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An opinion control rule with minimum adjustments to support the consensus reaching in bounded confidence model

Zhaogang Ding[a],Haiming Liang[a,*],Yucheng Dong[a],Francisco Chiclana[b],Enrique Herrera-Viedma[c],Francisco Javier Cabrerizo[d]

[a]*Business School, Sichuan University, Chengdu 610065, China*
[b]*Faculty of Technology, De Montfort University, Leicester LE1 9BH, United Kingdom*
[c]*Dept. of Computer Science and Artificial Intelligence, University of Granada, Granada 18071, Spain*
[d]*Dept. Software Engineering and Computer Systems, UNED, Madrid 28040, Spain*

Abstract

Opinion dynamics provides a modeling tool for the public opinion management. The existing studies mainly focused on building the evolution model of opinions. However, the control of public opinions has been a key problem in practical opinion dynamics. The objective of this paper is to propose an opinion control rule to support the consensus reaching. Based on the bounded confidence model, the consensus model with the minimum adjustment is proposed. Next, based on the proposed consensus model, we propose the opinion control rule to support the consensus reaching. Furthermore, a numerical example is given to illustrate the feasibility of the proposed opinion control rule. Through simulation experiments, we investigate the effects of adjustment thresholds and bounded confidences on the opinion control rule.

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Keywords: Opinion dynamics; opinion control rule; consensus model; minimum adjustments; bounded confidence.

1. Introduction

Opinion dynamics can be defined as a dynamic and iterative process. In opinion dynamics, a group of agents express their initial opinions over the same issue. Based on the communication regime, their opinions are continuously updated as the time elapses. At the final stage, a consensus (or fragmentation) among the agents [2-3, 8-12, 24] is formed.

The studies on opinion dynamics went back to French. French [15] proposed the social power model to explore the patterns of interpersonal relations and agreements. Later Harary [18] provided a necessary and sufficient condition to reach a consensus in French's model. According to French's study, different types of studies on opinion

*Corresponding author. Tel.: +86-28-82673492.

E-mail address: dzgzhaogang@stu.scu.edu.cn(Z. Ding), hmliang@scu.edu.cn(H. Liang), ycdong@scu.edu.cn(Y. Dong), chiclana@dmu.ac.uk(F. Chiclana), viedma@decsai.ugr.es(E. Herrera-Viedma), cabrerizo@issi.uned.es(F. Cabrerizo).

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formation have been proposed [20]: (i) opinion formation with continuous or discrete time [2,27,34], (ii) opinion formation based on different communication regimes [5-6,21,26,35], (iii) opinion formation with the multi-dimensional space of possible opinions [15,18,24], (iv) opinion formation in a specified network [16,30,33,36-37], and (v) opinion formation considering noises [22,32]. Among the studies mentioned above, bounded confidence model has become one of hot issues in opinion dynamics. Bounded confidence model assumes that each agent only communicates with the peers whose opinions are closely to its own. The earliest bounded confidence models are presented independently by Hegselmann and Krause [21] and by Deffuant and Weisbuch [6]. The two bounded confidence models are called the HK model and the DW model, respectively. In the HK model, agents synchronously update their opinions by averaging all opinions in their confidence sets; in the DW model, agents follow a pairwise-sequential updating procedure in averaging. Based on the HK model and DW model, the scholars conducted some extended studies. For example, Blondel et al. [1] discussed both the agent-based and density-based homogeneous HK models. Lorenz [28-29] reformulated the HK model as an interactive chain and analyzed the effects of heterogeneous confidence bounds. Dong et al. [13, 25] extended the HK model into the linguistic and uncertain environment.

The existing studies have made significant contributions on opinion dynamics. The existing studies mainly focused on building the evolution model of opinions. However, the control of opinions has been a key problem in practical opinion dynamics. With the rapid development of Internet, people can express their opinions conveniently. But the emergence of Internet also accelerates the spread of gossip in public opinions. If the public opinions are not controlled, it is easier to trigger the social conflicts and mass incidents. Furthermore, when controlling the public opinions, the opinion managers always hope that the opinions of all the agents reach a consensus with minimum adjustments.

The objective of this paper is to propose an opinion control rule with minimum adjustments. The reminder of this paper is arranged as follows: Section 2 introduces the HK bounded confidence model and consensus in opinion dynamics. Then, Section 3 proposes the opinion control rule. In Section 4, a numerical example is given, and several simulation experiments are designed to discuss the effects of adjustment thresholds and bounded confidences on the opinion control rule.

2. Preliminary

This section briefly introduces the basic knowledge regarding the HK model [21], and the consensus in opinion dynamics, which will provide a foundation for this study.

2.1. Bounded confidence model: the HK model

Consider a standardized opinion dynamics problem. Let $A = \{A_1, A_2, \ldots, A_N\}$ be a set of agents. Let t be the discrete time, $t = 0, 1, 2, \ldots$. The crisp opinion of agent $A_i \in A$ at time t is represented by $o_i(t) \in [0, 1]$. Let $O(t) = (o_1(t), o_2(t), \ldots, o_N(t))^T$ be the vector of the opinions of all the agents at time t called the opinion profile. Let ε be the bounded confidence.

The process of opinion evolution in the HK model include three steps:

(1) Determination of the confidence set

In opinion dynamics problem, agent A_i only trusts the opinions which differ not more than ε from his/her opinion. Let $I(A_i, O(t))$ be the confidence set of agent A_i at time t, where

$$I(A_i, O(t)) = \{A_j || o_i(t) - o_j(t)| \leq \varepsilon\}, \qquad i = 1, 2, \ldots, N,\ t = 0, 1, 2, \ldots \tag{1}$$

(2) Calculation of the weight

Agent A_i assigns the same weight to the agents in his/her confidence set $I(A_i, O(t))$. Let $w_{ij}(t)$ be the weight that agent A_i assigns to agent A_j at time t, where

$$w_{ij}(t) = \begin{cases} 1/|I(A_i, O(t))| & A_j \in I(A_i, O(t)) \\ 0, & A_j \notin I(A_i, O(t)) \end{cases}, \qquad i = 1, 2, \ldots, N,\ t = 0, 1, 2, \ldots \tag{2}$$

Clearly, $w_{ij}(t) \geq 0$ and $\sum_{j=1}^{N} w_{ij}(t) = 1$.