BCS - Neuroeconomics

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Introduction

The world defined in the problem is a grid consisting creatures named as Macpan. They are allowed four types of movements i.e up, down, right, left. Canteens exists at random places in the world to give out food necessary for Macpen to reproduce(1 Macpan $\rightarrow$ 2 Macpen) with food equally distributed among them.

There exists a *ghost gang* which appear once a day and takes a certain amount of food from everyone and if the food level of Macpan falls below 0 they die.

There exists 3 types of Macpen:

1. Helpful - Which gives some amount of food to other if present in excess.
2. Ungrateful - Doesn't share food at all.
3. Tit-for-tat - Will share food with the others based on their history with the grid community.

In this problem, we are required to analyze the type-wise population development of the grid world by simulating a virtual environment in python.

Environment

The environment follows all of the regulations set by the problem statement however there were many parameters and open-ends that were up to us that could lead to a variety of simulations. We have used PyGame to run our simulations and derive analyses.

General

Below mentioned are some major parameters that we have varied to get our overall analysis:

- Height & Width of the grid.
- Number of canteens in the world.
- Starting number of Macpen.
- Initial number of helpful, ungrateful & tit-for-tat Macpen.
- Number of days of simulation and hours per day.
- Reproduction threshold.
- Food given by canteen to a Macpan in a day.
- Food taken by the ghost gang each time they visit.

- Hunger- food lost after each step.
  (Other parameters are explained in the Readme in more detail.)

Macpen

- Each Macpan is given an ID.
- Initially, all Macpen spawn randomly all over the world. Just after spawning, each Macpan has some initial food and they scourge over the world in search of canteens while maintaining a history and thus developing an understanding about the world.
- All Macpen continuously move by 1 step in every iteration (every 1 hour) and never rest. When they die, they are despawned off the world.
- Each Macpan has a list named history_list which stores the grids coordinate visited and food acquired at that particular grid.
- Every Macpan is given a donate attribute which which classifies them into helpful if positive and ungrateful if negative.
- After reproducing each Macpan is divided into 2 Macpen with equal amount of food distributed from the amount that parent had at the time of reproduction. Each child Macpan is spawned into the same cell where the parent reproduced.
- Each child Macpen retains no history of their parent and their behavior (helpful, unhelpful or tit-for-tat) is the same as that of their parent.

Canteen

- Initially, canteens spawn randomly across the entire game board and their position is then constant wrt time.
- Canteen provides a certain amount of food to a Macpan at most once a day when a Macpan visits the canteen. Each canteen thus maintains a list of people it has fed in that day as well as the available food. At the end of each day, its records are reset.
- Canteen operates all day.
- Canteens have a limit to the total food they can provide to all the Macpen combined per day.

Donation Rate

- The donation rate for helpful and ungrateful is fixed at 1 & -1 respectively.
- Tit-for-tat case:

- For tit-for-tat case initial value is set at 0 and they act as helpful at the very first case.
- After first case, their interactions with others defines their history.
- Donation rate changes dynamically i.e either positive or negative depending upon their previous interactions with the grid community and thus they can donate or request accordingly.

Interactions

We have implemented an interaction policy using which the Macpen interact which each other and depending upon their nature and current state choose whether to share their food with a given Macpan.

Excess food: For a Macpan, excess food is defined as the difference between its current food possession and the amount of food taken away by the ghost gang. Thus, when a Macpan decides to share their food with another, it ensures its survival.

As defined in the problem statement, the helpful will always share its excess food. The decision for tit-for-tat Macpen will depend on the donate parameter. Also, the amount of food donated by a Macpan is the minimum amongst:

- The requirement of the other Macpan to survive, should the Ghost Gang visit.
- The excess currently possessed by the donating Macpan.

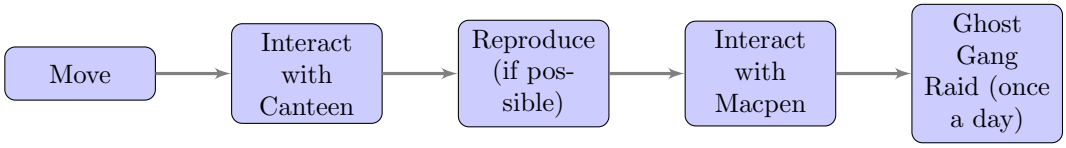
When more than 2 Macpen arrive at a cell, all possible combination of interactions are dealt with sequentially in a random order.

Movement

Our movement strategy is based on a completely random approach, which has led to quite interesting simulations. Whenever a player has to make a choice to move, he is equally likely to move in any direction irrespective of the reward he receives in a square/could receive if he moved into another square (based upon their history). Inspite of this, in every simulation, we could see a cluster forming around the canteen (more on this in the analysis section).

Simulation Process

The operations in each iteration are performed in the following order:



In every iteration, the Macpen will move into a new position. If there is a canteen in that cell, it will first take food from the canteen. After this, it will interact with other Macpen present in the same cell. Now, if a Macpan has sufficient food to reproduce, it will split into 2. Next, if the ghost gang is to arrive at the end of iteration, it will do so and sweep off food from every player currently in the grid world. Talk about movement (list, probabilities, movement is random with heuristic)

Other environments- different definition of excess food (helpful are more likely to prosper), Canteen have unlimited food Canteen can share food with a Macpan multiple times in a day. When each Macpan reproduces, its children are of different types.

Analysis

We ran various simulations in PyGame to visually understand our world and Macpen. Inspite of having no bias toward any direction, after a few days we could spot clusters around canteens.
This was a result of dying due to hunger. Population that moved away from the canteens couldn't survive since the Macpen were moving randomly and couldn't effectively locate another canteen (lack of vision). And since each step cost them (as well as the Kala Daku's tax took a toll upon them), they'd end up dying before being able to find a new canteen.
It was fun to see that tittat could co-exist inside colonies of helpful as well as colonies of unhelpful people. In a colony of helpful and unhelpful people, helpful people would eventually die out since they would share their excess food in almost every interaction. And since the movement policy is random, they wouldn't have an incentive to move towards the canteen when their food was running low. So a large chunk of their population would share their food with others and then die due to starvation.
Another interesting fact that was noticed is that in almost all the simulations, tit-for-tat population used to grow to the highest. This was because of their adaptability of becoming like the people around them. In a colony of helpful people, tittat people would largely (or at least, eventually) become helpful due to their extremeley positive history with the grid. Now, in a grid of unhelpful people, they'd become unhelpful, only relying upon themselves to grow.

This also gave rise to the observation that a colony of unhelpful+tittat people is denser as compared to that of helpful+tittat, since the entire community of helpful+tittat people is more likely to look after the survival of each individual in that community (the community as a whole behaves like a community of helpful people since the donation rate parameter of the tittat population is quite positive).

Analysis of the entire population as a whole showed that in most simulations, the following inequality held true:
tittat population > unhelpful population > helpful population

Similar Environments

- Alternative definition of excess food: Instead of defining excess food in terms of the limit to be safe from the Daku, if we define another EXCESS_THRESHOLD, which would be greater than the threshold required to be safe from the Daku. In that case, the skew between the populations would decrease and helpful people would also more likely be prosperous. We can think of this situation as the helpful people helping the people rationally/selfishly as compared to the selfless help they used to provided before.
- Canteen share their food multiple times in a day with the Macpen: In this case the population boom is likely to be bigger however we do not expect the distribution/movement to differ since our movement is not governed by the award received at a particular spot.
- Canteen has unlimited food supply: We expect more density around canteens in this case. It isn't due to our Macpen revolving more around the canteen, it is simply the fact that since the canteens can feed an infinite number of people, our randomly moving Macpen reproduce A LOT around the canteens thus the numbers around the canteen are higher.
- When each Macpan reproduces, its children are now of a random type, not necessarily the same type as that of the parent: In this case, we expect a more or less equitable distribution amongst the 3 types since each offspring can now be of any type.