UNIVERSITATEA DIN BUCUREȘTI

VIRTUTE ET SAPIENTIA

FACULTATEA DE FIZICĂ

Titlul tezei

Lucrare de Licenţă

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Cuvânt Înainte/Mulţumiri

Titlul acestuei Sectiuni este la alegere: Cuvant Inainte sau Multumiri; depinde ce doriti sa contina. Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.

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Introduction

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$$t = \frac{D_p}{D_0} \tag{1.1}$$

unde: D_p este doza totală acumulată numită paleodoza iar D_0 reprezintă doza anuală de radiaţii. Ecuatia in text se citeaza (1.1)

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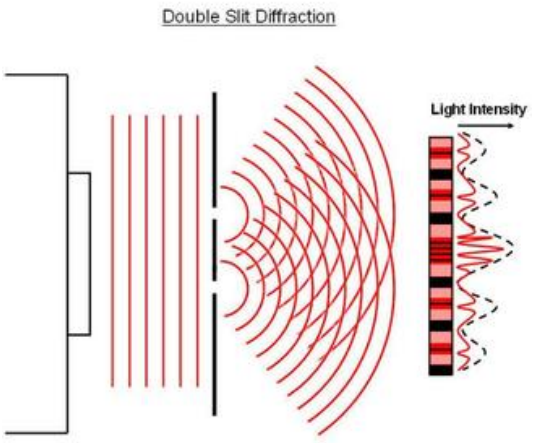

Figure 1.1: *Legenda figurii*

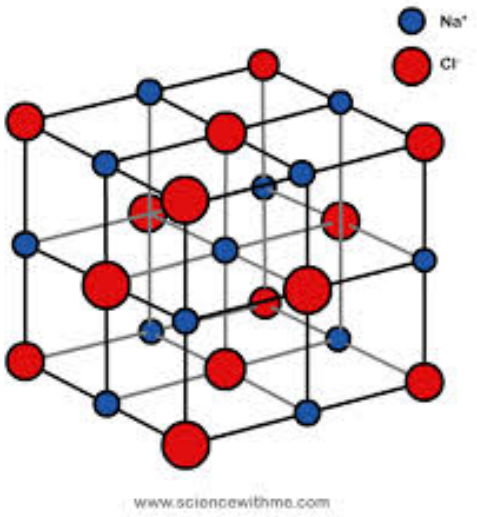

Figure 1.2: *Legenda figurii*

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Statistical Physics of Social Dynamics: A Brief Review

-translation + tradition
The idea of a physical modeling of social phenomena is not at all a new one. In an 1825 essay, french philosopher Auguste Comte defines social physics as: "that science which occupies itself with social phenomena, considered in the same light as astronomical, physical, chemical, and physiological phenomena, that is to say as being subject to natural and invariable Laws the discovery of which is the special object of its researches."[1, 2] He would later go on to refer to this new field as sociology.

2.1 The Ising Paradigm

-Ising + voter model

2.2 Cultural dynamics

-cultural dynamics

Table 2.1: *Equivalence of thermodynamics terms to social science according to Mimkes' model of regular mixtures*

Abbreviation	Natural Science	Social scienceă
A-B	Alloys	Societies
x	atomic percentage	size of minority (%)
	Functions	Feelings
G	free enthalpy	general happiness
T	temperature	tolerance
E_{AA}	cohesive energy	tradition, heritage
$E_{AB} > 0$	cohesive energy	curiosity, love
$E_{AB} < 0$	repelling energy	distrust, hate
$E = 0$	no cohesion	apathy
$\epsilon > 0$	attractive interaction	sympathy
$\epsilon = 0$	ideal solution	indifference
$\epsilon < 0$	repelling interaction	antipathy
	State of alloys	State of Society
	disorder, solubility	integration
	solubility limit	segregation
	phase diagram	intermarriage diagram

Model Setup

In this thesis, I model opinion dynamics by using a Potts-like agent-based model, and the evolution of the network structure is performed by using a slightly modified version of Axelrod's model of dissemination of culture. This chapter provides the reader with a detailed description of the proposed model.

3.1 Agent characteristics

A directional network consisting of N agents is used. Each agent is represented by a vertex in the network, accompanied by a set of three features. These features are:

1. **Vote:** a variable in the range of $v = 0..n$, representing the agent's opinion. *Votes* can be understood literally, as voting intention in an election, or, more generally, as an opinion subject to quick change in a social network.
2. **Cultural vector:** a vector $\sigma = (\sigma_1, ..., \sigma_F)$, with $\sigma_f = 0, 1, ..., q$, representing an immutable set of cultural characteristics. Here culture is understood as, in Axelrod's words, "*the set of individual attributes that are subject to social influence*".
3. **Energy:** defined as $\epsilon_i = -J \sum_j \delta v_i, v_j$, where $j \in$ inneighbors, and δ is the Kronecker delta symbol. Note that this definition is akin to the Potts model Hamiltonian, with the difference that in this case spins are replaced by *votes*.

3.2 Network rewiring

Each step, an agent is selected for which, with a certain probability, an inneighbour will be removed and another added. Here, I referred to the transition probability defined by Axelrod for his model of dissemination of culture:

$$\omega_{i,j} = \frac{1}{F} \sum_{f=1}^{F} \delta_{\sigma_f(i),\sigma_f(j)} \tag{3.1}$$

However, this probability only grows when to cultural characteristics are *identical*. In reality, beliefs are usually on a spectrum of intensity. For instance, a person with a belief

$\sigma_f = 3$ will find themselves more likely to interact with another with $\sigma_f = 4$ rather than one with $\sigma_f = 9$. Taking this into consideration, a new function η can be devised:

$$\eta_{i,j} = 1 - \frac{1}{F} * \frac{1}{q} \sum_{f=1}^{F} |\sigma_f(i) - \sigma_f(j)| \tag{3.2}$$

Using this revised probability, this stage in the time-step is defined by the following activities:

- One agent i is selected at random.
- Another agent j that is not an inneighbour is selected randomly.
- With a probability $\eta_{i,j}$ an edge from j to i is added, and i's energy ϵ_i is reevaluated.
- Now an agent k is selected randomly from i's inneigbours.
- With a probability $1 - \eta_{i,j}$ the edge from k to i is removed, and i's energy ϵ_i is reevaluated.

It is immediately apparent that this rewiring procedure will lead to similar agents becoming more connected, and eventually forming hubs. This behaviour mirrors the echo-chamber effect observed in social media.

3.3 Opinion dynamics

Having rewired the network the selected agent's connections, it will now reconsider its *vote*. This happens by attributing a new random vote to the agent, and reevaluating agent energy with the new vote. If the energy is lower, i.e. the agent's opinion is more in line with his influencers', then the new vote is kept. Otherwise, it will keep its new opinion with a certain probability, which is dependent on temperature (tolerance) T and difference in energy $\Delta\epsilon = \epsilon_{new} - \epsilon_{old}$:

$$p = exp(-\frac{\Delta\epsilon}{T}) \tag{3.3}$$

3.4 Overall execution procedure

Putting the network rewiring part and the opinion dynamics parts together, the algorithm will go through the following procedure:

Step 1: Generating initial population. A data vector containing N data structures is created, where each data structure contains the features described at section 2.1, with random votes and cultural vectors.

Step 2: Network initialization. A Barabási–Albert graph is initialized, growing by adding new vertices to N_0 initial vertices. Each new vertex is attached to k different vertices already present in the system by preferential attachment.

Step 3: Compute initial energy and vote distribution. Compute energy for each agent, count vote distribution, then store the data in the log.

Step 4: Select random agent.

Step 5: Network rewiring. Perform the network rewiring procedure on the selected agent, recalculating ϵ and E afterwards.

Step 6: Opinion dynamics. Perform the opinion dynamics procedure on the selected agent, recalculating ϵ and E afterwards.

Step 7: Advance to next step. Advance the time step and go back to Step 4 until desired number of steps is reached.

Step 8: Data export. The generated data containing the E time series, vote distribution over time and the final network form is exported.

3.4.1 Lorem ipsum

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NB *Citarile în text:* (Arhipova et al. 2000, Muhs 2013) sau [2,4]

Titlul capitolului 3

4.1 Lorem ipsum

4.2 Lorem ipsum

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Table 4.1: *Legenda tabelului*

Proba	Adâncimea (m)	Descriere sumară
PS I	4,5	brun deschis
L I	5,1	brun
L II	8,2	brun deschis
L III	9,1	brun deschis - roşietic
PS II	9,5	brun
L IV	10,1	brun închis - roşietic
PS III	10,4	brun închis
L V	10,9	roşu brun
L VI	11,8	roşu brun
PS IV	19,1	roşu brun isînchis

4.2.2 Lorem ipsum

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Concluzii/Concluzii Generale

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[1] Georg G. Iggers. Further remarks about early uses of the term "social science". *Journal of the History of Ideas*, 20(3):433, 1959.

[2] Auguste Comte. onsidérations philosophiques sur les sciences et les savants. *Le Producteur, journal philosophique de l'industrie, des sciences et des beaux arts*, I(465), 1825.