

# Analysis of social epidemic phenomena on SNS using social physics approach

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In the present age where consumer behavior remains on record through the Internet, purchase records and action records for huge quantities of consumers are left. In this paper, we propose a method based on social physics for analyzing and forecasting social phenomena, and possibly applying it to marketing etc. by using the voices of society's people recorded by blogs and Twitter as data. Social physics is a new frontier of physics alongside economic physics, but if there is a huge amount of data, the methodology of physics that has been the subject of experimental data on natural phenomena can also be applied to social science. The approach using this article will be one of significant approach in computational social science.

In this paper, we focus on social epidemic phenomena and consider how break and convergence can be measured on the theory of social physics. The social outbreak mainly treated in this research is Pikotaro and hydrogen water [2]. Hydrogen water became famous among Japanese women [2] in 2016 summer. Both are rapidly prevalent, and convergence abruptly in the case of the hydrogen water in Japan.

The theory used for analysis is a mathematical model of the hit phenomenon. This theory was submitted by Ishii et al. in 2012[1], supposing that humans advertise the opportunity to be interested in a certain topic, a review from a friend and rumors heard in town. This theory is the theory of social physics that quantitatively treats breaks and convergence of people's interests. It is a theory that can analyze breaks and convergence of reputation such as movies, music concerts, social incidents. We write down the equation of purchase intention at the individual person level  $I_i(t)$  as

$$\begin{aligned} \frac{dI_i(t)}{dt} = & \sum_{\xi} c_{\xi} A_{\xi}(t) - aI_i(t) + \sum_j d_{ij} I_j(t) \\ & + \sum_j \sum_k p_{ijk} I_j(t) I_k(t) \end{aligned} \quad (1)$$

where  $d_{ij}$  and  $h_{ijk}$  are the coefficient of the direct communication and the coefficient of the indirect communication for person  $i$ , respectively[1]. The advertisement and publicity effects are include in  $A_{\xi}(t)$  which is treated as an external force. The index  $\xi$  means sum up of the multi media exposures.

Using the mean field approximation, we obtain the following equation as equation for averaged intention in the society. The derivation of the equation is explained in detail in ref.[1].

$$\frac{dI(t)}{dt} = \sum_{\xi} c_{\xi} A_{\xi}(t) + (D - a)I(t) + PI^2(t) \quad (2)$$

This equation is the macroscopic equation for the intention of whole society. Using this equation, our calculations

for the Japanese motion picture market have agreed very well with the actual residue distribution in time [1].

Using the above theory, we analyze social epidemic phenomena in Japanese society. For example, we analyze the hydrogen water. We employ the equation (2) using the observed daily advertisement data on television as  $A_{\xi}(t)$ . In fig.1, we show the observed daily Twitter posting and theoretical prediction. As we can see in the figure, our calculation agree well with the observed Twitter posting numbers.

The parameters  $C$ ,  $D$  and  $P$  in eq. (2) is adjusted for the periods, 5-8, 8-13, 18-19, 19-24, 24-26 and 26-28 of May 2016. As we can see in fig.2, the strength of the indirect communication,  $P$  is strong at the beginning of the social epidemic phenomenon. It means that the indirect communication is a key of epidemic phenomena. We found similar result also for the break of Pikotaro.

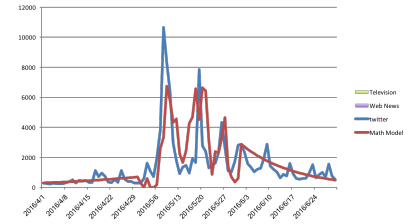


Figure 1: Observed daily number of posting on Twitter (blue) and theoretical calculation (red) for Hydrogen Water.

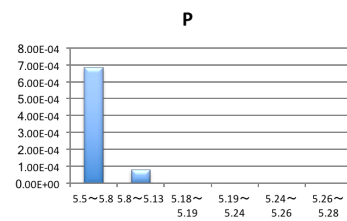


Figure 2: Strength of indirect communication of Hydrogen Water for the periods, 5-8, 8-13, 18-19, 19-24, 24-26 and 26-28 of May 2016.

- [1] Ishii A, Arakaki H, Matsuda N, Umemura S, Urushidani T, Yamagata N and Yoshida N, "The 'hit' phenomenon: a mathematical model of human dynamics interactions as a stochastic process", *New Journal of Physics* **14** (2012) 063018
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