Complex-System-and-Agent-Base-Model-for-Spreading-of-Rabies-due-to-stray-dogs

This project implements a Complex System of Spread of Rabies due to stray dogs.The system includes interactions between **stray dogs**, **pet dogs**, **pedestrians**, **pet dog owners**, and **dog sterilization officers**, while introducing the **vaccination of pet dogs** to control the spread of rabies. The system will also model how these agents interact to affect the population and health of both stray and pet dogs, as well as how it will affect the health of humans.

Scenario

In urban areas, certain locations such as bus stands, marketplaces, and religious sites are frequented by stray dogs. Among these dogs, some have been sterilized, and some may have been infected with rabies. In households, pet dogs rely on their owners to ensure they are vaccinated.

Stray dogs roam the city in search of food, and occasionally, pet dogs venture outside their homes, interacting with their surroundings. Due to factors such as abandonment, the population of female stray dogs tends to be higher than that of males. This imbalance contributes to a significant birth rate among strays. As these dogs navigate the city, interactions between infected and non-infected dogs can lead to the spread of rabies, increasing the number of infected strays.

Moreover, when pet dogs encounter infected strays, unvaccinated pets can contract rabies and inadvertently carry the disease back home. This poses a risk not only to the dogs but also to their owners, as rabies can be transmitted to humans through interactions with infected animals.

Also, dog officers operate in the city, focusing on sterilizing stray dogs to control the population growth. Importantly, these officers adhere to ethical standards, refraining from killing dogs.

However, the stray dog population can only decrease through the natural death of infected dogs or when they go without food for extended periods. This complex dynamic highlight the challenges of managing stray and pet dog populations while ensuring the safety and health of both animals and humans in the community.

To address the above complex system, an agent-based model should be simulated using netlogo.

Key Agents and their Simplex System Components

1. Stray Dogs

- **Beliefs:** Survival instinct, territoriality, fear of humans and Vehicles.
- **Emotions:** Fear, aggression, hunger.
- **Representations:** Mental maps of their environment, recognition of threats (e.g., humans, other dogs).
- **Habits:** Foraging behavior, sleeping patterns, social interactions.
- **Practices:** Territorial marking, scavenging for food.
- **Values:** Survival, reproduction.

2. Pet Dogs

- **Beliefs:** Loyalty to humans, fear of punishment.
- **Emotions:** Joy, fear, anxiety.
- **Representations:** Mental maps of their home environment, recognition of familiar faces.
- **Habits:** Feeding schedule, exercise routine, social interactions with humans and other dogs.
- **Practices:** Following commands, seeking attention from humans.
- **Values:** Comfort, companionship, security.

3. Pedestrians

- **Beliefs:** Awareness of rabies risk, fear of dog bites, belief in animal rights, religious beliefs, cultural norms.
- **Emotions:** Fear, anxiety, love and kindness towards dogs.
- **Representations:** Mental models of rabies transmission, understanding of prevention measures, Personal Experiences, Media portrayal of dogs.
- **Habits:** Walking routes, interactions with dogs.
- **Practices:** Feeding Stray dogs, Abandoning Female dogs, Throwing garbage in public places, Avoiding stray dogs, seeking medical attention after a bite.
- **Values:** Safety, health.

4. Pet Dog Owners

- **Beliefs:** Importance of pet vaccination, responsibility for pet safety.
- **Emotions:** Concern for pet health, fear of rabies.
- **Representations:** Understanding of rabies prevention measures, knowledge of local dog regulations.
- **Habits:** Pet care routines, leash training.
- **Practices:** Vaccinating pets, preventing interactions with stray dogs.
- **Values:** Pet well-being, public health.

5. Dog Sterilization Officers

- **Beliefs:** Importance of population control, effectiveness of sterilization programs.
- **Emotions:** Commitment to animal welfare, frustration with challenges.
- **Representations:** Understanding of dog behavior, knowledge of sterilization techniques.
- **Habits:** Work routines, interactions with stray dogs.
- **Practices:** Implementing sterilization programs, educating the public.
- **Values:** Animal welfare, public health.

Variables

- **Stray Dog Population**: The total number of stray dogs in the environment.
- **Pet Dog Population**: Number of pet dogs in the simulation.
- **Rabies Occurrence (Stray Dogs)**: The number of stray dogs infected with rabies.
- **Rabies Occurrence (Pet Dogs)**: The number of unvaccinated pet dogs infected with rabies.
- **Vaccination Rate (Pet Dogs)**: The percentage of pet dogs vaccinated, preventing rabies infection.
- **Sterilization Rate**: Rate at which stray dogs are sterilized by officers.
- **Adoption Rate**: Rate at which stray dogs are adopted, reducing the stray dog population.
- **Interaction Rates**: Frequency of interactions between stray dogs, pet dogs, pedestrians, and dog owners.
- **Rabies infected pedestrians:** Number of rabies infected pedestrians in the simulation.
- **Rabies infected dog owners:** Number of rabies infected dog owners in the simulation.
- **Rabies Death dogs:** Amount of dogs died due to rabies.

Processes and Interactions

1. **Stray Dog Movement and Interaction**
   - Stray dogs roam freely, seeking food and shelter.
   - Interaction with pet dogs happens when stray dogs encounter them on walks or when pet dogs escape their homes.
   - If a stray dog is rabid, it can spread rabies to pet dogs or pedestrians upon interaction.
   - Natural factors (illness, accidents) reduce the stray dog population.

2. **Pet Dog Behavior and Vaccination**
   - Pet dogs are typically confined to their home area but may interact with stray dogs during walks with their owners.
   - Pet dogs that are vaccinated cannot contract rabies, while unvaccinated pet dogs are at risk if they interact with rabid stray dogs.

3. **Pet Dog Owners**
   - Walk their dogs, during which pet dogs can interact with stray dogs.
   - Owners are responsible for vaccinating their dogs, preventing rabies spread.
   - Some pet dog owners may report stray dogs for capture or sterilization and may feed stray dogs, influencing their movement patterns.
   - Some may abandon the female pet dogs when their pets give birth to female dogs increasing the amount of stray dogs.

4. **Pedestrians**:
   - Pedestrians move through the environment, occasionally interacting with stray dogs.
   - They can be at risk of rabies if bitten by an infected stray dog.
   - Some pedestrians may also feed stray dogs, influencing their location choices.
   - Some pedestrians may adopt stray dogs helping to reduce the number of stray dogs

5. **Dog Sterilization Officers**:
   - Patrol the environment to catch and sterilize stray dogs to prevent uncontrolled reproduction.
   - They may also vaccinate dogs to prevent the spread of rabies among stray populations.

System Dynamics and Flow

1. **Initial Setup**
   - Defined as urban areas with various zones such as food sources (markets, restaurants), shelters (parks, abandoned buildings), and human interaction points (bus stops, residential areas).
   - Initialize the environment with stray dogs, pet dogs, pet dog owners, pedestrians, and dog sterilization officers.
   - Assign the percentage of female and male stray dogs in an urban area.
   - Assign initial vaccination rates for pet dogs and initial rabies infection status for a small percentage of stray dogs.

2. **Movement and Interaction**:
   - **Stray Dogs**: Move toward food sources and shelters, interact with pet dogs or humans based on proximity.
   - **Pet Dogs**: Stay near their owners but may interact with stray dogs when being walked or if they escape.
   - **Pet Dog Owners and Pedestrians**: Move through the environment, with a chance of interacting with stray dogs and influencing their behavior such as feeding.
   - **Sterilization Officers**: Periodically patrol areas with high stray dog populations, capturing and sterilizing stray dogs.

3. **Rabies Dynamics**
   - Stray dogs can become infected with rabies and may spread it to pet dogs and pedestrians through bites or close contact.
   - **Vaccination**: Vaccinated pet dogs are immune to rabies, reducing the spread of disease. Unvaccinated dogs have a chance of infection if they interact with a rabid stray dog.

4. **Reproduction and Sterilization**
   - Female stray dogs that are not sterilized reproduce, increasing the population.
   - Dog sterilization officers reduce the reproductive capacity of stray dogs through regular sterilization programs, helping to control the population.

5. **Adoption and Population Control**
   - Pet dog owners or pedestrians may adopt stray dogs, removing them from the street and reducing the stray population.
   - Captured dogs can either be sterilized and released or permanently removed from the street through adoption.

6. **Metrics and Outcomes**
   - **Stray Dog Population**: Track how sterilization and adoption rates impact the overall stray dog population over time.
   - **Rabies Cases**: Monitor the number of rabies cases among both stray and pet dogs, affected by the vaccination rate and interactions between rabid and healthy dogs.
   - **Sterilization Success**: Measure the effectiveness of dog sterilization officers in reducing the stray dog birth rate.
   - **Human Safety**: Track the number of human-pedestrian bites by rabid stray dogs to evaluate the public health impact.

Simulation Flow

1. **Initialize Environment**:
   - Set initial populations of stray and pet dogs.
   - Define zones for food sources, shelters, and human activity (residential areas, parks, etc.).
   - Assign vaccination rates and health statuses for pet and stray dogs.
2. **Agent Movement and Interaction**:
   - Stray dogs move randomly in search of food and shelter, with higher concentrations near markets and public spaces.
   - Pet dogs move with their owners and may interact with stray dogs when walked.
   - Dog sterilization officers periodically patrol the environment, sterilizing the dogs.
3. **Rabies Spread and Vaccination**:
   - Rabies spreads among stray dogs and between stray and unvaccinated pet dogs.
   - Vaccinated pet dogs act as barriers to the spread of rabies.
   - Human-pedestrian safety depends on the prevalence of rabid stray dogs and the level of interaction with humans.
4. **Reproduction and Control**:
   - Stray dogs reproduce if they are not sterilized.
   - Sterilization efforts reduce future population growth, while adoptions directly reduce the current population of stray dogs.
5. **Monitor and Evaluate**:
   - Track the population of stray and pet dogs, rabies occurrences, and the effectiveness of interventions (sterilization, vaccination, adoption).