The Effect of Social Media on Shaping Individuals 
Opinion Formation

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Abstract

In this paper, the influence of the social media on the opinion formation process is modeled during an election campaign. In the proposed model, peer-to-peer interactions and targeted online propaganda messages are assumed to be the driving forces of the opinion formation dynamics. The conviction power of the targeted messages is based on the collected and processed private information. In this work, the model is based on an artificial society, initially evenly divided between two parties. The bounded confidence model governs peer-to-peer interactions with a value of confidence parameter which leads to consensus. The targeted messages which was modeled as an external interacting source of information convert some weakly committed individuals to break this evenness. Both parties use the same methods for propaganda. It is shown that a very small external influence break the evenness of the opinion distribution which play significant role in the election results. Obtained opinion fluctuation time series have close resemblance with the actual election poll results.

Keywords: Opinion formation, social media, fake news, fabricated news.

1. Introduction

During the last decade internet and particularly online news services and social media networks have been the dominant information sharing channels. In the social media large groups of individuals, sharing similar interests form networks [1] which create mutual trust among the members of the network.
Information coming from a member of the network is accepted and propagated by the members of the group without much criticism [2, 3, 4]. Such a free environment makes the users vulnerable since as well as expressing their opinions they also reveal some personal data. Third parties may collect such personal information, process it and use for their purposes. Advertising agencies and political parties are willing to use the personal information to convince or to convert individuals. Hence the freedom of expressing opinion and spreading information may be misused to propagate rumor, gossip and misleading or false information [5, 6, 7]. The question, whether such interventions effect the public opinion or not [8] is still an open debate. The effect of an information system such as TV, newspaper, blogs, on the evolution of public opinion is studied in [9]. Also, the analysis of the frequency of interaction is considered in [10]. It is also shown that, to use/support some concepts which are valuable or very sensitive for the society, such as religion, nationality, cultural issues, collective beliefs can also make a profit for politicians [11] and even the ideas adopted by the minority of the society can be supported by the majority, after such a process. The effect of the social network utilizing degree-dependent fitness and attributes when there are competing opinion diffusion is introduced in [12]. The role of the social media on the social polarization of the society is studied through both data [1, 13] and model studies [6, 8]. Although the social studies still do not have clear evidence on the influence of such misleading information flow on the social preferences, it is shown that false news propagation is faster and broader than the spread of true news due to the attractiveness of the false news [14].

Recently, two very important social events, namely Brexit—the British referendum to leave the European Union—and 2016 US presidential election campaigns are the striking examples of such social phenomena. During the campaign the fake news are not only fabricated but more than that the issues are carefully selected by using personal information of the social media users [15, 17]. The collected personal information is used to convince and convert individuals. It is shown that in the US Presidential election campaigns some nodes and bots, i.e. automated accounts, in the social networks spread fabricated, fake, biased information, distort actual news, disseminate deceptive information [4, 8, 14, 16]. The severity of the outside interruption can be seen by comparing the numbers: Only on 20 election stories, the number of Facebook engagements are 8.7m fake news versus 7.3m mainstream
news starting from the beginning of August to the election day \[18\]. During a recent survey, nearly 85 percent of respondents stated that they believed fake news is a serious social problem \[19\].

The aim of this work is to build a model to study the effects of varying sources of fake and biased news on the opinion formation during an election campaign. The model society consist of \(N\) individuals with multi-component opinion on the election issues. On the decision-making process information, originating from different sources, play a vital role to build up opinion. For the simplicity election issues are limited in the model. The individuals exchange opinion on only three different issues (such as the economy, health services, security). Hence, each individual is identified by three real opinion values, but when it comes to making a decision on the vote, the choice is a result of combined opinion formed on all three issues. In this sense, the opinion structure of the model resembles Axelrod mode \[20\]. The individuals exchange opinion according to the bounded confidence model (BCM) \[21\]. Each individual is also subject to information flow through public services, social media, and online news sources. Some of this information may be fake, fabricated and even targets a particular individual. Targeted news specifically designed by considering the individual preferences \[15\] which is more effective on the non-committed individuals. To mimic the effects of the public services, social media, targeted, false or biased information spread a new interaction is introduced.

The model is tested on four different cases:

1. Individual interact with others through peer-to-peer interactions no external sources affects the dynamics.
2. One of the parties send messages to convert less convinced individuals.
3. Both of the parties send messages to convert less convinced individuals.
4. Both parties send messages but one sends more convincing (fabricated) messages.

In all four cases individuals exchange opinion through social media channels. The acceptability of the messages of online news sources are controlled by using different probability values which are discussed in detail in the results section.
The rest of this paper is organized as follows. Section 2 provides a background for the proposed model with bounded confidence opinion dynamics. Section 3 is devoted for presentation of the simulation results. Finally Section 4 concludes the paper.

2. The Model

The proposed model is based on an artificial society with \( N \) individuals. The communication network is a fully connected network with nodes, \( i = 1, \ldots, N \). This topology allows every individual to interact with every other mutually. Even though it looks too simple; it eliminates the artifacts of more complicated network topology which is essential for our discussion. The position of each member of the society is labeled by Latin alphabets \( i, j, \ldots \). Each individual carries a three opinion component which is labeled by Greek alphabet, \( \alpha = 1, 2, 3 \).

Eq.1 defines the opinion of an individual who has three opinion components in the matrix form.

\[
O = \begin{pmatrix}
o_{11} & o_{12} & o_{13} \\
o_{21} & o_{22} & o_{23} \\
\vdots & \vdots & \vdots \\
o_{N1} & o_{N2} & o_{N3}
\end{pmatrix}
\]  

(1)

Here \( N \) is the number of individuals, \( o_{\alpha} \), \( (o_{\alpha} \in \mathbb{R}^w) \) are the opinion values of \( i^{th} \) individual on the \( \alpha^{th} \) issue. All three opinion components are assigned randomly to each individual. Each opinion component has a Gaussian distribution with mean value \( <O> = \pm1 \), indicates two opposing views. In order to have some interaction between different views (different opinion individuals), variance of the Gaussian is used as the control parameter of the overlapping region.

At every interaction a randomly chosen pair of individuals exchange opinion on a randomly chosen issue. In each interaction individuals discuss on any one of the three issues in concern. Opinion exchange is realized according to BCM \([21]\) given in Eq.2.
If $|o_{i\alpha}(t) - o_{j\alpha}(t)| \leq \Delta$ \hspace{1cm} (2)

\begin{align*}
o_{i\alpha}(t) &= \omega o_{i\alpha}(t-1) + (1-\omega) o_{j\alpha}(t-1) \\
o_{j\alpha}(t) &= \omega o_{j\alpha}(t-1) + (1-\omega) o_{i\alpha}(t-1)
\end{align*}

Here $\Delta$ is the tolerance threshold, $\omega$ is the opinion exchange factor, and $t$ indicates discrete time steps.

Eq. 3 defines the interaction of external influences with the individuals.

If $o_{i\alpha} \leq \eta_{i,\alpha}$ then $o_{i\alpha} = \begin{cases} o_{i\alpha} + M_{i\alpha} & \text{if } P_{i\alpha} > r \\ o_{i\alpha} & \text{otherwise} \end{cases}$ \hspace{1cm} (3)

Here, $P_{i\alpha}$ is the probability of $i^{th}$ individual receiving an information on the issue $\alpha$, $r$ is a uniform random number between 0 and 1, $o_{i\alpha}$ and $\eta_{i,\alpha}$ are the opinion and the tolerance level of the $i^{th}$ individual on the issue $\alpha$ respectively.

At any discrete time step each individual, $i$, may receive a message on the issue $\alpha$ if he/she is supporting his/her idea less than a threshold value $\eta_{i,\alpha}$. The individual adopts the incoming message, $M_{i\alpha}$ with a probability of $P_{i\alpha}$. Hence the opinion value is replaced with a new value which is modified by the message content. Messages can be sent by either one of the two parties or by any existing friend. If the $i^{th}$ individual is a supporter of one of the parties but not a committed follower of its political stands on some of the issues the message may convert the individual as a new supporter of the opposite party.

The society can have different sensitivities on different issues which are represented as $s_{\alpha}$ in the numerical simulation. To deal with this scenario three opinion weights can be assigned, $s_{\alpha}$, $\alpha = 1,2,3$, to each three opinion components (Eq. 4).

$$RO_i(t) = s_1 o_{i1}(t) + s_2 o_{i2}(t) + s_3 o_{i3}(t)$$ \hspace{1cm} (4)

where $RO_i(t)$ is the resulted opinion of the $i^{th}$ individual, $s_{\alpha}$ and $o_{i\alpha}(t)$ are the weights, $\alpha = 1,2,3$, and the opinions on different issues respectively.

A binary decision of the individual proceed continuous opinion components which is calculated by using the sign of the Eq. 4

$$D_i = \begin{cases} 1 & \text{if } RO_i > 0 \\ -1 & \text{if } RO_i < 0 \end{cases}$$ \hspace{1cm} (5)
If the overall opinion of the individual is positive we say an individual is the 
supporter of the first view, otherwise the second view.

Both parties use regular media and social media communications to locate 
weakly committed individuals and try to win them over by sending messages. 
The system evolves a one-time step in discrete time as follows;

1. Choose randomly an individual, $i$, from the set $\{1, 2, \ldots, N\}$
2. Choose randomly a neighbor, $j$, from the set $\{1, 2, \ldots, N\}$
3. Choose randomly an issue, $\alpha$, to discuss from the set $\alpha = 1, 2, 3$
4. Check the opinion component difference between individual $i$ and indi-
   vidual $j$ on issues $\alpha$
5. If $diff = o_{i\alpha} - o_{j\alpha}$ is less than tolerance threshold, $\Delta$, exchange opinion 
   with the rule;
   \[
   o_{i\alpha}(t) = \omega o_{i\alpha}(t - 1) + (1 - \omega) o_{j\alpha}(t - 1) \\
   o_{j\alpha}(t) = \omega o_{j\alpha}(t - 1) + (1 - \omega) o_{i\alpha}(t - 1)
   \]
6. If $o_{i\beta} < \eta$, where $\beta$ is the issue on which external observer send mes-
   sages,
7. Individual $i$ receive a targeted message $M_{i\beta}$
8. Chose a random number, $r \in (0, 1)$
9. If $P_{\beta} > r$ where $P_{\beta}$ is the probability to adopt the message, individual 
   $i$ accepts the message and update opinion $o_{i\beta} = o_{i\beta} + M_{i\beta}$
10. Repeat starting from the first step and continue $N$ times.

The above steps describe 1 discrete time step. The system is followed 
until the final date of the campaign.

In the next section simulation results, obtained by applying the the pro-
posed model is introduced with figures.

3. Results and Discussion

The proposed model, described in section 2 contains two different but 
complementary interactions among the members of an artificial society which 
consists of $N = 40000$ fully connected individuals. Simulations are carried 
on discrete time steps. A time step is defined as the number of interactions, 
$O(N)$ which is sufficient for each individual to interact with at least with one
neighbor and one outside news source. At each time slice the averages are taken over the opinion configurations. In the simulations, 500 different initial opinion configurations are created. The time span of the election campaign is chosen as 200 time steps.

The society, initially, consists of equally divided group of individuals. Each opinion component has a Gaussian distribution with mean value \( \pm 1 \), indicates two opposing views, and variance \( \sigma^2 = 0.5 \). With these choices, the Gaussian opinion distributions overlap at the origin. As the variance becomes closer to 1 the overlapping opinions increases. The individuals who constitutes the overlap region (uncommitted supporters of opposing ideas) are the targeted individuals by the external influences to persuade to their view.

The interaction parameters are grouped into two. The first group is related to peer-to-peer interactions while the second one is external influences.

1. Peer-to-Peer Interaction Parameters Two parameters, the tolerance limit, \( \Delta_{\alpha} \) and opinion exchange parameter \( \omega \) controls the peer-to-peer interactions. \( \Delta_{\alpha} \) is taken as a constant for all members of the society and all issues, \( \Delta_{\alpha} = \Delta \). The choice of tolerance parameter \( \Delta = 1.216 \) allow the individuals to interact with a wide range of opinion holders only excludes extremists. The opinion exchange parameter is taken as, \( \Omega = 0.8 \) which controls the speed of the opinion formation process.

2. The influence of the external sources

The sign of the resultant opinion (Eq.(1)) is the indicator of the vote where the relative weights of the issues are taken equal for the simplicity of the discussions. The conviction parameter, \( \eta \), is considered as a small value in the simulation studies the value is used as \( \eta = 0.3 \). The news acceptance probability, \( P_\beta \), take different values according to the alignment of the opinion of the individual and the incoming news item. The message size, \( M_{i\beta} \), is also an other parameter which changes at each interaction. It is taken as random value, \( 0 \leq M_{i\beta} < 0.5 \).

Four different situations are considered: (a) averaged opinion with only peer-to-peer interactions \( (P_\beta = 0; \text{ for } \beta = 0, 1) \), (b) one of the opinion supporters spread information by using mainstream and social media while the other opinion spread only by peer-to-peer interactions, \( (P_0 = 0.5; \text{ and } P_1 = 0.0) \) (c) both opinion followers use the same means of external influences,
Figure 1: Paths of opinion change starting from statistically independent initial configurations.

\( P_\beta = 0.5; \text{ for } \beta = 0, 1 \) (d) both parties use influential sources together with peer-to-peer interactions, but one put more convincing arguments forward, \( P_0 = 1.0; \) and \( P_1 = 0.5. \)

3.1. Individual interact with others through peer-to-peer interactions no external sources affects the dynamics.

Figure 1 shows simulation results starting from different initial opinion configurations which may be interpreted as the opinion changes in a region during an election campaign (Paths of opinion). As it can be observed from the figure, (Figure 1) each initial configuration converges a different final state. This situation resemble election results in different election zones. In different election zones, majority support may be on different parties but the overall votes are the decisive factor for the result of the election.

In fact non of these individual paths has much meaning, the result of the campaign is the average of all these paths. Figure 2 (a) shows that if there is no external influences in the average both parties share the population almost equally.

The dynamics of opinion formation without external influences can be better understood by observing the changes of the opinion distributions. Figure 3 show the averaged opinion distributions for four instances of the election campaign.

At the initial stages of the campaign, \( t = 0 \) (Figure 3 (a)), the society is assumed to be equally divided on two opposing opinions. As soon as the campaign starts, bounded confidence dynamics unite individuals around the opposing opinions which sharpens the Gaussian opinion distributions. This situation is not stationary, a third peak start to appear around the origin, \( t = 40 \) (Figure 3 (c)). As the time passes, the supporters of both parties,
Figure 2: Time evolution of the configuration averaged opinion distributions.

Figure 3: The snapshots of the averaged opinion distribution without external influences.
apart from some extremists, converge towards a moderate opinion \((t = 60, \text{ Figure } 3 \text{ (d)})\) and the distribution remains the same (Figure 4 (a)).

3.2. One of the parties send messages to convert less convinced individuals.

In any election campaign, ideally, both parties use the same means to convince individuals. Never the less, it is not always possible to maintain the same level of publicity or use of media for both parties. The uncommitted \(|O_{i,\beta}| < \eta\) electors remain under one-sided news bombardment which may change opinion of some of the individuals who aim to vote for one party without a deep conviction. The average daily progress of the opinion formation results are presented by figure 2 (b).

If the outside sources can convince even a small group of uncommitted individuals it may be sufficient to win the election. The time dependent variations of the opinion distributions also give clear picture of the process of opinion changes. Figure 4 (b) show that at \(t = 100\), peer-to-peer interactions sharpen the Gaussian while the external influences change the heights of the Gaussian’s. At the final stages of the election campaign the middle peak lean towards the opinion who use external sources to convince moderate individuals.
3.3. Both of the parties send messages to convert less convinced individuals.

Figures 2 (c) and ?? (c) show that if both parties are using external news sources and the social media to convince the less committed individuals, the picture is quite similar to the one seen for only peer-to-peer interaction case. The moderate individuals fluctuate between two opposing opinions, hence, the final election result is unpredictable, figure 2 (c)

3.4. Both parties send messages but one sends more convincing (fabricated) messages.

The final consideration is that both parties use media and social media. One of the parties increase activities, send targeted, fake or fabricated messages, on the social media during the election period. This resemble the situation during 2016 US Presidential elections [22]. The situation is not as sewer as the one party usage of the social media (Discussed in subsection 3.2) but even such an effort difference can be sufficient for winning the election. Figure ?? show the

Fig.?? that the percentage of the decision of two parties under the effect of propaganda by both political side. This figure shows an alternating behavior and when it comes to election day the election result can be rather unpredictable.

4. Conclusions

Recently the internet is the primary source of acquisition of knowledge for the societies. This makes the internet a very powerful and unique. An exciting information, whether it is fake, fabricated or destructive propagate very fast among the members of the societies. Media can put forward some ideas or hide some information, by censoring, to make followers/members gain an advantage. In social interactions the spread of gossip and fabricated information has a very long history and it is not only limited with the online media [23]. Never the less the involvements of various data companies on the 2016 US presidential elections are publicly known and opened a debate on the violation of civil liberties [17]. Such a data-driven research needs of using an interdisciplinary approach. Using data science techniques to understand voter behavior on the segment of their ideas allow politicians to use digital-marketing strategies to reach individuals. Hence usage of powerful data analyzing techniques is becoming increasingly harmful to the civil liberties. As the 2020 US presidential election is approaching the studies
on the effects of the fake and fabricated news and personalized, targeted messages gain upmost importance.

The present work aims to introduce a simple agent-based model to simulate the effects of using gathered information to send targeted messages during an election process. Recent studies show that societies are almost evenly divided on the main political issues. Hence such a targeted external information bombardment may be very effective to change the opinions. Since all parties may use the same techniques, a small percentage of, (1% − 2%), opinion fluctuations may be decisive on the result of the elections. The above assumptions seem reasonably realistic considering voting processes such as Scottish referendum (55.3% − 44.7%), 2016 US Election (46.1% − 48.2%) and Brexit referendum (51.9% − 48.1%). It is observed that if both parties compete equally the election results are unpredictable. If one of the parties use the technological power and social media more than the opponents, can easily gain the required small percentage of the undecided voters. It is evident that in the next decade the use of artificial intelligence techniques to extract information from individuals social media history will be used more frequently unless some global legislative regulation on the use of private information.

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