Food Recommender Systems

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***Abstract*—This document discusses about proposal of food recommender systems using knowledge based framework, content-based and collaborative filtering system. Basically it gives you a concrete example of food application from normal to advantage system combine some smart algorithms.**

***Keywords*—Machine learning, mining, recommender system, food menu**

I. Introduction

Food is really a hot topic for day. “What should I eat?”, “balanced diet”, “vegetarian diet”, “food for fitness”. There too many choices with a little time to explore them all. Recommender systems help peple make decisions in these complex information spaces.

A recommender system or a recommendation system (sometimes replacing "system" with a synonym such as platform or engine) is a subclass of information filtering system that seeks to predict the "rating" or "preference" a user would give to an item.

Recommender systems help select out similar things whenever you select something online.

Recommender systems have become increasingly popular in recent years, and are utilized in a variety of areas including movies, music, news, books, research articles, search queries, social tags, and products in general. There are also recommender systems for experts, collaborators, jokes, restaurants, garments, financial services, life insurance, romantic partners (online dating), and Twitter pages. [1]

Nextflix, for example will suggest other movies that you might want to watch, a few years ago in 2009 offered a $1 million prize if you could improve their recommendation system by just 10%. Pandora will suggest different songs that you might want to listen to. Amazon will suggest what kinds of other products you might want to buy. It lead to somewhere between 10% and 25% increased revenue. Facebook will even suggest some of the other friends that you might want to add. Each of these systems operate using the same basic kind of algorithm. [2]

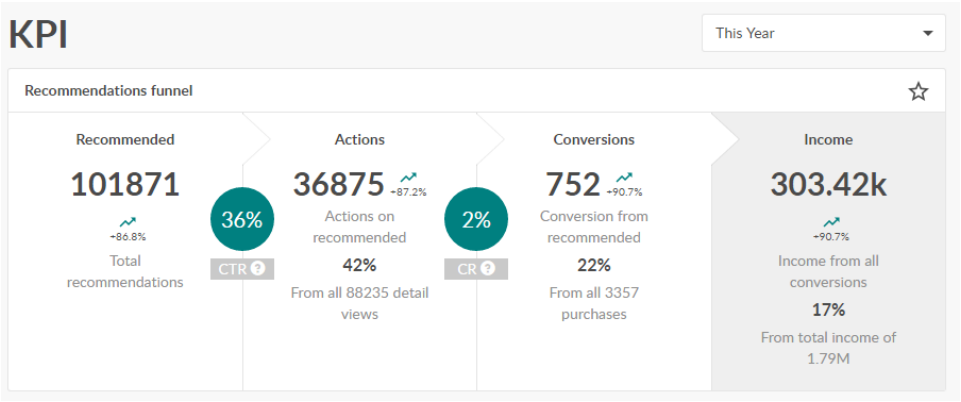

Figure 1: Income generated by personalized recommendations for a small e-shop. [3]

II. Benefits of a Recommendation Engine

A. Revenue

With years of research, experiments and execution primarily driven by Amazon, not only is there less of a learning curve for online customers today. Many different algorithms have also been explored, executed, and proven to drive high conversion rate vs. non-personalized product recommendations.

B. Customer Satisfaction

Many a time customers tend to look at their product recommendation from their last browsing. Mainly because they think they will find better opportunities for good products. When they leave the site and come back later; it would help if their browsing data from the previous session was available. This could further help and guide their e-Commerce activities, similar to experienced assistants at Brick and Mortar stores. This type of customer satisfaction leads to customer retention.

C. Personalization

We often take recommendations from friends and family because we trust their opinion. They know what we like better than anyone else. This is the sole reason they are good at recommending things and is what recommendation systems try to model. You can use the data accumulated indirectly to improve your website's overall services and ensure that they are suitable according to a user's preferences. In return, the user will be placed in a better mood to purchase your products or services.

D. Discovery

For example, the "Genius Recommendations" feature of iTunes, "Frequently Bought Together" of Amazon.com makes surprising recommendations which are similar to what we already like. People generally like to be recommended things which they would like, and when they use a site which can relate to his/her choices extremely perfectly then he/she is bound to visit that site again.

E. Drive traffic

A recommendation engine can bring traffic to your site. It achieves this with personalized email messages and targeted blasts.

F. Deliver Relevant Content

By analyzing the customer's current site usage and his previous browsing history, a recommendation engine can deliver relevant product recommendations as he shops. The data is collected in real-time so the software can react as his shopping habits change.

G. Engage Shoppers

Shoppers become more engaged in the site when personalized product recommendations are made. They are able to delve more deeply into the product line without having to perform search after search.

H. Convert Shoppers to Customers

Converting shoppers into customers takes a special touch. Personalized interactions from a recommendation engine show your customer that he is valued as an individual. In turn, this engenders his loyalty.

I. Increase Average Order Value

Average order values typically go up when a recommendation engine in uses to display personalized options. Advanced metrics and reporting can definitively show the effectiveness of a campaign.

J. Increase Number of Items per Order

In addition to the average order value rising, the number of items per order also typically rises when a recommendation engine is employed. When the customer is shown options that meet his interest, he is more likely to add items to his purchase.

K. Control Merchandising and Inventory Rules

A recommendation engine can add your own marketing and inventory control directives to the customer's profile to feature products that are promotionally prices, on clearance or overstocked. It gives you're the flexibility to control what items are highlighted by the recommendation system.

L. Reduce Workload and Overhead

The volume of data required to create a personal shopping experience for each customer is usually far too large to be managed manually. Using an engine automates this process, easing the workload of your IT staff and your budget.

M. Provide Reports

Providing reports is an integral part of a personalization system. Giving the client accurate and up to the minute reporting allows him to make solid decisions about his site and the direction of a campaign.

N. Offer Advice and Direction

An experienced provider can offer advice on how to use the data collected and reported to the client. Acting as a partner and a consultant, the provider should have the know-how to help guide the ecommerce site to a prosperous future. [4]

Figure 2: Product recommendation engine can be an analytic system for your business. [5]

III. FOOD RECOMMENDER SYSTEMS

A. Normal application

We go to normal application. Coordinate module is client application may be on browser, ios, android to get data, action or feedback of user about item (food). Coordinate module will collect request and send it to Logic server and wait to response. Logic server get the request and fetch data or other operation like insert, edit, delete on Storage Data server. This is a normal application and all response will be decided base on raw data from server and it's not a dynamic logic and dynamic content response also.

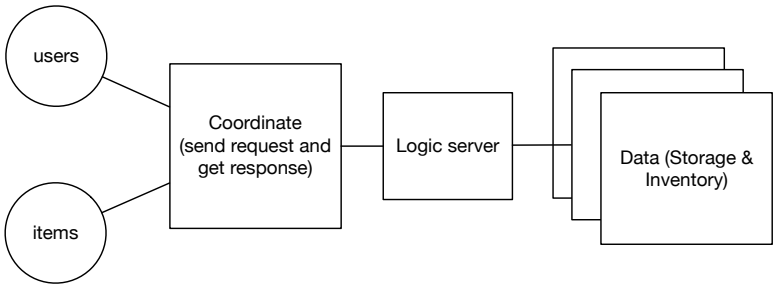

Figure 3: Normal application

B. Integrate with Recommender engine

Important thing of recommender engine is the data. The more data is, the better system is. Collecting data by some ways:

- From request of users via interaction on items (ex: like, vote, comment, sharing).
- From web crawler to get item public info and user social info. This approach will get a rich of useful data for Intelligence system.
- From feeback or survey via promotion strategy. The system should intergrated with payment engine like blockchain and take own token to share with user for promotion program.

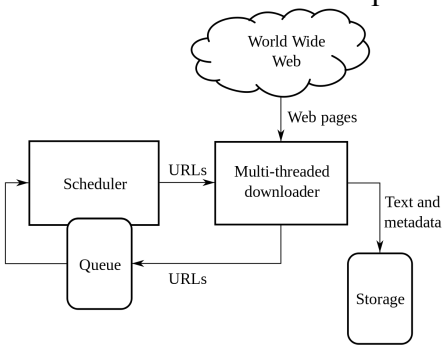

Figure 4: Web crawler [6]

C. Data mining phase

The better approach to interage recommender engine is separate module between current application with new one module. Recommender engine get data from Database server and take request by App Server

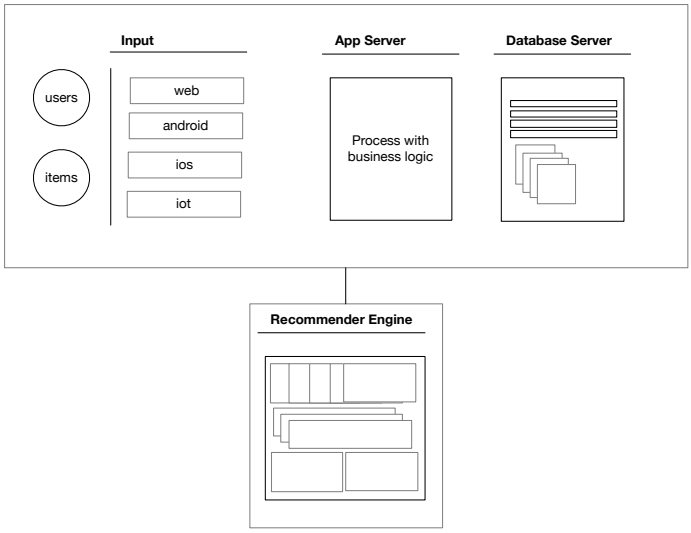

Figure 5: Integrate Recommender Engine architecture

For faster query processing, recommender engine need to preprocess data to get specific, ontology, index, characteristic of data, we call this process is learning. Learning will be automatically executed to refresh data on time.

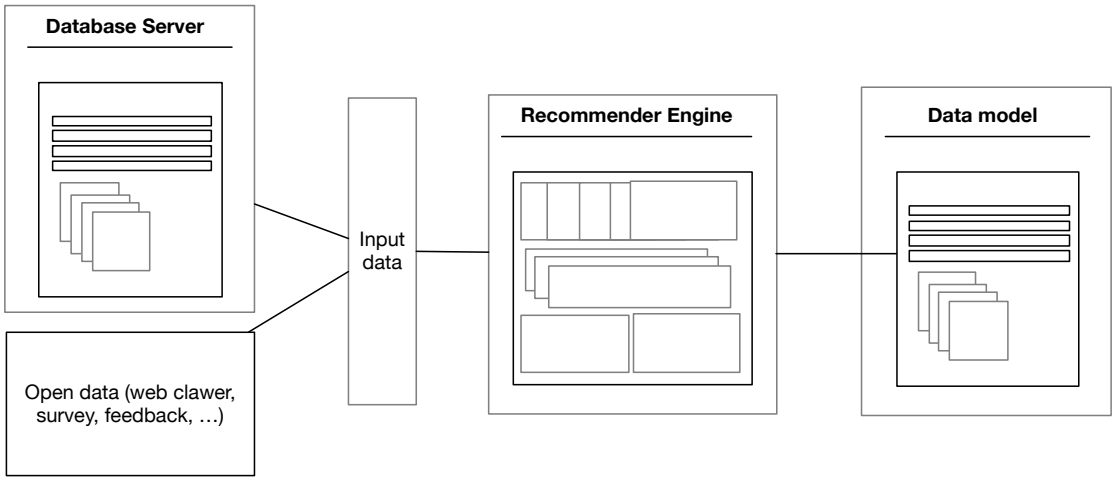

Figure 6: Data mining phase

Recommender Engine use some algorithms are knowledge based framework, content-based and collaborative filtering system for data mining and get a final data model.

Knowledge based recommender systems [7]

Both users and items have attributes. The more you know about your users and items, the better results can be expected. Such attributes are very useful and data mining methods can be used to extract knowledge in forms of rules and patterns that are subsequently used for recommendation. Even the long text description can be processed by advanced NLP tools [8]. Then, recommendations are generated based on item similarity.

The construction of the knowledge base basically relied on some domain experts, nutrition guides and clinical practice guidelines. It consists of two forms of knowledge: ontology and rules. The ontology-based knowledge represents knowledge structure of food and their relations. In addition, it also

represents knowledge structure of user and user's health-related status. The rule-based knowledge represents decision model used in generating recommendation results.

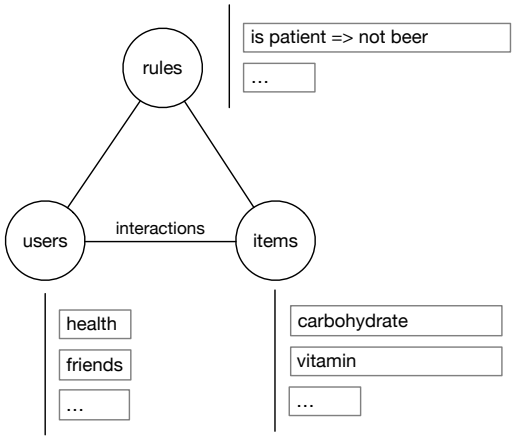

Figure 7: Knowledge based architecture

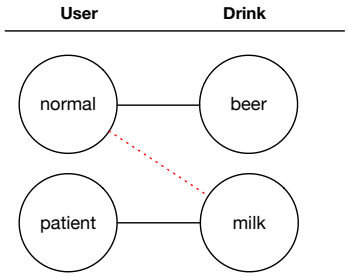

Figure 8: Example recommendation with knowledge based

Content based recommender systems

Another common approach when designing recommender systems is content-based filtering. Content-based filtering methods are based on a description of the item and a profile of the user's preferences. In a content-based recommender system, keywords are used to describe the items and a user profile is built to indicate the type of item this user likes. In other words, these algorithms try to recommend items that are similar to those that a user liked in the past (or is examining in the present). In particular, various candidate items are compared with items previously rated by the user and the best-matching items are recommended.

Such systems are recommending items similar to those a given user has liked in the past, regardless of the preferences of other users. Basically, there are two different types of feedback.

Explicit feedback is intentionally provided by users in form of clicking the "like"/"dislike" buttons, rating an item by number of stars, etc. In many cases, it is hard to obtain explicit feedback data, simply because the users are not willing to provide it. Instead of clicking "dislike" for an item which the user does not consider interesting, he/she will rather leave the web page or switch to another TV channel.

Implicit feedback data, such as "user viewed an item", "user finished reading the article" or "user ordered a product", however, are often much easier to collect and can also help us to compute good recommendations. Various types of implicit feedback may include:

Interactions (implicit feedback):

- user viewed an item
- user viewed item's details
- user added an item to cart
- user purchased an item
- user have read an article up to the end

Content based recommenders work solely with the past interactions of a given user and do not take other users into consideration. The prevailing approach is to compute attribute similarity of recent items and recommend similar items. [9]

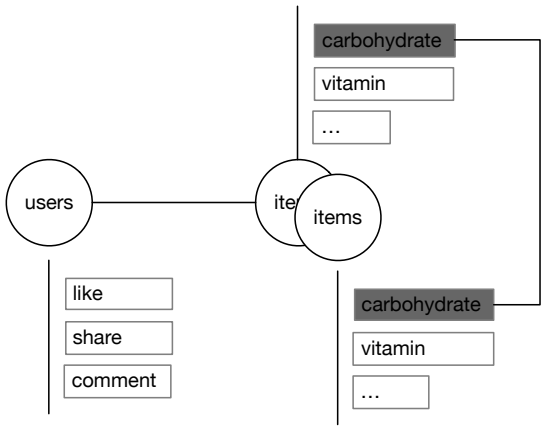

Figure 9: Content based architecture

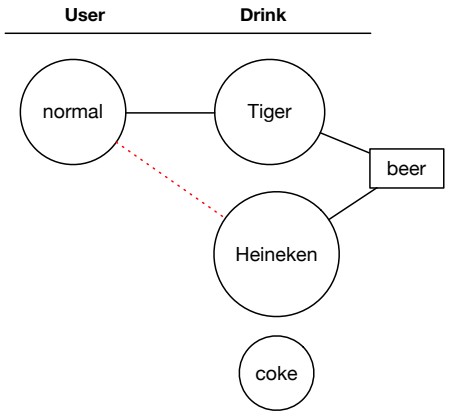

Figure 10: Example recommendation with content based

Collaborative filtering

Last group of recommendation algorithms is based on past interactions of the whole user-base. These algorithms are far more accurate than the algorithms described in previous sections, when a "neighborhood" is well defined and the interactions data are clean.

Algorithm 1: General outline of neighborhood algorithms

input : Number of items to be recommended $N \in \mathbb{N}$,
Number of neighbors used for ranking $k \in \mathbb{N}$,
User to recommend items to u,
List of all items *Items*,
User-Item matrix of ratings R

output: N items to be recommended

foreach *item* $\in$ *Items* **do**
  if *item* $\notin u.rated\_items$ **then**
    $item.rank \leftarrow$ rank_according_to_nearest_neighbors($k, u, item$)
descending_rank_sort(*Items*)
return top(N, *Items*)

Figure 11: General outline of neighborhood algorithms

Algorithm 2: Weighted-Rules Recommendation

input : Set of train users $\mathcal{U}$, Test user $U \in \mathcal{U}$, Set of association rules $\mathcal{R}$, Number of items to recommend $N \in \mathbb{N}$

output: Top-N recommendations $R(U) \subseteq \mathcal{I}$, $|R(U)| \leq N$

$\mathcal{R}^+ \leftarrow \{(X \Rightarrow Y) \in \mathcal{R} \mid X \subseteq U\}$
$C \leftarrow$ init_table()
for $(X \Rightarrow Y) \in \mathcal{R}^+$ **do**
  foreach $i \in (Y \setminus U)$ **do**
    if $i \notin C$ **then**
      $C[i] \leftarrow 0$
    $C[i] \leftarrow C[i] +$ measure($(X \Rightarrow Y), \mathcal{U}$)
$S \leftarrow$ descending_sort_by_value(C)
$R(U) \leftarrow \emptyset$
for $i \leftarrow 1$ **to** N **do**
  $R(U) \leftarrow R(U) \cup \{S[i]\}$
return $R(U)$

Figure 12: Weighted-Rules Recommendation algorithms

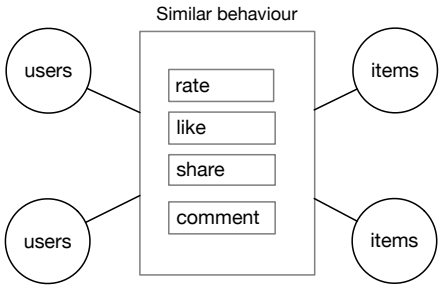

Figure 13: Collaborative architecture

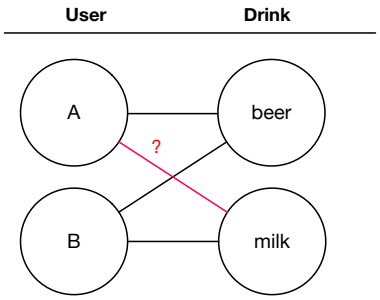

Figure 14: Example recommendation with collaborative filtering

In recommender systems, it is important to update model frequently (after each user interaction), to be able to generate new recommendations instantly. Whereas lazy learners are easy to update, rule based models have to be retrained, which is particularly challenging in large production environments.

D. *Data prediction*

Trigger by user request via App Server and depend on characteristic of data which get from data mining phase, the recommender engine will response a list of recommendation results.

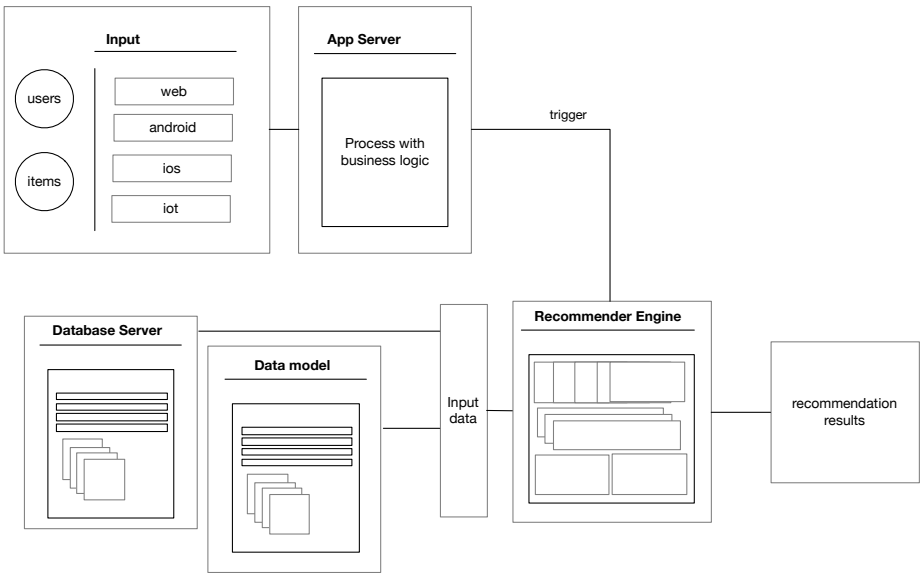

Figure 15: Response recommendation results archiecture

IV. Conclusion

This paper describes development of a recommender systems with food application example. There are many implementation about recommender algorithm with SaaS (Software as a service) [10] license and Open source also [11]. We give a separate approach module, we can create a recommender module and intergate it without issue about platform or compatibility with current application.

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