Modeling Indirect Influence on Twitter

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ABSTRACT

Social influence in social networks has been extensively researched. Most studies have focused on direct influence, while another interesting question can be raised as whether indirect influence exists between two users who are not directly connected in the network and what affects such influence. In addition, the theory of complex contagion tells us that more spreaders will enhance the indirect influence between two users. The authors’ observation of intensity of indirect influence, propagated by parallel spreaders and quantified by retweeting probability in two Twitter social networks, shows that complex contagion is validated globally but is violated locally. In other words, the retweeting probability increases non-monotonically with some local drops. A quantum cognition based probabilistic model is proposed to account for these local drops.

Keywords: Cognitive Informatics, Complex Contagion, Information Diffusion, Quantum Cognition, Social Computing, Social Influence, Twitter

1. INTRODUCTION

Thanks to the fast development of Web2.0, many online social networks have emerged, where the observation of information diffusion, or social influence, in large-scale data becomes possible. Social influence has been studied by many researchers, including the validation of influence (Anagnostopoulos et al., 2008; Crandall et al., 2008) the propagation of influence among multiple types of social (Gruhl et al., 2004; Cha et al., 2009; Hong et al., 2011) the maximization of influence spread in the whole network kempe, and the probabilistic

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modeling of direct influence (Tang et al., 2009; De Choudhury et al., 2007). However, most relevant studies focused on direct influence, while another relevant question regarding social influence may be raised as to whether a user can exert indirect influence on his/her friends’ friends and what affects such influence. Normally, multiple intermediate persons called spreaders are involved in the indirect communication between two persons, i.e., the sender and the receiver. Those spreaders may have a combinational effect on the indirect influence propagated from the sender to the receiver.

A concept closely related to indirect influence is complex contagion. Unlike simple contagion, which can spread in social networks after just one contact with a single infected neighbor like a disease, complex contagion is a phenomenon where multiple sources of exposure to a new idea are required before an individual adopts the idea (Centola & Macy, 2005). That is to say, repeated exposures of an individual to an idea recommended by his/her multiple neighbors positively affect the probability he/she will eventually follow that idea. Romero et al. (2011) studied the spread of hashtags in Twitter and quantified the probability of a user adopting a new hashtag as the function of the number of his/her neighbors who have already adopted it. They found that the spread of political hashtags validates the complex contagion, where the adoption probability increases monotonically as the number of neighbors who had already adopted the same hashtags increases, until a plateau is finally reached. By contrast, for idiom hashtags, complex contagion does not take effect, and the adoption probability decays rapidly when more neighbors have adopted the same hashtags.

The problem we are studying is similar to Romero et al. (2011), but we focus on message spread behavior and indirect influence on Twitter. A concrete example of this is shown in Figure 1 where Alice sends out original messages, Charlie and Carol further spread Alice’s messages (i.e., by retweeting) and Bob finally receives them. After that, Bob may choose to further spread Alice’s messages to others, just like his two neighbors Charlie and Carol have done, or not. Here, the intent of Bob to further spread Alice’s messages would reflect the intensity of the indirect influence of Alice on Bob, which can be measured as the probability that Bob will further spread Alice’s messages, given that Charlie and Carol have already spread these messages. If complex contagion takes effect, the influence intensity will be higher when both Charlie and Carol spread Alice’s messages than when either or none of the two spread them.

In this paper, we examine the intensity of indirect influence as the function of the number of parallel spreaders between two users on Twitter who don’t have direct following relations. We found that complex contagion is observed globally but is violated locally. Especially, when the number of spreaders increases from one to two, there’s an obvious drop in the intensity. The newly emerging field of quantum cognition is applied to interpret the local drops in terms of interference effect on the process of decision-making. Recently, an article from NewScientist indicated how humans may actually think in a “quantum” manner (Buchanan, 2011). Research from cognitive science has also provided some initial evidence of quantum-like cognitive interference in human decision-making (Khennikov, 2010; Busemeyer et al., 2009). These cognitive experiments showed that the classical law of total probability was violated. Instead, quantum probability (Gudder, 1988) was applied to explain the experimental results. In addition, quantum cognition has been employed to further advance the theory of information retrieval (IR) (Piwowarski et al., 2010; Zuccon et al., 2009; Zhang et al., 2010).

Our main contributions are:

- Examine the change of parallel indirect influence between the sender and the receiver, quantified by retweeting probability, with the number of spreaders and found that such probability increases non-monotonically with some local drops;
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