Active Opinion Maximization in Social Networks

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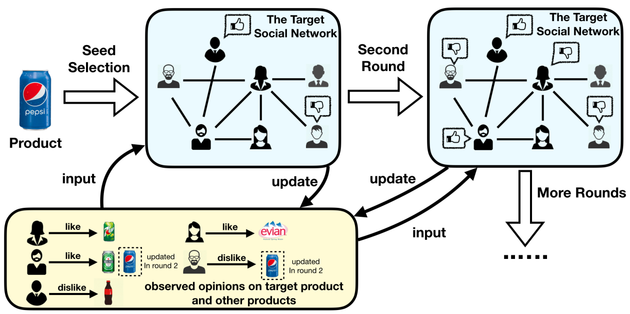
Overview



Objective: finding the optimal seed selection for each round under the given budget that maximizes the total opinion spread.

Diffusion Model: Linear Threshold (LT), we extend it to multi-round setting (MLT). It could be changed to Independent Cascade (LT) effortlessly.

Opinion Model: We assume that each user has inherent opinion towards product/item, which does not affected by his/her neighbors.

Side Information: We use the observed opinions on other products expressed by users (the yellow box in the figure) to help modeling the user profile. The profile of target item (Pepsi in the figure) is learned gradually and actively from round to round.

Applications: Online marketing campaign, brand reputation building, market segmentation, *etc.*

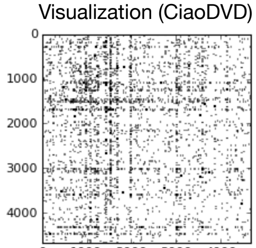
Dataset

	# Nodes	# Edges	# Items	# Ratings	Linkage
Flixster	5,372	58k	3,470	110k	undirected
CiaoDVD	4,658	40k	16k	72.6k	directed

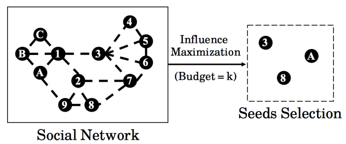
- Threshold: randomly assign to users in the network via a uniform distribution.
- Weights: quantify using Jaccard Coefficient

$$w_{ij} = \frac{|\Gamma_{in}(u_i) \cap \Gamma_{out}(u_j)|}{|\Gamma_{in}(u_i) \cup \Gamma_{out}(u_j)|}$$

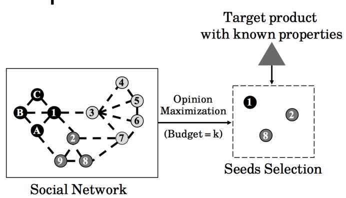
Visualization (CiaoDVD)



Influence Maximization

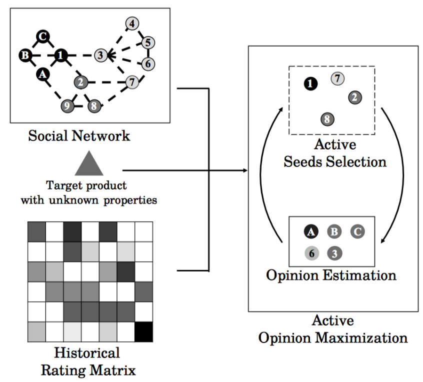


Opinion Maximization



- **(Q1)** How to fuse opinion maximization with information diffusion?
- **(Q2)** How to perform opinion maximization while users' opinions are mostly unknown?
- **(Q3)** How to minimize negative opinions spread?
- **(Q4)** How to tackle the hardness (NP-hard) of the proposed problem?

Active Opinion Maximization



opinion function(implicit) seeds of each round

$$\underset{\mathcal{S}^{(1)},\ldots,\mathcal{S}^{(T)}}{\text{maximize}}\ I_\ell(\mathcal{S}^{(0)},\ldots,\mathcal{S}^{(T)})$$

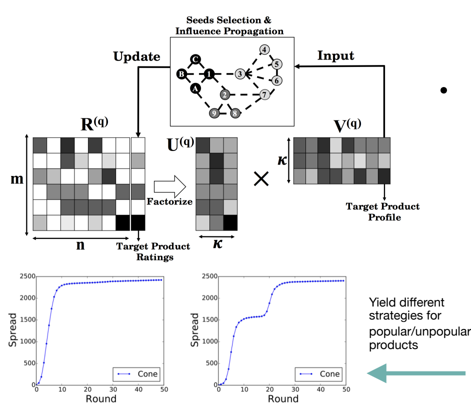
$$\text{s.t. } |\mathcal{S}^{(q)}| = k^{(q)}, \mathcal{S}^{(q)} \subseteq \mathcal{V} \setminus C^{(q-1)}$$

users infected until round q-1

budget of each round all users

- **(S1)** We employ multi-round linear threshold (MLT) as the diffusion model, and we adjust the objective function for maximizing opinion instead of influence spread.

- **(S2)** Active Learning on Target Product



(a) Popular item (r_{avg} = 2.91) (b) Unpopular item (r_{avg} = 2.18)

- **(S3, S4)** CONE wisely avoid negative user groups by using greedy search:

Algorithm 1 Greedy Algorithm for Opinion Maximization

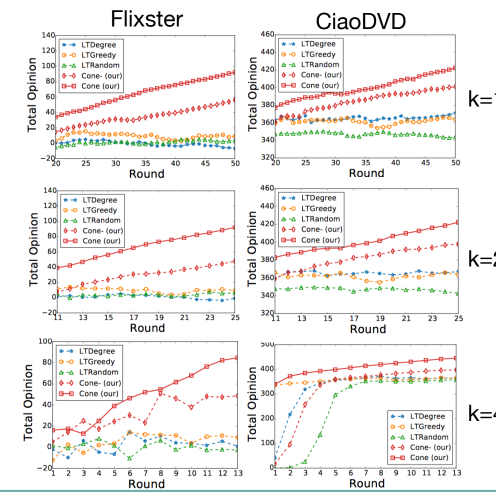
Require: social network $G = (\mathcal{V}, \mathcal{E})$, target product p_t, estimated ratings vector $\hat{\mathbf{r}}^{(q)}$, seed user size for current round $k^{(q)}$, the set of active users $C^{(q-1)}$.

initialize $\mathcal{S}^{(q)} \leftarrow \emptyset$
while $\mathcal{V} \setminus (C^{(q-1)} \cup \mathcal{S}^{(q)}) \neq \emptyset \wedge |\mathcal{S}^{(q)}| \neq k^{(q)}$ **do**
  $O_{\max} \leftarrow -\infty$
  for each u in $\mathcal{V} \setminus (C^{(q-1)} \cup \mathcal{S}^{(q)})$ **do**
    $\mathcal{S} \leftarrow C^{(q-1)} \cup \mathcal{S}^{(q)} \cup \{u\}$
    propagate influence up to ℓ-layer with seeds $\mathcal{S}$ to obtain the set of activated users C
    $O \leftarrow \sum_{u_i \in C}(\hat{r}_i^{(q)} - r_{\text{neutral}})$
    if $O > O_{\max}$ **then**
      $O_{\max} \leftarrow O$, $u_{\text{best}} \leftarrow u$, $C_{\text{best}} \leftarrow C$
    end if
  end for
  $\mathcal{S}^{(q)} \leftarrow \mathcal{S}^{(q)} \cup \{u_{\text{best}}\}$, $C^{(q)} \leftarrow C_{\text{best}}$
end while
Return $\mathcal{S}^{(q)}$

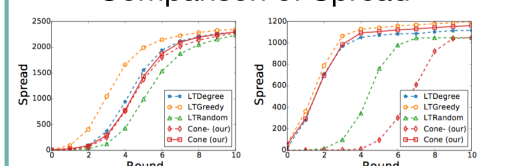
Number of +/- Opinions

Methods	# pos. (↑)	# neg. (↓)	# pos. - # neg. (↑)	rank
		Flixster		
LTRANDOM	1278.00 (4)	1146.92 (4)	170.67(4)	4.00
LTDEGREE	1274.00 (5)	1109.00 (3)	165.00(5)	4.33
LTGREEDY	1363.08 (1)	1277.30 (5)	216.15(2)	2.67
CONE-	1283.16 (3)	1082.50 (1)	200.63(3)	2.33
CONE	1328.00 (2)	1098.88 (2)	229.13(1)	**1.67**
		CiaoDVD		
LTRANDOM	648.09 (5)	451.40 (2)	196.61 (5)	4.00
LTDEGREE	749.66 (2)	544.46 (4)	205.22 (3)	3.00
LTGREEDY	788.85 (1)	588.27 (5)	200.65 (4)	3.33
CONE-	658.44 (4)	430.84 (1)	227.61 (2)	**2.33**
CONE	743.01 (3)	490.61 (3)	252.47 (1)	**2.33**

Comparison of Opinion



Comparison of Spread



(a) Flixster (b) CiaoDVD

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