

Analysis of social epidemic phenomena 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.

We write down the equation of purchase intention at the individual 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} , 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[1]. The advertisement and publicity effects are included in $A_{\xi}(t)$ which is treated as an external force. The index ξ means sum up of the multi media exposures. Word-of-mouth (WOM) represented by posts on social network systems like blog or twitter is used as observed data which can be compared with the calculated results of the model. The unit of time is a day. Here, it is assumed that the height of interest $I(t)$ of people attenuates exponentially.

We consider the above equation for every consumers in the society. 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. 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 this equation, our calculations for the Japanese motion picture market agree very well with the actual residue distribution in time. The advertisement and publicity effects are obtained from the dataset of M Data and the WOM represented by posts on social network systems are observed using the system of Hottolink.

Using the above theory, we analyze social epidemic phenomena in Japanese society, especially among female. For example, we analyze the hydrogen water. Hydrogen water became famous among Japanese women [2] in 2016 summer. 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 number and calculated 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.

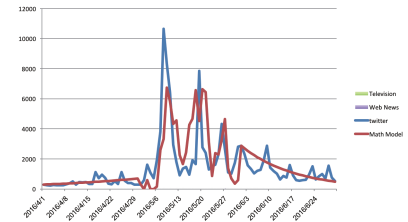


Figure 1: Observed daily number of posting on Twitter (blue) and theoretical calculation (red) for Hydrogen Water.

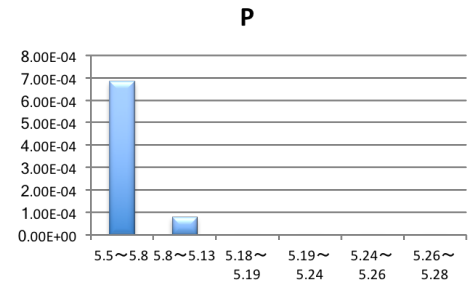


Figure 2: Strength of indirect communication of Hydrogen Water for the periods, 5-8, 8-13, 18-19, 19-24, 24-26 and 26-28 of May 2016.

- [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
- [2] ANNE BAUSO, 2016. We Tried the Miracle Water People in Japan Are Obsessed With, [online] 7 March, Available at: <http://www.allure.com/story/hfactor-hydrogen-water-review> [Accessed 31 January 2017]