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Introducing serendipity in a social network model of knowledge diffusion

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ABSTRACT

In this paper, we study serendipity as a possible strategy to control the behavior of an agent-based network model of knowledge diffusion. The idea of considering serendipity in a strategic way has been first explored in Network Learning and Information Seeking studies. After presenting the major contributions of serendipity studies to digital environments, we discuss the extension to our model: Agents are enriched with random topics for establishing new communication according to different strategies. The results show how important network properties could be influenced, like reducing the prevalence of hubs in the network's core and increasing local communication in the periphery, similar to the effects of more traditional self-organization methods. Therefore, from this initial study, when serendipity is opportunistically directed, it appears to behave as an effective and applicable approach to social network control.

1. Introduction

Models of knowledge and information diffusion in networks have been analytically studied since long, mostly in sociology, economics, and information science. It is inherently an interdisciplinary research since its roots, as evident in the classical Simon's study [1] of a class of distribution functions, the Yule–Simon distribution, which often occurs in nature, especially in social phenomena. Interestingly, modern studies of how ideas spread in a network of homogeneous agents demonstrated that the distribution is an extension of the Yule–Simon distribution [2]. Other important cumulative nonlinear effects of knowledge diffusion in networks, like the distribution of popularity of an idea [2,3], have their roots in works like the de Solla Price's study of Cumulative Advantage distribution [4], which models situations where failure does not breed failure and success breeds success. Other important research have considered the relation between knowledge diffusion and network structure [5,6], the emergence of collective behavior [7,8], and self-organization [9,10].

Another key research area for our work is related to learning and how to model the process of learning in an agent-based network. In Gale and Kariv model of social learning [11], the process of learning among agents depends on the network structure and is subject to local rules of agents behavior. De Laat et al. [12] studied how modern Social Network Analysis can improve networked and collaborative learning studies. In particular, they focused on the analysis of interaction patterns and community formation. Recently, Guechtouli [13] characterized knowledge in an agent-based model as an array of stockpiles, meaning that a certain agent may have different knowledge with different degree of expertise and agents choose the most competent agent in the population. A similar assumption was already made in the study on growth and diffusion of knowledge by Jovanovic and Rob [14], where heterogeneity of knowledge distribution in a network is key to its diffusion. Our agent-based model of knowledge diffusion [15,16] represents an extended version

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of Guechtouli's direct transfer knowledge model by constraining the choice of the most competent agent to the network structure.

In this work we aim at addressing the unexplored relationship between *knowledge diffusion models* and *serendipity studies*. The concept of serendipity has become of interest for agent-based models of knowledge diffusion and network learning because, it is assumed, if properly controlled, it could be an effective tool for influencing the interactions between agents and the diffusion process, and for escaping an excessive tendency of social networks to homophily and homogeneity. Therefore, our motivating research question is: could serendipity be introduced into a social network as a strategy for influencing the dynamic of the knowledge diffusion process and the network characteristics? The answer seems positive, from this initial study.

Simulations have been run based on different synthetic social networks produced with an extended version of the model fully described in [16]. Serendipity in agent behavior has been modeled as new topics *randomly* inserted in agents' state during a simulation. Such a solution wish to represent the typical "unexpected encounter" of serendipity and to modify both the agent's criterion of choice of who to communicate with and how knowledge among agents is transmitted. Different strategies to induce a serendipitous behavior have been tested.

2. Background on serendipity

2.1. Definitions of serendipity

The concept of *serendipity* has a long history of attempts at defining it. Van Andel [17] defines it as "the art of making an unsought finding" and dates back its initial diffusion to literary circles of the 18th century. Defining serendipity as an "art" is a clear indication of the perceived elusive nature of the concept. More recently, with the diffusion of serendipity studies in some academic fields, definitions of serendipity have lost that "artistic nuance" in favor of more pragmatic descriptions for which chance is one important ingredient of a process involving the individual enjoying a serendipitous experience and the environment in which the individual lives.

It was only when serendipity has been recognized as interesting for Information Seeking research that more structured and less anecdotal studies appeared [18,19]. Serendipity as "an unexpected experience prompted by an individual's valuable interaction with ideas, information, objects, or phenomena", as recently described by McCay-Peet et al. [20], is an example of more meaningful and elaborate definition. In that case, like in similar ones, the personal and unexpected nature of the experience is stressed, as well as the (perceived) value/benefit obtained and the many possible sources of serendipitous encounters (ideas, information, people, etc.)

The most important innovation with respect to the understanding of serendipity's nature introduced by Information Retrieval and Information Seeking studies was to consider it as a phenomenon and an experience to be pursued [18,21]. If serendipity could be somehow facilitated or enabled, then the issue of *control* becomes relevant, although it shows some paradoxical elements [22]. Several scholars commented that if serendipity could be controlled, then an event is no longer serendipitous, but predictable or reproducible. Others have argued against this apparent contradiction noting that even though serendipity cannot be fully controlled being characterized by chance, the perception of serendipitous encounters could be enhanced as well as the odds of an unexpected positive event [18,19,22–25].

Erdelez first contributed to serendipity research by introducing the notion of *information encountering* as a fortuitous way of acquiring information different from browsing or information seeking [26]. Her second contribution was to introduce four categories of *information users: non encounterers*, people that very seldom perceive to have experienced an information encounter; *occasional encounterers*, those that perceive to have information encounters from time to time, but credit just luck for those events; *encounterers*, those which often experience information encounters, and finally *super-encounterers*, people that recognize in information encountering a suitable and effective strategy for acquiring information, a fruitful complement of active information seeking and browsing.

2.2. Serendipity in networks and knowledge diffusion

Still few studies have directly addressed the relation between serendipity and a digital environment: How are serendipitous events supported by the environment and which are the most relevant features of the context? The interest in these research questions has grown in recent years, in particular in the area of Networked Learning [27–29], where serendipity as a possible strategy for improving the diffusion of knowledge or ideas has become an active research topic.

In Networked Learning studies, the focus recently shifted from predetermined learning systems to "the act of learning as a response to changes in the learning environment" [30]. Interestingly, Kop noted that "people will first and foremost find information from people with whom they have a strong relationship" [27], which is the narrative definition of the typical community formation of social networks based on proximity and friends-of-friends relationships. Another relevant observation by Kop is that not all nodes are equal when network learning is considered, therefore it is likely that environments better supporting serendipity would handle nodes with different characteristics in different ways. Finally, crucial with respect to our work on *agent-based models of social network* is Kop's conclusion that "facilitating more randomness in our information stream" is a challenging goal in search strategies. Correspondingly, also Makri et al. [21], discussing serendipity in the field of Information Science and Technology, draw a similar conclusion: "A new way of thinking about how to support serendipity in digital environments involves moving away from trying to serve up serendipity itself and towards empowering users to create their own personal recipes for it by supporting strategies that may increase its likelihood.". *Randomness in information stream*, as we will see, is precisely the mechanism we have introduced and studied in our agent-based model.