

Learning Socially Optimal Information Systems from Egoistic Users

Karthik Raman Thorsten Joachims

Department of Computer Science
Cornell University, Ithaca NY

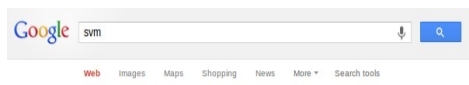
karthik@cs.cornell.edu
www.cs.cornell.edu/~karthik

tj@cs.cornell.edu
www.cs.cornell.edu/People/tj

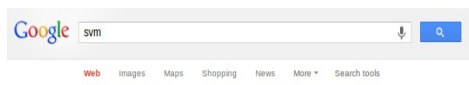
Sept 23, 2013



Example: (Extrinsic) Diversity in Web Search

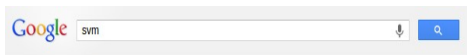


Example: (Extrinsic) Diversity in Web Search



What did the user mean?

Example: (Extrinsic) Diversity in Web Search



[Web](#) [Images](#) [Maps](#) [Shopping](#) [News](#) [More](#) [Search tools](#)

[Silvercorp Metals Inc - Home](#)

www.silvercorpmetals.com

Silvercorp is a low-cost silver-producing Canadian mining company with multiple miners in China which has paid a cash dividend since 2007. The Company is ...
[News](#) [Contact Us](#) [Company](#) [Projects](#) [Silvertp Project](#)

[Silvercorp Metals Inc - News](#)

www.silvercorpmetals.com/news/

Apr 15, 2013 Silvercorp Reports Underground Diamond Drilling and Tunneling ...

[News for silvercorp metals](#)



[It's Time For Retail Investors To Capture Metals Upside](#)

ETF Daily News - 3 hours ago

It's Time For Retail Investors To Capture Metals Upside.

[Silvercorp Metals appoints senior VP](#)

Proactive Investors USA & Canada - 1 day ago

[Technical Briefing: Pan American Silver Corp., Silvercorp Metals Inc., Silver... MarketWatch](#) - 1 day ago

[SVM: Summary for Silvercorp Metals Inc Ordinary - Yahoo! Finance](#)

finance.yahoo.com/q?s=SVM

View the basic SVM stock chart on Yahoo! Finance. Change the date range, chart type and compare Silvercorp Metals Inc Ordinary against other companies.

[Silvercorp Metals - Wikipedia, the free encyclopedia](#)

en.wikipedia.org/wiki/Silvercorp_Metals

Silvercorp Metals Inc. (Silvercorp) is a Canadian based, China focused precious metals company engaged in the acquisition, exploration, and development of ...

[Silvercorp Metals Inc. Stock Quote SVM | The Motley Fool](#)

www.fool.com/quote/nyse/silvercorp-metals-inc/svm

Silvercorp Metals Inc. (SVM) Description. Silvercorp Metals Inc. is engaged in the acquisition exploration development and mining of high-grade silver-related ...

[Silvercorp Metals Inc. \(USA\): NYSE:SVM quotes & news - Google ...](#)

www.google.com/finance?ckj=7766473

Get detailed financial information on Silvercorp Metals Inc. (USA) (NYSE:SVM) including real-time stock quotes, historical charts & financial news, all for free!

[Silvercorp Metals Inc.: TSE:SVM quotes & news - Google Finance](#)

www.google.com/finance?ckj=701872

Get detailed financial information on Silvercorp Metals Inc. (TSE:SVM) including real-time stock quotes, historical charts & financial news, all for free!

Silvercorp

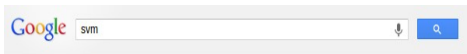
Metals

40%



7

Example: (Extrinsic) Diversity in Web Search



Web Images Maps Shopping News More Search tools

About 5,220,000 results (0.18 seconds)

Scholarly articles for support vector machine

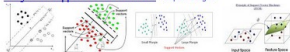
- [Support vector machine](#) - Carles - Cited by 138
- [Least squares support vector machine classifiers](#) - Suykens - Cited by 3698
- [Support vector machine classification and validation of ...](#) - Furey - Cited by 1678

Support vector machine - Wikipedia, the free encyclopedia

en.wikipedia.org/wiki/Support_vector_machine
In machine learning, **support vector machines** (SVMs, also support vector networks) are supervised learning models with associated learning algorithms that ...

Kernel trick - Quadratic programming - Positive-definite kernel - Linear classifier

Images for support vector machine - Report images



[PDF] An Idiot's guide to Support vector machines (SVMs)

www.cs.ucf.edu/courses/cap6412/fal2009/papers/Berwick2003.pdf
by R Berwick - Cited by 5 - Related articles

1. An Idiot's guide to **Support vector machines** (SVMs). R. Berwick, Village Idiot. SVMs: A New. Generation of Learning Algorithms. • Pre 1980: – Almost all ...

[PDF] Support Vector Machine Tutorial

www.cs.columbia.edu/~kaffy/cs4701/documents/jason_svm_tutorial.pdf
Support Vector Machine (and Statistical Learning Theory) Tutorial. Jason Weston. NEC Labs America, 4 Independence Way, Princeton, USA.

SVM-Light Support Vector Machine

svmlight.joachims.org
Training software for large-scale SVMs. (Free for non-commercial use)

[PDF] Support Vector Machines - CS 229

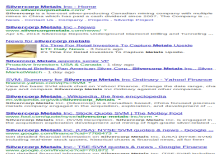
cs229.stanford.edu/notes/cs229-notes3.pdf
CS229 Lecture notes. Andrew Ng. Part V. **Support Vector Machines**. This set of notes presents the **Support Vector Machine (SVM)** learning algorithm. SVMs are ...

Support Vector Machines (SVM) - StatSoft

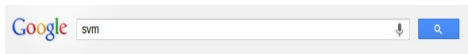
www.statsoft.com/textbook/support-vector-machines/
Support Vector Machines are based on the concept of decision planes that define decision boundaries.

Silvercorp
Metals
40%

Support Vector
Machines
35%



Example: (Extrinsic) Diversity in Web Search



Web Images Maps Shopping News More Search tools

About 636,000 results (0.18 seconds)

Ad related to **svm cards**

SVM Cards - Top Brand Gift Cards Seal The Deal
www.solutionsthatmotivate.com/incentive
It's An Offer They Can't Refuse.

SVM: Gift Cards, Gas Gift Cards, Retail Gift Cards, Online Gift Cards
www.svmcards.net/
SVM is the leader in sales, marketing and promotion of gas gift cards and many other forms of gift cards including service and retail gift cards.

Gasoline Gift Cards

No one has more options for Gasoline Gift Cards than SVM ...

Shop for Cards

SVM has an enormous selection of gift cards covering nearly every ...

Exxon Mobil Gas Card - Gift ...

SVM is the leader in sales, marketing and promotion of gas ...

More results from svmcards.net »

Gift Cards, Gas Gift Cards ...

Soldiers: Angels Tank Support Thank you for your interest in ...

Card Replacement Form

Complete and print this form and return it with your card(s) to:

Prepaid cards

SVM's prepaid options include prepaid Visa cards and prepaid ...

SVM (company) - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/SVM_(company)

SVM LP began as Stored Value Marketing in 1997. SVM is based in the Des Plaines, Illinois and is a provider of gasoline, restaurant, and other retail gift cards ...

Gift Card FAQs | SVM

www.svmcards.com/home/content/faqs.cfm
Frequently asked questions about orders, payments, and using your gift cards.

About SVM Management | SVM

www.svmcards.com/home/about-us
Members of the SVM management team have extensive experience in the industry and continually work to give SVM customers the best quality service ...

About SVM Gift Cards | SVM

www.svmcards.com/home/content/our_company.cfm
SVM is an experienced and efficient prepaid gift card provider and gift card fulfillment service company committed to the highest quality customer service.

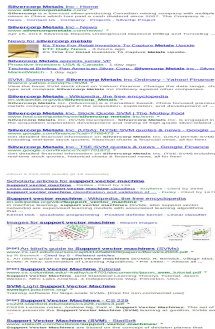
Contact Us | SVM

www.svmcards.com/home/about-us
SVM is located in Des Plaines, Illinois near Chicago's O'Hare Airport. Contact us

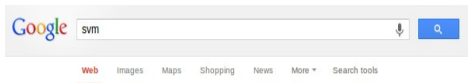
Silvercorp Metals
40%

Support Vector Machines
35%

SVM Gift Cards
15%



Example: (Extrinsic) Diversity in Web Search



About 6,510,000 results (0.33 seconds)

[Society for Vascular Medicine : About SVM : Home](#)

[www.vascularmed.org/](#)

About SVM. Who is SVM - Leadership - Committees - Newsletter - Newsletter Archive - SVM Awards - Mission Statement - History of SVM - Past Presidents - Code ...

[Annual Meeting](#)

SVM 25th Anniversary and Scientific Sessions. June 12-14 ...

[History of SVM](#)

SVM History. In 1989, 14 individuals met and formed the ...

[Join SVM](#)

Join SVM. Join a unique community of vascular clinicians ...

[More results from vascularmed.org >](#)

[Society for Vascular Medicine \(SVM\) - Deerfield, IL - Doctor | Face...](#)

<https://www.facebook.com/VascularMed>

Society for Vascular Medicine (SVM), Deerfield, IL. 182 likes · 0 talking about this. Attend the SVM 25th Annual Meeting June 12-14, 2014 San Diego, California ...

[Society for Vascular Medicine - Wikipedia, the free encyclopedia](#)

en.wikipedia.org/wiki/Society_for_Vascular_Medicine

The **Society for Vascular Medicine** is a United States-based medical specialty professional society in the field of vascular medicine. Vascular medicine is a ...

[Jobs - The Society for Vascular Medicine](#)

[www.jobtarget.com/c/search.cfm?site_id=1772](#)

Jobs 1 - 25 of 56 - View job search results from The **Society for Vascular Medicine**. Discover available job & career opportunities on the **The Society for Vascular** ...

[Career Center Jobs - The Society for Vascular Medicine - JobTarget](#)

[www.jobtarget.com/home/?site_id=1772](#)

The **Society for Vascular Medicine's** career center offers a variety of available jobs in the industry. Find a job on **The Society for Vascular Medicine**, or post a job ...

[Choosing Wisely | Society for Vascular Medicine](#)

[www.choosingwisely.org/doctor-patient...society-for-vascular-medicine/](#)

Lab tests to look for a clotting disorder will not alter treatment of a venous blood clot, even if an abnormality is found. DVT is a very common disorder, and recent ...

[Vascular Related Exams](#)

Vascular Related Exams. American Board of Vascular ...

[Vascular and Endovascular](#)

You can take the Vascular and Endovascular Review Courses ...

[Find a Physician](#)

Find a Physician. Search through the SVM Member Directory—a ...

Silvercorp Metals
40%

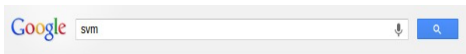
Support Vector Machines
35%

SVM Gift Cards
15%

Society of Vascular Medicine
10%



Example: (Extrinsic) Diversity in Web Search



Web Images Maps Shopping News More Search tools

[SVM: Summary for Silvercorp Metals Inc Ordinary - Yahoo! Finance](#)
finance.yahoo.com/q?s=SVM

View the basic SVM stock chart on Yahoo! Finance. Change the date range, chart type and compare Silvercorp Metals Inc Ordinary against other companies.

Board - Options - Historical Prices - News

[Support vector machine - Wikipedia, the free encyclopedia](#)
en.wikipedia.org/wiki/Support_vector_machine

In machine learning, support vector machines (SVMs), also support vector networks) are supervised learning models with associated learning algorithms that ...

Kernel trick - Quadratic programming - Positive-definite kernel - Linear classifier

[SVM](#)

[www.svmcards.net/](#)

SVM is the leader in sales, marketing and promotion of gas gift cards and many other forms of gift cards including service and retail gift cards.

[SVM-Light Support Vector Machine](#)

[svmlight.joachims.org/](#)

Training software for large-scale SVMs. [Free for non-commercial use]

[Silvercorp Metals Inc. \(USA\): NYSE-SVM quotes & news - Google](#)

[www.google.com/finance?cjl=7766473](#)

Get detailed financial information on Silvercorp Metals Inc. (USA) (NYSE:SVM) including real-time stock quotes, historical charts & financial news, all for free!

[Silvercorp Metals Inc - Home](#)

[www.silvercorpmetals.com/](#)

NYSE:SVM USD\$ 3.26 +0.04 +1.09% Volume: 628,926 September 17, 2013.
TSX:SVM CAD\$ 3.36 +0.03 +0.9% Volume: 91,397 September 17, 2013.

[Kernel-Machines.Org — Kernel Machines](#)

[www.kernel-machines.org/](#)

This page is devoted to learning methods building on kernels, such as the support vector machine. It grew out of earlier pages at the Max Planck Institute for ...

[SVM Stock Quote - Silvercorp Metals Inc. Stock Price Today \(SVM\)](#)

[www.marketwatch.com/investing/stock/svm](#)

Updated stock quote for svm - including svm stock price today, earnings and estimates, stock charts, news, futures and other investing data.

[Society for Vascular Medicine \(SVM\) - Deerfield, IL - Doctor | Face](#)

<https://www.facebook.com/VascularMed>

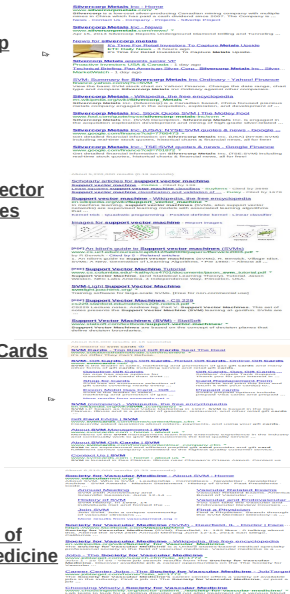
Society for Vascular Medicine (SVM), Deerfield, IL. 182 likes · 0 talking about this. Attend the SVM 25th Annual Meeting June 12-14, 2014 San Diego, California ...

**Silvercorp
Metals**
40%

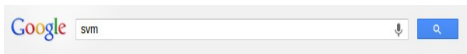
**Support Vector
Machines**
35%

SVM Gift Cards
15%

**Society of
Vascular Medicine**
10%



Example: (Extrinsic) Diversity in Web Search



[SVM: Summary for Silvercorp Metals Inc Ordinary - Yahoo! Finance](#)
finance.yahoo.com/q?s=SVM
View the basic SVM stock chart on Yahoo! Finance. Change the date range, chart type and compare Silvercorp Metals Inc Ordinary against other companies.
Board - Options - Historical Prices - News

[Support vector machine - Wikipedia, the free encyclopedia](#)
en.wikipedia.org/wiki/Support_vector_machine
In machine learning, support vector machines (SVMs), also support vector networks) are supervised learning models with associated learning algorithms that ...
Kernel trick - Quadratic programming - Positive-definite kernel - Linear classifier

[SVM](#)
www.svmcards.net/
SVM is the leader in sales, marketing and promotion of gas gift cards and many other forms of gift cards including service and retail gift cards.

[SVM-Light Support Vector Machine](#)
svmlight.joachims.org/
Training software for large-scale SVMs. [Free for non-commercial use]

[Silvercorp Metals Inc. \(USA\): NYSE-SVM quotes & news - Google](#)
www.google.com/finance?cqi=7766473
Get detailed financial information on Silvercorp Metals Inc. (USA) (NYSE:SVM) including real-time stock quotes, historical charts & financial news, all for free!

[Silvercorp Metals Inc - Home](#)
www.silvercorpmetals.com/
NYSE: SVM USD\$ 3.26 +0.04 +1.09% Volume
TSX: SVM CAD\$ 3.26 +0.03 +0.9% Volume

[Kernel-Machines.Org — Kernel-Machines.org](#)
www.kernel-machines.org/
This page is devoted to learning support vector machine. It grew out of ...

[SVM Stock Quote - Silvercorp Metals Inc](#)
www.marketwatch.com/investing/stock/SVM
Updated stock quote for SVM - Silvercorp Metals Inc. Includes price, volume, estimates, stock charts, news, future earnings and dividends.

[Society for Vascular Medicine \(SVM\)](#)
https://www.facebook.com/VascularMedicine
Society for Vascular Medicine (SVM), Dear Friends,
This. Attend the SVM 25th Annual Meeting June 12-14, 2013 in San Francisco, California ...

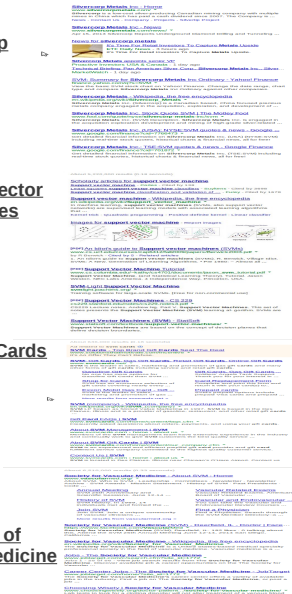
SOCIALLY BENEFICIAL

Silvercorp Metals
40%

Support Vector Machines
35%

SVM Gift Cards
15%

Society of Vascular Medicine
10%



Socially optimal solutions in Information systems

- **Problem:** Common content for users with different tastes.
 - ▷ Hedge against uncertainty in user's preferences.

Socially optimal solutions in Information systems

- **Problem:** Common content for users with different tastes.
 - ▷ Hedge against uncertainty in user's preferences.
 - ▷ **Ex:** News Sites, Product & Media Recommendation, Frontpages.

Socially optimal solutions in Information systems

- **Problem:** Common content for users with different tastes.
 - ▷ Hedge against uncertainty in user's preferences.
 - ▷ **Ex:** News Sites, Product & Media Recommendation, Frontpages.
- Diverse User population: N user types.
- User type i has probability p_i .

Socially optimal solutions in Information systems

- **Problem:** Common content for users with different tastes.
 - ▷ Hedge against uncertainty in user's preferences.
 - ▷ **Ex:** News Sites, Product & Media Recommendation, Frontpages.
- Diverse User population: N user types.
- User type i has probability p_i .
- **Personal** utility for object (e.g. ranking) \mathbf{y} : $U_i(\cdot, \mathbf{y})$.

Socially optimal solutions in Information systems

- **Problem:** Common content for users with different tastes.
 - ▷ Hedge against uncertainty in user's preferences.
 - ▷ **Ex:** News Sites, Product & Media Recommendation, Frontpages.
- Diverse User population: N user types.
- User type i has probability p_i .
- **Personal** utility for object (e.g. ranking) \mathbf{y} : $U_i(\cdot, \mathbf{y})$.
- **Social** utility is the expected utility (over all users):

$$U(\cdot, \mathbf{y}) = \mathbf{E}[U_i(\cdot, \mathbf{y})] = \sum_{i=1}^N p_i U_i(\cdot, \mathbf{y})$$

Socially optimal solutions in Information systems

- **Problem:** Common content for users with different tastes.
 - ▷ Hedge against uncertainty in user's preferences.
 - ▷ **Ex:** News Sites, Product & Media Recommendation, Frontpages.
- Diverse User population: N user types.
- User type i has probability p_i .
- **Personal** utility for object (e.g. ranking) \mathbf{y} : $U_i(\cdot, \mathbf{y})$.
- **Social** utility is the expected utility (over all users):

$$U(\cdot, \mathbf{y}) = \mathbf{E}[U_i(\cdot, \mathbf{y})] = \sum_{i=1}^N p_i U_i(\cdot, \mathbf{y})$$

- **Goal:** Find Socially Optimal Solution $\mathbf{y}^* = \operatorname{argmax}_{\mathbf{y}} U(\cdot, \mathbf{y})$.

Socially optimal solutions in Information systems

- **Problem:** Common content for users with different tastes.
 - ▷ Hedge against uncertainty in user's preferences.
 - ▷ **Ex:** News Sites, Product & Media Recommendation, Frontpages.
- Diverse User population: N user types.
- User type i has probability p_i .
- **Personal** utility for object (e.g. ranking) \mathbf{y} : $U_i(\cdot, \mathbf{y})$.
- **Social** utility is the expected utility (over all users):

$$U(\cdot, \mathbf{y}) = \mathbf{E}[U_i(\cdot, \mathbf{y})] = \sum_{i=1}^N p_i U_i(\cdot, \mathbf{y})$$

- **Goal:** Find Socially Optimal Solution $\mathbf{y}^* = \operatorname{argmax}_{\mathbf{y}} U(\cdot, \mathbf{y})$.
- **Challenge:** Learn from egoistic, weak, noisy user feedback.

Challenge of egoistic feedback

- **Challenge:** Learn from egoistic, weak, noisy user feedback.

Challenge of egoistic feedback

- **Challenge:** Learn from egoistic, weak, noisy user feedback.
- User i 's feedback reflects them behaving as per personal utility U_i .

Challenge of egoistic feedback

- **Challenge:** Learn from egoistic, weak, noisy user feedback.
- User i 's feedback reflects them behaving as per personal utility U_i .
- **Not** social utility U .
 - ▷ As in the case of prior work [RSJ12] for the **intrinsic** diversity problem.

Challenge of egoistic feedback

- **Challenge:** Learn from egoistic, weak, noisy user feedback.
- User i 's feedback reflects them behaving as per personal utility U_i .
- **Not** social utility U .
 - ▷ As in the case of prior work [RSJ12] for the **intrinsic** diversity problem.
- Need to infer social utility from such **conflicting, individual** feedback.

Challenge of egoistic feedback

- **Challenge:** Learn from egoistic, weak, noisy user feedback.
- User i 's feedback reflects them behaving as per personal utility U_i .
- **Not** social utility U .
 - ▷ As in the case of prior work [RSJ12] for the **intrinsic** diversity problem.
- Need to infer social utility from such **conflicting, individual** feedback.

User Interest	Pref Ranking
Company	a_1, a_2, a_3, \dots
ML	
Gift Cards	
<i>Social Opt</i>	

The screenshot shows a Google search for "svm". The search results are as follows:

- Support vector machine - Wikipedia, the free encyclopedia**: en.wikipedia.org/wiki/Support_vector_machine *
 In machine learning, **support vector machines (SVMs)**, also support vector networks) are supervised learning models with associated learning algorithms that ...
 Kernel trick - Quadratic programming - Positive-definite kernel - Linear classifier
 ✗
- SVM - Summary for Silvercorp Metals Inc Ordinary - Yahoo! Finance**: finance.yahoo.com/q?s=SVM *
 View the basic **SVM** stock chart on Yahoo! Finance. Change the date range, chart type and compare Silvercorp Metals Inc Ordinary against other companies.
 Board - Options - Historical Prices - News
 ✓
- SVM**: www.svmcards.net/ *
 SVM is the leader in sales, marketing and promotion of gas gift cards and many other forms of gift cards including service and retail gift cards.
 ✗
- SVM - Light Support Vector Machine**: wwwright.com/learn/svm/ *
 Training software for large-scale SVMs. [Free for non-commercial use]
 ✗
- Silvercorp Metals Inc. (USA): NYSE-SVM quotes & news - Google**: www.google.com/finance?tid=7766473 *
 Get detailed financial information on Silvercorp Metals Inc. (USA) (NYSE: SVM) including real-time stock quotes, historical charts & financial news, all for free!
 ✓
- Silvercorp Metals Inc. - Home**: www.silvercorpmetals.com/ *
 NYSE: SVM USD\$ 3.28 +0.04 + 1.09% Volume: 828,926 September 17, 2013.
 TSX: SVM CAD\$ 3.36 +0.03 + 0.9% Volume: 91,097 September 17, 2013.
 ✓
- Kernel-Machines.org - Kernel Machines**: www.kernel-machines.org/ *
 This page is devoted to learning methods building on kernels, such as the **support vector machine**. It grew out of earlier pages at the Max Planck Institute for ...
 ✗
- SVM Stock Quote - Silvercorp Metals Inc. Stock Price Today (SVM)**: www.marketwatch.com/investing/stock/svm *
 Updated stock quote for **svm** - including **svm** stock price today, earnings and estimates, stock charts, news, futures and other investing data.
 ✓
- Society for Vascular Medicine (SVM) - Deerfield, IL - Doctor | Face...**: <https://www.facebook.com/VascularMed/> *
 Society for Vascular Medicine (SVM), Deerfield, IL. 182 likes · 0 talking about this. Attend the SVM 25th Annual Meeting June 12-14, 2014 San Diego, California ...
 ✗

Challenge of egoistic feedback

- **Challenge:** Learn from egoistic, weak, noisy user feedback.
- User i 's feedback reflects them behaving as per personal utility U_i .
- **Not** social utility U .
 - ▷ As in the case of prior work [RSJ12] for the **intrinsic** diversity problem.
- Need to infer social utility from such **conflicting, individual** feedback.

User Interest	Pref Ranking
Company	a_1, a_2, a_3, \dots
ML	b_1, b_2, b_3, \dots
Gift Cards	
<i>Social Opt</i>	

Google svm

Web Images Maps Shopping News More Search tools

[Support vector machine - Wikipedia, the free encyclopedia](#)
en.wikipedia.org/wiki/Support_vector_machine *
In machine learning, support vector machines (SVMs, also support vector networks) are supervised learning models with associated learning algorithms that ...
kernel trick - Quadratic programming - Positive-definite kernel - Linear classifier

[SVM - Summary for Silvercorp Metals Inc Ordinary - Yahoo! Finance](#)
finance.yahoo.com/?s=SVM *
View the basic SVM stock chart on Yahoo! Finance. Change the date range, chart type and compare Silvercorp Metals Inc Ordinary against other companies.
Board - Options - Historical Prices - News

[SVM](#)
www.svmcards.net/ *
SVM is the leader in sales, marketing and promotion of gas gift cards and many other forms of gift cards including service and retail gift cards.

[SVM - Light Support Vector Machine](#)
svmright.joachims.org/
Training software for large-scale SVMs. [free for non-commercial use]

[Silvercorp Metals Inc. \(USA\): NYSE SVM quotes & news - Google ...](#)
www.google.com/finance?csi=7786473 *
Get detailed financial information on Silvercorp Metals Inc. (USA) (NYSE: SVM) including real-time stock quotes, historical data & financial news, all for free!

[Silvercorp Metals Inc. - Home](#)
www.silvercorpmetals.com/ *
NYSE: SVM US\$3 26 +0.04 +1.08% Volume: 828,826 September 17, 2013. TSX: SVM CAD\$ 3.26 +0.03 +0.9% Volume: 91,387 September 17, 2013.

[Kernel-Machines.Org - Kernel Machines](#)
www.kernel-machines.org/ *
This page is devoted to learning methods building on kernels, such as the support vector machine. It grew out of earlier pages at the Max Planck Institute for ...

[SVM Stock Quote - Silvercorp Metals Inc. Stock Price Today \(SVM ...](#)
www.marketwatch.com/investing/stock/svm *
Updated stock quote for svm - including svm stock price today, earnings and estimates, stock charts, news, futures and other investing data.

[Society for Vascular Medicine \(SVM\) - Deerfield, IL - Doctor | Face ...](#)
https://www.facebook.com/VascularMed *
Society for Vascular Medicine (SVM), Deerfield, IL. 182 likes · 0 talking about this. Attend the SVM 25th Annual Meeting June 12-14, 2014 San Diego, California ...

Green checkmarks are placed to the right of the following search results: Support vector machine - Wikipedia, SVM - Summary for Silvercorp Metals Inc Ordinary, SVM, SVM - Light Support Vector Machine, Kernel-Machines.Org - Kernel Machines.

Red X marks are placed to the right of the following search results: SVM - Summary for Silvercorp Metals Inc Ordinary, SVM, SVM - Light Support Vector Machine, Silvercorp Metals Inc. (USA): NYSE SVM quotes & news, Silvercorp Metals Inc. - Home, SVM Stock Quote - Silvercorp Metals Inc. Stock Price Today (SVM ...), Society for Vascular Medicine (SVM) - Deerfield, IL - Doctor | Face ...

Challenge of egoistic feedback

- **Challenge:** Learn from egoistic, weak, noisy user feedback.
- User i 's feedback reflects them behaving as per personal utility U_i .
- **Not** social utility U .
 - ▷ As in the case of prior work [RSJ12] for the **intrinsic** diversity problem.
- Need to infer social utility from such **conflicting, individual** feedback.

User Interest	Pref Ranking
Company	a_1, a_2, a_3, \dots
ML	b_1, b_2, b_3, \dots
Gift Cards	c_1, c_2, c_3, \dots
<i>Social Opt</i>	

Google svm

Web Images Maps Shopping News More Search tools

[Support vector machine - Wikipedia, the free encyclopedia](#)
en.wikipedia.org/wiki/Support_vector_machine
In machine learning, support vector machines (SVMs, also support vector networks) are supervised learning models with associated learning algorithms that...
Kernel trick - Quadratic programming - Positive-definite kernel - Linear classifier

[SVM Summary for Silvercorp Metals Inc Ordinary - Yahoo! Finance](#)
finance.yahoo.com/q/%3E-SVM
View the basic SVM stock chart on Yahoo! Finance. Change the date range, chart type and compare Silvercorp Metals Inc Ordinary against other companies.
Board - Options - Historical Prices - News

[SVM](#)
www.svmcards.net/
SVM is the leader in sales, marketing and promotion of gas gift cards and many other forms of gift cards including service and retail gift cards.

[SVM - Light Support Vector Machine](#)
svm.light.joeltrons.org/
Training software for large-scale SVMs. [free for non-commercial use]

[Silvercorp Metals Inc. \(USA\) NYSE-SVM quotes & news - Google](#)
www.google.com/finance?cid=7766473
Get detailed financial information on Silvercorp Metals Inc. (USA) (NYSE:SVM) including real-time stock quotes, historical charts & financial news, all for free!

[Silvercorp Metals Inc - Home](#)
www.silvercorpmetals.com/
NYSE: SVM US08 3.26 +0.04 +1.08% Volume: 828,926 September 17, 2013
TSX: SVM CAD9 3.38 +0.03 +0.9% Volume: 91,297 September 17, 2013.

[Kernel-Machines.Org - Kernel Machines](#)
www.kernel-machines.org/
This page is devoted to learning methods building on kernels, such as the support vector machine. It grew out of earlier pages at the Max Planck Institute for ...

[SVM Stock Quote - Silvercorp Metals Inc. Stock Price Today \(SVM\)](#)
www.marketwatch.com/investing/stock/svm
Updated stock quote for SVM - including SVM stock price today, earnings and estimates, stock charts, news, futures and other investing data.

[Society for Vascular Medicine \(SVM\) - Deerfield, IL - Doctor | Face...](#)
https://www.facebook.com/VascularMed
Society for Vascular Medicine (SVM), Deerfield, IL, 182 likes · 0 talking about this. Attend the SVM 26th Annual Meeting June 12-14, 2014 San Diego, California ...

Red X marks are placed to the right of the following search results:
- Support vector machine - Wikipedia, the free encyclopedia
- SVM Summary for Silvercorp Metals Inc Ordinary - Yahoo! Finance
- SVM - Light Support Vector Machine
- Silvercorp Metals Inc. (USA) NYSE-SVM quotes & news - Google
- Silvercorp Metals Inc - Home
- Kernel-Machines.Org - Kernel Machines
- SVM Stock Quote - Silvercorp Metals Inc. Stock Price Today (SVM)
- Society for Vascular Medicine (SVM) - Deerfield, IL - Doctor | Face...

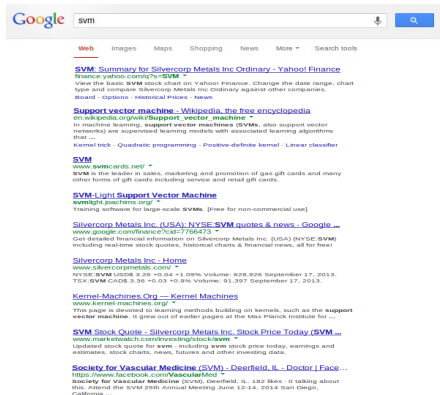
A green checkmark is placed to the right of the search result:
- SVM

Challenge of egoistic feedback

- **Challenge:** Learn from egoistic, weak, noisy user feedback.
- User i 's feedback reflects them behaving as per personal utility U_i .
- **Not** social utility U .
 - ▷ As in the case of prior work [RSJ12] for the **intrinsic** diversity problem.
- Need to infer social utility from such **conflicting, individual** feedback.

User Interest	Pref Ranking
Company	a_1, a_2, a_3, \dots
ML	b_1, b_2, b_3, \dots
Gift Cards	c_1, c_2, c_3, \dots
<i>Social Opt</i>	a_1, b_1, c_1, \dots

- Even if social optimal is presented, users may indicate preferences for other rankings.



Google svm

Web Images Maps Shopping News More Search tools

SVM - Summary for Silvercorp Metals Inc Ordinary - Yahoo! Finance
finance.yahoo.com/q?s=SVM
View the basic SVM stock chart on Yahoo! Finance, change the date range, chart type and compare Silvercorp Metals Inc ordinary against other companies.
Board - Options - Historical Prices - News

Support vector machine - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Support_vector_machine
In machine learning, support vector machines (SVMs), also support vector networks) are supervised learning models with associated learning algorithms that ...
Kernel trick - Quadratic programming - Positive-definite kernel - Linear classifier

SVM
www.svmcards.net
SVM is the leader in sales, marketing and promotion of gas gift cards and many other forms of gift cards including service and retail gift cards.

SVM - Light Support Vector Machine
svmlight.joachims.org
Training software for large-scale SVMs. [Free for non-commercial use]

Silvercorp Metals Inc. (USA) - NYSE:SVM quotes & news - Google
www.google.com/finance?oiid=7766473
Get detailed financial information on Silvercorp Metals Inc. (USA) (NYSE:SVM) including real-time stock quotes, historical charts & financial news, all for free!

Silvercorp Metals Inc. - Home
www.silvercorpmetals.com
NYSE: SVM USDS 3.25 +0.04 +1.25% Volume: 628,926 September 17, 2013.
TSX: SVM CAD\$ 3.36 +0.03 +0.9% Volume: 91,397 September 17, 2013.

Kernel-Machines Org - Kernel Machines
www.kernel-machines.org
This page is devoted to learning methods building on kernels, such as the support vector machine. It grew out of earlier pages at the Max Planck Institute for ...

SVM Stock Quote - Silvercorp Metals Inc. Stock Price Today (SVM)
www.marketwatch.com/investing/stock/svm
Updated stock quote for svm - including svm stock price today, earnings and estimates, stock charts, news, futures and other investing data.

Society for Vascular Medicine (SVM) - Deerfield, IL - Doctor | Face...
https://www.facebook.com/VascularMed
Society for Vascular Medicine (SVM), Deerfield, IL, 182 likes · 0 talking about this. Attend the SVM 25th Annual Meeting June 12-14, 2014 San Diego, California ...

- [CG98, ZCL03, CK06]: Address Extrinsic Diversity.
 - Do not use learning.
- [YJ08, SMO10, RJS11]: Use learning for diversity.
 - Require relevance labels for all user-document pairs.
- [RKJ08]: Uses online learning: Array of (decoupled) MA Bandits.
 - Learns very slowly. Does not generalize across queries.
- [SRG13]: Couples the arms together.
 - Does not generalize across queries. Hard-coded notion of diversity.
- [YG12]: Generalizes across queries.
 - Requires cardinal utilities.
- [RSJ12]: Learns from user preferences.
 - Requires all users directly optimize social utility U .

Preferential Feedback

- *What feedback do we obtain from users?*

Preferential Feedback

- *What feedback do we obtain from users?*
 - ▷ Implicit feedback (e.g. clicks) is timely and easily available.

Presented (y)

A screenshot of a Google search for "svm". The search bar at the top shows "svm" and a search button. Below the search bar are navigation links: Web, Images, Maps, Shopping, News, More, and Search tools. The search results are as follows:

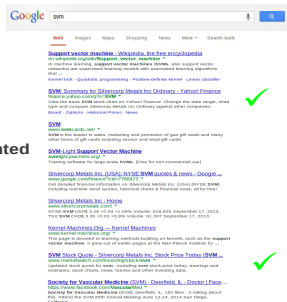
- Support vector machine - Wikipedia, the free encyclopedia**
In machine learning, support vector machines (SVM), also support vector machines, are supervised learning models with associated learning algorithms that...
- SVM Summary for Silvercorp Metals Inc Ordinary - Yahoo! Finance**
Yahoo Finance content for SVM
- SVM**
SVM is the leader in sales, marketing and promotion of gas gift cards and many other forms of gift cards including dinner and retail gift cards.
- SVM Light Support Vector Machine**
Training software for large-scale SVMs. (http://www.cis.hawaii.edu)
- Silvercorp Metals Inc (NYSE:NYSE:SVM) Quotes & News - Google**
View the latest SVM stock price on Yahoo! Finance. Change the date range, chart type and compare Silvercorp Metals Inc Ordinary against other companies.
- Silvercorp Metals Inc - Home**
www.silvercorpmetals.com
- Kernel-Machines Org - Kernel Machines**
This page is devoted to learning methods building on kernels, such as the support vector machine. It grew out of earlier pages at the Max Planck Institute for ...
- SVM Stock Quote - Silvercorp Metals Inc Stock Price Today (SVM)**
Real-time stock quote for SVM including open, high, low, volume, average and 52-week high, 52-week low, market cap, dividend and other trading data.
- Society for Vascular Medicine (SVM) - Deerfield, IL - Doctor | F1000**
F1000 is the online journal of the Society for Vascular Medicine (SVM), Deerfield, IL, USA. It is talking about SVM, attend the SVM 20th annual meeting June 12-14, 2014 San Diego, California ...

Green checkmarks are placed to the right of the "SVM Summary for Silvercorp Metals Inc Ordinary - Yahoo! Finance" and "SVM Stock Quote - Silvercorp Metals Inc Stock Price Today (SVM)" results.

Preferential Feedback

- *What feedback do we obtain from users?*
 - ▷ Implicit feedback (e.g. clicks) is timely and easily available.
- User feedback does not reflect cardinal utilities.
 - ▷ Shown in user studies [JGP⁺07].

Presented (y)



Preferential Feedback

- *What feedback do we obtain from users?*

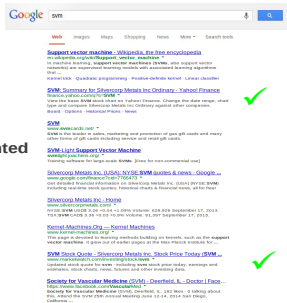
- ▷ Implicit feedback (e.g. clicks) is timely and easily available.

- User feedback does not reflect cardinal utilities.

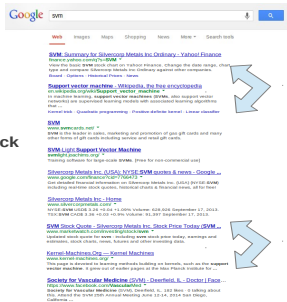
- ▷ Shown in user studies [JGP⁺07].

- **KEY:** Treat user feedback as preferences.

Presented (y)



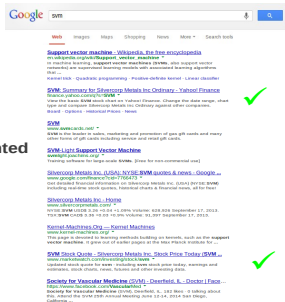
Feedback (y')



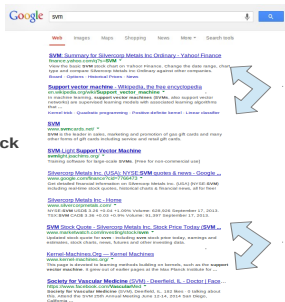
Preferential Feedback

- *What feedback do we obtain from users?*
 - ▷ Implicit feedback (e.g. clicks) is timely and easily available.
- User feedback does not reflect cardinal utilities.
 - ▷ Shown in user studies [JGP⁺07].
- **KEY:** Treat user feedback as preferences.
- How do we learn from such preferential feedback?

Presented (y)



Feedback (y)



Learning model

Repeat forever:

- System receives context \mathbf{x}_t .
- System makes prediction \mathbf{y}_t .

Learning from Preferences: Coactive Learning [SJ12, RJSS13]

Learning model

Repeat forever:

- System receives context \mathbf{x}_t .
- System makes prediction \mathbf{y}_t .

e.g. : Search Engine

User Query

Ranking

Learning model

Repeat forever:

- System receives context \mathbf{x}_t .
- System makes prediction \mathbf{y}_t .
- $\text{Regret} = \text{Regret} + U(\mathbf{x}_t, \mathbf{y}_t^*) - U(\mathbf{x}_t, \mathbf{y}_t)$

e.g. : Search Engine

User Query

Ranking

Social utility

Learning model

Repeat forever:

- System receives context \mathbf{x}_t .
- System makes prediction \mathbf{y}_t .
- $\text{Regret} = \text{Regret} + U(\mathbf{x}_t, \mathbf{y}_t^*) - U(\mathbf{x}_t, \mathbf{y}_t)$
- System gets (preference) feedback:
 $U_i(\mathbf{x}_t, \bar{\mathbf{y}}_t) \geq_{\alpha, \delta} U_i(\mathbf{x}_t, \mathbf{y}_t)$

e.g. : Search Engine

User Query

Ranking

Social utility

Learning model

Repeat forever:

- System receives context \mathbf{x}_t .
- System makes prediction \mathbf{y}_t .
- $\text{Regret} = \text{Regret} + U(\mathbf{x}_t, \mathbf{y}_t^*) - U(\mathbf{x}_t, \mathbf{y}_t)$
- System gets (preference) feedback:
 $U_i(\mathbf{x}_t, \bar{\mathbf{y}}_t) \geq_{\alpha, \delta} U_i(\mathbf{x}_t, \mathbf{y}_t)$

e.g. : Search Engine

User Query

Ranking

Social utility

**Feedback received in terms of personal utilities U_i .
But regret is in terms of social utility U .**

Learning model

Repeat forever:

- System receives context \mathbf{x}_t .
- System makes prediction \mathbf{y}_t .
- $\text{Regret} = \text{Regret} + U(\mathbf{x}_t, \mathbf{y}_t^*) - U(\mathbf{x}_t, \mathbf{y}_t)$
- System gets (preference) feedback:
 $U_i(\mathbf{x}_t, \bar{\mathbf{y}}_t) \geq_{\alpha, \delta} U_i(\mathbf{x}_t, \mathbf{y}_t)$

e.g. : Search Engine

User Query

Ranking

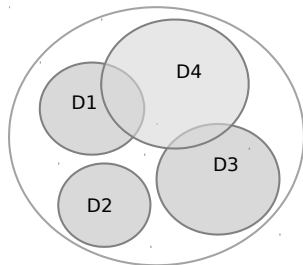
Social utility

Feedback received in terms of personal utilities U_i .
But regret is in terms of social utility U .

How does we model utilities?

Modeling User Utility: Submodularity

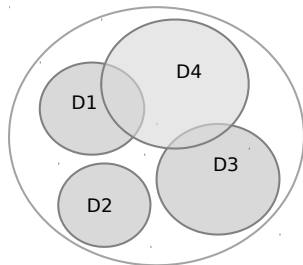
- Assume personal utilities are submodular.
- **Diminishing returns:** Marginal benefit of additional document on ML diminishes if 10 docs already shown vs only 1 previous doc.



- Computing ranking \approx Submodular maximization
- Use simple, efficient greedy algorithm.
- Approximation guarantee of $\frac{1}{2}$ (under partition matroid constraint).

Modeling User Utility: Submodularity

- Assume personal utilities are submodular.
- **Diminishing returns:** Marginal benefit of additional document on ML diminishes if 10 docs already shown vs only 1 previous doc.



- Computing ranking \approx Submodular maximization
- Use simple, efficient greedy algorithm.
- Approximation guarantee of $\frac{1}{2}$ (under partition matroid constraint).

- *How does this lead to diversity?*

Diversity via Submodularity: An example

Posn	Doc	machine	learning	metal	silver
1					
2					
3					
4					
MAX of Col					

Doc	Words
d_1	ma:3 le:3
d_2	ma:5 le:2
d_3	ma:2 le:5
d_4	ma:2 le:3
d_5	me:3 si:5
d_6	me:6 si:2
d_7	me:4 si:2 ma:1
d_8	me:3 si:1 ma:1

Doc	Marginal Benefit	
d_1		
d_2		
d_3		
d_4		
d_5		
d_6		
d_7		
d_8		

Word	Weight
machine	5
learning	7
metal	4
silver	6

Diversity via Submodularity: An example

Posn	Doc	machine	learning	metal	silver
1					
2					
3					
4					
MAX of Col					

Doc	Marginal Benefit	
d_1	$3*5 + 3*7$	36
d_2		
d_3		
d_4		
d_5		
d_6		
d_7		
d_8		

Doc	Words
d_1	ma:3 le:3
d_2	ma:5 le:2
d_3	ma:2 le:5
d_4	ma:2 le:3
d_5	me:3 si:5
d_6	me:6 si:2
d_7	me:4 si:2 ma:1
d_8	me:3 si:1 ma:1

Word	Weight
machine	5
learning	7
metal	4
silver	6

Diversity via Submodularity: An example

Posn	Doc	machine	learning	metal	silver
1					
2					
3					
4					
MAX of Col					

Doc	Words
d_1	ma:3 le:3
d_2	ma:5 le:2
d_3	ma:2 le:5
d_4	ma:2 le:3
d_5	me:3 si:5
d_6	me:6 si:2
d_7	me:4 si:2 ma:1
d_8	me:3 si:1 ma:1

Doc	Marginal Benefit	
d_1	$3*5 + 3*7$	36
d_2	$5*5 + 2*7$	39
d_3	$2*5 + 5*7$	45
d_4	$2*5 + 3*7$	31
d_5	$3*4 + 5*6$	42
d_6	$6*4 + 2*6$	36
d_7	$1*5 + 4*4 + 2*6$	33
d_8	$1*5 + 3*4 + 1*6$	23

Word	Weight
machine	5
learning	7
metal	4
silver	6

Diversity via Submodularity: An example

Posn	Doc	machine	learning	metal	silver
1	d_3	2	5	0	0
2					
3					
4					
MAX of Col		2	5	0	0

Doc	Words
d_1	ma:3 le:3
d_2	ma:5 le:2
d_3	ma:2 le:5
d_4	ma:2 le:3
d_5	me:3 si:5
d_6	me:6 si:2
d_7	me:4 si:2 ma:1
d_8	me:3 si:1 ma:1

Doc	Marginal Benefit
d_1	$3*5 + 3*7$ 36
d_2	$5*5 + 2*7$ 39
d_3	$2*5 + 5*7$ 45
d_4	$2*5 + 3*7$ 31
d_5	$3*4 + 5*6$ 42
d_6	$6*4 + 2*6$ 36
d_7	$1*5 + 4*4 + 2*6$ 33
d_8	$1*5 + 3*4 + 1*6$ 23

Word	Weight
machine	5
learning	7
metal	4
silver	6

Diversity via Submodularity: An example

Posn	Doc	machine	learning	metal	silver
1	d_3	2	5	0	0
2					
3					
4					
MAX of Col		2	5	0	0

Doc	Words
d_1	ma:3 le:3
d_2	ma:5 le:2
d_3	ma:2 le:5
d_4	ma:2 le:3
d_5	me:3 si:5
d_6	me:6 si:2
d_7	me:4 si:2 ma:1
d_8	me:3 si:1 ma:1

Doc	Marginal Benefit	
d_1	$(3-2)*5$	5
d_2	$(5-2)*5$	15
d_3	-	-
d_4	0	0
d_5	$3*4 + 5*6$	42
d_6	$6*4 + 2*6$	36
d_7	$4*4 + 2*6$	28
d_8	$3*4 + 1*6$	18

Word	Weight
machine	5
learning	7
metal	4
silver	6

Diversity via Submodularity: An example

Posn	Doc	machine	learning	metal	silver
1	d_3	2	5	0	0
2	d_5	0	0	3	5
3					
4					
MAX of Col		2	5	3	5

Doc	Words
d_1	ma:3 le:3
d_2	ma:5 le:2
d_3	ma:2 le:5
d_4	ma:2 le:3
d_5	me:3 si:5
d_6	me:6 si:2
d_7	me:4 si:2 ma:1
d_8	me:3 si:1 ma:1

Doc	Marginal Benefit	
d_1	$(3-2)*5$	5
d_2	$(5-2)*5$	15
d_3	-	-
d_4	0	0
d_5	$3*4 + 5*6$	42
d_6	$6*4 + 2*6$	36
d_7	$4*4 + 2*6$	28
d_8	$3*4 + 1*6$	18

Word	Weight
machine	5
learning	7
metal	4
silver	6

Diversity via Submodularity: An example

Posn	Doc	machine	learning	metal	silver
1	d_3	2	5	0	0
2	d_5	0	0	3	5
3	d_2	5	2	0	0
4					
MAX of Col		5	5	3	5

Doc	Marginal Benefit	
d_1	$(3-2)*5$	5
d_2	$(5-2)*5$	15
d_3	-	-
d_4	0	0
d_5	-	-
d_6	$(6-3)*4$	12
d_7	$(4-3)*4$	4
d_8	0	0

Doc	Words
d_1	ma:3 le:3
d_2	ma:5 le:2
d_3	ma:2 le:5
d_4	ma:2 le:3
d_5	me:3 si:5
d_6	me:6 si:2
d_7	me:4 si:2 ma:1
d_8	me:3 si:1 ma:1

Word	Weight
machine	5
learning	7
metal	4
silver	6

Diversity via Submodularity: An example

Posn	Doc	machine	learning	metal	silver
1	d_3	2	5	0	0
2	d_5	0	0	3	5
3	d_2	5	2	0	0
4	d_6	0	0	6	2
MAX of Col		5	5	6	5

Doc	Words
d_1	ma:3 le:3
d_2	ma:5 le:2
d_3	ma:2 le:5
d_4	ma:2 le:3
d_5	me:3 si:5
d_6	me:6 si:2
d_7	me:4 si:2 ma:1
d_8	me:3 si:1 ma:1

Doc	Marginal Benefit	
d_1	0	0
d_2	-	-
d_3	-	-
d_4	0	0
d_5	-	-
d_6	$(6-3)*4$	12
d_7	0	0
d_8	0	0

Word	Weight
machine	5
learning	7
metal	4
silver	6

More General Submodular Utility

- *Can we use other submodular functions?*

More General Submodular Utility

- Can we use other submodular functions?

✓ Yes.

- Given ranking/set $\mathbf{y} = (d_{i_1}, \dots, d_{i_n})$, aggregate features as:

$$\phi_F^j(\mathbf{x}, \mathbf{y}) = F(\gamma_1 \phi^j(\mathbf{x}, d_{i_1}), \gamma_2 \phi^j(\mathbf{x}, d_{i_2}), \dots, \gamma_n \phi^j(\mathbf{x}, d_{i_n}))$$

- ▷ $\phi^j(\mathbf{x}, d_i)$ is j^{th} feature of d_i .
- ▷ F is a submodular function (modeling decision).
- ▷ $\gamma_1 \geq \gamma_2 \geq \dots \geq \gamma_n \geq 0$ are position-discount factors

More General Submodular Utility

- Can we use other submodular functions?

✓ Yes.

- Given ranking/set $\mathbf{y} = (d_{i_1}, \dots, d_{i_n})$, aggregate features as:

$$\phi_F^j(\mathbf{x}, \mathbf{y}) = F(\gamma_1 \phi^j(\mathbf{x}, d_{i_1}), \gamma_2 \phi^j(\mathbf{x}, d_{i_2}), \dots, \gamma_n \phi^j(\mathbf{x}, d_{i_n}))$$

- ▷ $\phi^j(\mathbf{x}, d_i)$ is j^{th} feature of d_i .
 - ▷ F is a submodular function (modeling decision).
 - ▷ $\gamma_1 \geq \gamma_2 \geq \dots \geq \gamma_n \geq 0$ are position-discount factors
- Utility modeled as linear in aggregate features: $U(\mathbf{x}, \mathbf{y}) = \mathbf{w}_*^T \phi_F(\mathbf{x}, \mathbf{y})$
 - ▷ Submodular aggregation leads to diversity.

Social Perceptron for Ranking

- 1 Initialize weight vector $\mathbf{w}_1 \leftarrow \mathbf{0}$.
- 2 Given context \mathbf{x}_t compute $\mathbf{y}_t \leftarrow \operatorname{argmax}_{\mathbf{y}} \mathbf{w}_t^\top \phi(\mathbf{x}_t, \mathbf{y})$.
- 3 Observe user clicks \mathcal{D} .
- 4 Construct preference feedback $\bar{\mathbf{y}}_t \leftarrow \text{PrefFeedback}(\mathbf{y}_t, \mathcal{D})$.
- 5 $\bar{\mathbf{w}}_{t+1} \leftarrow \mathbf{w}_t + \phi(\mathbf{x}_t, \bar{\mathbf{y}}_t) - \phi(\mathbf{x}_t, \mathbf{y}_t)$
- 6 Clip: $\mathbf{w}_{t+1}^j \leftarrow \max(\bar{\mathbf{w}}_{t+1}^j, 0)$
- 7 Repeat from step 2.

Social Perceptron for Ranking

- 1 Initialize weight vector $\mathbf{w}_1 \leftarrow \mathbf{0}$.
- 2 Given context \mathbf{x}_t compute $\mathbf{y}_t \leftarrow \operatorname{argmax}_{\mathbf{y}} \mathbf{w}_t^\top \phi(\mathbf{x}_t, \mathbf{y})$.
 - ▷ Using greedy algorithm.
- 3 Observe user clicks \mathcal{D} .
- 4 Construct preference feedback $\bar{\mathbf{y}}_t \leftarrow \text{PrefFeedback}(\mathbf{y}_t, \mathcal{D})$.
- 5 $\bar{\mathbf{w}}_{t+1} \leftarrow \mathbf{w}_t + \phi(\mathbf{x}_t, \bar{\mathbf{y}}_t) - \phi(\mathbf{x}_t, \mathbf{y}_t)$
- 6 Clip: $\mathbf{w}_{t+1}^j \leftarrow \max(\bar{\mathbf{w}}_{t+1}^j, 0)$
- 7 Repeat from step 2.

Social Perceptron for Ranking

- 1 Initialize weight vector $\mathbf{w}_1 \leftarrow \mathbf{0}$.
- 2 Given context \mathbf{x}_t compute $\mathbf{y}_t \leftarrow \operatorname{argmax}_{\mathbf{y}} \mathbf{w}_t^\top \phi(\mathbf{x}_t, \mathbf{y})$.
 - ▷ Using greedy algorithm.
- 3 Observe user clicks \mathcal{D} .
- 4 Construct preference feedback $\bar{\mathbf{y}}_t \leftarrow \text{PrefFeedback}(\mathbf{y}_t, \mathcal{D})$.
 - ▷ Pairwise feedback.
- 5 $\bar{\mathbf{w}}_{t+1} \leftarrow \mathbf{w}_t + \phi(\mathbf{x}_t, \bar{\mathbf{y}}_t) - \phi(\mathbf{x}_t, \mathbf{y}_t)$
- 6 Clip: $\mathbf{w}_{t+1}^j \leftarrow \max(\bar{\mathbf{w}}_{t+1}^j, 0)$
- 7 Repeat from step 2.

Social Perceptron for Ranking

- 1 Initialize weight vector $\mathbf{w}_1 \leftarrow \mathbf{0}$.
- 2 Given context \mathbf{x}_t compute $\mathbf{y}_t \leftarrow \operatorname{argmax}_{\mathbf{y}} \mathbf{w}_t^\top \phi(\mathbf{x}_t, \mathbf{y})$.
 - ▷ Using greedy algorithm.
- 3 Observe user clicks \mathcal{D} .
- 4 Construct preference feedback $\bar{\mathbf{y}}_t \leftarrow \text{PrefFeedback}(\mathbf{y}_t, \mathcal{D})$.
 - ▷ Pairwise feedback.
- 5 $\bar{\mathbf{w}}_{t+1} \leftarrow \mathbf{w}_t + \phi(\mathbf{x}_t, \bar{\mathbf{y}}_t) - \phi(\mathbf{x}_t, \mathbf{y}_t)$
 - ▷ Perceptron update.
- 6 Clip: $\mathbf{w}_{t+1}^j \leftarrow \max(\bar{\mathbf{w}}_{t+1}^j, 0)$
 - ▷ To ensure submodularity.
- 7 Repeat from step 2.

Definition

User feedback is **expected α_i, δ_i -informative** if $\bar{\xi}_t \in \mathfrak{R}$ is chosen s.t. :

$$\mathbf{E}_{\bar{\mathbf{y}}_t}[U_i(\mathbf{x}_t, \bar{\mathbf{y}}_t)] \geq (1 + \delta_i)U_i(\mathbf{x}_t, \mathbf{y}_t) + \alpha_i \left(U_i(\mathbf{x}_t, \mathbf{y}_t^{*,i}) - U_i(\mathbf{x}_t, \mathbf{y}_t) \right) - \bar{\xi}_t.$$

Regret Bound

Definition

User feedback is **expected** α_j, δ_j -**informative** if $\bar{\xi}_t \in \mathfrak{R}$ is chosen s.t. :

$$\mathbf{E}_{\bar{\mathbf{y}}_t}[U_i(\mathbf{x}_t, \bar{\mathbf{y}}_t)] \geq (1 + \delta_i)U_i(\mathbf{x}_t, \mathbf{y}_t) + \alpha_i \left(U_i(\mathbf{x}_t, \mathbf{y}_t^{*,i}) - U_i(\mathbf{x}_t, \mathbf{y}_t) \right) - \bar{\xi}_t.$$

Theorem

For any $\mathbf{w}_* \in \mathbf{R}^m$ and $\|\phi(\mathbf{x}, \mathbf{y})\|_{\ell_2} \leq R$ the average regret of the SoPer-R algorithm can be upper bounded as:

$$REG_T \leq \frac{1}{\eta T} \sum_{t=0}^{T-1} \mathbf{E}_i[p_i \bar{\xi}_t] + \frac{R\|\mathbf{w}_*\|}{2\eta} + \frac{\sqrt{15}R\|\mathbf{w}_*\|}{\eta\sqrt{2T}}.$$

with: $\delta_i \geq \left(\Gamma_F \cdot \frac{1 - p_i}{p_i} \right)$, $\eta = \min_i p_i \alpha_i$.

Theorem

Average regret of the SoPer-R algorithm can be upper bounded as:

$$REG_T \leq \frac{1}{\eta T} \sum_{t=0}^{T-1} \mathbf{E}_i[p_i \bar{\xi}_t] + \frac{R \|\mathbf{w}_*\|}{2\eta} + \frac{\sqrt{15R} \|\mathbf{w}_*\|}{\eta \sqrt{2T}}.$$

with: $\delta_i \geq \left(\Gamma_F \cdot \frac{1 - p_i}{p_i} \right)$, $\eta = \min_i p_i \alpha_i$.

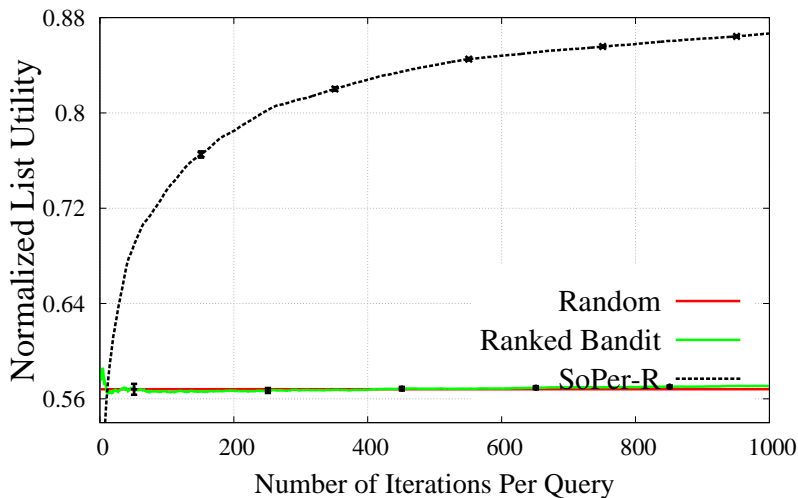
- Does not depend on number of dimensions.
 - ▷ Only on feature ball radius R .
- Decays gracefully with noisy feedback (the α_i s and η).
- **Need not converge to optimal.**
 - ▷ Partly due to NP-hardness of submodular maximization.

- **SoPer-S** Algorithm for predicting diverse sets.
- See paper for more details.

Experimental Setup

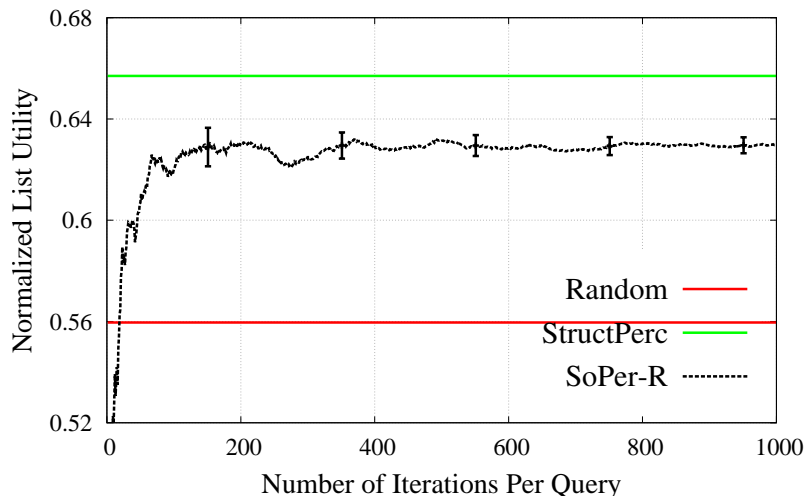
- Used standard **TREC 6-8 Interactive** search-diversification dataset:
 - ▷ Each query has 7-56 user types.
- Setup as in previous work [BJYB11, RJS11].
- Simulated user behavior:
 - ▷ Users scan rankings top to bottom.
 - ▷ Click on first document relevant to them (with small error chance).
- Utility function: Normalized DCG-coverage function (*i.e.*
$$F(x_1, \dots, x_n) = \max_i \gamma_i x_i$$
) upto rank 5.

Learning to Diversify: Single Query



- Improved learning for single-query diversification.

Learning to Diversify: Cross-Query



- *StructPerc* is (rough) skyline: Uses optimal for training.
- **First method** to learn cross-query diversity from implicit feedback.

User Fncn	SoPer-R Function		Rand
	MAX	SQRT	
MAX	.630 \pm .007	.620 \pm .006	.557 \pm .006
SQRT	.656 \pm .007	.654 \pm .007	.610 \pm .007

- Robust to difference between submodular functions used in *User's* utility and *Algorithm's* utility.

User Fncn	SoPer-R Function		Rand
	MAX	SQRT	
MAX	.630 \pm .007	.620 \pm .006	.557 \pm .006
SQRT	.656 \pm .007	.654 \pm .007	.610 \pm .007

- Robust to difference between submodular functions used in *User's* utility and *Algorithm's* utility.

Random	No Noise	Noise
.557 \pm .006	.630 \pm .007	.631 \pm .007

- Works even if user feedback is noisy

- Proposed online-learning algorithms for aggregating conflicting user preferences of a diverse population.
 - ▷ Utilizes the coactive learning model.
- Modeled user utilities as submodular.
- Provided regret bounds for algorithms.
- Works well empirically and is robust.

THANKS



What did the user mean?

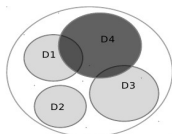


Presented (y)



Feedback (y')

QUESTIONS?



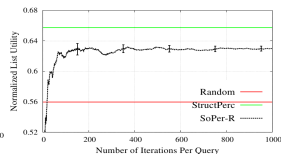
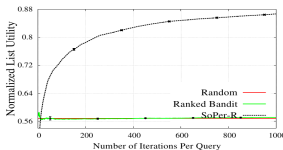
Poster #15

Theorem

Average regret of the SoPer-R algorithm can be upper bounded as:

$$REG_T \leq \frac{1}{\eta T} \sum_{t=0}^{T-1} \mathbf{E} [p_t \tilde{L}_t] + \frac{R \|\mathbf{w}_*\|}{2\eta} + \frac{\sqrt{15R} \|\mathbf{w}_*\|}{\eta \sqrt{2T}}$$

with: $\delta_t \geq \left(r_F \cdot \frac{1-p_t}{\rho} \right)$, $\eta = \min \rho \alpha_t$.



 C. Brandt, T. Joachims, Yisong Yue, and J. Bank.

Dynamic ranked retrieval.

In *WSDM*, 2011.

 Jaime Carbonell and Jade Goldstein.

The use of MMR, diversity-based reranking for reordering documents and producing summaries.

In *SIGIR*, pages 335–336, 1998.

 Harr Chen and David R. Karger.

Less is more: probabilistic models for retrieving fewer relevant documents.

In *SIGIR*, pages 429–436, 2006.

 T. Joachims, L. Granka, Bing Pan, H. Hembrooke, F. Radlinski, and G. Gay.

Evaluating the accuracy of implicit feedback from clicks and query reformulations in web search.

TOIS, 25(2), April 2007.

 Karthik Raman, Thorsten Joachims, and Pannagadatta Shivaswamy.

Structured learning of two-level dynamic rankings.

In *CIKM*, pages 291–296, 2011.

 Karthik Raman, Thorsten Joachims, Pannaga Shivaswamy, and Tobias Schnabel.

Stable coactive learning via perturbation.

In *ICML*, pages 837–845, 2013.



Filip Radlinski, Robert Kleinberg, and Thorsten Joachims.

Learning diverse rankings with multi-armed bandits.

In *ICML*, pages 784–791, 2008.



Karthik Raman, Pannaga Shivaswamy, and Thorsten Joachims.

Online learning to diversify from implicit feedback.

In *KDD*, pages 705–713, 2012.



Pannaga Shivaswamy and Thorsten Joachims.

Online structured prediction via coactive learning.

In *ICML*, 2012.



Rodrygo L.T. Santos, Craig Macdonald, and Iadh Ounis.

Selectively diversifying web search results.

In *CIKM*, pages 1179–1188, 2010.



Aleksandrs Slivkins, Filip Radlinski, and Sreenivas Gollapudi.

Ranked bandits in metric spaces: learning optimally diverse rankings over large document collections.

JMLR, 14:399–436, 2013.



Yisong Yue and Carlos Guestrin.

Linear submodular bandits and their application to diversified retrieval.

In *NIPS*, pages 2483–2491, 2012.



Yisong Yue and Thorsten Joachims.

Predicting diverse subsets using structural SVMs.

In *ICML*, pages 1224–1231, 2008.



Cheng Xiang Zhai, William W. Cohen, and John Lafferty.

Beyond independent relevance: methods and evaluation metrics for subtopic retrieval.

In *SIGIR*, pages 10–17, 2003.

- **TREC 6-8 Interactive** diversification dataset:
 - ▷ Contains 17 queries. Each has 7-56 user types. Binary relevance labels.
 - ▷ Similar results observed for WEB diversification dataset.
- Setup details:
 - ▷ Re-ranking documents relevant to ≥ 1 user.
 - ▷ Probability of user type \propto # of documents relevant to user.
- DCG-position discounting: $\gamma_i = \frac{1}{\log_2(1+i)}$.

Regret Bound

Definition

User feedback is **expected** α_i, δ_i -**informative** for user with personal utility function U_i , if $\bar{\xi}_t \in \mathfrak{R}$ is chosen s.t. for some given $\alpha_i \in [0, 1]$ and $\delta_i > 0$:

$$\mathbf{E}_{\bar{\mathbf{y}}_t}[U_i(\mathbf{x}_t, \bar{\mathbf{y}}_t)] \geq (1 + \delta_i)U_i(\mathbf{x}_t, \mathbf{y}_t) + \alpha_i \left(U_i(\mathbf{x}_t, \mathbf{y}_t^{*,i}) - U_i(\mathbf{x}_t, \mathbf{y}_t) \right) - \bar{\xi}_t.$$

Theorem

For any $\mathbf{w}_* \in \mathbf{R}^m$ and $\|\phi(\mathbf{x}, \mathbf{y})\|_{\ell_2} \leq R$ the average regret of the SoPer-R algorithm can be upper bounded as:

$$REG_T \leq \frac{1}{\eta T} \sum_{t=0}^{T-1} \mathbf{E}_i[p_i \bar{\xi}_t] + \frac{\beta R \|\mathbf{w}_*\|}{\eta} + \frac{\sqrt{2} \sqrt{4 - \beta^2} R \|\mathbf{w}_*\|}{\eta \sqrt{T}}.$$

with: $\delta_i \geq \left(\Gamma_F \cdot \frac{1 - p_i}{p_i} \right)$, $\eta = \min_i p_i \alpha_i$ and $\beta = (1 - \beta_{gr}) = \frac{1}{2}$.