approaching digital simulation tools to study complex processes on art, psychology, urban design, geography, sociology, medicine, biology, etc...
#forma13
I. The Workshop
WHAT IS FORMA?

FORMA is an initiative to promote agent-based thinking among researchers from every single discipline such as art, biology, maths, sociology, economics and urbanism. Agent-based systems are used to study complex realities, which can hardly be shaped by traditional methods. The aim of this special event is therefore, to provide participants with a solid agent-based modelling expertise that will enhance their understanding of complex processes within their field of research.

The workshop is organized around a limited number of case studies, selected among proposals submitted by researchers from all over Spain. Each case study has a clear target to be addressed during the three full-days of the event, and the authors of the proposal are assigned an agent-based modelling expert plus a team of students, typically from Computer Science and Mathematics, that are in the process of developing modelling skills.

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Forma provides an interdisciplinary space where students can work together to solve real problems, while researchers from any field meet the opportunity to work hand in hand with highly skilled programmers towards their research targets. This event unfolds as a great networking tool, where minds with different assets meet to pursue common interests. After this first edition, many of the teams have continued developing their models, or established other kinds of collaboration, even sending abstracts together for international conferences etc.

Apart from the "hands-on" work, the workshop includes top level speakers from the European Network for Social Intelligence, as well as daily tutorials on "soft-learning-curve" languages for agent-based modelling, such as NetLogo, and also Processing. Researchers with no previous knowledge of these tools, will develop enough understanding to prototype new case studies in the future through agent-based modelling, even if only conceptually.
OPEN CALL AND SELECTION PROCESS

In this first edition, a total of fourteen proposals were received, from which a total of twelve were selected, leaving out only two proposals that were too broad for the scope of the workshop.

The communication strategy of the open call for proposals, being the first edition of FORMA, was mainly two-fold: On the one hand, direct contact was established with researchers from the two main universities in Seville, US and UPO, holding brief meetings to discuss potential topics within their research that could benefit from agent-based modelling. Three out of five proposals coming from US had been discussed with some members of the organization prior to their submission.

On the other hand, an important effort was made to advertise both on paper and digital media. Prints were distributed throughout all main centres of US and UPO, and other cultural entities and research centres such as ICAS (Institute of Culture and Arts of Seville) and IPTS (one of the seven scientific institutes of the European Commission's Joint Research Centre), while almost every communication department from major universities in Spain, received a request via email to post the open call in their local bulletins. Some departments were also emailed directly.

Other digital channels like twitter were used intensively to spread the call for proposals and participants. Finally, prior to the workshop, two Processing "jams" we organized in May and July respectively, with the purpose of introducing both the language (and its potential application for agent-based modelling), and FORMA. Both events were held at independent cultural hubs in Seville’s city center (Tramallol and La Mirada Rota) and had a good number of participants from very various backgrounds.

From the twelve selected proposals listed below, N3, N4, N5b, N5c and N5d were submitted by research teams from Universidad de Sevilla. Proposals P1 and P2 were submitted by independent researchers from Seville.

Proposals from other Universities in Spain and abroad were: N1 (Universidad Nacional Autónoma de México), N2a (Universidad de Granada & European Centre for Soft Computing), N5a (Universidad de Alcalá) and N6 (Polytechnic University of Catalonia - Barcelona Tech). Finally, proposal N2b was submitted by an independent consultancy based in Barcelona (SustainValues)
CASE STUDIES SELECTED

P1. Helicoidal interrelation of prime numbers
Author: Javier Sánchez Bravo

N1. Birth and Death Master Equation for the Evolution of Complex Networks
Author: Federico Cruz Ponce de León

N2a. Modelling Consumer Behaviour and Marketing Actions
Authors: Manuel Chica Serrano, Oscar Cordón García

N2b. The value creation framework
Author: Luisa Nenci

N3. Changes in personal networks during ecological transitions
Author: Isidro Maya Jariego, Carla Andreia Carvalho Gómez, Cristina Varo Martín

N4. Will the frog jump out? Institution-Faculty relationships in the University of South Zembla
Authors: Jose Pérez de Lama, Antonio Sáseta Velázquez, María José Lera Rodríguez

N5a. Residential settlement of the population at sub regional scale
Author: Carolina de Carvalho Cantergiani

N5b. Mobility, social diversity and sustainability
Authors: Simona Pecoraio, Pablo Pérez Ganfornina

N5c. Making city in the “non-city”: integration versus isolation
Author: Antonio Piñero Valverde

N5d. Case study for the regeneration of neighbourhoods: health patterns of barrio de Villa Coronilla, Cochabamba
Authors: Salas Mendoza Muro, Carolina Ureta, Sergio Rodríguez Estévez, Luz Fernández Valderrama

N6. Microbial populations within a bioreactor operating with different protocols
Authors: Pablo Araujo Granda, Marta Ginovart Gisbert

P2. Green Alcazar
Author: Sergio Rodríguez Estévez. Salas Mendoza Muro, Francisco J. Pazos García

*N=NetLogo, P=Processing
SELECTION CRITERIA FOR CASE STUDIES

FORMA is targeted towards studying complex processes by means of agent-based modelling. The criteria followed during the selection of case studies in this first edition have been:

- **Contemporary subjects:** The case study shall address a topic along the lines of the new information paradigm, digital societies, technological advances and other subjects in which network behaviour plays a decisive role.

- **Complex processes:** Models should aim to clarify a well-defined phenomenon, which due to its inherent complexity requires advanced computational techniques and an interdisciplinary approach.

- **Spatial interaction:** The workshop targets the study of complex processes in which spatiality, be it literal or abstract, has a strong influence over the behaviour of the system at play.

- **Visual understanding:** Proposals shall request for results that can be directly communicated through a graphic visualization of the model and be easily understood by all audiences.

- **Clear identification of the problem:** Because of the limited time to develop the models during the workshop, it is fundamental that a key question is clearly identified in the author’s proposal.
**TEAMS & ORGANIZATION**

Once the case studies were selected, one month prior to the workshop, a brief documentation explaining each proposal was uploaded to the website. Then, all participants were invited to fill in a form via email indicating three of the selected case studies ordered by preference, and also, a short note on their background. With that information the organization distributed the participants in teams of 4 to 8 members per team, and assigned a modelling assistant to each one of them as well. Every participant was informed of the team they had been assigned to beforehand.

The workshop opened on Wednesday 23th Oct, 5.00 pm with a short introduction. Then followed a lecture by F. J. Miguel Quesada, introducing social simulation and agent based modelling. And finally, a round of ten-minute presentations of all the proposals, carried out by their respective authors.

Next day kicked off at 9.00 am with another lecture by F. J. Miguel Quesada, suggesting the ODD protocol as a means to create a common understanding between researchers and technical modelling experts. Afterwards, teams started working on their proposals until evening, first addressing the main features of the model on a conceptual level, and then outlining the structure of the code itself (teams were asked to write an ODD protocol and to design work-flow diagrams of their models before actually coding them). Modelling assistants had the task to lead and work hand in hand with all team members. Directors and guest tutors performed individual desk-critics with all teams throughout the day. During the first half of the day, there were two parallel programming sessions of two hours each, to introduce Processing and NetLogo to those participants who had no previous experience with either of the two languages.

The third day, Friday 25th, opened with a morning lecture by Francisco Linares, looking into real applications of agent based modelling in the field of Sociology. The rest of the day unfolded quite like Thursday, including the two-hour programming sessions, working in teams (now focusing on code development) and desk-critics.

Finally, on Saturday 26th, all teams presented the results of their models throughout the morning, and by the end of the last presentation there was a discussion session and debate which marked the end of FORMA13.
CREDITS

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- Jaime de Miguel Rodríguez

Graphic design:
- Javier Aldarias Chinchilla

Special thanks:
To all the persons not listed above, involved in the coordination of the event, and to all participants, especially students, whose enthusiasm and commitment gave life to the workshop.
PARTICIPANTS

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- Oscar Córdon García
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II. Results
N1. BIRTH AND DEATH MASTER EQUATION FOR THE EVOLUTION OF COMPLEX NETWORKS

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Brief:
d(k) = ?1 (C1 + k) (N1 k)
b(k)= ?2 (C2 + k) (N2 k)

These two equations define probabilities for a certain node k in a network: the first is the probability b(k) for the node k to delete one of its links, while the second is the probability d(k) of the node to give birth to a new link. The higher the degree of the node, the more likely it is that it will be chosen for the deletion or creation of a link. The rest of the variables are defined by the observer with certain restrictions to keep the network within certain limits. The proposal is to create a program similar to the one in the NetLogo Model Library called "Preferential Attachment", where the probability that a node will be connected to a newly created node is directly proportional to its degree, but using the link variable.

Key question: How does a network evolve (in discrete time) using variable probability for the creation and deletion of links?

ODD Protocol:
Purpose: Create a program that can model the evolution of a network of constant creation and deletion of links with variable probability dependent on the birth and death equations.

State Variables and Scales: The nodes will be a fixed number of agents created with the turtle global and will be joined to each other as dictated by the equations by the link global. Each node will have one variable at first: degree (later on, an implementation could be made for the addition of a state variable, which will indicate if the node is, on average, losing or earning more links). For each tick, a link must be created and another deleted. The spatial scale is unimportant in this model.

Process Overview and Scheduling: The model should start with the number of nodes indicated by the observer, with the number of links depending on what type of network is warranted for the later evolution of that network dictated by the equations. The first process to occur is to update the degree of each node as well as the value of d(k) and b(k) for each of the k nodes (as a system memory saver and for a more efficient, an indicator could be made so that only the nodes whose degree was altered should be updated). The program should then choose a node for the creation of a new link as well as another node for the deletion of one of its links (it can be the same node). In another instruction, have the node chosen for birth create a link to a randomly chosen node. Do the same for the node chosen for death. Update any plots and counters that are monitoring the network.

Design Concepts: At a certain point, the graph of the degree of the nodes, when plotted against the number of nodes with that same degree, should start to form a beta function. The nodes have a maximum probability for both the creation and deletion of links at around 50 neighbors (when using 100 total nodes), so when a node nears that
number, it should experience an increased rate of change. The analysis of the networks will be done with other software to facilitate the implementation of the model and increase the depth of the conclusions.

Initialization: The other variables shall be chosen by the observer; including the total number of nodes and the type of graph to begin with, as well as the variables in the equation that have not been defined.

Input: No external input needed yet. A later proposal for the upload of certain preconceived networks to the NetLogo interface may be pertinent.

Submodels: The total number of nodes, for now, will remain at 100 to facilitate further analysis. The other variables in the equation have been chosen for their repeated discoveries within several realworld phenomena. Since how the network will evolve using the equations is unknown, a calibration must be made after the model is complete.

**Flow chart:**

![Flow chart](https://github.com/culturadigital/forma13/blob/master/N1.nlogo)

**Code:** N1_code.nlogo

View it on Github: [https://github.com/culturadigital/forma13/blob/master/N1.nlogo](https://github.com/culturadigital/forma13/blob/master/N1.nlogo)

**Model snapshots:**
Conclusions: We were able to finish a very near final draft of the program in NetLogo thanks to everyone's understanding of the ODD protocol. The team was composed of people familiar with the interface as well as we all had a background in computer programming, which made for an easy workload. For now, the network seems to run...
perfectly, every tick has a newly created and newly deleted link, however the beta
distribution that should form is not as expected. The implementation of the variable
probability does not seem to be the problem as the method was modified from the
"Lottery Example" code of the NetLogo library, so a revision of the behavior of the
equation itself is needed. Without the program, this would not have been so evident.
We were also able to implement different starting networks to start the program such
as a scalefree network, however we were unaware of the "Network" extension of
Netlogo that allows you to do exactly that with much less effort. All in all, we were very
successful in achieving the goals put forth in the beginning.

References:

- L. Luthi, et al. Cooperation and community structure in social networks, Physica A
- Roberto Alvarez-Martinez, et al. Birth and Death Master Equation for the Evolution of
  Complex Networks.

Related models:

- http://ccl.northwestern.edu/netlogo/models/PreferentialAttachment
- https://github.com/shawngraham/netlogo
- https://github.com/donovantc/peertrustsimulation
N2A. MODELLING CONSUMER BEHAVIOUR AND MARKETING ACTIONS

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Brief: The goal of the case is to study and model the consumer behaviour when choosing and buying different products of a specific market. The behaviour of good companies are also modelled by applying dynamic marketing actions when sales change. These actions will try to maximize their sales in the competitive market of the model.

Key question: What are the sales of our product in the market and how do our marketing actions affect my sales?

ODD Protocol: Goal: Simulation of Orange Aquarius sales in Seville with respect to the competitors Gatorade, Radical and Trina. The aim of each Enterprise is to maximise the sales of its products within agents’ population.

Entities: Two kind of agents are involved: consumers and products/enterprise. Interactions between consumers are modelled by means of a randomly generated small-world shaped social network.

State variables:

State variables for CONSUMER agent:

- Priority to the price of a product ([0,1]). A valuation of 1 means that consumer ignores the quality of a product and bases it choices on the price only. The opposite means that the consumer takes into account only the quality.
- Priority vector, to store a preference value for each of the products (real vector with [0,1] values).
- Influenciability by other’s opinions ([0,1]). 1 means max influenciability.
- Proactiveness denotes how proactive is each agent while spreading its experiences with products to its neighbourhood ([0,1]). 1 means max proactiveness.
- Level of expectation ([0,1]) denotes how difficult is to satisfy an agent's demand on a product. A valuation of 1 means max expectation.

State variables for PRODUCT-EMTERPRISE agent:

- Price ([0,1]). 1 means max price possible.
- Quality ([0,1]). 1 means max quality possible.
- Sales. Number of items sold for this class of product during the whole simulation. It will be a natural number, and the goal of the enterprises during the simulation is to maximize its value.

Scales: Time scale: tick = day.
The time unit for the simulation is a day and the whole simulation lasts for two years.
In a day (tick) consumers can buy products, and enterprises can change their marketing action plan in order to increase their products sales.

Procedures: Time is discrete (one day chunks). There are always available products in stock, thus consumer can always choose between all of them.

- Initialization: The social network between consumers is randomly initialized following a small-world topology. During the simulation the network remains static. Most of agent's parameters are randomly initialized, for details about parameter initialization visit the code (the initial value of some parameters is bound to the value of others).
- The main procedure can be divided in four stages. Initialization, opinion broadcasting between consumers, buying and preferences modification stage (consumers) and finally revisit marketing action plans (enterprises):

```
A. Buying procedure: First consumer agents choose (with 50% probability) if they have the need to buy a drink. In case the answer is positive they have to choose between one of the products. In this decision some factors are involved (price, consumer preferences, priority of the consumer for a cheap product or a high quality one, etc.), and the utility function for each product is as follows:

\[ f(\text{product}) = (\text{priority_to_price}) \times \text{price} + (1 - \text{priority_to_price}) \times \text{preference_for_this_product} \]

Once the utility is computed for each product, the selection is made by means of a random weighted choice (using a weighted probability distribution), where the weights are the utility value for each product. After selecting a product, the sales for this product are updated.
```
• B. Update of product preferences based on the product purchased: After buying a product, the priority the consumer has for the product is updated based on the satisfaction obtained, the level of expectation and the price. If the consumer has a high expectation level and the product quality is low, the probability for the consumer to not be satisfied with the purchase is high. In this case, the priority of the consumer for this product will be decreased by 0.1; otherwise, it will be increased by 0.05.

Expressing this in pseudocode:

- If quality of the purchased product is lower than the expectation level of the agent:
  - The probability for the consumer to not be satisfied is \( \frac{(\text{expectation level} - \text{product quality})}{\text{expectation level}} \);
  - If consumer is not satisfied then \( \text{priority(product)} = \text{priority(product)} - 0.1 \)
- Otherwise (quality of the purchased product is greater than the expectation level of the agent):
  - \( \text{Priority (product)} = \text{priority(product)} + 0.05 \)

• C. Neighbourhood influence in agent’s priorities about products: We have already seen how consumer’s priority about a product changes according to its satisfaction with the last product purchased. Independently from this, consumer’s priorities about products change due to the opinions the consumer receives from its neighbouring agents. This process depends on other factors as the proactiveness of the agents broadcasting their opinion and the influenciability degree of the consumer accepting others’ opinions. Firstly, and based on the influenciability parameter, in each day (tick) the consumer decides if today he is going to accept others’ opinion. In this case, depending on the proactiveness of the neighbours, the influencing opinions are collected and an average priorities vector is computed. Once we have this vector, the consumer’s priorities vectors (from the agent receiving others’ opinion) is modified according to the following expression:

\[ f(\text{new priorities}) = (\text{influenciability}) \times \text{AveragePrioritiesProactiveNeighbours} + (1 - \text{influenciability}) \times \text{FormerPriorities} \]
D. Enterprises’ marketing action plans in order to improve product sales: Every month, enterprises can change their products’ marketing action plans in order to improve sales. In order to keep it simple, marketing action plans consist on the variation of price and quality product attributes.

In a first step the enterprise decides if is necessary to act (if sales rate is high, Why am I going to change anything on my product?). Every month each enterprise checks its own and competitors’ sales. If sales are above the average of competitors sales, business are going well so we do not touch anything. Otherwise, there are two possible actions (one of those is randomly chosen):

- Price decrease: the enterprise decides to decrease the price of the product in 0.05, and as consequence of this, the product quality also decreased in 0.05 (bound parameters).
- Quality increase: the enterprise decides to increase the quality of the product in 0.05, and as consequence of this, the product price also decreased.

After updating the marketing action plans, the enterprise waits one moth to analyse the effects of the changes and reconsider the plans again if necessary.

In this model, enterprises do no have access to any information about consumers preferences, thus the can base their decisions only on sales information.
Input parameters (User configurable input parameters in the model):

- Consumers’ population.
- Number of available products.
- Quality - price relationship in order to compute the quality property of the products.
- Some parameters are generated by means of a normal distribution with fixed standard deviation (0.1) and user provided mean. The input parameters for the means are:
  - Mean for the consumers expectation level.
  - Mean for consumers' priority towards price.
  - Mean for consumers' priority.
  - Mean for consumers' proactiveness.

**Code:** N2a_code.nlogo  
View it on Github: https://github.com/culturadigital/forma13/blob/master/N2a.nlogo

**Model snapshots:**
Figures 1, 2. Product prices are randomly generated. Product quality is computed adding a random number within the range [-quality/price-relationship, quality/price-relationship]. Consumer parameters expectation level, priority towards price, influenciability and proactiveness are computed following a normal distribution with 0.1 as standard deviation and the following input parameters as mean: mean_expectation_level, mean_price_priority, mean_influenciability and mean_proactiveness. The size of consumer turtle is proportional to its priority towards the price. The colour of the consumer turtle represents the purchased product (white for none).

Conclusions: We developed the model using Netlogo and configured different parameters to run simulations (number of products and costumers, ratio price-quality for the products, agent activity in the social network, etc...). A graphic with the sales lets us observe changes in sales when companies vary their products characteristics (quality and/or price). Future extension of the model will consider marketing actions depending on the characteristics of the consumers.

References:


Related models:

• http://ccl.northwestern.edu/netlogo/models/community/customerBehavior
• http://ccl.northwestern.edu/netlogo/models/community/EXPLORE
• http://ccl.northwestern.edu/netlogo/models/community/Neteffect
• http://ccl.northwestern.edu/netlogo/models/community/ModelMarket
• http://ccl.northwestern.edu/netlogo/models/community/Location%20Game
• http://ccl.northwestern.edu/netlogo/models/community/OptionsMarket
• http://ccl.northwestern.edu/netlogo/models/community/Facebook
• http://ccl.northwestern.edu/netlogo/models/community/Fall-of-banks
• https://sites.google.com/site/jkgeconoeng/GBLCSA.zip
• http://www.css.gmu.edu/node/81
• https://github.com/ancadumitrache/DutchHousingMarketSim
N2B. THE VALUE CREATION FRAMEWORK

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Brief: The Value Creation Framework (Perrini, 2006) helps companies and the investment community to better understand how a more inclusive stakeholder-oriented governance systems positively affects corporate performance. While firms values, belief and activities have been already identified and classified into drivers, influencer and influenced, variables specification their interaction mechanisms and rules have not been evaluated yet.

A simplified NetLogo model has been built to frame and analyse company’s policy and related actions on people values and consequential corporate performances impacts.

Satisfaction has been chosen as the main variable including in calculation: salary, mobility and training variation, training and satisfaction variation against average.

Key question: With which level of decreasing satisfaction a talented worker will leave the enterprise?

ODD Protocol:
1. Surrounding

The physical and social surrounding of the model is the enterprise department of HR where HR policies are implemented and evaluated though financial and non-financial indicators.

100 people are working in the company 6 executive (one each department) 18 middle management managers and 76 employees. The relative share between functions presume a manufacture company with a production chain where 70 people will turn everyday with scheduled days off and holidays.

The company is based in Spain where the base salary is 15.500 euro (data INE 2011), the senior salary is between 30-45 (data from internet job search) and executive 42-75.000 (data from internet job search)

For the implementation or execution of this multi-agent social model a particular set of parameters and initial values have been created. Different values of the parameters will also be analysed as a result generated by the interactions emerging between these agents while running the model though accessing to the rules list.

2. Agents and Rules

<table>
<thead>
<tr>
<th>Function (F)</th>
<th>1 Executive 2 Manager 3 Employee</th>
<th>Only managers: If (Executive &gt; Manager)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talent (T)</td>
<td>T=0 Employees T&gt;1 F=2,3</td>
<td>Training α + Tt-1</td>
</tr>
<tr>
<td>Salary (S)</td>
<td>Actual Memory</td>
<td>Sb=S (Total Budget / S)</td>
</tr>
<tr>
<td>Training (Tr)</td>
<td>Actual Memory</td>
<td>Trb=T (Total Budget / Tr + Sal)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mobility (M)</th>
<th>F3 M=0 Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level (L)</td>
<td>Tick Access</td>
</tr>
<tr>
<td>Satisfaction (Sat)</td>
<td>Actual Memory</td>
</tr>
</tbody>
</table>

The company as an overall budget with which is in part used to pay the Salaries (S) of
workers and the rest is divided into staff incentives, whether in the form of additional remuneration, or Training (Tr) to improve the profile of workers. The Company strategy is to decide what% of that extra is to be used for each of these purposes.

The Training given to workers through courses has a cost which is proportional to the talent of the employee who receives it (indicating some degree of specialization and the need to train, and hence to greater specialization, higher cost).

The strategy is devised by year which means equal to 5 ticks in the model.

Workers belong to 3 main Functions (F): executives, managers and employees. They can change their Function (F) automatically with the Level (L) which is changing every 7 years (5*7= 35 ticks).

Base salary depends on the level to which it belongs, an initial level of salary is decided.

Talent of each employee is measured by a numerical quantity and is initially given randomly.

The training increases a worker's talent, with a non-linear function, as the more the talented a worker is the more training has to receive to enhance its talent.

The main variable to be measured is Satisfaction (Sat), which measures the level of satisfaction that a worker has in his company after each cycle (one year equal to 5 ticks).

Satisfaction is measured as a function that depends on the working conditions of the employee such as: salary variation (on the tick with reference of the previous tick) their talent, training received and peer working conditions - average level of satisfaction, average level of salary, training received by others but the one analysed - to evaluate the influence on satisfaction due to the interaction within peers in spreading 'insatisfaction'.

If the satisfaction level of a worker falls below a threshold (which depends on model conditions related to talent, salary, etc.), then the employee leaves the company.

**Flow chart:**
**Code:** N2b_code.nlogo
View it on Github: https://github.com/culturadigital/forma13/blob/master/N2b.nlogo

**Model snapshots:**

![Figure 1](image1.png)

Figure 1. Employees with properties initialised. Red, blue and yellow agents correspond to executives, managers and employees, respectively.

![Figure 2](image2.png)

Figure 2. Initial running time. Green agents represent workers with low levels of satisfaction.
Conclusions:

- Mobility was eliminated because ineffective. A strategy to link it with the salary or satisfaction was not found.
- Adjustments have to be made because satisfaction drops too soon and no evaluation can be done to determine which parameter has more influence over this drop.
- The Budget Total allowed to the company each cycle, should be revised, ie do they influence some working conditions, the size of the workforce, etc, which budget will be provided from the company next cycle?
- When a worker reaches the critical level of satisfaction leave the company. IF in the other hand, the company has a Budget could be use it to make "new contracts" to fill in new workers/retain talents.

References:


Related models:

- http://ccl.northwestern.edu/netlogo/models/community/Location%20Game
- http://ccl.northwestern.edu/netlogo/models/community/OptionsMarket
- http://ccl.northwestern.edu/netlogo/models/community/Facebook
- http://ccl.northwestern.edu/netlogo/models/community/Fall-of-banks
- https://sites.google.com/site/jkgeconoeng/GBLCSA.zip
- http://www.css.gmu.edu/node/81
- https://github.com/ancadumitrache/DutchHousingMarketSim
N3. CHANGES IN PERSONAL NETWORKS DURING ECOLOGICAL TRANSITIONS

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Brief: The changes experienced by the personal networks of High School students when they start to study at the University are described. A group of students from Alcalá de Guadaira enters in a metropolitan way of life when they start to study in Seville, as they start to commute almost everyday between the city where they reside and the city where they study (separated by 15 kilometers). The relationship between the changes experienced in the composition and the structure of the personal networks are examined. We are also interested in evaluating how the changes in the personal network of each student is related to the connection they have with the cohort of students experiencing the same educational transition.

Parameters:
1. Representing the process of changes in the personal network after incorporating to the university.
   - H1: Inverse relationship between level of heterogeneity (composition) and the structural cohesion of the network (structure).
   - H2: Competence between active multiplex relationships (there is a limit in the number of multiplex relationships an individual could maintain simultaneously).
   - H3: Graphic summary of the personal networks.
2. Classification of the personal networks regarding (a) percentage of alteri from the city where they reside, (b) multiplexity (and distribution/connectivity of multiplex links), (c) structure of the personal network.
3. Define the probabilities of desconection from the whole network depending on the type of personal network of each individual, in order to study the disaggregation process of the whole network.

Key question: How are the changes in the composition of the personal network related to the structure of the personal network? Which types of personal networks may be identified? How the type of personal network is related to the position each individual occupy in the whole network of High School students living the transition?

ODD Protocol:
Goal: Design a model that simulate the population behaviour when they change their environments. This model allows to have a better understanding on how the process is happening. The model consists on describing the changes that a group of students suffers in their personal networks when they start to study at University, they develop a new metropolitan lifestyle and they move to a new big town, that are relatively near to their original city. Its interesting to analyze how the structure network changes to understand how this network is evolving and to compare it with experimental samples.
Entities, variables and scales:

- Agents: People
- Links: Social Relationships between people
- Temporal extension: One tick in the model represent 1.08 days. Total 18 Months (500 ticks)

Process summary and scheduling: Each person win or lose relationships following some rules. The model allows a user to change this rules to study the resulting network and compare it with the obtained in the real world experiment. This experimentation allows to understand how people are changing their social networks when changing from a context to another. Time is considered to be discrete.

- Initialization: Is done by loading a social network in DL format which describe the network at the beginning of the process.
- One-step-go: Each rule is applied to each agent.
- Rules:
  - if (randomfloat 1 < a) [an agent lose an original relationship and get a new friend from new city]
  - ask agents with [agent:type = "M"] [if (randomfloat 1 < b) [make relationship with new city person]]
  - ask agents with [agent:type = "M"] [if (randomfloat 1 < c) [make relationship with old city person]]
  - ask agents with [agent:type = "A"] [if (randomfloat 1 < d) [lose relationship with old city person]]

*agent has type == "M" if is from new city
*agent has type == "A" if is from old city
The a, b, c and d parameters are configurable through the model interface

Design concepts:

- a. Define rules to create and lose nodes and links between them.
- b. Changes in the networks properties during the transition from T1 to T2 (18 months).

- Fundamental principles: We assume that the behaviour of a person when he/she changes his/her social environment follows some rules to lose his/her original social relationships and win some new city relationships.
- Perception: Agents are not experimenting any perception, just follows some probabilistic rules depending on four variables.
- Interaction: Agents interacts with each other just adding or losing relationships between them.
- Randomness: The model uses randomness to modelate probabilistic processes (winning or losing relationships with new or old agents).
- Observation: The main goal of this model is to simulate the behaviour of students who are changing their environment, so the way to analyze that is through some measures in the original and final network (18 months later). Network measurements that are showed by the simulation are:
  - Degrees Histogram.
  - Degree Mean.
  - Density: Num of links / Num of nodes.

Initialisation: Is done by loading a social network in DL format which describe the
network state at the beginning of the process.

Inputs: The model uses data from social networks in DL format.

**Code**: N3_code.nlogo  
View it on Github: https://github.com/culturadigital/forma13/blob/master/N3.nlogo

**Model snapshots:**

![Figure 1. Initial state of a network (data is obtained from real world).](image1)

![Figure 2. State of the network and its measures after 247 ticks of evolution applying model rules.](image2)
Conclusions: We have designed a model that simulates the behaviour of students who changes their environment. After implementing the model and performing several experiments we have found that is possible to model this behaviour through few simple rules. Just taking into account frequency of losing and winning relationships between people, it can demonstrate that the change in the social environments follows simple rules although the evolution of networks can looks very complex if we analyze it like a centralized system.

References:


Related models:

- http://ccl.northwestern.edu/netlogo/models/TeamAssembly
- https://github.com/donovantc/peertrustsimulation
N4. WILL THE FROG JUMP OUT? INSTITUTION-FACULTY RELATIONSHIPS IN THE UNIVERSITY OF SOUTH ZEMBLA

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Brief: During the great crisis of 2007-2013, the central government of the evil Charles Kinbote and his minister E. Shade, are inflicting severe policies cutting down budgets on social services, and particularly in the areas of basic and university education. In the old and honorable University of South Zembla, located in the southern capital of the country, the Board and its collaborators hold an ambiguous position by supporting rebellious discourses against the followers of Kinbote-Shade, while at the same time making effective those resolutions coming from the central government among their faculty.

A minority yet substantial part of the faculty, the Pink-Bloc, promotes resistance against the Board and higher authorities, is making efforts to call on a faculty strike as a proof of power, and as a means to balance political forces. However, most faculty, despite feeling under attack, remain passive, perhaps because they are skeptical towards any act of mobilization, or simply because the best way to keep their jobs is to adapt to the emergent conditions the best they can.

The Pink-Bloc will take the metaphor of the frog in the cooking pot, which became popular after American politician Al Gore, to interpret the political techniques of the University of South Zembla, which are being developed by the Board thanks to the unestimable collaboration of the historically honorable labor unions, which after so many years of dedication to fight capitalist oppression, have finally been abducted by the local spheres of power...

Key question: Will the frog jump out? Or what are the conditions required in order for a faculty strike to take place in the University of South Zembla? And what level of success could such strike achieve upon different configurations of these conditions?

ODD Protocol:
Purpose: What we have is an attempt of a model for an hypothetic case of cutbacks that could result in a strike. All of this in an academic/university environment. Our intention is to develop a first approach for a more elaborated model in the future.

State variables and scales: There are two kind of agents in the model. The first one is called "machine" ("aparato") and represents the government/administration. It's an observer-like agent so it's not represented explicitly in the model but his actions have a deep impact in the evolution of the situation and the mood of our second group of agents. The so-called "frogs" that represent the whole bunch of Teaching and Research Staff in the university.
The "machine" is meant to be a bureaucratic system that have the ability of changing the aim of the "frogs". Its role is supposed to be played by the observer by pressing buttons that will trigger actions such as "confusion", "increment the dedication time", "salary reduction" and "dismissal" at any time.

The "frogs" are literally represented in our model by turtles, as well as the links among them that represent the relation of influence existing in real human networks. They have four characteristics:

- Category: Represents the status of the frog in the university, the sector they belong to.
- VPS: Represents the psychological status of the agent. The natural inclination for protesting against their situation at work.
- Pression: Represents the pressure they are subject to.
- Jump: It's calculated as vps times pression and it represents the current predisposition for going to strike or protest. The color of the frogs is related to their "jump".

Process overview and scheduling: The process is very simple, as time goes by, two things happen to the frogs. The first is passive infection of the feelings around them accordingly to the people in their immediate environment, "neighbours" throughout time. The second one is conformity, that represents the natural cooling of the spirit of an annoyed person.

The rest of actions are executed by the observer whenever he wants. And represent the actions of the machine.

Design concepts: As a first approach, the model try to collect the basic feelings and responses from university personnel to the actions of the machine.

At this moment, the agents don't have the ability of learning from their environment, but it could be a nice case study for a more developed model.

The links among frogs are created as a clustered graph that could represent research, friends, or teaching groups in the university. With some people very interconnected between them and less connections with other groups.

While the model is running, a graphic of the number of frogs divided in three groups (grey, green, pink) is draw in real time so you can see how does the global mood is in the model and how do machine actions affect people from a global viewpoint.

The colour of a frog is a sign of his mood. It gives us visual information of the situation. There are three main groups:

- Grey: Passive people that are satisfied with their situation.
- Green: People that are unsatisfied with their situation or the situation of people near them.
- Pink: Active people that have a big enthusiastic attitude and are determined to change things.

Initialization: One must set the number of frogs that will be in the model, the average node degree of the link graph and the percentage of fired people every time you apply dismiss. The initial percentage of different frog category follows a 40-30-30 rule. The other data are taken randomly.

Flow chart:
Note: “A?” is true if a button has been pressed during that GO loop

**Code:** N4_code.nlogo
View it on Github: https://github.com/culturadigital/forma13/blob/master/N4.nlogo

**Model snapshots:**
Figure 1. A random initial configuration of the simulation

Figure 2. Step showing many active (pink) frogs due to some machine actions
Figure 3. Stable situation after some time without “machine” actions. Everybody is calm

Figure 4. Graphic detail of salary reduction

**Conclusions:**

Our participation in Forma13 developing a Netlogo sketch of Zembla was the team's first experience working with Netlogo to digitally simulate an emergent social system. Ease of use and immediate visual and numeric outputs are excellent features of the platform. The opportunity to work in multidisciplinary teams offered by Forma13 was highly appreciated. Our short modelling experience shows that fine tuning of parameters is a key issue for the achievement of a significant simulation.

Concerning the Zembla model, we think that it is an interesting concept that we have sketched, but that, of course, it would need further work to make it a relevant simulation model. In the state of development achieved at Forma13 we consider it might already have some use in triggering some debate on social dynamics among activists.

In order to have real use, we think that one or several alternative models - conceptual and algorithmic - on political-and-activist motivation, networking and action should be developed, testing them against data retrieved in different real situations.

**References:**
• Emmanuel RODRíGUEZ, 2003, El gobierno imposible. Trabajo y migraciones en la metrópolis de la abundancia, Traficantes de Sueños, Madrid
• Michael HARDT, Antonio NEGRI, 2004, Multitude: War and Democracy in the Age of Empire, Hamish Hamilton - Penguin, Nueva York

Related models:
• http://ccl.northwestern.edu/netlogo/models/Ethnocentrism
• http://ccl.northwestern.edu/netlogo/models/Rebellion
• http://ccl.northwestern.edu/netlogo/models/community/Facebook-share...
• http://ccl.northwestern.edu/netlogo/models/community/Occupational-Stress...
• http://ccl.northwestern.edu/netlogo/models/community/Smoking-motivation...
N5A. RESIDENTIAL SETTLEMENT OF THE POPULATION AT SUB REGIONAL SCALE

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Brief: The Community of Madrid (CM) is strategically placed in Spain and functionally important since it concentrates the transport network main connections, important industrial activities and central administrative services, among others. It results to be very active demographically, producing important territorial changes, confirmed by urban and potential urban land growth statistics, for example. The study area is an important urban-industrial corridor that connects the megalopolis of Madrid and Barcelona, named Corredor del Henares within 18 municipalities.

This area has been historically characterized as population and productive activities attractor during periods of decentralization of Madrid and other neighbor municipalities. It can be considered a potential area for urban growth analysis and simulation due to its important demographic growth and land use dynamics. And moreover, those results are also important for being useful for planning and territorial management of its territory.

Analyzing the dynamics of the study area, the three selected agents we consider influence its urban growth are: population, real estate agents and urban planners. They simultaneously induce this phenomenon through their own behavior, stimulating the creation of new urban settlements.

The three agents’ behaviors do not compete for the same goal; instead they are re-feed according to each other action. It means that the planners assign new urban areas (having into account the still not-urban areas); the real estate agents look for available places to build new residence on previously classified urban areas; and finally the population considers the offer of new and empty housing to choose new residences.

The challenge in the model presented in this document is to simulate the residence election of the population that finally decides to move. Three groups of population are considered according to their behavior, defined according to their economic status (high, medium and low income), that is supposed to be the most important factor that induces residential changes.

Key question: How urban growth at Corredor del Henares (Madrid) can be understood and represented through the behavior of groups of population with different economic status in respect to their residential choices?

ODD Protocol: The main goal of this model is to understand how is the urban behavior at Corredor del Henares through the simulation of the residential choices made by different groups of population considering their income levels.

Purpose: Simulate residential changes of high, medium and low income population. The model product is, by one side, the amount of people that change residence together with the class they belong to, and on the other side, the type of housing they choose and what their satisfaction level is.
State variables and scales

- **Entities (agents):** In our case, we consider "agents" the ones who present certain behavior, do something and take a decision, while "environment" is all the components of the system that present any property that affects agents' behavior, but with static attributes (at least at this stage of the model). In our case, "agents" are high, medium and low income population. It won’t be considered at individual scale (person), but as a population unit (group of people). As "environment", we consider the housing with its attribute, according to the following:

  - **State Variables (Property):**

<table>
<thead>
<tr>
<th>Agents (turtles)</th>
<th>Environment (patches)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>POULATION</strong></td>
<td><strong>HOUSING</strong></td>
</tr>
<tr>
<td>Attribute</td>
<td>Description</td>
</tr>
<tr>
<td>Typology of population (TPP)</td>
<td>High, medium, low income (qualitative)</td>
</tr>
<tr>
<td>Adaptable (ADP)</td>
<td>The number of failed tries of the population searching for housing (continuous)</td>
</tr>
<tr>
<td>State (STT)</td>
<td>Satisfied or unsatisfied (boolean)</td>
</tr>
<tr>
<td>Tolerance (TOL)</td>
<td>Time necessary to adapt to new typology of housing</td>
</tr>
</tbody>
</table>

At the beginning of the model, there will be a parameter called **PERCENTAGE (%)** that indicates the amount of random changes on initial income type of the population.

- **Scale (Spatial and Temporal Resolution):** The study area is represented by a matrix of 800 x 800, each unit with 50m x 50m.

Temporally, the project aims to analyze residential changes each month, even though the temporal unit (tick) is not yet resolved (since a tick will be probably lower than that), so there will be no fixed temporal unit at this testing stage.

Process overview and scheduling: The first and only action is the movement of the unsatisfied population to available residential buildings (that comply with some characteristics). In this case the order is not important, since all population act simultaneously. But as the model must define an order to be able to run, we will let it random. No external updating is necessary, as it is a simple model that will feed itself with the new information generated.

Design Concepts

- **Basic principles:** There are social, economic and territorial aspects that affect the behavior of the population regarding changing residence. Although in the present proposal they are defined in a very superficial way through a limited set of actions. After the running of the model, we will be able to reanalyze those same aspects on the new distribution, and find some relation and conclusions about their relations.

- **Emergence:** The choice of residential change is unforeseen, since it varies according to a high number of combinations of non-deterministic criteria. The action will depend on the satisfaction, that in the present simulation is defined by the coincidence of the income level and housing typology (which change could be random).

- **Adaptation:** The population occupies housing of their own economic level, and among them, they prefer the ones with better quality respect to territorial position. For
each income level the weight of spatial preferences differ according to the distance to roads, public transport or services (health and education facilities).

On the other side, at the end of each action the population can occupy housing with typology different to their income possibilities, since it is possible to adapt to the neighborhood, housing, life style, etc., and then they become part of the new class associated to the current house typology they are living in.

- Objectives: The objective of the population is to be satisfied. It is defined in function of its income level and the typology of their housing. Externally, the model considers a percentage of change on the income level symbolizing sudden welfare or economic failure.
- Learning: There is not any learning process represented at this stage of the model.
- Prediction: The prediction here is more related to the situation of the neighborhood that must probably be similar to each population own neighborhood in order to be comfortable.
- Sensing: The population takes into account their own income level in order to choose a new house in accordance to their economic possibilities. Of course they also consider the population capacity of the new building where they intend to move to take a final decision. The population supposes to know the situation of the housing around (at a certain distance) and its capacity.
- Interaction: As a group, the total of the population that lives in a neighborhood, as well as their income level, influences the new population that aims to move there. Also, the capacity and typology of the housing within the area they are searching.
- Stochasticity: There are some population income level changes made randomly (following a percentage defined by the user in the interface), representing a job change, unemployment rate, lottery winning, etc.
- Collectives: There is not any collective represented in this model.
- Observation: There is not any observation output expected besides the new distribution of population, or any result that could be described at this development stage.

Initialization: The model starts with the current distribution of the population with their income level incorporated. Also, the number of housing is distributed in a matrix indicating what typology they have together with their other characteristics.

Input data: The initial situation presents the distribution of housing (real place according to GIS data), with typology (obtained from GIS layer of high, medium and low type according to the average housing price), capacity (according to housing density defined in a GIS), quality (three options regarding the interest of each type of population, calculated through their distance to roads, public transport and services) and number of people (GIS layer attribute).

The initial distribution of population income level depends on the typology of the housing they belong.

Submodels: This is a submodel by itself that is part of a general model (under development) that considers and integrates also the behavior of the real estate agents and urban planners. It does not present other submodels associated.

Flow chart:
Code: N5a_code.nlogo
View it on Github: https://github.com/culturadigital/forma13/blob/master/N5a.nlogo

Model snapshots:

Figure 1. Temporal interface of netlogo model with the distribution of population over the study area
Conclusions: The development of the model is at a very early stage to reach any conclusion. At the moment we have theoretical assumptions that the population move according to certain characteristics of own income and residence typology, together with territorial preferences (proximity to facilities, for example). However, the model is not yet completed in order to have results.

References:


Related models:

• https://github.com/dgolicher/netlogo
• https://github.com/adriancbjie/IBG
N5C. MAKING CITY IN THE "NON-CITY": INTEGRATION VERSUS ISOLATION

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Brief: In Andalusia there exist around 350,000 irregular constructions according to city-planning land-use specifications, which prove to be a serious territorial and social problem, raising nowadays up to becoming the biggest obstacle when attempting to obtain a rational, coherent and sensible arrangement in good part of the Andalusian territory.

Although in the outcrop of this type of settlements, circumstances of diverse nature concur, all of them present/display certain similarities: its spontaneous and absent character of planning, the environmental affections that cause or deficiencies generalized in services and infrastructural matter.

To date, the solutions developed by the Administration reveal their incapacity to solve this problem efficiently and, largely, they show a progressive spacing between the normative frame and the reality that is tried to order, inasmuch as it is tried of unidirectional way to assimilate these differentials processes to the model of traditional compact city and it is producing serious distortions, when situations indecisive or nonviable not to take to the practice.

Consequently, the demand of a new approach of the problem is clear, that takes care in greater measurement the specific characteristics of these irregular processes and raise innovating alternatives in which the active participation is essential from the affected ones.

In that sense, and aiming to deepen in the definition of strategies for urban-territorial integration of these irregular settlements, we have made one first approach in the exercises of factory of the Masters in Urbanism, Planning and Urban Design and, recently, we have been awardees from one of the aids of investigation promoted by the Public Work Agency of Andalusia.

Without damage to the complexity of the problem created, we attempt to develop expertise in the simulation of complex scenes - as it is the case with a great space component and, to the time, of enormous social impact, all it to the aim to clarify new ways to articulate these territories of "not-city", in which the users are - in good measureme - protagonists of the possible solutions.

Conscious of the difficulties and diversity of situations, in this proposal we try to clarify the viability of solutions that, one at a time, prove - in our certain opinion abuse of the parameters of the norm of applicable regulation and, of another one, promote alternatives that emanate of the own affected population.

Key question: Can new ways be articulated to integrate in the territory the existing illegal housing plots in Andalusia?

ODD Protocol:
Purpose: The aim of the model is to evaluate the degree of satisfaction of settlement inhabitants as well as to measure the level of impact of different alternatives for urban-territorial integration.
Entities, state variables and scale: We shall consider three types of entities or agents: units of housing population (population), spatial units of housing plots and the Administration.

- Population:
  - Socio-economic level (low-medium-high)
  - Energy
  - Satisfaction (%)
- Patches (land plots):
  - Building typology (simple-average-developed)
  - Legal (true or false)
  - Protected (true or false)
  - Impact level (1-10)
- Administration:
  - Energy

The model is based on a regular grid taking up to 32x32 cells, which is approximately equivalent to a settlement area of 500x500 m.

Time wise there are no limits upfront, and the minimum time lapse considered is a span of 3 months (1 tick).

Process summary: Starting from an initial state defined in the "setup" (creation of patches, "god" and the initial population of the settlement), an initial level of impact is calculated.

On a second step, the population is updated with a certain number of newcomers, and the Administration will execute actions such as land-use verification, measuring impact levels, re-qualification to enable new protected areas, and when suitable, legalization of the irregular housing plot.

Once the Administration has executed these actions, they will trigger new processes among the settlement in the form of housing typology improvements, reduction of impact levels, applying for legalization, nil, or complaints.

After one full cycle is completed, results are then calculated and displayed (satisfaction level and impact levels).

Flow chart:

Diagram 1. "Setup" function
Diagram 2. Initialization ("Go" function)

Diagram 3. Creation of new inhabitants / land owners in the settlement
Diagram 4. Actions executed by the Administration
Diagram 5. Actions executed by land owners

Diagram 6. Updating impact levels

**Code**: N5c_code.nlogo
View it on Github: https://github.com/culturadigital/forma13/blob/master/N5c.nlogo

**Model snapshots:**
Figure 1. System status at simulation startup. Green patches are protected land. White - rural land. Red - built area over protected land. Brown - built area over rural land.

Figure 2. Unexpected turning point of impact trend at tick 200 (50 years)

**Conclusions:** After an initial model has been developed, we have realised that assessing impact levels and especially satisfaction degree among the population, require a much deeper analysis prior to the modelling phase.

Nevertheless, we have discovered an unexpected phenomenon that might lead us to some fundamental findings in our research. Despite the simplicity of the model, the simulation shows a turning point in the impact level of the settlements after approximately 50 years of its initialization. Of course, the time lapse is not very reliable, but if this turning point does happen at some point it could be of very useful value to understand and reduce the processes of degradation inherent to self-organizing communities.

Moreover, this initial attempt has proved very useful to define a long term agenda in our study of irregular settlements through agent based modelling.

**References:**

- Decreto 2/2012, de 10 de Enero, de regulación de edificaciones y asentamientos en el SNU (BOJA núm. 19, de 30-enero-2012); y, de modo específico, las Normativas Directoras que lo desarrollan (Orden de 5 de marzo de 2012)
Related models:

- https://github.com/dgolicher/netlogo
- https://github.com/adriancbjie/IBG
Biotechnology experimentation in the laboratory with microorganisms is not always viable, involves a series of constraints such as: cost, time, safety, security, equipment, sterility and others. These tasks could be managed with the virtual experimentation. The use of a virtual bioreactor would facilitate the understanding of the real system favoring final handling.

People in different training courses seek to respond a series of questions, such as: what is a bioreactor? Could I handle a bioreactor? What happens within a bioreactor? Which behavior has a population of microorganisms within a bioreactor?

The answers could be obtained using a simulated complex system (virtual bioreactor), which facilitates the analysis of the behavior and response of different populations of microorganisms in different conditions of culture medium that can be controlled by the observer.

The choice of a basic approach to study microbial system, either at the level of population (usually continuous with differential equations) or based on the individual (discrete and computational model) is an important decision that should be taken depending on the project, the system characteristics, the problem to study and assumptions when the continuum is not applicable.

Individuals based Models (IbMs) deal with individuals (live actors) as discrete autonomous entities. These individuals have particular characteristics that change according to the biological actions of its own behavior, interactions with others and the environment.

Population-level approaches are mainly used for prediction purposes, due to its simplicity and efficiency computational, and they are widely used. The IbMs power is the features offered to interpret, understand and investigate the dynamics of living systems. Allow us to treat the intrinsic variability of all living being, with the emergence of the population behavior from the actions and interactions at the individual level.

The main objective is to develop a microbial bioreactor simulator, which is easy to understand, and that it could be adapted to specific applications and useful for people on the life sciences field.

Parameters: the system will be a virtual bioreactor operating with different protocols (batch or continuous culture), which will contain initial amounts of nutrients, a number of viable microorganisms, who will adapt to the environment that they are, because they consume nutrients and generate end products, maintaining they viability over the time.
Agent (micro-organism) variables:
- a. Position in space (XY coordinates)
- b. Biomass
- c. Maintenance requirements
- d. Reproduction biomass
- e. Reproduction time

The environment variables (culture medium):
- a. Nutrient concentrations
- b. Product concentrations

System variables:
- a. Nutrient input flow.
- b. Culture medium output flow
- c. Dilution ratio
- d. Operation time

**Key question:** Is it possible to simulate the behavior of a microbial population in different conditions within a bioreactor?

**ODD Protocol:**
1. Overview

Purpose: The purpose of this model is to provide a virtual bacterial bioreactor with an operating protocol to manipulate the entrance of nutrient, stirring and output of medium in order to produce biomass. Only a qualitative study of some mechanisms is acceptable to explore or investigate the behaviour of this system.

In addition, the idea to implement this model into the 3D version in the near future has motivated some of the approaches used.

Entities, state variables, and scales: Basic entities are bacteria and spatial cells of the medium where these microbes evolve. The bacterial attributes are: an identity number, a location (i.e., the spatial xy-coordinates of the grid lattice), a mass (as a source of energy that can be used for the reproduction and movement) the mass to start reproduction and the mass for the entrance to the latency state. The grid cells attributes are: the x and y integer coordinates for each site, the nutrient content and end product content. It can simulate a population of up to hundreds bacterial cells in a 40x40 spatial grid cells. This is a non-parameterized version so there is not a real units correspondence.

Process overview and scheduling: At each time step of the simulation, a set of actions a set of actions are performed.

The sets of rules governing the behaviour of each bacterium are:
- Uptake of nutrient particles in order to increase the bacterial biomass, with excretion of the end product to the spatial cell.
- Reproduction by bipartition with the generation of two "new" bacterial cells when the mass is greater than a threshold.
- Viability that is assumed till the mass is under certain threshold, translating the cell to a latency state.
- (i) Active motion only when the bacterium has not achieved nutrient (randomly to a neighbour patch)

The sets of rules regarding spatial cells include:
• The entrance of fresh medium.
• The culture stirring or agitation to avoid adhesion of bacteria in the input flow mechanism or in order to achieve homogenization.
• Output of medium (with nutrient and product) and bacteria.

The global scheduling of the simulation model is made up of various elements:

• (1) initialization of the system with the input data chosen by the user, where initial configuration of the bacterial population and the spatial environment are set up, as well as the parameters for the operating protocol;
• (2) the main loop (time step), in which all the rules for each bacterium and the medium are implemented and repeated, and the external actions on the system are applied, until reaching the end of the simulation;
• (3) the output of results at the end of each time step.

2. Design concepts

Basic principles: The general concepts and basic principles of this model are taken from the knowledge of the general biology of the bacteria and the experimental setup with bioreactors.

Emergence: The operating protocol or external manipulation of the bioreactor is decisive for the dynamics of the biomass production and behaviour of the bacterial population. These features arise from the growth, reproduction and viability of the individuals which are conditioned by local nutrient availability (affected by the entrance or not of fresh medium, and/or the output of the growth medium). Therefore, the individual activity is highly affected by the operating protocol of the culture.

Adaptation: Individual adaptation of the individuals to the availability of the nutrient conditions found to their environment.

Sensing: The bacteria are sensitive to the presence or absence of nutrient in its neighbour.

Interaction: Interactions between bacteria are indirect; they are conducted by the interactions with surrounding medium. There may be competence for nutrient when availability is not sufficient.

Stochasticity: It is introduced into the model when setting some individual actions:

• To fix the initial position of the individuals in the medium In the control of the minimum mass for reproduction and for the entrance of the latency state, using Gaussian distributions around the expected mean values.
• In the position of a new bacterium during the reproduction process.
• To choose the patches to perform the output of the medium.
• To perform the shake of the medium in order to change the position of the bacteria.

Observation: Number of individuals as a counter, and temporal evolutions of the total biomass, the amount of nutrient and the amount of end product.

3. Details

Initialization: The input data builds the system in its initial state, generating the "world" with spatial characteristics, a distribution of nutrient (each patch has an amount of nutrient obtain from a normal distribution with a specific mean value and standard deviation fixed by the user) and a population with initial individual characteristics for
each bacterium: mass, a mean biomass for reproduction and a minimum mass to entry in the latency phase, that can be fixed by the user. The inputs that have to be set up are initial number of bacteria, initial amount of nutrient. Possible operating protocols are: nutrient entrance (there is the option to open or close the entrance of the nutrient in each time step, flow-on or flow-off), stirring or shake the system, and output of the medium (nutrient, product and biomass), the strength of the shaking of the bioreactor and the diffusion coefficient for the nutrient and product can be fixed.

Input data: Not considered.

Submodels: At each time step the model considers the following individual actions:

- ii) Uptake and growth. The quantity of nutrient that a bacterium may absorb is assumed constant and it is limited by the available nutrient of its own spatial cell, this nutrient increase its own biomass. Otherwise, if there is not nutrient the bacterium entries in the latency or hibernate state.

- iii) Reproduction is done by bipartition. Each individual cell has a particular mass to initiate this process, which is given by the mean value chosen by the user and a Gaussian around it. Once this mass is achieved, the bacterium splits, and two new bacteria appear. One remains in the same location and the other chose one of the neighbour patch, each one having half of the progenitor biomass.

- iv) Cell viability is controlled. If the individual does not find nutrient it change to the latency state. As soon as the bacterium can achieved nutrient, its leaves this latency state and became viable again.

- i) Movement. A bacterium can move randomly from its spatial cell to a one of the 8 adjacent spatial cells only if it has no nutrient in its own patch, and it decreases of own mass with this action.

Diffusion of nutrient and end product is performed in the medium.

Stirring or shaking the culture can be decided by the user.

The entrance of fresh medium identified as the entrance of nutrient is carried out according to the handling instructions given by the user at the beginning of the simulation or during th extracting process. When a specific amount of nutrient has to be introduced, there is a shaking process, and an amount of the medium is taken out of the system (this is done with the extraction of an amount of nutrient and end product, as well as a set of bacterial cells chosen randomly).

Flow chart:
**Code:** N6_code.nlogo

View it on Github: https://github.com/culturadigital/forma13/blob/master/N6.nlogo

**Model snapshots:**

**Figure 1.** System status at simulation startup

**Figure 2.** Bacterium at exponential growth

**Figure 3.** Bacterium at mature phase

**Conclusions:**
A first version of a virtual bioreactor implemented in NetLogo has been developed to understand the effect that has the nutrients dynamics on the behavior of a bacterial population in a closed environment.

This preliminary version, without any built-in variable parameterization, allows the discussion of different ideas related to the management on a bioreactor.

The simulations carried out, shows that the system control from sliders built into the simulator interface (agitation, nutrient input flow, time of execution) generates different growths of the microbial population.

It would be necessary identify indicators to assess this bacterial growth and production of biomass according to the different manipulations or values of the model parameters.

It would be necessary to perform with the virtual bioreactor built a series of simulation experiments to analyze the behavior of the model and test the implemented code.

The product developed after these controls and consequent improvements could become a useful simulator for the academic world.

References:


Related models:

- http://ccl.northwestern.edu/netlogo/models/community/Smog
P2. GREEN ALCAZAR

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Brief: The Alcazar of Seville, the oldest royal residence in use in Europe, is an essential node within the network of gardens that along the history of gardening and agriculture have served as laboratories of acclimatization and dispersal of plant species on the planet.

It is a conglomerate of gardens created by different cultures. A palimpsest in which new species have been inserted depending on the inhabitants who lived in the fortress, as well as influenced by the exchange networks that they established with the rest of the world.

The gardens have more than 20.000 plants belonging, at least, to 183 different species; and that are organized into three groups: Islamic gardens, Renaissance and Modern ones.

From this perspective, the unique distribution of species in the gardens of the Alcazar is the result of a slow overlay made by many travelers throughout history.

Some time ago we found a postcard of the gardens of the Alcazar intitled "El libirinto" ("The labyrinth", but misspelled). This postcard subtly suggests the purpose of the research we proposed.

In its foreground we can see the new labyrinth of the palace. It is dated in 19XX, so it shows a young stage of it... at most twenty years after its creation. Obviously, the title of the postcard refers to this space, where it is difficult to orientate yourself but yet easy to describe, easy to understand its structure; a vegetation pattern composed of arcs of cypress and myrtle hedges (which did not appear in the original project, but that ended up being selected by their availability in Seville with a low cost ).

In the background, the constructed contour that the gardens possess is insinuated. A series of fences, walls and architectures that transform those spaces in an unexpected secret in the dense urban fabric of the city center.

Between these two levels, an eventful green lush, colorful, emerges... Specifically we are referring to the "Jardin Inglés" (English garden), but could well be the vision of other gardens where the overlapping vegetation along the time has caused the loss of the initial patterns to silently conquer a certain exuberance close to the climax (which has been appreciated by many scholars as a loss of identity). Thus, compared to a geometrical structure, this space represents another kind of labyrinth, not geometrical but botanical, with a resulting pattern of species much more difficult to describe. This does not mean that there is no organization, therefore, the challenge of this research is to approach the understanding and appreciation of this "random" pattern.

Key question: What are the spatial association patterns among the different vegetation species in the Alcazar of Seville?

ODD Protocol: The aim of this research is to analyze the compositional relationships among species, that is, the pattern that organizes them. To this end, we propose to
find a visual and mathematical model that could explain the probability of appearance of species depending on the neighbouring ones.

- 1. Botanical Catalogue: we have identified and located, in a first approach, over 20,000 plants distributed in at least 150 different species (subsequently, the study has been completed, identifying more than 180 species, but for the realization of this model we used the initial results). However, this analysis does not allow us to approach the pattern of relations of the vegetation of the Real Alcazar, only their number. We can say that this is the botanical "palette".

- 2. Network Analysis: taking advantage of the existence of the database with the identification and location of all specimens, we analyzed mathematically and visually the association probabilities of each species relative to the other ones in a particular area (in this case, the gardens of the Alcazar) through Network Theory. In this sense, this analysis represents something like the garden style, this means not only the palette of available species, but the pattern of their relations, the precise mixture, the alchemy that lies beneath.

To perform the analysis, which is still in process, we have proceeded as follows:
- Data Capture: Identification and localization of the different specimens and systematization in an alphanumeric database.
- Database optimization: A simple python script was used to obtain smaller and more manageable databases that would allow to proceed further with data analysis.
- Clustering analysis: On a following step, Hierarchical Clustering was explored using R language.
- Data filtering: In this stage we obtained a database where you can see the distance to each species relative to the other ones, in a detailed manner.
- LAYOUT 1: In order to make the information more understandable, we have performed a modeling of the data in Processing. This display is structured as a circle in which perimeter 150 species are distributed. At the same time they are ordered by frequency of occurrence using a logarithmic scale.
- LAYOUT 2: Concurrently, those nodes (logarithmically scaled) are joined together by graphs representing the probability of real appearance. In order to simplify (and not undermine the analysis) we performed a filtering of the information by limiting only to the relations between species located within a distance of 10 meters (this measure could be re-evaluated to understand the existence of different degrees of association). The thickness of the graphs varies depending on the frequency of appearance.

(in progress)
- LAYOUT 3: Another aim is to discretize these patterns of association in terms of different variables that can modify the behaviors (types of gardens, presence of infrastructure like roads, architecture, etc.).

- SIMULATION 1: Taking advantage of programs like Net-logo (multiagent systems) we have proposed a series of simulations of growth and evolution of the Alcazar gardens after the insertion of "n" specimens. The objective of this procedure is to check the veracity of the behavioral assumptions that we have made. In a first version, this simulation is executed in response to the behaviors of different species as well as to the characteristics of the spaces where they are inserted.

- SIMULATION 2: Later, we would like to complicate these analyzes with the inclusion of more variables related to the shades, the presence of mutualism networks, etc.

**Flow chart:**
Code: P2_code.pde
View it on Github: https://github.com/culturadigital/forma13/blob/master/P2.pde

Model snapshots:

Figure 1. Visualization of species by population
Conclusions: Until now, the historic gardens have been analyzed from historical, stylistic, or botanical, approaches, etc. Views that are always more or less closed, and more or less integrated. This new approach, linked to network theory and creative data visualization, allows probing new possibilities oriented not only to the botanical identification of species, but also the architecture of its relations in space. We believe that this knowledge will be of great importance for a better understanding, maintenance, replacement or replication of the landscape features of those gardens. Likewise, we understand a relevant degree of innovation represented thus far we have not found similar contributions in the field of landscape architecture in historic gardens.

References:

- Margalef, Ramón "Teoría de los sistemas ecológicos". Barcelona, Universidad de Barcelona, 1991