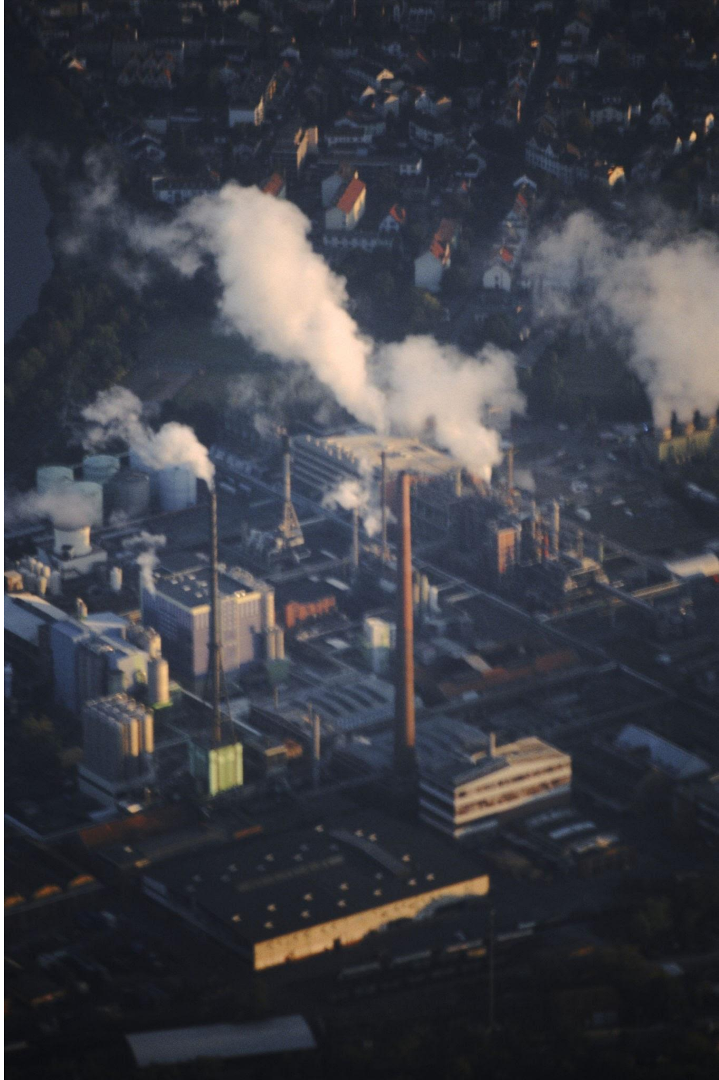
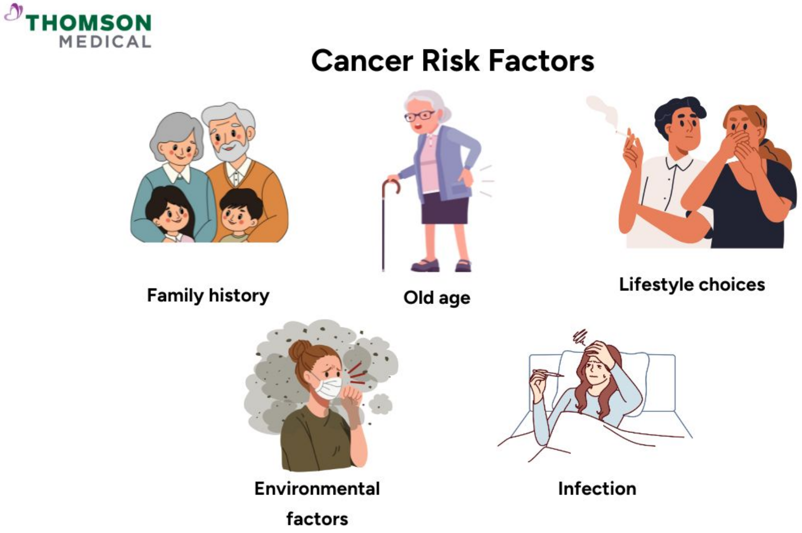
Simulation of Cancer Risk from Multi-Factor Environmental Exposure in Hanoi

DO Thanh Dat
NGUYEN Dang Trung
NGUYEN Thanh Binh



1. Project description

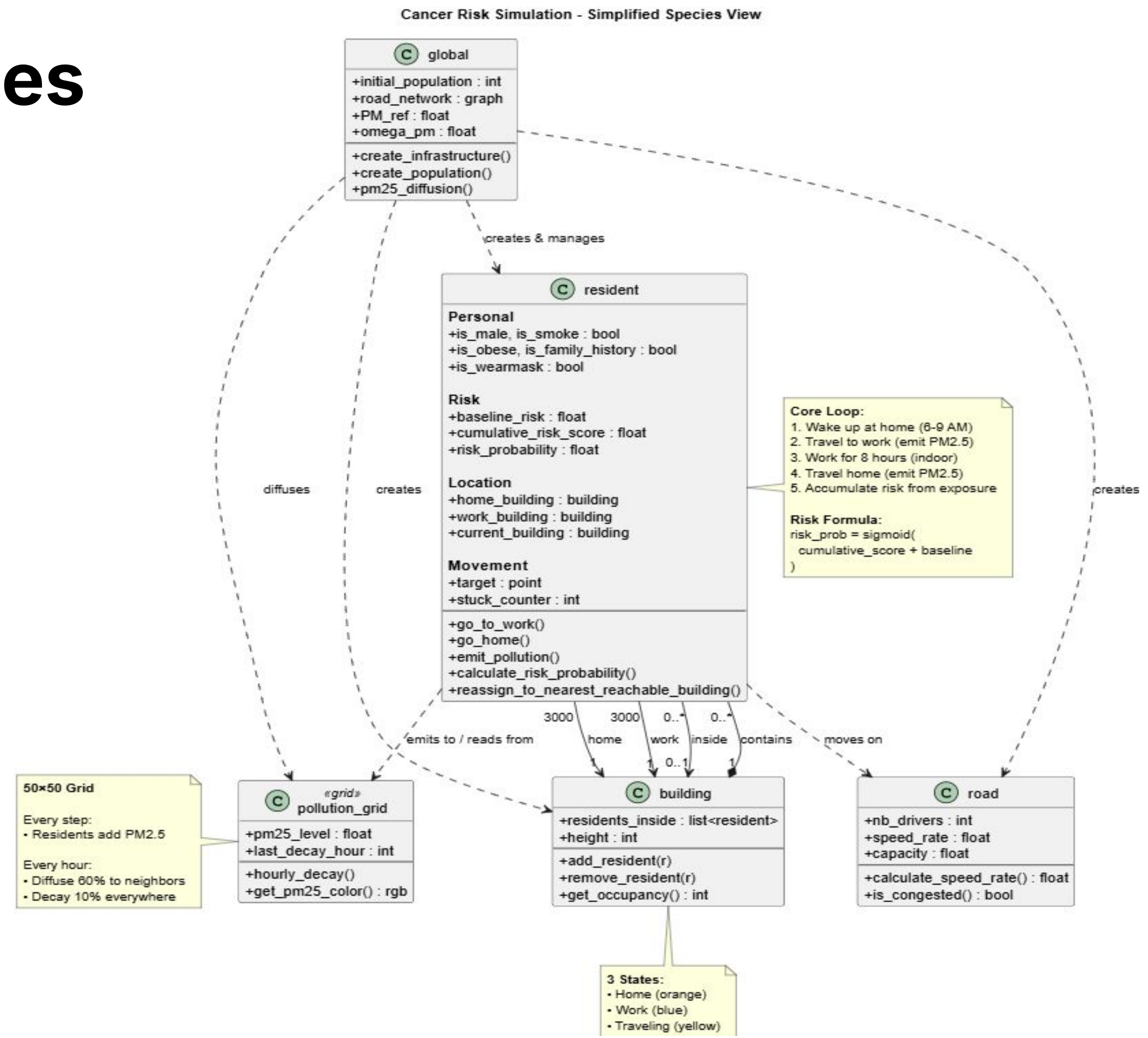
This project aims to simulate how environmental factors affect the chances of people having cancer using GAMA platform. The simulation will focus on a small area with high air pollution rate, with thousands of people going to work and going home.



1. Ideas & Flow

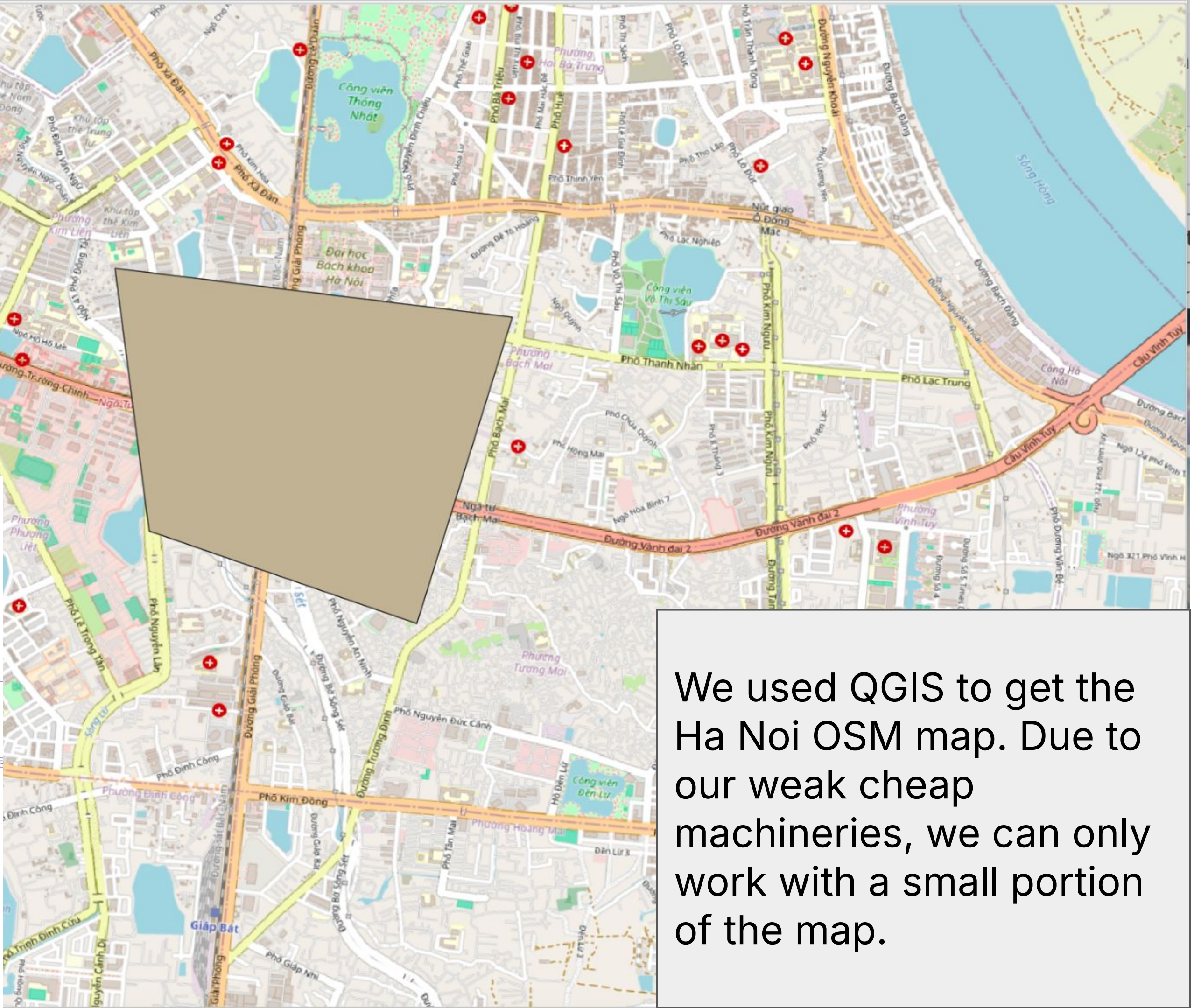
- Map spawning with buildings and roads
- Non-homeless, hardworking residents with various attributes.
- Residents travel back and forth from home to work and emit pollution
- Also, residents are exposed to dirty air
- Calculate risk score and risk probability overtime

2. Species



Cancer Risk Simulation - Simplified Species View
global
+initial_population : int
+road_network : graph
+PM_ref : float
+omega_pm : float
+create_infrastructure()
+create_population()
+pm25_diffusion()
creates & manages
diffuses
creates
creates
resident
Personal
+is_male, is_smoke : bool
+is_obese, is_family_history : bool
+is_wearmask : bool
Risk
+baseline_risk : float
+cumulative_risk_score : float
+risk_probability : float
Location
+home_building : building
+work_building : building
+current_building : building
Movement
+target : point
+stuck_counter : int
+go_to_work()
+go_home()
+emit_pollution()
+calculate_risk_probability()
+reassign_to_nearest_reachable_building()
Core Loop:
1. Wake up at home (6-9 AM)
2. Travel to work (emit PM2.5)
3. Work for 8 hours (indoor)
4. Travel home (emit PM2.5)
5. Accumulate risk from exposure
Risk Formula:
risk_prob = sigmoid(
cumulative_score + baseline
)
emits to / reads from
3000
3000
0..*
0..*
home
work
inside
contains
moves on
1
1
0..1
1
50×50 Grid
Every step:
• Residents add PM2.5
Every hour:
• Diffuse 60% to neighbors
• Decay 10% everywhere
«grid»
pollution_grid
+pm25_level : float
+last_decay_hour : int
+hourly_decay()
+get_pm25_color() : rgb
building
+residents_inside : list<resident>
+height : int
+add_resident(r)
+remove_resident(r)
+get_occupancy() : int
road
+nb_drivers : int
+speed_rate : float
+capacity : float
+calculate_speed_rate() : float
+is_congested() : bool
3 States:
• Home (orange)
• Work (blue)
• Traveling (yellow)

Ha Noi map

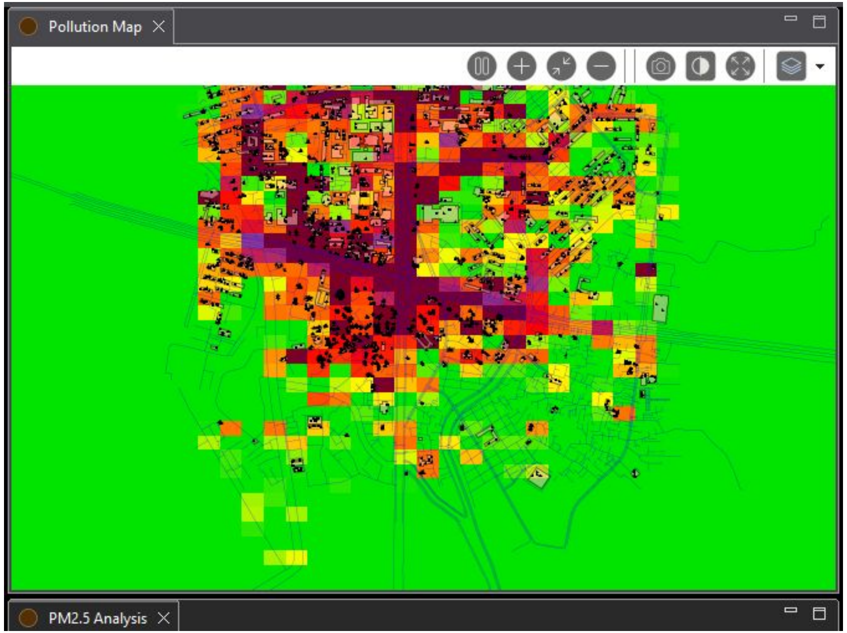


We used QGIS to get the Ha Noi OSM map. Due to our weak cheap machineries, we can only work with a small portion of the map.

3.1 P.M 2.5 Update || a. Decay

- The map is divided into a grid of 50×50
- Each grid represents a small air section with p.m level
- Each t = 1h, p.m 2.5 value vanished by 10%

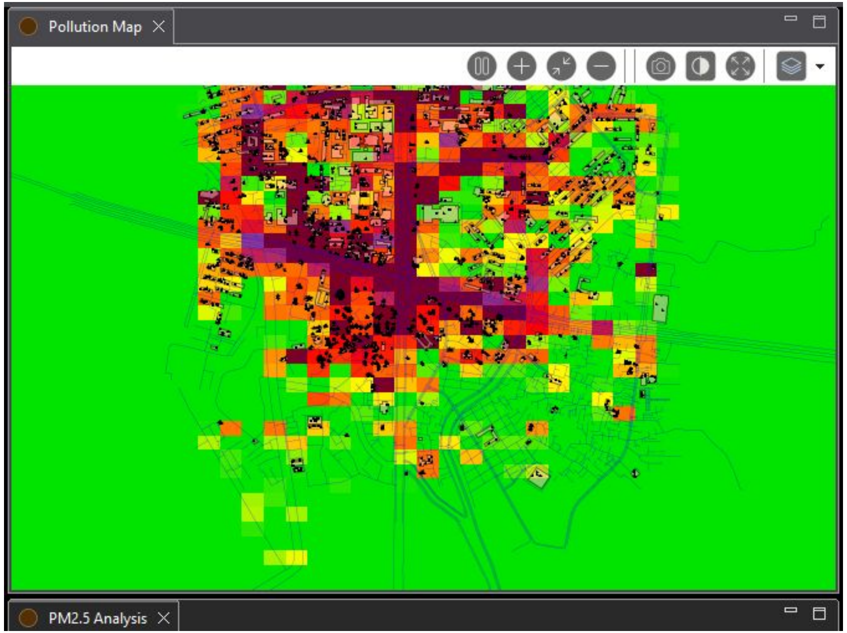
$$PM(t+1) = PM(t) \times (1 - \lambda)$$



Reference: Uniform Diffusion.gaml

3.1 P.M 2.5 Update || b. Diffuse

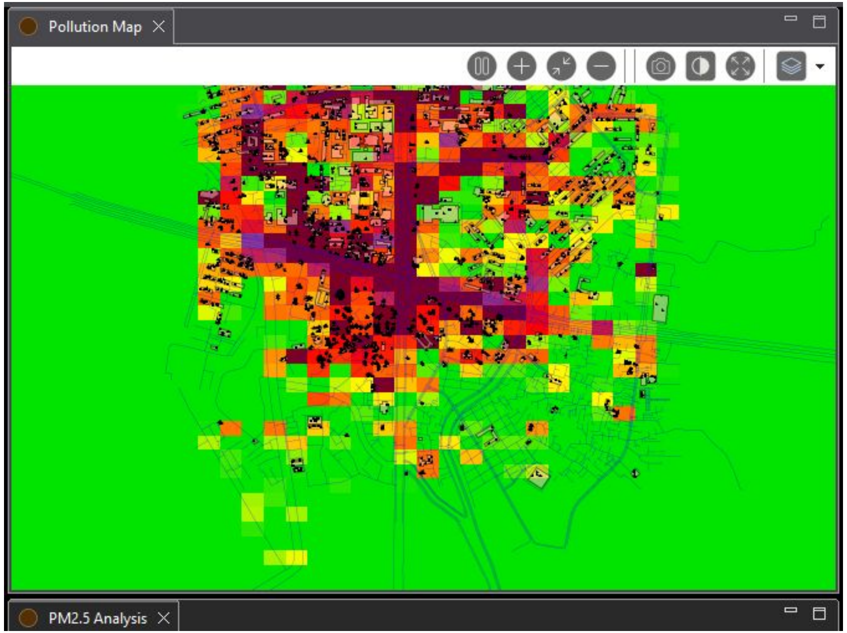
Each t = 1h, p.m 2.5 value diffuses 60% to 8 neighbors



$$PM_c(t+1) = PM_c(t) + D \sum_{n \in neighbors} (PM_n(t) - PM_c(t))$$

3.1 P.M 2.5 Update || c. Emission

- The air is polluted by residents
- Each resident emits 10-20 µg/m^3 per step while travelling



3.2 P.M Dose

All residents are exposed to dirty air in the simulation.

$$PM\_dose(t) = PM_z(t) \cdot \Delta t + \theta_{micro}(t) \cdot protect(t)$$

where :

Δt = expose duration

$$\theta_{micro}(t) = \begin{cases} 1 & // \text{ outside} \\ <1 & // \text{ inside (home / work)} \end{cases}$$

$$protect(t) = 1 - mask\_effective$$

Normalization to prevent mismatch scaling

$$x_{pm}(t) = \min\left(1, \frac{PM\_dose(t)}{PM\_ref}\right)$$

where $PM\_ref = 150$

3.3 Acumulative Risk Score

Risk Score represents increment exposure to harmful factors

$$S_i(t+1) = S_i + w_{pm} \cdot x_{pm}(t)$$

where w_{pm} : wight contribution of ari pollution

3.4 Risk Probability

Risk Probability represents the chance of one person got the diseases over time (t)

$$risk\_prob(t) = \sigma\left[k \cdot \left(S_i(t) + baseline\right) + b\right]$$

where: $baseline = \sum \theta_{personal\ risk}$

e.g: $\begin{cases} \text{If smoker = true} \rightarrow \theta_{smoker} = 0{,}6 \\ \text{If family\_his = true} \rightarrow \theta_{family} = 0{,}2 \end{cases}$

k and b are adjusters

5. Challenges

- Mismatch of time steps
- Lack of ground truth information.
- Unexpected residents behaviours
- Unexpected batch simulation errors

6. Future Work

- Add more factors (water, food,etc.)
- Add weather and seasonal changes (those will affect natural P.M score).
- Calibrate parameters
- Adjust residents movement behaviors to support yearly simulation.
- HEZ, LEZ areas.
- And many more!

VIETNAM FRANCE UNIVERSITY

Thank you for listening!

Any questions?