DISCRETE POPULATION MODELS

Due date: 2/16/2016

In our previous exercise we used differential equations to predict the evolution of an epidemic. In this exercise we will do the same, only this time we will use a stochastic approach to modeling.

1. Build a city with population density $\sigma = N/A$ and uniform areal distribution. By using Monte Carlo analysis, determine the time it takes for an epidemic to spread throughout the population. Determine the speed of disease propagation in terms of stochastic steps. First evaluate limiting cases ($\sigma \to 0$, $\sigma \to 1$), then do a general case ($N_{\text{steps}}(\sigma)$). Compare that to the results from the previous example.

2. You can do a similar exercise for the kangaroos and dingos. This time around there is no such thing as 10^{-5} kangaroos where the population can still recover. Compare the "orbital" time, and show that population death is an inevitable consequence predicted by discrete population models.

3. For more realistic examples the continuous, ODE-based model becomes overly complicated, but the stochastic approach remains straight-forward. Test it on different population distributions, include recovery, immunization, recurring diseases, diseases in dingos/kangaroos, meteorite impacts, etc.

4. *Extra credit:* the transition between states $S_n \to S_{n+1}$ can be described by the Markov matrix (a.k.a. the *transition* or *stochastic* matrix) $\mathcal{M}$. Learn about Markov matrices and use them to describe the epidemic model.