Systems Thinking and Modeling in Social Networks: A Case Study of Controlling COVID-19 Conspiracy Theories

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Abstract

Complexity and dynamicity of the social networks are categorized as NP-hard problems to solve and analyze. These variables on social networks such as actions and interrelationships between the network's users, different behaviors, users' feedbacks and the networks' dynamics make the analysis intractable. Systems thinking and modeling methods orient the relationships between all parts in online social networks for the first time. Complexity theories, system dynamics, and game theoretic approaches implemented by system thinkers help investigate the system's parties' relationships. These methods also present a useful tool to interpret the social networks' complex interactions, dynamic activities in online networks and communities between users and their online dynamic interactions. In this paper, systems thinking concepts and organizational cybernetics are employed to analyze the anti-lock down demonstration against COVID-19 at Michigan state. We also present a systematic analysis to control, analyze, and comprehend the users' actions, tweets, retweets, and feedback in a complex and dynamic environment between two campaigns.

Keywords

Complexity Theory, System Dynamics, Black Box, Feedback Analysis, Concept Mapping, Organizational Cybernetics, Noncooperative Game Theory, Network Influence.

Introduction

The complexity of communication in the social media platforms has increased the information flow and helped conduct influence operations in the recent years. People use social media platforms to post and share information, stories, comments, write about interesting topics, communicate with friends and family, coordinate big gatherings, and invite friends to their special activities.

In the past few months, most social media platforms recorded a massive increase in the number of stories, comments, news, guidelines, and ideas about the COVID-19 pandemic posted every day. However, when a post or story is shared, the user sharing it, usually has a specific understanding of it as well as has a specific agenda behind sharing it. Later, when the post traverses through the social network, these components change over time. Posts receive positive or negative feedback from users that receive these posts. These changes, sometimes, reshape the entire context of the post, its purpose, and even its meaning. Users that receive these posts may respond by correcting the information in the post, or support it by retweeting it, or even categorize it as misinformation. Thus, to determine whether a post has factual information, misinformation or disinformation, it requires evaluations and judgments of content, context, purpose, etc. Moreover, a proper strategy is required to provide efficient feedback as shown in Figure 1. In this regard, many tools are available to improve the decision making for content managers to assess the validity of fact in a given posted comment, tweet, or story (Søe 2018).

However, the features mentioned in (Søe 2018) are not sufficient to track down any conspiracy theories and stem attempts by malicious users to spread, and influence users' behaviors in a social network. Moreover,

(Søe 2018) does not consider information flow or its diffusion over time on online social networks. Additionally, there is lack of information about the rumors' actions, resources, and activities or any changes in malicious actors' dissemination strategies on the online social network. These strategies could reveal information on coordinating structures or algorithmic manipulation techniques being used to influence the entire network.

For example, in the efforts to stem fake news, the fact-checker applications need a better systematic way to investigate and connect their findings to include variety of variables in their analysis to overcome gaps in regular methods (Søe 2018). Supplementing fact-checkers' judgments with useful systems thinking approaches such as game theory and graph theories will bring increased knowledge and provide additional evidence when they have identified falsities and their analysis would provide enhanced ideas for methods on how to stop those rumors. Understanding how the systems topics in social media would work would make the fact-checkers analysis more proactive and function better for analyzing any hoaxes or in this current scenario COVID-19 related misinformation. Systems thinking would help us better understand any deceptions in different views, different languages, and analyze their quality and threats in different times. These systematic approaches will help to find the hidden interactions, interrelated or connected interdependent parts between the managers and the rumors to collect more useful information about hoaxes' spread/spreaders and open the path for further investigations (Losty and Weinberg 1976).

Any social network database has useful information, comments, languages, sources, and categories, but supplementing them with additional information based on systems thinking methods that can provide more information about rumors would help the professionals tremendously. Information related to the rumors' (or set of rumors') structures, resources, influences, sentiment measures, centrality measures, their impact on the entire network, number of likes, retweets, mentions, other coordinating rumors, their hotspots in the network, etc. will help the professionals to identify the challenges facing those who support systems thinking and modeling in social media and to make better decisions when addressing any COVID-19 misinformation or hoaxes.

The paper is organized to investigate the systems thinking methods such as complexity theories and system dynamics in section 2. Section 3 will deliberate the systems thinking efforts in social media and introduce the research dataset. Mapping concept and organizational cybernetics is introduced in section 4. The results are presented in section 5. And finally, the research discussion and future works are explained in section 6.

Systems Thinking and Modeling

Due to the social network analysis complexities (Mann 2004), this research will implement for the first time, to the best of authors' knowledge, the systems thinking approaches for orienting the relationships between all parts in online social networks. Modern approaches implemented by systems thinkers investigated the system's local parties' relationships to study the entire system. Systems thinking is a useful tool to interpret the social networks' complex interactions, dynamic activities in online networks and communities, and online users' interactions over time. Many empirical studies have introduced the systems thinking and modeling as classes of intelligent attempts that are combined progressively, using traditional methods to solve many complex problems (Losty and Weinberg 1976).

Adapting a complex social network system necessitates a set of connected, interdependent parts of users that may include rumors spreading conspiracy theories and professionals acting on their end to limit such actions; where these agents would perform noncooperative actions against each other. Likewise, all parties' involvement in dynamic online social networks resulting in complex interactions, behaviors, and movements. Such complexities need "systems thinking" models such as causal feedback (VanderWeele and An 2013), power laws (Muchnik et al. 2013), centralized models (Tassa and Cohen 2013), decentralized models (Tassa and Cohen 2013), boundary conditions (Du et al. 2018; Wobst 1974), control theory (Weng et al. 2013), information theory (Peng et al. 2017), decision and game theory (Chan and McCarthy 2014a), system dynamics (Losty and Weinberg 1976), and set, graph and network theory (Zafarani et al. 2014) (Chan and McCarthy 2014b). In addition, different parties' interrelationships in online social networks; for example, groups of rumors spreading fake news, radical behaviors, and conspiracy theory; and others are acting as professionals (government agencies, academic institutions, fact-checkers, researchers, systems thinkers, etc.) trying to push back to stop the rumors' behaviors with respect to the network's dynamic

circumstances, local behaviors over time, and their relationships to their social network as a whole, as shown in Figure 1.

In this research, we attempt to answer questions related to utilizing systems thinking to model the information exchange between both rumors propagators and professionals debunking them in complex dynamic social networks. We also focus on characterizing systems structures and functions to be useful to predict and maximize the professionals' reactions to minimize the rumors diffusion. Identifying approaches that help better understand and simulate both sides' interactions, optimize the model's outcomes, and identify the best strategy to reveal the misinformation sources and rumors behaviors. The research focuses to involve useful formal models to increase the understanding of complex systems and improve the effectiveness of systems thinkers' steps.

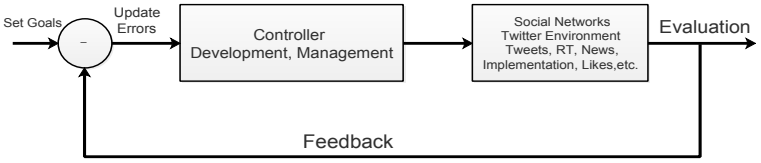


Figure 1. Block diagram of a negative feedback in a Twitter network.

System Dynamics and Complexity Theory

This research offers two organizing ideas, system dynamics and complexity theory, that would help the professionals to simplify the complex interactions, dynamics movements, and interconnections in social networks.

System Dynamics

Dynamic systems such as social network requires to employ the science of feedback, powerful simulations, and multiple loops in non-linear systems (Mann 2004). System dynamics in social networks would help the professionals to understand the structure of complex users' behaviors so that they can intervene and make sure behavior that meets with their preset goals. For example, a set of users is trying to influence the network with a new operation or starts an election campaign to meet their goals after a period of time on Twitter. They will start their campaign to spread their agendas, generating more posts every day to encourage further new tweets, etc. In addition, regardless of their hard work, but they will face set of variables that are linked to positive and negative feedbacks during their campaign as shown in Figure 1. If their campaign's goals meet lots of interested users, then their idea may become extremely influential, generating more alliances on Twitter and these supportive feedbacks would generate influence loops. In addition, based on the feedbacks, the campaign might change strategy repeatedly with respect to time and may have different state of equilibrium or change in more complicated ways (Losty and Weinberg 1976).

Complexity Theory

Many online platforms in social networks arena are complex in that they consist of many interacting users and managers with often different and competing interests that would generate chaos and complexity in the analysis. Complexity theory would help to reveal the difficult organizational aspects that would generate disorder, irregularity and randomness in dynamic systems. Utilizing complexity theory would help to study and help to predict small actions from users in long-term behaviors very significantly (Mann 2004). Initial conditions at early prediction would suggest that the single action of a user's behavior might, over time, alter a conspiracy theory, terror attack, radical actions etc.

social network as well as the users' interactions with their natural environment. Since social networks are not just complex adaptive systems rather than complex evolving systems; social networks are not only bounded by the fixed rules of interaction on their parts, they can change the rules of their development over time. Most definitions of such complex and unpredictable systems include some notion of the relationship between the users' constantly unpredictable behaviors that would start unpredictable behavior in a network and independent users self-organizing by simple rules in their environment.

Current Systems Thinking Efforts in Social Media

The field of social network analysis would need to adapt the systems thinking and its accompanying modeling approaches. More efforts from scholars are needed to study these topics, more research is needed that emphasizes systems thinking view. Complex social networks need multi-disciplinary methods to model the complexity and study dynamicity integrations. Online social networks present linear and nonlinear systems that require quantitative and qualitative approaches, and singular and holist thinking. Systems thinkers in social networks need to make lots of effort to answer questions such as, how to optimize the information flow between users and environment by implementing systems thinking approaches? How to characterize and optimize results of the systems methods and positive feedbacks to the social networks? In a complex dynamic social network, which methods could return the best analysis and optimize the results? How the information and knowledge will change in an online dynamic social network?

Dataset

For the purpose of this research, we used a Twitter network related to an armed protest demonstration against COVID-19 lockdown at Michigan capital on May 12th through May 15th, 2020 ("Coronavirus: Armed Protesters Enter Michigan Statehouse - BBC News" n.d.). This data set consists of 3840 users and 4658 links as presented in Figure. 2.

Methods

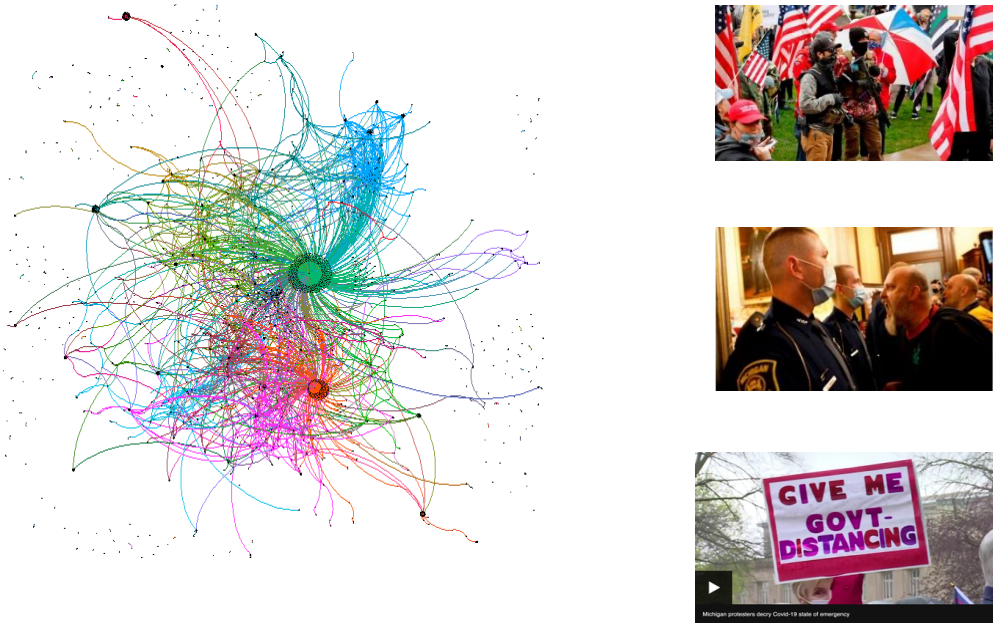
Concept Mapping

Concept mapping is a systems method that enables groups to describe their ideas on any topic and represent these ideas visually in a map. The general procedure for concept mapping has been described in detail by Trochim (Trochim and Kane 2005).

To accomplish this analysis, users were brainstormed or free listed a large set of tweets addressing their ideas about the COVID-19 lockdown in Michigan state ("Armed Protesters Demonstrate against Covid-19 Lockdown at Michigan Capitol | US News | The Guardian" n.d.). All users on Twitter posted their ideas, and each user did as many tweets, retweet, mentioned about the protest on May 14th, 2020. These data were assessed in a sequence of multivariate statistical analyses that included multidimensional scaling and hierarchical cluster analysis methods. The resulting maps showed each of the tweets, with more similar ones located nearer each other, and illustrated how the tweets were groups into clusters as discussed in section 5.

Organizational Cybernetics

Organizational cybernetics is the study of control and communication between a system and environments that includes negative feedback mechanism, variety of behaviors, improved complex systems, organizations, and the black box (Mann 2004). Such systems such as the black box techniques suggest that the managers should not try to break the systems down into parts to understand them, but rather to control them through monitoring their outputs and manipulating their inputs appropriately. The negative feedback process can be used to ensure that they are regulated to achieve preferred goals. Organizational cybernetics is working like system dynamics would investigate the relationships between the systems and feedback from the environment, and would help the managers to decide what operational strategies will be best to achieve the systems' goals over time (Mann 2004). However, this method would investigate the interaction between an organization and the environment as explained in (Mann 2004), but in social networks the analysis may include multiple organizations interacting with their communities. For this reason, this research is proposing an organization cybernetics method for two organizations pursuing noncooperative actions in a Twitter network as presented in Figure 3.



Coronavirus: Armed protesters enter Michigan statehouse ("Coronavirus: Armed Protesters Enter Michigan Statehouse - BBC News" n.d.)

Figure 2. Twitter network against Covid-19 lockdown at Michigan capital, May 12th-May 15th, 2020.

Results

Over the course of the protest, from May 12th through May 15th, users tweeted 4950 tweets. Preliminary analysis revealed that users from either side of the spectrum were engaged in an online tug of war and conducting influence operations to promote their agenda. While armed protesters that posted tweets to influence the network to maximize the armed participants joining the protest, users from the other side of the spectrum tweeted to stop such a movement and reminded participants to use more peaceful options.

Table 1 shows the top 15 tweets posted in three days, we sorted and scored all posts based on the number of tweets and retweets to identify the network's patterns over three days (Trochim and Kane 2005).

Tweet ID #1, trending from May 12th through May 13th, was reporting about the armed protest "**Ahead of an armed rally planned for the Capitol building in Lansing, Michigan, this coming Thursday, groups are promoting violence against Gov. Gretchen Whitmer on Facebook, in violation of the social media company's policies.**". Tweet ID #6, was trending at the same time as a response and negative feedback to tweet ID #1 "**Plain and simple she needs to eat lead and send a statement to the rest of the democrats that they are next," a man from Fennville wrote. An armed rally is planned in Lansing on Thursday, where civilians can bring guns into the statehouse.**" This is a simple example of interactions between many users trying to influence and spread information, where both parties are engaged in noncooperative actions on the first day of the protest campaign on Twitter as shown in Figure 3.

On May 13th, both parties changed their strategies on Twitter by pushing new tweets into the network. Pro-gun protesters promoted Tweet ID #4 - "**On Thursday, armed protestors who threatened the lives of the Michigan Governor and lawmakers will show up at the statehouse to protest stay-at-home orders. Because they're allowed inside with guns, @SenPolehanki will be wearing a bullet-proof vest. This is not freedom.**" However, the pro-peace protesters continued to spread tweet ID #1, but when tweet ID #4 started to trend, they changed their strategy and started pushing Tweet ID# 5. The Government tweeted "**Today in the Michigan State Senate, I discussed my Senate Resolution to prohibit firearms in the State Capitol**. Also, "**No more deliberation. There is nothing more to study. The Capitol Commission must act now to prohibit guns in the Capitol to avoid a catastrophic incident."** in a way to respond to tweet ID # 4. This anecdotal evidence indicates the complexity of interactions

between users, where both sides tried to spread against each other, and their behaviors changed over time to counter each other.

Tweet ID	Tweet	Score
1	Ahead of an armed rally planned for the Capitol building in Lansing, Michigan, this coming Thursday, groups are promoting violence against Gov. Gretchen Whitmer on Facebook, in violation of the social media company's policies.	958
2	Michigan closed down its capitol in Lansing today and canceled its legislative session rather than face the possibility of an armed protest and death threats against Democratic Governor Gretchen Whitmer.	810
3	You're not allowed to bring posters into the Michigan statehouse, but you can open carry guns inside. Because of the 200 armed insurrectionists who showed up - again - at the Capitol today, lawmakers shut down the session. This is not freedom. This is not Democracy.	489
4	On Thursday, armed protestors who threatened the lives of the Michigan Governor and lawmakers will show up at the statehouse to protest stay-at-home orders. Because they're allowed inside with guns, @SenPolehanki will be wearing a bullet-proof vest. This is not freedom.	304
5	Today in the Michigan State Senate, I discussed my Senate Resolution to prohibit firearms in the State Capitol. "No more deliberation. There is nothing more to study. The Capitol Commission must actnow to prohibit guns in the Capitol to avoid a catastrophic incident.	183
6	"Plain and simple she needs to eat lead and send a statement to the rest of the democrats that they are next," a man from Fennville wrote. An armed rally is planned in Lansing on Thursday, where civilians can bring guns into the statehouse.	159
7	The armed rally in Lansing, Michigan, has begun, and of course it features misogyny, racism and bigotry.	128
8	Michigan's policy of housing COVID-19 nursing home patients with uninfected patients comes under scrutiny	94
9	"The violent, racist, extreme rhetoric that has already been connected to Thursday's rally I think is… concerning isn't a strong enough word," @GovWhitmer on the armed "protest" planned to take place in Lansing on Thursday.	82
10	@GovWhitmer has no legal right to lock us down and restrict our Constitutional rights! Every #mileg who is working with her is also responsible for said tyranny! #Michigan is opening whether you assholes like it or not!	82
11	"These protests, in a perverse way, make it likelier that we're going to stay in a stay-home posture," @GovWhitmer	81
12	While armed insurrectionists in Michigan continue their extremism today in Lansing, #StudentsDemandAction volunteers across the state are focused on activism. Join them.	78
13	In a private Facebook page called "The People of Michigan vs Gov. Gretchen Whitmer" a gun extremist wrote, "Hopefully the police decide that fucking with pissed off armed men is a bad idea."	73
14	NEW: Democrat state rep. voices criticism of Michigan's nursing home policy that "has been putting long-term care patients recovering from the virus in the same facilities with patients who don't have the virus." #migov #michigancoronavirus	67
15	The Legislature has a role as the voice of the people! If only 2020 @GovWhitmer would listen to 2012 @GretchenWhitmer.	60

Table 1. Most popular tweets on Covid-19 lockdown at Michigan capital, May 2020.

On May 14th, the day of the armed protest, was the most complex day, where we found thousands of tweets being pushed by both the parties. The most tweeted/retweeted post was Tweet ID #2, "**Michigan closed down its capitol in Lansing today and canceled its legislative session rather than face the possibility of an armed protest and death threats against Democratic Governor Gretchen Whitmer."**. Followed by Tweet ID #3, 7, 8, 11,12 and 15. On this day, all actions and behaviors were unpredictable due to volume of tweets, change in the tweets' context and the spread of information across the network, where all hundreds of users were trying to influence the environment.

Finally, on May 15th, a day after the protest, tweet ID # 2 and 3, 11,12 started to trend. These tweets received the greatest number of retweets and user engagement after the protest but did not receive much attention during the protest.

To simulate the complex behaviors from users on Twitter, the organization cybernetic theory is designed to illustrate two organizations acting against each other on Twitter. This method can reveal the complex, dynamic, and noncooperative actions from the armed protestors, and other parties' users feedbacks trying to spread information to slow down or stop the upcoming protest.

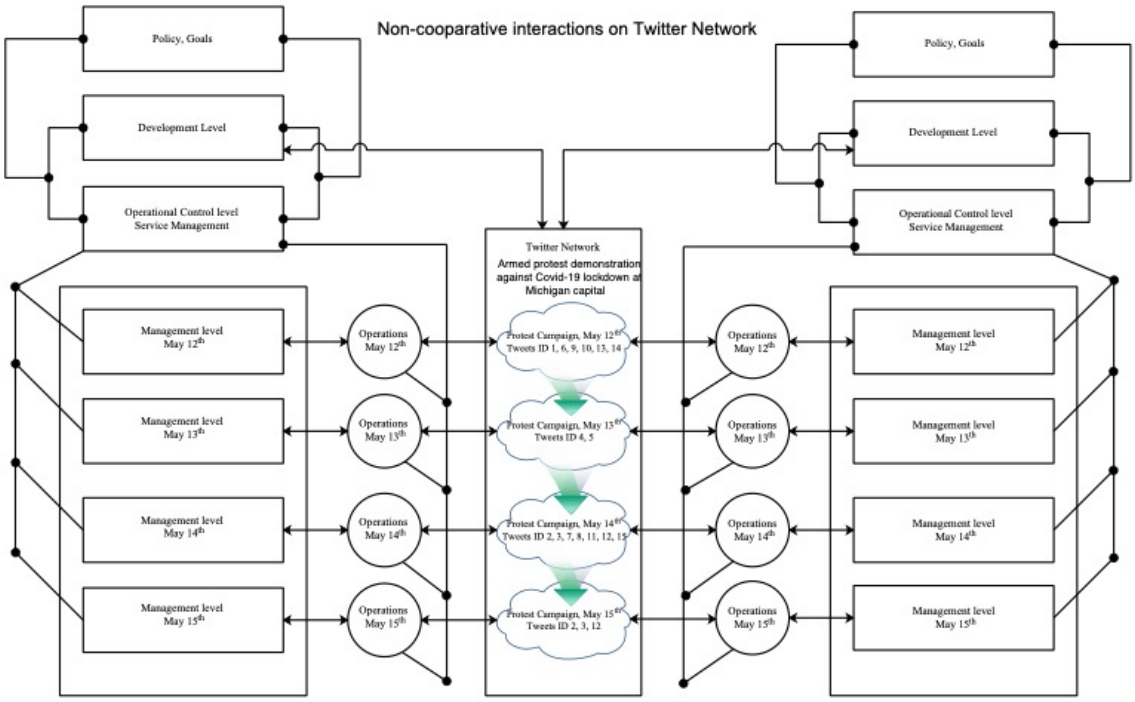


Figure 3. Non-cooperative interaction between two COVID-19 campaigns on Twitter network

In Figure 3, we presented both parties' as two organizations acting against each other in different ways to influence the network. Then each side was broken down into four operational units (one operational unit for each day, May 12th through May 15th). Each day has its own localized management and its own relations with the relevant part of the Twitter environment or the outside world. The operational units may interact or can be the same unit every day by sharing information, rotating spots, shifts, and bots. This level of operational units may have sort of flexibility to be able to deal with different environments or actions on the network. They may have to report to their local managers, or operational control level and required implementation functions to make them able to respond to any changes in their environments. Also, they can receive feedback on their performance and tasks correction actions from a higher level.

The local managements also need to make sure the fluency in the process, and the local management can report information to operation control and speeding vital communication all the way to the policy level. This will help to correct any unpresented feedback, changes in the protest plans, and to lower down any surprises that they need to be immediately aware of.

The development is where the internal information received from the operational control level, information about the total outside and Twitter environment in a form that facilitates decision-making, in other words this level is acting like an operational room for the campaign.

The policy level needs to make sure that the network system adapts to the protest and Twitter's network as and when necessary and needs to maintain the benefits to be gained from the campaign. This level should articulate the identity and purposes of the whole (anti) protest and reflect them to the entire network. The policy level can increase the influence by employing integrated users, bots, media, ads etc. and organize the level as an elaborate, interactive assemblage of managers. However, this level can recruit experts to enhance the campaign's performance and how different parts, or the campaigns work as whole and doing in relation to their goals.

Conclusion

Systems thinking methods are useful tools to merge different disciplines into social networks analysis. Considering one concept such as operational research approaches would limit the analysis into few variables, where methods such as game theory cannot consider variety of the social networks' variables into the solution. Implementing Complexity theories, feedback analysis, and network dynamics methods are helpful to track the users' single actions, predict their reactions, control the networks' information flow, and study the interrelationships between both users' and the outside environment. In this research, we studied two campaigns' behaviors on Twitter, where both campaigns implemented noncooperative actions for spreading information related to an armed protest demonstration against COVID-19 lockdown at Michigan capital on May 12th through May 15th, 2020. The mapping concept and organizational Cybernetics methods are used to study both campaigns interactions from the systems thinking perspectives and track their complex actions and reactions over times.

For future work, each of the complexity theory, system dynamics, game theory, networks influencers methods would need more in-depth research. Considering such topics into the online social networks are necessary.

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