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Article

Analysis of Network Modeling for Real-world Recommender Systems

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Abstract: Nowadays, recommendation systems are existing everywhere in the internet world, online people are presented with the required needs not just for actual physical products, but also for several other things such as songs, places, books, friends, movies, and many more requirements. Most of the systems are developed with the basic collaborative and hybrid filtering, where the people or users are recommended items that the choices are based on the right preferences of other people by applying the machine intelligence strategies. In this research, the importance of network modeling is analyzed in solving real-world problems.

Keywords: Recommender System, Recommendation System, Collaborative Filtering, Machine Learning, Artificial Intelligence, Hybrid Methods

1. Introduction

The most important intuitive approach to modeling the communications between items and the users are done with the bipartite network as shown in Figure 1. The network construction of customer and product is sketched in Figure 2. Consider the toy illustration in which the customers are interconnected to the products that are purchased. The two important questions are raised with the edge prediction networks [1,2].

1. Suggestions or Recommendations - What items should be recommended to the customers as new products?

2. Product targeting - Which users should be contacted in a marketing operation for an explicit product?

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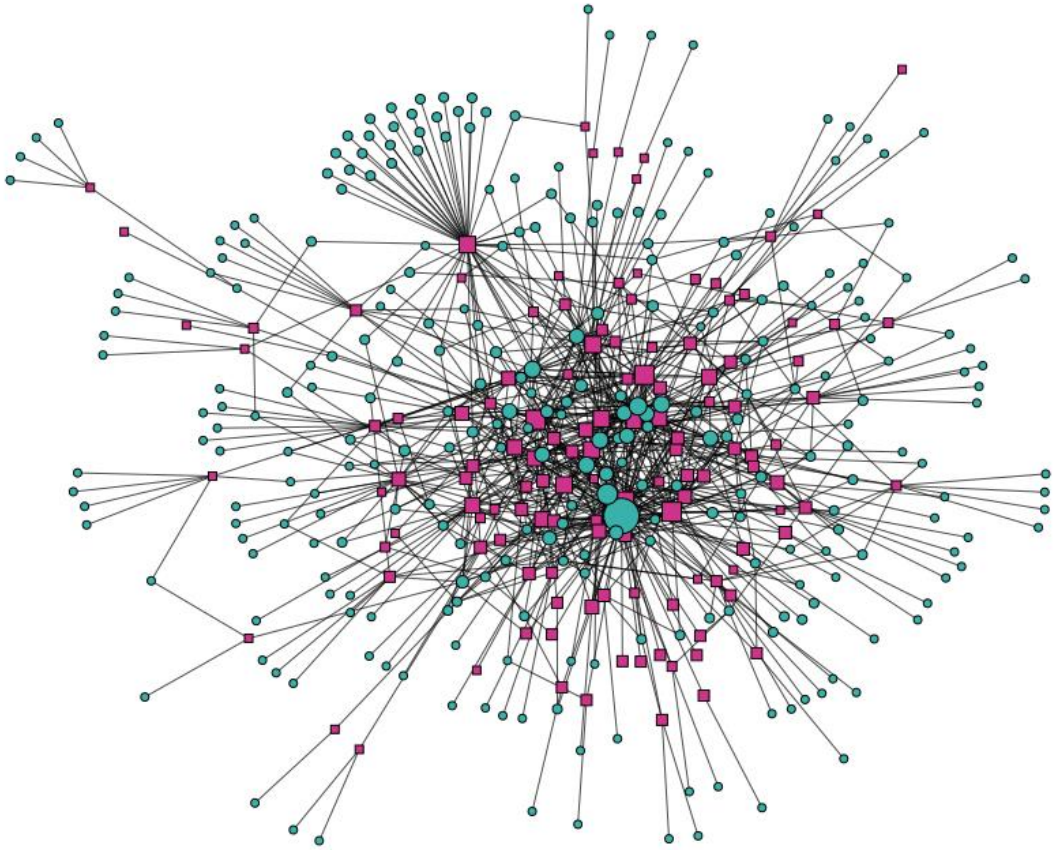

Figure 1. A larger bipartite network.

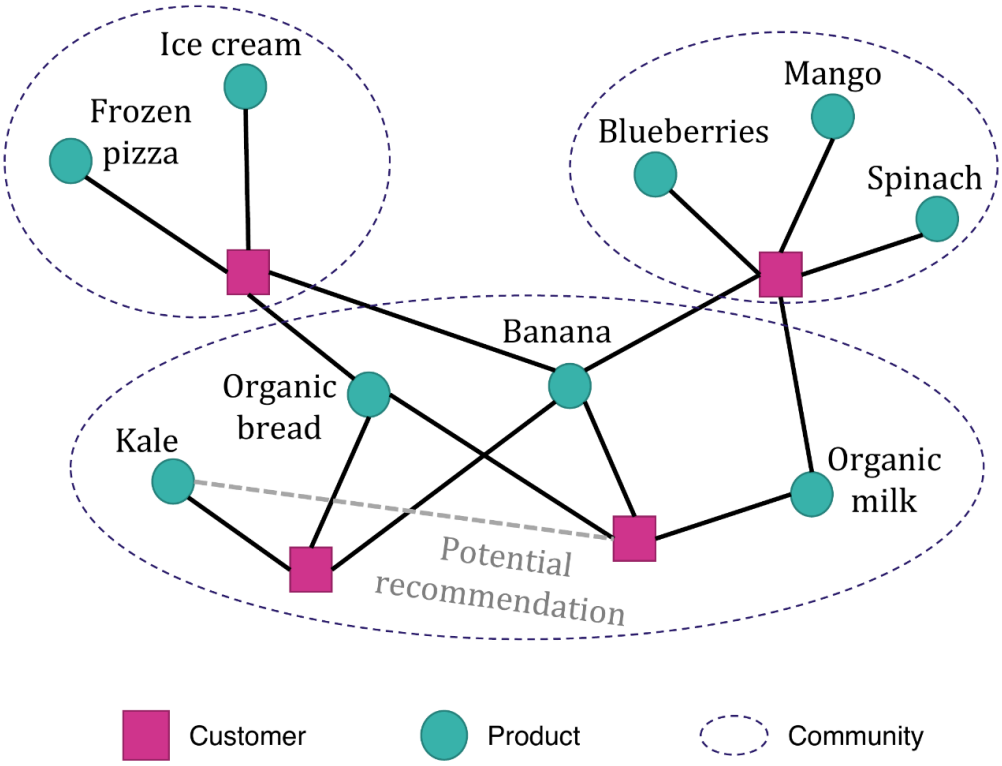

Figure 2. Network construction of customer and product.

2. Networks & Structure of Community

A network is defined as an abstract system representation that consists of a collection of objects as *nodes* or vertices that interact with each other through the *edges* which are connecting the vertices. These are arising in different domains and are used to solve many real-world problems. One important feature of networks is the modular structure in which the nodes are grouped or clustered into *communities* [3,4].

3. Targeting or recommendations approach

Logically, the items in a community of customers that the items not yet purchased are taken for the right recommendations. Likewise, in a marketing operation for the identified products, the right customers to target are available in the community of the product. The second example should be elaborated on in detail. The primary steps in a network-science recommendations approach are depicted in Figure 3.

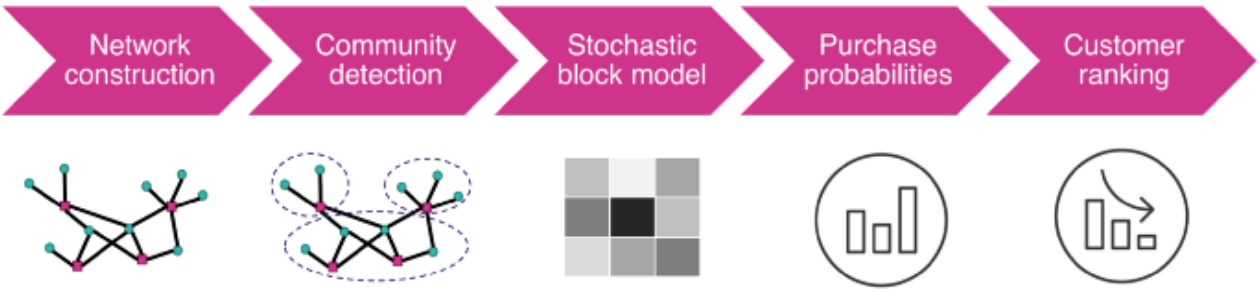

Figure 3. Primary steps in a network-science recommendations approach.

3.1. Construction of Network

The network model is constructed from the data that needs products, customers, and time required for collective purchase. The edges are drawn between the product and the customer at the time of purchase. When the purchases are required more volumes are indicated using the weights of edges. The values of weights also include the item count (for example, how many items did a customer purchase?) and item penetration (Identify the proportion of things purchased by a customer are specific items?). The weighted network is constructed from the data shown in Figure 4.

Customer ID	Basket ID	Date	Product	Quantity
12345	99999	01-05-2018	Banana	2
12345	99999	01-05-2018	Ice cream	1
12345	78987	07-05-2018	Banana	3
...	...	...	...	...

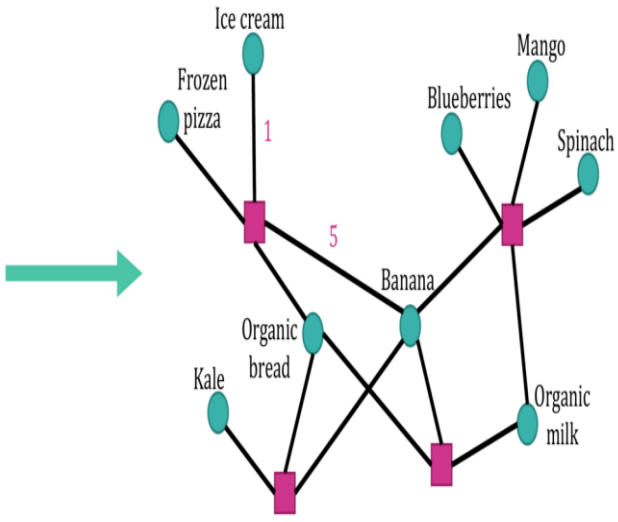

Figure 4. Construction of weighted network model from data.

3.2. Detection of Community

The community detection method is applied next to group the products and customers into meaningful groups by modularity optimization with a quantity q that partitions the network into different communities. The detection of community is an NP-hard problem that can be solved using approximation and soft computing approaches [5-8] as shown in Figure 5.

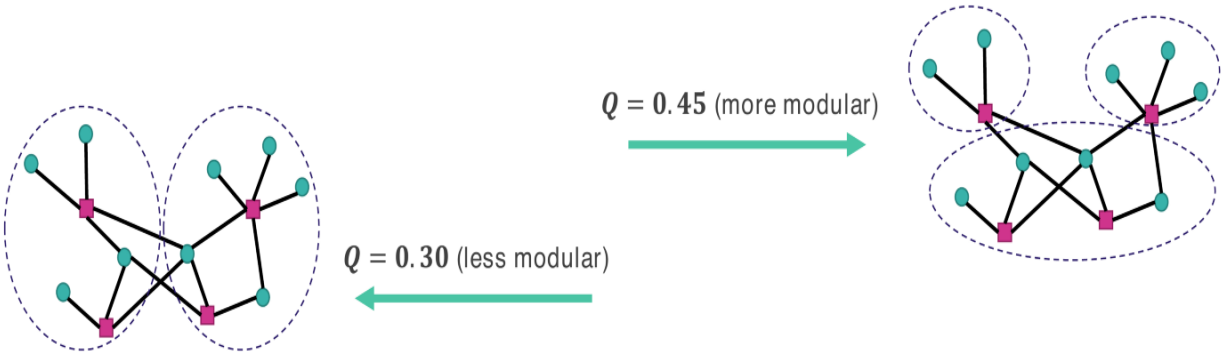

Figure 5. Detection of Community as an Optimization.

3.3. Probabilistic Block Model

In a network, every customer and product is available in a block or community. This step evaluates the edge parameters required to construct a block as shown in Figure 6.

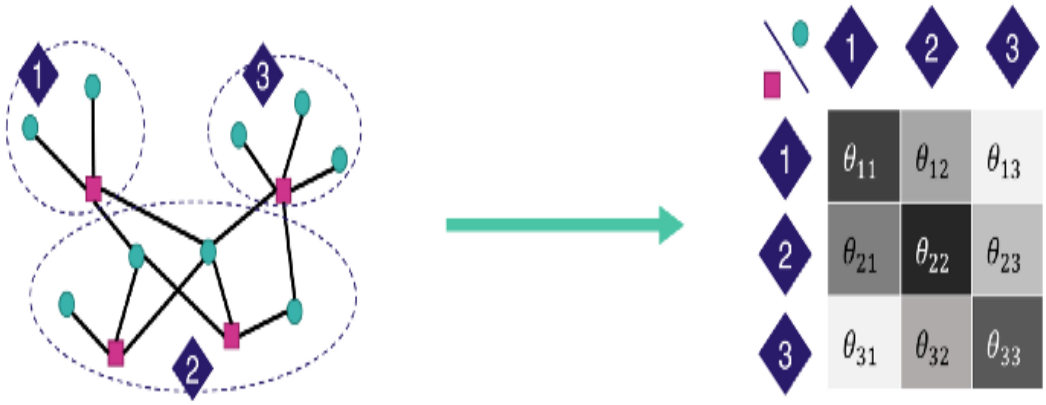

Figure 6. Probabilistic Block Model with parameters.

3.4. Purchase Probabilities

Given any product and customer, the probability of determining if there is an edge between product p and customer c is

$$\mathbb{P}(c \text{ is connected to } p) = \text{scaling factor} \times \text{degree}(c) \times \text{degree}(p) \times \theta_{rs}. \quad (1)$$

Equation 1 depends on certain factors – the probability of community-specific θ*rs*, the degree c, degree of p. The purchase probabilities are calculated as shown in Figure 7.

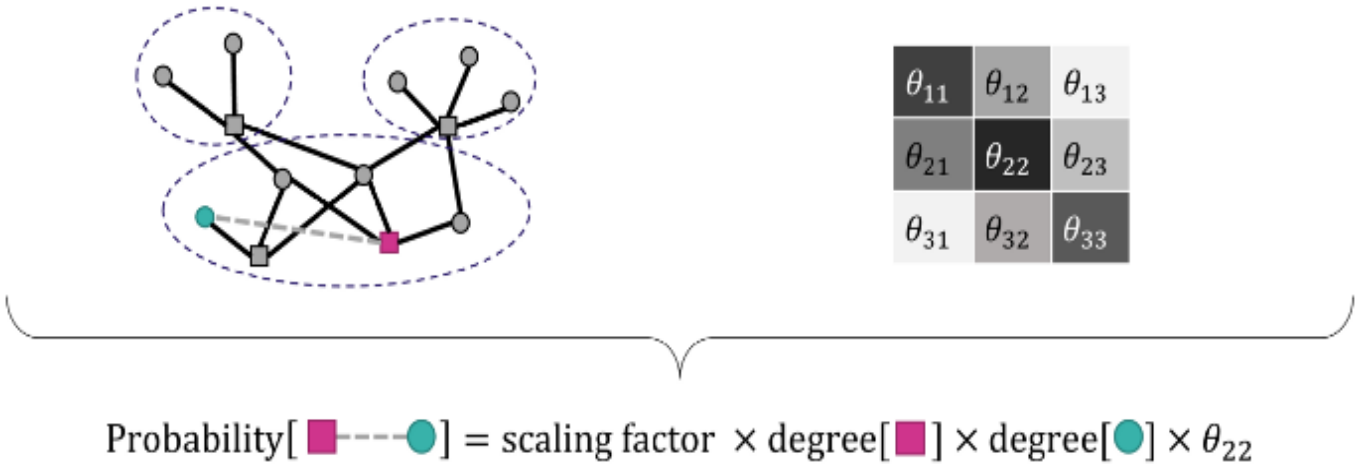

Figure 7. Purchase probability calculation.

3.5. Customer Ranking

Finally, the purchase probabilities are sorted in the reverse order to obtain the customer ranking that defines the target product affinity measurement to identify the top customers.

4. Validation and Analysis

The data has been analyzed for ten thousand customers with a promotional offer. Based on the constructed network model, the customers are ranked based on the affinity measures. The ranking is applied for the spending comparison with gains charts that plots the percentage of the positive response to the population size as a function. The ranking is predicted when there are more positive responses between the customers with high ranks that can be identified from the figure where a curve lies above the line of diagonals as shown in Figure 8.

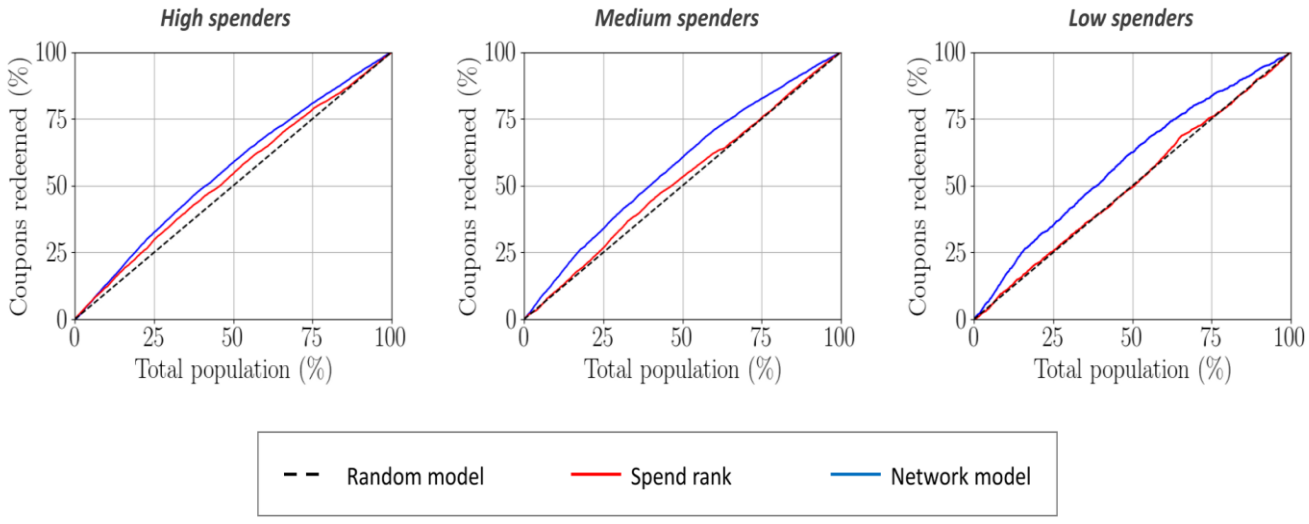

Figure 8. Ranking customers – comparison.

The experimental results show that the network model performs better than category spend such that the model identifies the customers who are interested to redeem the coupons based on the customer's affinity measure.

5. Conclusions & Future Work

Network modeling with bipartite networks represents the data purchase in an unsupervised manner. The detection of a community takes more computational time. This research analyzes the importance of network modeling. These models can further be extended for more complicated real-world problems that can be solved with machine learning approaches [9-21].

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