Modeling COVID-19 Spread with Monte Carlo Techniques

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1. Introduction

COVID-19 is a disease unprecedented in our time, affecting millions in the last 7 months and millions more each day. Tracking active cases is a priority for many institutions and governments all over the world. Monte Carlo simulations allow us to run a large number of random samples to construct empirical distributions which statistics can be estimated from. From these distributions, we can model the number of daily new COVID-19 cases under different scenarios.

2. Methods

Goal

To model the number of daily new and total COVID-19 cases in Horry County using Monte Carlo techniques.

Parameter	Definition
nd	Simulation period (in days)
Rt	Infection rate (function of time/day)
muT	Expected number of days until infection occurs
p	Proportion of immune people in the population
n_0	Initial number infected people

Figure 1: *Table of important parameter definitions.*

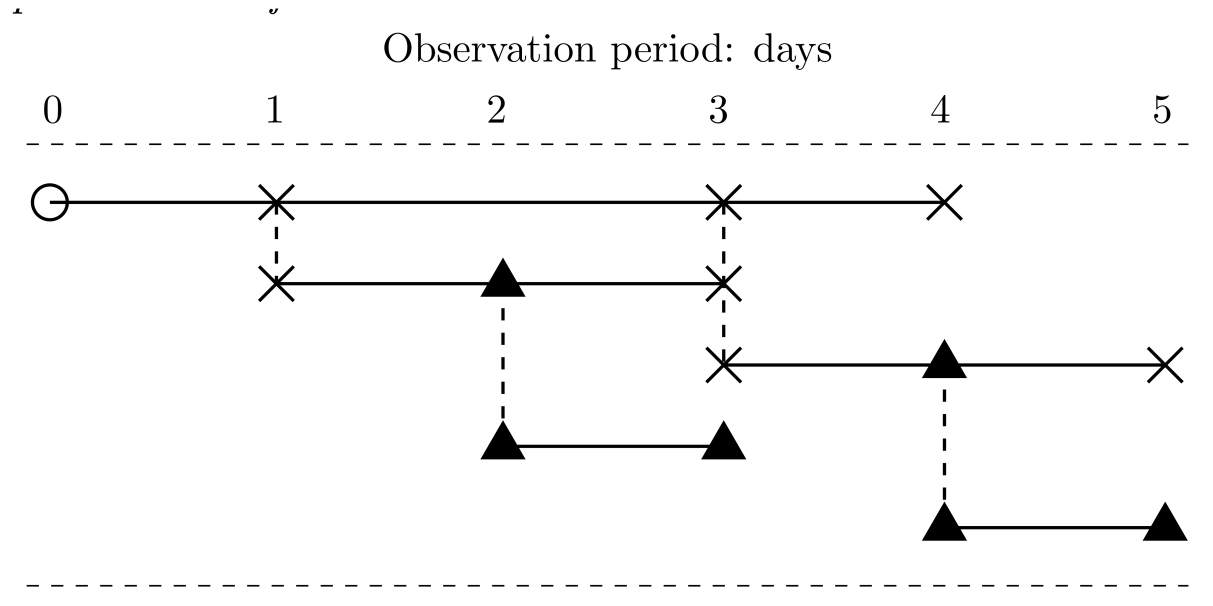


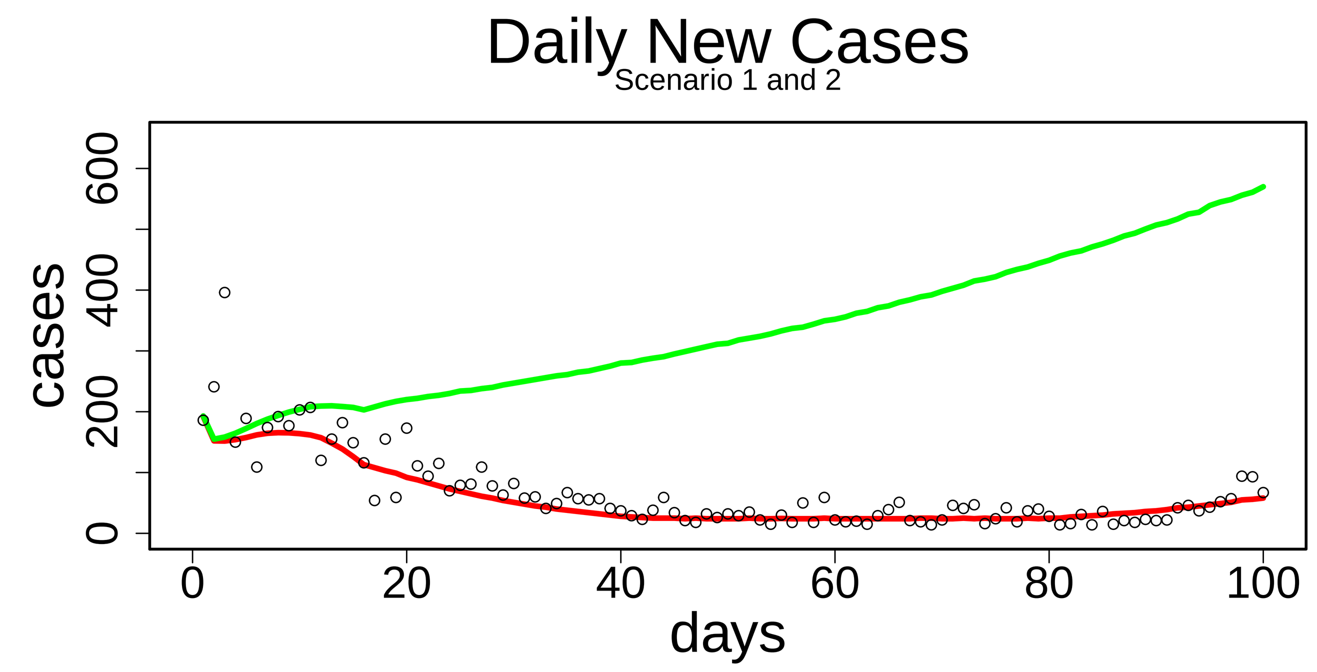
Figure 2: *A schematic of a stochastic point process model with hypothetical population of 5 people.*

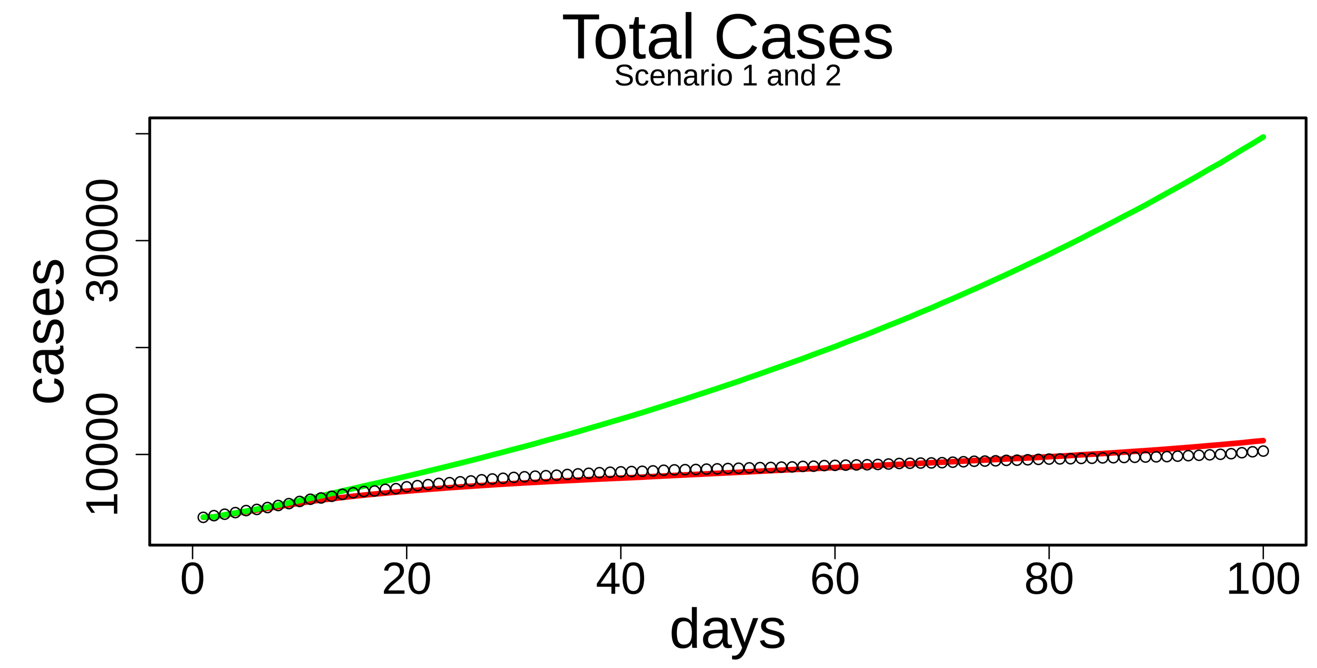
Algorithm

1. Define input parameters $days$, nd, Rt, muT, $sizeV$, $limit$, p, and n_0
2. For each initial infected person in n_0, generate immunity or susceptibility with probability p vs $1-p$
   a. If person is susceptible with probability $1-p$, generate how many people they will infect from Poisson(Rt)
      i. For each person they will infect, generate the number of days until infection occurs from negative binomial (muT)
      ii. Update daily case count and total case count
   b. If person is immune with probability p, no one is infected
3. Repeat step 1 using the newly infected group from each day on days 2 through the end of the simulation period (nd)

Since this is generated by random sampling, it will vary from run to run and we will summarize the results using bootstrapping.

3. Results





Parameter	Scenario 1	Scenario 2
nd	100 day simulation period	100 day simulation period
Rt	Variable infection rates resembling reality: 0.85(10d), 0.65(30d), 1(38d), 1.4(22d)	Constant infection rate: 1.1(100d)
limit	Population size of 434,000	Population size of 434,000
n_0	186 initial infected	186 initial infected

4. Conclusion

The models of COVID-19 spread under different scenarios found using Monte Carlo techniques provides a simpler, but imprecise view of COVID-19 spread dynamics. While it should not be used for predicting exact future cases, it is useful for making decisions under different hypothetical scenarios that could stop the spread of COVID-19 or other infectious diseases.

5. References

1. Xie, G. A novel Monte Carlo simulation procedure for modelling COVID-19 spread over time. Sci Rep 10, 13120 (2020). https://doi.org/10.1038/s41598-020-70091-1
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