

RECOMMENDATION SYSTEMS

Company	Music Genre Stations	Pandora Everywhere
About	Today's Hits	Pandora On Your Phone
Advertising	Today's Country	Pandora In Your Car
Submit Your Music	Today's Hip Hop And Pop Hits	Pandora In Your Home
Blog	Today's R&B And Hip Hop Hits	Pandora For Your Business

How does Pandora do it?

Specialists listened to every song and gave each of them various attributes (about 30 to a hundred)

Two songs are similar if their distance in that n -dimensional space is minimal

This works with a binary scale or a point system



streets of philadelphia bruce springsteen



Upload



vevo

Bruce Springsteen - Streets Of Philadelphia



BruceSpringsteenVEVO



201,563

+ Add to Share ... More

32,391,752

94,169 1,737

Uploaded on Oct 2, 2009

Bruce Springsteen's official music video for 'Streets Of Philadelphia' Click to listen to Bruce Springsteen on Spotify: <http://smarturl.it/RSprinnSpot?lQid=R>

Up next

Autoplay



U2 - With Or Without You
by U2VEVO
133,684,635 views



Mix - Bruce Springsteen - Streets of Philadelphia
by YouTube



Bruce Springsteen - My Hometown
by BruceSpringsteenVEVO
4,743,422 views



Bruce Springsteen - I'm On Fire
by BruceSpringsteenVEVO
14,969,589 views



Bruce Springsteen - Dancing In the Dark
by BruceSpringsteenVEVO
39,301,520 views



Bruce Springsteen - Born in the U.S.A.
by BruceSpringsteenVEVO
10,510,751 views



Guns N' Roses - November Rain
by GunsNRosesVEVO
466,972,341 views



Freddie Mercury - Streets of Philadelphia 1991
by Sliver Life
5,577,944 views



Bruce Springsteen Streets of Philadelphia Oscar 1994
by markinosteven
2,021,920 views



USA FOR AFRICA - We Are The World
by mrflashhouse
85,453,605 views



Mike & The Mechanics - The living Years
by Ryder276
9,823,275 views

How does YouTube do it?

Algorithmic:

- Find all users who listened to the song
- Find the song that set of people had listened to the most

The actual solution is a little more computationally effective
(we will get to that)

Pandora:

- intrinsic recommendation system
- internal elements (features) of the songs are used to measure similarity

YouTube:

- extrinsic recommendation system
- recommendations are solely based on peer preferences
- hence the term “collaborative filtering”

svd: single value decomposition

Let's review Matrices and Matrix Multiplication

RECOMMENDATION SYSTEMS

$$\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix} = \begin{bmatrix} (1 \times 5 + 2 \times 7) & (1 \times 6 + 2 \times 8) \\ (3 \times 5 + 4 \times 7) & (3 \times 6 + 4 \times 8) \end{bmatrix}$$

$\begin{bmatrix} 19 & 22 \\ 43 & 50 \end{bmatrix}$

$$\begin{bmatrix} N \times K \end{bmatrix} \begin{bmatrix} K \times M \end{bmatrix} = \begin{bmatrix} N \times M \end{bmatrix}$$

svd: single value decomposition

Inverse of Matrix Multiplication is Decomposition

Factorization is not unique:

$$24 = 4*6 = 3*8 = 2*2*6$$

Factorization is not always exact:

$$23 = 4*6$$

RECOMMENDATION SYSTEMS

$$\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix} = \begin{bmatrix} (1 \times 5 + 2 \times 7) & (1 \times 6 + 2 \times 8) \\ (3 \times 5 + 4 \times 7) & (3 \times 6 + 4 \times 8) \end{bmatrix}$$

$$\begin{bmatrix} N \times K \end{bmatrix} \begin{bmatrix} K \times M \end{bmatrix} = \begin{bmatrix} N \times M \end{bmatrix}$$

$$\begin{bmatrix} 19 & 22 \\ 43 & 50 \end{bmatrix} \xrightarrow{\text{factorize}} \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix}$$

RECOMMENDATION SYSTEMS

	DIEHARD	BRAVEHEART	MULAN	CASABLANCA	HOME ALONE
TOM	5	3	2	2	3
SALLY	3	4	3	5	2
NIKIL	1	5	3	5	1
KIM	1	1	4	4	2

RECOMMENDATION SYSTEMS

	ACTION	COMEDY	HISTORY	COMING-OF-AGE	ROMANCE
TOM	5	5	1	1	1
SALLY	3	5	3	2	5
NIKIL	1	1	5	1	1
KIM	1	4	4	4	3

	DIE HARD	BRAVEHEART	MULAN	CASABLANCA	HOME ALONE
ACTION	5	5	4	2	3
COMEDY	2	1	2	2	4
HISTORY	1	5	4	4	1
COMING-OF-AGE	2	2	4	2	4
ROMANCE	1	4	4	5	1

svd: single value decomposition

Matrix decomposition is not really SVD but something similar

The method is commonly called SVD++...

.. you provide the $M \times N$ matrix and a K

.. the algorithm is typically SGD or ALSWR

Stochastic Gradient Descent

Alternating Least Squares with Weighted-Lambda-Regularization

Collaborative Filtering

Entries & Subjects Matrix can be decomposed:

(Entries & Features) and (Features & Subjects)

Collaborative Filtering

Entries & Subjects Matrix can be decomposed:

(Entries & Features) and (Features & Subjects)

Then you can predict rating, find similar entries or similar subjects.

AP News example: Articles and words

Collaborative Filtering

How to choose “K”?

Collaborative Filtering

How to choose “K”?

Could try various K , decompose, multiply and compare (RMSE) to original matrix (cross-validation)

Or look at Eigen Values

Collaborative Filtering

What if the ratings are not clearly defined?

Collaborative Filtering

What if the ratings are not clearly defined?

Could use click, percentage of view, number of views, like, share

Collaborative Filtering

What are its sensitivities?

Collaborative Filtering

What are its sensitivities?

Normalization is important.

Outliers and noise get magnified.

Collaborative Filtering

What if there is a progression or order to the content?

Collaborative Filtering

What if there is a progression or order to the content?

Have to do some supervision.

Collaborative Filtering

What about empty values?

Collaborative Filtering

What about empty values?

Use averages. Or sparse matrix solvers.

Collaborative Filtering

Octave has in built SVD and NMF

Python has many libraries including GraphLab, divisi2

Consider looking at Incremental-SVD

Intrinsic recommendation systems

Features are well defined

Don't need user data to begin

Manual

Extrinsic recommendation systems

Automatic

Features are undefined

Need a lot of user data

Not automatically adaptive to special cases (like order-specific entries)

Combined technique

Begin with the intrinsic knowledge

Better understanding of the content

Effective initial recommendation

Once enough data points are accumulated, switch to the extrinsic model

Combined technique

Double the work

Most effective, especially for timely content

This is what Netflix does... likely the best recommendation system

Review of terms

Collaborative Filtering

Single Value Decomposition (SVD)

Non-negative Matrix Factorization (NMF)

Feature Extraction

Related topics

Principal Component Analysis (PCA)

Dimensionality Reduction

Clustering

A versatile set of tools

Recommendation

Classification

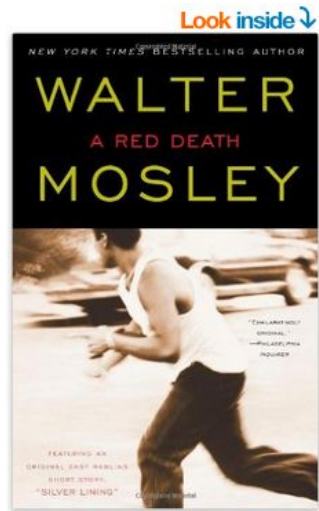
Data Compression

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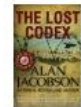
by [Walter Mosley](#) (Author)

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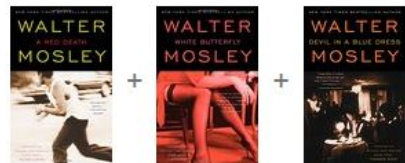
It's 1953 in Red-baiting, blacklisting Los Angeles, a moral tar pit ready to swallow Easy Rawlins. Easy is out of "the hurting business" and into the housing (and favor) business when a racist IRS agent nails him for tax evasion. Special Agent Darryl T. Craxton, FBI, offers to bail him out if he agrees to infiltrate the First American Baptist Church and spy on alleged communist organizer Chaim Wenzler. That's when the murders begin....



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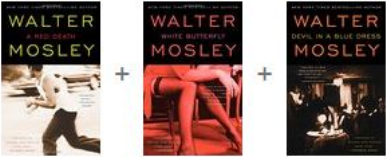
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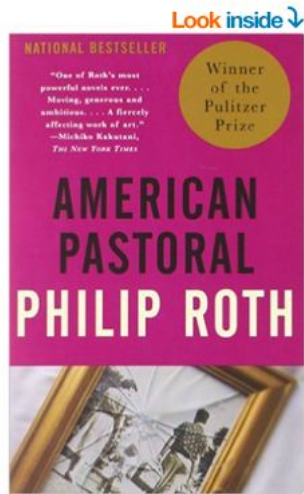
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Editorial Reviews

From Publishers Weekly

This is the second novel in Mosley's superb series featuring Easy Rawlins, a black private investigator living in 1950s Los Angeles. (Aug.) In July Norton will publish *White Butterfly*, a third Mosley mystery starring Rawlins, which received a starred review in PW (Fiction Forecasts, May 4). Copyright 1992 Reed Business Information, Inc. --This text refers to an out of print or unavailable edition of this title.

American Pastoral (Nathan Zuckerman Book 1) and over one million other books are available for Amazon Kindle. [Learn more](#)



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American Pastoral Paperback – February 3, 1998

by Philip Roth (Author)

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Amazon.com Review

Philip Roth's 22nd book takes a life-long view of the American experience in this thoughtful investigation of the century's most divisive and explosive of decades, the '60s. Returning again to the voice of his literary alter ego Nathan Zuckerman, Roth is at the top of his form. His prose is carefully controlled yet always fresh and intellectually subtle as he reconstructs the halcyon days, circa World War II, of Seymour "the Swede" Levov, a high school sports hero and all-around Great Guy who wants nothing more than to live in tranquillity. But as the Swede grows older and America crazier, history sweeps his family inexorably into its grip: His own daughter, Merry, commits an unpardonable act of "protest" against the Vietnam war that ultimately severs the Swede from any hope of happiness, family, or spiritual coherence. --This text refers to an out of print edition.

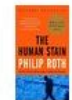
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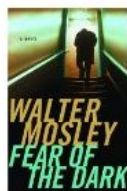
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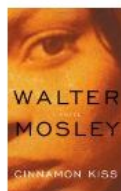
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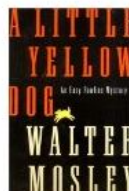
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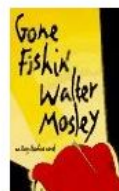
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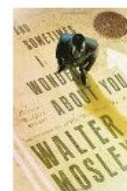
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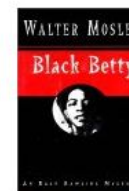
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