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PIB: Profiling Influential Blogger in Online Social Networks, A Knowledge Driven Data Mining Approach

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Abstract

Online Social Networks (OSNs) facilitate to create and spread information easily and rapidly, influencing others to participate and propagandize. This work proposes a novel method of profiling Influential Blogger (IB) based on the activities performed on one's blog documents who influences various other bloggers in Social Blog Network (SBN). After constructing a social blogging site, a SBN is analyzed with appropriate parameters to get the Influential Blog Power (IBP) of each blogger in the network and demonstrate that profiling IB is adequate and accurate. The proposed Profiling Influential Blogger (PIB) Algorithm survival rate of IB is high and stable.

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Keywords: Blog document; Data mining; Influential blogger; Online social networks; Profiling; Social blog network.

1. Introduction

The web content, creation and usage has dramatically changed in the recent past with the evolution of Online Social Networks (OSNs). The rise of social media platforms such as Twitter, Google+, Facebook, Blog network etc., is generating a huge amount of data by the hour. Focus on user – generated content, activities and social network, has brought the scope for study and influence over OSNs. A social blog network is viewed as an OSN composed of nodes that represent blogs and links representing relations between blogs, e.g., myspace.com, blogger.com etc., allowing easy spread of information.

Blog growth is massive. Different types of information, opinions from different perspective is found on blogs by different bloggers on the same topic. Traditionally, people use to follow the words from different persons for taking any decision or to gather any information regarding an issue, which has been totally changed by blog networks. Here bloggers discuss their topic of interest, opinions or confusions openly, which are solved or answered by other bloggers. People with similar interest move closer by sharing their thoughts in their respective posts on blogs. This leads to people creating interesting contents and imposing on others by posting it publicly. Others who find it interesting, perform some actions on that blog, in-turn increasing the influence power of that blogger.

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Motivation: In Social Blog Networks, a user can create a personal webpage called Blogs and store diaries, commentaries and news of their interests. Bloggers share their opinion in their blog; people in friends link with similar interests access and use the content for themselves or propagate. The blog content generators and its users form a micro – blogging unit. The bloggers establish relations with other blogs through activities like, links, comments, trackbacks, scraps, bookmarks, blogrolls etc., Based on the activities performed on the blog documents by different bloggers in that network, the influential blogger is determined. Identifying influential blogger helps in understanding as to why some information spreads faster than others, making it essential to find groups with similar interest. Influential bloggers usually play a vital role in both political and economic world. These influential bloggers may involve their followers into antisocial activities directly or indirectly and propagandize their mission in physical world, which *motivates* us to carry out this work.

Contributions: This paper attempts to explore the characteristics of an Influential Blogger in Social Blog Network. We has presented an algorithm PIB which identifies *Trackback, Scrap,* and *Bookmark* as appropriate parameters in identifying the information diffusion. A key parameter which determines the influence power of the blogger is introduced in the PIB Algorithm.

The rest of the paper is *organized* as follows: Section-2 gives a brief review of the literature survey. The problem definition to determine IB is discussed in Section-3. The mathematical model is derived in Section-4. The Profiling Influential Blogger (PIB) algorithm is presented in Section-5. Performance Analysis through Simulations is discussed in Section-6. Conclusions are presented in Section-7.

2. Literature Survey

Yoon *et al.,*[1] proposed an approach to identify behavioral patterns exhibited in a blog network and defined a parameter *Propensity* which is divided into two types; (i) Information – oriented Propensity (IoP) – propensity of using the blog network to search, disseminate and share information, (ii) Friendship – oriented Propensity (FoP) – propensity of using the network to establish and encourage interpersonal interactions. This approach clearly identifies the pattern and purpose of the blog networks. Moon *et al.,*[2] have developed Quantifying Influence Model (QIM), composed of interpersonal similarity and degree of information propagation, to identify influential bloggers based on homophily and vulnerability with bloggers. Influential bloggers and Popular bloggers are differentiated on Naver blog data. Experimental results show that QIM determines quality and quantity of social ties according to their importance.

Narayanam *et al.,*[3] focused on target set selection problem, which involves discovering a small subset of influential users of social network. The ShaPley value – based Influential Nodes (SPINs) algorithm concentrates on two variants; top-k nodes and λ coverage problem and is based on the independent cascade model. The SPIN outperforms the Greedy[4] and the *Leskovec Krause Guestrin*(LKG)[5] algorithms in terms of running time. Lim *et al.,*[6] proposed an approach to determine influential users in a blog network using classification and clustering techniques of data mining. The influential bloggers actually motivate other users in a blog network resulting in increased business activity. An action – based network approach is proposed by Zhang *et al.,*[7] to measure the user influence in a popular news media. Twitter is considered as a representative micro – blogging service and is based on retweet or reply relationship. This action – based user influence algorithm inturn adopts the idea of PageRank algorithm, which involves both action network structure and the number of interactions among users.

Akritidis *et al.,*[8] investigated the issue of influential bloggers who are both productive and influential. It is mainly based on two parameters (i) *blogger's productivity index* (ii) *blogger's influence index*. The new method is able to identify significant temporal patterns in the blogging behavior and the blogging activity. Yang *et al.,*[9] proposed UserRank and PageRank method for identifying influential users in an online healthcare community. The degree of influence between two members, the content similarity and response immediacy between messages posted in the same thread is calculated. Experiments were conducted on three forum datasets of MedHelp – Swine Flu forum, Smoking Addiction forum and Alcoholism forum.

Zhang *et al.,*[10] proposed a novel clustering coefficient communities combination model with an assumption of merely two types of users in micro – blog; opinion leaders and common members. The user with their key connections can be deemed as a micro – blog network model named as LM (Leader – Members) model. The LM model involved

user behavior and direction of connections depicting well about the small world and scale – free properties of micro – blog network and clusters that help to mark the number of active/inactive nodes in the group.

Basaras *et al.,*[11] focused on finding influential spreader nodes through a measure; *m*-power community index, that is an amalgam of coreness and between centrality. This approach finds influential spreader nodes for a single as well as on a multiple origin process and outperforms the traditional methods. Zygmunt *et al.,*[12] proposed a new algorithm for determining life cycle of social groups and their cores. The approach determines the groups in social network and identifies the influential user in the group using core coefficient. It is useful in analysis of group evaluation, group formation and group continuation.

Allen *et al.,*[13] proposed scalable pushing protocols that use social information concerning the interests of the network nodes as well as the frequency of encounters, and helping to identify information diffusion in the network. They have incorporated the spatiotemporal scope of the updates, which is considered in current internet services. Jiang *et al.,*[14] proposed an evolutionary game theoretic framework to model the dynamic information diffusion process in social networks. The framework is analyzed in uniform and non-uniform degree networks. Experiments conducted on synthetic and real world data sets of *Facebook* and *Memetracker* show effectiveness of the social network users' information forwarding behaviors.

3. Problem Definition and Proposed System

Earlier, identifying influential bloggers was based on Topological method, Centrality measures, and the number of activities that happened on blog documents. However, these methods cannot accurately determine the tangible influential blogger, since a blogger would have performed multiple activities on one's own blog documents to increase his influential power. Profiling the appropriate influential blogger in social blog network is critical, since any propaganda, either good or bad, rapidly spreads far and wide, influencing many people directly and indirectly.

3.1 Proposed method

There are various kinds of activities performed by a blogger in social blog network. The activities of bloggers are recorded and analyzed in order to appropriately address the influential blogger. To overcome the disadvantage of existing methods[6], we propose a novel method to profile the *Influential Blogger* (IB) in a social blog network based on the activities performed by other bloggers on one's blog documents. IB is a blogger who influences the highest number of other bloggers through their blog documents in the network. IB may also vary depending upon the activities performed by new bloggers on documents of others with reference to time.

The relationship between two bloggers can be classified into the following activities: (i) *Comment* (ii) *Bookmark* (iii) *Trackback* and (iv) *Scrap*. When a relationship exists between documents of any two bloggers, either through scrap or trackback or bookmark, then further actions between those two bloggers is not counted. This helps in tracking Influential Blogger and his *Influential Blog Power* (IBP) in the network accurately.

Weak and strong relationships exist between bloggers. *Comment* activity can be considered into the category of weak relationship as it does not necessarily guarantee that the blogger is influenced by the blog just because he has commented on the blog document. Hence *comment* activity has been excluded in the proposed PIB approach. It is easy to predict the relationship between bloggers in the case of *Bookmark*. A blogger would not *bookmark* the document unless it is of interest to him.

The activities performed by any other Blogger-B, C, D and E on the document created by Blogger-A is considered as direct influence while it is observed that the bloggers reproduce the document content of others in their own document only if it is of same interest and/or if they are influenced by the content of the document. Any document that is reproduced by activities like *trackback* or *scrap* by other bloggers, can also be performed on the reproduced documents by few other bloggers as well, which in turn increases the power of the original document indicating indirect relationship between bloggers document. Thus, *trackback* and *scrap* activities depict the actual information diffusion in the network and contribute in determining the influential relationships between bloggers appropriately with their diffusion history.

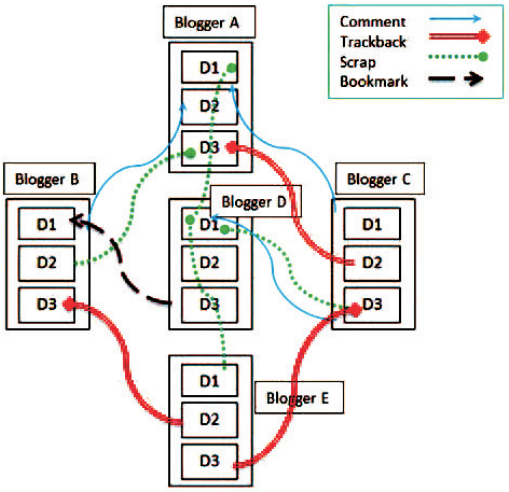

Fig. 1. Activities model in a social blog network.

3.2 Scenario

Figure 1 explains a model scenario of activities in a social blog network with Bloggers-A, B, C, D and E as an example. D1, D2, D3, and so on are the documents of each blogger shown respectively. The activities on any document can be in two ways (i) Direct and (ii) Indirect. An activity performed by any blogger on an original document created by a blogger is considered as Direct influence of the created document while the activities performed by other bloggers on the reproduced documents using either *scrap* or *trackback* are referred as Indirect influence of the created/reproduced documents.

Figure 1 shows both direct and indirect influence of the documents created by Bloggers-A, B, C, D and E. D2 of Blogger-B has *scraped* D3 of Blogger-A, D2 of Blogger-C has *trackbacked* D3 of Blogger-A, D1 of Blogger-D has *scraped* D1 of Blogger-A, D2 of Blogger-E has *trackbacked* the D3 of Blogger-C and also Blogger-D has *bookmarked* the D1 of Blogger-B. All these activities have happened on the documents created by respective bloggers by their own, hence are grouped under direct influence power while calculating IBP of a blogger. D1 of Blogger-D has *scraped* D1 of Blogger-A, which got *scraped* by D1 of Blogger-E. This activity represents indirect influence of D1 of Blogger-A on D1 of Blogger-E. Similarly D3 of Blogger-C *scraped* D1 of Blogger-D, which in turn got *trackbacked* by D3 of Blogger-E depicting clearly the indirect influence of D1 of Blogger-A on D3 of Bloggers-C and E respectively. These indirect influence power of each document is considered while calculating the IBP of that particular document for that blogger. The different activities have been represented in Figure 1.

The degree of influence a particular blogger has made on others, cannot be defined just by *User Content Power* (UCP) which is the sum of *Document Content Power* (DCP) of that blogger's documents taking into account their time of exposure unlike the existing method[6]. Instead, we propose to consider the *Influential Blog Power* (IBP) of a blogger of that network as the number of different bloggers who were influenced by performing either or all of the activities like *bookmark, scrap* or *trackback* on the documents of that blogger.

3.3 Illustration

Table 1 shows the illustration wherein the number of different bloggers who are influenced by the bloggers-1, 2 and 3 are 5, 1 and 2 respectively. Blogger-3 with UCP as 26 is not the influential blogger even though the documents have many activities performed on them, as these activities are performed by only 2 different bloggers. Whereas Blogger-1 with UCP as 11 has influenced 5 different bloggers, hence Blogger-1 is considered to be the Influential Blogger of the network as the blogger under consideration is having highest IBP.

Table 1. PIB algorithm illustration.

Blogger ID (BID)	Document Content Power) (DCP)	User Content Power (UCP)	Number of Bloggers who did Activities(B_T)	Comment Activities(c)	Other Activities [Bookmark(b)] [Scrap(s)] [Trackback(t)]	Number of Bloggers who did other Activities(IBP)
Blogger-1	$D1 = 2$, $D2 = 5$ $D3 = 3$, $D4 = 1$	11	6	2	9	5
Blogger-2	$D1 = 4$ $D2 = 6$	10	4	6	4	1
Blogger-3	$D1 = 1$, $D2 = 8$ $D3 = 7$, $D4 = 6$ $D5 = 3$, $D6 = 1$	26	3	19	7	2

Table 2. Table of notations.

Symbols	Description
t	Trackback Activity
s	Scrap Activity
b	Bookmark Activity
c	Comment Activity
DB	Different Blogger
A	Direct Activity
IA	Indirect Activity
Dn	n^{th} Document
n	Number of documents
IBP	Influential Blog Power
IB	Influential Blogger
$A_{\text{Total\_DB\_}Dn}$	Total (direct and indirect) activities performed by different bloggers on n^{th} document of a blogger
$A_{O\_DB\_D}$	Other activities of different bloggers on all documents of a blogger
DP	Document Power (Set of unique bloggers who performed other activities on all documents of a blogger)
DP_x	Set of unique bloggers who performed other activities on x^{th} document of a blogger

4. Mathematical Model

The table of notations shown in Table 2 describes the symbols used in mathematical modeling of the proposed method. The total activities performed by different bloggers on n^{th} document of a blogger is the Sum of all direct and indirect activities like; *trackback, scrap, bookmark* and *comment*, performed on that document.

$$\begin{aligned} A_{\text{Total\_}DB\_Dn} = {} & A_{t\_DB\_Dn} + A_{s\_DB\_Dn} + A_{b\_DB\_Dn} + A_{c\_DB\_Dn} \\ & + IA_{t\_DB\_Dn} + IA_{s\_DB\_Dn} + IA_{b\_DB\_Dn} + IA_{c\_DB\_Dn} \end{aligned} \tag{1}$$

Other activities performed by different bloggers on all documents of a blogger is extracted after subtracting direct and indirect comment activities from the total activities.

$$A_{O\_DB\_D} = \sum_{x=1}^{n} (A_{\text{Total\_}DB\_Dx} - A_{c\_DB\_Dx} - IA_{c\_DB\_Dx}) \tag{2}$$

The *Document Power* (DP) is the set of unique bloggers who are influenced and is extracted based on different bloggers who performed other activities on a document. The set of unique bloggers who performed other activities on all the documents of that blogger is found based on different bloggers who were influenced by all the documents of a blogger.

$$DP = \begin{cases} DP_x\{null\} & \text{if } x = 0 \\ \sum_{x=1}^{n} (DP \cup DP_x) & \text{if } 1 < x < n \end{cases} \tag{3}$$

```
1: while True do
2:     for each and every blogger in the network. do
3:         Initialize DP={null}.
4:         for each and every document of a blogger. do
5:             Find all the activities performed by different bloggers on the document.
6:             Exclude comments to get other activities.
7:             Extract and update DP of the document by taking the set of different bloggers who performed other activities.
8:         end for
9:         Get the IBP of that blogger by taking number of unique bloggers who performed other activities.
10:    end for
11:    Finally, profile IB of the network taking Max(IBP).
12: end while
```

Algorithm 1. Profiling influential blogger (PIB) algorithm.

The Influential Blog Power of a blogger is the total number of unique bloggers who performed other activities on all documents of that blogger.

$$IBP = \text{Count}(DP) \tag{4}$$

The Influential Blogger of the network is the one who influences more number of bloggers in the network through the documents under consideration and is profiled by determining maximum of IBP.

$$IB = Max(IBP) \tag{5}$$

Hence the blogger with highest IBP is profiled to be the IB of that network.

5. Algorithm

Many activities are performed on documents of one blogger by the other bloggers. In that case, only one activity is counted as it is sufficient to prove that some relationship exists between documents and prove that the said document has influenced the other bloggers. Algorithm-1 denotes the steps followed in Profiling Influential Blogger (PIB) based on the said logic.

The total number of activities performed by different bloggers on the documents of each blogger considering both direct and indirect activities is calculated. Since *comments* cannot prove the existence of relationship between commented documents and the blogger, all the *comment* activities are excluded from the total activities to get other activities. The *Document Power* (DP) is extracted based on unique bloggers who performed other activities on the document. Eventually, DP contains the set of unique bloggers who performed other activities on all documents of a blogger. The *Influential Blog Power* (IBP) of a blogger is counted by the total number of unique bloggers who performed other activities on all documents of that blogger and the blogger with highest IBP is considered as the Influential Blogger of that network.

6. Simulation Results and Performance Analysis

We constructed a Social blogging application site using Java and XML, and allowed the public to use it. Around 200 users registered with it as bloggers in a span of one month. Nearly 30 bloggers created documents and published them to the public as blog documents. Roughly around 1000 activities were carried out on the documents created by bloggers and were logged. The data collected from this application is stored in MySQL database and is used for simulation and analysis of our proposed PIB method.

From the data collected, the number of activities on documents of bloggers are extracted, and then their DCP and UCP values for each day are calculated according to the existing method[6]. The activities performed by different bloggers on other's documents were extracted. Excluding the *comment* activities from the total activities, the unique bloggers who performed other activities on all the documents of each blogger is obtained and stored as a DP set.

Table 3. PIB algorithm illustration.

Blogger ID (BID)	Document Content Power) (DCP)	User Content Power (UCP)	Number of Bloggers who did Activities(B_T)	Comment Activities(c)	Other Activities [Bookmark(b)] [Scrap(s)] [Trackback(t)]	Number of Bloggers who did other Activities(IBP)
BID-1	$D1 = 29206$ $D2 = 32086$ $D3 = 372$ $D4 = 4$	15663.672	4	126	60	2
BID-2	$D5 = 34906$	8866.124	4	66	204	3
BID-3	$D6 = 5974$	1517.396	3	7	194	3
BID-4	$D7 = 18938$	4809.744	2	35	118	1
BID-5	$D8 = 30240$	7680.96	3	58	148	2
BID-6	$D1043 = 1116$	283.464	5	2	8	3
BID-7	$D1044 = 9436$	2396.744	5	19	9	4
BID-8	$D1045 = 3622$	919.988	7	7	6	6
BID-9	$D1046 = 1158$	294.132	3	2	12	3
BID-10	$D1047 = 654$	166.116	5	1	9	4
BID-11	$D1048 = 1078$	273.812	4	2	8	4
BID-12	$D1049 = 1128$	286.512	5	2	9	5
BID-13	$D1050 = 4024$	1022.096	3	8	1	1
BID-14	$D1051 = 4030$	1023.62	3	8	2	2
BID-15	$D1052 = 4054$	1029.7160	4	8	3	3
BID-16	$D1053 = 684$	173.738	5	1	11	4
BID-17	$D1054 = 622$	157.988	4	1	10	3
BID-18	$D1055 = 1564$	397.2580	6	3	9	5
BID-19	$D1056 = 598$	151.892	4	1	9	3
BID-20	$D1057 = 666$	169.1640	5	1	10	4

Then, IBP, the number of different bloggers who performed only other activities, which is the count of unique bloggers present in DP set of each blogger is obtained. Finally, blogger having highest IBP is determined to be the IB of the network as per the PIB approach. Table 3 shows the simulation results with actual values logged during Time Unit-T1 in our social blogging site.

For the purpose of analysis, we selected six Top Bloggers with IDs: BID-1, BID-2, BID-4, BID-3, BID-8, and BID-12 based on top four UCP values and top two IBP values respectively and observed their influence for four days. The existing method determined that the blogger with highest UCP as the influential blogger where as PIB approach determined the blogger with highest IBP as the influential blogger.

Figure 2 shows UCP of each blogger in different time units and is observed that blogger with highest UCP as influential, varying over different time units. Activities like *Trackback, Scrap, Comments* performed on each document are considered while determining DCP of documents of each blogger. The graph in Figure 2 shows low stability of influential user, changing every time unit due to the fact that a slight change in the number of activities performed or the time of exposure of their documents drastically changes their UCP values, thus changing their positions between Influential Blogger and Non-Influential Blogger frequently.

Figure 3 depicts the IBP according to the PIB approach. The graph shows BID-8 having highest IBP during all the time units considered for analysis and hence that blogger is the IB in the network. In the proposed method, depicted results show high stability of IB over all the time units because of the fact that IBP value changes only when a new blogger performs any activity on the documents of others, and the occurrences of which is predictively low.

The survival rate of the Influential Blogger over time, shown in Figure 4 depicts clearly that in the time unit T1, the Influential Blogger is 100 percent assumed to continue as the only Influential Blogger throughout. But as in time unit T2, with the existing method, another Influential Blogger has come to existence, making the Influential Blogger of T1 to continue to survive as Influential Blogger with only 50 percent chances. Like wise in T3, another different Influential Blogger came to existence making the Influential Blogger of T1 to continue to survive as Influential Blogger with only 33.33 percent chances. Whereas in the proposed PIB method, the First Influential Blogger continued to be influential in all the three time units T2, T3 and T4. Thus, the survival rate of Influential Blogger is high and stable in PIB approach compared with the existing ones, as the IB is stable throughout the four time units.

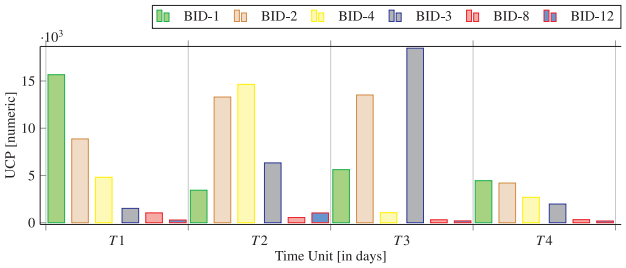

Fig. 2. User content power of six top bloggers over time.

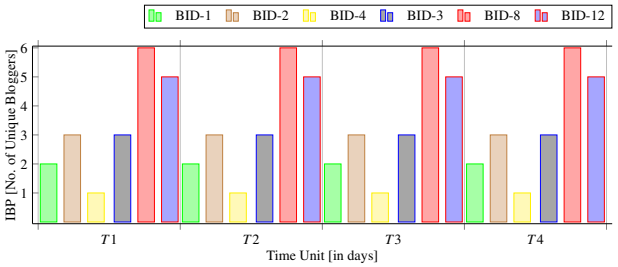

Fig. 3. Influential blog power of six top bloggers over time.

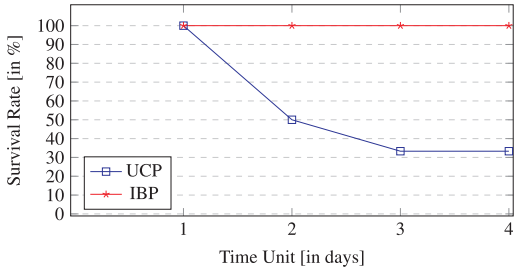

Fig. 4. Survival rate of influential blogger over time.

7. Conclusions

The paper presents the PIB Algorithm for profiling the Influential Blogger (IB). Earlier studies determined the influential users based on the number of activities performed on their blog documents and the time of exposure of each document. We have proposed and evaluated a novel method for profiling Influential Blogger, mining the bloggers activities data and discovering the knowledge out of it in a blog network. Our simulation results show that the survival rate of Influential Blogger is high and stable using appropriate parameters: *Trackback, Scrap* and *Bookmark* for identifying the information diffusion in SBN when compared with existing State-of-the-Art works.

The PIB algorithm when applied on social blog network of known criminals, helps in identifying the information diffusion of criminal activities and also the most influential member of that group. This approach is suitable for targeted advertising and marketing. The avenues for future work include are profiling the blogger based on the content of documents posted, extracting the pattern of information diffusion to classify active/passive members and the properties of Bridge Blogger in multi – group SBNs.

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