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The Grazing Game: Combining Log-normal Distributions, Intelligent Agents and Evolutionary Algorithms to Model Industry and Firm Behavior

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Background

The use of simulations to model behavior has increased in popularity; with increased computing power and software capabilities simulations have been able to replicate complex real-world behaviors. For a thorough text on the subject, see Philip Ball's Critical Mass: How One Thing Leads to Another.[1] Two simulations using cellular automata, also known as intelligent agents, which are frequently referenced are the sandpile game and the forest fire game.[2] Based on the behavior of the agents in this work; we set forth a game which would allow for basic modeling of industry and firm behavior by following a similar game.

In the Grazing Game, we take the view that there are three key elements; (i) the field, or game board, (ii) resources, allocated across the field that vary over time, and, (iii) the players, which make decisions about where they would like to be on the field based on their own capabilities and the status of the resources. At each step of the game, players evaluate the field using their attributes to detect resources, move accordingly based on their attributes and then come to rest. Players seek to achieve some target value of Karma in their moves. We outline several methods by which the game can be made more complex and also look at how the results could be used to evaluate industry and firm competitive behavior.

	Field	Resources	Players
Description	The game board, consisting of adjacent areas. The field is the location upon which resources are allocated and the positions that players desire to achieve.	Resources are allocated to the field. The number of resources can vary, as well as their individual characteristics.	Players seek to attain positions on the field which will give them a certain relative value. The players have different abilities (ie resource perception and movement) and may pursue different resources.
Facets in Iteration 1 of the Game	A simple grid Field has no boundaries (ie spherical surface) Locations may have	Single resource Random log normal distribution Resource changes in	Ability to perceive resources (distance) Steps to move in a single turn

[1] Philip Ball, Critical Mass: How One Thing Leads to Another (New York, NY: 2004)

[2] Relevant papers can be found in arXiv here; [http://xstructure.inr.ac.ru/x-bin/auththeme3.py?level=1&index1=-15547&skip=0]

	limited carrying capacity	distribution after each play	
Facets in Iteration 2 of the Game	Rather than simple grid, locations have a range of connections Create artificial boundaries	Multiple resources Resources may have force-multiplier effects Resources may shift at different rates	Different attractions to different resources
Facets in Iteration 3 of the Game	Locations may have long distance ties to far parts of the board (travel)	Resources may have combinatorial values (derivatives) Resources may have greater ability to attract players (publicity) False and/or negative resources	Ability to understand derivatives Ability to communicate between players Players may have no ability to determine resources; may simply mimic nearby players Karma calculations may change over time

Rounds

The players will move (or attempt to move) each turn. The game will be played for thousands of turns; allowing Karma calculations at the end of each turn. By varying the characteristics of the field, resources and the players, we will be able to interpret which methods maximize player Karma. As we vary the game characteristics over time, we will find better analogs to competitive landscapes faced in industries, allowing for simulation of strategies. By overlaying this with the different characteristics found in players, and eventually in communities of players, we will be able to see what strategies maximize player performance and Karma.

Constituents

1. The field
    a. Assume a geometrically uniform area (ie a square) or playing field. There are no end or corner locations (imagine playing on the surface of a sphere).
    b. Entrants (players) are deposited at random on the map in a log normal fashion. (X = # of entrants / Y = # of locations with that many entrants is log normal)
        i. New entrants enter in a log normal fashion based on the presence of existing participants
    c. Spots on the map have a relative value (values could be of anything, imagine 'goodness' or the amount of a desired resource.) (Such that; X = # of locations with a given value of goodness / Y = Amount of Goodness = log normal)

d. There is a change in goodness value at a location over a time period. (This change is bi-directional, such that it moves up and down.[3] Such that X = % of locations that experience a given level of change and Y = % of change in a given time period.)
    i. Amount of time that goodness persists at a location (Such that if we were to evaluate the duration that a spot were to hold the 'Max Goodness Value' title, X = duration of time that a max holder held that title and Y = number of max holders with that duration of time)

2. The Players
    a. Entrants attempt to pursue geographies of high value (again, assume the values are measures of goodness).
        i. Entrants are capable of perceiving goodness (Such that; X = an entrants ability to perceive goodness and Y = number of entrants with that given amount of capability)
            1. Ability to perceive goodness of a specific location is the function of distance to the location, this too is log normal
    b. Entrants' desire to pursue goodness follows a log normal distribution (Such that X = % of entrants that have a desire to move and Y = % of entrants that have a given desire level)
        i. This too changes over time in a bi-directional log normal fashion
    c. Speed of pursuit follows a log normal distribution. (Such that X = % of entrants able to move at a given speed and Y = speed at which entrants can move)

3. Play of the Game
    a. FIRST TURN
        i. Populate board with initial values
        ii. Populate board with initial players
        iii. Allow players to calculate
        iv. Allow players to move
    b. SECOND TURN
        i. Calculate players relative happiness value
            1. Happiness = F (Desire, [Value*Target - Value*Current])
            2. Calculate Happiness of the entire board, SUM (ALL PLAYERS)
        ii. Recalculate board values
        iii. Allow players to calculate
        iv. Allow players to move
    c. N TURNS
        i. Calculate players relative happiness values
        ii. Repeat (ii) – (iv) above

4. Objectives
    a. Measure changes in aggregate happiness over time
        i. Are their trends?

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[3] Critical Mass – Bi-Directional movement graph

    b. Measure changes in aggregate happiness under different values of the variables
        i. Do some variables have a greater impact?

5. Other modifications
    a. Introduce carnivores that want to be where the herbivores are
    b. Introduce herding or flocking behavior
    c. Introduce types of geographic value (again, Lognormal distribution) and different kinds of consumers (LND here, too).
    d. Introduce Communication between geographies and between players
    e. Players may desire to be near each other or far away from each other (bi-directional)
    f. Meta-geographic values – ability for some geographies to support multiple sub-categories at certain times
    g. Introduce race to the players
    h. Introduce coordination among the players

Evaluating Long Term Results

1. How often and how far are players moving?
2. How much stability is there? Over 500, 1 000, 10 000 moves?
3. What variables influence performance the most? Do any of them matter?
4. What variables change the play of the game?
5. If we introduce different rules to the agents, what improves performance? If we put the agents through an evolutionary process, culling weak players at random, which strategies win out?