



Deterministic models for opinion formation through communication: A survey[☆]

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ABSTRACT

A fundamental question in modeling opinion dynamics is to know how can opinion be formed and evolved in a social network? This is an thorny subject which has attracted a hulk of attitudes and whetted the curiosity of researchers from various disciplines. One of the major points of view rests on the fact that opinion can be formed and revised through a process called social influence. This latter lies at the heart of the opinion modeling process and it has two types: Informational social influence, where a user forms his opinion according to information he obtained from a certain number of agents in his friendship and neighborhood, normative social influence is the second type of social influence and it lead to conformity. A very few empirical studies indicate that, it is also important to consider the normative influence in the opinion modeling process. In contrary, informational Influence is one of the main underlying premises used by many well-known theoretical models of opinion dynamics

In the literature two main approaches have been adopted on how each individual updates her opinion: deterministic and probabilistic. Here, we focus only with deterministic models. We present various forms of modeling opinion dynamics in social networks and we show how opinions change following to social influence. Within the course of analysis, we point out both the strengths and weakness of many approaches. We aim to provide theoretical insight which may serve as guidelines for scientists, practitioners, researchers, consultants and developers who intend to design new methods in this area of interest.

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1. Introduction

The rise of World Wide Web accelerated the development of large-scale social networks. In recent years, both social network and social media have become ubiquitous in our daily life and have allowed hundreds of millions of Internet users worldwide to produce and consume content. This is how the internet becomes a global incipient for discussion of topics, ideas and events.

Online social networks have offered an incredible platform for information exchange and have proved to be very powerful in many situations. As an example, we may mention Facebook during the 2010 Arab spring [1]. Various contents can be exchanged between Internet users such as photos, videos and articles. They are allowed also to express their opinions and give their hot takes, concerning many issues. During the past decades, much research attention has been drawn to understand how opinions change fol-

lowing to social influence. This latter lies at the heart of individuals opinion formation because users may form or update their opinion about a particular topic by learning from the information and opinions that their friends/neighbors share. There has been increasing interest to study how opinions are formed and evaluated over time and how they change following different social interactions.

In the literature, two main approaches have been adopted on how each individual updates her opinion: deterministic and probabilistic. The probabilistic approaches, named also the Bayesian approaches, have been widely used for managing uncertainty, and more recently, for opinion formation. The first work has been introduced by Bikhchandani et al. [2] and Banerjee [3], where they proposed to explain the uniformity in economic social behaviors. After that, similar ideas have been applied to Bayesian learning from observations of past sequential actions [4–6] and communication learning, in which individuals learn through communication other than the observation of others actions[7,8]. In this article, the part of our interest in opinion and belief dynamics is to understand the deterministic approaches, named also the non-Bayesian models.

[☆] This document is a collaborative effort.

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In the past decades, the non-Bayesian models have been based in the empirical similarity [9,10]. Meaning that, individuals form beliefs about a situation based on their experiences in similar situations in the past. In particular, the tendency toward consensus and the possibility that dispersed information may not aggregate despite consensus are common features of these approaches. After that, several other forms of rule-of-thumb behavior are also used. Notable, among them there are the Ising model [11], the voter model [12,13] and others. After that, the trends of modeling opinion in social networks have been focused in social influence. The opinions of the agent for a single issue, evolve dynamically over time as a function of their neighbors opinions influence. Among these models there are Friedkin–Johnsen model [14], DeGroot model [15], the combination of DeGroot and FJ models [16,17]... In these years, much research attention has been drawn to develop a multidimensional model of opinion dynamics. In these models such as [18–20] opinions are multidimensional, representing the agents attitudes on several topics, which those topic-specific attitudes are interrelated.

In addition to this introductory section, the manuscript is divided into six distinct but complementary sections: The second section describes some concepts necessary to understand the rest of the manuscript. We start with the definition of opinion and where the beliefs and points of view came from. Because our visions of thing and the world can be influenced by our social environment, our emotional nature, our prejudices as usually factors, we propose to present the different forms of social influence.

To facilitate the construction of opinion dynamics models, we present in the third section, the key components in opinion formation proposed by Acemoglu and Ozdaglar [21]. Then, we present two groups of opinion dynamics models. In the first group, the opinions are considered discrete (often accepting only two different results (binary or ordinal/quantized)). However, the continuous opinions are classified as a second group, where they are modeled as continuous variables (which may correspond to beliefs about certain underlying variable state or the probability that a given statement is true).

An overview on the state of the art of opinion dynamics modeling methods will be presented in the fourth section. In the first sub-section, we will start by present the DeGroot model, which is a simple model of belief and consensus formation over social networks. We will see, however, that the specific assumptions it makes on how beliefs are updated may have certain non-desirable implications. Motivated by this, we will present, in the second and the third section, the different enhancements proposed to avoid limitations, respectively named the duplication of information and the disagreement/misinformation between agents.

Because there are several deterministic models, we introduce in section five a comparative table summarizing the different parameters used in most approaches. Section six concludes with a brief discussion and ours propositions of future work to improve some works. Finally a conclusion is given in the final section of this paper.

2. Background

As a result of social interactions with other people, opinions can be revised, changed and updated. So, we start by giving a definition of opinions, social influence and forms of influence. Then we present the term of opinion dynamics, known as the evolution of opinion over time and we investigate the key components in opinion formation.

2.1. Opinion

Opinion being increasingly used. It is extremely complex and we cannot provide it a single definition. In the most current sense, opinion may mean way of thinking about a topic or set of subjects, a personal judgment that is not necessarily true. Opinions are uttered spontaneously, directly, and brutally, that is to say without any definitions or explanations or demonstrations or arguments.

Acemoglu and Ozdaglar [21] treat the opinion as a reasoning product from ones context knowledge base where new knowledge fragments acquire through various types of learning experience. Schwitzgebel [22], definite opinion as a fact or proposition that an individual holds to be true. Opinions, in contrast, include both personal beliefs and attitudes or judgments that are not founded on proof or certainty. The question that needs to be answered here is where do these beliefs and opinions come from? It is true that certain phenotypic characteristics have biological and genetic bases. Yet, we do not think that our beliefs are imprinted on us by our genes, but they usually come from uncontrolled sources such as everyday experiences, media, education, interests, and passions. Actually, these phenomena influence our mind unconsciously.

Our opinions are acquired through various types of learning experiences [23]. Families play a main role in teaching some basic principles and beliefs to their children [21,22]. Much of it, however, much of opinion formation will take place in the social environment through a process of social learning. Banduras social learning theory [24], posits that people learn from one another, via observation, imitation, and modeling. Most human behavior is learned observationally through modeling: from observing others, one forms an idea of how new behaviors are performed, and on later occasions this coded information serves as a guide for action.

2.2. Social influence

The study of the influence of social backgrounds on opinion dates back to the early XXth century. Charcot, who worked on hysteria, is the first one who has done these studies in this context [25]. He thought that these behaviors were there because of the heart impact of the social environment on people. Social influence is the influence exerted by an individual or a group on each of its members implying a change in behavior.

All impressions and changes in social life or relationships with others affect individuals or groups deeply, whether they are conscious of that or not. One of the central aspects of social influence is that we rely heavily on the ideas and opinions of others.

According to Edgar Morin [26], four forms of social influence can be outlined:

- Standardization: the group members influence each other
- Obedience: a person agrees to behave in accordance with the requests of an authority
- Innovation: a minority influences a majority
- The Conformism: also named as social pressure, is the influence of groups behavior that encourages an agent to change his behaviors to follow the group norms (a majority influence on a minority).

Two core conformity studies illustrating the effect of groups behaviors on individual's behaviors are Asch [27] and Sherif [28]. In these models, people were found to follow the rest of the group opinion. Sherif demonstrated that people tend to infer realities by referring to each other's judgments, resulting in private acceptance. Asch demonstrated that, even there are differences in two opinions, individuals still tend to accept opinions that, on their own, they would consider wrong. According to the study of Deutsch and Gerard [29], the social influences underlying conformity motivation

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