

Course Name - Recommender Systems
Professor Name - Prof. Mamata Jenamani
Department Name - Industrial and Systems Engineering
Institute Name - Indian Institute of Technology Kharagpur
Week - 08
Lecture - 40

Lecture 40: Trust aware recommender systems

Hello everyone. Welcome to the last lecture in this series and we are going to today talk about Trust Aware Recommender System. So, what exactly this trust is? From sociological point of view, trust is belief, reliability of a trustor to trustee. So, there are two persons, person who trusts and another person to whom he trusts. So, these are typical properties of trust. It is a very subjective topic dependent.

If you are trusting your friend in terms of whatever study items, study material he suggests, you may not trust him for your clothing. This is again asymmetric. Asymmetric in the sense, if I trust you, you may not be trusting me. It is time sensitive.

Now, I trust you, but after sometime, after a year or so, because of your certain observation about you, I do not trust you anymore. And it is propagative. So, if I trust you, if I like, I may not directly trust you, but I can trust you if my friend trusts you. You might not have gone to some doctor, but if your friend suggests, because the friend trusts the doctor, you may go to him. So, it is a situation like this.

It can be transitive. Then in recommender system context, trust is how the trustor uses, how the trustor user relies on trust user. Sometimes it can also be treated as a social relation between two users while providing recommendations. So, this trust is another source which can now be added for while making recommendation. So, first ask it to build a trust network.

It is a trust is among the users. About the network, last class we studied network consists of the nodes here also. The nodes are the users and the links between them represent the trust. So, here we can do it by explicitly asking. There are many websites which actually take such kind of data, opinion, film trust, etcetera.

And you can also get it implicit manner by collecting the data from social network looking at how the nodes features are similar, how they exchange messages, how they like each other's posts, etcetera. This is one example of opinion where of course, this is very old one where the trusts are taken. So, trust network. So, it is a weighted and a directed graph in which the nodes are the users and edges are the trust between the users. In a trust network, trust is information about the social relationship and it represents as a label for the link.

The strength of edge shows the amount of trust between user in two ends of every edge. And as I told you, it is may not be a symmetric one. Now, adjustments. So, as a result if because it is between user and user you are building a network, you have one adjacency matrix. So, what is adjacency matrix? Probably this is first time we are coming to the term.

The screenshot shows the Epinions website interface. The top navigation bar includes categories like Home & Garden, Electronics, Health & Beauty, etc. The main content area is divided into several sections:

- Email Alerts:** A section for managing email notifications.
- Web of Trust:** A section showing a user's trust network. It includes a list of users the user trusts (astef trusts) and a list of users who trust the user (astef is trusted by). The list of users who trust the user is highlighted with a red box.
- dramastef's Profile:** A section showing the user's profile, including their name, location, member since date, and activity summary.
- dramastef's Recent Opinions:** A table showing the user's recent reviews.

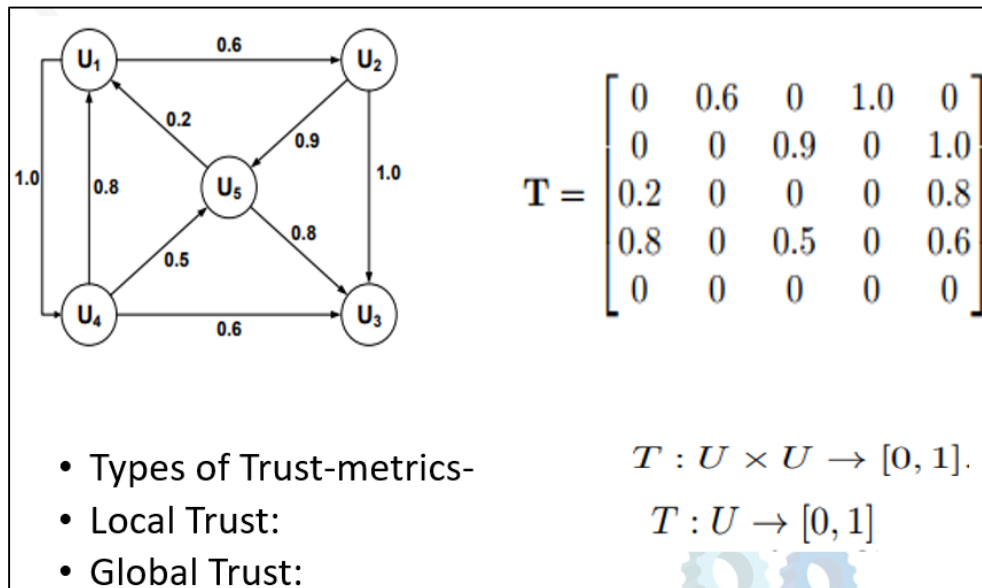
Date Written	Review Title	Product / Topic	Product Rating	Review Rating
Nov 15, 2012	Cooking with Trader Joe's Cookbook: Easy Lunch Boxes	Kelly Lester - 1938706005 in Books	★★★★★	Very Helpful
Apr 7, 2012	No matter how it feels, the truth is that Diapers Are NOT Forever!	Elizabeth Verdick - Diapers Are Not Forever in Books	★★★★★	Very Helpful
Apr 6, 2012	Potty Train in Three Days - worked for us!	0971639906 in Books	★★★★★	Very Helpful
Sep 2, 2011	Mythos Academy - School of the gods	0758266928 in Books	★★★★☆	Very Helpful

So, if you are acquainted with graph theory, etcetera, you know what an adjacency matrix is. So, among all the nodes, all the users in this case, so you have a matrix which is called adjacency matrix. So, this adjacency matrix T here has the values T_{ij} which has the edges and you have a trust value between 0 to 1. And this 0 to 1, how do you get it? You get it using exfoliaty asking or implicitly. Now, it has many properties.

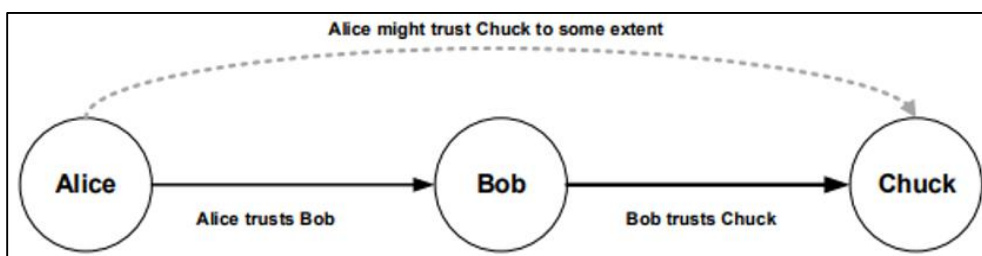
It is a very complex network. It follows the power law degree of distribution. So, it is a scale free network as well. This is one example trust matrix and this is the graph trust network and this is the corresponding adjacency matrix with the trust values. As you can see, this is not a symmetric matrix.

So, there can be something called two types of matrix you can find out, local trust and global trust. Local trust is one person trusting others. Global trust is how the how in general people trust each other. I mean who is there somebody in this society, in this society which is represented by this graph whom everybody trusts, who is more trusted among these individuals, that is a kind of global trust. So, this problem in this trust network is this is basically a very sparse.

So, how do we make it dense? By considering transitive relationships that we discussed. So, while doing so, considering transitive relationships, we come across two terms trust propagation and trust aggregation. How while determine this transitive trust? We make inferences that is how we propagate the trust and that we propagate through individual paths and when multiple paths merge together, we aggregate the trust. So, this trust propagation and aggregation play an important role in design of social recommender system. About the social recommender system, we have talked about structural recommendation in a network, but about the social recommender systems which is basically the outcome of this trust, which is basically the outcome of this trust.

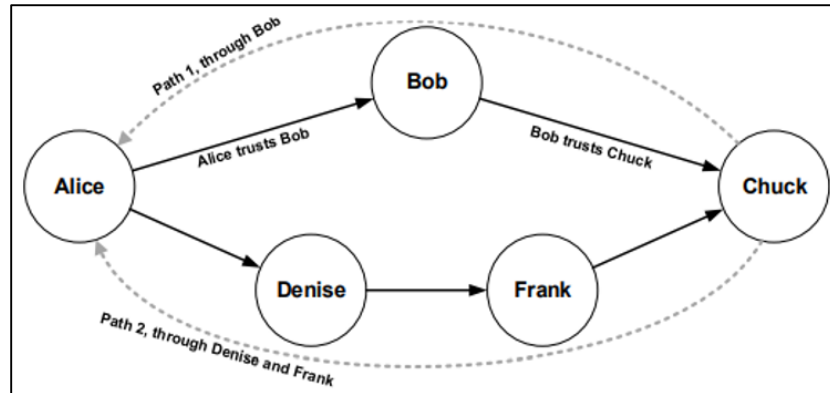


Now how do we infer or how do we propagate trust? There can be some path based approach. Trust can be binary as well or it can have some value which is between 0 to 1. So, when we follow a trust based path based approach, the idea is as we move ahead, let us say my I trust him this much and this person trust him. So, how much should I trust him? I do not have a direct path. So, indirectly I can give certain trust value.



So, what is this trust value that I give? We should have a function to compute this using this and this as my input. So, that function should give less importance to this because this is after one step. So, there has to be some kind of linear decay function to represent this. So, this is some kind of very simple method for trust inference or propagation. So,

considering all the users adjacent to u , you can find out the you can infer the trust value between u and v .



Now, T_{ui} denote the trust between user u and I mean the this look at this, this is the trust between user u and I , this is between i and v and you take the sum and you normalize. So, here you can also trust these are of course, heuristics approaches. So, you find out the shortest distance from u_i to u_j and d_{max} is the maximum allowable trust propagation length and you can make a function like this where d_{ij} of course, has to be less than equal to d_{max} and you create this use this function for trust propagation. Now, here that was the maximum length, the third approach it could be the average path length considering all the paths together. Now, you can also propagate trust in a weighted network, weighted network in the sense you have some kind of weight associated with this actually in the first three cases that was binary, but now we can have a weighted some weight will be attached here.

So, you can multiply and how do you aggregate? You can for aggregating you can use various operators, take the minimum of when aggregation is happening when you are getting the trust value, infer trust value from multiple paths you have to now aggregate put them together and come up with a single value. So, that single value can be minimum, maximum or average or weighted average or weighted sum considering all the paths taken together. So, there are certain more popular approaches for trust inference, they are tidal trust, mole trust and so on there are many many this thing of which we will throw little bit light on this tridal trust. Now, the concept of tridal tridal trust goes like this, it considers the shorter paths are more reliable for propagation. So, this is the basic assumption, it has two phases in the forward phase and phase the nodes are explored from source i to sink j in breadth first order in order to discover all the shortest path from i to j and also a set of trust thresholds.

Now, in the backward phase where you do recursive trust computation only the edges lying on the shortest path which was discovered in the first phase are used with trust which is at least this threshold. Now, how to incorporate this trust in recommender

system? Trust once you construct this trust network and got rid of sparsity problem considering the transitive relationship transitive property of the trust you have now you are now ready with something called a trust matrix which is a user to user trust matrix. Now, this matrix you are supposed to use in your recommendation process. So, this can be used in your memory based method, this can also be used in a model based method. So, we will be talking only because we are just giving the overview of this we will be talking about the memory based method in which we use it for rating prediction.

$$t_{u,v} = \frac{\sum_{i \in adj(u)} t_{u,i} t_{i,v}}{\sum_{i \in adj(u)} t_{u,i}},$$

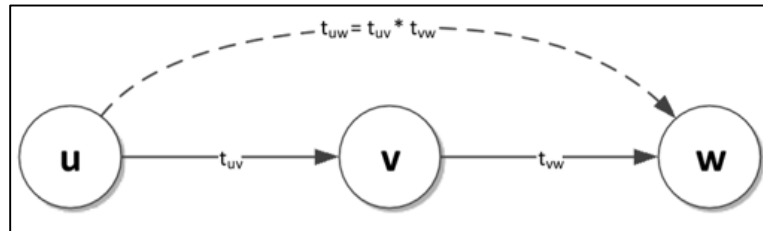
And this rating prediction in a memory based method this is the average rating of ith user and this is from the neighbors and you weight it give certain weight based on the trust that you have on that particular neighbor. So, in the neighborhood method you incorporate in this manner. So, this was the brief discussion on using trust as an additional source of information while making recommendation. So, these are the books and this is the conclusion. Trust is about how much the truster user relies on the trust user.

$$t_{i,j} = \begin{cases} \frac{d_{max} - d_{i,j} + 1}{d_{max}} & \text{if } d_{i,j} \leq d_{max} \\ 0 & \text{otherwise} \end{cases}$$

$$d_{max} = \text{average path length}$$

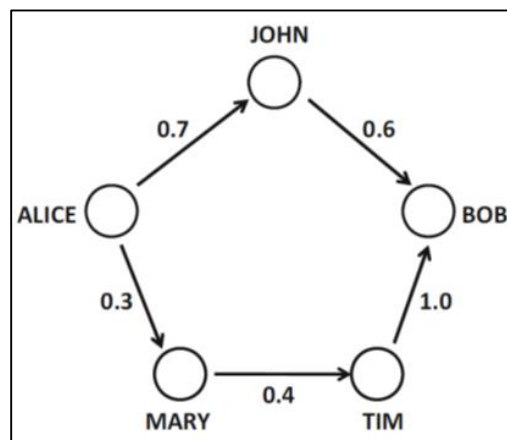
Trust network is a weighted and directed graph. This trust network can be populated by the trust values collected implicitly or explicitly. This matrix is sparse and can be now populated considering trust aggregation and inference methods. Now, trust can be incorporated in recommender system and in particular we saw in neighborhood method this can be added as weights. This is the end of this lecture this series of lectures and if you remember at the time of introduction when I was started describing about this system I have shown you this figure.

Let us see let us just retrospect what all we did. That time we said that we will be talking about the data we talked about the data like user item feedback matrix explicitly collecting the data these are the basic three settings. Then we also had side information item features user features context we also talked about trust social social connectivity knowledge and so on. So, those are certain additional information. So, about this data part we really knew a lot of things.



$$t_{u,w} = \prod_{(a_k, a_l) \in \text{path}(u,w)} t_{a_k, a_l}$$

Then we talked about models we talked about models content based collaborative filtering various varieties of collaborative filtering and then we talked about hybridization these are the classical sets. Then we talked about few others in this we talked about context aware knowledge based social and trust conversational that is knowledge based are basically sometimes they are also used for conversation and certain additional things also we discussed.



Then coming then come to evaluation we did evaluation we covered all these measures and we talked about online user study offline and beyond this also specifically for user studies and online methods we also additionally talked about how to draw reliable conclusions.

- Rating for user u_i to item j is given as follows

$$\hat{r}_{i,j} = \bar{r}_i + \frac{\sum_{u_k \in \mathcal{N}_{\mathcal{G}_t}(u_i)} t_{i,k} \cdot (r_{k,j} - \bar{r}_k)}{\sum_{u_k \in \mathcal{N}_{\mathcal{G}_t}(u_i)} t_{i,k}}$$

So, some inferential statistics also we studied in this section. So, beyond this also we went and coming to challenges we talked about various types of bias and cold start problem and occasionally we have talked about security privacy etcetera, but we did not give much importance to all this.

So, more or less we covered almost everything that we decided from the beginning. Thank you hope you will enjoy this you have enjoyed this course.