**Worksheet 4 Report Analysis**  
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**Task: Dynamic Clustering in a Sugarscape Model**

**Code Explanation**

* Create Grid w/ Hotspots:
  + This will generate a grid of random sugar values lying between 1 to 3.
  + Generate 10 random 3x3 patches as hotspots with a sugar level of 10 to attract the agents there.
* Random Agent Initialisation:
  + Places agents randomlly across grid in order to prevent forced initial clustering.
  + None of the agents is aware of the sugar distribution beforehand, but rather moves according to motion rules.
* Agent Motion
  + It can go up, down, left, right, or stay in one turn.
  + Their movements are based on the sugar level of the surrounding cells with a random factor to break up any rigid clumping.
  + The agents prefer high-sugar cells but also would diverge to cells of moderately low sugar.
* Sugar Degradation on the grid:
  + Sugar values on the grid slightly decrease each turn, so agents are motivated to keep going and will not stay in the same position forever.
  + This ensures that hotspots will regenerate overtime as agents locally deplete the sugar level.
* Density-Based Clustering Calculation:
  + Defines clustering through a check on local density within a 3x3 neighborhood of the current agent.
  + If there are more than 4 neighbours in that region for an agent, then it belongs to a cluster.
* Density index: It reaches up to the ratio between the value of the clustered agents with respect to all agents.
* Running the Simulation:
  + The model runs 1000 iterations of moving agents and updating the sugar values of the grid, each time calculating the cluster index.
  + It keeps track of the index of clustering overtime.
* Plot of Clustering Index:
  + A line plot indicates the clustering index against time, which gives an indication of how agents dynamically form and dissolve clusters around sugar hotspots.
  + The breakdown below gives all the details in code and discusses how this model has represented the process through its activities of dynamic clustering among agents.

**1. What does happen with your new rule changes?**

Once hotspots are added, in concert with stochastic preference for movement in the direction of high-sugar cells, the agents begin crowding around high-sugar locales, but the stochasticity allows some of them to wander off into other areas of the grid; results are fluctuating rather than rigid, immediate clustering. These dynamics in the clustering index over time show that on average, agents make and break clusters dynamically in response to local sugar availability.

**2. Does this pan out as you thought, or differently? Why?**

These results are not surprising. By giving the agents a preference for the high sugar cells in a noisy way we had avoided rigid clustering like the previous runs. The density based cluster index nicely captured this change in dynamics; agents moved to the high sugar areas, but didn't rigidly lock into clusters. The desired balance between attraction and exploration had occurred and we had succeeded in making the clustering dynamics more life-like.

**3. What does it say about the world?**

These results are in agreement with the explanation that accessibility of resources could determine whether or not one would choose to settle down or cluster in one area, but the introduction of variability in the individual level and exploratory behavior would introduce dynamical social organization and not strict segregation. Therefore, in real situations, resource availability molds population clumping, while diversity in the locomotion of individuals could give rise to flexible, not-so-segregated communities. That insight may help frame urban planning policy: Resource hotspots, in conjunction with free movement options, can result in less rigid neighborhood segregation.

**4. Include a plot or figure**

The following plot of the clustering index as a function of time shows the fluctuating level of clustering. This reflects that agents are dynamically forming and dissolving clusters about sugar hotspots. In contrast to the previous models discussed, the clustering index was fixed; this plot reflects the influence of our new rules with a meaningful and time-dependent pattern of clustering.

A graph of blue lines

Description automatically generated