Application of a physical model in the study of dynamic co-authorship networks formed from scientific articles

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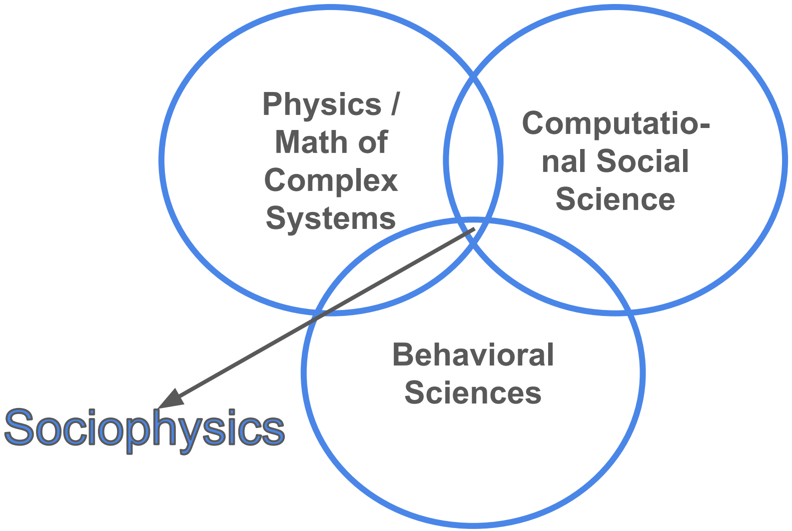
Content

Introduction

What is the sociophysics?

Sociophysics is a novel branch of interdisciplinary physics that studies the collective phenomena that emerges from the interactions of individuals as elementary units in social structures.



Introduction

Adolphe Quetelet
(1796 - 1874)

SUR L'HOMME

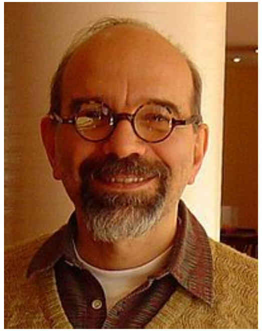
DÉVELOPPEMENT DE SES FACULTÉS,

ESSAI DE PHYSIQUE SOCIALE;

TOME PREMIER.

PARIS,

1835



Serge Galam

Journal of Mathematical Sociology, 1982, Vol. 9, pp. 1-13
0022-250X/82/0901-0001$06.50/0

SOCIOPHYSICS: A NEW APPROACH OF SOCIOLOGICAL COLLECTIVE BEHAVIOUR. I. MEAN-BEHAVIOUR DESCRIPTION OF A STRIKE

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The idea of a physical modeling of social phenomena is in some sense older than the idea of statistical modeling of physical phenomena (Castellano, Fortunato, & Loreto, 2009).

Introduction

Which fields have been investigated?

Human dynamics

Opinion dynamics

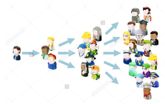
Vehicular traffic

Cultural dynamics

Language dynamics

Crowd behavior

Group decision making

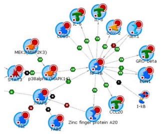


Social spreading phenomena

Network theory

Network theory has emerged almost twenty years ago, as a new field for characterizing interacting complex systems (Bianconi, 2015).

Internet networks



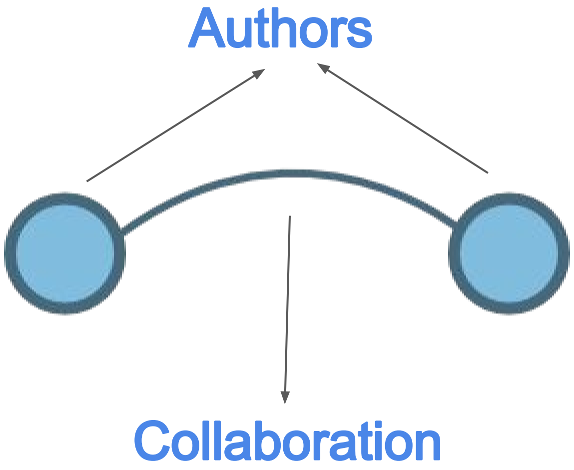
Biological networks

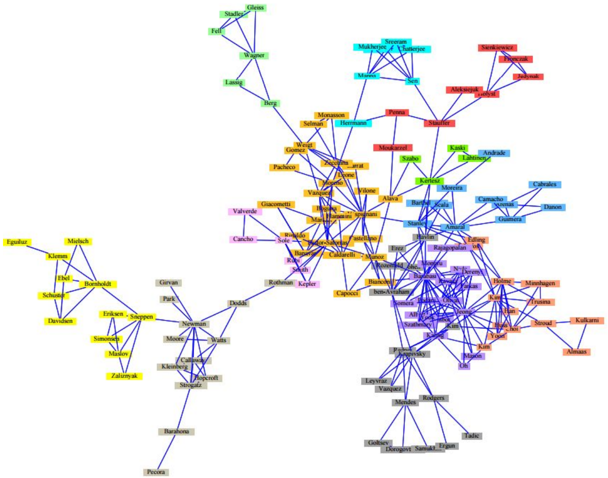
Social networks

Introduction

Which social network?

Networks of coauthorship of scientists or other academics provide some of the best documented examples of social networks (Newman and Park 2003).





The largest component of the network of coauthorships. This component contains 142 scientists. The vertices are colored according to the communities. The communities correspond reasonably closely to geographical and institutional divisions between the scientists shown.

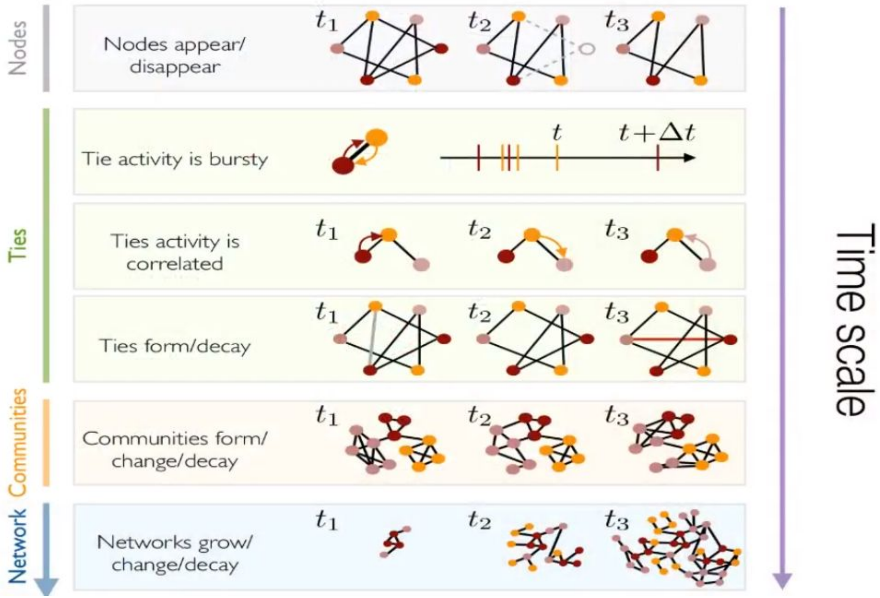
Justification

Why study coauthorship networks?

- Co-authorship networks investigate the collaborative patterns of researchers.
- Hennemann (2010) used co-authorship networks to trace the development of science and technology in China.
- Demirkan (2012) showed that biotechnology firms depend heavily on social network of researchers for the exchange and production of knowledge.
- Co-authorship network analysis was used by a Brazilian Ministry as a tool for Strategic planning and capacity building (Morel et al., 2009).

Justification

- Studies in co-authorship networks have been mostly on “static” data (Kumar, 2015).



Introduction to Complex Systems [Figure]. Retrieved from http://fundacionsicomoro.org/introduccion-los-sistemas-complejos/

Justification

- There is a single basic question of social dynamics: how do the interactions between social agents create order out of an initial disordered situation? (Castellano, Fortunato, & Loreto, 2009).
- Social networks are often divided into groups or communities (Newman and Park 2003).

Technological contribution

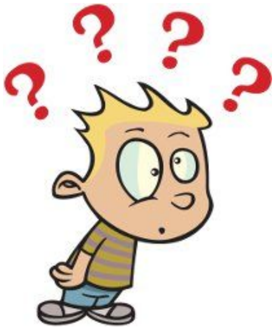
Scientific communities

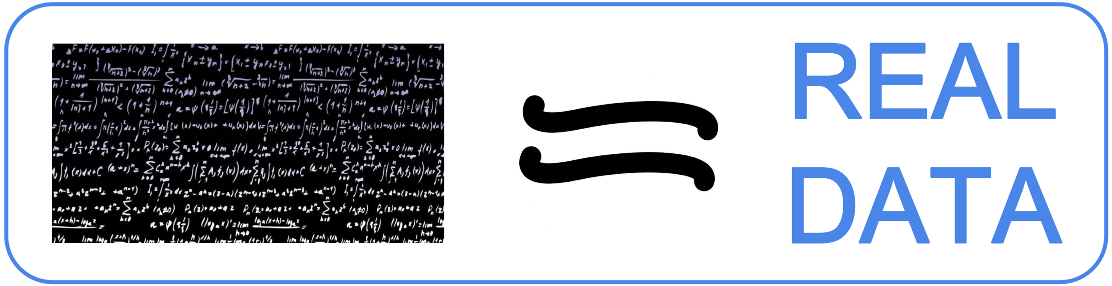
TOS

TREE OF SCIENCE

Justification

- The introduction of a profusion of theoretical models has been largely justified by vague plausibility arguments, with no direct connection to measurable facts. Very little attention has been paid to the stringent quantitative validation of models and theoretical results. The contribution of physicists in establishing social dynamics as a sound discipline grounded on empirical evidence has been so far insufficient (Castellano, Fortunato, & Loreto, 2009).





Background

Sociophysics: A New Approach of Sociological Collective Behaviour. I. Mean-behaviour Description of a Strike.

In the present paper we study a simple model of collective behaviour, which we propose to call a model of mean behaviour (M.B.). We apply this model to the description of a strike process in a big plant. We consider an ensemble of identical individuals, taking into account the contacts between them and a few sociological characteristics of the society they belong to. In order to find what is the actual state of the collective out of all the a priori possible states, we introduce the principle of minimum dissatisfaction (Galam, Gefen (Feigenblat), & Shapir, 1982).

Background

TABLE 1. Definition of parameters and variables of the MB Model.

Quantity	Notation	Comment
<u>Microscopic Level</u>		
Individual production	$\tilde{\mu}_i$	$0 \leq \tilde{\mu}_i \leq 1$
Normalized individual production	μ_i	$-1 \leq \mu_i \leq 1$
Contact	J_{ij}	$J_{ij} = J > 0$
<u>Macroscopic Level</u>		
Number of workers	N	$N > 1$
Entropy	$S = \ln L$	
Social permeability	$1/T$	
Mean production	$M = \langle\mu_i\rangle$	$-1 \leq M \leq 1$
Effective salary	H	
Dissatisfaction function	F	Principle of Minimum Dissatisfaction

$$\mu_i = 2(\tilde{\mu}_i - \tfrac{1}{2})$$

$$-J_{ij}\mu_i\mu_j$$

$$M = \langle\mu_i\rangle = 1/N \sum_i \mu_i$$

$$S = \log L$$

$$-\mu_i H$$

Background

The *Principle of Minimum Dissatisfaction (PMD)* would then state:

"Given H, T and J, the variables of the system M and S assume values Mo and So (both functions of H, T and J) such that F is minimum".

A general expression for the differential of F is (for a fixed J):

$$dF(H,T) = -MdH - SdT$$

Background

Its consider the dissatisfaction caused by interactions between individuals and the influence of H.

$$- \sum_{i,j} J_{ij}\mu_i\mu_j - H \sum_i \mu_i \xrightarrow[\{J_{ij}\}=J]{} -J \sum_{i,j} \mu_i\mu_i - H \sum_i \mu_i$$

$$\boxed{M = \frac{C(H/T)}{1 - (a'/k)}}$$

with

$$a' = aC/J \qquad K = T/J \qquad K_C = a'$$

Background

The individual phase ($K > K_c$)

The collective phase ($K < K_c$)

- The collective phase includes a region of parameters, for which the system has two possible states: a state of work ($M > 0$) and a state of strike ($M < 0$).

The actual state of the plant (i.e., whether it is a "strike state" or a "work state") depends on its "history" *(the phenomenon of hysteresis)*.

Background

Suppose we start from a state of M > 0, and the system has Mo > 0 (the plant is in a state of work).

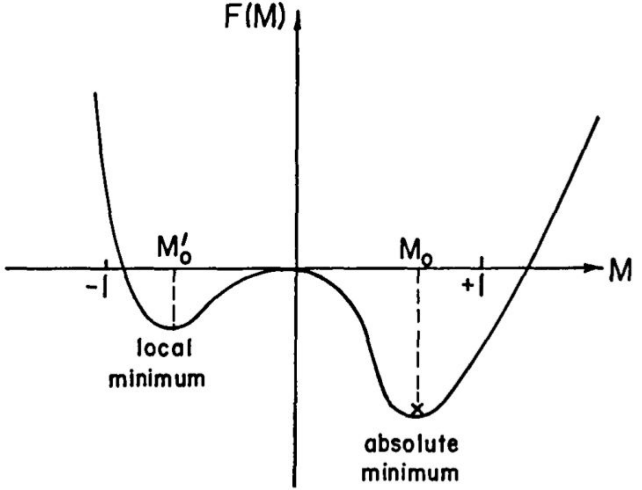


Figure 1. Dissatisfaction function F vs. M for K < K_i. In the following x denotes the actual state of the system H > 0.

F has two minima—the lowest one represents the actual state of the plant.

Background

Decreasing H, the other minimum (with Mo’ < 0) becomes lower, and the system, being still at Mo > 0, is in a metastable state.

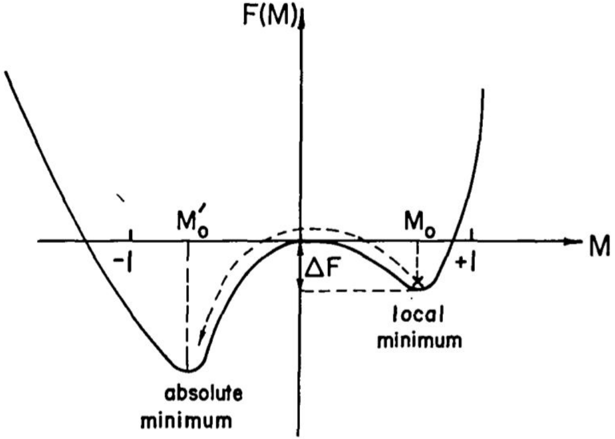


Figure 2. A metastable case with H < 0. The dashed line denotes a possible jump to a stable strike state due to some perturbation.

The fact that the system is at Mo > 0 (though the "strike state" at Mo’ < 0 is more stable) reflects the dependence of the system on it’s history.

Background

The system may jump to Mo’ (i.e., from a "work state" to a "strike state") in one of two cases:

1. When H decreases further and we reach the limit of metastability (the minimum at Mo > 0 disappears).

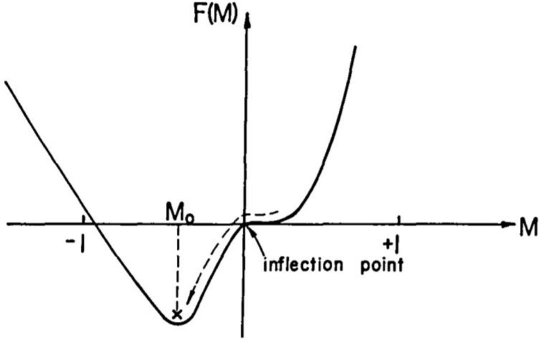


Figure 3. The limit of metastability for H < 0. F has only one minimum.

Background

2. Due to some perturbation. Such a perturbation, either external (e.g., external influence) or internal (small group of working calling for a strike) can virtually raise the dissatisfaction of the workers by at least ΔF (for a short time) such that the system can "overcome the barrier" and shift to the stable state.

Background

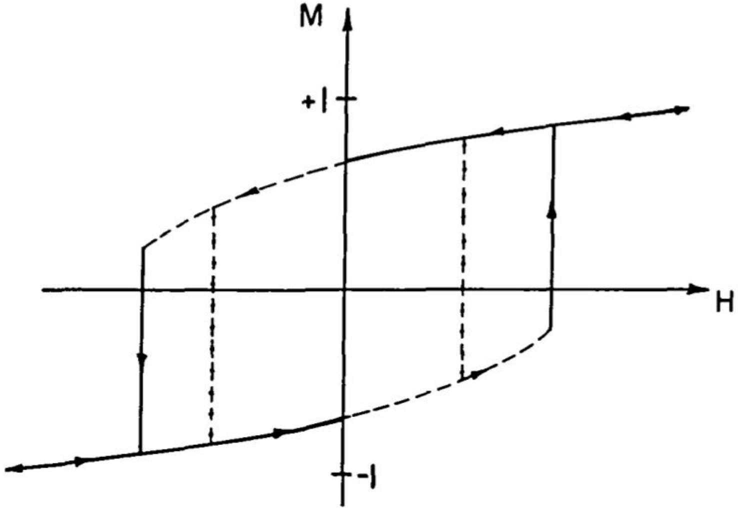


Figure 4. M vs. H for $K < K_c$. Arrows show the direction in which H is changed. Solid lines denote stable states. Dashed lines denote metastable states. "Dot-dash" lines show possible jumps from metastable to stable states.

Background

Conclusions

- The ratio between the inverse of the social permeability and the contact (denoted by $K = T/J$) determined the character of the plant. For K smaller than a certain critical value, the behaviour of the system is essentially "collective." For larger values of K, the character of the system is individual.
- There are metastable states of the system. In those cases the system is in a state of work (apparently a normal, stable state of work), but a small perturbation (e.g., external influence, a small group of workers calling for a strike) may cause the system to shift to a stable state of strike.
- In this work, we considered a simplified model. Beyond considering the specific case of work and strike in a plant, we suggest that the importance of this approach lies in the use of physical methods.

Research question

Which physical model can be used in the characterization of the dynamic present within the coauthorship networks?

Objectives

General objective

To propose a model of dynamic social networks using a physical model through the statistical analysis of co-authors of scientific articles.

Objectives

Specifical objectives

To develop and implement an algorithm program for the extraction of co-authors from data downloaded from Web of Science.

To analyze the dynamic behavior of coauthorship networks by means of statistical physics.

To determine the adjustment of different physical models with respect to the behavior of coauthorship networks dynamic.

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THANKS !