

Fighting Zombies With Mathematical Models

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Models

- Basic Zombie Model (SZR)
- SZR with Latent Infection (SIZR)
- SIZR with Quarantine (SIZRQ)
- SIZRQ with Treatment
- Impulsive Attacks
- Escape to the Stars!

Introduction

Computer Aided Analysis is a course for Mechanical, Electrical, and Computer Science Engineering Students. In this class, students learn how to analyze data and model equations using the C programming language, Bash, and GNUplot. We use the mighty Vim text editor, and present our findings in Latex documents. The final project was to recreate and analyze the results found in the paper *When Zombies Attack!: Mathematical Modelling of an outbreak of Zombie Infection*, using the tools learned in the class.

I created 6 computer programs to simulate the infection. They all follow the same form as the first model, but have additional parameters (and logic in the case of the Impulse Attacks and Escape to the Stars).

```
basicModel.c
while (t < 1000){
    printf("%f\t%f\t%f\t%f\n", t, S, Z, R);

    s = S;
    z = Z;
    r = R;

    S = - Beta * s * z * dt + s;
    Z = Beta * s * z * dt + Zeta * r * dt - Alpha * s * z * dt + z;
    R = Delta * s * dt + Alpha * s * z * dt - Zeta * r * dt + r;

    t += dt;
}
```

Table 1:Symbol Reference

α	Human Defeating Zombie in Encounter Success Rate
β	Human Infection Rate
δ	Human Natural Death Rate
ζ	Zombie Resurrection Rate
ρ	Infected Human turning into Zombie Rate
γ	Death in Quarantine Rate
σ	Zombie placed into Quarantine Rate
κ	Infected Human put into Quarantine Rate

The Basic Model (SZR)

The first model is the simplest, and is very close to the SIR model for predicting the flow of an epidemic. It has three classes, Suseptible, Zombie, and Removed, and has the parameters α , β , δ and ζ . In this graph, α was low and β was high, to simulate an aggressive zombie invasion against people who weren't prepared to deal with them.

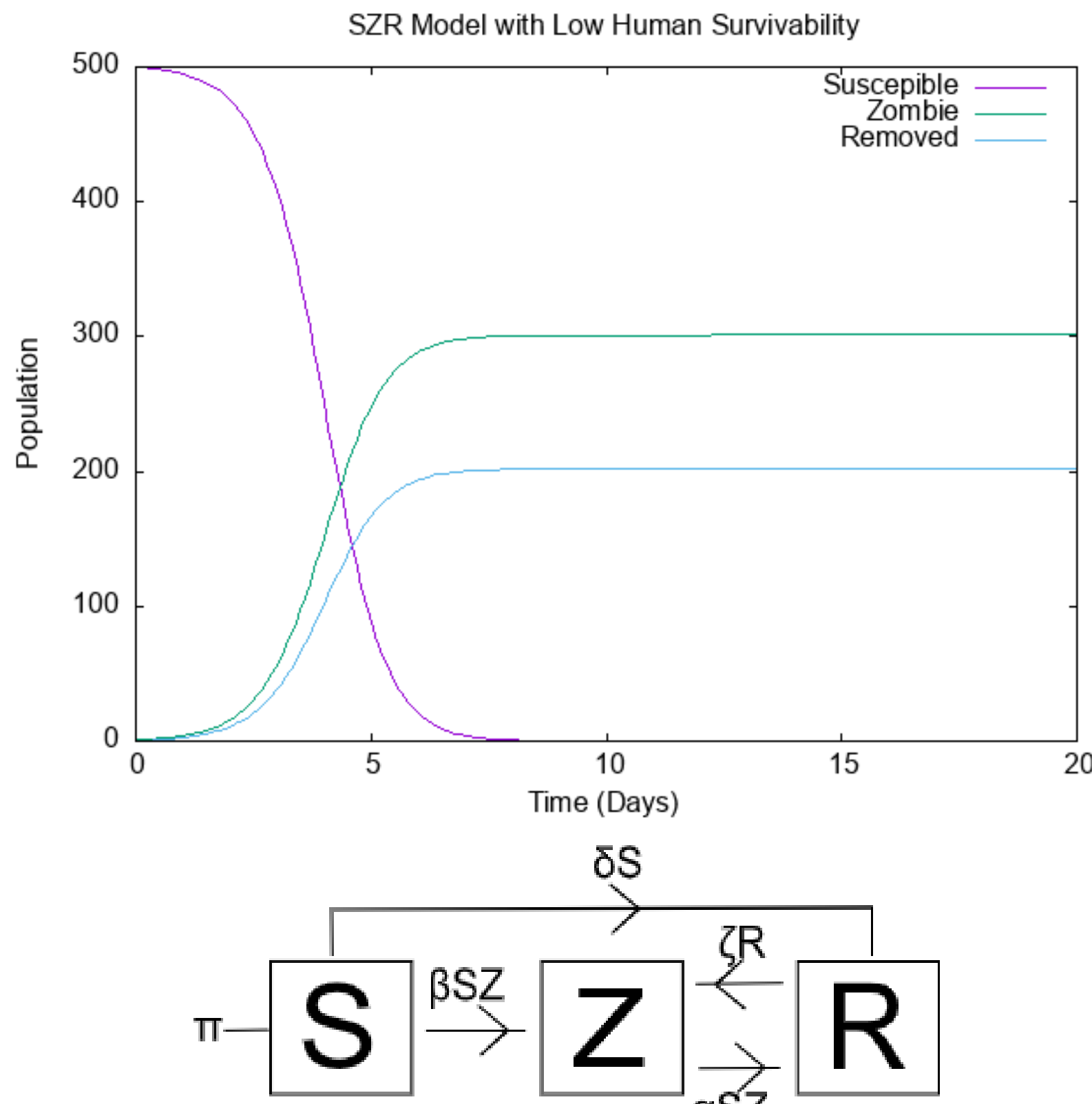


Figure 1:SZR Model with Low Human Survivability (β)

SIZR Model

The SIZR model adds the Infected class, to simulate an invasion where it takes time to become a zombie. For my model, I had high ζ and δ values to simulate an scenario where people were dying rapidly due to lack or aggressive competition for resources. It is survival of the fittest, and not everyone is equipped to make it in a zombie world. The ζ parameter is the zombie rate of resurrection, and since it's higher that means more deaths produce more zombies.

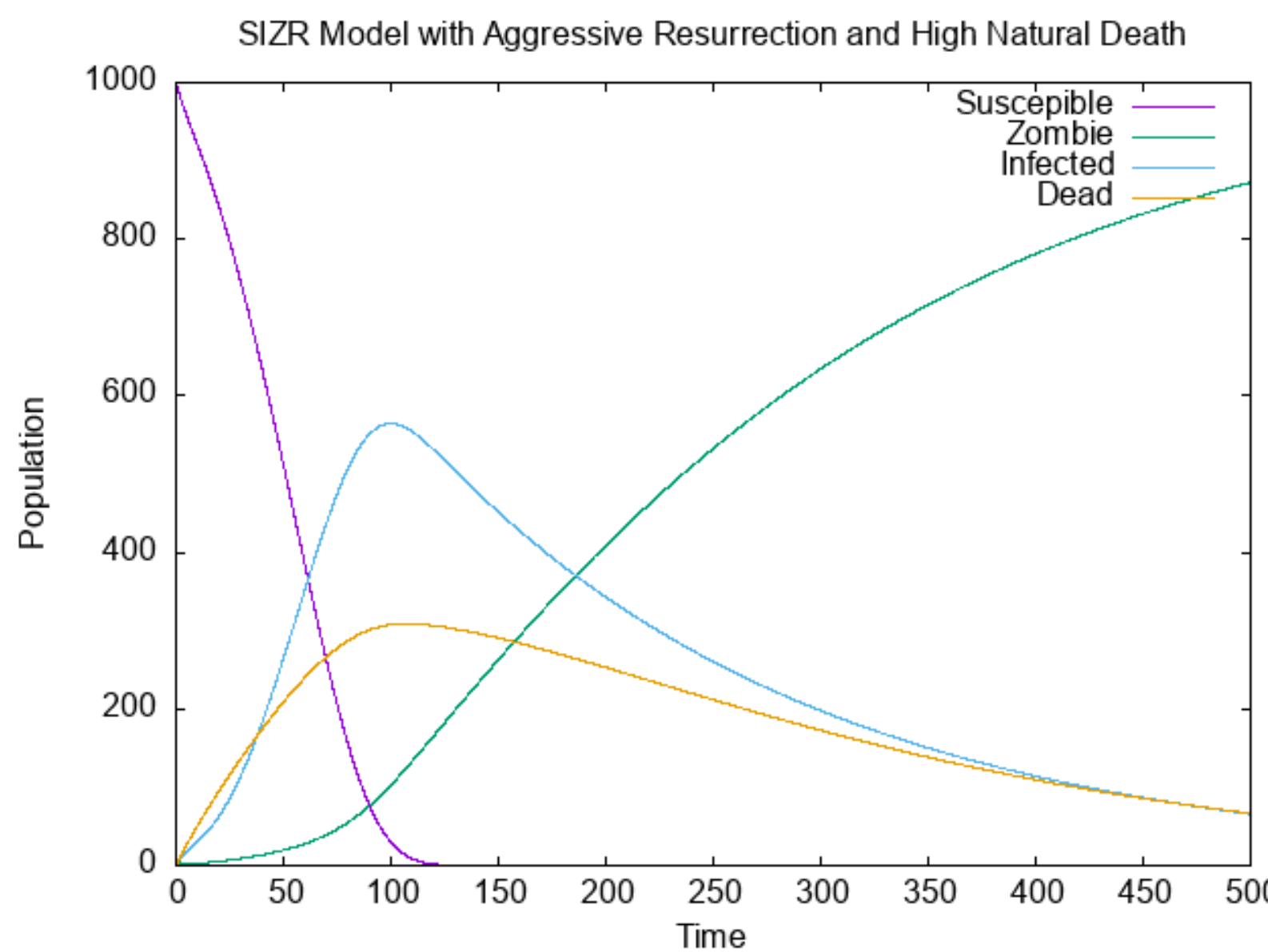


Figure 2:SIZR Model with Aggressive Resurrection and High Natural Death

SIZRQ Model

This model adds a quarantine class. In my model, I used a high value for κ , γ and σ to simulate an aggressive government response to quarantine, and a high death rate for the disease. In this simulation, ζ is 0, so once someone dies from the disease they don't come back as a zombie.

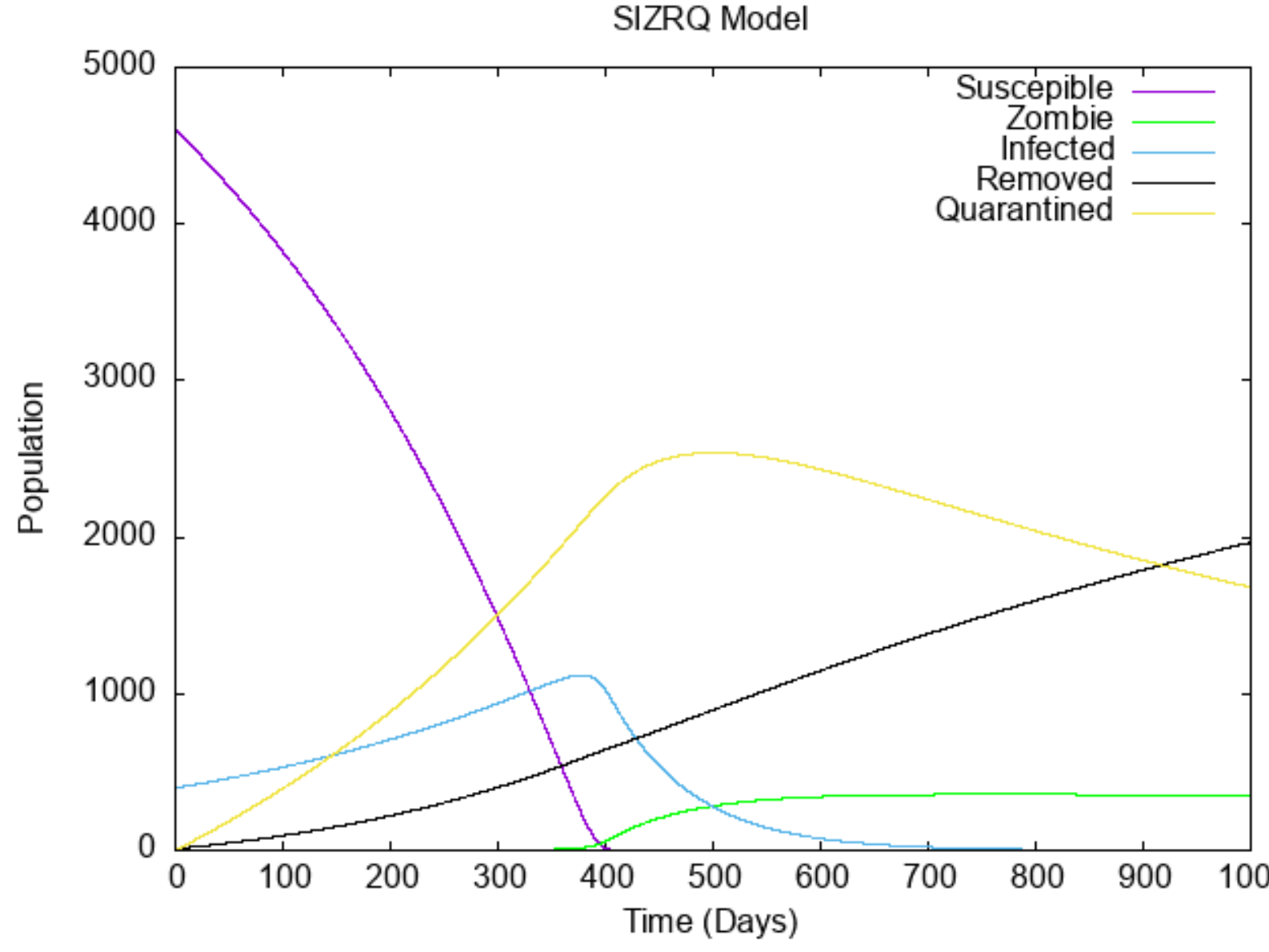


Figure 3:SIZRQ Model with Aggressive Quarantining

Model with Treatment

This is the first simulation where humanity actually survived. In this simulation, the cure is very effective, but chance of exposure to zombies is a lot higher. We see in this model that the human population asymptotes to zero, making a scenario found in most zombie media.

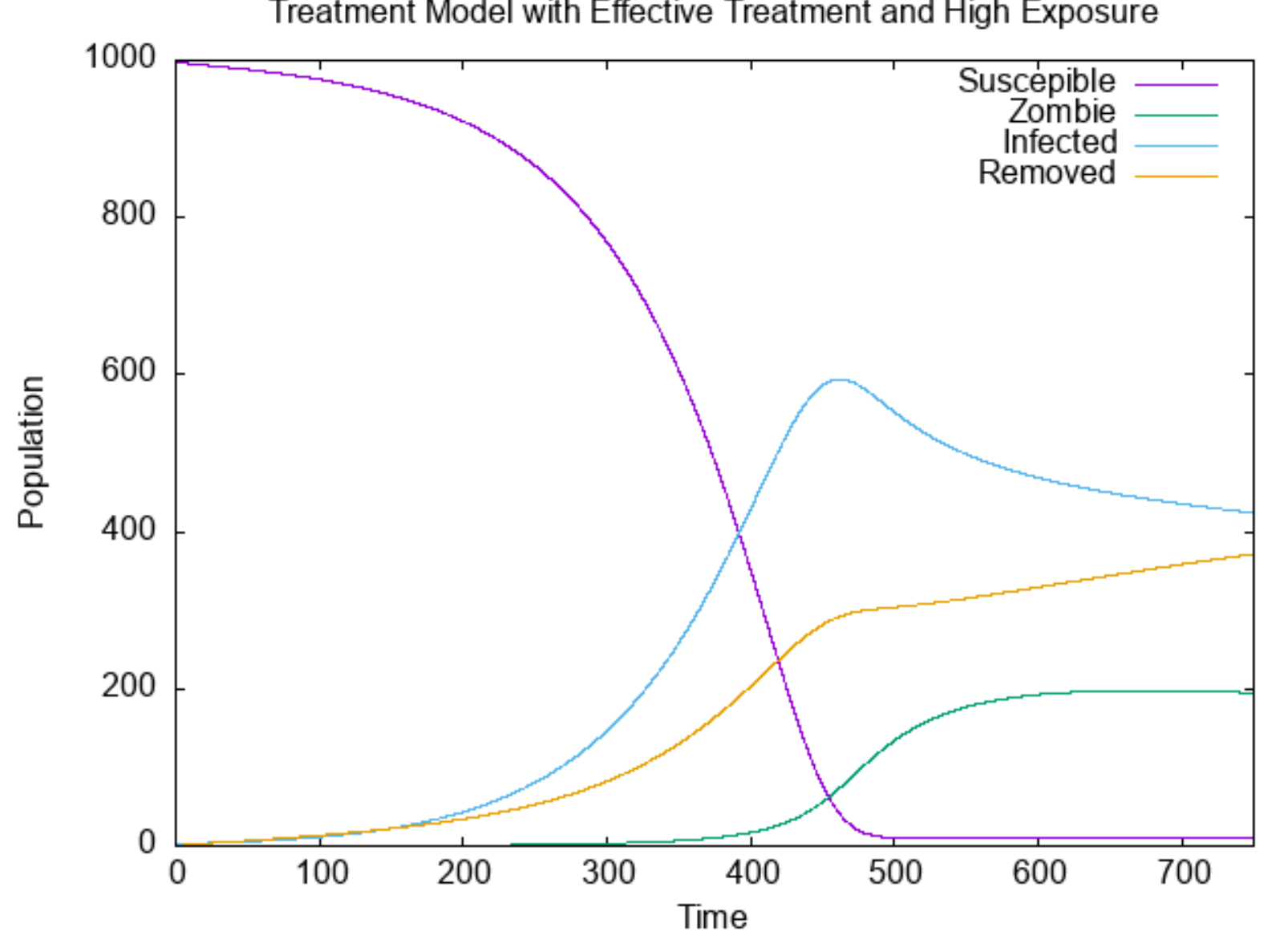


Figure 4:Model with Treatment

Impulse Attacks

An impulse attack is a scenario where humans band together to wipe out a large amount of zombies. An example of this could be a nuclear bomb being detonated on a large group of zombies. In my model, we suppose that humanity has used Google Bard (an AI) to detonate nuclear missles every month in the area with the most zombies. However, humanity has died off long before the zombies, and a faceless war of machine versus former man ensues.

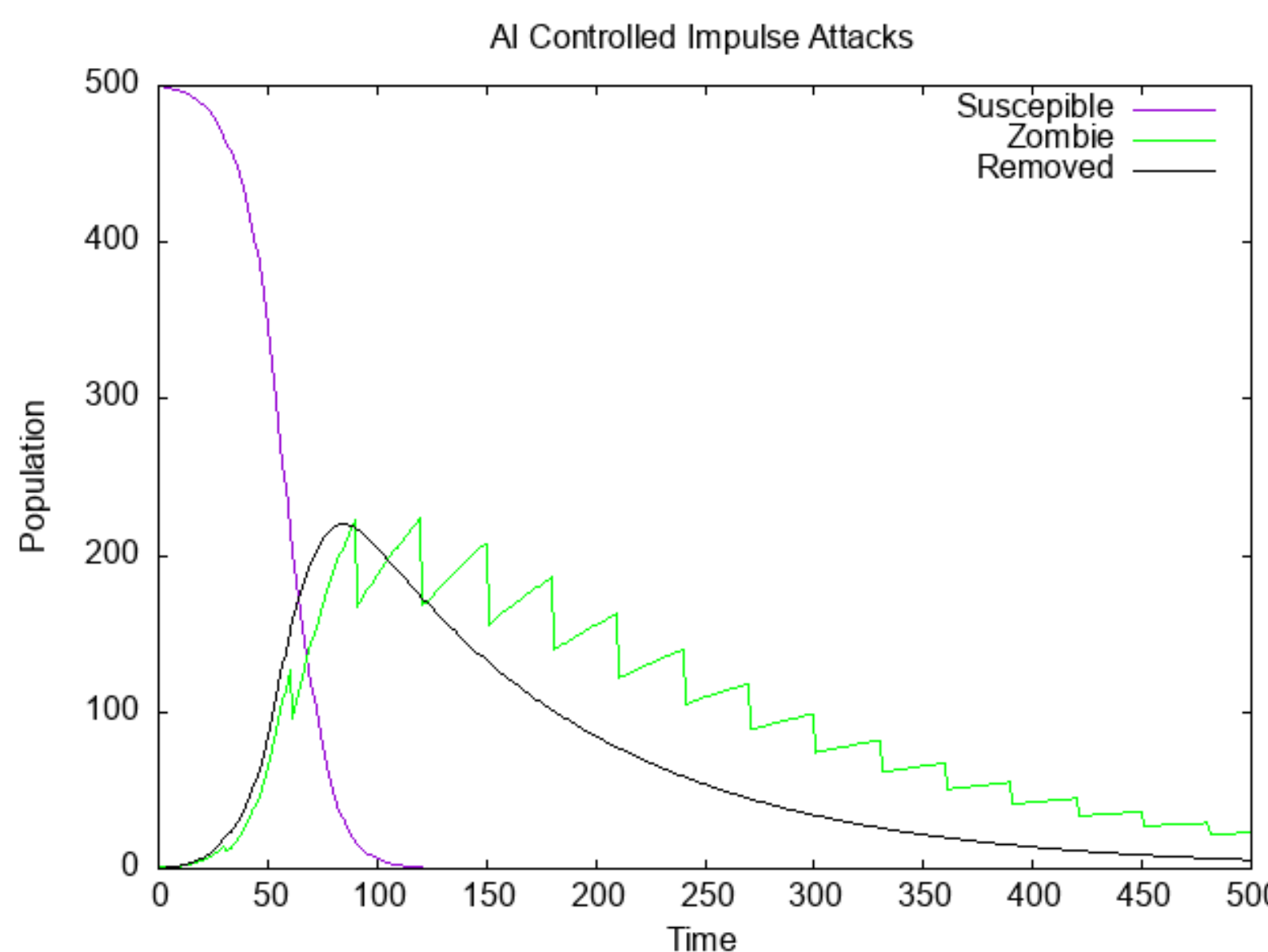


Figure 5:The Faceless War: Automated Impulse attacks against the Zombie Hoard

Escape to the Stars!

My custom scenario was for a team of talented engineers to create starships to evacuate humanity. This model uses the following classes: Suseptible, Zombie, Removed, Engineer, and Martian. Most of the symbols are the same, but Σ is the education rate, ϵ is the Suseptible evacuation rate, γ is the engineer zombification rate, and θ is the engineer evacuation rate. Susepibles can die by zombies, be evacuated to Mars, or get trained to become engineers. The engineers don't start their evacuation until all susepibles have been evacuated.

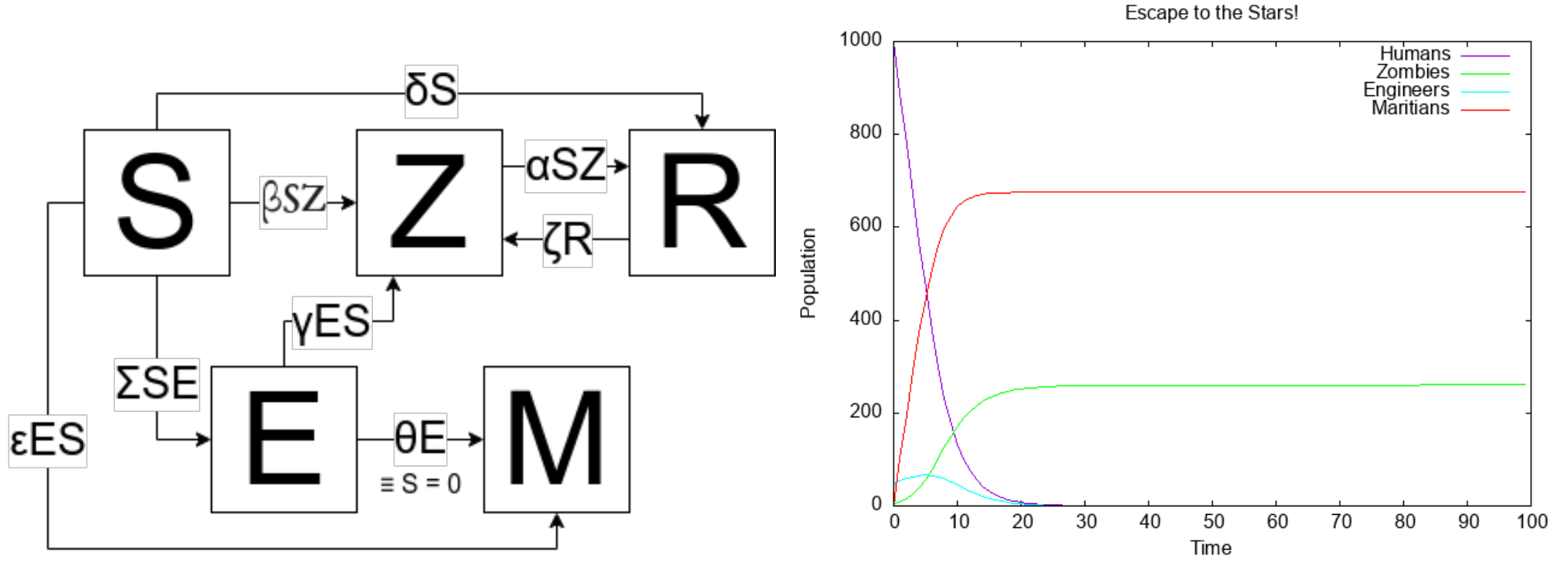


Figure 6:Model and Graph for Escape to the Stars Scenario