1. Static Graph Aproach

* 1. Set up “arena”
     1. *N* Individuals are placed randomly on a uniform square, with positions drawn from a random uniform distribution between 0 and 1.
     2. Each individual is given a shell size drawn from a random normal distribution (absolute value).
  2. How to define connections
     1. An edge is defined when one individual wants the shell of another individual.
     2. Here we assume that hermit crabs, as they grow, need to trade up and require shells larger than their current one.
  3. Conditions for an edge
     1. Each individual can only “see” a defined proportion of the area around them, in the default case here we use a circle centered on the individual with a radius of 0.2.
     2. Edges are drawn only when the individual can see the shell they want.
     3. Individuals want a new shell that is larger than their current one, to accommodate growth, but not too much larger, such that they would be vulnerable, or be unable to defeat the crab currently in the shell if it is not empty.
     4. Edges are drawn only when the shell is greater than the focal individual’s but less than 1.5 times its shell size.
  4. Analyze resulting graph
     1. The graph resulting from following these simple rules leads to the network of potential shell swaps at a given point in time for these hermit crabs.
     2. One plus the average path length between any two given nodes in the network (hermit crabs in this case) tells us the expected length of a vacancy chain in this group of individuals.

1. Monte Carlo Simulation
   1. Set up “arena”
      1. The arena for the Monte Carlo simulations are set up in the same way as the static network approach. A number of individuals are randomly placed on a uniform square and assigned shell sizes drawn from the absolute values of a normal distribution.
   2. Introduce new player
      1. A new, empty, shell is introduced in a location with coordinates drawn from a random uniform distribution.
      2. The size of the empty shell is defined.
   3. Make connections
      1. Connections are made based on the same rules as the static network, with a slight modification.
      2. In this case we are not interested in the entire network, but only on the chain centered on this newly introduced shell.
      3. A single connection is made to an individual fulfilling the conditions described above
         1. Chosen either at random from the pool of all individuals fulfilling the condition or as the closest (Euclidean distance) individual.
      4. The process for making a connection is repeated until no more connections can be made
   4. Get chain length
      1. The final length of the chain is recorded and the process is repeated, with a new location for the shell (of the same size).
      2. A distribution of chain lengths can then be analyzed.
   5. Sensitivity
      1. What parameters are most important to chain length
         1. Distance threshold
            1. Distance threshold was set to a default of a circle with radius 0.2 arbitrarily.
            2. How does chain length change when the threshold is altered
            3. Test distance thresholds of circles of radii 0.1 to 1
         2. Upper and lower limit to shell swap size
         3. Shell size distribution
         4. Location distribution

**Results**

1. Average path length in static and Monte Carlo approaches
2. Sensitivity of the different parameters