Matrix Factorization Explained | What is Matrix Factorization?

By Great Learning Team / Updated on Oct 31, 2022 / 9987

Table of contents

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Open the browser, search for a product, scan the entire range, click, swipe, and smile!

Without batting an eyelid, we can purchase the latest model of mobile phones and electronic gadgets, or contemporary furniture or home accessories, just snapping our fingers. The e-commerce sites customize their range of offerings, as per our budget, needs, and tastes. And the happy customer will surely knock again in the future, and even recommend the site on his social circuit. So, every e-commerce site or content provider endeavors to enhance the online shopping experience, to attract and retain customers, bag higher ratings and positive reviews, and stay ahead of the competition. For this purpose, they
engine.

Matrix factorization is one of the most sought-a
enabling the system to gauge the customer's e
rank the right product or service, and recomme
requirement, the lead translates into a transact

What is Matrix Factorization

This mathematical model helps the system spli
rectangular array of numbers or functions, to di
users and items.

Where is Matrix Factorizatio

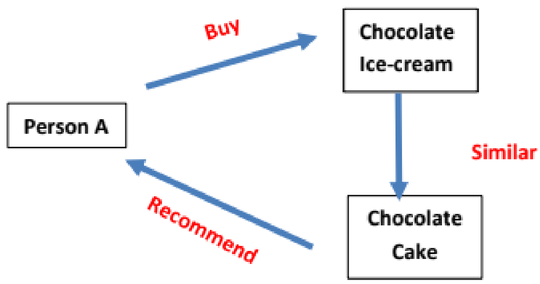
Once an individual raises a query on a search e
output in the form of recommendations. The sys

filtering- to make recommendations.

Content-Based Filtering

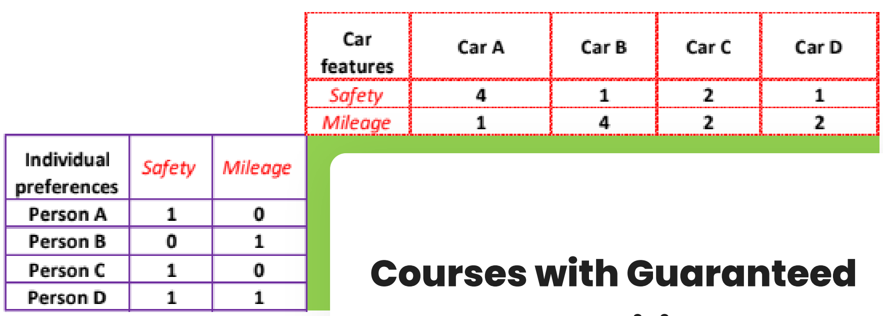
This approach recommends items based on user preferences. It matches the requirement, considering the past actions of the user, patterns detected, or any explicit feedback provided by the user, and accordingly, makes a recommendation.

Example: If you prefer the chocolate flavor and purchase a chocolate ice cream, the next time you raise a query, the system shall scan for options related to chocolate, and then, recommend you to try a chocolate cake.



How does the System make recommendations?

Let us take an example. To purchase a car, in addition to the brand name, people check for features available in the car, most common ones being safety, mileage, or aesthetic value. Few buyers consider the automatic gearbox, while others opt for a combination of two or more features. To understand this concept, let us consider a two-dimensional vector with the features of safety and mileage.



Car features	Car A	Car B	Car C	Car D
Safety	4	1	2	1
Mileage	1	4	2	2

Individual preferences	*Safety*	*Mileage*
Person A	1	0
Person B	0	1
Person C	1	0
Person D	1	1

1. In the above graph, on the left-hand side, we h
provide a rating on safety and mileage. If the i
that particular feature, we assign 0. Now we co
Person D opts for both Safety and Mileage.
2. Cars are been rated based on the number of f
fewer features.
   - A ranks high on safety and low on mileage
   - B is rated high on mileage and low on safety
   - C has an average rating and offers both safe
   - D is low on both mileage and safety
3. The blue colored ? mark is the sparse value, wh
consideration list for buying the car or has forg
4. Let's understand how the matrix at the center
individuals. Person A has given an overall ratin

through the following calculations-

- For Car A = (1 of safety preference x 4 of safety features) +(0 of mileage preference x 1 of mileage feature) = 4;
- For Car B = (1 of safety preference x 1 of safety features) +(0 of mileage preference x 4 of mileage feature) = 1;
- For Car C = (1 of safety preference x 2 of safety features) +(0 of mileage preference x 2 of mileage feature) = 2;
- For Car D = (1 of safety preference x 1 of safety features) +(0 of mileage preference x 2 of mileage feature) = 1

Now on the basis of the above calculations, we can predict the overall rating for each person and all the cars.

If person C is asking the search engine to recommend options available for cars, basis the content available, and his preference, the machine will compute the table below:

- It will rank cars based on overall rating.
- It will recommend car A, followed by car C.

Also Read: What is Machine Learning?

Mathematics behind the recommendations made using content-based filtering

In the above example, we had two matrices, that is, individual preferences and car features, and 4 observations to enable the comparison. Now, if there are ***'n'*** number of observations in both matrix ***a*** and ***b***, then-

- **Dot Product**
  The dot product of two length- n vectors a and b are defined as:

The dot product is only defined for vectors of th
observations.

- **Cosine**
  There are alternative approaches or algorithm
  similarities. It is used to determine the nearest
  search engine can make such a recommendo
  similarity between two vectors a and b is, in fa

By applying the definition of similarity, this will equal 1 if the two vectors are identical, and it will be 0, if the two are orthogonal. In other words, similarity is a number ranging from 0 to 1 and tells us the extent of similarity between the two vectors. Closer to 1 is highly similar and closer to 0 is dissimilar.

- **TF-IDF (Term frequency and Inverse document frequency)**
  Let us assume the matrix only has text or character elements, then the search engine uses TF- IDF algorithm to find similarities and make recommendations. Each word or term has its respective TF and IDF score. The product of the TF and IDF scores of a term is called the TF-IDF weight of that term.

The TF (term frequency) of a word is the number of times it appears in a document. When you know it, you can find out if a term is being used too often or too rarely.

The IDF (inverse document frequency) of a word is the measure of how significant that term is in the whole corpus.

The higher the TF-IDF score (weight), more impo

Advantages of content-based filtering

The model does not require any data about oth
makes it easier to scale it up to a large number
a) The model can capture specific interests of a
very few other users are interested in.

Disadvantages of content-based filter

a) Since the feature representation of the items
domain knowledge. Therefore, the model can o

b) The model can only make recommendations
limited ability to expand on the users' existing ir

Collaborative Filtering

This approach uses similarities between users and items simultaneously, to provide recommendations. It is the idea of recommending an item or making a prediction, depending on other like-minded individuals. It could comprise a set of users, items, opinions about an item, ratings, reviews, or purchases.

Example: Suppose Persons A and B both like the chocolate flavor and have them have tried the ice-cream and cake, then if Person A buys chocolate biscuits, the system will recommend chocolate biscuits to Person B.

Types of collaborative filtering

Collaborative filtering is classified under the memory-based and model-based approaches:

How does system make recommenda

In collaborative filtering, we do not have the rati
overall rating, given by the individuals for each
not know about the car or is not under the cons

The task in hand is to predict the rating that Person C might assign to Car C (? marked in yellow) basis the similarities in ratings given by other individuals. There are three steps involved to arrive at a collaborative filtering recommendation.

Step-1

Normalization: Usually while assigning a rating, individuals tend to give either a high rating or a low rating, across all parameters. Normalization usually helps in balancing and evens out such measures. This is done by taking an average of rating available and subtracting it with the individual rating($x - \bar{x}$)
a) In case of Person A = (4+1+2+1)/4 = 2 = $\bar{x}$, In case of Person B = (1+4+2)/3 = 2.3 =$\bar{x}$
Similarly, we can do it for Persons C and D.
b) Then we subtract the average with individual rating
In case of Person A it is, 4-2, 1-2, 2-2, 1-2, In case for Person B = 1-2.3,4-2.3,2-2.3
Similarly, we can do it for Persons C and D.
You get the below table for all the individuals.

If you add all the numbers in each row, then it w
to zero. From zero, if individual rating for each c
does not like the car.

Step-2

Similarity measure: As discussed in content-b
the ratio between their dot product and the pro

Step-3

Neighborhood selection: Here in Car C column, we find maximum similarities between ratings assigned by Persons A and D. We use these similarities to arrive at the prediction.

Mathematics behind recommendations made using collaborative filtering

In this approach, similarities between pair of items are computed using cosine similarity metric. The rating for target item ***'i'*** for an active user ***'a'*** can be predicted by using a simple weighted average as:

where k is the neighborhood of most similar items rated by active user a, and ***w(i,j)*** is the similarity between items ***i*** and ***j***.

Advantages of collaborative filtering

- There is no dependence on domain knowledg
- The model can help users discover new intere item, but the model might still recommend it b
- To some extent, the system needs only the fee does not require contextual features.

Disadvantages of collaborative filterir

- The matrix cannot handle fresh items, for insta and thus, will rarely occur as a recommendati
- The output of the recommendation could be b particular car, then the recommendation will f

So, this was all about matrix factorization, the ap portals are attracting larger footfalls than the b learning and the algorithms used to search info

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