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Trends and fashions: the approach of agent-based models

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Objetives

Initially, the project aims to implement the model presented by Bettencourt[1], which considers a homogeneous population with no restrictions on the interactions between agents - that is, any agent can influence or be influenced by another. The results will be implemented and reproduced using the Python language. Complex networks[2] will then be incorporated into Bettencourt's model, allowing for more realistic interactions between agents and the representation of authentic social circles. The main objective is to understand the mechanisms behind the spontaneous formation of trends and fashions through agent-based simulations and to verify how the topology of the network of mutual influence between agents affects these dynamics.

Materials and Methods

The methodology involves simulating a system with N agents that exhibit emergent or collective properties, such as trends or fashions. Each agent follows a single trend out of the L trends available at a given time, and all trends are initially equally attractive, without bias. The growth or decline of each trend, called momentum, is given by $p_i(t) = N_i(t) - N_i(t-1)$, where $N_i(t)$ is the number of agents following trend i at time t.
Interactions between agents can alter their tendencies. When two agents i and j meet, if the momentum of i's tendency, p_i , is less than j's, then i adopts j's tendency (conformism pressure). Otherwise, if p_i is greater than or equal to p_j but less than a threshold p_{crit} , i adopts a new unprecedented trend (pressure for singularity). Each interaction corresponds to a time step of $1/N$, and after N interactions, the momentum's of the trends are recalculated.
To interpret and characterize the system described, some global measures are introduced, inspired by analogues from statistical physics, which capture relevant properties. The cycles of rise and decline of trends can be seen as an alternation between states of order (a single dominant trend) and disorder (coexistence of several trends). This uncertainty is measured by Shannon's entropy S, defined as:

$$S = -\sum_{i=1}^{L} n_i \ln n_i, \tag{1}$$

where $n_i = N_i/N$ represents the fraction of agents following the trend i. To interpret the self-organized criticality of the system, the percolation theory is used, characterized by two exponents: the percolation strength P_{c} (fraction of the system occupied by the largest group) and the percolation susceptibility S_{c} (average fraction size of the groups with the largest subtracted). Formally, we have:

$$P_c = \frac{\max(N_i)}{N} \tag{2}$$

and

$$S_c = \frac{\left(\sum_{i=1}^{L} N_i^2\right)}{N^2} - P_c^2. \tag{3}$$

Once the model has been implemented, the *NetworkX* library from *Python* will be used to generate and visualize the complex networks that will represent the agents' social networks. The networks will be generated using the Erdős-Rényi random graph model, the Watts-Strogatz small world model and the Barabási-Albert scale-free model. With these models, it will be possible to analyze how the topology of the network influences the cycles of formation and decline of trends and fashions.

Results

With the model described, it is possible to generate cycles of trend formation and decline. These cycles are represented by the plots of the measurements shown in Figures 1 and 2. When a dominant trend appears ($P_c = 1$), entropy reaches its minimum ($S = 0$), representing the most ordered state of the system. The maximum entropy occurs with a uniform distribution $n_i = 1/L$, resulting in $S = \ln L$. The percolation susceptibility, whose plot has been omitted here, shows a similar behavior, peaking when P_c is minimum and being zero when it is maximum.

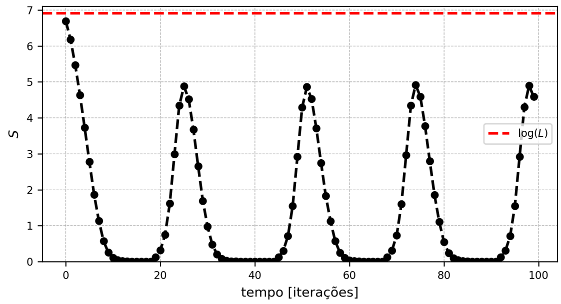

Figure 1: Shannon entropy for $N = 10^5$, $L = 10^3$ and $p_{\text{crit}} = 1$.

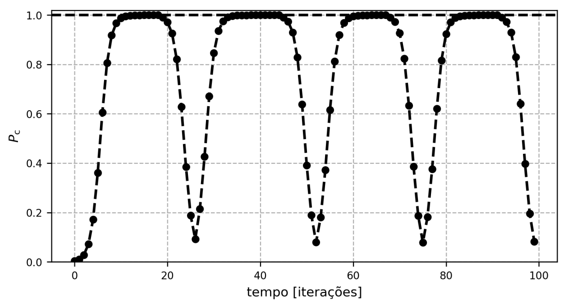

Figure 2: Percolation strength for $N = 10^5$, $L = 10^3$ and $p_{\text{crit}} = 1$.

By including complex networks in the model, it was possible to obtain results similar to those presented previously with the three models mentioned. The evolution of the system is illustrated in Figure 3, which shows the formation of a dominant trend (all agents with the same color), its decline and then the formation of another.

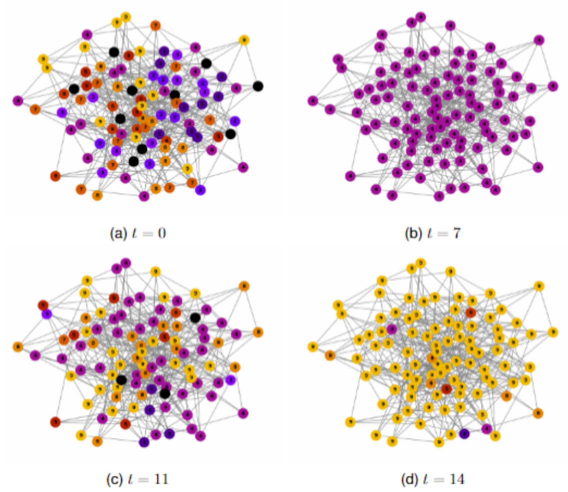

Figure 3: Evolution of the complex network of agents generated by the Erdős-Rényi model with $N = 10^2$, $L = 10$ and $p_{\text{crit}} = 1$.

Conclusions

This project developed an agent-based model capable of describing the dynamic pattern of formation and decay of trends and fashions, taking into account the pressures for conformism and singularity. We observed alternating cycles of order, dominated by a single trend, and disorder where many small trends compete for popularity. In addition, complex networks were implemented to generate the interaction network between agents, thus making the model more realistic.

Acknowledgments

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References

[1] Luis MA Bettencourt. From boom to bust and back again: the complex dynamics of trends and fashions. *arXiv preprint cond-mat/0212267*, 2002.

[2] Mark EJ Newman. The structure and function of complex networks. *SIAM review*, 45(2):167–256, 2003.