Recommender System & Its Application in Healthcare

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Outline

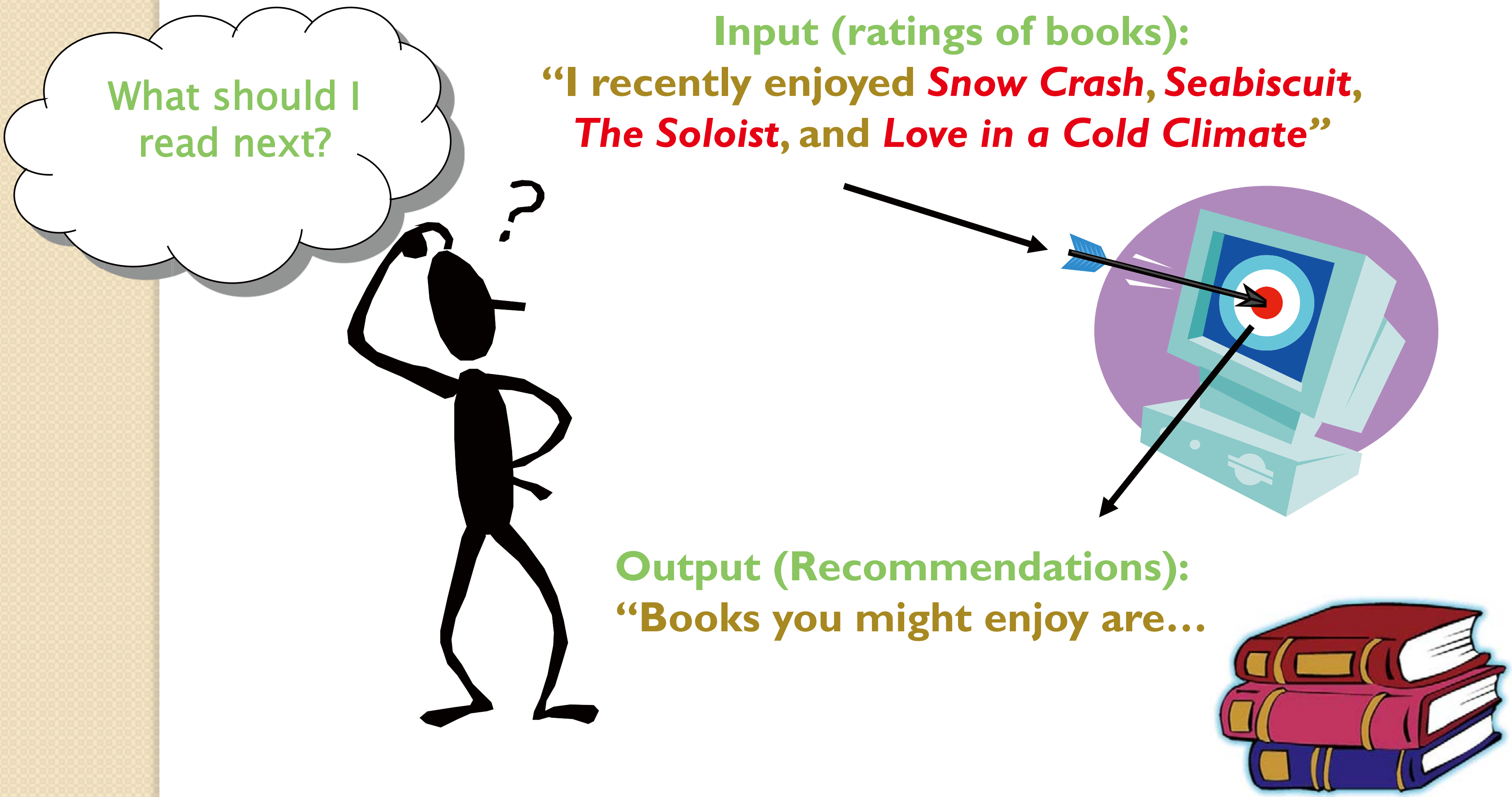
- What is recommender system?
- Our focuses
- Application of RS in healthcare
- Research directions

Recommender system is a technological proxy for a social process

Recommendations from friends

Recommendations from Online Systems

Basic interaction paradigm of recommender systems



Why is it so popular in current Web environment?

- Recommender systems **to help users**
  - handle with information overload
  - discover interesting items (e.g., friends, videos, blogs, articles, etc.) in the social environment

- Term became notable in 2004
  - Enhancing creativity, communications, secure **information sharing**, **collaboration**
  - Leading to the evolution of ***web-culture communities***: social-networking sites, video sharing sites, blogs, wikis, etc.

Covering research areas

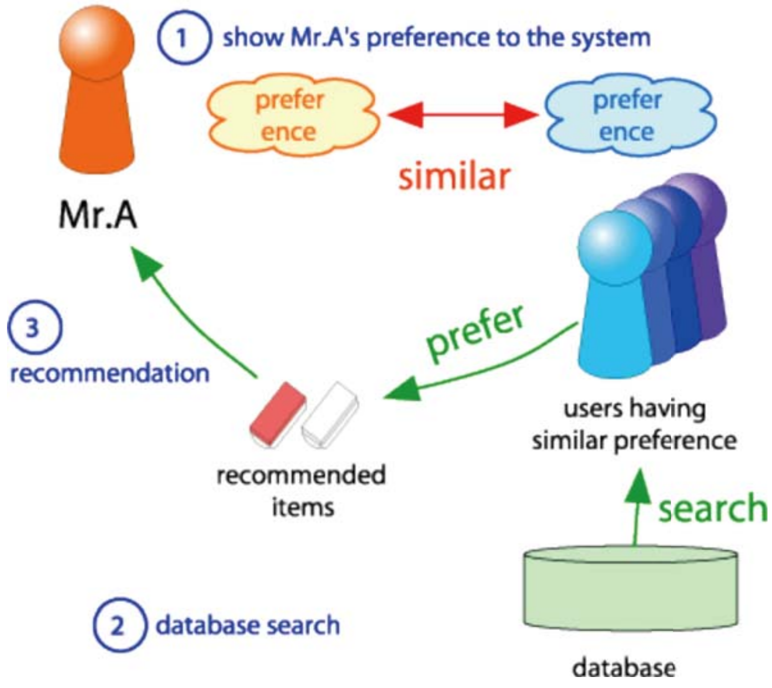
- Machine Learning
  - Development of algorithms and techniques that allow computers to "learn“
- Information Retrieval
  - Searching of documents and information in documents (e.g. web search engines)
- Human computer interaction
  - Usability, understanding the user, evaluating systems
- User modeling
  - Modeling of user preferences or profile
- Designing and building complex information systems
  - Data representation, integration and interoperability, business models

Major Techniques

Technique	Typical background	Typical input	Typical process
Collaborative filtering	Ratings from **U** of items in **I**	Ratings from **u** of items in **I**	Identify users in **U** similar to **u**, and extrapolate from their ratings of **i**
Content-based	Features of items in I	u's ratings of items in I	Generate a classifier that fits u's rating behavior and use it on i
Demographic	Demographic information about U and their ratings of items in I	Demographic information about u	Identify users that are demographically similar to u, and extrapolate from their ratings of i
Utility-based	Features of items in I	A utility function over items in I that describes u's preferences	Apply the function to items and determine i's rank
Knowledge-based	Features of items in I; knowledge of how these items meet a user's needs	A description of u's needs or interests	Infer a match between i and u's need

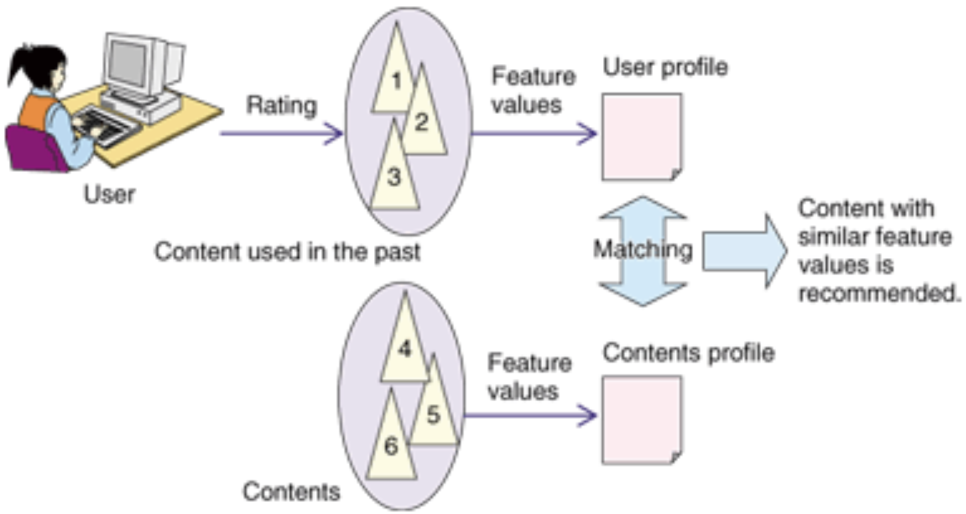
Collaborative filtering

"You like most of the same movies Joe and Linda like, so you might like these other movies they liked."



Content-based technique

"You like movies starring Maggie Cheung."



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Our previous research works

1. User interface design
2. Fusing auxiliary resources
   - Social relationships
   - Tags
   - Reviews

1. User interface design

The most popular product

	Manufacturer	Price	Processor speed	Battery life	Installed memory	Hard drive capacity	Display size	Weight
	—	$2'095.00	1.67 GHz	4.5 hours	512 MB	80 GB	38.6 cm	2.54 kg

We also recommend the following products

		Manufacturer	Price	Processor speed	Battery life	Installed memory	Hard drive capacity	Display size	Weight
	Why?	—	$1'220.49	1.8 GHz	5 hours	1 GB	100 GB	38.1 cm	2.95 kg
	Why?	—	$2'148.99	2.0 GHz	4 hours	1 GB	100 GB	39.1 cm	2.90 kg
	Why?	—	$1'379.00	3.3 GHz	2 hours	512 MB	100 GB	43.2 cm	4.31 kg
	Why?	—	$1'179.00	3.2 GHz	2 hours	512 MB	80 GB	39.1 cm	3.62 kg
	Why?	—	$1'529.00	1.7 GHz	6.5 hours	512 MB	80 GB	33.8 cm	1.77 kg
	Why?	—	$1'599.00	1.7 GHz	6.5 hours	512 MB	80 GB	33.8 cm	1.91 kg
	Why?	—	$1'425.00	1.6 GHz	5.5 hours	512 MB	80 GB	39.1 cm	2.86 kg
	Why?	—	$2'235.00	1.8 GHz	2.5 hours	1 GB	100 GB	43.2 cm	3.99 kg
	This product has higher processor speed and bigger hard drive capacity but is heavier		$1'190.00	3.2 GHz	1 hours	512 MB	80 GB	39.1 cm	3.72 kg
			$1'125.00	1.5 GHz	6 hours	512 MB	80 GB	30.7 cm	2 kg
	Why?	—	$2'319.00	1.67 GHz	4.5 hours	512 MB	100 GB	43.2 cm	3.13 kg
	Why?	—	$1'499.00	1.5 GHz	5 hours	512 MB	80 GB	33.8 cm	1.91 kg
	Why?	—	$1'739.99	1.5 GHz	4.5 hours	512 MB	80 GB	38.6 cm	2.49 kg
	Why?	—	$1'629.00	1.8 GHz	5.8 hours	512 MB	60 GB	38.1 cm	2.81 kg
	Why?	—	$1'625.99	1.5 GHz	5 hours	512 MB	80 GB	30.7 cm	2.09 kg
	Why?	—	$1'426.99	1.5 GHz	5 hours	512 MB	60 GB	30.7 cm	2.09 kg
	Why?	—	$2'099.99	1.2 GHz	9 hours	512 MB	60 GB	26.9 cm	1.41 kg
	Why?	—	$2'075.00	1.8 GHz	1.67 hours	512 MB	100 GB	43.2 cm	4.4 kg
	Why?	—	$1'649.00	1.1 GHz	8.5 hours	512 MB	40 GB	26.9 cm	1.36 kg
	Why?	—	$627.10	1.6 GHz	1.5 hours	256 MB	40 GB	38.1 cm	2.81 kg
	Why?	—	$969.00	1.2 GHz	6 hours	256 MB	39 GB	30.7 cm	2.22 kg
	Why?	—	$520.00	1.13 GHz	3.5 hours	128 MB	30 GB	35.8 cm	2.59 kg
	Why?	—	$1'929.00	1.2 GHz	4 hours	512 MB	60 GB	26.9 cm	1.41 kg
	Why?	—	$1'595.00	1.0 GHz	5.5 hours	512 MB	40 GB	26.9 cm	1.41 kg

List view

vs.

The most popular product

	Manufacturer	Price	Processor speed	Battery life	Installed memory	Hard drive capacity	Display size	Weight
	—	$2'095.00	1.67 GHz	4.5 hour(s)	512 MB	80 GB	38.6 cm	2.54 kg

We also recommend the following products because

they are cheaper and lighter, but have lower processor speed

	Manufacturer	Price	Processor speed	Battery life	Installed memory	Hard drive capacity	Display size	Weight
	—	$1'499.00	1.5 GHz	5 hour(s)	512 MB	80 GB	33.8 cm	1.91 kg
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	—	$1'595.00	1 GHz	5.5 hour(s)	512 MB	40 GB	26.9 cm	1.41 kg

they have higher processor speed and bigger hard drive capacity, but are heavier

	Manufacturer	Price	Processor speed	Battery life	Installed memory	Hard drive capacity	Display size	Weight
	—	$1'220.49	1.8 GHz	5 hour(s)	1 GB	100 GB	38.1 cm	2.95 kg
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	—	$2'075.00	1.8 GHz	1.67 hour(s)	512 MB	100 GB	43.2 cm	4.4 kg

they have longer battery life and lighter weight, but smaller display size

	Manufacturer	Price	Processor speed	Battery life	Installed memory	Hard drive capacity	Display size	Weight
	—	$1'529.00	1.7 GHz	6.5 hour(s)	512 MB	80 GB	33.8 cm	1.77 kg
	—	$1'599.00	1.7 GHz	6.5 hour(s)	512 MB	80 GB	33.8 cm	1.91 kg
	—	$1'125.00	1.5 GHz	6 hour(s)	512 MB	80 GB	30.7 cm	2 kg
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	—	$969.00	1.2 GHz	6 hour(s)	256 MB	39 GB	30.7 cm	2.22 kg

they are cheaper, but heavier

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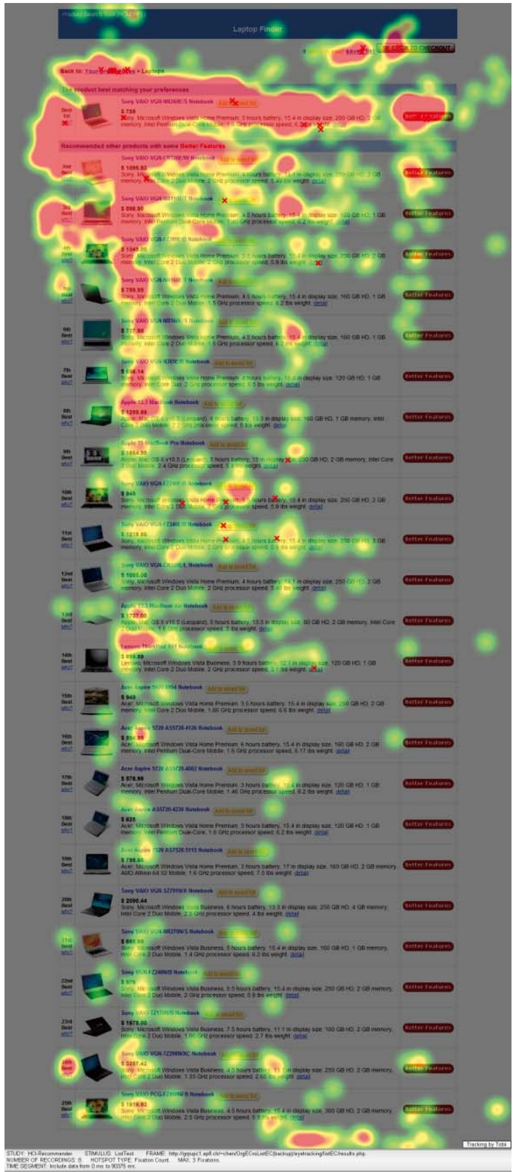
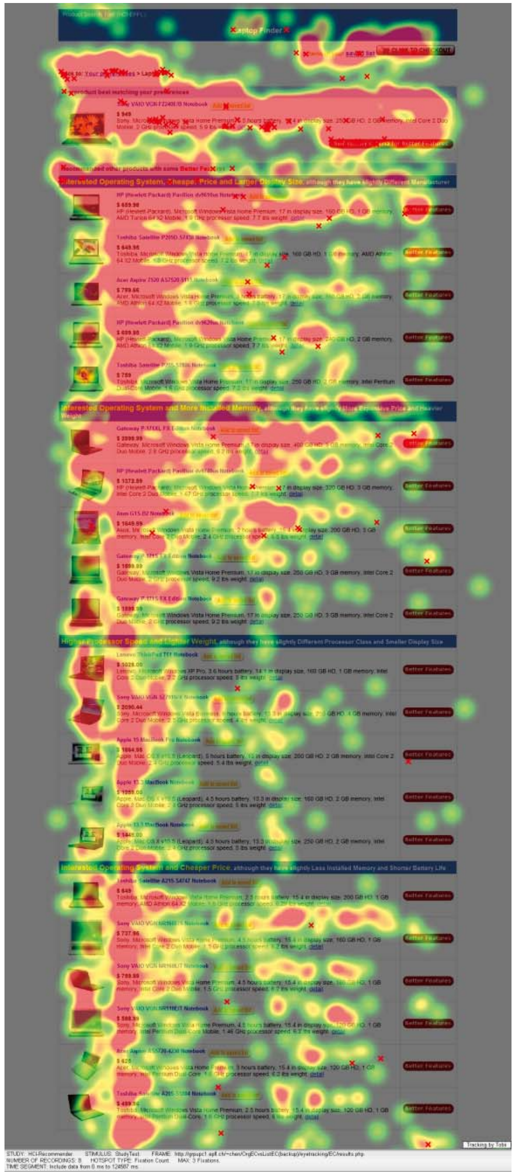
Organized view

Eye-tracking experiment: Hotspot plot



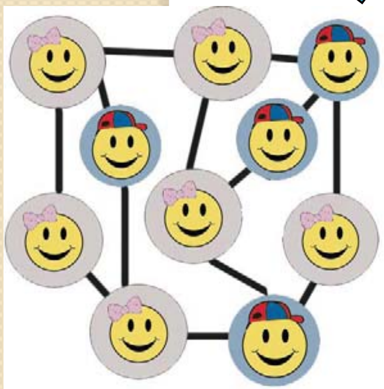


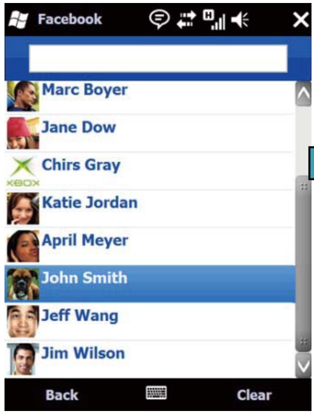
List view vs. Organized view

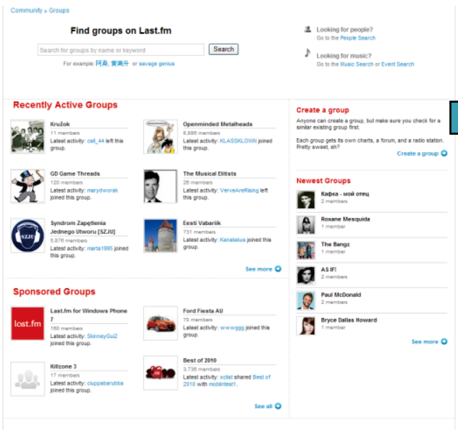
Our previous research works

1. User interface design
2. Fusing auxiliary resources
    - Social relationships
    - Tags
    - Reviews

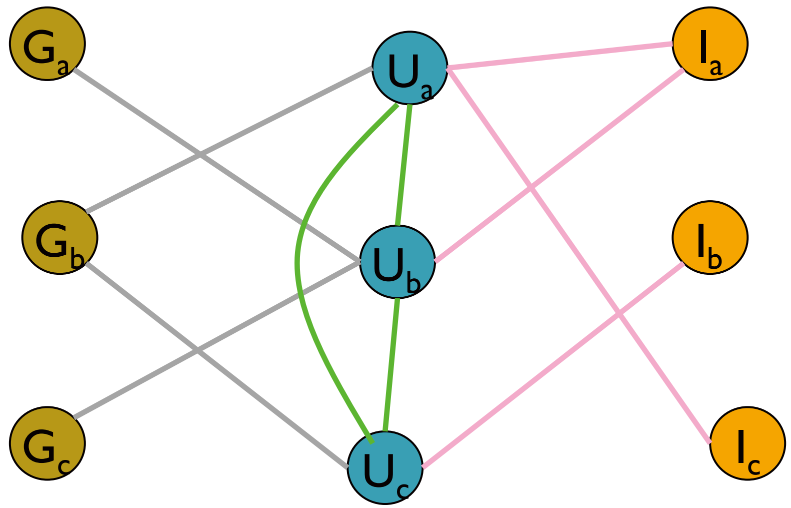
2.1 Augmenting Collaborative Recommender by Fusing Explicit Social Relationships







Approach 1: social graph



Approach 2: matrix factorization

$$\min_{u*,i*} \sum_{u,i} c_{ui}(p_{ui} - x_u^T y_i)^2 + \lambda(\sum_u \|x_u\|^2 + \sum_i \|y_i\|^2)$$

$$\alpha \min_{u*,i*} \sum_{u,i} c_{ui}(p_{ui} - x_u^T y_i)^2 + \lambda(\sum_u \|x_u\|^2 + \sum_i \|y_i\|^2) + \lambda_f(\|x_u - \frac{1}{|F(u)|} \sum_{f \in F(u)} x_f\|^2) + (1-\alpha) \min_{u*,g*} \sum_{u,g} c^*_{ug}(p^*_{ug} - x_u^T z_g)^2$$
$$+\lambda(\sum_u \|x_u\|^2 + \sum_i \|z_g\|^2)$$

2.2 Incremental Tag-Aware User Profile Building to Augment Item Recommendations

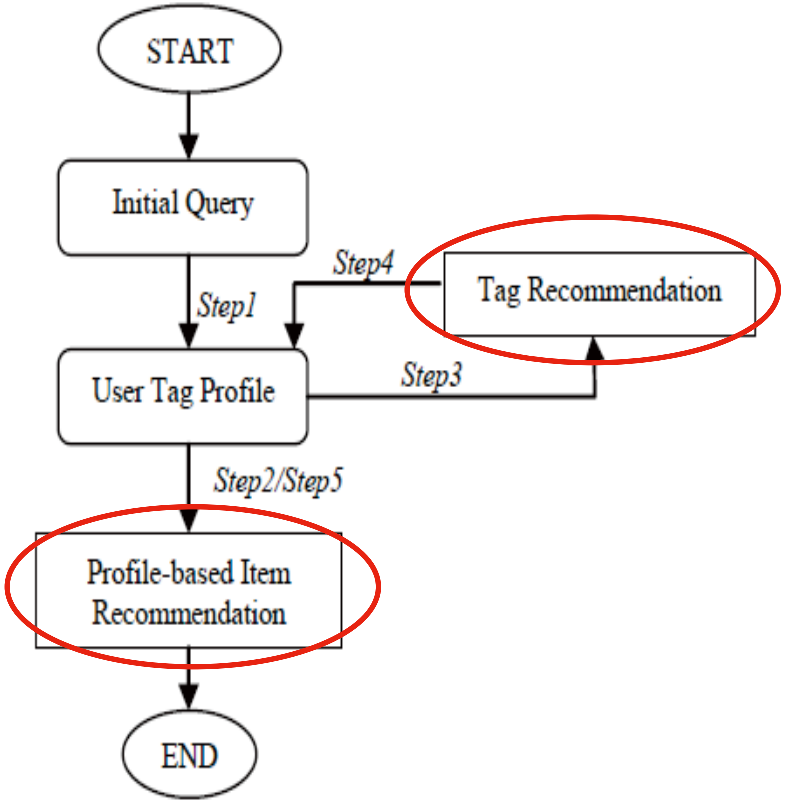


Figure 1: The overall flow of hybrid design

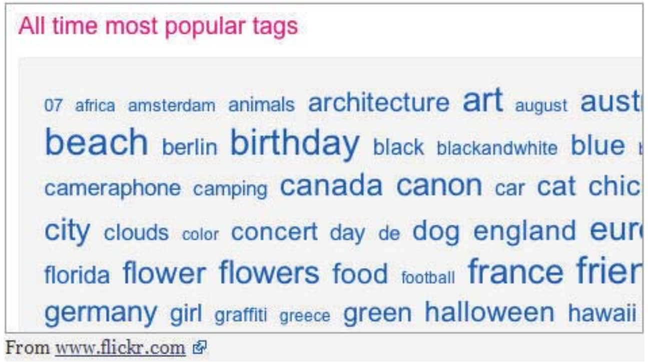
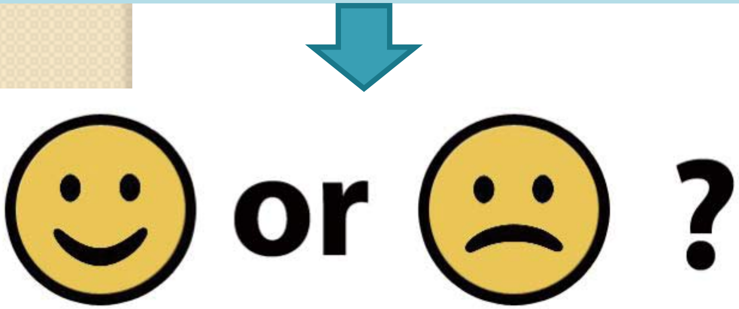


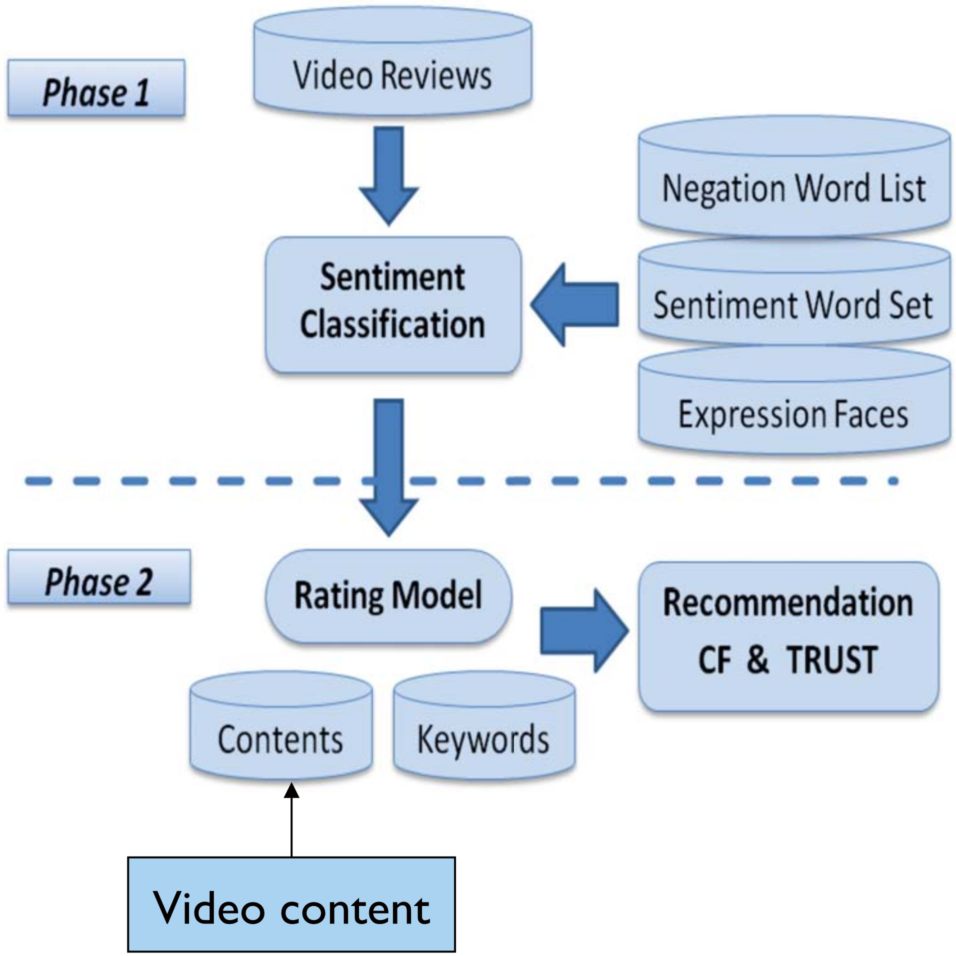
Figure 4: snapshot of the recommended tags

Figure 6: The interface of our movie recommender system.

2.3 Review-based recommender system
-- document-level

I was pleasantly surprised by this fairy tale type movie. Director Bryan Singer and his fellow cast and crew members came through and pulled something that remains an average flick for our entertainment. I am not crazy about this movie, it just attains to being a decent flick. It seemed that if it went any further wasting time or spending time on development the cheesiness would have kicked in. But in Jack the Giant Slayer the enjoyment comes out of the build-up and freight of these huge giants.





2.3 Review-based recommender system
-- feature-level

I bought an iPhone a few days ago. It was such a nice phone. The touch screen was really cool. The voice quality was clear too. Although the battery life was not long, that is ok for me. However, my mother was mad with me as I did not tell her before I bought the phone. She also thought the phone was too expensive, and wanted me to return it to the shop. …

Feature 1: touch screen

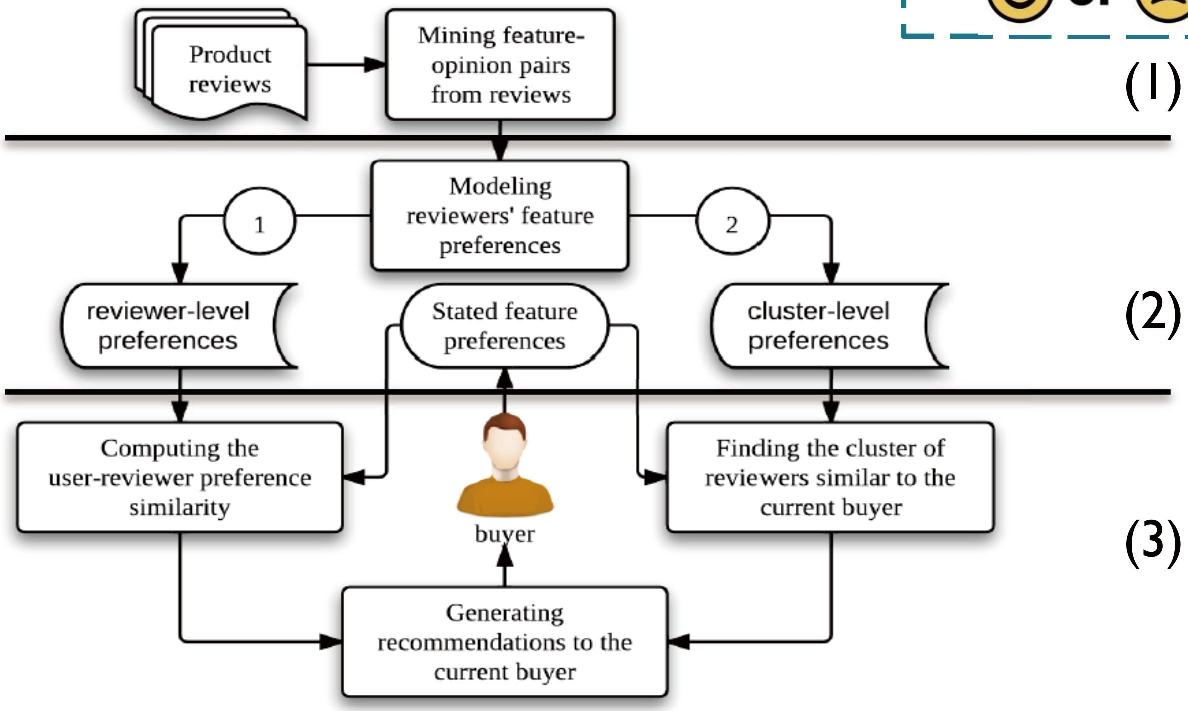
☺ or ☹ ?

Feature 2: voice quality

☺ or ☹ ?

Feature 3: battery life

☺ or ☹ ?



Publications

- Li Chen, Wei Zeng and Quan Yuan. A Unified Framework for Recommending Items, Groups and Friends in Social Media Environment via Mutual Resource Fusion. *Expert Systems with Applications (ESWA)*, 2013.
- Weishi Zhang, Guiguang Ding, Li Chen, Chunping Li and Chengbo Zhang. Generating Virtual Ratings from Chinese Reviews to Fuse into Collaborating Filtering Algorithms. *ACM Transactions on Intelligent Systems and Technology (TIST)*, 2013.
- Li Chen and Pearl Pu. Experiments on User Experiences with Recommender Interfaces. *Behaviour & Information Technology*, 2013.
- Feng Wang and Li Chen. Recommending Inexperienced Products via Learning from Consumer Reviews. In *Proceedings of 2012 IEEE/WIC/ACM International Conference on Web Intelligence (WI'12)*, Macau, October 04-07, 2012.
- Quan Yuan, Li Chen and Shiwan Zhao. Factorization vs. Regularization: Fusing Heterogeneous Social Relationships in Top-N Recommendation. In *Proceedings of the 5th ACM Conference on Recommender Systems (RecSys'11)*, pages 245-252, Chicago, IL, USA, October 23-27, 2011.
- Ho Keung Tsoi and Li Chen. Incremental Tag-Aware User Profile Building to Augment Item Recommendations. In *ACM Conference on Computer Supported Cooperative Work (CSCW'11), 2nd Workshop on Social Recommender Systems (SRS'11)*, Hangzhou, China, March 19-23, 2011.

http://www.comp.hkbu.edu.hk/~lichen/?page_id=29

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- What is recommender system?
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- Application of RS in healthcare
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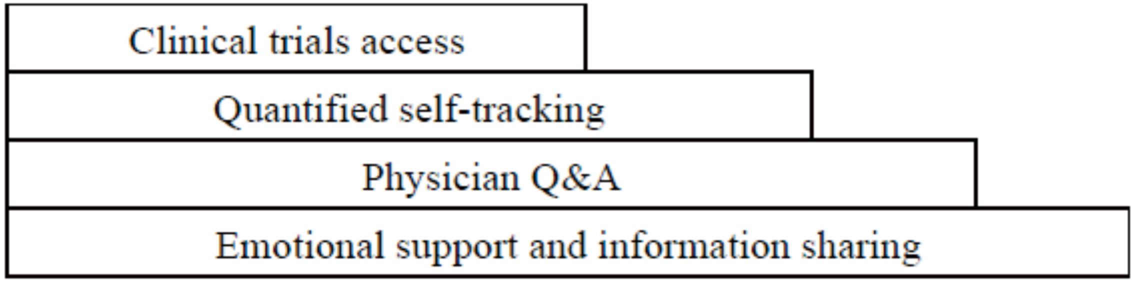
Application of recommender systems in healthcare area

- Patient-driven health social network
  - a website where consumers may be able to find health resources at a number of different levels



  - the potential to find others in similar health situations and share information about conditions, symptoms and treatments

Swan, M. Emerging patient-driven health care models: an examination of health social networks, consumer personalized medicine and quantified self-tracking. *International Journal of Environmental Research and Public Health* 6(2), 492–525, 2009.

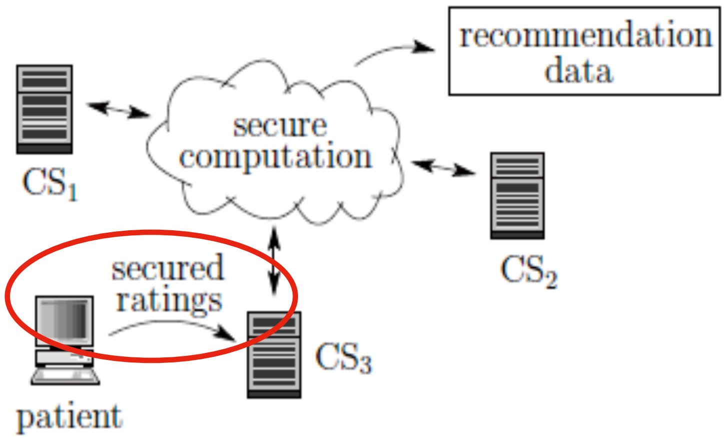
A commercial health social network with 115,000 users

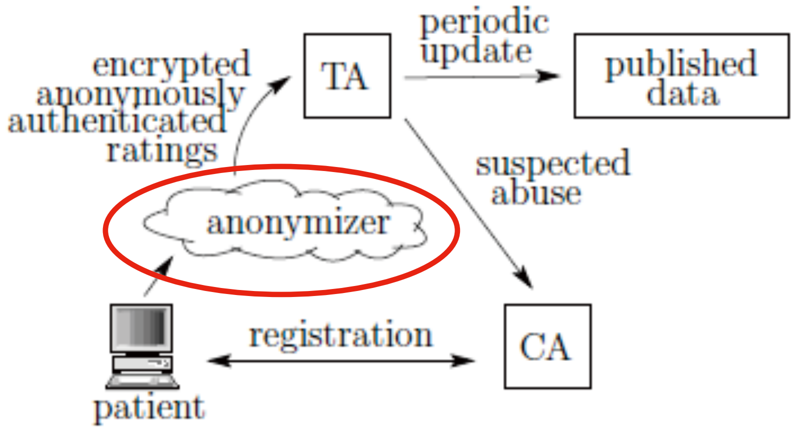
"Share your experiences with treatments.
Find patients just like you.
Learn from others who know"

- Main functionality:
  - Collaborative filtering to identify potentially related conditions patients and match patients in similar situations
  - Quantified self-tracking
  - Clinical trials access

A reliable doctor recommender system

Patients can rate physicians based on their satisfaction, affording the patients more fine-grained control over how to choose the physician who best suits their needs.





Patients contribute secured (e.g., encrypted) ratings, and the computation of all recommendations is performed over secured data

Patients use a system for anonymous routing to submit her contribution to the entity that receives all patient ratings and publishes information about them

Hoens, T. Ryan, Marina Blanton, and Nitesh V. Chawla. Reliable medical recommendation systems with patient privacy. In *Proceedings of the 1st ACM International Health Informatics Symposium*, 173-182, ACM, 2010.

Personalized health education

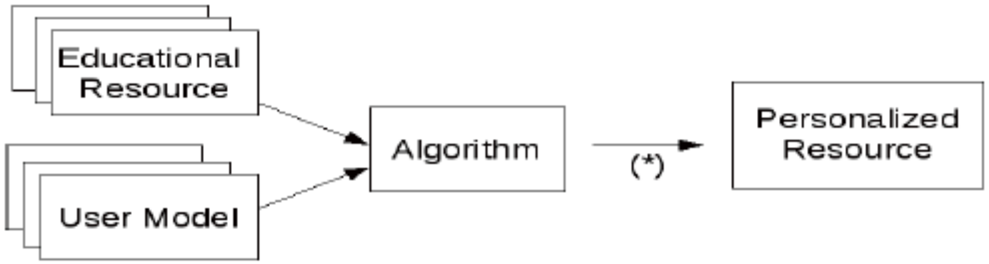
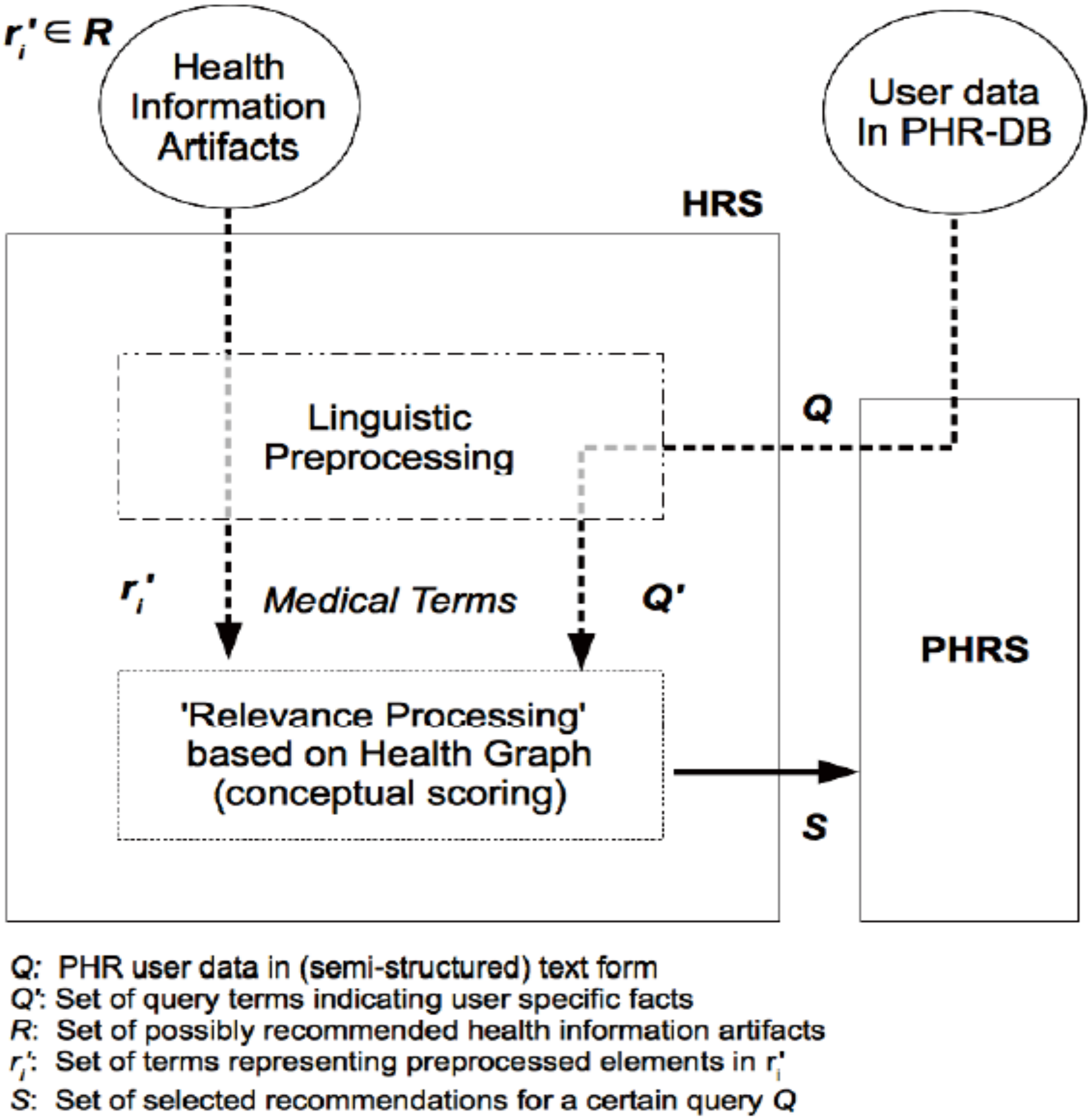


Table 1. Challenges and opportunities in the algorithms

CTHES	RS	RS for Health Education
Grounded on medical expert knowledge for a specific health problem. High dependency on the human experts: it makes it difficult to increase number of users or resources.	*Collaborative-based:* based on the ratings of similar users (-) need of critical mass of users (-) lack of knowledge about new items and new users *Content-based:* based on the user's previous ratings of similar items (+) results don't depend on other users (-) need of information about the items and previous user ratings (-) super specialization of the recommendations	RS approaches could be used to gather aspects, which are not taken into account by CTHES approaches (such as personal preferences). The RS algorithms could learn from the previous interactions with the system. RS could be used to incorporate additional resources from the Internet.

- CTHES: Computer-Tailoring Health Education Systems
- RS: Recommender Systems

Fernandez-Luque, Luis, Randi Karlsen, and Lars K. Vognild. Challenges and opportunities of using recommender systems for personalized health education. *Stud. Health Technol. Inform.* 150, 903-907, 2009.



A proposed health recommender system (HRS) interacting with a personal health record (PHR) system to obtain individual relevance on the basis of a health graph

Wiesner, Martin, and Daniel Pfeifer. Adapting recommender systems to the requirements of personal health record systems. In *Proceedings of the 1st ACM International Health Informatics Symposium*, 410-414, ACM, 2010.

Nursing care plan recommender system

- Patient care phenomena are so complex that it is difficult for many nurses to create effective comprehensive care plans for their patients
- Nursing care plan system:
  - To provide clinical decision support, nursing education, clinical quality control
  - To interactively provide a ranking list of the suggested items in order to **maximize efficiency and care quality in a hospital setting**

Table 1. A sample ranking list.

Previous selection:	You have selected 28 (health maintenance), 12 (pain acute).			
Ranking list	Ranking	Code	Description	Value
	1	52	Knowledge deficit	0.91
	2	37	Risk for infection	0.66
	3	39	High risk for injury	0.33
	4	68	Physical mobility alteration	0.19
	5	05	Anxiety	0.17
	6	78	Skin integrity, impaired	0.16
	7	67	Self-care deficit, bathing/hygiene	0.10
	8	79	Skin integrity, risk for impaired	0.05

- Properties of clinical recommender systems
  - To recommend all the required items to nurses
  - There is rating system because a patient’s requirement for a particular item is based on objective means and not on subjective desires

Duan, L., W. N. Street, and E. Xu. Healthcare information systems: data mining methods in the creation of a clinical recommender system. *Enterprise Information Systems* 5 (2), 169-181, 2011.

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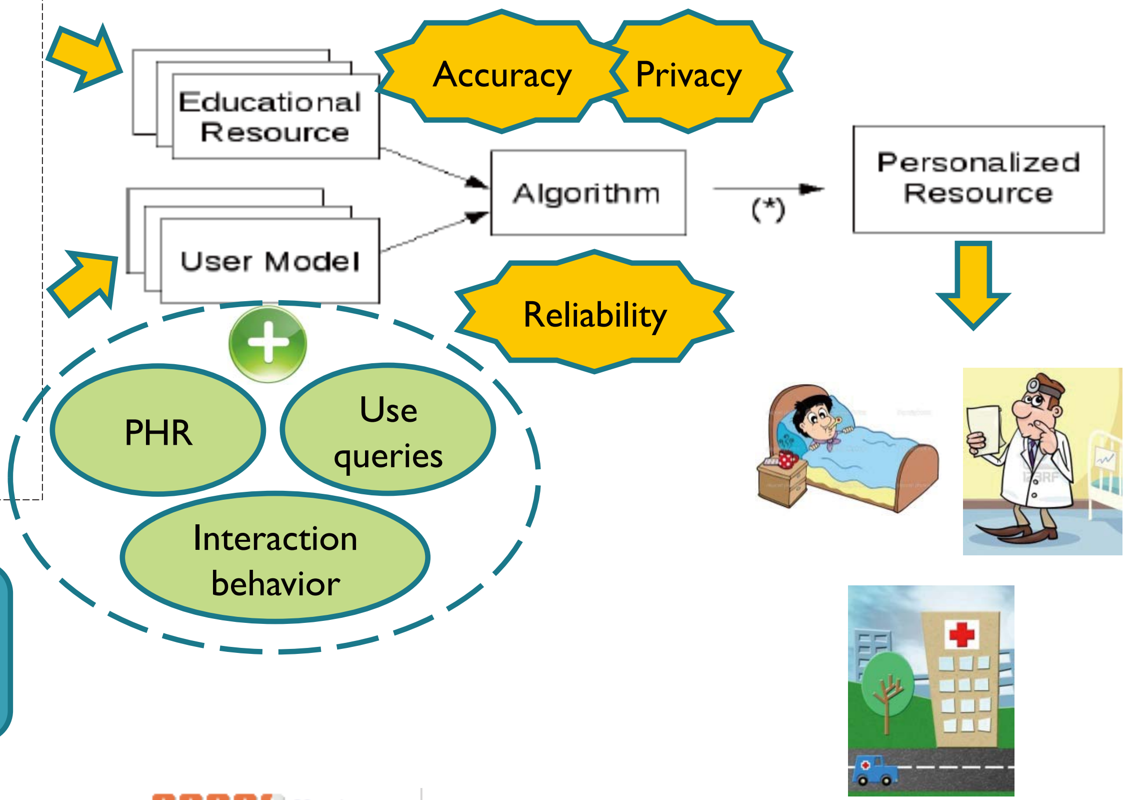
Taking advantage of additional health resources from social network

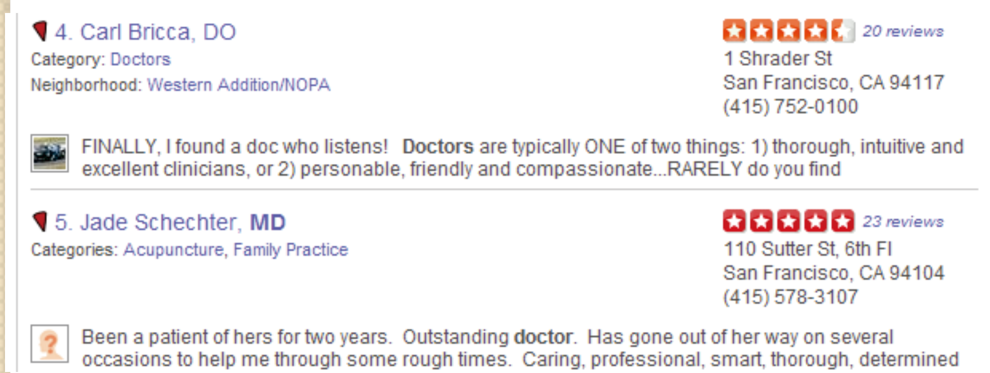
Tags

Patients' reviews to doctors/medicines

Social relationships

Our background





4. Carl Bricca, DO — 20 reviews
Category: Doctors
Neighborhood: Western Addition/NOPA
1 Shrader St
San Francisco, CA 94117
(415) 752-0100

FINALLY, I found a doc who listens! **Doctors** are typically ONE of two things: 1) thorough, intuitive and excellent clinicians, or 2) personable, friendly and compassionate...RARELY do you find

5. Jade Schechter, **MD** — 23 reviews
Categories: Acupuncture, Family Practice
110 Sutter St, 6th Fl
San Francisco, CA 94104
(415) 578-3107

Been a patient of hers for two years. Outstanding **doctor**. Has gone out of her way on several occasions to help me through some rough times. Caring, professional, smart, thorough, determined

Thanks!

- Q&A