

A BILLIARD TABLE MODEL FOR RUMOR PROPAGATION IN A RANDOM SMALL-WORLD NETWORK AND ITS EXTENSION TO A LARGE-WORLD SYSTEM MODELING CHEMICAL KINETICS AS COLLISIONAL DYNAMICS ON A MACROSCOPIC LEVEL.



It is rumored that the authors of this paper are:

Nisheeth, Shashi and Venkat

Introduction

The study of rumor-mongering is an emergent concept in applied mathematics and the social sciences. Contemporary solutions usually employ epidemical models upon small-world networks or Markov chains under the assumption of random walk behavior.

We intend to simulate and study the problem of rumor propagation in small networks through what we denominate the ‘billiard table’ model. We also consider, theoretically, the idea of scaling both processes up to a macroscopic level and considering the generic problem of rumor propagation as a problem in chemical kinetics.

Overview of design

To conceive of the rumor propagation process as the movement of balls on a billiard table, we must enlist the aid of the following analogies:

Rumor propagation	Billiard ball model
Types of rumors	Intensity of billiard cue impulse
	Spin and English provided by initial impulse
Psychological profiles of recipients	Mass of balls
Duration of event interest	Friction of table surface
Recipient's personal networking	Distance between balls
Boredom	Velocity-dependent coefficient of restitution

A discussion of the appropriateness of the analogies follows:

1. It is known that the nature of the rumor plays an important role in deciding the eventual extent of its spread. Rumors that lend themselves to easy dissemination have been found to typically contain:
 - i. Sexuality
 1. Innuendo
 2. Accidental/Malicious Exposure
 3. Improbability
 - ii. Notoriety
 1. Idiosyncratic behavior
 2. Ability incommensurate with achievement
 3. Achievement incommensurate with ability
 - iii. Local relevance

2. It is known that a rumor recipient will proceed to transmit it with an impetus that varies as a function of his psychological profile
 - i. Personal involvement with rumor
 - ii. Jungian typology
 - iii. Berne's Transactional Analysis

3. It is known that the duration of relevance of a rumor is directly related to the extent of its spread

4. It is known that the density of a recipient's personal network i.e. The number of people he interacts with regularly within the duration of the event interest, directly affects his/her contribution to the spread of the rumor.
5. It is known that a person's inclination to spread a rumor will decrease upon each encounter with another person who already knows of it.

Problem in General Physics

We are now left with a physics problem of modeling a set of billiard balls with variable masses and random spacing on a table. Solutions to this exist already in the form of Java applets and all that is required is to change the parameters for the program with the following algorithm.

Design Algorithm

1. Assign the initial cue impulse a value between 1 to 100 depending upon the type of rumor through the following scheme:
 - i. Assign each of the six sub - classifications a scale of 1 to 10, assign local relevance a score of 40
 - ii. Rate the rumor according to relevance on all six scales
 - iii. The cumulative value is assigned as the initial cue impulse

2. We assign masses to the balls at random as a fraction of the heaviest ball M such that:

$$m = (1 - f) M$$

Where,

m is mass of random ball
 M is mass of heaviest ball
 f is fraction

This fraction is arrived at by considering random points on a Gaussian distribution with a peak at 1 on the Y-axis.

3. Carl Jung developed a system of typology for characterizing personality types. We employ his 8 stratifications to assign masses to our balls, in increments of 0.125M in increasing order as follows:
 - i. Introverted intuitive thinking type
 - ii. Introverted intuitive feeling type
 - iii. Introverted sensate thinking type
 - iv. Introverted sensate feeling type
 - v. Extroverted intuitive thinking type
 - vi. Extroverted intuitive feeling type
 - vii. Extroverted sensate thinking type

viii. Extroverted sensate feeling type

The maximum mass contribution through this factor will be M for the extroverted sensate feeling type – the typological gasbag.

4. We increment or deduct a mass m' based on whether the rumor represents a Child-Child interaction or a Parent-Child interaction, as conceived by the British psychologist Eric Berne.
5. Coefficient of rolling friction is assigned between 0 and 1, based on the duration of relevance of the event on a logarithmic scale.
6. Relative spacing is determined at random and will vary for each network topology. It is not relevant to the logical flow of the algorithm.
7. We also include coefficients of restitution in our model. These, however, differ from the physical coefficients of restitution in being monotonically increasing functions of the velocity of the balls.

Chemical kinetics approach to large-world networks

We have seen that the billiard table model, in terms of parameters associated with rumor propagation, is a comprehensive simulation. The next step is to realize that scaling this model up to a high enough order of magnitude, we arrive at the theory of chemical kinetics as a possible simulacrum for large-world networks, a problem that is so far unaddressed. Here, we examine the feasibility of drawing this parallel analogy, and analyze empirical evidence to bolster our assertion.

Chemical Kinetics	Billiard ball model
Enthalpy	Intensity of billiard cue impulse
Chirality and Isomerism	Spin and English provided by initial impulse
Mass of molecules	Mass of balls
Impurities	Friction of table surface
Mean Free Path	Distance between balls
Gibbs' Free Energy	Velocity-dependent coefficient of restitution

Overview of Design

We propose a kinetics model that takes the form of a non-linear differential equation:

$$dN(t)/dt - I \ln(t + 1) = \sum \alpha_1(t) N_i(t) + \sum \alpha_2(t) N_i(t)^2$$

Where,

$N(t)$ is the number of people who know the rumor at time t
 α_1 is of an Arrhenius form $\alpha_1 = A \exp(-\Delta H/RT)$
 α_2 is of the form $\max[A' \exp(-\alpha_3 N(t)^2) - B', 0]$
 I is the impurity factor introduced by the duration of relevance of the event
 t is time in days

We justify this in terms of our analogies as follows:

1. ΔH is the enthalpy of the system, in our model – the initial cue impulse
2. T , as is evident from the theory of collisions, is a scaled version of the mean free path
3. The summation runs over the different masses assigned to the sample points (N_i)
4. α_3 is a linear function of the networking density of any given topology, and is equated to density in the kinetics model.
5. A , A' , B , B' and R are parameters that require empirical calculation through physical observations

Explanation

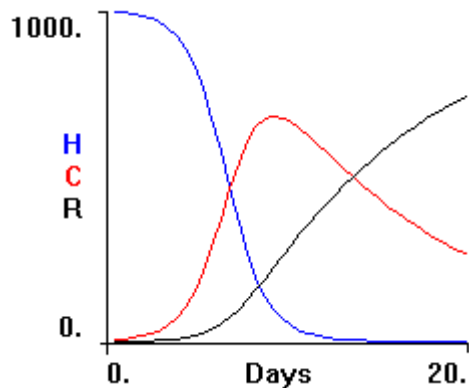
As may be seen from the form of the NLD, the system exhibits the following characteristic behavior:

1. α_1 behaves as a forward rate constant of a chemical reaction. At inception, it is α_1 that decides the rate of the reaction
2. As the reaction approaches steady state, the contribution of the first term tends to zero, and the second term becomes of paramount importance in deciding the long-term behavior of the system

3. The long-term behavior of the system has two alternatives – an equilibrium of rumor propagation or a decay into innocuity. This depends entirely on the term $A' \exp(-\alpha_3 N_i(t)^2)$.
4. Should this term be greater than the threshold value of B' at steady state, the rumor shall have attained a state of equilibrium and hence, for a large enough sample space, may be termed an ‘urban legend’. Should the term not exceed B' , the second term in the NLD shall go to zero and the rumor shall be considered dissipated.

Simulation results

Based on a simulation with arbitrarily assigned constant values run on a futuristic neuron-driven computing device that eschews determinism and numerical accuracy in favor of ribaldry and amusement, a basic graph for an overview of the nature of the results follows:



Here,

H represents the number of ‘healthy’ people, who have not heard of the rumor
 C represents the number of ‘carriers’, the people who are spreading the rumor
 $R = H - C$ represents the number of ‘recovered’ people, those who are no longer spreading the rumor

Conclusion

Through this study, we have undertaken the hitherto unaccomplished task of modeling rumor propagation on large-world networks. We achieve a reasonable degree of verisimilitude through building our model using individual molecular collisions (“billiard balls”) at the small-world level and arriving at the macroscopic model through the already established relationship between collision theory and chemical kinetics.

Pending empirical testing, we cannot assert with complete confidence as to the accuracy of our model’s predictions for the critical threshold of a particular social topology.

However, given the accuracy of our parameter selection, the verisimilitude of our modeling, and the conceit of our heads, we see no reason to believe otherwise and hope to bring forth empirical evidence for the same anon.

References:

1. D. J. Watts, *Small Worlds* (Princeton University Press, 1999).
2. D. Maki and M. Thomson, *Mathematical Models and Applications* (Prentice-Hall, Englewood Cliffs, 1973).
3. S.C. Manrubia, J. Delgado, B. Luque, Small-world behavior in a system of mobile elements, *Europhys. Lett.* 53 (2001) 693–700.
4. D.H. Zanette, Dynamics of rumor propagation on small-world networks, 2001. *Cond-mat/0110324*.
5. “Psychology and the East”, C F Jung
6. “Games People Play”, E Berne

Acknowledgements:

Josh Tenenbaum, Head of BCS, MIT, for being the inspiration for this project. I wish to prof to him and this, for all that it is an entry to the Ig Nobel contest, with a bit less levity and a lot more rigor, should allow me some modicum of *locus standi*

IIT Madras, for providing us with a sense of superiority over other mortals that allows us to be vapid enough to fritter away our youth doing stuff like this

Our hostel wing mates for making our lives inane enough for us to be driven by sheer frustration into developing this and justify the continuance of our pathetic existence to ourselves

The Ig Nobel Prize coordinators, the incomparable, unsurpassable, most benevolent, most magnificent, most puissant Fudu and ID; for sucking up is supposed to always pay.