

An evidential opinion dynamics model based on heterogeneous social influential power



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ABSTRACT

This paper introduces an evidential opinion dynamics model combining Dempster–Shafer evidence theory to explore the opinion evolution. Our model is an improvement of the Continuous Opinions and Discrete Actions (CODA) model. The process of people updating their opinions is regarded as a decision making process. The unavoidable uncertainty of the opinion evolution is handled by Dempster–Shafer evidence theory. Thereby, a new opinion group, i.e. the neutrals, is introduced into the system. Simulations show the neutral group plays a significant part in the opinion evolution. An opinion ice-breaking process at the early stage of the opinion evolution is observed. It is found that the consensus is not always reached then clusters emerge instead, which depends on the proportions of supporters, neutrals and opponents. The individual's influential power is taken into account. With the positive feedback mechanism of people's influential power, the obtained results are in accordance with people's daily cognition such as the *Authority Effect* and the *Matthew Effect*. The final influential power distribution of all individuals in our model presents power-law characteristic.

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1. Introduction

Within the field of sociophysics [1–6], the models of opinion dynamics have attracted a great deal of attention in recent years [7–11]. These models would roughly fall into two classes: discrete opinion [12–14] and continuous opinion [15–17] models. Moreover, people in reality are usually provided with a limited number of choices, frequently with as few as two (e.g. yes or no, support or opposition, agree or disagree). The Voter model [18,19] and Majority model [20] were proposed based on two-state discrete variables. However, in some instances, people's

opinions could vary continuously from one to the other, rather than merely being restricted to two extremes: approval or disapproval. Notably, once the continuous opinions are initially set up, the range of opinions is limited to a certain extent [21–23].

Martins [24,25] designed another type of model known as the Continuous Opinions and Discrete Actions (CODA) model. This model introduces a dichotomy where the continuous opinion of the individual is not observed and just as his or her inner opinion expressing the degree for himself or herself to make certain choice, while a discrete external action is known by the individual's neighbors as his or her opinion decision. Each individual updates own inner opinion and external action based on the observation of such external actions of neighbors. Naturally, the CODA model is more suitable for understanding some

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phenomena in the daily life. Having good scalability, the CODA model is also used to analyze many opinion formation phenomena [26]. Its model variations have been proved equivalent to the continuous models [27] as well as a general case to the discrete models [28].

It is universal that decision-making plays an indispensable role in modern society [29–32]. For example, people would like to know what options are taken by those who are around them before deciding whether to change their own opinions and actions or not. However, it is not always true that people tend to copy the observed options. And the observation might have various consequences, depending on people's own characteristics and the individuals they interact with [33]. This can lead to people being more likely to be persuaded by those who not only share similar, even the same, opinions with them but also have bigger influential power than them. Such fact is known as the *Authority Effect* [34] in psychology. In this paper, we adopt the widely accepted idea that individuals will benefit more or less from their interactions with others [35]. And we bring a parameter to quantify the influential power of each individual and consider the social feedback and accumulation of it. Besides, unlike many classic models mentioned above where an individual is merely affected by one specific adjacent neighbor, each individual in our proposed model will collect the action information of several individuals before updating his or her opinion and making a decision. We utilize the Moore's neighborhood relationships [36] in a lattice network, which is used earlier for cellular automata and depicted in Fig. 1, emphasizing the influence coming from one's vicinity. Such neighborhood relationship also means that people would be affected not only positively by the similarities but also inversely by differences.

Nevertheless, we also realize that the real life is full of uncertainty and human communication could be imprecise, which many psychology studies have revealed.

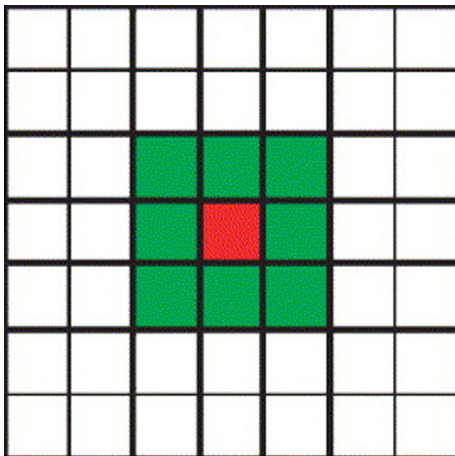


Fig. 1. A lattice network with the Moore's neighborhood. In our proposed model, the red lattice would be the individual who collects information for updating its opinion, and the eight green ones around would be its neighbors, or say sources. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Thereby, the every piece of action information obtained would be more or less unreliable and incomplete for the individual. In such situation, it is inevitably hard to make appropriate decisions. Therefore, the opinion updating process could be regarded as a decision making process with uncertain information. Due to the good performance of handling uncertainty and incompleteness embedded in information, Dempster–Shafer evidence theory [37,38] has been widely applied to fields such as group decision making [39–41] and other fields [42–45]. Considering the above reasoning, we present an evidential CODA model where the individuals regard the collected action information coming from the neighborhood as pieces of information or evidences. It is noteworthy that our E-CODA model has an expanded external action range by introducing the neutral action in the system. Every individual would collect the evidences first, then use D-S evidence theory to fuse them into one as reference coming from the surroundings. Afterwards they conclude their new opinions about the issue according to the fused reference. We explore the impact of utilizing the evidential updating rule on consensus or clusters formation in opinion evolution and examine the result. Combining CODA model and D-S evidence theory not only gains our model the ability to describe the reality better but also to handle the uncertainty embedded in collected action information.

Moreover, the influential power of the neighbors as well as their closeness to the individual are taken into consideration, in distinguishing the influence of different neighbors. We adopt the idea of the feedback mechanism of individuals' influential power: once the individual changes his or her external action, the successful persuaders will get a bonus for the contribution made by their influential power.

The remainder of the paper is organized as follows. Section 2, provides a short overview of basic concepts and notations in D–S evidence theory. In Section 3 we present the E-CODA model, in which an evidential methodology is then proposed for opinion updating. We update individuals' influential power along with the process as well. And various results from numerical simulations are acquired in Section 4. Finally, we draw our conclusions in Section 5.

2. Dempster–Shafer evidence theory

While being seen as an alternative to the Bayesian theory, comparatively, D–S theory offers a number of advantages, including the opportunity to assign measures of probability to focal elements (e.g. groups of decision alternatives), also allowing for the attachment of probability to the frame of discernment (all possible decision alternatives). For brevity, in this paper only the important fundamental aspects, which are necessary for the subsequent opinion updating method, of D–S theory are described.

Let $\Theta = \{h_1, h_2, \dots, h_n\}$ be a finite also exclusive set of n hypotheses, called the *frame of discernment*. A *mass function*, $m : 2^\Theta \rightarrow [0, 1]$, is a function defined as

$$\forall A \subseteq \Theta, m(A) \geq 0, \quad \text{and} \quad \sum_{A \subseteq \Theta} m(A) = 1 \quad (1)$$

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