Wicked Problem Formulation:
The Simulation of an Outbreak of Zombies

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Team

Tianchen Luo: problem formulation coding, q-function coding, report writing
Yi Zheng: operators coding, adjusting parameters, report writing

Introduction

Zombie outbreaks are always a popular topic. There are a bunch of fictions, movies and TV series that depict different kinds of zombie apocalypses. So we come out with an idea to formulate our own world where human fighting zombies and try to protect the country from zombies.

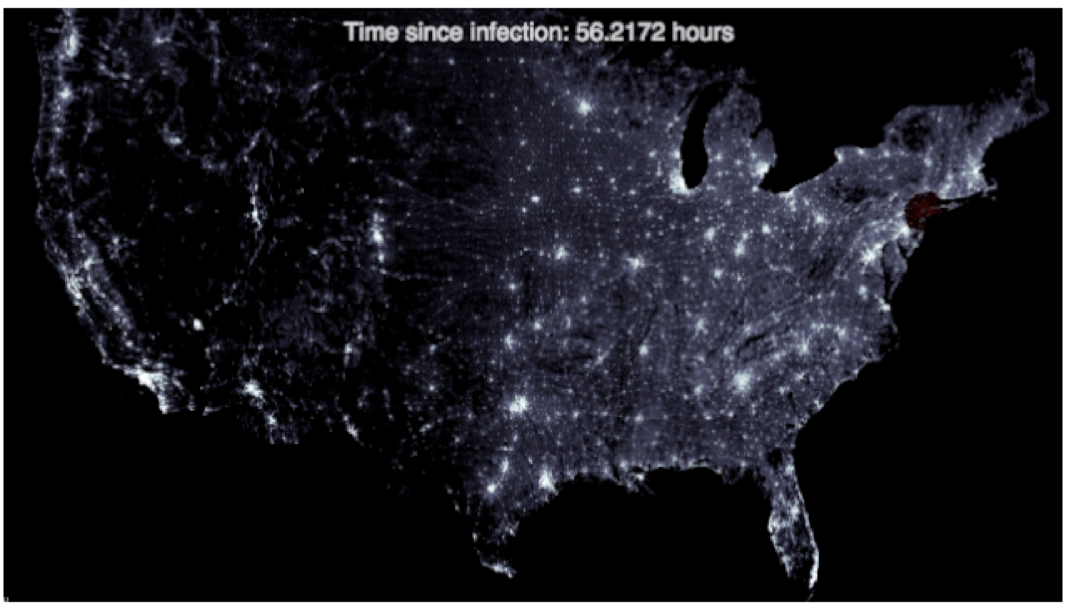

Image generated from http://mattbierbaum.github.io/zombies-usa/

Purpose

Basically, we simulate an outbreak of zombies in our program. In the simulation, we formulate a wicked problem: How can people prevent the outbreak of zombies through different actions. We define the status of all districts in a country in a specific day to be each state in our problem, so we can use the State-Space Search to solve our problem. Our program is supposed to simulate all the actions of zombies and humans after an outbreak of zombies and then do the Depth-First Search to get a solution path to all possible results.

AI Technique

The AI technique we used in this project is wicked problem formulation and state-space search. In our problem, we first make sure that zombie breakout is a wicked problem:

1. There is no definitive formulation of an outbreak of zombies problem.
2. Zombie breakout has no stopping rule. But we defined several goal criterions to help us better understanding what's going on after zombie breakout.
3. There is no true-or-false solution to prevent an outbreak of zombies, only good or bad.
4. There is no exact solution to prevent an outbreak of zombies.
5. Every solution is a "one shot operation", because there is no opportunity to learn by trial-and-error, every attempt counts significantly. In our problem, any attempts may lead to the distinction of human beings.
6. Problem doesn't has an enumerable set of potential solution. Our zombie breakout problem may have nearly infinitely many potential solutions.
7. This zombie outbreak problem is essentially unique.
8. It can be considered to be a symptom of another problem. Our problem can be considered to be a symptom of certain disease spreading problem.
9. And lastly, it can be explained in numerous way.

Then, we start to formulate the problem and design our state-space representation. We assume there are 16 districts in our problem, and every district has different status, like human population, zombie population, defence ability and attack power. Our main structure for representation is a dictionary. We use the district name as the key, and all the status of that district in a list as the key value. During the search, each district takes an action first, which will change some status of that district. Then zombies take action and all districts' status may be changed. After those, we will get a new state for next-step search.

Our DEMO setting

1. There are 16 districts
2. The population of each district is 100, and one of the districts will have 100 zombies.
3. The human attack power starts from 8 (8 persons can kill 1 zombie)
4. The human defence power starts from 2 (when 16 persons kill 2 zombie, 1 person will get infected)
5. The Zombify rate is 80±15 (Infected human has 80±15 probability to become a zombie)
6. Zombie will outbreak in one random district with a population of 100.(there will be no human in that dist)
7. Every single day(turn):
   Human could attack zombies, build walls, develop weapons or develop medicine(Each district would choose the best action based on the action evaluation function.). Then zombie would spread, also attack and infect humans.

Sample Solutions:

There are a bunch of possible solutions to this problems, since there are some random factors such as the location of the first outbreak district, zombify rate as well as the human actions. Below are some possible solutions.

Dist0 H/I/Z(A,D,R) = 100/0/0(1.40,9.10,15)	Dist1 H/I/Z(A,D,R) = 100/0/0(1.40,9.10,15)	Dist2 H/I/Z(A,D,R) = 89/3/0(1.40,9.10,15)	Dist3 H/I/Z(A,D,R) = 100/0/0(1.40,9.10,15)
Dist4 H/I/Z(A,D,R) = 100/0/0(1.40,9.10,15)	Dist5 H/I/Z(A,D,R) = 71/2/0(1.40,8.70,15)	Dist6 H/I/Z(A,D,R) = 1/2/0(1.40,9.10,15)	Dist7 H/I/Z(A,D,R) = 81/3/0(1.40,9.10,15)
Dist8 H/I/Z(A,D,R) = 85/3/0(1.40,9.10,15)	Dist9 H/I/Z(A,D,R) = 1/1/0(1.40,9.10,15)	Dist10 H/I/Z(A,D,R) = 0/0/0(8.00,1.50,70)	Dist11 H/I/Z(A,D,R) = 18/1/0(1.40,9.10,15)
Dist12 H/I/Z(A,D,R) = 100/0/0(1.40,9.10,15)	Dist13 H/I/Z(A,D,R) = 79/1/0(1.40,9.10,15)	Dist14 H/I/Z(A,D,R) = 24/1/0(1.40,9.10,15)	Dist15 H/I/Z(A,D,R) = 87/1/0(1.40,9.10,15)

```
None
Human won!
116 states examined.
```

Human won

Dist0 H/I/Z(A,D,R) = 0/0/49(8.00,1.50,70)	Dist1 H/I/Z(A,D,R) = 0/0/43(8.00,1.50,65)	Dist2 H/I/Z(A,D,R) = 0/0/40(8.00,1.50,45)	Dist3 H/I/Z(A,D,R) = 0/0/42(7.70,1.50,35)
Dist4 H/I/Z(A,D,R) = 0/0/42(8.00,1.50,65)	Dist5 H/I/Z(A,D,R) = 0/0/36(8.00,1.50,65)	Dist6 H/I/Z(A,D,R) = 0/0/38(8.00,1.50,40)	Dist7 H/I/Z(A,D,R) = 0/0/30(8.00,1.50,15)
Dist8 H/I/Z(A,D,R) = 0/0/44(8.00,1.50,45)	Dist9 H/I/Z(A,D,R) = 0/0/37(8.00,1.50,45)	Dist10 H/I/Z(A,D,R) = 0/0/31(8.00,1.60,30)	Dist11 H/I/Z(A,D,R) = 0/0/36(7.70,1.60,15)
Dist12 H/I/Z(A,D,R) = 0/0/40(7.70,1.50,40)	Dist13 H/I/Z(A,D,R) = 0/0/37(8.00,1.50,20)	Dist14 H/I/Z(A,D,R) = 0/0/33(8.00,1.80,15)	Dist15 H/I/Z(A,D,R) = 1/3/36(7.40,1.80,15)

```
None
zombie won!
60 states examined.
```

Zombie won

Dist0 H/I/Z(A,D,R) = 0/0/1(8.00,1.50,40)	Dist1 H/I/Z(A,D,R) = 0/0/4(8.00,1.50,45)	Dist2 H/I/Z(A,D,R) = 0/0/4(8.00,1.50,65)	Dist3 H/I/Z(A,D,R) = 0/0/4(8.00,1.50,70)
Dist4 H/I/Z(A,D,R) = 1/3/0(1.40,8.30,15)	Dist5 H/I/Z(A,D,R) = 0/0/0(8.00,1.50,35)	Dist6 H/I/Z(A,D,R) = 0/0/3(8.00,1.50,65)	Dist7 H/I/Z(A,D,R) = 0/0/4(8.00,1.50,65)
Dist8 H/I/Z(A,D,R) = 1/3/0(1.40,9.10,15)	Dist9 H/I/Z(A,D,R) = 1/2/0(1.40,9.10,15)	Dist10 H/I/Z(A,D,R) = 0/0/0(4.40,2.00,15)	Dist11 H/I/Z(A,D,R) = 0/0/4(4.10,2.20,15)
Dist12 H/I/Z(A,D,R) = 1/3/0(1.40,9.10,15)	Dist13 H/I/Z(A,D,R) = 1/3/0(1.40,9.10,15)	Dist14 H/I/Z(A,D,R) = 1/3/0(1.40,9.10,15)	Dist15 H/I/Z(A,D,R) = 0/0/0(8.00,1.50,40)

```
None
After 730 days, humans are still fighting zombies.
```

Still fighting in given time limit(Deadlock 1)

Dist0 H/I/Z(A,D,R) = 99/1/0(1.40,9.10,15)	Dist1 H/I/Z(A,D,R) = 75/3/0(1.40,9.10,15)	Dist2 H/I/Z(A,D,R) = 78/3/0(1.40,9.10,15)	Dist3 H/I/Z(A,D,R) = 72/2/0(1.40,9.10,15)
Dist4 H/I/Z(A,D,R) = 69/3/0(1.40,9.10,15)	Dist5 H/I/Z(A,D,R) = 1/3/0(1.40,9.10,15)	Dist6 H/I/Z(A,D,R) = 1/3/0(1.40,9.10,15)	Dist7 H/I/Z(A,D,R) = 1/2/0(2.00,5.40,15)
Dist8 H/I/Z(A,D,R) = 70/3/0(1.40,9.10,15)	Dist9 H/I/Z(A,D,R) = 1/1/0(1.40,9.10,15)	Dist10 H/I/Z(A,D,R) = 0/0/0(8.00,1.50,65)	Dist11 H/I/Z(A,D,R) = 0/0/4(8.00,1.50,60)
Dist12 H/I/Z(A,D,R) = 89/1/0(1.40,9.10,15)	Dist13 H/I/Z(A,D,R) = 1/2/0(1.40,5.30,15)	Dist14 H/I/Z(A,D,R) = 0/0/4(8.00,1.50,70)	Dist15 H/I/Z(A,D,R) = 0/0/4(8.00,1.50,70)

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lone
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Still fighting in given time limit(Deadlock 2)

Dist0 H/I/Z(A,D,R) = 99/1/0(2.40,9.10,20)	Dist1 H/I/Z(A,D,R) = 2/1/0(2.40,9.10,20)	Dist2 H/I/Z(A,D,R) = 2/1/0(2.40,9.10,20)	Dist3 H/I/Z(A,D,R) = 0/0/4(7.80,2.50,68)
Dist4 H/I/Z(A,D,R) = 36/1/0(2.40,9.10,20)	Dist5 H/I/Z(A,D,R) = 2/1/0(2.60,8.40,20)	Dist6 H/I/Z(A,D,R) = 2/1/0(2.40,9.10,20)	Dist7 H/I/Z(A,D,R) = 2/1/0(2.40,9.10,20)
Dist8 H/I/Z(A,D,R) = 2/1/0(2.40,8.40,20)	Dist9 H/I/Z(A,D,R) = 0/0/4(7.60,2.00,76)	Dist10 H/I/Z(A,D,R) = 0/0/4(8.00,2.10,80)	Dist11 H/I/Z(A,D,R) = 2/1/13(6.80,2.60,52)
Dist12 H/I/Z(A,D,R) = 2/1/0(2.40,9.10,20)	Dist13 H/I/Z(A,D,R) = 2/1/13(6.40,2.70,60)	Dist14 H/I/Z(A,D,R) = 0/0/4(8.00,2.00,80)	Dist15 H/I/Z(A,D,R) = 0/0/4(8.00,2.00,80)

```
None
After 730 days, humans are still fighting zombies.
```

Still fighting in given time limit(Deadlock 3)

Coding excerpt:

```
def dominated_by(s,dist_num):
    human, infected, zombie = s[dist_str(dist_num)][:3]
    if (human+infected) >= DOMINATION_RATE*(human+infected+zombie):
        return "human"
    elif zombie >= DOMINATION_RATE*(human+infected+zombie):
        return "zombie"
    else:
        return "mixed"
```

The dominated_by function is one of the most important functions that could help us analyse what action a district should use, which side will win the game and how to attack efficiently. If DOMINATION_RATE is 0.9, a district's human population must exceed 90% of its total population to dominate the district.

Summary

Tianchen Luo: Before doing this project, I didn't fully understand how to define a wicked problem and why it's so hard to solve the wicked problems. During coding the problems, I found there are too many parameters that will cause infinitely many different results. And it's really annoying when everything didn't behave like what you want. I spent a lot time on finding the best way to beat zombies or the eradicate humans. After doing all those, I understand more about the importance of solving a wicked problem. Although we could not solve them with some exact solution, but by using the techniques from AI, we could try to find the better solutions that will give us more chance to solve the problems.

Yi Zheng: This project definitely help me get more familiar with problem formulation, especially for the wicked problem. Also, this project is very inspired and creative since this topic is very open and there is no exact problem formulation before. It is kind of like the game design to write the code for this project, because we define all the actions of both zombies and humans. Besides, we used an operator that is totally different from what we did in previous homeworks and I think that is the most challenging but enjoying part of the project.

To be improved

If we could get more time, we might figure out some heuristic function so that we could use the Astar Search to solve the problem with much bigger size and more complicated situation. In addition, we could design the UI to display each state and let the user to interact with program such as changing some parameters, making orders for humans and develop new actions.