NANYANG TECHNOLOGICAL UNIVERSITY

SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

AI6125 Multi-Agent System

Assignment 1:

Literature Review on the topic of

MultiAgent System

Zheng Weixiang

Wzheng014@e.ntu.edu.sg

G2103278G

Table of Contents

Introduction

Today, users are getting increasingly engaged with online media via the Internet. And with the greater popularity of social networks comes with some unprecedented problems. Misinformation is one of the most noticeable problems. I am interested in general, of how we can eliminate misinformation or fake news in social networks. I will start by describing the application, and then extract some research problems and challenges to discuss, do some research on the problems and discuss their methodologies and then conclude their ideas and also talk about some of my ideas in the end.

Application Description

We want to build an application to show how we can eliminate the misinformation or fake news in social networks. In order to do that, there are few key functionalities that we need to pay special attention to: 1. We want to build something that could model the whole social network e.g., Facebook in a large scale, 2. It is able to run a simulation of fake news diffusion, or just any kind of information diffusion. At first, we want to see that if no action is performed, how fast the misinformation is spreading. Then in the comparison group, we want to see that if certain action is performed to intervene the spread, how effective it is.

Research Problems and Challenges

In order to build such an application, there are some real-world research problems to be pointed out and to be answered, and they are:

1. How to model Social Networks structure using Multi-Agent System?
2. How to simulate diffusion of information in the social networks?
3. How do we prevent misinformation from spreading in a social network?

Some challenges to these research problems are:

1. Complexity of social networks
2. Diffusion has many factors, which makes it more difficult to model
3. Lack of effective way to prevent people from believing and spreading misinformation.

Methodologies in the Literature

After searching for the relevant papers online, I found the following literatures:

1. Diffusion in Social Networks: A Multiagent Perspective [2],

2. Social Network Chatbots for Smoking Cessation: Agent and Multi-Agent Frameworks [3],

The first paper introduces how we can model diffusion in Social Networks, based on the previous studies [4]. The second paper introduces the innovative way of prevent people from doing things through the internet. I am thinking about applying the method of Smoking Cessation onto the spread of misinformation.

Diffusion in Social Networks: A Multiagent Perspective

This paper discusses the diffusion from a multi-agent perspective. The author claim diffusion can be seen as a multiagent system interaction based on the following facts: 1. diffusion in Social Networks can be described as the collective behavior of a set of autonomous social actors for interacting on something in the Social Networks [4], 2. multiagent computing has already been widely envisioned to be a powerful paradigm for modeling collective interactions of autonomous multi-entity systems [5], 3. Social Networks can be modeled as multiagent systems [4]

The author further proposes the framework as follows: Diffusion actors, which are the ones spreading misinformation can be seen as the agents from the multiagent perspective. Diffusion media, which is the place to be diffused, in our context is social networks, can be seen as the interaction environments in Multi-Agent System. Diffusion contents, which is what to be diffused, can be seen as the interaction objects in Multi-Agent System. The similarity between diffusion and Multi-Agent System can be further formalized by tuple mapping <A, I, O, P, D> → <A, N, C, P, D> where <A, I, O, P, D> are the key elements in Multi-Agent System: A refers to agents, I refers to Interactions between agents, O refers to interaction objects, P refers to interaction protocols and regulations, D refers to decision mechanism. In <A, N, C, P, D>, A refers to agents who diffuse information in the Social Network, N refers to the Social Network itself, refers to the content being diffused in the Social Network, P refers to the diffusion protocols, D refers to the decision mechanism.

The author continues by introducing two types of decision-making mechanisms in Multi-Agent System: 1. Deterministic decision mechanism, 2. Nondeterministic decision mechanism. Then he further maps the two types of mechanisms to the two types of diffusion: 1. Deterministic diffusion, 2. Nondeterministic diffusion. The main difference between these two models is that in deterministic diffusion models, the receiver actor's state can be deterministically decided by the states of sender actors; whereas in nondeterministic diffusion models, the receiver actor's state is not deterministically decided by but only influenced with a probability by the states of sender actors' states. Then he talks about five models under these two categories.

Usually, in the existing studies, deterministic diffusion models contain the following three models:

1. Neighbor imitation model [6], in which each receiver actor's acts solely on the basis of its own local perception of the Social Network and all it's doing is to imitate the average strategy of its neighbors [7], there is also an improved Neighbor Imitation Model [8].
2. Linear Threshold Model, a commonly used deterministic model, in which whether an actor is influenced is determined by the sum of its neighbors' weights. It is only influenced when the sum exceeds the threshold of the actor [9].
3. Deterministic Game Theory Model, in which none of the states of the actors are probabilistic. This model is typically used when an individual's behavior is a deterministic strategic choice among competing alternatives.

Among the nondeterministic models, the following two typical classes are often observed:

4. Independent Cascade Models, which is sometimes called Epidemic Models as well. It is very much like how virus spread and causes epidemic hence the name. The underlying assumption of this kind of models is that: the actor adopts a new behavior with a specific probability when they come into contact with others who have already adopted it. The important factor in this kind of models is therefore the diffusion probabilities. It should be considered and specified in advance [9].
5. Nondeterministic Game Theory Model. It is similar to the Independent Cascade Models except the way of adoption. Nondeterministic Game Theory Models are based on the notion of utility maximization instead of exposure. It is assumed in Nondeterministic Game Theory Model each individual makes a rational choice to maximize the payoff [10].

These are all models the author has mentioned in the paper. However, the author also mentioned some factors that may affect the effectiveness of these models including but not limited to

a) The difference in composition between Social Network and Multi-Agent System e.g., Social Networks are in large scale, dynamic and active whereas Multi-Agent Systems contain restricted and artificial interactions. Social Networks contain large number of actors whereas Multi-Agent Systems in general contain a smaller number of actors. Social Networks focus more on empirical analysis on the observed data whereas Multi-Agent System focus more on the development of negotiation theory and models,
b) The difference in objective between Social Network and Multi-Agent System e.g., Multi-Agent Systems aim at guaranteed success or to maximize social welfare whereas Social Networks in general aim to maximize or minimize the influence.

Social Network Chatbots for Smoking Cessation: Agent and Multi-Agent Frameworks

This paper discusses how we could use MAS to address behavior and coordination tasks in CBT(Chatbots) systems. My idea of referring this paper is that: if we treat spreading misinformation as an addictive behavior, we could utilize the same method [2] to change user behaviors, if it turns out spreading misinformation is not that addictive, then it should be easier for our application to stop the spread of misinformation instead of application being inapplicable. This paper also mentioned user profiling, which I think will be useful in a sense that we could categorize all users on a Social Network into two categories: misinformation spreaders and healthy users. Then it would be easier for our application to proceed following actions on those misinformation spreaders. I will review the MAS & Chatbots, JDF Program Design and the Multi-Agent Design parts.

To address the limitations of little support for conversation flow management, coordination and user profiling, CBTs have explored different approaches, including the adoption of MAS as underlying technology to support modeling human-like behaviors and dynamics [2]. In [11], author uses an innovative way of combining CBT and MAS as a stimulus-reply state automaton and a goal-driven agent (defined as Partially Observable Markov Decision Process). There are two types of goals for an agent:

1. An immediate goal, which can be achieved within a single step in the dialogue
2. A global goal, which can be achieved only by the end of the conversation

By doing so, we have successfully added elements of pragmatics to the dialogues. Then we need to program the chatbot so that it can respond to the stimuli from the environment based on its mood and different interaction modes [11].

JDF is the name of first edition of smoking cessation program launched in 2015 [2]. It was designed to be a 2-staged process. The interaction begins with the bot asking demographic questions and assessing the type of smoking dependence. Then, after two weeks of monitoring the smoker's pattern, the participants can define the distracting actions that they are willing to follow during the given cravings. The second phase starts by elaborating the knowledge built in P1, the CBT can provide any-time support by associating the request of support to the corresponding actions defined in P1. After a certain period (16 weeks) though, the activities might become repetitive, thus losing effectiveness. Therefore, an agent-based CBT framework is proposed. We will go ahead and have a look at the multi-agent-based CBT framework.

We will omit the part of single-agent-based framework in [2], but in the paper, the author mentioned the disadvantages of single-agent-based framework is mainly inconvenience of information sharing between different participants. Delegating the management of all participants to a single agent implies the sequential execution of the support behaviors. Although we can probably implement the application in multi-process or multi-thread way. It is not as efficient as multi-agent implementation. Also, there is no simple way to make processes interacting with each other, thus hampering information sharing between similar profiles [2]. The need for distributed interactions is one of the main motivations for a multi-agent-based architecture [2]. In the multi-agent-based SMAG, modules and structures are common to all agents, but behavior and knowledge modules can assume different identities after start-up. Different from single-agent system, a gateway-agent is introduced to dispatch incoming chat message to the agent related to a given user therefore enabling the communication between different agents. The author concludes the advantages of multi-agent-based framework as follows: 1. Enable to reuse the agent knowledge in further studies, 2. Migrating capability, 3. Enhance the CBT knowledge about the smoking cessation and the participants, 4. More efficient tailored support. The author also mentioned some limitations of the framework: 1. There is no standardized communication between agents, 2. The lack of adaptive model of user, 3. Design of multi-agent-based framework is more complicated than that of single-agent-based framework [2].

Conclusion and Ideas

After reviewing the two papers, we have found that multi-agent system in very powerful in a lot of ways. Multi-Agent System is a good tool to model Social Networks and Diffusion of information inside Social Networks, and it could also model the diffusion of a virus. At the same time, it is capable of powering some application to make it more efficient.

Similar to the JDF application, I hope to implement am algorithm that could run on the backend server of the social network like Facebook or Twitter, it could identity the spreader of misinformation based on users' action and history (user profile), and whenever detect reposting or posting, we could intervene the spread of misinformation (similar to JDF), we could inform the user that content is misinformation (persuasive action), if the user insists, the algorithm should at least mark the posted content as misinformation or misleading to all other users (mark inappropriate content). In such a way, we quarantine the misinformation spreader and prevent potential exposure to other users (Multi-Agent System Model for Diffusion of Information). It is very likely that after such kind of intervention, misinformation will be reduced by a large amount on the Social Networks.

References

[1] N. Sardana, R. Cohen, J. Zhang and S. Chen, "A Bayesian Multiagent Trust Model for Social Networks," in IEEE Transactions on Computational Social Systems, vol. 5, no. 4, pp. 995-1008, Dec. 2018, doi: 10.1109/TCSS.2018.2879510.

[2] Y. Jiang and J. C. Jiang, "Diffusion in Social Networks: A Multiagent Perspective," in IEEE Transactions on Systems, Man, and Cybernetics: Systems, vol. 45, no. 2, pp. 198-213, Feb. 2015, doi: 10.1109/TSMC.2014.2339198.

[3] D. Calvaresi, J. Calbimonte, F. Dubosson, A. Najjar and M. Schumacher, "Social Network Chatbots for Smoking Cessation: Agent and Multi-Agent Frameworks," 2019 IEEE/WIC/ACM International Conference on Web Intelligence (WI), 2019, pp. 286-292.

[4] Y. Jiang and J. C. Jiang, "Understanding Social Networks From a Multiagent Perspective," in IEEE Transactions on Parallel and Distributed Systems, vol. 25, no. 10, pp. 2743-2759, Oct. 2014, doi: 10.1109/TPDS.2013.254.

[5] J. Liu, X. Jin and Kwok Ching Tsui, "Autonomy-oriented computing (AOC): formulating computational systems with autonomous components," in IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans, vol. 35, no. 6, pp. 879-902, Nov. 2005, doi: 10.1109/TSMCA.2005.851293.

[6] Jiang, Jiuchuan, and Xiaojun Xia. "Prominence convergence in the collective synchronization of situated multi-agents." Information Processing Letters 109.5 (2009): 278-285.

[7] A. Jadbabaie, Jie Lin and A. S. Morse, "Coordination of groups of mobile autonomous agents using nearest neighbor rules," in IEEE Transactions on Automatic Control, vol. 48, no. 6, pp. 988-1001, June 2003, doi: 10.1109/TAC.2003.812781.

[8] Ohtsuki, H., Hauert, C., Lieberman, E. et al. A simple rule for the evolution of cooperation on graphs and social networks. Nature 441, 502–505 (2006). https://doi.org/10.1038/nature04605

[9] Saito K., Kimura M., Ohara K., Motoda H. (2010) Behavioral Analyses of Information Diffusion Models by Observed Data of Social Network. In: Chai SK., Salerno J.J., Mabry P.L. (eds) Advances in Social Computing. SBP 2010. Lecture Notes in Computer Science, vol 6007. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-12079-4_20

[10] A. Montanari and A. Saberi, “The spread of innovations in social networks,”

Proc. Nat. Acad. Sci. USA, vol. 107, no. 47, pp. 20196–20201,2010.

[11] Bentivoglio, C., Bonura, D., Cannella, V., Carletti, S., Pipitone, A., Pirrone, R., Rossi, P. & Russo, G. (2010). Intelligent Agents supporting user interactions within self regulated learning processes. Journal of e-Learning and Knowledge Society, 6(2), 27-36. Italian e-Learning Association. Retrieved February 12, 2022 from https://www.learntechlib.org/p/43443/.