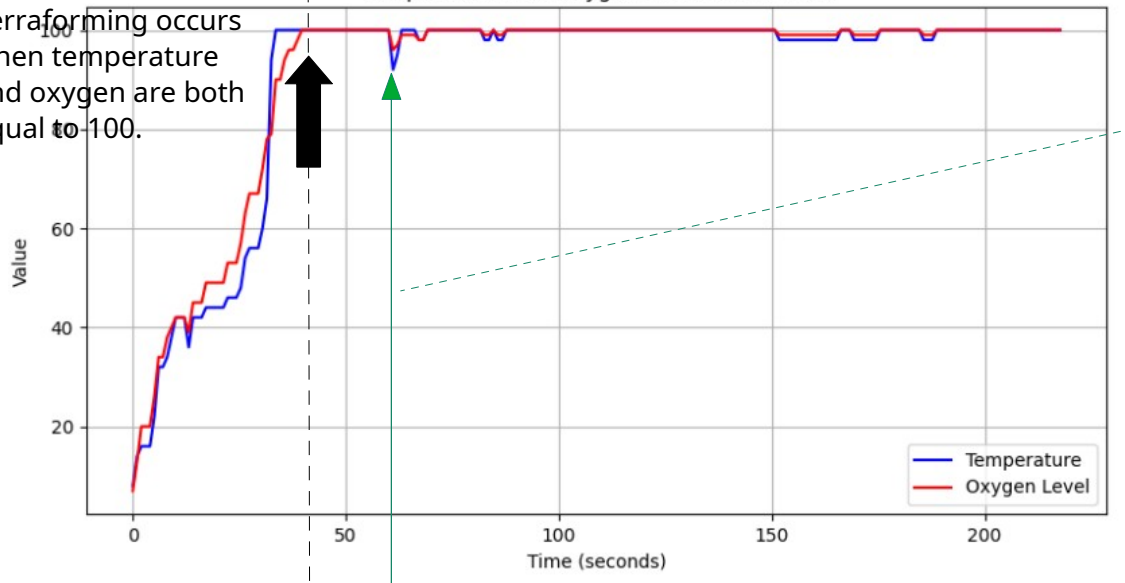
Post-terraforming:



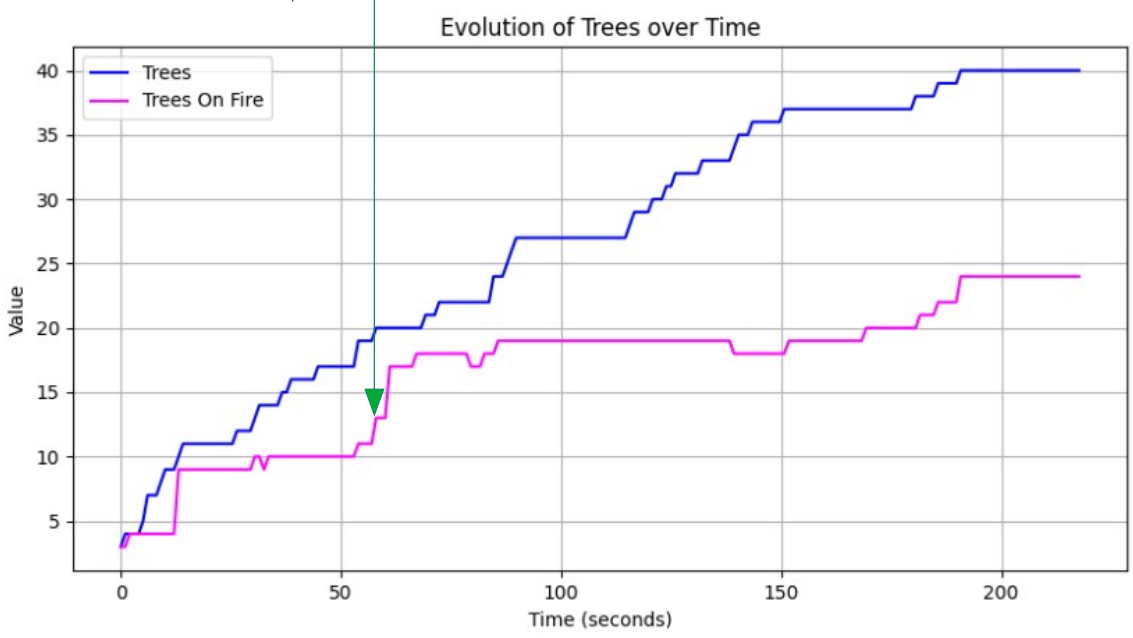
GRAPHS

Tipping Point:
Terraforming





Terraforming occurs when temperature and oxygen are both equal to 100.



Before the tipping point: Humans are vulnerable to aliens

- the human population has a tendency to decrease despite the small peaks of reproduction. They decrease because of the KillerAliens who kill them and lifetime.

- the alien population tends to increase because even if they have a limited lifetime like humans, they manage to reproduce. In addition, they are invulnerable to humans.

After the tipping point : Aliens are vulnerable to humans (roles reversed)

- the human population tends to increase very clearly

- the alien population drops drastically

We see that when there are more trees on fire, the temperature and oxygen drop. However, they quickly increase again because other trees are planted.

Despite the fact that the number of trees on fire increases, the temperature and oxygen continue to increase. This is due to the fact that the number of trees is greater than the number of trees on fire. In addition, the temperature and oxygen also increase thanks to the melting of ice by the OceanHumans.

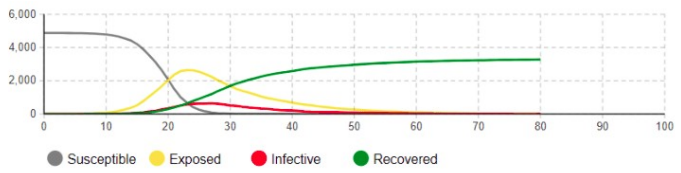


Figure taken from the article “SEIR model with unreported infected population and dynamic parameters for the spread of COVID-19” by Ziren Chen, Harold A. lay Jr et al.

If we cut this graph each time the susceptible humans start to decline, we clearly see a repeating cycle that is similar to a real SEIR system of epidemic spread.