Mathematical Modeling and Simulation of a Zombie Epidemic

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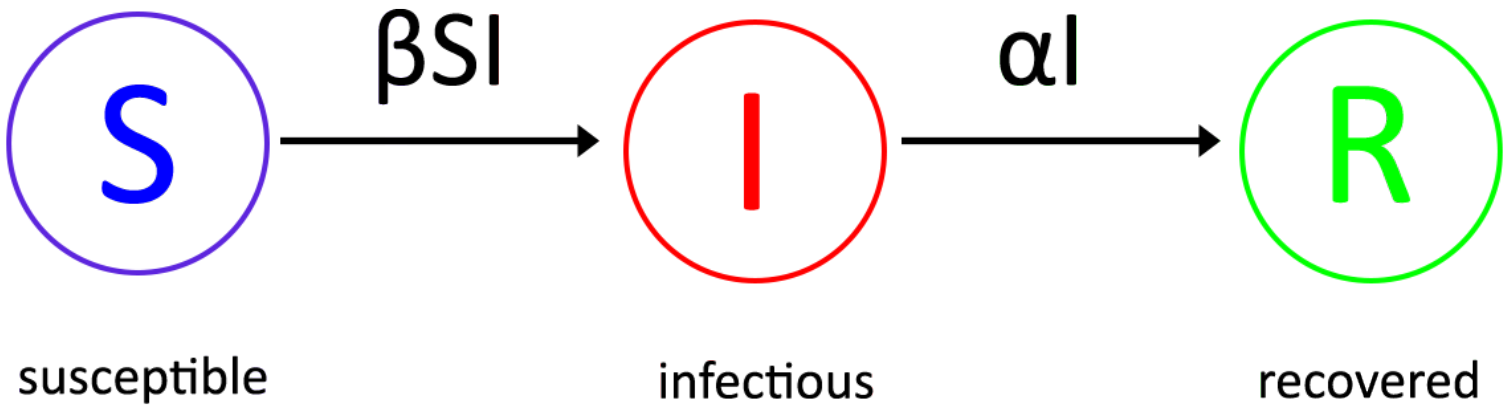
Mathematical Modeling for Infectious Disease

- Describe disease scenario in terms of mathematical language
- Study the outbreak dynamics
- Predict the future flow
- Take informed decisions effectively and efficiently

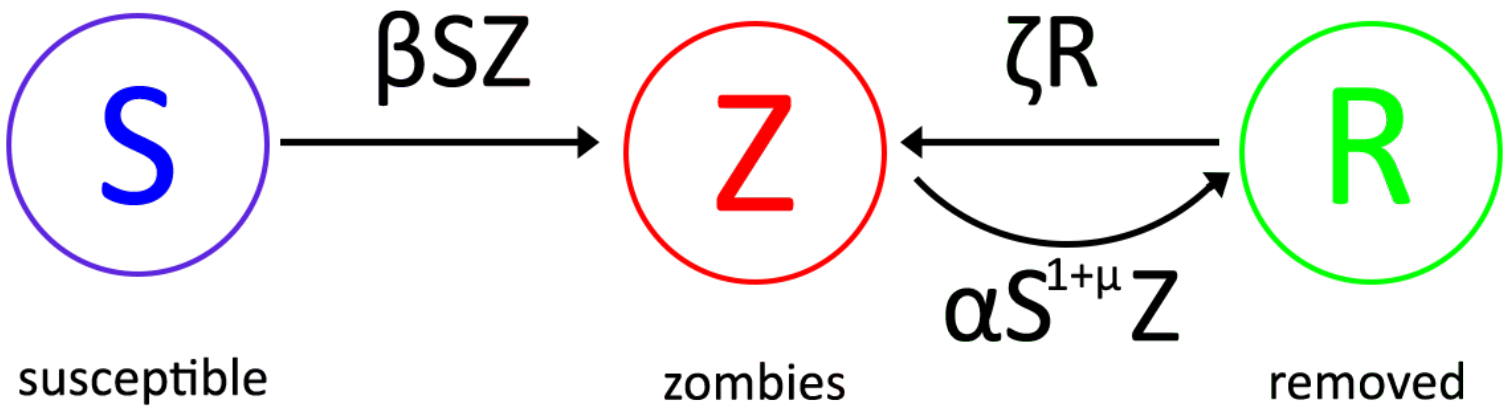
SIR Epidemic Model



$$S'(t) = -\beta SI$$
$$I'(t) = \beta SI - \alpha I$$
$$R'(t) = \alpha I$$

Reference- [1]

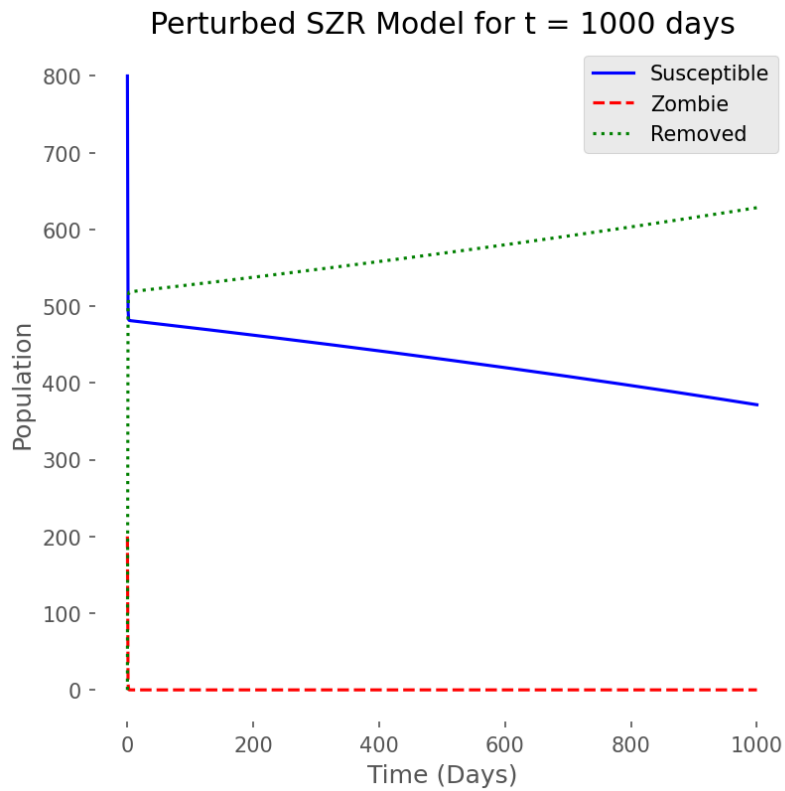
SZR Model with Perturbation



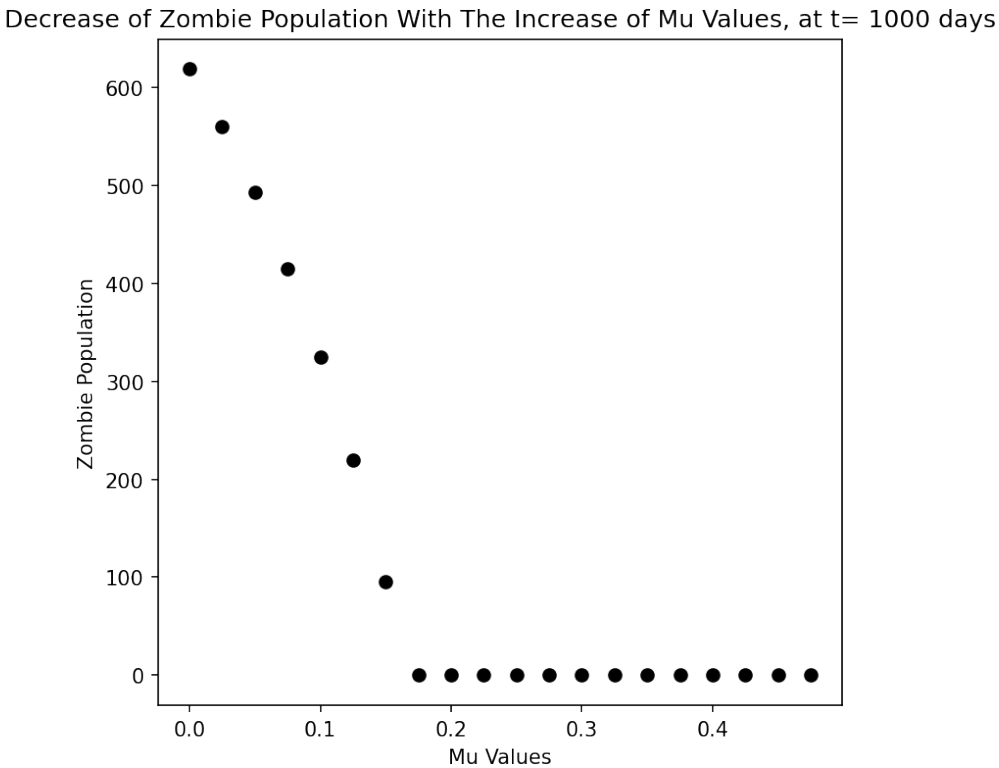
$$S'(t) = -\beta SZ$$
$$Z'(t) = \zeta R + \beta SZ - \alpha S^{1+\mu} Z$$
$$R'(t) = \alpha S^{1+\mu} Z - \zeta R$$

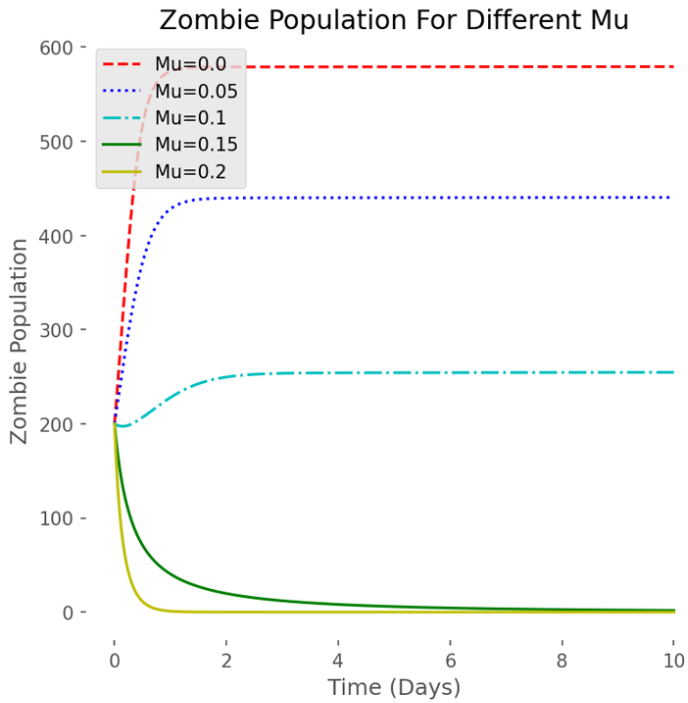
Reference- [2], [3]

SZR Model- Graph Comparison

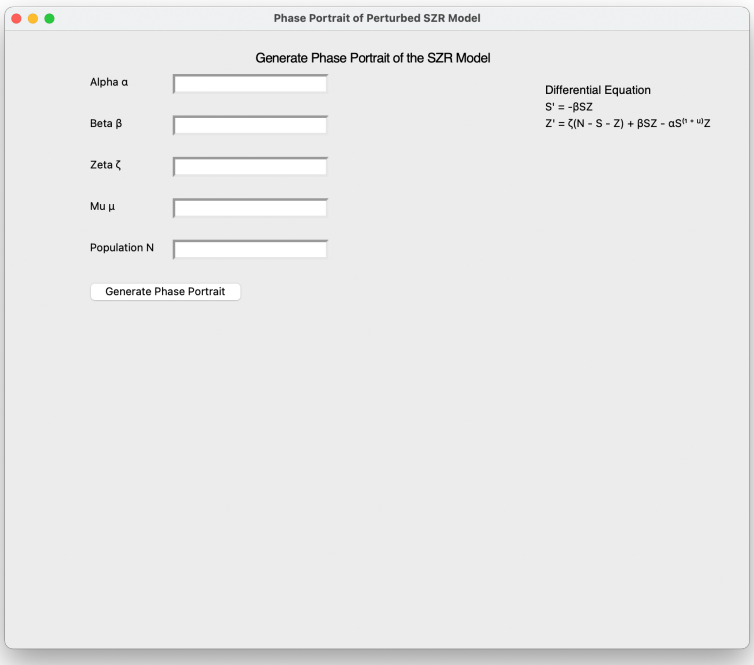


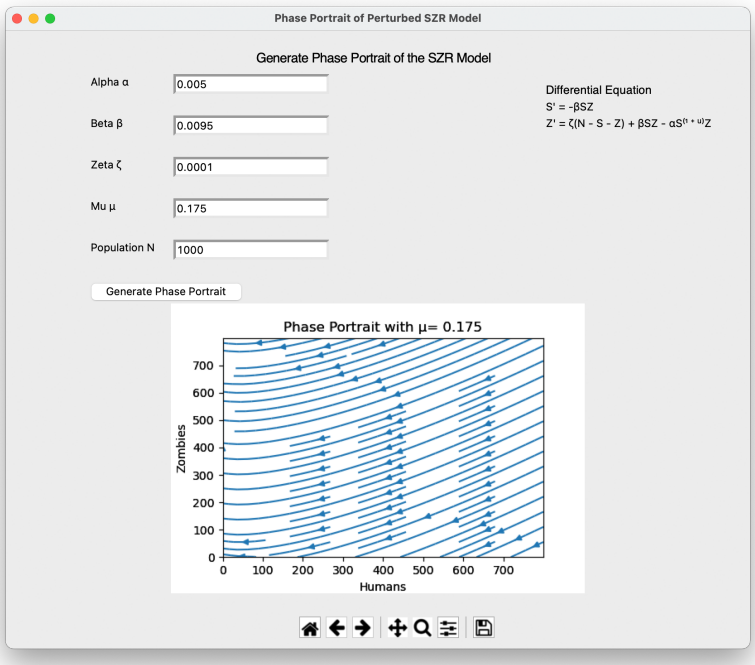
SZR Model with Perturbation- Perturbation Impacts



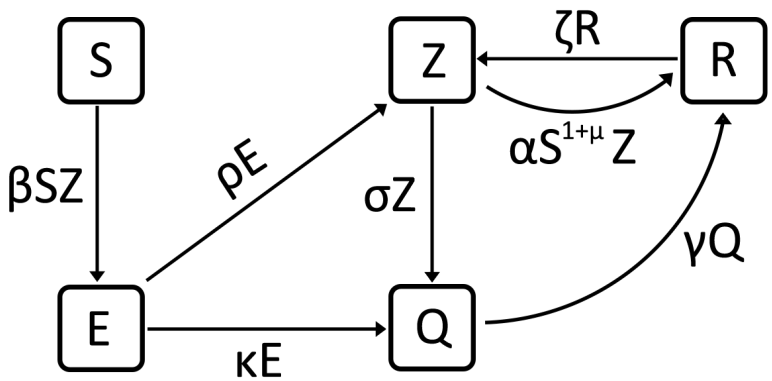


SZR Model with Perturbation- Graphical Interface Program





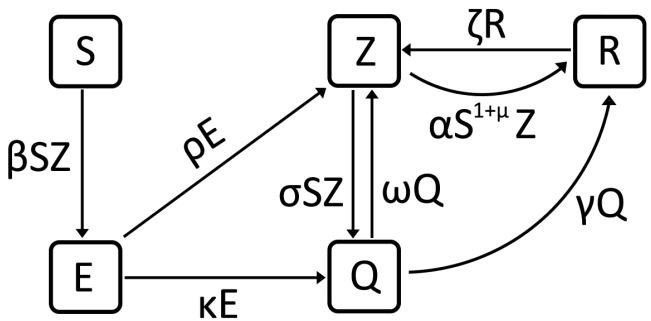
Quarantine Model



$$S' = -\beta SZ$$
$$E' = \beta SZ - (\rho + \kappa)E$$
$$Z' = \rho E + \zeta R - \sigma Z - \alpha S^{1+\mu} Z$$
$$Q' = \kappa E + \sigma Z - \gamma Q$$
$$R' = \alpha S^{1+\mu} Z + \gamma Q - \zeta R$$

Reference- [3]

Modified Quarantine Model



$$S' = -\beta SZ$$
$$E' = \beta SZ - (\rho + \kappa)E$$
$$Z' = \rho E + \zeta R - \sigma SZ - \alpha S^{1+\mu} Z + \omega Q$$
$$Q' = \kappa E + \sigma SZ - \gamma Q - \omega Q$$
$$R' = \alpha S^{1+\mu} Z + \gamma Q - \zeta R$$

Modified Quarantine Model

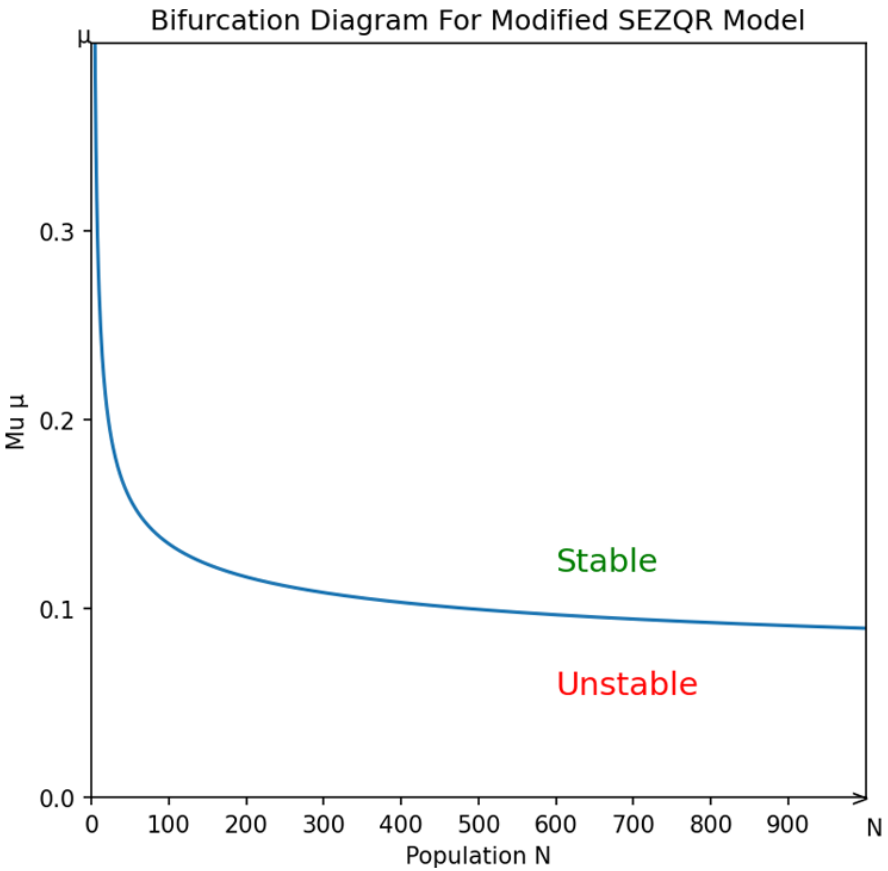
Basic Reproduction Number–

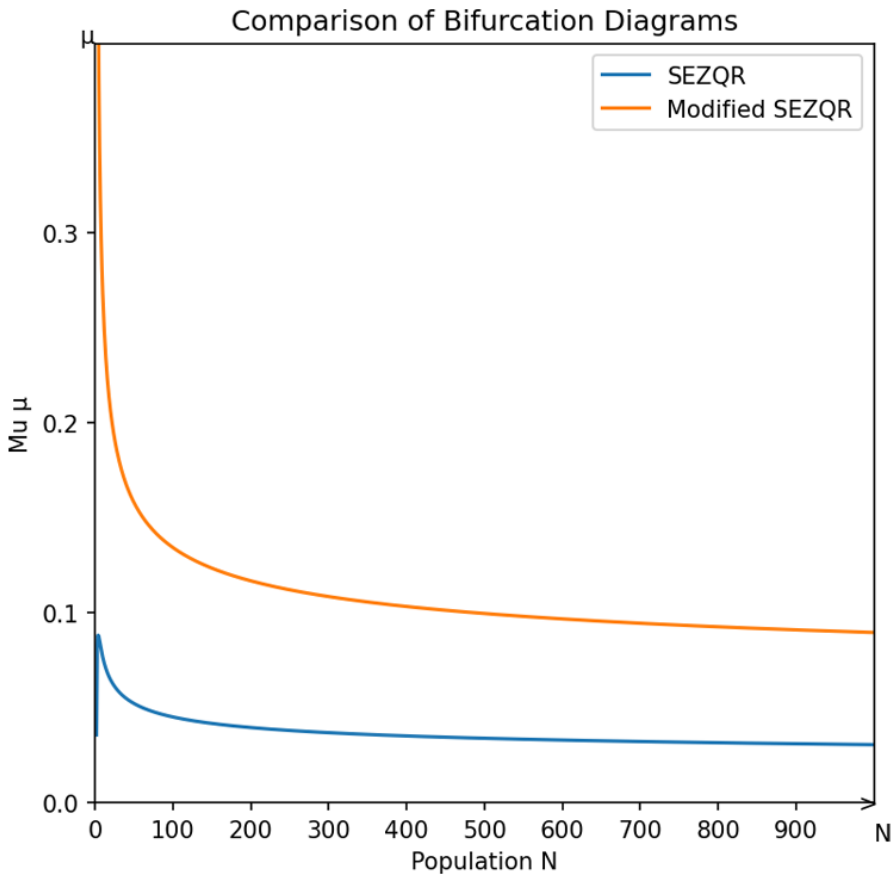
$$R_0(\mu) = \frac{-\beta N[(\zeta-\rho)(\gamma+\omega)+\kappa(\zeta-\omega)]}{(\rho+\kappa)\left[(\gamma+\omega)\left(\alpha N^{1+\mu}+\sigma N+\zeta\right)+\sigma N(\zeta-\omega)\right]}$$

Condition for Disease Free Equilibrium–

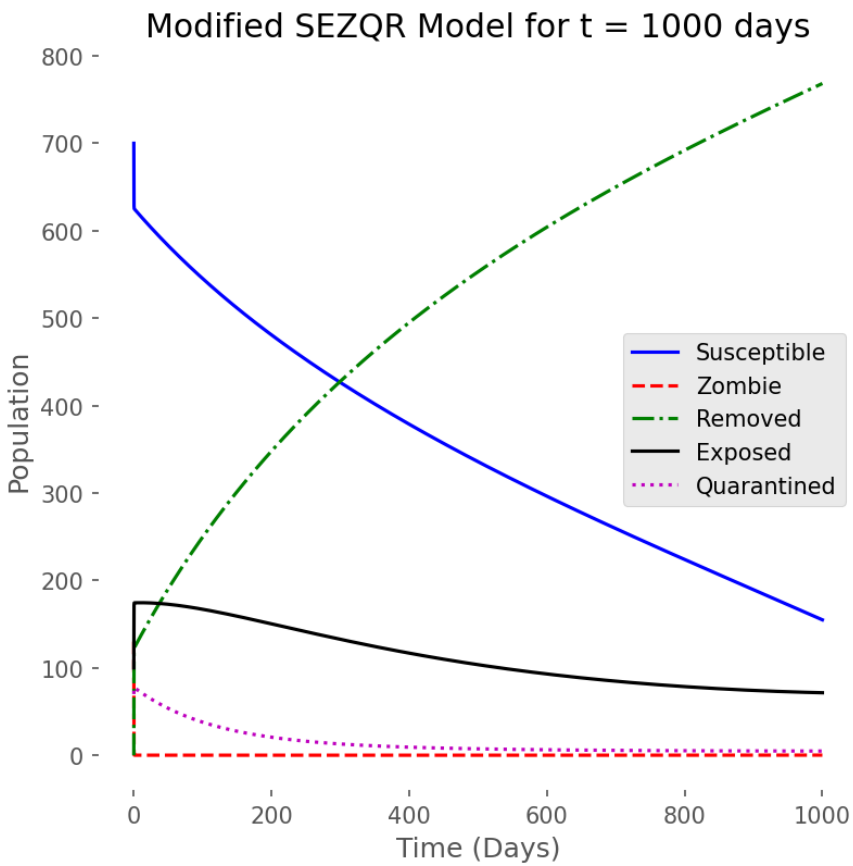
$$\mu > \frac{\ln\left(\frac{\beta N[(\zeta-\rho)(\gamma+\omega)+\kappa(\zeta-\omega)]+(\rho+\kappa)[\sigma N(\zeta-\omega)+(\gamma+\omega)(\zeta+\sigma N)]}{-\alpha(\gamma+\omega)(\rho+\kappa)}\right)}{\ln(N)} - 1$$

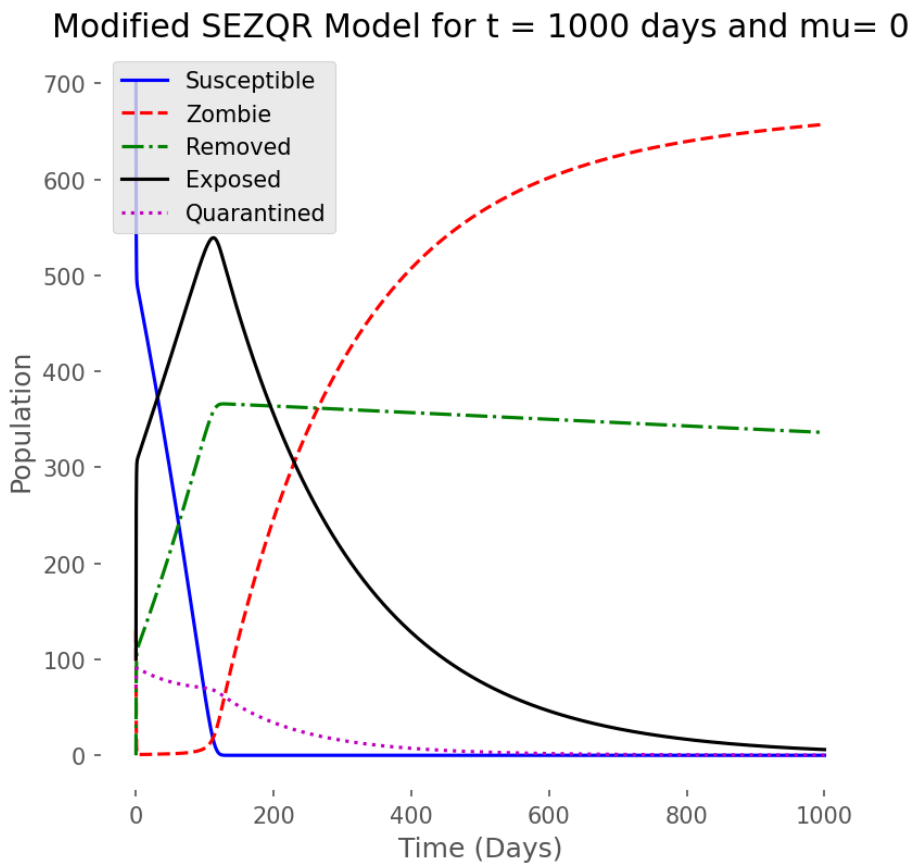
Modified Quarantine Model- Bifurcation Diagrams



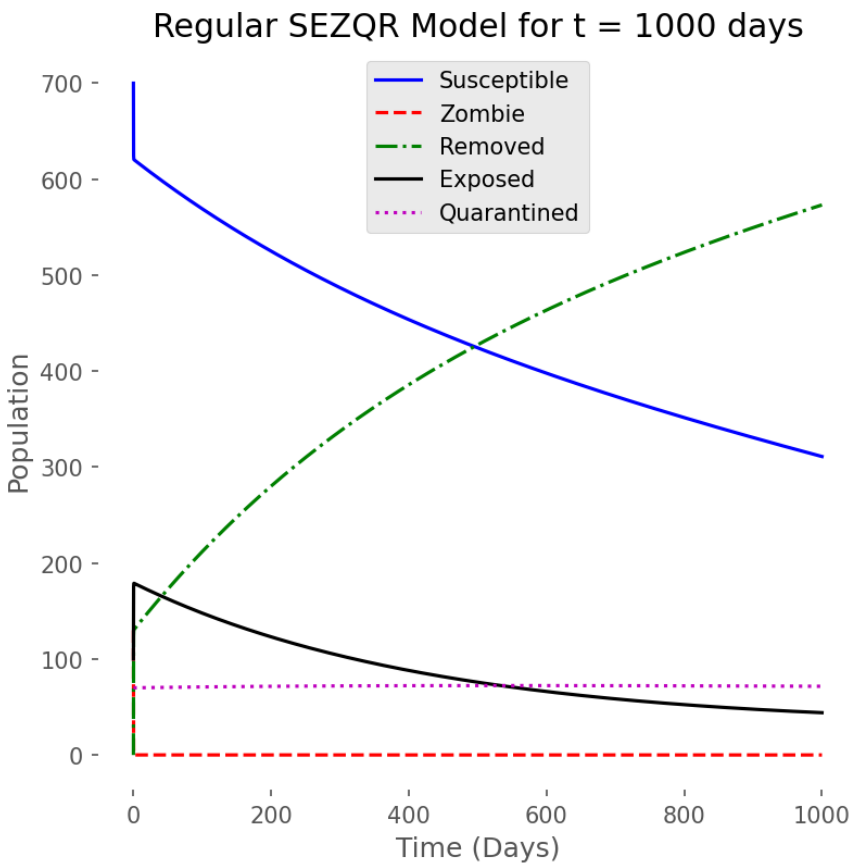


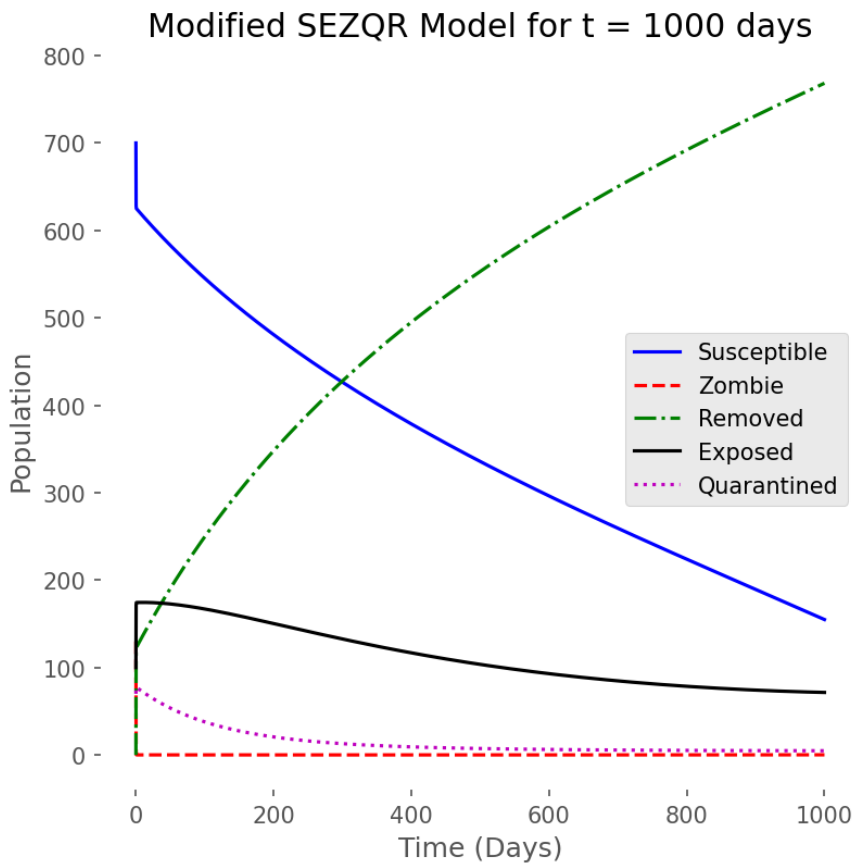
Modified Quarantine Model- Graph Comparison 01



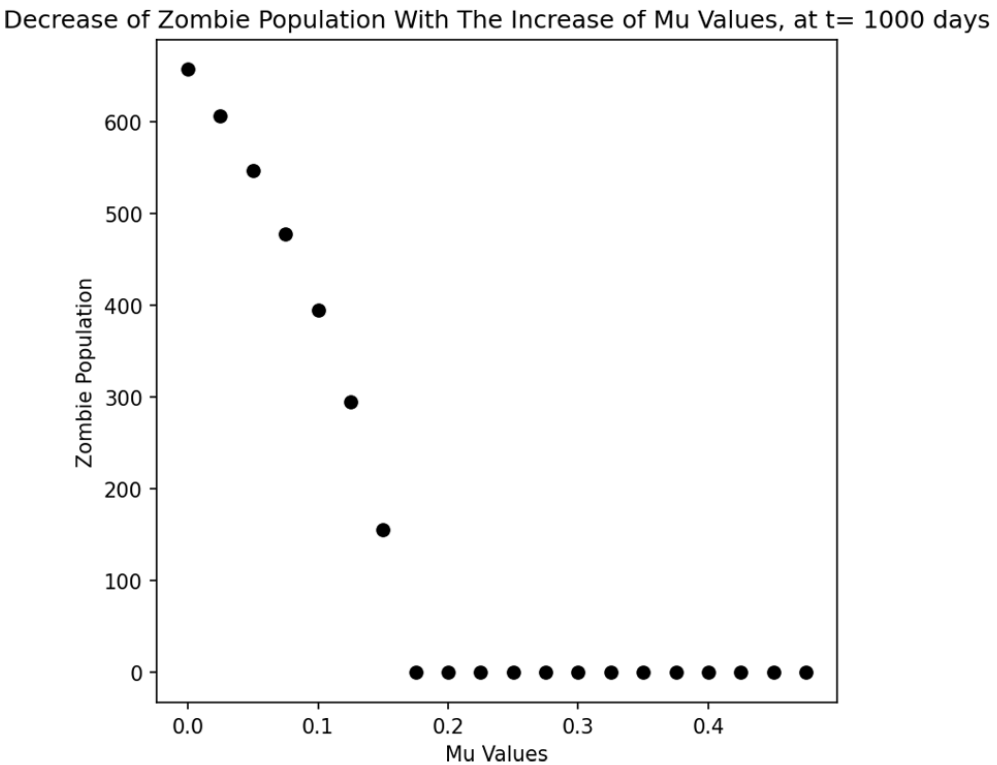


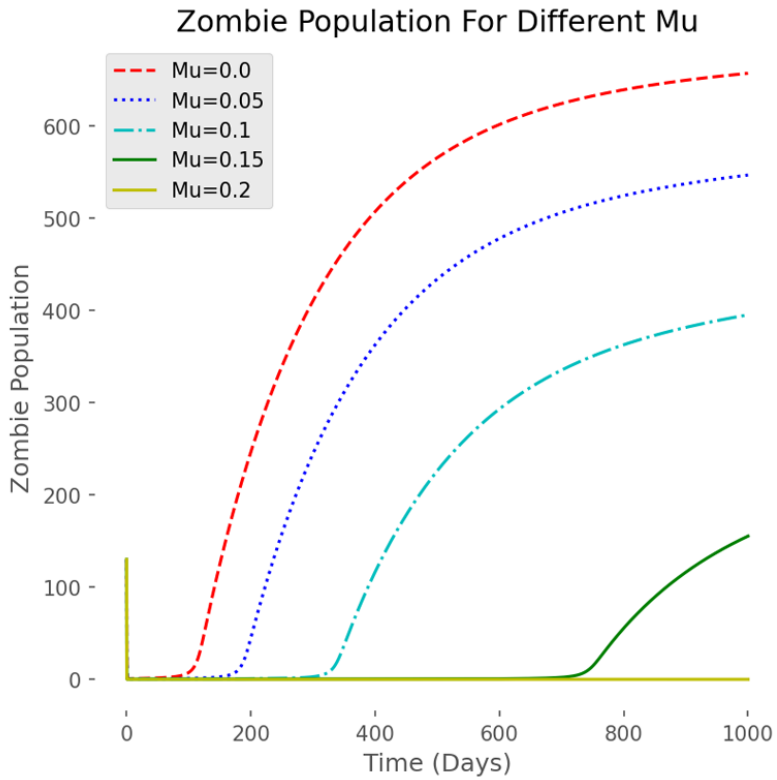
Modified Quarantine Model- Graph Comparison 02





Modified Quarantine Model- Perturbation Impacts





Conclusion

- Zombie epidemic can be a good approach to simulate real-world infectious disease outbreaks.
- Parameter estimates depend on real-world data.
- More variables and complications are needed to be considered to make the model more practical as well as pragmatic.

References

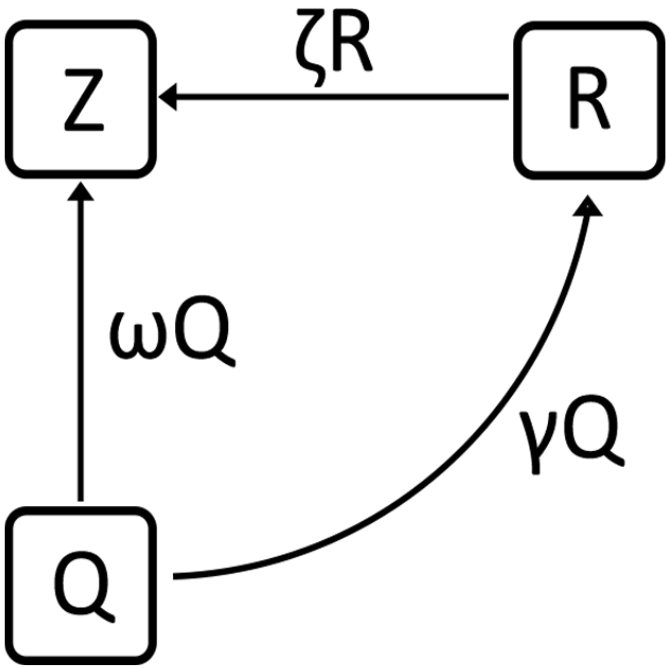
[1] Kermack, W. O., & McKendrick, A. G. (1927). A contribution to the mathematical theory of epidemics. Proceedings of the royal society of london. Series A, Containing papers of a mathematical and physical character, 115(772), 700-721.
URL- https://doi.org/10.1098/rspa.1927.0118

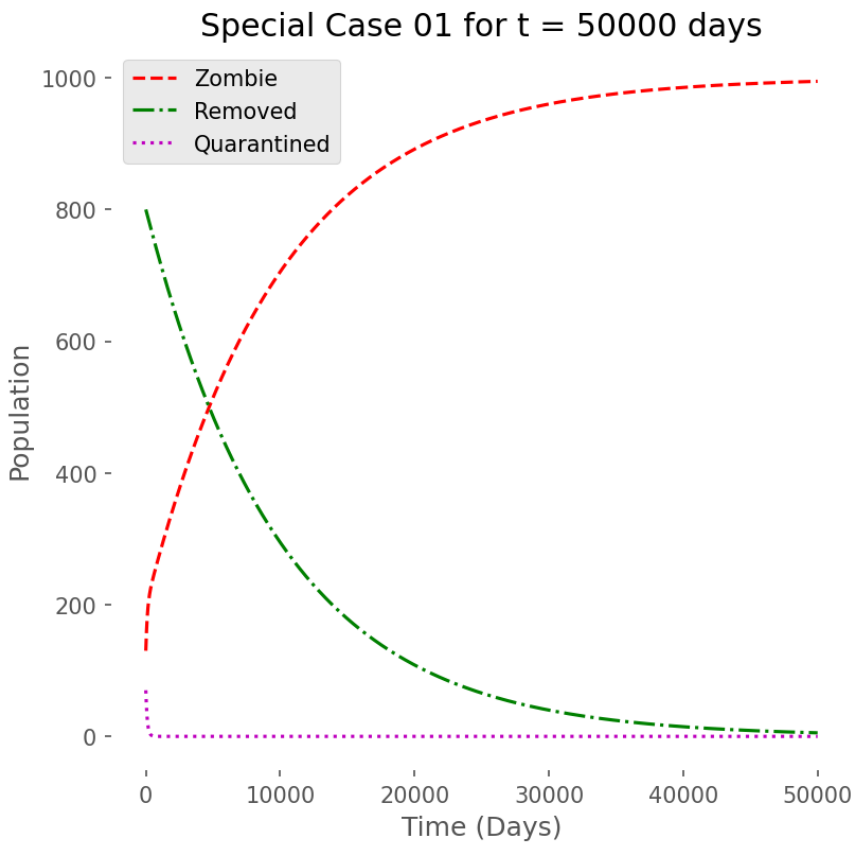
[2] Munz, P., Hudea, I., Imad, J., & Smith, R. J. (2009). When zombies attack!: mathematical modelling of an outbreak of zombie infection. Infectious disease modelling research progress, 4, 133-150.
URL- https://webspace.science.uu.nl/~frank011/Classes/modsim/Handouts/Zombies.pdf

[3] Allen, R. F., Jens, C., & Wendt, T. J. (2014). Perturbations in Epidemiological Models. Letters in Biomathematics, 1(2), 173-180.
URL- https://doi.org/10.1080/23737867.2014.11414478

Thank You

Backup Slide 01





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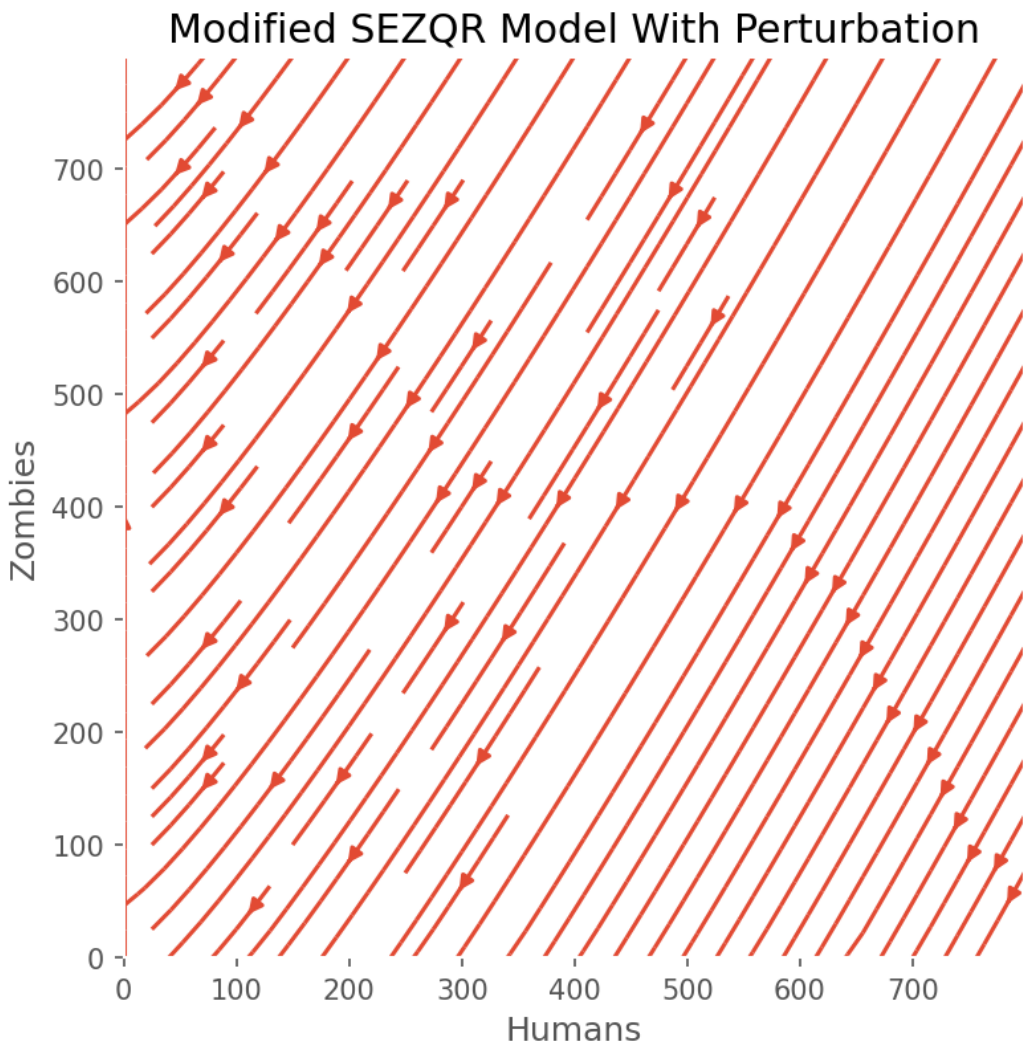

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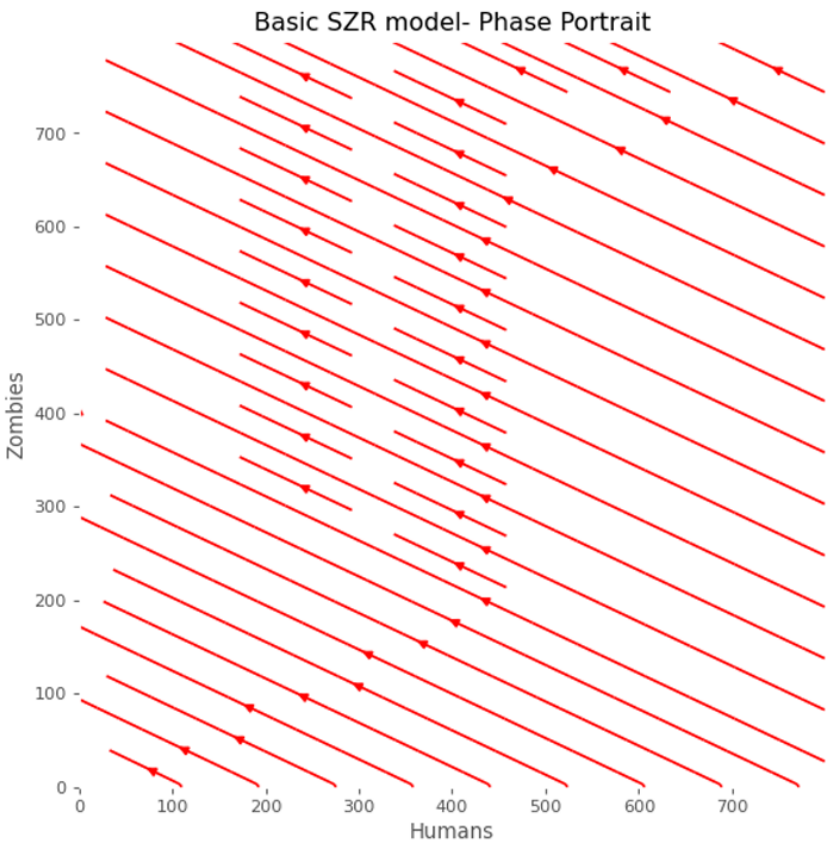

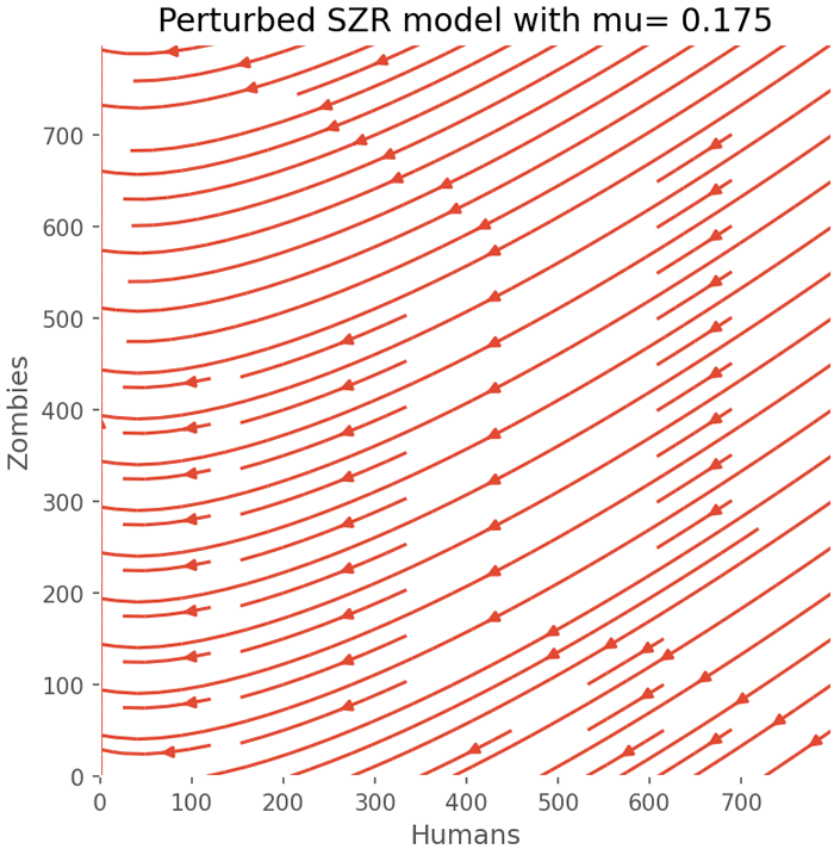

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