# ABM based on SEIR modelisation

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C++ version of SEIR - SMA model.

Each simulation is running in less than 1 second. There is no graphical interface.

## ODD description of the model :

### 1 - Purpose :

*What is the purpose of the model ?*

The purpose of this model is to simulate the propagation and the evolution of an epidemy, based on SEIR differencial equations.

This model is a toy case.

### 2 – Entities, state variables and scales :

*What kinds of entities are in the model? By what state variables, or attributes, are these entities characterized? What are the temporal and spatial resolutions and extents of the model?*

The only entity in this model is **humans**.

They are describe by the following attributes :

_pos : The position of the human on the map

_state : The number of iteration that the human spent on one stateName. For example, if _state value is 25, the human has been in the specific stateName for the last 25 iteration. When a human changes stateName, state value go to 0.

_stateName : The state of the human => Susceptible, Exposed, Infected or Recovered.

_symbol : The way to represent the human graphicaly on the map, depending on the stateName he has.

The timestep of this model is the day : each iteration represent one day. Humans are moving on a matrix.

### 3 – Process overview and scheduling :

*Who (i.e., what entity) does what, and in what order? When are state variables updated? How is time modeled, as discrete steps or as a continuum over which both continuous processes and discrete events can occur? Except for very simple schedules, one should use pseudo-code to describe the schedule in every detail, so that the model can be reimplemented from this code. Ideally, the pseudo-code corresponds fully to the actual code used in the program implementing the ABM*

Humans are separated in 4 lists : Susceptible, Exposed, Infected and Recovered.

They are moving in this order.

When a human moves, we increment his attribute « _state » that represent the time spent in one stateName.

Before moving, there is a check of parameter values to see if humans have to swap states (i.e., go for from exposed to infected, from infected to recovered, from recovered to susceptible). This changing is conditionned by a negative exponential law, according to Raphael specifications.

Infected humans have specific behavior : They can move multiple times (fixed to 1 to match Raphael specification) in one iteration, and they can infect susceptible humans that are in their neigborhood (and these humans go from susceptible to exposed).

Pseudo-code :

```
For all humans in susceptible :
        Search randomly for free position on the map
        If free position :
                newHumanPosition -> newFreePositionFound
        If not free position :
                newHumanPosition->oldPosition (The human doesn't move)


For all humans in exposed :
        If state value > negExpLaw(durationIncubation) :
                Add this human in infected human list
                Delete this human from exposed human list
        Else
                Search randomly for free position on the map
                If free position :
                        newHumanPosition -> newFreePositionFound
                If not free position :
                        newHumanPosition->oldPosition (The human doesn't move)


For all humans in infected :
        if state value > negExpLaw(durationInfection) :
                Add this human is recovered human list
                Delete this human from infected human list
        For number of deplacement in parameter file :
                moveRandomly on the map
                If there is susceptible human in neighborhood :
```

contamine neighboor

For all humans in recovered :

If state value > negExpLaw(durationImmunity) :

Add this human in susceptible human list

Delete this human from recovered human list

Else

Search randomly for free position on the map

If free position :

newHumanPosition -> newFreePositionFound

If not free position :

newHumanPosition->oldPosition (The human doesn't move)

## 4 – Design concepts :

- Basic Principles :

*Which general concepts, theories, hypotheses, or modeling approaches are underlying the model's design? Explain the relationship between these basic principles, the complexity expanded in this model, and the purpose of the study. How were they taken into account? Are they used at the level of submodels (e.g., decisions on land use, or foraging theory), or is their scope the system level (e.g., intermediate disturbance hypotheses)? Will the model provide insights about the basic principles themselves, i.e. their scope, their usefulness in real-world scenarios, validation, or modification (Grimm, 1999)? Does the model use new, or previously developed, theory for agent traits from which system dynamics emerge (e.g., 'individual-based theory' as described by Grimm and Railsback [2005; Grimm et al., 2005])?*

The model is a simple toy case to work on reproducibility between different represention of an epidemy.

The agent (Humans) have no intelligence by themselves : The world is moving them, checking for everything.

We use a Moore's neighborhood to check for contamination from infected to susceptible.

- Emergence :

*What key results or outputs of the model are modeled as emerging from the adaptive traits, or behaviors, of individuals? In other words, what model results are expected to vary in complex and perhaps unpredictable ways when particular characteristics of individuals or their environment change? Are there other results that are more tightly imposed by model rules and hence less dependent on what individuals do, and hence 'built in' rather than emergent results?*

Nothing, classical SEIR results.

- Adaptation :

*What adaptive traits do the individuals have? What rules do they have for making decisions or changing behavior in response to changes in themselves or their environment? Do these traits explicitly seek to increase some measure of individual success regarding its objectives (e.g., "move to the cell providing fastest growth rate", where growth is assumed to be an indicator of success; see the next concept)? Or do they instead simply cause individuals to reproduce observed behaviors (e.g., "go uphill 70% of the time") that are implicitly assumed to indirectly convey success or fitness?*

Nothing.

- Objectives :

*If adaptive traits explicitly act to increase some measure of the individual's success at meeting some objective, what exactly is that objective and how is it measured? When individuals make decisions by ranking alternatives, what criteria do they use? Some synonyms for 'objectives' are 'fitness' for organisms assumed to have adaptive traits evolved to provide reproductive success, 'utility' for economic reward in social models or simply 'success criteria'. (Note that the objective of such agents as members of a team, social insects, organs—e.g., leaves—of an organism, or cells in a tissue, may not refer to themselves but to the team, colony or organism of which they are a part.)*

Nothing

- Learning :

*Many individuals or agents (but also organizations and institutions) change their adaptive traits over time as a consequence of their experience? If so, how?*

Nothing

- Prediction :

*Prediction is fundamental to successful decision-making; if an agent's adaptive traits or learning procedures are based on estimating future consequences of decisions, how do agents predict the future conditions (either environmental or internal) they will experience? If appropriate, what internal models are agents assumed to use* *to estimate future conditions or consequences of their decisions? What tacit or hidden predictions are implied in these internal model assumptions?*

Nothing

- Sensing :

*What internal and environmental state variables are individuals assumed to sense and consider in their decisions? What state variables of which other individuals and entities can an individual perceive; for example, signals that another individual may intentionally or unintentionally send? Sensing is often assumed to be local, but can happen through networks or can even be assumed to be global (e.g., a forager on one site sensing the resource levels of all other sites it could move to). If agents sense each other through social networks, is the structure of the network imposed or emergent? Are the mechanisms by which agents obtain information modeled explicitly, or are individuals simply assumed to know these variables?*

The world know the position of each human on the map. When a human is moving, the world check is the futur position is free.

- Interaction :

*What kinds of interactions among agents are assumed? Are there direct interactions in which individuals encounter and affect others, or are interactions indirect, e.g., via competition for a mediating resource? If the interactions involve communication, how are such communications represented?*

Infected humans can infect susceptible humans, if they are in their neighborhood.

- Stochasticity :

*What processes are modeled by assuming they are random or partly random? Is stochasticity used, for example, to reproduce variability in processes for which it is unimportant to model the actual causes of the variability? Is it used to cause model events or behaviors to occur with a specified frequency?*

We use Mersenne Twister generator to have randomness.

Randomness is used in different cases :

- When a human moves, he randomly choose a place on the map
- To contamine a human, we use random number. If the value is below the transmission rate, the human isn't contaminated.
- To swap between each states SEIR.

- Collectives :

*Do the individuals form or belong to aggregations that affect, and are affected by, the individuals? Such collectives can be an important intermediate level of organization in an ABM; examples include social groups, fish schools and bird flocks, and human networks and organizations. How are collectives represented? Is a particular collective* *an emergent property of the individuals, such as a flock of birds that assembles as a result of individual behaviors, or is the collective simply a definition by the modeler, such as the set of individuals with certain properties, defined as a separate kind of entity with its own state variables and traits?*

Humans are separated in 4 groups with different behavior : Susceptible, Exposed, Infected and Recovered.

- Observation :

*What data are collected from the ABM for testing, understanding, and analyzing it, and how and when are they collected? Are all output data freely used, or are only certain data sampled and used, to imitate what can be observed in an empirical study ("Virtual Ecologist" approach; Zurell et al., 2010)?*

The data we have has resultats are the rate of human being in each 4 states during time. We can observe the evolution of the epidemy.

We use jupyter notebook with Python to work with these data.

## 5 – Initialization :

*What is the initial state of the model world, i.e., at time t = 0 of a simulation run? In detail, how many entities of what type are there initially, and what are the exact values of their state variables (or how were they set stochastically)? Is initialization always the same, or is it allowed to vary among simulations? Are the initial values chosen arbitrarily or based on data? References to those data should be provided.*

We have several parameters to this simulation, that are stocked in a file :

size : The size of the map. It's a square. In this simuation, we use 100. So, the map has 100 * 100 = 10 000 cases.

NbHuman : The number of human in the simulation at start that are susceptible. Here we use 999.

NbSeek : The number of human that are seek at the beginning of the simulation. Here we use 1.

NbIteration : The number of days of the simulation. Here we use 730.

NbMovingByDay : The number of deplacement each iteration for susceptible humans. Here we use 1.

TransmissionRate : The probability to contamine a neighbor.

DurationIncubation : The time a human spend in Exposed StateName.

DurationInfection : The time a human spend in Infected StateName.

DurationImmunity : The time a human spend in Recovered StateName.

At the beginning, human are placed randomly on the map.

## 6 – Input data :

*Does the model use input from external sources such as data files or other models to represent processes that change over time?*

Yes, the model us the config file with parameters described before.

## 7 – Submodels :

*What, in detail, are the submodels that represent the processes listed in 'Process overview and scheduling'? What are the model parameters, their dimensions, and reference values? How were submodels designed or chosen, and how were they parameterized and then tested?*