Analysis of behavior of attenuation of social memories on movie and social scandal using sociophysics approach

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Abstract

Time decay of memory is measured using social media data. The behavior of decay of memory is known to be different for individual personal memory and for social memory. For personal memory, the decay is power law like. However, the decay of social memory seems to be exponential like decay, at least for popular movies. This result is significant to analyze social phenomena using sociophysics approach. Moreover, we found that the decay form is mixed decay of exponential and power law like for the social scandal topics.

1 Introduction

Intentions of humans in societies can be measured by using social network systems. In this paper, we focus our attention to the decay of intention in societies that appears in the time variation of number of posting of blogs or twitter per days. In psychology, it is well known that forgetting curve has exponential form [1]. On the other hand, Crane and Sornette found that the forgetting curve is power law form from other experiments [2]. For Japanese social media, Sano et al. found power laws generally approximate the functional forms of growth and decay with various exponents values between $-0.1$ and $-2.5$.[3,4] On the contrary, in the paper of the mathematical model for hit phenomena[5], the author indicate that the decay of the reputation of movie is exponential by using the observed data on reputation of 25 movies as blogs. This exponential decay is built into the model.

Thus, in this study, we focus on the decay behavior of postings of blogs for many movies in Japanese market or some social scandals in Japanese society to confirm that the decay behavior is exponential form or power law form. This problem is related to the memory of human. The attention of human for a certain topic decreases because of forgetfulness or loss of attention with the passage of time. Such decay of attention has two meanings; attenuation of individual human memory or attenuation of social memory.

The social memory is not equal to the memory of an individual human who is a member of the society. Social memories include advertisement spot message on TV, advertisement on Internet and advertisement posters pin up in cities. Moreover, for the social memory, the speed of forgetting of each person in the society is considered to depend on the forgetting speeds of peoples around the person. In this study, we try to analyze decay of posts on social media as decay of social memory using the mathematical model for hit phenomena, a model to describe time variation of intention of people in societies.

In this paper, the responses in social media are observed using the social media listening platform presented by Hottolink. Using the data set presented by M Data Co.Ltd monitors the exposure of each film.

2 Forgetting memory model and the mathematical model for hit phenomena

The mathematical form of forgetting memory has two types; exponential law and power law,

\[ I(t) = I_0 e^{-a(t-t_0)} \]

\[ I(t) = \frac{I_0}{(t-t_0)^a} \]

It is well known that the exponential decay model corresponds to the line of semi-log scale graph and the power law model correspond to a line of the double-logarithmic scale graph.

According to the ref.5, we write down the equation of intention of each person using the exponential form as

\[
\frac{dI_i(t)}{dt} = -aI_i(t) + \sum_j d_{ij}I_j(t) + \sum_k h_{ijk}I_j(t)I_k(t) + f_i(t) 
\]

(1)

where $d_{ij}$, $h_{ijk}$ and $f_i(t)$ are the coefficient of the direct communication, the coefficient of the indirect communication, and the random effect for person $i$, respectively. We consider the above equation for every consumer so that $i = 1, \ldots, N_p$.

Taking the effect of direct communication, indirect communication, and the decline of audience into account, we obtain the above equation for the mathematical model for the hit phenomenon. The advertisement and publicity effect for each person can be described as the mean field value of the random effect $\langle f_i(t) \rangle$.

Eq. (1) is the equation for all individual persons, but it is
not convenient for analysis. Thus, we consider here the ensemble average of the purchase intention of individual persons as follows:

\[ \langle I(t) \rangle = \frac{1}{N} \sum I_i(t) \]

Taking the ensemble average of eq. (1), we obtain the following form as the intention of society as collective mode,

\[ \frac{d \langle I(t) \rangle}{dt} = -a \langle I(t) \rangle + D \langle I(t) \rangle + P \langle I(t) \rangle^3 + \langle f(t) \rangle \]

where

\[ N \delta d = D \]

\[ N^2 \rho = P \]

If we use the power law form as model of memory decay, we obtain the following formula in the similar derivation as mathematical model for hit phenomena, (2)

\[ \frac{d \langle I(t) \rangle}{dt} = -a \langle I(t) \rangle + D \langle I(t) \rangle + P \langle I(t) \rangle^2 + \langle f(t) \rangle \]

\[ (3) \]

3 Detail of calculation

For adjusting decay parameters, we employ the Monte Carlo-like method. For the purpose of reliability, we introduce here the so-called “R-factor” (reliable factor). The R-factor has been well known in the field of low-energy electron diffraction (LEED) experiments [6]. In LEED experiments, the experimentally observed curve of current vs. voltage is compared with the corresponding theoretical curve by adjusting parameters (coordinates of atomic positions) using the R-factor.

For our purpose, we define the R-factor as follows:

\[ R = \frac{\sum (f(i) - g(i))^2}{\sum (f(i)^2 + g(i)^2)} \]

where the functions f(i) and g(i) correspond to observed posts in social media and calculation result, respectively. The smaller the R-factor, the better the match in functions f and g. This R-factor technique has been used as established adjusting technique in the LEED study for over 30 years. We use this R-factor as a guide to get the best adjustment of our parameters for each decay curves.

4 Results of Observation

In this study, we observe several social media data as examples of decay behaviors. We show the observation of decay behavior for personal memory and social memory. We select posts in social media for the St. Valentine’s day as an example of personal memory, because posts are mainly on their own personal reason. The personal memory here means the distribution of social media posts around a certain memorial days like birthday, St Valentine day, Marine Day (Japanese national holiday), etc. We select posts in social media for films as social memory, because many person in society pay attention to the film. We also select posts for the Japanese academic scandal as the third example. The social memory means that the not person but society memorizes the events or topics. A part of social memories are due to advertisements on TV, newspapers, magazines and posters in many places in cities.

4.1 Personal memory

As the topic of personal memory, we select "St Valentine's day". The St Valentine's day is, in Japan, the day of courtship from women to men. Fig.1 shows the original decay curve on the measured data. Fig.2 is the semi log scale graph of this. Fig.3 is the double-logarithmic graph of it. It is clear that the result support the power law form. Similar results were obtained by Sano et.al.[3,4]

Fig.1 The decay of posting for St Valentine's day.

Fig.2 Semi-log graph of St Valentine's day.

Fig.3 Double-logarithmic graph of St Valentine's day.
4.2 Social memory

As examples of social memory, we select entertainment case; 6 films, Departure, Red Cliff, Aibo, Twentieth century boys1 and 2, Thermae Romae and Deathnote in Japanese market. The decay of the number of posts per each day are plotted in semi-log and double-logarithmic scale in fig.4 and 5 respectively.

The results shows us that the decay feature is exponential form for movie. In fig.6, we show the calculation using the mathematical model for hit phenomena with the exponential decay form for the movie Thermae Romae compared with the measured daily posting counts for Twitter on the movie. The parameters in eq.(2) are adjusted to the measured data using the Monte Carlo technique (see ref.5). The histogram corresponds to the exposure time of the movie on TV for each days. The calculation agrees well with the measured social network data for Twitter. Thus, we found that the attenuation of the social memory on entertainments can be described as the exponential decay form.

4.3 Social scandal

We show here an academic scandal in Japan as another type of example of decay behavior. In 2014, the scandal of the stimulus-triggered acquisition of pluripotency cell (known as STAP cell) happen in Japanese famous research institute RIKEN. In January of 2014, the observation of STAP cells was reported on Nature[7,8]. The research was mainly done by Dr.H Obokata and a part of the experiment was done by Prof. T Wakayama of Yamanashi University Japan. The STAP project was strongly supported and promoted by Prof. Y Sasai who is very famous for the researches on embryonic stem cells. However, soon after the publication of the paper, it was pointed out by many researchers in the world that the conclusion of the papers are not confirmed by their experiments.

In March, one of the key authors, Prof. T Wakayama proposed to withdrawn the papers of Nature because of questionable points on the papers. On 1 April 2014, RIKEN concluded that Obokata had falsified data to obtain her results. Finally, their papers have been withdrawn.

It means that the decay behavior of memory of personal memorial day and the entertainment event are different. For entertainment events, we can expect a lot of advertisement information in society and these advertisements are parts of social memory.
sued on TV or on newspapers or on Internet in Japan because of very high popularity of the STAP cell problem.

Recently, we use the STAP cell incident as an example of an application of the mathematical model for social phenomena [9]. In our previous work, we succeed to reproduce the daily posting counts for blog and Twitter for the posting including the word "Obokata" using the model. It is very lucky for our analyst that the name Obokata is very rare family name in Japan. In this calculation, however, we do not include memory decay terms because of very short-range time scale of each incident on this scandal.

In fig. 7, we show the observed counts of posting for STAP cell scandal and the corresponding calculation using the mathematical model for hit phenomena of eq. (2). The detail of the calculation is described in ref. 8.

The observed blog data for STAP cell scandal is drawn on fig. 8 and fig. 9 as the semi-log and double-logarithmic scale graph. The data are number of posting including the word "Dr. Obokata" or "STAP". The decays are shown for the time point of the three arrows indicated in fig. 7. We found that the observed data is shown to be, not exponential law nor not power law, because the curves in the two graphs fig. 8 and fig. 9 are not linear for both case. Thus, we can pointed out that, for social scandal, the social memory decay is not exponential nor power law like.

5 New model of memory decay

In the above section, we found that the both exponential decay law and power decay law do not hold in the case of the social scandal. From fig. 8 and fig. 9, the decay curve seems to be between the exponential decay and the power decay. Thus, we introduce a new model of decay for the following form,

\[ \frac{1}{(t-t_0)^\alpha} e^{-\beta (t-t_0)} \]  \hspace{1cm} (4)

This is a compromise of exponential decay and power decay. This decay form is the solution of the following differential equation.

\[ \frac{dI(t)}{dt} = - \left( \frac{\alpha}{t-t_0} + \beta \right) I(t) \]  \hspace{1cm} (5)

Using (4), we can fit the observed data for the social scandal, STAP cell as shown in the following figures. The adjustment technique we use for \( \alpha \) and \( \beta \) is the Monte Carlo-like technique described in section 3. In the figures, we show the observed decay data for "Dr. Obokata" and "STAP" for the time point of the three arrows in fig. 7 for blog.

From the figures 10, 11, 12, 13, 14 and 15, we found that the new decay form (4) work well for social media posting on the social scandal. In fig. 16, we show the semi-log graph corresponds to the fig. 10. The graph also shows that our new formula work well to adjust the observed data.
In table 1 we show the adjusted parameters $\alpha$ and $\beta$ of eq.(4) adjusted to the decay curves for the words "Dr.Obokata" and "STAP" for both blog and Twitter on the decay of the time points indicated in fig.7 as three arrows.
In Table 1, we found that some adjustments are very good. The behavior is almost power-law decay. Those indicate simply that the corresponding decay behavior is not exponential nor power for all three time points. The adjustment of our calculated R-factor values are very small, these indicate that the calculation results with observed decay curve on social media posts is shown in Table 2 as values of R-factor. Since the R-factor values are very small, these indicate that the adjustments are very good.

In Table 1, we found that some β values are very small. Those indicate simply that the corresponding decay behavior is almost power-law decay. Those do not indicate that the small exponential decay factor like 10^-8 would be very long-time decay.

Therefore, we can write down the equation of intention of each person using the above new decay as:

\[
\frac{dI_i(t)}{dt} = -\left(\frac{\alpha}{(t-t_0)} + \beta\right) I_i(t) + \sum d_{ij} I_j(t) + \sum k h_{ijk} I_j(t) I_k(t) + f_j(t)
\]

instead of eq.(2) or (3). We can consider that the new decay form (4) is very general form as a decay form of the attenuation of posts on social media. For the exponential decay, we set to be \(\alpha = 0\) and for the power decay, we set to be \(\beta = 0\). The new mathematical model for hit phenomena, eq.(6), is the compromise of exponential decay and power decay. We can derive both decay form from this new equation (6).

It will be very interesting if we can consider that the form eq.(4) is the compromise of personal memory decay and social memory decay.

<table>
<thead>
<tr>
<th>Blog</th>
<th>Obokata1</th>
<th>Obokata2</th>
<th>Obokata3</th>
<th>STAP1</th>
<th>STAP2</th>
<th>STAP3</th>
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Table 2 R-factor for adjustment of calculation of decay curve with eq.(4) and observed curve for for the words "Dr.Obokata" and "STAP" for both blog and Twitter on the decay of the time points indicated in fig.7 as three arrows.

From values in table 1, we found that the decay behavior for the social scandal on both blog and Twitter, the decay form is a compromise of exponential decay and power decay for all three time points. The adjustment of our calculation results with observed decay curve on social media posts is shown in Table 2 as values of R-factor. Since the R-factor values are very small, these indicate that the adjustments are very good.

6 Conclusions

For entertainment like movie, we found that the decay of memory of it is exponential form and it is different from attenuation of personal memory. The results support that the exponential form of attenuation of memory is used in the mathematical model of hit phenomena. We also found that the decay form is not exponential nor power law for the social scandal topics like STAP cell scandal in Japan at 2014. We present a new decay form and corresponding new mathematical model for hit phenomena as a compromise of exponential decay and power decay.

References


