



遼寧科技大學
University of Science and Technology Liaoning

2018年软件学院学术交流会

报告人：杨丹
2018.5.12



实体推荐Entity Recommendation



Entity Graphs



Knowledge Graph



Satori Knowledge Base



Knowledge Definition



Address: 400 Broad St, Seattle, 98109
Phone: (800) 937-9582
Opened: Apr 21, 1962
Height: 605 feet (184.41 m)
Floors: 6



NFL championships: 2013
Head coach: Pete Carroll
Founded: 1976
Division: NFC West

Home Field

Location

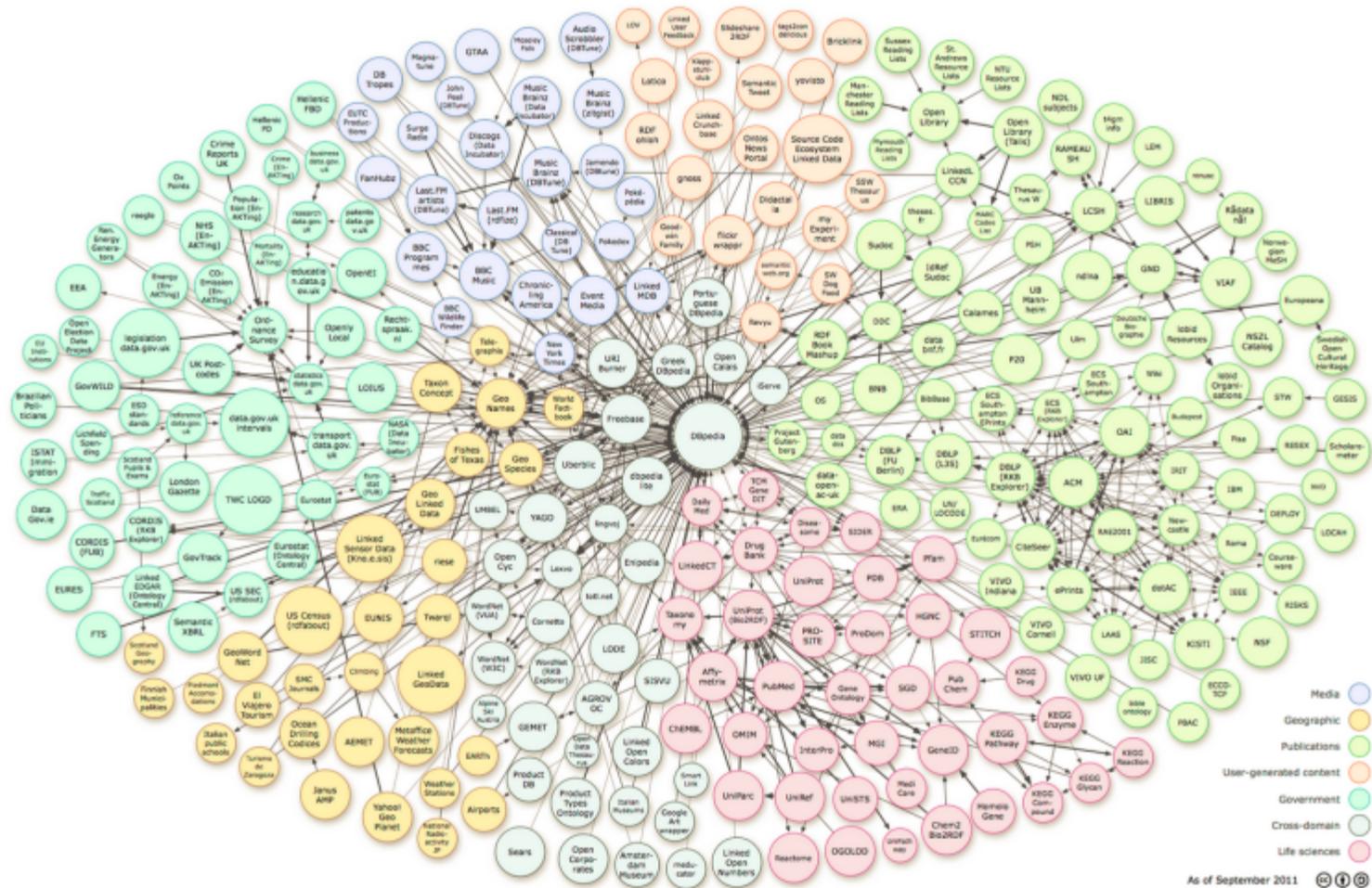


Founded: Mar 30, 1971 · Pike Place Market
Customer service: +1 800-782-7282
CEO: Howard Schultz
Founders: Jerry Baldwin · Zev Siegl · Gordon Bowker

Headquarters

Population: 652,405 (2013)
Area: 142.55 sq miles (369.20 km²)
Mayor: Ed Murray

Entity Graphs



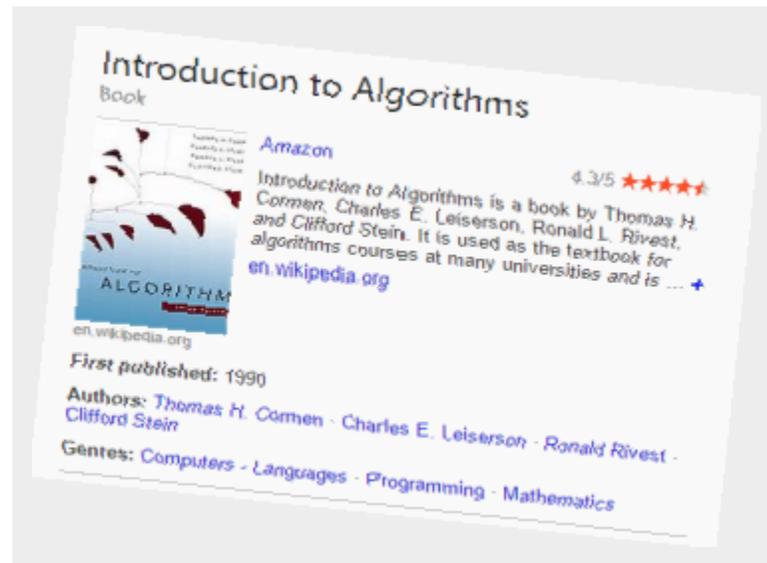
Why “Entity Recommendation”

- Information Overload



Help Explore the
Knowledge Base

Why “Entity Recommendation”



Introduction to Algorithms - People also search for

The Art of Computer Programming	Computers and Intractability	Artificial Intelligence: A Modern App...	Computer Graphics: Principles a...	Operating System Concepts	Introduction to Automata Theory, Lan...	Modern Operating Systems	Concrete Mathematics	Introduction to the Theory of Computation	Database System Concepts

Why “Entity Recommendation”



Leonardo DiCaprio

American Actor

Leonardo Wilhelm DiCaprio is an American actor and film producer. He has been nominated for ten Golden Globe Awards, winning two, and five Academy Awards. DiCaprio began his career by appearing in television commercials, after which he had recurring roles in TV series such as the soap opera Santa Barbara and the sitcom Growing Pains in th... +

en.wikipedia.org



Wikipedia



IMDb



Twitter



Facebook

Born: Nov 11, 1974 (age 40) · Los Angeles, California

Height: 6' 0" (1.83 m)

Partner: Gisele Bündchen (2000 - 2005)

Upcoming movies: [The Revenant](#)

Parents: [George DiCaprio](#) · [Imelin Indenbirken](#)

Nominations: [Academy Award for Best Actor \(2005, 2007, 2014\)](#) · [Academy Award for Best Picture \(2014\)](#) +

Movies and TV shows

[See all \(10+\)](#)



[The Wolf of Wall Street](#)
2013



[Titanic](#)
1997



[The Great Gatsby](#)
2013



[Inception](#)
2010



[The Departed](#)
2006

Romance

[See all \(5+\)](#)



[Toni Garm](#)



[Bar Refaelli](#)



[Blake Lively](#)



[Gisele Bündchen](#)



[Monica Hansen](#)

People also search for

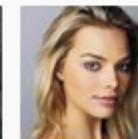
[See all \(10+\)](#)



[Kate Winslet](#)



[Jordan Belfort](#)



[Margot Robbie](#)



[Johnny Depp](#)



[Brad Pitt](#)

Why “Entity Recommendation”



machine learning



www 2015

Machine learning



Machine learning is a subfield of computer science that evolved from the study of pattern recognition and computational learning theory in artificial intelligence. Machine learning explores the construction and study of algorithms that can ... [en.wikipedia.org](#)

Subdisciplines of: [Artificial intelligence](#) · [Computer Science](#)

Subdisciplines: [Supervised learning](#) · [Deep learning](#)

Academic conferences: [AAAI 2016](#) · [NIPS 2015](#) · [ICML 2015](#) · [IJCAI-15](#) · [KDD 2015](#) · [CVPR 2015](#) · [ICASSP 2016](#) · [ICDM 2015](#) +

Related people

[See all \(10+\)](#)



[Andrew Ng](#)



[Arthur Samuel](#)



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[Geoffrey Hinton](#)



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People also search for

[Data mining](#)

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WWW 2015

Dates: May 20 - 22, 2015

Location: [Florence](#)

Website: [WWW 2015](#)

Abstracts due: Nov 03, 2014

Submissions due: Nov 10, 2014

Notification date: Jan 17, 2015

Final version due: Mar 08, 2015

People also search for

[CIKM 2015](#) (Oct 19, 2015)

[AAAI 2016](#) (Feb 12, 2016)

[SIGIR 2015](#) (Aug 09, 2015)

[KDD 2015](#) (Aug 10, 2015)

[VLDB 2015](#) (Aug 31, 2015)

[IJCAI-15](#) (Jul 25, 2015)

[ICDE 2015](#) (Apr 13, 2015)

Technologies

- Natural Language Processing
- Machine Learning
- Information Retrieval
- Recommender Systems
- Text and Log Mining
-

Data Sources

- Wikipedia
 - Semi-structured free Internet encyclopedia, contributed by community members
- Freebase
 - Structured data composed mainly by its community members
 - Acquired by Google on July 2010, and will be retired on June 2015
 - Data will be ported to WikiData
- WikiData
 - a collaboratively edited knowledge base
- DBPedia
 - Extracted structured information from Wikipedia
- Yago
 - a knowledge base automatically extracted from Wikipedia and other sources
 - Accuracy 95.02% based on manual evaluation
- Web Documents
- Queries and Search Click Log

Applications

- Entity Pane Experiences
- Entity Recommendation
 - Recommendation and Ranking
 - Interpretation
 - Exploration
 - Personalization
- Factoid Answers
- Graph Search
- Conversational Question and Answering
- Natural Language Question and Answering
-

Traditional Recommender Systems

- Recommender Systems have been well studied from many aspects

Collaborative filtering

Content-based

Context-aware

Rating-based

Learning to Rank

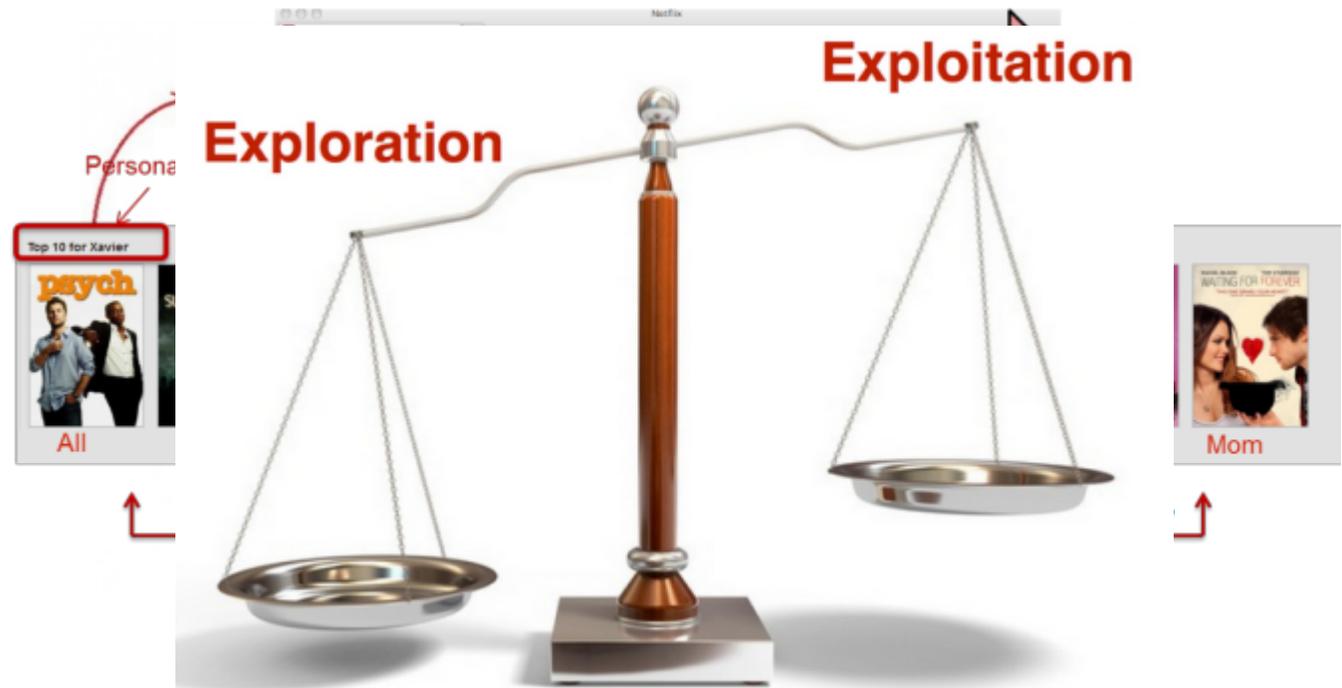
Diversity

Serendipity

Social-Aware

Temporal

Explore/Exploit



Traditional Recommender Systems

- Majority of the algorithms is focusing on Personalization
 - $P(item|user)$
 - User-Item Matrix

	v_1	v_2	v_3	v_4	v_5
u_1	1		2	3	
u_2		3			1
u_3		4		5	
u_4	5			4	
u_5		2	5		4

	v_1	v_2	v_3	v_4	v_5	v_6
u_1		1	1		1	
u_2	1			1		1
u_3			1			1
u_4	1			1		
u_5		1	1			1

Entity Recommender Systems

- Entity Graph

Heterogeneous Graph

Freebase

2K+ commonly used types

30K+ commonly used properties



Entity Recommender Systems

- Entity Graph

Hugh Size
Freebase
47M+ topics
2.9B+ facts



Entity Recommender Systems

- Non-Personalized
 - $P(item|item)$
 - $P(item|query)$

Collaborative filtering

Collaborative filtering is a technique used by some recommender systems. Collaborative filtering has two senses, a narrow one and a more general one. In general, filtering for information or pattern collaboration among multiple

en.wikipedia.org

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[Cosine similarity](#)

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[Learning to rank](#)

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1,440,000,000 RESULTS

Any time ▾

2015 WWW Conference start date

May 20, 2015

[Data from WWW2015](#)

Entity Recommender Systems

- Personalization
- Personalization
 - $P(item|user)$



Entity Recommender Systems in Search

- Recommendation & Ranking
- Interpretation
- Entity Collection Recommendation
- Exploration
- Personalization

Recommendation & Ranking

Tom Cruise



Tom Cruise, is an American film actor and producer. He has been nominated for three Academy Awards and has won three Golden Globe Awards. He started his career at age 19 in the 1981 film Endless Love. After portraying supp... +
en.wikipedia.org

www.imdb.com

Born: Jul 3, 1962 (age 51) · Syracuse, New York

Height: 5' 7" (1.70 m)

Spouse: [Katie Holmes \(2006 - 2012\)](#) · [Nicole Kidman \(1990 - 2001\)](#) · [Mimi Rogers \(1987 - 1990\)](#)

Children: [Connor Cruise](#) · [Suri Cruise](#) · [Isabella Jane Cruise](#)

Upcoming movies: [Edge of Tomorrow](#)

Siblings: [Lee Ann Mapother](#) · [Marian Mapother](#) · [Cass Mapother](#)

Movies



[Oblivion](#) 2013 [Jack Reacher](#) 2012 [Edge of Tomorrow](#) 2014 [Rock of Ages](#) 2012 [Mission: Impossible](#) 2011

People also search for



[Brad Pitt](#) [Leonardo DiCaprio](#) [Tom Hanks](#) [Bruce Willis](#) [Johnny Depp](#)

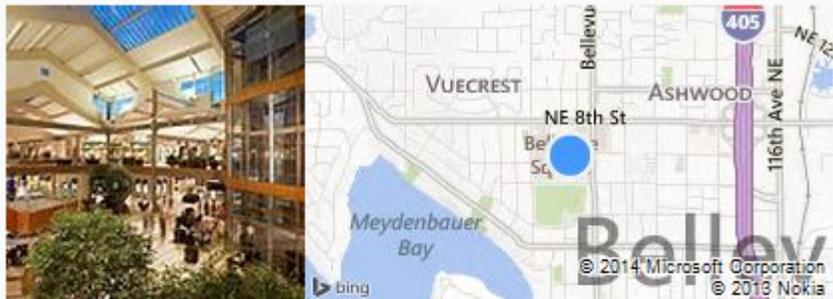
Hao Ma



I worked on many interesting problems in both

Concrete Mathematics [Amazon](#) 4.5/5 ★★★★★

Bellevue Square



en.wikipedia.org

Bellevue Square is a shopping center in Bellevue, Washington. The mall has 180 retail stores, with anchors JCPenney, Macy's, and Nordstrom, and specialty stores such as Tiffany's, Hugo Boss, Armani Exchange, Lego, Victorinox Swiss Army, and the Microsoft Store. Restaurants include P.F. Chang's, The Cheesecake Factory, Red Robin, and R... +
en.wikipedia.org

Built: 1946

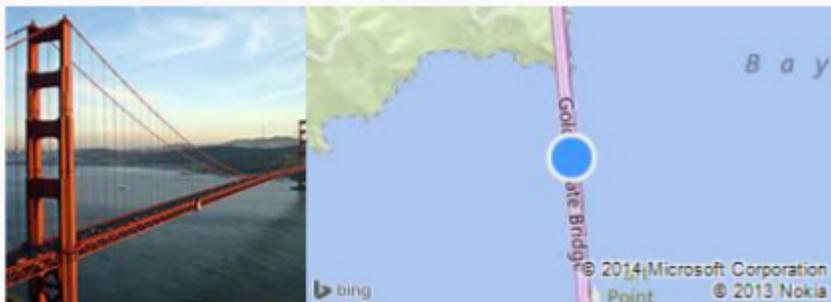
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Interpretation

Golden Gate Bridge



en.wikipedia.org

The Golden Gate Bridge is a suspension bridge spanning the Golden Gate strait, the mile-wide, three-mile-long channel between San Francisco Bay and the Pacific Ocean. The structure links the U.S. city of San Francisco, on the northern tip of the San Francisco Peninsula, to Marin County, bridging both U.S. Route 101 and California State R... +

en.wikipedia.org

Built: 1937

Length: 8,980 feet (2,737 m)

Height: 746 feet (227.40 m)

Architects: [Joseph Strauss](#) · [Charles Alton Ellis](#) · [Irving Morrow](#)

Location: [San Francisco](#) · [Marin County](#)

Crosses: [Golden Gate](#)

Bridge type: [Suspension bridge](#) · [Truss bridge](#) · [Truss arch bridge](#)

Charles Alton Ellis was a professor, structural engineer and mathematician who was chiefly responsible for the structural design of the Golden Gate Bridge.



[Joseph Strauss](#)
Architect



[Charles Alton Ellis](#)
Architect



[Irving Morrow](#)
Architect

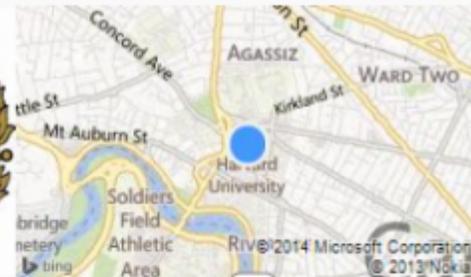


[Amadeo Giannini](#)



[Leon Moisseiff](#)

Harvard University



www.harvard.edu

Harvard University is a private Ivy League research university in Cambridge, Massachusetts, whose history, influence and wealth have made it one of the most prestigious universities in the world. Established in 1636 by the Massachusetts legislature and soon thereafter named for John Harvard, Harvard is the United States' o... +

en.wikipedia.org

Address: 1350 Massachusetts Ave, Cambridge, MA, 02138 · [Directions](#)

Ranking: #2 National University (2014)

Undergraduates: 6,658 (2014)

Acceptance rate: 6% (2014)

Tuition: \$42,292 USD (2014)

Founder: [John Harvard](#)

School color: [Crimson](#)

Mascot: [Harvard University John Harvard](#)

Born in Honolulu, Hawaii, Barack Obama is a graduate of Columbia University and Harvard Law School, where he was president of the Harvard Law Review.

Related people



[John Harvard](#)
Founder



[Drew Gilpin Faust](#)



[Mark Zuckerberg](#)
Alumni



[Barack Obama](#)
Alumni



[Bill Gates](#)
Alumni

and Understanding, Flore

Entity Collection Recommendation

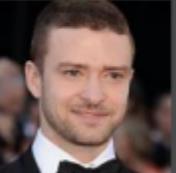
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pop musicians

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Pop musicians frequently mentioned on the web

								
Michael Jackson 1958 - 2009	Katy Perry	Taylor Swift	Lady Gaga	Elvis Presley 1935 - 1977	Britney Spears	Justin Bieber	Justin Timberlake	Miley Cyrus

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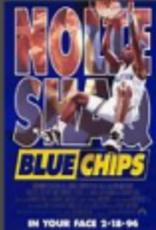
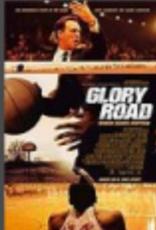
basketball movies

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Basketball - Movies

Popular first

									
Space Jam (1996) ★★★★☆	He Got Game (1998) ★★★★★	White Men Can't Jump (1992) ★★★★★	Coach Carter (2005) ★★★★★	Like Mike (2002) ★★★★★	Blue Chips (1994) ★★★★★	Glory Road (2006) ★★★★★	Hoosiers (1987) ★★★★★	Finding Forrester (2001) ★★★★★	BASEketball (1998) ★★★★★

Entity Collection Recommendation

bing MS Beta

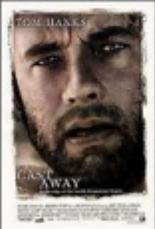
tom hanks drama movies

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Tom Hanks - Drama movies

Drama Popular first

									
Captain Phillips (2013) ★★★★★	Saving Mr. Banks (2013) ★★★★★	Forrest Gump (1994) ★★★★★	Cast Away (2000) ★★★★★	The Green Mile (1999) ★★★★★	Saving Private Ryan (1998) ★★★★★	Larry Crowne (2011) ★★★★★	Philadelphia (1994) ★★★★★	Cloud Atlas (2012) ★★★★★	Sleepless in Seattle (1993) ★★★★★

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tom hanks romance movies

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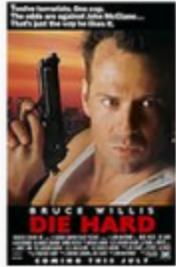
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Tom Hanks - Romance movies

Romance Popular first

									
Forrest Gump (1994) ★★★★★	Big (1988) ★★★★★	Larry Crowne (2011) ★★★★★	Sleepless in Seattle (1993) ★★★★★	The Terminal (2004) ★★★★★	You've Got a Tail (1998) ★★★★★	Splash (1984) ★★★★★	Joe Versus the Volcano (1990) ★★★★★	My Big Fat Greek Wedding (2002) ★★★★★	Mamma Mia! (2008) ★★★★★

Die Hard (1988)



Die Hard is a 1988 American action film directed by John McTiernan and written by Steve de Souza and Jeb Stuart, based on the 1979 novel Nothing Lasts Forever by Roderick Thorp. Die Hard follows off-duty New York City Police Department offi... +

en.wikipedia.org

en.wikipedia.org

Summary: R - 2hr 11min - Action/Adventure

Release date: Jul 15, 1988

Director: John McTiernan

Sequel: Die Hard 2

Story by: Roderick Thorp

Music by: Michael Kamen

Watch movie

Reviews

★★★★★ (993,662)

Explore more

Die Hard movies

Bruce Willis movies

Action movies (Ranked at #6)

Movies about Christmas (Ranked at #5)

Movies about terrorism (Ranked at #3)

Cast



Bruce Willis
John McClane



Alan Rickman
Hans Gruber



Reginald VelJohnson
Sgt. Al Powell (a...)



Bonnie Bedelia
Holly Gennaro ...

Exploration



die hard movies



MS Beta

50,500,000 RESULTS

Any time

[Die Hard film series - movies](#)



christmas movies



MS Beta

125,000,000 RESULTS

Any time

Christmas - Movies



terrorism movies



MS Beta

15,000,000 RESULTS

Any time

movies



ntity F

2015

25

Personalized Recommender Systems

- Problem definition

User-Item Matrix

	Rating/Frequency				
	v_1	v_2	v_3	v_4	v_5
u_1	1		2	3	
u_2		3			1
u_3		4		5	
u_4	5			4	
u_5		2	5		4

	Implicit/One-class					
	v_1	v_2	v_3	v_4	v_5	v_6
u_1		1	1		1	
u_2	1			1		1
u_3			1			1
u_4	1			1		
u_5		1	1			1

Personalized Recommender Systems

- Memory-based methods
 - Pearson Correlation Coefficient
 - Vector Space Similarity/Cosine Similarity
- Model-based methods
 - Matrix Factorization
 - Probabilistic models
 - Clustering
 - Classification
 - ...

Personalized Recommender Systems

- Memory-based methods
 - Pearson Correlation Coefficient**
 - Vector Space Similarity/Cosine Similarity
- Model-based methods
 - Matrix Factorization**
 - Probabilistic models
 - Clustering
 - Classification
 - ...

Personalized Recommender Systems

- Memory-based methods

Items

U ₁												
U ₂	1	3	4		2		5			3	4	
U ₃												
U ₄		3	4			3	4		3	4		4
U ₅												
U ₆	1		3	5	2		4	1			3	

Users

Personalized Recommender Systems

- Memory-based methods

Items

Users

U ₁													
U ₂	1	3		4		2		5			3	4	
U ₃													
U ₄		3		4			3	4		3	4		4
U ₅													
U ₆	1			3	5	2		4	1			3	

Personalized Recommender Systems

- Memory-based methods

Items

Users

U ₁												
U ₂	1	3	4		2		5			3	4	
U ₃												
U ₄		3	4			3	4		3	4		4
U ₅												
U ₆	1		3	5	2		4	1			3	

Personalized Recommender Systems

- Memory-based methods

Items

Users

U ₁												
U ₂	1	3	4	2	5			3	4			
U ₃												
U ₄		3	4		3	4		3	4		4	
U ₅												
U ₆	1		3	5	2	4	1			3		

Personalized Recommender Systems

- Memory-based methods

Items

u ₁													
u ₂	1	3	4		2		5			3	4		
u ₃													
u ₄		3	4			3	4		3	4		4	
u ₅													
u ₆	1		3	5	2		4	1			3		

Users

Personalized Recommender Systems

- Memory-based methods

Items

Users

u ₁													
u ₂	1	3	4		2		5			3	4		
u ₃													
u ₄		3	4			3	4		3	4		4	
u ₅													
u ₆	1		3	5	2		4	1			3		

Why is Entity Recommender System different?

- The problem definition for traditional recommender systems is clearer than entity recommender systems since most of the time **user-item matrix** is given

Rating/Frequency

	v_1	v_2	v_3	v_4	v_5
u_1	1		2	3	
u_2		3			1
u_3		4		5	
u_4	5			4	
u_5		2	5		4

Implicit/One-class

	v_1	v_2	v_3	v_4	v_5	v_6
u_1		1	1		1	
u_2	1			1		1
u_3			1			1
u_4	1			1		
u_5		1	1			1

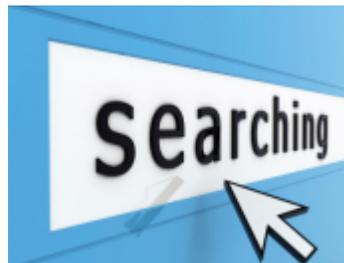
Why is Entity Recommender System different?

- Entity recommender systems are embedded within searching process, users' preferences on entities are more difficult to observe

Users



Queries



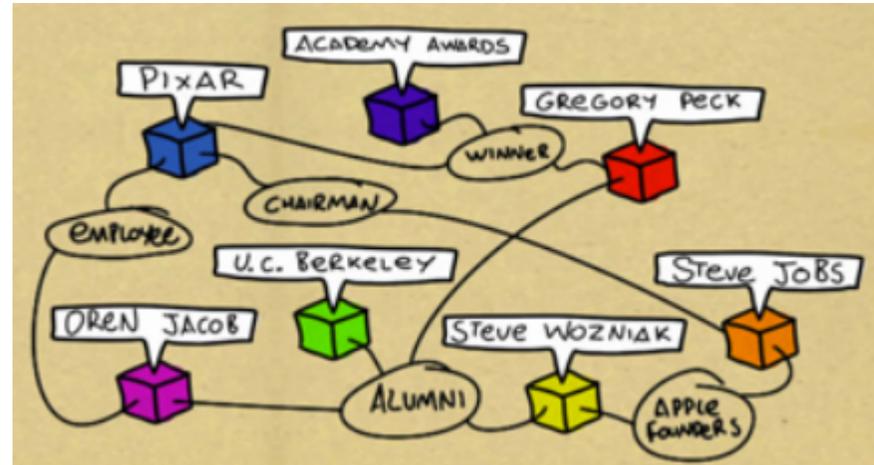
Clicks



Why is Entity Recommender System different?

- The huge Entity Graph with knowledge makes entity recommender systems more **challenging** and also **appealing**

Entities



Thanks!