

CS 262 – Computational Social Science

Fall 2020

Final Project Report

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Present an Agent Based Model of

**Vaccination and Neutering: Methods to Control
Urban Stray Dog Populations and Rabies-Spread
Among Humans**

Purpose

The purpose of this model is to show that vaccination and neutering is a more effective method of controlling urban free-roaming dog populations, and of containing the spread of canine-transmitted rabies among the urban human population, in the long-term. This will hopefully show evidence against the prevalent inhumane practice of mass cullings of free-roaming dogs in Pakistan, which is a practice that dominates the policy dialogue and represents general public perceptions.

Entities/ Agents

This model has 2 different agents:

- **Dogs**: these represent individual stray dogs in an urban settlement.
- **Humans**: these represent individual humans that populate an urban settlement. Each human is represented by individual coloured (red or green) patches on the grid.

These agents are classified by the following attributes:

Dog attributes

- **Age**: This attribute represents the age of the dogs. It can be between 0 to 13 years¹

¹ This is based on the average lifespan of an Indian Pariah Dog, which is a common stray breed found across India and Pakistan.

- **Lifespan**: This attribute represents the lifespan of the dog. The lifespan increases or decreases based on the human-dog or dog-dog interactions such as vaccination or the transmission of rabies.
- **Sex**: This attribute describes the sex of the dogs. Assigned randomly with a 50/50 ratio at initialization as well as at birth.
- **Rabid?**: This attribute describes whether a dog is rabid or not. 10% of the dogs are initially rabid at the time of set-up². This initial percentage is fixed. Once a dog is rabid, it can not change to not-rabid, since it will simply die without being cured.
- **Sterilized?**: This attribute is a binary attribute that can either be true or false. It is true if the dog has been sterilized/ neutered/ spayed. It is false if the dog has not been sterilized/ neutered/ spayed. It is initially false for all dogs.
- **Vaccinated?**: This attribute is a binary attribute that can either be true or false. It is true if the dog has been vaccinated against rabies. It is false if the dog has not been vaccinated against rabies. It is initially false for all dogs.
- **Adoptability**: This attribute describes how adoptable a dog is. It is a number greater than 0, and less than or equal to 1. A dog is more adoptable if:
 - It is a female (0.3)
 - It is a puppy/ less than 6 months of age (0.35)
 - It has been neutered (0.175)
 - It has been vaccinated (0.175)
- **Colour**: the colour shows a dog's health state:
 - Yellow dogs represent non-rabid dogs that are not vaccinated or neutered.
 - Orange dogs represent dogs who are non-rabid and vaccinated

² This is a somewhat arbitrary number since there aren't any statistics on rabid dogs. The intuition is that the number of rabid dogs can not be more than the number of non-rabid dogs, and that rabid dogs in any case are sparse.

- Pink dogs represent dogs who are non-rabid and neutered
- Blue dogs represent dogs who are non rabid, vaccinated, and neutered.
- Violet dogs represent dogs who are rabid.
- **Bred?:** a binary attribute that tells whether a female dog has given birth or not. It is set to False at the time of initialization. It changes to True after a dog has given birth, and changes to False 6 months later.
- **Last-litter-period:** this attribute represents the amount of time in weeks since a dog last gave birth. A dog can only give birth twice in a year.

Human attributes

- **Disease-ridden?:** this attribute describes whether a human has rabies or not. This attribute is also visually represented by the patch color red. Conversely, the patch colour green represents a healthy human. A black patch means there is no human on that patch.
- **Dog-friendly?:** this binary attribute can be either true or false, based on the global variable *friendly-probability*. Dog friendliness encompasses the following:
 - likelihood that someone is going to adopt a stray dog
 - People whose “dog-friendly” attribute is true will not get rabies at all.³
- **Colour:** green patches represent healthy humans. Red patches represent humans who have rabies. Initially, all humans are green, i.e, not rabid.

State/Global Variables

This model has the following global variables:

³ This behavior shows that people who are dog friendly will have knowledge about rabid dog behavior, and will not approach a rabid dog nor will they aggravate it, which is the usual cause for a rabid dog to attack. Therefore, they are safe from rabies from stray, rabid dogs.

- **Number of Dogs**: this is the total number of dogs present at the time of initialization. It can range from 500 to 1000. The default value is 750.
- **Number of Humans**: this is the total number of humans present at the time of initialization. It can range from 0 to 1000. The default value is 900.
- **Friendly-Probability**: decides the percentage of humans that are friendly towards dogs during set-up. The default value is 0.3.
- **Neutering-Rate**: The rate, in %, of neutering operations carried out on a weekly basis. The default value is 0.
- **Vaccination-Rate**: The rate of vaccinations carried out on a weekly basis. The default value is 0.
- **Max-kill-capacity**: The number of killings carried out on a weekly basis. The values range from 0 to 100. The default value is 1.
- **Simulation-run-time**: an input from the observer to decide how long they want the simulation to run. Input is a number representing the time period in years.

Process Overview and Scheduling

On each tick, the following processes occur:

- Dog-get-neutered
- Dogs-get-vaccinated
- Rabies-spread-dogs
- Rabies-spread-humans
- Adopt
- Kill
- Dogs-reproduce
- Increase-in-age

Stop Simulation

The simulation stops when the number of ticks is equal to the input “*simulation-run-time-years*”

Sensing

- Rabid dogs can sense when another dog or human is in its location/ territory/ cell.
- A human can sense whether an “adoptable” dog is in its location/ territory/ cell.

Interaction

- Dogs bite other dogs
- Dogs bite humans
- Humans medically treat dogs
- Humans adopt dogs
- Humans kill dogs
- Dogs mate and reproduce

Stochasticity/ Randomness

The randomness in our model occurs as follows:

- Dogs are randomly placed in the grid.
- Dogs are initially randomly rabid

- Humans are randomly friendly
- Puppies that get rabies from their mother is random
- Spread of rabies is random.

Setup and Initialization

- Humans and dogs distributed randomly on the grid.
- Black patches represent no humans, or areas with no humans.
- Green patches represent healthy humans.

Input Data

The input data is are all the state variables that will be implemented via a slider:

- *Number of Dogs*
- *Number of Humans*
- *Friendly-Probability*
- *Neutering-Rate*
- *Vaccination-Rate*
- *Max-Kill-Capacity*
- *Rabies-spread-rate*

This input data will be implemented via a input box:

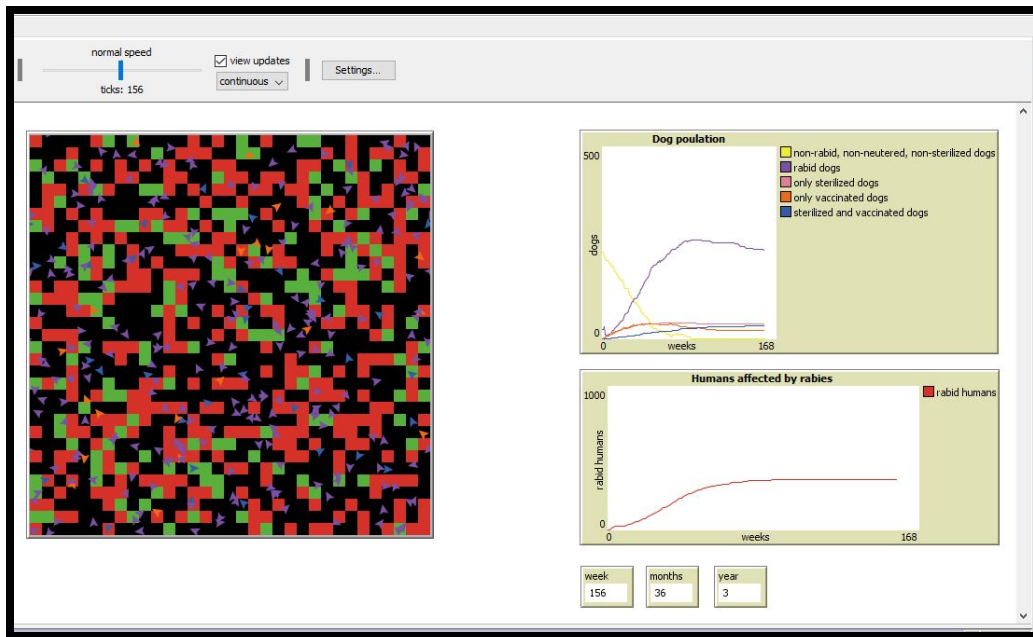
- *Simulation-run-time-years*

Output

The output will be in the following forms:

- One plot that shows the dog population every week, rabid dogs every week, dogs sterilized every week and dogs vaccinated every week.

- A plot that shows the number of humans and number of rabies cases in humans every week
- A visual representation using colour coordination. Red patches and violet dogs represent rabies cases; the green patches represent non-rabid humans; blue dogs represent sterilized and neutered dogs.



Submodels/ Processes

- **Dog-gets-vaccinated:** if the dog is non-rabid, it will be vaccinated. The number of dogs that get vaccinated weekly is determined by *vaccination-rate*. Once the dog is treated, the following changes will be made to this attributes:
 - his “vaccinated?” attribute will change to true. After they have changed to true, they can not change.
 - Its color will change to orange
 - It’s “adaptability” attribute will increase by 0.175.

- **Dog-gets-neutered:** if the dog is non-rabid, it will be neutered. The number of dogs that get vaccinated weekly is determined by *neutering-rate*. Once the dog is neutered, the following changes will be made to its attributes:
 - His “neutered?” attribute will be changed to true. After it is true, it can not change.
 - Its color will change to pink.
- **Rabies-spread-humans:** rabies will spread from dog to human if and only if the dog enters the same cell as a non-dog-friendly human. If a human gets bit, the following changes to his attributes will be made:
 - His colour will change to red
 - His attribute is “disease-ridden?” will change to true
- **Rabies-spread-dog:** if a non-rabid dog enters the same cell as a rabid dog, he will get infected.
 - The dog’s “rabid?” attribute will change to true.
 - His lifespan will be reduced to 7 days only. After 7 days, he will die. During this time, he may or may not infect another dog or person.
- **Dogs-reproduce:** a female dog will reproduce twice a year given the following conditions are true:
 - She is a female
 - Her attribute “Sterilized?” is false.
 - Her attribute “bred?” is false
 - Her age is greater than 6 months.
 - She hasn’t given birth in the past 6 months.

Each litter will be of 1-6 dogs.
- **Adopt:** a human will adopt a dog given that the following conditions are true:
 - The human’s “dog-friendly?” attribute is true

- The dog's "adaptability" attribute is greater than 0.6.
- The dog will no longer be visible on the grid, since it is no longer a free-roaming dog.
- **Kill:** at every tick, dogs die in a given community based on the kill-rate.
- **Die:** if a dog has reached the end of its lifespan, it will die naturally.
- **Increase-in-age:**
 - A dog's age will increase by 7 days each tick
 - If the age is equal to the lifespan, the dog will die.
 - If age is more than 6 months, 24 weeks, "adaptability" value will decrease by 0.35

Notes/Assumptions

- Once a dog is adopted, he will remain adopted and will not become a free-roaming dog again.
- Dogs are only contracting rabies from other dogs within this environment.
- Our model does not show whether or not the humans that are infected die or get treated. It only shows the net dog-human rabies transfer.
- We are assuming that killings, vaccinations, and neutering are happening at a steady rate which is not the case in real life.
- The model shows that dogs are being killed in an accelerated time-frame, which would suggest that mass cullings are the way to go. However, the following factors show that it's not a good option:
 - Rabies is still being spread

- In real-life, piles of dead bodies are actually more detrimental to public health.

References

1. Ahmed, T., Asghar, M. W., Khalid, S., & Mushtaq, M. H. (2019, May 26). A short report on epidemiological investigation of dog bite cases in association with temperature rise as a part of climate change. Retrieved December 09, 2020, from <http://www.als-journal.com/634-19/>
2. The Welfare of Stray Dogs-Rabies. (n.d.). Retrieved December 08, 2020, from <https://www.wsdindia.org/rabies.htm>